SCARBOROUGH OFFSHORE PROJECT PROPOSAL

Development Division
Revision 5 Submission
February 2020

Woodside

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ACRONYMS AND ABBREVIATIONS

Acronym	Description
AFFF	Aqueous Film Forming Foam
AFMA	Australian Fisheries Management Authority
AHS	Australian Hydrographic Service
AIMS	Australian Institute of Marine Science
ALARP	as low as reasonably practicable
AMFA	Australian Fisheries Management Authority
AMOSC	Australian Marine Oil Spill Centre
AMPs	Australian Marine Parks
AMSA	Australian Maritime Safety Authority
AODN	Australian Ocean Data Network
APPEA	Australian Petroleum Production and Exploration Association
AUV	autonomous underwater vehicle
BESS	Battery energy storage system
BHA	bottom hole assembly
BIA	biologically important areas
BOD	biological oxygen demand
BOP	blow out preventer
BRUVS	baited remote underwater video stations
BTEX	benzene, toluene, ethylbenzene and xylenes
CAMBA	China Australia Migratory Bird Agreement
CCR	crushed calcareous rock
CITES	International Convention on International Trade in Endangered Species of Wild Fauna and Flora
CME	Chamber of Minerals and Energy of Western Australia
COLREGS	Convention on the International Regulations for Preventing Collisions at Sea 1972
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTE	critical technology elements
DAP	data access portal
DAWE	Department of Agriculture, Water and the Environment
DBCA	Department of Biodiversity, Conservation and Attractions
DEE	Department of Environment and Energy
DEWHA	Department of the Environment, Heritage, Water and the Arts, ACT
DJTSI	Department of Jobs, Tourism, Science and Innovation
DMIRS	Department of Mines, Industry Regulation and Safety
DoEE	Department of the Environment and Energy (former)
DoF	Department of Fisheries
DoT	Department of Transport
DP	dynamic positioning
DPaW	Department of Parks and Wildlife

Acronym	Description
DPIRD	Department of Primary Industries and Regional Development
DST	drill stem test
DWER	Department of Water and Environmental Regulation
E&P	exploration and production
EGPMF	Exmouth Gulf Prawn Managed Fishery
EMBA	environment that may be affected
EP	environmental plan
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPO	environment protection order
EPO	environmental performance outcomes
ESD	ecologically sustainable development
FEED	front end engineering design
FFFP	film-forming fluoroprotein foams
FID	final investment decision
FLNG	floating liquefied natural gas
FPU	floating production unit
FWS	United States Fish and Wildlife Service
GHG	greenhouse gas
GVP	gross value of production
H2S	hydrogen sulphide
HFC	hydrofluorocarbons
HSEQ	health safety, environment and quality
IAOGP	International Association of Oil & Gas Producers
IAPP	International Air Pollution Prevention
IEA	International Energy Agency
IGEM	Industry-Government Environmental Meta-database
ILTs	in-line tee
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IMS	invasive marine species
ISV	Subsea installation vessel
JAMBA	Japan Australia Migratory Bird Agreement
KEF	Key Ecological Features
KLC	Kimberly Land Council
KP	kilometre point
LE	equivalent sound level
Lp	sound pressure level
Lpk	peak sound pressure level
LBL	long baseline
LNG	liquified natural gas

Acronym	Description
MAC	Murujuga Aboriginal Corporation
MARPOL	International Convention for the Prevention of Pollution from Ships
MBES	multi-beam echo sounder
MDO	marine diesel oil
MEG	Mono-Ethylene Glycol
MMAs	marine management area
MMF	mackerel managed fishery
MNES	matters of national environmental significance
MODU	mobile offshore drilling unit
MP	marine park
NBPMF	Nickol Bay Prawn Managed Fishery
NCPMF	North Coast Prawn Managed Fisheries
NDCs	Nationally Determined Contributions
NDE	non-destructive examination
NES	national environmental significance
NICNAS	Commonwealth Government's National Industrial Chemicals Notification and Assessment Scheme
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NOPTA	National Offshore Petroleum Titles Administrator
NOx	Oxides of nitrogen
NTU	nephelometric turbidity unit
NWBM	non-water based muds
NWMR	North-west Marine Region
NWS	North West Shelf
NWSTF	North West Slope Trawl Fishery
ODS	ozone depleting substances
OPEP	oil pollution emergency plan
OPGGS Act	Offshore Petroleum and Greenhouse Gas Storage Act 2006
OPMF	Onslow Prawn Managed Fishery
OPP	Offshore Project Proposal
OSMP	Operational and Scientific Monitoring Plan
PFAS	poly-fluoroalkyl substances
PK	peak sound level
PNEC	predicted no effect concentration
PPA	Pilbara Ports Authority
PRCs	perfluorocarbons
PTS	permanent hearing loss
RFSU	ready for start-up
ROV	remotely operated vehicle
SBTF	southern Bluefin Tuna Fishery

Acronym	Description
SCE	solid control equipment
SCM	subsea control module
SDUs	subsea distribution units
SEEMP	ship energy efficiency management plan
SEL	sound exposure level
SIV	subsea installation vessels
SMPEP	shipboard marine pollution emergency plan
SOLAS	safety of life at sea
SOPEP	shipboard oil pollution emergency plan
SPL	sound pressure level
SPRAT	species profile and threats database
SSDP	southern seawater desalination plant
SSF	specimen shell managed fishery
SURF	subsea umbilicals, risers and flowlines
TAC	total allowable catch
TACC	Dampier Technical Advisory and Consultative Committee
TcF	trillion cubic feet
TD	total depth
TPH	total petroleum hydrocarbons
TRL	technology readiness level
TSEP	Trunkline system expansion project
TSHD	trailing suction hopper dredgers
TSS	total suspended solids
TTS	temporary hearing threshold shift
UNCLOS	United Nations Convention on the Law of the Sea 1982
USBL	ultra-short baseline
VOCs	volatile organic compounds
VSP	vertical seismic profiling
WA	Western Australia
WAF	Water Accommodated Fractions
WAFIC	Western Australia Fishing Industries Council
WAITOC	Western Australian Indigenous Tourism Operators Council
WAMSI	Western Australian Marine Science Institution
WBS	water based muds
WCDSC	West Coast Deep Sea Crustacean Managed Fishery
WDTF	Western Deepwater Trawl Fishery
WHO	World Health Organisation
WMS	Woodside Management System
WOMP	Well Operations Management Plan

Acronym	Description
Woodside	Woodside Energy Limited
WHRU	Waste heat recovery unit
WSTF	Western Skipjack Tuna Fishery
WTBF	Western Tuna and Billfish Fishery
WWF	World Wildlife Fund
XC	Xanthomonas campestris / xanthan gum

UNITS

Unit	Description
°C	degrees Celsius
µg/L	micrograms per litre
µm	micrometre
bbl/day	barrels per day
Bq/m3	becquerels per cubic metre
cui	cubic inches
dB	decibel
dB re 1 µPa2.s	dB level of the time-integrated, squared sound pressure normalised to a one second period
DO (%SAT)	dissolved oxygen %saturation
FTU	Formazin turbidity unit
g/m^2	grams per metre squared
ha	hectare
Hz	hertz
kHz	kilo hertz
km	kilometre
kPa	kilopascal
L	litre
Lux	unit of illuminance
m	metre
m^2	metres squared
m^3/d	cubic metre per day
m^3/day	cubic metres per days
m^3/hr	cubic metres per hour
ML/day	megalitre per day
mm	millimetre
Mm3	cubic megametre
MMScf	millions of standard cubic feet
mol	mole
mS/cm	milli siemens per *centimetre*
Mt	metric tons
NTU	nephelometric turbidity unit
pH	hydrogen ion concentration
ppm	parts per million
psi	pounds per square inch
SEL24h	?
t	tonne
Tcf (100%, 2C)	trillion cubic feet (Ethane)
TSS	total suspended solids

Unit	Description
µg/m3	micrograms per cubic metre
w/w	weight by weight
$W/m^2/sr$	watt per square metre per steradian (SI unit of radiance)
µPa	micropascal

EXECUTIVE SUMMARY

ES1. INTRODUCTION

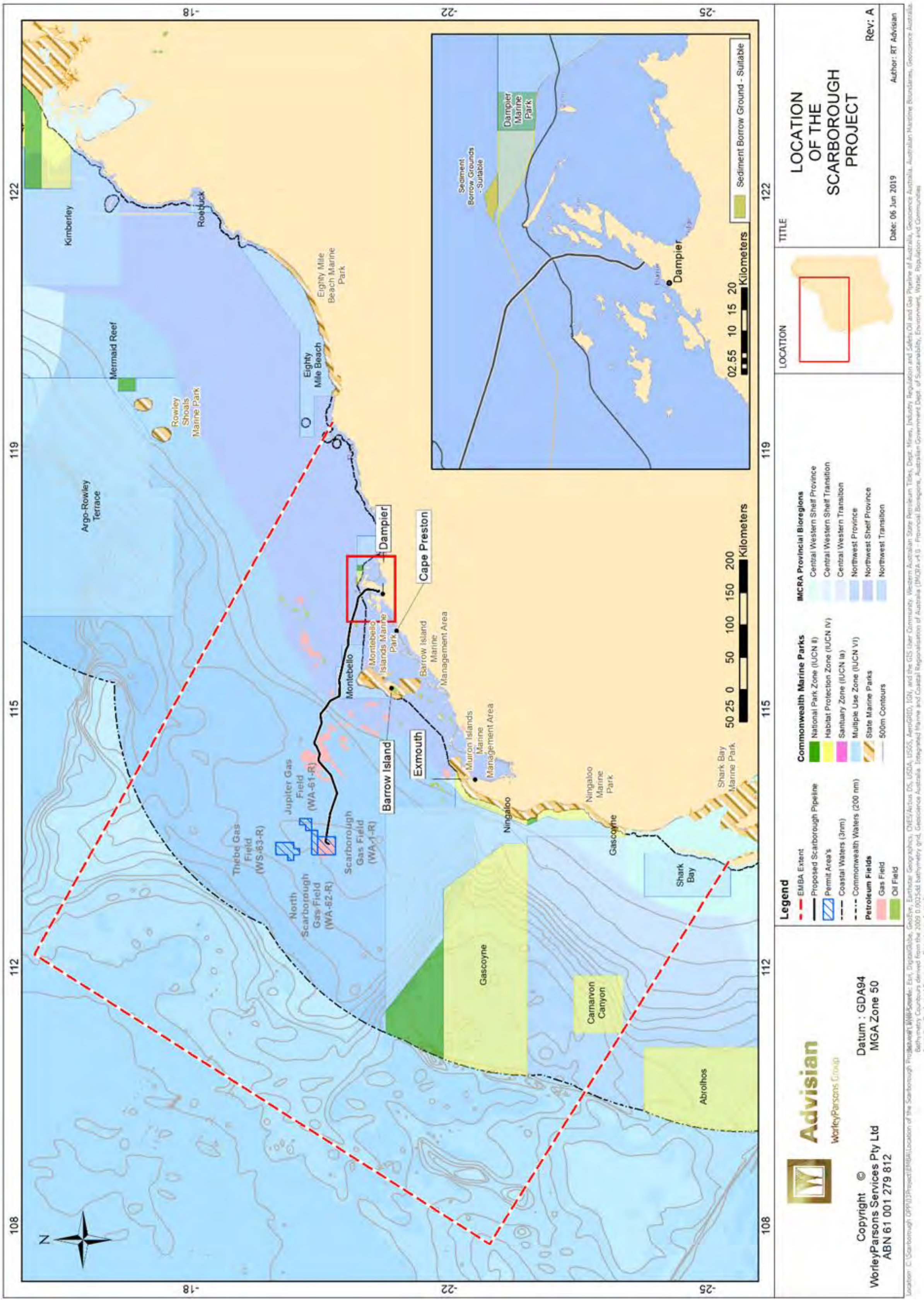
The Scarborough gas resource, located in Commonwealth waters approximately 375 km off the Burrup Peninsula, forms part of the Greater Scarborough gas fields, comprising the Scarborough, North Scarborough, Thebe and Jupiter gas fields.

Woodside Energy Ltd (Woodside), is proposing to develop the gas resource through new offshore facilities. These facilities are proposed to be connected to the mainland through an approximately 430 km trunkline to an onshore facility. Woodside's preferred concept is to process Scarborough gas through a brownfield expansion of the existing Pluto LNG onshore facility (Pluto Train 2) (Figure ES-0-1). Part of the operating strategy of the expanded Pluto LNG facility may be to divert some gas through the onshore interconnector pipeline to the Karratha Gas Plant.

The proposed offshore development, referred to as 'Scarborough', targets the commercialisation of the Scarborough and North Scarborough gas fields, through the construction of a number of subsea, high-rate gas wells, tied back to a semi-submersible Floating Production Unit (FPU) moored in approximately 900 m of water close to the Scarborough field (Figure ES-0-2).

The proposed development of Scarborough is an integral part of Woodside's Burrup Hub vision for a regional gas hub which will secure economic growth and local employment opportunities for Western Australia. In addition to the development of the Scarborough and North Scarborough fields, the Thebe and Jupiter gas fields provide opportunities for future tieback to Scarborough infrastructure. As the proposed trunkline route crosses the Carnarvon Basin, in close proximity to other undeveloped fields, Woodside is also engaging with other resource owners to explore opportunities for future development.

Woodside is targeting a final investment decision (FID) in 2020 to be ready for first cargo in 2024. Achieving these milestones is subject to joint venture approvals, regulatory approvals and commercial arrangements being finalised.



Note: Refer to section 5.1 for definition of Environment that may be Affected (EMBA)

Figure ES-0-1: Location of the proposed development of Scarborough

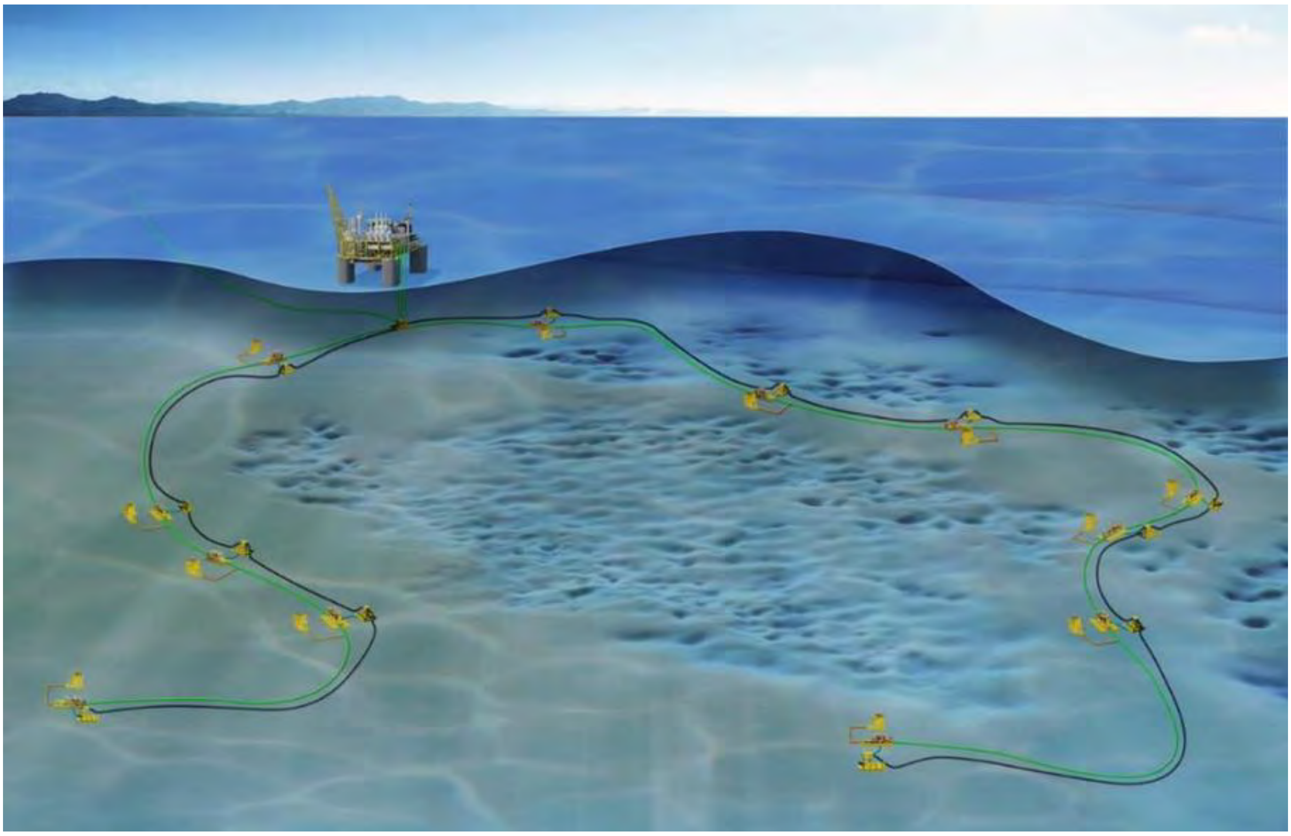


Figure ES-0-2: Schematic of the upstream components of the proposed development of Scarborough (note schematic not to scale)

Proponent

Woodside is Operator of the various joint ventures relating to the Scarborough, North Scarborough, Thebe and Jupiter fields, which comprise both Woodside and BHP Billiton Petroleum (North West Shelf) Pty Ltd (**"BHP"**). Current equity participation of the joint venture is as described in Table ES-0-1.

Table ES-0-1: Current Scarborough equity participants

Gas Fields	Woodside Interest	BHP Interest
Scarborough (WA-1-R)	73.5%	26.5%
North Scarborough (WA-62-R)	73.5%	26.5%
Thebe (WA-63-R)	50%	50%
Jupiter (WA-61-R)	50%	50%

Woodside is the largest Australian natural gas producer. The company operates Australia's biggest resource development, the North West Shelf Project (NWS Project) in Western Australia.

Woodside recognises that strong environmental performance is essential to success and continued growth. Woodside has an established methodology to identify impacts and risks and assess potential consequences of activities. Strong partnerships, sound research and transparency are the key elements of Woodside's approach to the environment.

Document Purpose and Scope

This Offshore Project Proposal (OPP) has been prepared by Woodside as Operator of WA-1-R, WA 62-R, WA 61-R and WA-63-R in accordance with the requirements of the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Environment Regulations), and associated guidelines.

Under the Environment Regulations, an OPP is required to be submitted for all offshore projects to the National Offshore Petroleum Safety and Environment Management Authority (NOPSEMA) for authorisation. The OPP process involves the proponent's evaluation and NOPSEMA's assessment of the potential environmental impacts and risks of petroleum activities conducted over the life of an offshore project. The process includes a public comment period and requires a proponent to ensure environmental impacts and risks will be managed to acceptable levels.

Unlike the previous EPBC Act process, the requirement for an OPP applies to all offshore projects regardless of the potential level of impact or risk to the environment that the project may present.

More information can be found on the OPP process on NOPSEMA's website https://www.nopsema.gov.au/environmental-management/assessment-process/offshore-project-proposals/

This OPP presents the assessment of the potential environmental impacts and risks associated with the project. It is an early stage, whole-of-project assessment which, subject to acceptance by NOPSEMA, will form the basis for future activity-specific EPs that will be prepared and submitted to NOPSEMA, and will be required to be assessed and accepted prior to any activity related to Scarborough to commence.

As required under the Environment Regulations, the content of this OPP includes:

- a description of the project, including location and proposed timetable
- a description of the environment that may be affected by the project, including details of relevant environmental values and sensitivities
- environmental performance outcomes for the project
- a description of any feasible alternative to the project, or alternative activity to that forming part of the project
- a description of the legislative and other requirements that apply to the project
- a description and evaluation of the environmental impacts and risks of the project, appropriate to the nature and scale of each impact or risk
- a summary of any public comments made and how they were evaluated and addressed
- a demonstration of any changes made to the proposal as a result of public comment.

The contents of this OPP are in accordance with the requirements of the OPGGS (Environment) Regulations and align with current OPP content guidelines (N-04790-GN-1663) and NOPSEMA OPP Assessment Policy (N-04790-PL-1650).

ES2. WOODSIDE HEALTH, SAFETY AND ENVIRONMENTAL MANAGEMENT SYSTEM

The Woodside Management System (WMS) defines how Woodside will deliver its business objectives and the boundaries within which all Woodside employees and contractors are expected to work. Environmental management is one of the components of the overall WMS.

Within the WMS, the overall direction for Environment is set through Woodside's corporate Health Safety, Environment and Quality (HSEQ) Policy. The policy provides a public statement of Woodside's commitment to minimising adverse effects on the environment from its activities and to improving environmental performance. It sets out the principles for achieving the objectives for the environment and how these are to be applied. The policy is applied to all Woodside's activities, and employees, contractors and Joint Venture partners engaging in activities under Woodside operational control. Key principles of the policy include:

- Implementing a systematic approach to HSEQ risk management
- Complying with relevant laws and regulations and applying responsible standards where laws do not exist
- Setting, measuring and reviewing objectives and targets that will drive continuous improvement in HSEQ performance
- Embedding HSEQ considerations in our business planning and decision-making processes
- Integrating HSEQ requirements when designing, purchasing, constructing and modifying equipment and facilities
- Maintaining a culture in which everybody is aware of their HSEQ obligations and feels empowered to speak up and intervene on HSEQ issues
- Undertaking and supporting research to improve our understanding of HSEQ and using science to support impact assessment and evidence-based decision making
- Taking a collaborative and proactive approach with our stakeholders
- Requiring contractors to comply with our HSEQ expectations in a mutually beneficial manner
- Publicly reporting on HSEQ performance

The objectives under the WMS define the mandatory performance requirements that apply to all Woodside activities, and the performance of its employees and contractors within their area of responsibilities. The management commitments made in the Scarborough OPP and subsequent EPs will be implemented through a management framework specific to Scarborough but integrated into the WMS.

ES3. ENVIRONMENTAL LEGISLATION AND OTHER ENVIRONMENTAL MANAGEMENT REQUIREMENTS

Scarborough is located in Commonwealth waters and therefore falls under Commonwealth jurisdiction. The legislation of relevance to Scarborough include:

- The *Environmental Protection and Biodiversity Conservation Act 1999* - The EPBC Act is the Commonwealth Government's primary environmental legislation. This is the principal statute for the protection and management of matters of National Environmental Significance (NES). Under the EPBC Act, any action that is likely to have a significant impact on matters of NES must not be undertaken without the approval of the Minister. Actions with the potential to impact on matters of NES trigger the Commonwealth environmental assessment and approval process. Assessment under the EPBC Act, administered by the Department of Agriculture, Water and the Environment (DAWE) includes an assessment of the impacts of a proposal on matters of NES listed under Part 3 of the EPBC Act.

  However, in 2014, NOPSEMA became the sole Commonwealth regulator for environmental management of offshore petroleum activities following streamlining of regulatory processes under the OPGGS Act and the EPBC Act. The effect of streamlining is that offshore petroleum activities are no longer required to be subject to separate authorisation processes under the OPGGS Act and the EPBC Act.

To allow for streamlining to occur, several changes to the Environment Regulations administered by NOPSEMA were made. This included introducing the OPP authorisation process to allow for public scrutiny and comment on offshore petroleum developments early in the project lifecycle. The OPP process reflects the level of transparency and opportunity for public comment that is provided for as part of the ‘Environmental Impact Statement/Public Environmental Review’ assessment process under the EPBC Act.

- The *Offshore Petroleum and Greenhouse Gas Storage Act 2006* - The OPGGS Act is the principal Act governing offshore petroleum exploration and production in Commonwealth waters. Specific environmental, resource management and safety obligations are set out in associated Regulations:
    - Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009
    - Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011 (Resource Management and Administration Regulations)
    - Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Environment Regulations)

Beyond the OPP, other approvals required under the OPGGS Act and associated regulations. Unless an offshore petroleum activity has prior approval under the EPBC Act (pre-2014), an OPP must be accepted by NOPSEMA before the proponent can submit EPs and other related approvals for activities that make up the project: These are outlined below:

- EPs - Under the Environment Regulations, a titleholder is required to have in place an accepted EP before commencing a petroleum activity. The EP must be appropriate for the nature and scale of the activity and describe the activity, the existing environment, details of environmental impacts and risks and the control measures for the activity. In addition, the EP must include an implementation strategy to demonstrate that the impacts and risks can be managed to ALARP and an acceptable level and to describe how appropriate environmental performance outcomes, standards and measurement criteria outlined in the EP will be met. The EP must also provide a summary of all consultation undertaken with relevant persons. EPs will be supported with appropriate oil pollution emergency plans (OPEPs) and operational and scientific monitoring plan (OSMPs), which are required as a part of an EP’s implementation strategy, noting that these may be developed to support a range of activities or phases of a project. The EPs will be submitted and accepted by NOPSEMA before the activities listed above can commence.
- Other Petroleum Activity Approvals - In addition to environmental approvals as discussed, the Resource Management and Administration Regulations also require that a Safety Case and a Well Operations Management Plan (WOMP) are assessed and accepted by NOPSEMA for petroleum facilities, along with any relevant licences to support pipelines, infrastructure and production.

ES4. DESCRIPTION OF THE PROJECT AND ALTERNATIVES ANALYSIS

Project Overview

Key components of the proposed development of Scarborough include:

- Surface infrastructure – Floating Production Unit (FPU) in approximately 900 m of water over the Scarborough reservoir
- Subsea infrastructure - infield infrastructure, including wellheads, manifolds, flowlines and umbilicals, trunkline and communications lines
- Wells – anticipated to drilling in two phases. Drilling of the Scarborough and North Scarborough gas fields, with potential for future fields (including Thebe and Jupiter gas fields) to be tied back to the facility
- Trunkline installation – installation of a 32-inch gas trunkline to extend for a total of 430 km using trenching and backfill (for nearshore only)
- Commissioning – Commissioning of the overall production system will be conducted from the FPU once on location
- Operations – hydrocarbon extraction and processing will take place at the FPU, to meet the trunkline specifications. Gas will be exported via the trunkline.
- Decommissioning - the facilities will be decommissioned in accordance with good oilfield practice and relevant legislation and practice at the time

Project Schedule

As Operator, Woodside is targeting Final Investment Decision (FID) in 2020. The first drilling phase is scheduled in 2020 followed by the installation of the trunkline in 2022, FPU installation in 2023, first cargo in 2024 and phase 2 drilling (potentially including Thebe and Jupiter) in 2025. Decommissioning is expected to be commence in 2055[1].

Project Location

The proposed Scarborough and North Scarborough fields are located in permits WA-1-R and WA-62-R (Permit Area), in Commonwealth waters approximately 375 km north west off the Burrup Peninsula in the North West of Australia. Water depths within the Permit Area range between approximately 900 m to 1000 m. Wells may also be drilled and tied back to the FPU from the Thebe and Jupiter fields, located in permits WA-63-R and WA-61-R respectively.

All subsea and subsurface infield infrastructure and wells are located in Commonwealth waters. The trunkline from the FPU to the onshore Pluto LNG Facility will be the only part of the offshore development which traverses into State waters. The trunkline route is shown in Figure ES-0-2. The location at which the trunkline will cross into State waters is about 20 km north-west from the shore and in water depths of 31 m.

[1] *If additional or third-party reservoirs have been tied into Scarborough Project infrastructure, this could increase the project's economic life and therefor delay decommissioning activities.*

Project Stages

Key stages of the development and associated activities are:

- Development drilling which includes:
  - Geotechnical surveys
  - Drilling operations
  - Well completion
  - Well flow-back
- Installation and commissioning which includes:
  - Installation of FPU
  - Installation of subsea infrastructure
  - Pre-commissioning
  - Trunkline installation
  - Pipeline stabilisation
- Operations which includes:
  - FPU operations
  - Hydrocarbon extraction
  - Hydrocarbon processing
  - Hydrocarbon export via pipeline
- Inspection, maintenance and repair which includes:
  - Inspection
  - Maintenance and repair
  - Well intervention
- Decommissioning which includes:
  - Removal of subsea infrastructure (subject to other provisions of the OPGGS Act)
  - Well abandonment
- Support operations which includes:
  - Mobile offshore drilling unit (MODU) operations
  - Vessel operations
  - Remotely operated vehicle (ROV) operations
  - Helicopter operations

Assessment of Alternatives

Woodside has considered development options and undertaken a comparative assessment (including a 'no development' option) to identify the benefits, risks and impacts of each. The comparative assessment process used by Woodside evaluated options against a set of criteria, including environment and safety.

Five development concept options were identified for Scarborough. In consideration of all the assessment drivers, Woodside's preferred development concept is that Scarborough gas would be processed through a brownfield expansion of the Pluto LNG Facility, where additional LNG processing capacity and domestic gas infrastructure will be installed. The composition of Scarborough gas is well suited to the Pluto LNG Facility, which is designed for lean gas and nitrogen removal.

As part of Woodside's preferred concept of a brownfield expansion of the existing Woodside-operated Pluto LNG Facility to process Scarborough gas, Woodside is considering and assessing a range of options for facilities, activities, installation and construction methods, including mooring of construction vessels, manning of the FPU, piling techniques, trunkline route and MODU design. These are detailed in the OPP.

ES5. DESCRIPTION OF THE ENVIRONMENT

The proposed development of Scarborough occurs in Commonwealth waters off the northwest coast of Western Australia (WA), within the North-west Marine Region (NWMR) (Integrated Marine and Coastal Regionalisation of Australia (IMCRA) 4.0). The target fields occur within the Northern Carnarvon Basin on the Exmouth Plateau, and are about 375 km offshore from Dampier, in water depths of approximately 900 – 970 m, with the proposed trunkline ultimately crossing into State waters along the same alignment as the Pluto Gas Export Pipeline (Figure 4-3).

The environmental context of the proposed development of Scarborough has been described according to zones of relevance to the project:

- The Project Area, which is divided further into the Offshore Project Area (the area covered by WA-1-R, WA-62-R, WA-61-R, and WA-63-R), the Trunkline Project Area (the proposed trunkline route with a 1.5 km buffer either side) and the Borrow Grounds Project Area (the proposed location for the borrow grounds).
- The environment that may be affected (EMBA) by Scarborough, which is the largest spatial extent where unplanned events could have an environmental consequence on the surrounding environment (Figure 5-2). The maximum extent of area that may be affected is driven by the potential area that may be exposed to hydrocarbons in the event of a worst-case spill scenario (i.e. a 2,000 m^3 vessel fuel tank rupture; refer to Section 7.2.6). The EMBA has been derived by merging the maximum spatial extent for all stochastic modelling results, that is the result of 100 single trajectories run for each scenario. While the EMBA considers all hydrocarbon phases, it is characterised by the low exposure zone for entrained hydrocarbons. The EMBA has been set with some buffer (approximately a minimum of 50 km) to accommodate exposure below these levels (noting that below these levels any biological impacts are not expected to occur). The EMBA also extended inshore to accommodate for a spill scenario occurring anywhere along the trunkline route and simplified to a rectangular shape for ease of use. The modelling that was used to derive the EMBA is detailed in the report provide in Appendix I.

Studies and reviews of the Exmouth Plateau and North West Shelf have been compiled and/or undertaken to provide an understanding of the physical, biological and socio-economic environmental conditions within the Project Area. These studies contribute to long-term datasets for the region and the majority have been made available in the public domain.

A summary of the existing environment relevant to the proposed development of Scarborough is provide below.

Marine Regional Characteristics

The Offshore Project Area, and the western part of the Trunkline Project Area, is in the Northwest IMCRA Province. As the trunkline traverses the continental shelf it crosses into the Northwest Shelf IMCRA Province (Figure 5-1). These provinces are the start of a transition between tropical and temperate marine areas; and include migration routes and breeding locations for some important whale and bird species (DEWHA, 2008a). No additional IMCRA Provinces occur in the EMBA.

The continental shelf in the vicinity of the Project Area is wide, with a change of slope at about the 20 m bathymetric contour (IMCRA Technical Group, 1998). Inside this contour there is a series of limestone islands (South and North Muiron, Serrurier, Bessieres, Thevenard, Rosily, Barrow and the Montebello islands); with fringing coral reefs typically occurring on the seaward side of most of these islands (IMCRA Technical Group, 1998).

Further offshore from the continental slope is the Exmouth Plateau, within which the Offshore Project Area lies. The Exmouth Plateau is a deepwater plateau, with a narrow, steep southern slope and a wider, less steep northern slope. The Montebello Trough along the south-east edge of this plateau drains into the Cape Range Canyon; while the northern portion of the plateau comprises the Dampier Ridge and Swan Canyon.

Physical Characteristics of the Project Area

The seafloor of the Offshore Project Area is generally flat and uniform with water depths ranging from 900 m to 970 m. The Trunkline Project Area extends from the Offshore Project Area across the continental slope to the inner continental shelf, in waters approximately 35 m deep. The Borrow Ground Project Area lies in shallow waters (approximately 35 - 45 m), where the seabed in generally flat and uniform with no important subsea features.

The predominant seabed type at the Offshore Project Area is mud and calcareous clay, and along the Trunkline Project Area is calcareous gravel, sand and silt. The Borrow Ground Project Area is characterised by calcium carbonate seabed deposits.

Currents, waves and winds, tides, water temperature and salinity in the Project Area, as well as water and air quality, and underwater noise and ambient light conditions, are expected to be typical of the North-west Marine Bioregion's tropical offshore environment.

Marine Fauna of Conservation Significance

Primary productivity of the NWMR is generally low. Distribution of pelagic fauna is primarily concentrated in waters closer to shore with species presence more likely along the Trunkline Project Area than within the Permit Area. Many species however have known distribution which extends to within the deeper waters of the Project Area. Demersal species are generally concentrated around areas containing hard substrate habitats of which none are present within close proximity to the Project Area. The benthic environment within the Project Area is homogenous and widely spread with no sensitive species present.

Within the Offshore Project Area, a total of 25 conservation significant species may be present during the project, with the addition of one BIA for the Pygmy blue whale. Within the Trunkline Project Area, a total of 46 conservation significant species may be present with an additional ten BIAs intersecting the Trunkline Project Area. Within the Borrow Ground Project Area, a total of 35 conservation significant species may be present with an additional nine BIAs intersecting the area. Across the entire EMBA, 92 conservation significant species may be present, covering 12 BIAs. Neither the Project Area nor EMBA intersect any Threatened Ecological Communities.

Key Ecological Features

Key ecological features (KEFs) are not matters of NES and have no legal status in their own right; however, they are considered as components of a Commonwealth marine area. KEFs are parts of the marine ecosystem that are considered to be important for a marine region's biodiversity or ecosystem function and integrity. KEFs have been identified by the Australian Government based on advice from scientists identifying regions with important attributes associated with ecosystem function and biodiversity.

The Project Area intersects the following three KEFs (Figure 5-37):

- Exmouth Plateau (Permit Area and Trunkline Project Area).
- Ancient coastline at 125 m depth contour (Trunkline Project Area).
- Continental slope demersal fish communities (Trunkline Project Area).

Additional KEFs within the EMBA include:

- Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula (~175 km from Permit Area and ~21 km from the Trunkline Project Area).
- Commonwealth waters adjacent to Ningaloo Reef (~20 km from the Permit Area and 22 km from the (Trunkline Project Area).
- Glomar Shoals (5 km from the Trunkline Project Area and ~34 km from the Permit Area).

All KEFs are solely within Commonwealth waters.

Protected Places

Protected places of the NWMR and adjacent State waters which either overlap with the Project Area or the EMBA are listed below along with their approximate distance:

- World Heritage Properties
  - Ningaloo Coast (186 km from Project Area; within the EMBA)
- National Heritage Properties
  - Ningaloo Coast (natural) (186 km from Project Area; within the EMBA)
  - Dampier Archipelago (indigenous) (8 km from Project Area; within the EMBA)
- Commonwealth-managed Australian Marine Parks (AMPs)
  - Montebello (intersects Trunkline Project Area; within the EMBA)
  - Dampier (<1 km from Borrow Ground Project Area; within the EMBA)
  - Gascoyne (77 km from Project Area; within the EMBA)
  - Ningaloo (186 km from Project Area; within the EMBA)
  - Carnarvon Canyon (405 km from Project Area; within the EMBA)
  - Shark Bay (475 km from Project Area; within the EMBA)
- State-managed Marine Parks (MPs)
  - Montebello Islands (25 km from Project Area; within the EMBA)
  - Barrow Island (73 km from Project Area; within the EMBA)
  - Ningaloo (182 km from Project Area; within the EMBA)
  - Shark Bay (550 km from Project Area, within the EMBA)
- State-managed Marine Management Areas (MMAs)
  - Barrow Island (40 km from Project Area, within the EMBA)
  - Muiron Islands (177 km from Project Area; within the EMBA)
- Nationally important wetlands.

- o Exmouth Gulf East (outside Project Area; within the EMBA)
- o Hamelin Pools (outside Project Area; within the EMBA)
- o Learmonth Saline Coastal Flats (outside Project Area; within the EMBA)
- o Shark Bay East (outside Project Area; within the EMBA).

There are no Wetlands of International Significance within the Project Area or EMBA.

Socio-Economic Values

Socio-economic values in the NWMR of relevance to the Project Area and EMBA include:

- Five Commonwealth-managed commercial fisheries, overlapping the Project Area
- Seven State-managed commercial fisheries overlapping the Project Area, and three additional fisheries overlapping the EMBA
- Recreation and tourism activities overlapping the EMBA, including charter fishing, other recreational fishing, diving, snorkelling, whale, Whale shark, marine turtle and dolphin watching, cruise ship stop overs and yachting.
- Commercial shipping, overlapping the Project Area, although mainly restricted to waters to the east and south of the Offshore Project Area and along the Trunkline Project Area.
- Oil and Gas exploration and operation, overlapping the EMBA (closest project is located 70 km east of the Project Area).
- The Australian Defence Force have a Defence Training Area that intersects with the Offshore Project Area and Trunkline Project Area.

ES6. IMPACT AND RISK ASSESSMENT METHODOLOGY

Under the OPGGS (Environment) Regulations, a titleholder is required to detail and evaluate all the environmental impacts and risks associated with the proposed project, and to demonstrate that the project can be undertaken in such a way that the environmental impacts and risks will be managed to an acceptable level.

An assessment of the impacts and risks associated with the proposed development of Scarborough has been undertaken in accordance with Woodside's Environment Impact Assessment Guideline and Risk Assessment Procedure, following the systematic approach below:

1. **CONTEXT SETTING**
   a. Establishing the context based on the proposed activities
   b. Establishing the context for the environment in which the proposal is to take place
   c. Review of the significance/sensitivity of receptors and levels of protection
   d. Environmental legislation and other requirements
   e. External requirements
   f. Internal requirements
2. **IMPACT AND RISK ASSESSMENT**
   a. Impact and Risk Identification
   b. Impact and Risk analysis
   c. Impact and Risk evaluation
   d. Determining Acceptability

3. IMPACT AND RISK TREATMENT

a. Identifying Controls

The other key steps of the Woodside Risk Management Process including implementation (which includes the steps to monitor, review and report) and stakeholder consultation.

ES7. EVALUATION OF ENVIRONMENTAL IMPACTS AND RISKS

The OPP has identified the impacts and risks associated with the proposed development of Scarborough. This will inform the subsequent EPs that must include an implementation strategy to demonstrate that the impacts and risks can be managed to ALARP and an acceptable level and to describe appropriate environmental performance outcomes, standards and measurement criteria.

The residual impacts and risks associated with each aspect of Scarborough were determined to be acceptable following implementation of the key management controls, as outlined in Table ES-0-1

Table ES-0-1 Summary of Environmental Impacts and Risks associated with the proposed development of Scarborough – Planned Activities

Aspect	Source of aspect (Activities)	Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity	Magnitude	Impact significance level	Acceptability
Routine Light Emissions	Vessel operations FPU operations MODU operations Hydrocarbon processing.	Ambient light	Change in ambient light	**EPO 1.1**: Undertake the Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 1.2:** Undertake the Scarborough development in a manner that will not have a substantial adverse effect on a population of seabirds or shorebirds, or the spatial distribution of the population. **EPO 1.3:** Undertake the Scarborough development in a manner that will not substantially modify, destroy or isolate an area of important habitat for a migratory species. **EPO 1.4**: Undertake the Scarborough development in a manner that will not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species. **EPO 1.5:** Trunkline installation and borrow ground activities will be undertaken in a manner that aims to avoid the displacement of marine turtles from important foraging habitat or from habitat critical during nesting and internesting periods.	**CM1:** Lighting will be limited the minimum required for navigational and safety requirements, with the exception of emergency events.	Low value (open water)	Slight	Negligible (F)	Acceptable
		Seabirds and migratory shorebirds	Change in fauna behaviour			High value species (e.g. wedge-tailed shearwater)	No lasting effect	Slight (E)	Acceptable
		Marine reptiles				High value species (e.g. flatback turtle)	No lasting effect	Slight (E)	Acceptable
Routine Atmospheric Emissions affecting Air Quality	FPU operations MODU operations Vessel operations Well flowback Hydrocarbon processing.	Air quality	Change in air quality	**EPO 2.1:** Undertake the Scarborough development in a manner that will not result in a substantial change in air quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	**CM2:** Vessel and MODU compliance with Marine Order 97 (Marine Pollution Prevention – Air Pollution), including: • International Air Pollution Prevention (IAPP) Certificate, required by vessel class • Use of low sulphur fuel when available • Ship Energy Efficiency Management Plan (SEEMP), where required by vessel class • Onboard incinerator to comply with Marine Order 97. **CM3:** Optimisation of flaring to allow the safe and economically efficient operation of the facility.	Low value (open water)	Slight	Negligible (F)	Acceptable
Routine Greenhouse Gas Emissions	FPU operations MODU operations Vessel operations Well flowback Hydrocarbon processing.	Climate	Climate change	**EPO 3.1:** Optimise efficiencies in air emissions and reduce direct GHG emissions to ALARP and Acceptable Levels. **EPO 3.2:** Actively support the global transition to a lower carbon future by net displacement of higher carbon intensity energy sources.	**CM4:** Facilities will be designed and operated to optimise energy efficiency, including: • The FPU will be designed to have no continuous operational flaring • Design optimisation to reduce direct GHG emissions to ALARP • development of energy management plans prior to operations • Fuel and flare analysis, baselining and forecasting throughout the life of operations • Annual setting of energy efficiency improvement and flare reduction targets • Ongoing optimisation of energy efficiency through periodic opportunity identification workshops/studies, evaluation and implementation.	Low value	Slight	Negligible (F)	Acceptable

Aspect	Source of aspect (Activities)	Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity	Magnitude	Impact significance level	Acceptability
					CM5: Reporting of Scarborough scope 1 GHG emissions as per regulatory requirements. **CM38:** The range of management and mitigation measures relating to third party GHG emissions may include: • Working with the natural gas value chain to reduce methane emissions in third party systems (e.g. regasification and distribution), such as through the adoption of the Methane Guiding Principles. • Promoting the role of LNG in displacing higher carbon intensity fuels • Supporting the development of new technologies to reduce higher carbon intensive energy sources • Advocacy for stable policy frameworks that reduce carbon emissions. • Monitoring the global energy outlook including the demand for lower carbon intensive energy such as LNG and displacing higher carbon intensive fuels. • Mechanisms to ensure adaptive management of these measures for the duration of the project in accordance with the Environment Regulations, including regular reviews in conjunction with relevant operations Environment Plan revision cycles.				
Routine Acoustic Emissions	Vertical seismic profiling Pre-lay surveys Drilling operations (including MODU operations) Installation of FPU – piling FPU operations Hydrocarbon extraction Vessel operations (including trunkline installation vessels) Helicopter operations Removal of subsea infrastructure.	Ambient noise	Change in ambient noise	**EPO 4.1**: Undertake the Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 4.2:** Undertake the Scarborough development in a manner that prevents a substantial adverse effect on a population of fish, marine mammals, marine reptiles, or the spatial distribution of a population. **EPO 4.3**: Undertake the Scarborough development in a manner that will not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species. **EPO 4.4**: Impact piling activities will not occur during the months of May and June, and November and December to avoid peak migration periods of the pygmy blue whale.	**CM6:** Woodside VSP Procedure implemented while VSP operations are undertaken to prevent prolonged exposure to marine fauna. **CM7:** For impact piling activities, Woodside will implement the soft start procedure at the commencement of piling activities and shut down zones during the activity. **CM8:** EPBC Regulations 2000 Part 8 Division 8.1 Interacting with cetaceans. **CM37**: Impact piling activities required for FPU installation will not occur during the peak migration periods for the northern migration of the pygmy blue whale (May and June) and southern migration (November and December).	Low value (open water)	No lasting effect	Negligible (F)	Acceptable
		Fish	Change in fauna behaviour Injury/mortality to marine fauna			High value species (MNES species known to be present.)	No lasting effect	Slight (E)	Acceptable
		Marine reptiles	Change in fauna behaviour Injury/mortality to marine fauna			High value species (i.e. flatback turtle)	No lasting effect	Slight (E)	Acceptable
		Marine mammals	Change in fauna behaviour Injury/mortality to fauna			High value species (i.e. pygmy blue whale)	No lasting effect	Slight (E)	Acceptable
Physical Presence –	Surveys Vessel operations	Commonwealth managed fisheries	Changes to the function interests or	**EPO 5.1:** Undertake the Scarborough development in a manner that prevents a substantial adverse effect on the sustainability of commercial fishing.	**CM9:** Vessels to adhere to the navigation safety requirements including the Navigation Act 2012 and any subsequent Marine Orders.	High value marine user	Slight	Minor (D)	Acceptable

Aspect	Source of aspect (Activities)	Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity	Magnitude	Impact significance level	Acceptability
Displacement of Other Users	MODU operations FPU operations Helicopter operations Trunkline installation Installation of the FPU and subsea infrastructure. Removal of subsea infrastructure	State managed fisheries	activities of others	**EPO 5.2:** Undertake the Scarborough development in a manner that does not interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted.	**CM10:** Notify Australian Hydrographic Service (AHS) of activities and movements prior to activity commencing. **CM11:** Notify representatives of State and Commonwealth fisheries of activities.	High value marine user	Slight	Minor (D)	Acceptable
		Shipping				Medium value marine user	Slight	Slight (E)	Acceptable
		Industry				Medium value marine user	Slight	Slight (E)	Acceptable
Physical Presence – Seabed Disturbance	Pre-lay surveys Drilling operations Installation of the FPU and subsea infrastructure Trunkline installation and stabilisation Removal of subsea infrastructure MODU operations Vessel operations ROV operations.	Water quality	Change in water quality	**EPO 6.1:** Undertake Scarborough development in a manner that prevents a substantial change to water quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health. **EPO 6.2:** Undertake activities within the borrow ground to not harm or cause destruction to the sea floor habitats (including significant areas of sponge habitat) of the Dampier Marine Park habitat protection zone. **EPO 6.3:** Changes to water quality in the Montebello Marine Park as a result of the trunkline installation will be not be inconsistent with the objective of the multiple use zone. **EPO 6.4:** Undertake Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 6.5**:Seabed Disturbance from trunkline installation within the Montebello Marine Park will be limited to less than 0.07%of the total park area. **EPO 6.6**: Trunkline installation and borrow ground activities will be undertaken in a manner that aims to avoid the displacement of marine turtles from important foraging habitat or from habitat critical during nesting and internesting periods. **EPO 6.7:** Undertake Scarborough Trunkline Installation within the Montebello AMP in a manner that will be not be inconsistent with the objective of the multiple use zone. **EPO 6.8:** Undertake Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of the Continental Slope Demersal Fish Communities KEF results.	**CM12:** Infrastructure will be positioned on the seabed within design footprint to reduce seabed disturbance. **CM33:** A 250m buffer zone will be implemented between the offshore borrow ground and the Dampier AMP **CM34:** Development of a management framework for dredging and backfill activities based on water quality to manage activities to achieve EPO 6.2 and EPO 6.4	Low value	Slight	Negligible (F)	Acceptable
		Epifauna and infauna	Change in habitat			Low value	Minor	Slight (E)	Acceptable
		Coral	Change in habitat			High value	Slight	Minor (D)	Acceptable
		Marine turtles	Change in habitat Injury or mortality			High value	Slight	Minor (D)	Acceptable
		AMPs	Change in habitat Change in water quality			High value	Slight	Minor (D)	Acceptable
		KEFs	Change in habitat Change in water quality Injury or mortality			High value	Slight	Minor (D)	Acceptable
Routine and Non-Routine Discharges: Sewage and Greywater	Vessel operations MODU operations FPU operations	Water quality	Change in water quality	**EPO 7.1:** Undertake Scarborough development activities in a manner that does not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	**CM13:** Compliance with relevant MARPOL, Commonwealth requirements and subsequent Marine Order requirements for sewage management.	Low value (open water)	Slight	Negligible (F)	Acceptable
Routine and Non-Routine Discharges: Food Waste	Vessel operations MODU operations FPU operations	Water quality	Change in water quality	**EPO 8.1:** Undertake Scarborough development activities in a manner that does not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	**CM14:** Compliance with relevant MARPOL, Commonwealth requirements and subsequent Marine Order requirements for waste discharges. **CM15:** Implementation of waste management procedures which provide for safe handling	Low value (open water)	No lasting effect	Negligible (F)	Acceptable

Aspect	Source of aspect (Activities)	Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity	Magnitude	Impact significance level	Acceptability
					and transportation, segregation and storage and appropriate classification of all waste generated.				
Routine and Non-Routine Discharges: Chemicals and Deck Drainage	Vessel operations MODU operations FPU operations	Water quality	Change in water quality	**EPO 9.1:** Undertake Scarborough development activities in a manner that does not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	**CM14:** Compliance with relevant MARPOL, Commonwealth requirements and subsequent Marine Order requirements for waste discharges. **CM15:** Implementation of waste management procedures which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.	Low value (open water)	No lasting effect	Negligible (F)	Acceptable
Routine and Non-Routine Discharges: Brine and Cooling Water	Vessel operations MODU operations FPU operations	Water quality	Change in water quality	**EPO 10.1:** Undertake Scarborough FPU and support operations in a manner that prevents a substantial change to water quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health. **EPO 10.2:** Undertake Scarborough FPU and support operations in a manner that prevents a substantial adverse effect on a population of plankton including its life cycle and spatial distribution. **EPO 10.3**:Undertake Scarborough FPU and support operations in a manner that prevents significant impacts on the values of the Exmouth Plateau KEF. **EPO 10.4:** Undertake Scarborough FPU and support operations in a manner that prevents a substantial adverse effect on a population of fish, or the spatial distribution of the population. **EPO 10.5**: Undertake Scarborough FPU and support operations in a manner that prevents a substantial modification, destruction or isolation of an area of important habitat for a migratory species **EPO 10.6**: Undertake Scarborough FPU and support operations in a manner that prevents serious disruption of the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species. **EPO 10.7:** Undertake Scarborough FPU and support operations in a manner that prevents a substantial adverse effect on a population of marine mammals or the spatial distribution of the population. **EPO 10.8:** Undertake Scarborough FPU and support operations in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results. **EPO 10.9:** Undertake Scarborough FPU and support operations in a manner that avoids any change in spawning biomass of a commercially important species and does not lead to changes in recruitment that may be discernible from normal natural variation	**CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints.	Low value (open water)	No lasting effect	Negligible (F)	Acceptable
		Plankton	Injury/ mortality to fauna			Low value (open water)	No lasting effect	Negligible (F)	Acceptable
		Fish	Injury/ mortality to fauna			High value (protected species)	No lasting effect	Slight (E)	Acceptable
		Marine mammals	Injury/ mortality to fauna			High value (protected species)	No lasting effect	Slight (E)	Acceptable
		KEFs	Change in water quality			High value	No lasting effect	Slight (E)	Acceptable
		Commercial Fisheries	Injury/ mortality to fauna			High value marine users	No lasting effect	Slight (E)	Acceptable
Routine and Non-Routine	Hydrocarbon extraction	Water quality	Change in water quality	**EPO 11.1:** Undertake Scarborough FPU operations in a manner that will not result in a substantial change in water		Low value (open water)	Slight	Negligible (F)	Acceptable

Aspect	Source of aspect (Activities)	Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity	Magnitude	Impact significance level	Acceptability
Discharges: Operational Fluids	Hydrocarbon processing.	Sediment quality	Change in sediment quality	quality (including temperature) which may adversely impact on biodiversity, ecological integrity, social amenity or human health. **EPO 11.2:** Undertake Scarborough FPU operations in a manner that prevents a substantial change to sediment quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health. **EPO 11.3:** Undertake Scarborough FPU operations in a manner that prevents a substantial adverse effect on a population of plankton including its life cycle and spatial distribution. **EPO 11.4**: Undertake Scarborough FPU operations in a manner that prevents a significant impact on the values of the Exmouth Plateau KEF. **EPO 11.5:** Undertake Scarborough FPU operations in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 11.6:** Undertake Scarborough FPU operations in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results.	**CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **CM18:** Development of a management framework for produced formation discharges.	Low value (open water)	No lasting effect	Negligible (F)	Acceptable
		Plankton	Injury/ mortality to fauna Injury/ mortality to fauna			Low value (open water)	No lasting effect	Negligible (F)	Acceptable
		Epifauna and Infauna	Injury/ mortality to fauna			Low value (open water)	No lasting effect	Negligible (F)	Acceptable
		KEFs	Change in habitat			High value	No lasting effect	Slight (E)	Acceptable
Routine and Non-Routine Discharges: Subsea Installation and Commissioning	Installation of the FPU Installation of subsea infrastructure Commissioning.	Water quality	Change in water quality	**EPO 12.1:** Undertake Scarborough installation and commissioning in a manner that prevents a substantial change to water quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health. **EPO 12.2:** Undertake Scarborough installation and commissioning in a manner that prevents a substantial change to sediment quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health. **EPO 12.3:** Undertake Scarborough installation and commissioning in a manner that prevents a substantial adverse effect on a population of plankton including its life cycle and spatial distribution. **EPO 12.4:** Undertake Scarborough installation and commissioning in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 12.5:** Undertake Scarborough installation and commissioning in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results.	**CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints.	Low value (open water)	Slight	Negligible (F)	Acceptable
		Sediment quality	Change in sediment quality			Low value (open water)	Slight	Negligible (F)	Acceptable
		Plankton	Injury/ mortality to fauna			Low value (open water)	No lasting effect	Negligible (F)	Acceptable
		Epifauna and Infauna	Injury/ mortality to fauna			Low value (open water)	No lasting effect	Negligible (F)	Acceptable
		KEFs	Change in habitat			High value habitat	No lasting effect	Slight (E)	Acceptable
Routine and Non-Routine Discharge: Drilling	Drilling operations Well abandonment. Well intervention	Water quality	Change in water quality	**EPO 13.1:** Undertake Scarborough drilling activities in a manner that does not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	**CM19:** WBM will be used during drilling activities as the first preference. Where WBM cannot meet required technical specifications, NWBM may be used following technical justification.	Low value (open water)	Slight	Negligible (F)	Acceptable
		Sediment quality	Change in sediment quality			Low value (open water)	Slight	Negligible (F)	Acceptable

Aspect	Source of aspect (Activities)	Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity	Magnitude	Impact significance level	Acceptability
		Plankton	Injury/ mortality to fauna	**EPO 13.2:** Undertake Scarborough drilling activities in a manner that prevents substantial change in sediment quality, which may adversely impact biodiversity, ecological integrity, social amenity or human. **EPO 13.3:** Undertake Scarborough drilling activities in a manner that prevents a substantial adverse effect on a population of plankton including its life cycle and spatial distribution. **EPO 13.4:** Undertake Scarborough drilling activities in a manner that does not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 13.5:** Undertake Scarborough drilling activities in a manner that prevents significant impacts on the values of the Exmouth Plateau KEF. **EPO 13.6:** Undertake Scarborough drilling activities in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results.	**CM20:** Bulk overboard discharge of NWBM is prohibited. **CM21:** Drill cuttings returned to the MODU will be processed to reduce oil on cuttings to < 6.9% by weight on wet cuttings (measured as a well average only including sections drilled with NWBM) prior to discharge. **CM22:** Drill cuttings returned to the MODU will be discharged below the waterline.	Low value (open water)	No lasting effect	Negligible (F)	Acceptable
		Epifauna and Infauna	Injury/ mortality to fauna			Low value (open water)	No lasting effect	Negligible (F)	Acceptable
		KEFs	Change in habitat			High value habitat	Slight	Minor (D)	Acceptable

Table ES-0-2 Summary of Environmental Impacts and Risks associated with the proposed development of Scarborough – Unplanned Activities

Aspect	Source of aspect (Activities)	Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity	Risk Consequence	Likelihood	Risk Rating	Acceptability
Unplanned Discharge: Chemicals	Drilling operations FPU operations. Vessel operations MODU operations ROV operations Helicopter operations	Water quality	Change in water quality	**EPO 14.1**: Undertake Scarborough development in a manner that will prevent an unplanned release of chemicals to the marine environment resulting in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	**CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **CM15:** Implementation of waste management procedures which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.	Low value (open water)	Negligible (F)	Highly Unlikely	Low	Acceptable
Unplanned Discharge: Solid Waste	Vessel operations MODU operations FPU operations	Water quality	Change in water quality	**EPO 15.1:** Undertake Scarborough development in a manner that will prevent an unplanned release of solid waste to the marine environment resulting in a significant impact. **EPO 15.2:** Undertake Scarborough development in a manner that will prevent a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. **EPO 15.3:** Undertake Scarborough development in a manner that will prevent a substantial adverse effect on a population of seabirds or shorebirds, or the spatial distribution of the population. **EPO 15.4:** Undertake Scarborough development in a manner that will prevent a substantial adverse effect on a population of fish or the spatial distribution of the population. **EPO 15.5:** Undertake Scarborough development in a manner that will prevent a substantial adverse effect on a population of marine mammals or the spatial distribution of the population. **EPO 15.6:** Undertake Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact results on marine ecosystem functioning or integrity results. **EPO 15.7:** Undertake Scarborough development in a manner that will prevent a substantial adverse effect on a population of marine reptiles or the spatial distribution of the population. **EPO 15.8:** Undertake Scarborough development in a manner that will not substantially modify, destroy or isolate an area of important habitat for a migratory species. **EPO 15.9:** Undertake Scarborough development in a manner that will not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**CM23:** Project vessels compliant with Marine Order 95 (pollution prevention – Garbage). **CM15:** Implementation of waste management procedures which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.	Low value (open water)	Negligible (F)	Remote	Low	Acceptable
		Migratory shorebirds and seabirds	Injury/mortality to fauna			High value species	Minor (D)	Remote	Low	Acceptable
		Fish				High value species	Minor (D)	Remote	Low	Acceptable
		Marine mammals				High value species	Minor (D)	Remote	Low	Acceptable
		Marine reptiles				High value species	Minor (D)	Remote	Low	Acceptable
Physical Presence (Unplanned): Seabed Disturbance	Vessel operations MODU operations FPU operations Trunkline installation	Epifauna and infauna	Change in habitat Injury/ mortality to fauna	**EPO 16.1:** Undertake the Scarborough development in a manner which prevents unplanned seabed disturbance. **EPO 16.2:** Undertake the Scarborough development in a manner which does not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an	**CM12:** Infrastructure will be positioned on the seabed within design footprint to reduce seabed disturbance.	Low value	Negligible (F)	Highly Unlikely	Low	Acceptable

Aspect	Source of aspect (Activities)	Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity	Risk Consequence	Likelihood	Risk Rating	Acceptability
		KEFs	Change in habitat	adverse impact on marine ecosystem functioning or integrity results. **EPO 16.3:** Undertake the Scarborough development in a manner which does not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results.		High Value	Minor (D)	Highly Unlikely	Moderate	Acceptable
Physical Presence (Unplanned): IMS	Installation of FPU Installation of subsea infrastructure Trunkline Installation MODU operations Vessel operations.	Epifauna and infauna	Change in ecosystem dynamics	**EPO 17.1:** Undertake the Scarborough development in a manner which prevents a known or potential pest species (IMS) becoming established. **EPO 17.2** Undertake the Scarborough development in a manner which does not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 17.3:** Undertake the Scarborough development in a manner which prevents a substantial adverse effect on water quality such that an adverse impact on industry use occurs. **EPO 17.4:** Undertake the Scarborough development in a manner which does not interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted.	**CM24:** Compliance with the Woodside Invasive Marine Species Management Plan. **CM25:** Requirements of the Australian Ballast Water Management to be met.	Low value habitat (homogenous)	Negligible (F)	Remote	Low	Acceptable
		Coral				High value	Minor (D)	Remote	Low	Acceptable
		Seagrass				High value	Minor (D)	Remote	Low	Acceptable
		Macroalgae				Low value	Negligible (F)	Remote	Low	Acceptable
		Industry, Shipping, Defence	Changes to the functions, interests or activities of other users			Medium value	Slight (E)	Remote	Low	Acceptable
Physical Presence (Unplanned): Collision with Marine Fauna	Vessel operations	Marine Mammals; Marine reptiles	Injury to/ mortality of fauna	**EPO 18.1:** Undertake the Scarborough development in a manner which prevents a vessel strike with protected marine fauna during project activities. **EPO 18.2** Undertake the Scarborough development in a manner which does not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 18.3:** Undertake the Scarborough development in a manner which prevents a substantial adverse effect on a population of marine mammals or the spatial distribution of the population. **EPO 18.4:** Undertake the Scarborough development in a manner which prevents a substantial adverse effect on a population of marine reptiles or the spatial distribution of the population. **EPO 18.5:** Undertake the Scarborough development in a manner which does not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**CM8:** EPBC Regulations 2000 Part 8 Division 8.1 Interacting with cetaceans. **CM32**: Marine fauna interaction mitigation measures to be considered and implemented as appropriate during the EP process.	High value species	Slight (E)	Highly Unlikely	Low	Acceptable
Unplanned Hydrocarbon Release	Drilling operations Commissioning FPU operations Hydrocarbon extraction Hydrocarbon processing Gas export Decommissioning.	Sediment quality	Change in sediment quality	**EPO 19.1:** No release of hydrocarbons to the marine environment due to a vessel collision associated with the Scarborough development.	**CM26:** All vessels and facilities (appropriate to class) will comply with MARPOL 73/78, the Navigation Act 2012, the Protection of the Sea (Prevention of Pollution from Ships Act 1983 and subsequent Marine Orders including: • waste management requirements • management of spills aboard • emergency drills. **CM27:** Relevant Stakeholders will be notified of activities prior to commencement. **CM28:** Vessels will have in place a valid and appropriate Shipboard Oil Pollution Emergency Plan and/or Shipboard	Low value (open water)	Negligible (F)	Highly Unlikely	Low	Acceptable
		Water quality	Change in water quality			Low value (open water)	Negligible (F)	Highly Unlikely	Low	Acceptable
		Plankton	Injury/ mortality to fauna			Low value (open water)	Negligible (F)	Highly Unlikely	Low	Acceptable
		Fish	Change in fauna behaviour			High value species	Minor (D)	Highly Unlikely	Moderate	Acceptable

Aspect	Source of aspect (Activities)	Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity	Risk Consequence	Likelihood	Risk Rating	Acceptability
			Injury/ mortality to fauna		Marine Pollution Emergency Plan. Emergency response activities will be implemented in accordance with the SOPEP/SMPEP. **CM29:** Environment Plans and Oil Pollution Emergency Plans will be accepted and in place, appropriate to the credible hydrocarbon spill scenario associated with activities during the development of Scarborough. Emergency response activities will be implemented in accordance with the OPEP. **CM30:** Emergency response capability will be maintained in accordance with EP, OPEP and related documentation. **CM31:** Well Operations Management Plan accepted and in place for all wells, in accordance with the Offshore Petroleum and Greenhouse Gas Storage Act requirements, which include: • Blowout Preventer (BOP) installation during drilling operations • regular testing of BOP.	High value species	Minor (D)	Highly Unlikely	Moderate	Acceptable
		Marine mammals	Change in fauna behaviour			High value species	Minor (D)	Highly Unlikely	Moderate	Acceptable
			Injury/ mortality to fauna			High value species	Minor (D)	Highly Unlikely	Moderate	Acceptable
		Marine Reptiles	Change in fauna behaviour			High value species	Slight (E)	Highly Unlikely	Low	Acceptable
			Injury/ mortality to fauna			High value species	Minor (D)	Highly Unlikely	Moderate	Acceptable
		Seabirds and migratory shorebirds	Change in fauna behaviour			High value species	Slight (E)	Highly Unlikely	Low	Acceptable
			Injury/ mortality to fauna			High value species	Minor (D)	Highly Unlikely	Moderate	Acceptable
		Coral	Change in habitat			High value habitat	Major (B)	Highly Unlikely	Moderate	Acceptable
		Seagrass				High value habitat	Slight (E)	Highly Unlikely	Low	Acceptable
		Macroalgae				Low value habitat (homogenous)	Negligible (F)	Highly Unlikely	Low	Acceptable
		Mangroves				High value habitat	Slight (E)	Highly Unlikely	Low	Acceptable
		Shoreline habitats				Low value habitat	Negligible (F)	Highly Unlikely	Low	Acceptable
		Saltmarsh				High value habitat	Slight (E)	Highly Unlikely	Low	Acceptable
		KEFs	Change in habitat			High value	Minor (D)	Highly Unlikely	Moderate	Acceptable
		AMPs	Change in habitat			High value	Minor (D)	Highly Unlikely	Moderate	Acceptable
		Protected Places				Medium value	Slight (E)	Highly Unlikely	Low	Acceptable

Aspect	Source of aspect (Activities)	Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity	Risk Consequence	Likelihood	Risk Rating	Acceptability
		Commonwealth and state managed fisheries	Changes to the functions, interests or activities of other users			High value marine user	Slight (E)	Highly Unlikely	Low	Acceptable
		Tourism and recreation	Changes to the functions, interests or activities of other users			Medium value users	Slight (E)	Highly Unlikely	Low	Acceptable
			Change in aesthetic value			Medium value users	Slight (E)	Highly Unlikely	Low	Acceptable
		Settlements	Changes to the functions, interests or activities of other users			Medium value users	Slight (E)	Highly Unlikely	Low	Acceptable
			Change in aesthetic value			Medium value users	Slight (E)	Highly Unlikely	Low	Acceptable
		Industry	Changes to the functions, interests or activities of other users			Medium value	Slight (E)	Highly Unlikely	Low	Acceptable
		Defence	Changes to the functions, interests or activities of other users			Medium value	Slight (E)	Highly Unlikely	Low	Acceptable

ES8. CUMULATIVE IMPACTS AND RISKS

Cumulative effects of other marine users, proposed developments, as well as all key stages and aspects of the proposed development of Scarborough have been considered as part of this OPP process ensuring a holistic/lifecycle assessment of impacts.

Cumulative impacts and risks from the proposed development of Scarborough may occur in two ways:

- Aspect-based – Cumulative or combination effects may arise from other activities/projects resulting in the same aspects as those identified in this OPP.
- Receptor-based – Cumulative or combination effects on a receptor may arise, both from multiple aspects of Scarborough and similar/multiple aspects resulting from other activities/projects.

Aspects arising from the proposed development of Scarborough may compound with similar aspects caused by other third-party activities/developments, to result in a cumulative impact. Other activities/developments include:

- Pluto LNG Project
- Equus Field Development
- Commonwealth and State managed fisheries
- Commercial shipping.

All other activities/developments are located outside of the EMBA.

The aspects identified which were common to these activities/developments and the proposed development of Scarborough are those typically related to vessel movements, which include:

- Physical presence (routine): displacement of other users
- Light emissions
- Routine and non-routine discharges: project vessels.

As a large development within an already busy marine area, there was wide-ranging potential for cumulative impacts to occur as a result of Scarborough. However, the cumulative impact assessment has shown that there is little cross-over in spatial extent of aspects, both within Scarborough itself and when considering aspects in combination with other activities/developments. The majority of emissions and discharges, particularly those which will occur during the full lifecycle of Scarborough, will be made within the Permit Area, which is remote and unlikely to result in interactions with other activities/developments.

When considering potential cumulative impacts on receptors, it is clear that in most cases the phased approach of development proposed for Scarborough will alleviate the potential for cumulative pressure on receptors, allowing recovery/return to baseline conditions between impact events. It is still possible that individuals will experience combination effects from multiple impact events in the vicinity of the Offshore Project Area, however this is not predicted to occur on a population level for any receptors. Where cumulative impacts are predicted, i.e. light emissions on marine reptiles, the assessment concludes that no significant impacts will occur, and any cumulative impacts will be acceptable.

ES9. ENVIRONMENTAL PERFORMANCE FRAMEWORK

Overview

The proposed development of Scarborough will be undertaken in accordance with the OPP. This will be implemented by ensuring that all petroleum activities are within the scope of the accepted OPP, and the adoption of controls and EPOs specified in the OPP in any future petroleum activity EPs.

Woodside, as Operator, has developed the Environmental Management Implementation Approach for Scarborough, which consists of:

- Managing activities in accordance with existing fit-for purpose systems, practices and procedures under the Woodside WMS
- Identifying key roles and responsibilities for Woodside and Contractor personnel in relation to the implementation and management of EPOs for Scarborough
- Developing plans and procedures for emergency preparedness and response for all future petroleum activities
- Monitoring of EPO implementation through successful implementation of controls, environmental performance standards and associated measurement criteria specific to the activity for which an EP is being developed.
- Undertaking environmental performance audits
- Reporting on the environmental performance of the project to NOPSEMA
- Managing changes to the OPP concerning changes to activity scope, changes in understanding of the environment, and potential new advice from external stakeholders.

Implementing Requirements of the OPP in Future EPs

The OPP provides guidance on how the different elements of Scarborough which are petroleum activities will be reflected within Environment Plans. Key Management Controls and Environmental Performance Outcomes for each aspect of the project have also been presented, as follows:

- Aspects related to drilling activities
- Aspects related to installation and commissioning activities
- Aspects related to operational activities
- Aspects related to decommissioning activities
- Aspects related to installation, maintenance and repair activities

ES10. CONSULTATION

Stakeholder consultation and engagement is an integral component of the environmental impact assessment and environmental authorisation process for OPPs.

The objectives of the stakeholder consultation process are to:

- Provide stakeholders with opportunities to obtain information about the development of Scarborough including the physical, ecological, socio-economic and cultural environment that may be affected, the potential impacts that may occur and the prevention and mitigation measures proposed to avoid or minimise those impacts.
- Work with stakeholders to understand the key environmental and social factors associated with the development of Scarborough and potential impacts.

- Gain feedback from stakeholders on their concerns in relation to the development of Scarborough and where possible, address stakeholder concerns through further activities, or by implementing additional mitigation measures.

The stakeholder consultation for Scarborough is a component of Woodside's broader consultation program for all Burrup Hub opportunities including the Browse Development, NWS Extension, Pluto Expansion, Pluto-NWS Interconnector and activities to integrate industrial-scale solar power generation with gas-fired generation and battery storage for our future Burrup Hub LNG operations.

Specific to Scarborough, Woodside is undertaking a phased program of consultation:

- **Phase 1:** Preliminary consultation undertaken during the impact assessment process and preparation of the OPP.
- **Phase 2**: Formal consultation under the public review process of the draft OPP by NOPSEMA.
- **Phase 3**: Ongoing consultation during project planning and execution.

Phase 1 – Preliminary consultation commenced in 2018 and is built on the broader consultation and engagement process that Woodside has in place for the region. It is undertaken up until the point of formal consultation under the OPP process. Phase 1 consultation activities have included:

- Developing a dedicated project website https://www.woodside.com.au/our-business/burrup-hub/scarborough-to-pluto which includes a detailed video explaining key characteristics of the proposal, information regarding the approvals, up-to-date fact sheets and point of contact.
- Preparing a Scarborough fact sheet uploaded to the Woodside website and provided directly to key stakeholders via email.
- Preparing fact sheets uploaded to the Woodside website, describing some of the key issues associated with the development of Scarborough.
- Holding community forums and group meetings including information sessions which were undertaken in May 2019 in Karratha and Roebourne. These sessions were to address the environmental issues associated with the development of Scarborough in preparation for the release of the draft OPP and formal public consultation process (Phase 2).
- Holding one-on-one meetings between environment, stakeholder and project management representatives.
- Emailing information directly to key stakeholders, including details of Scarborough and key milestones including approval submissions.

Phase 2 – Formal consultation via a public review of the Scarborough OPP. It was determined by NOPSEMA that an eight week formal consultation period would apply, and the formal consultation period ran from 5 July 2019 until 30 August 2019.

Phase 3 – Ongoing consultation will continue on acceptance of the OPP, to engage with stakeholders during the preparation of EPs and execution of Scarborough.

1 INTRODUCTION

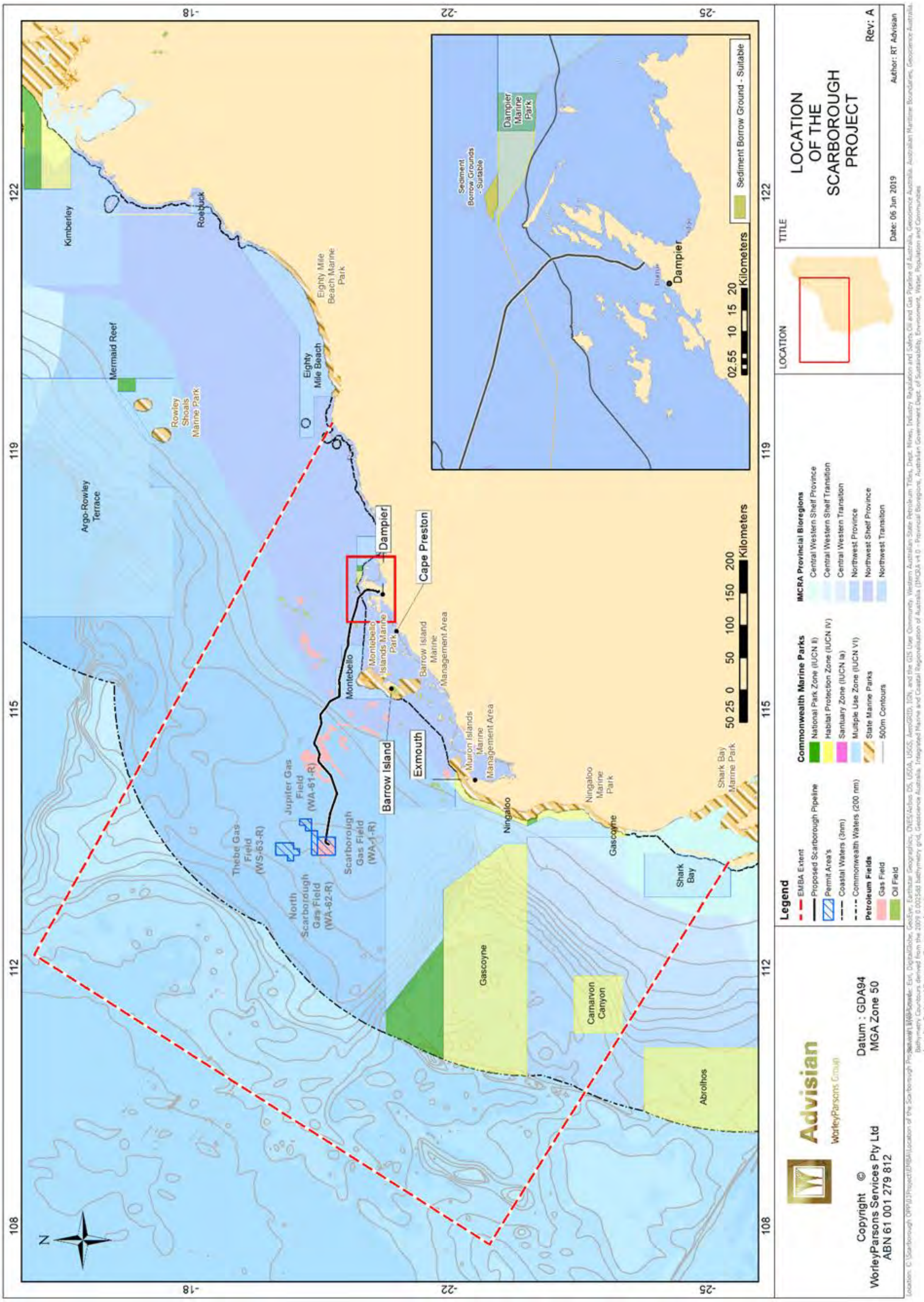
The Scarborough gas resource, located in Commonwealth waters approximately 375 km off Western Australia's Burrup Peninsula, forms part of the Greater Scarborough gas fields, comprising the Scarborough, North Scarborough, Thebe and Jupiter gas fields. The Scarborough gas resource is estimated to hold 11.1 Tcf (100%, 2C in accordance with reserves increase announcement 8 November 2019) of dry gas.

Woodside Energy Ltd (Woodside), is proposing to develop the gas resource through new offshore facilities. These facilities are proposed to be connected to the mainland through an approximately 430 km trunkline to an onshore facility. Woodside's preferred concept is to process Scarborough gas through a brownfield expansion of the existing Pluto LNG onshore facility (Pluto Train 2) (Figure 1-1). Part of the operating strategy of the expanded Pluto LNG facility may be to divert some gas through the onshore interconnector pipeline to the Karratha Gas Plant.

The proposed offshore development, referred to as the development of Scarborough, targets the commercialisation of the Scarborough and North Scarborough gas fields, through the construction of a number of subsea, high-rate gas wells, tied back to a semi-submersible Floating Production Unit (FPU) moored in about 900 metres of water close to the Scarborough field (Figure 1-2).

The proposed development of Scarborough is an integral part of Woodside's Burrup Hub vision for a regional gas hub which will secure economic growth and local employment opportunities for Western Australia for years to come. In addition to the development of the Scarborough and North Scarborough fields, the Thebe and Jupiter gas fields provide opportunities for future tieback to Scarborough infrastructure. As the proposed trunkline route crosses the Carnarvon Basin, in close proximity to other undeveloped fields, Woodside is also engaging with other resource owners to explore opportunities for future development.

Woodside is targeting a final investment decision (FID) in 2020 to be ready for first cargo in 2024. Achieving these milestones is subject to joint venture approvals, regulatory approvals and commercial arrangements being finalised.



Note: Refer to Section 7 for definition of Environment that may be Affected (EMBA)

Figure 1-1: Location of Scarborough

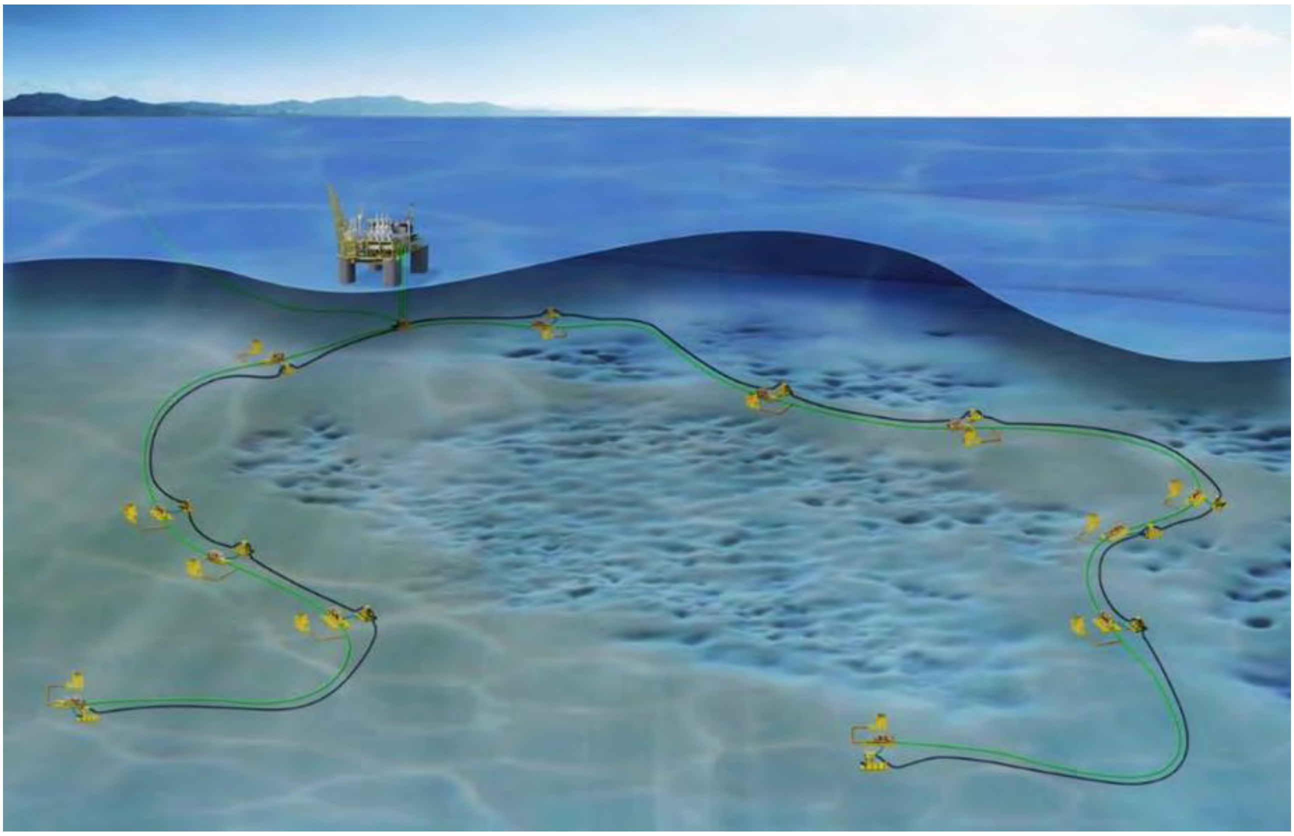


Figure 1-2: Schematic of the upstream components of the proposed development of Scarborough (note schematic not to scale)

1.1 Proponent

Woodside is Operator of the various joint ventures relating to the Scarborough, North Scarborough, Thebe and Jupiter fields., which comprise both Woodside and BHP Billiton Petroleum (North West Shelf) Pty Ltd (**"BHP"**). Current equity participation of the joint venture is as described in Table 1-1.

Table 1-1: Current Scarborough Equity Participants

Gas Fields	Woodside Interest	BHP Interest
Scarborough (WA-1-R)	73.5%	26.5%
North Scarborough (WA-62-R)	73.5%	26.5%
Thebe (WA-63-R)	50%	50%
Jupiter (WA-61-R)	50%	50%

Woodside is the largest Australian natural gas producer. The company operates Australia's biggest resource development, the North West Shelf Project (NWS Project) in Western Australia.

The Woodside-operated producing LNG assets in the north-west of Australia are among the world's best facilities. The NWS Project has been operating for 35 years delivering one-third of Australia's oil and gas production from one of the world's largest LNG facilities. Pluto LNG also forms part of Woodside's outstanding base business, and since commissioning in 2012, has delivered over 500 LNG cargoes.

Woodside recognises that strong environmental performance is essential to success and continued growth. Woodside has an established methodology to identify impacts and risks and assess potential consequences of activities. Strong partnerships, sound research and transparency are the key elements of Woodside's approach to the environment.

1.2 Proponent Contact Details

Woodside, as proponent of Scarborough, can be contacted at:

Scarborough
Mia Yellagonga
11 Mount Street, Perth, WA, 6000
Email: feedback@woodside.com.au
Phone: 1800 442 977

A dedicated Project Website is available at address:

https://www.woodside.com.au/our-business/burrup-hub/scarborough-to-pluto

1.3 Project Overview and Location

1.3.1 Project Overview

The upstream development concept for Scarborough comprises a number of subsea gas wells drilled to target petroleum resources of the Scarborough and North Scarborough fields tied back to an FPU moored in about 900 m of water, over the Scarborough field. Woodside proposes that the FPU topsides have processing facilities for gas dehydration and compression. Once processed, it is proposed that the gas will be transported through an approximate 430 km trunkline to onshore. The Thebe and Jupiter fields provide opportunities for future tie-backs to Scarborough infrastructure. Woodside's preferred development option for the processing of Scarborough gas is a trunkline to the Woodside-operated Pluto LNG Facility, which will require brownfield expansion under existing approvals to process the Scarborough gas.

The Scarborough gas resource has been appraised and determined to be dry gas, with only trace levels or no condensate expected. The gas has no detectable hydrogen sulphide (H_2S) and only trace levels of carbon dioxide.

The key components of Scarborough are:

- drilling of the Scarborough and North Scarborough gas fields, with potential for future fields (including Thebe and Jupiter gas fields) to be tied back to the facility
- installation of subsea infield infrastructure, including wells, drill centres, manifolds, flowlines, umbilicals, risers and moorings
- installation of an FPU over the Scarborough field
- installation of an approximately 430 km long trunkline from the FPU to the Burrup Peninsula
- commissioning of the trunkline and production facilities
- operation of the facilities for their lifetime (designed for approximately 30 years[2])
- maintenance of all infrastructure over the life of the project
- decommissioning after economic life is reached
- extraction of offshore sediments to be used for stabilisation of the trunkline.

[2] While the design life for the Scarborough Project is 30 years, it is possible that this may be extended through various engineering redesign options that may be contemplated in the future.

1.3.2 Project Location

The Scarborough and North Scarborough fields are located 375 km west-north-west of the Burrup Peninsula in the north-west of Australia, within offshore petroleum permits WA-1-R and WA-62-R. The Thebe and Jupiter fields are located to the north and north-east of the Scarborough and North Scarborough fields, within offshore petroleum permits WA-63-R and WA-61-R respectively (; the commercialisation of these fields provide potential opportunity for future expansion of Scarborough.

In Commonwealth waters, the Scarborough Project Area comprises the areas outlined in Figure 1-1, encompassing the extent of the retention lease areas for WA-1-R, WA-62-R, WA-63-R and WA-61-R, defined as the Offshore Project Area, as well as the gas trunkline, which lies within the Trunkline Project Area of 3 km width, extending from the location of the FPU to the State water limits (from which point environmental approvals are required under the *Environment Protection Act* (EP Act) and *Environment Protection and Biodiversity Conservation Act* (EPBC Act)). Additionally, potential borrow ground areas have been identified for sourcing sediments to be used to stabilise some of the sections of the trunkline in both State and Commonwealth waters and are termed the Borrow Grounds Project Area.

For the purpose of this OPP, the area comprising the Offshore Project Area, Trunkline Project Area and Borrow Grounds Project Area is collectively defined as the Project Area.

1.4 Document Purpose and Scope

1.4.1 Background to the OPP

This OPP has been prepared in accordance with the requirements of the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Environment Regulations), and associated guidelines.

In 2014, NOPSEMA became the sole Commonwealth regulator for environmental management of offshore petroleum activities following streamlining of regulatory processes under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) and EPBC Act. The effect of streamlining is that offshore petroleum activities only require approval by NOPSEMA under the OPGGS Act, and no longer require separate approval by the Minister for the Environment under the EPBC Act.

To allow streamlining to occur, several changes were made to the Environment Regulations administered by NOPSEMA. This included introducing the requirement that a proponent submits an offshore project proposal (OPP), for all offshore projects, to NOPSEMA for approval. The OPP process involves the proponent's consideration and NOPSEMA's assessment of the potential environmental impacts and risks of petroleum activities conducted over the life of an offshore project. The process includes a public comment period prior to approval and requires a proponent to ensure environmental impacts and risks will be managed to acceptable levels.

Unlike the previous EPBC Act process, the requirement for an OPP applies to all offshore projects regardless of the potential level of impact or risk to the environment that the project may present. An OPP for a project must be accepted by NOPSEMA before the proponent can submit Environment Plans (EPs) for activities that make up the project.

More information can be found on the OPP process on NOPSEMA's website https://www.nopsema.gov.au/environmental-management/assessment-process/offshore-project-proposals/.

Once the OPP is accepted, EPs will be developed and submitted to NOPSEMA for acceptance prior to the commencement on any petroleum activities within the scope of this OPP (Section 3.2.1).

1.4.2 Purpose

This OPP has been prepared by Woodside as Operator of WA-1-R, WA 62-R, WA 61-R and WA-63-R to present the assessment of the potential environmental impacts and risks associated with the development of Scarborough. It is an early stage project assessment which, subject to acceptance by NOPSEMA, will form the basis for future activity-specific EPs that will be prepared and submitted to NOPSEMA, and will be required to be assessed and accepted prior to any activity related to Scarborough to commence.

As required under the OPGGS (Environment) Regulations, the content of this OPP includes:

- a description of the project, including location and proposed timetable
- a description of the environment that may be affected by the project, including details of relevant environmental values and sensitivities
- environmental performance outcomes for the project
- a description of any feasible alternative to the project, or alternative activity to that forming part of the project
- a description of legislative and other requirements that applies to the project
- a description and evaluation of the environmental impacts and risks of the project, appropriate to the nature and scale of each impact or risk
- a summary of any public comments made and how they were evaluated and addressed
- a demonstration of any changes made to the proposal as a result of public comment.

The contents of this OPP are in accordance with the requirements of the OPGGS (Environment) Regulations and align with current OPP content guidelines (N-04790-GN-1663) and NOPSEMA Policy of OPP Assessment (N-04790-PL-1650), as shown in Table 1-2.

Table 1-2: Concordance of OPGGS (Environment) Regulations with OPP

OPGGS (E) Regulations	Requirements	Relevant Section of OPP
Regulation 5A Submission of an Offshore Project Proposal		
5A (5) (a)	Include the proponent’s name and contact details.	Section 1.2
5A (5) (b)	Include a summary of the project, including the following: (i) a description of each activity that is part of the project (ii) the location or locations of each activity (iii) a proposed timetable for carrying out the project (iv) a description of the facilities that are proposed to be used to undertake each activity (v) a description of the actions proposed to be taken, following completion of the project, in relation to those facilities.	Section 4
5A (5) (c)	Describe the existing environment that may be affected by the project.	Section 5
5A (5) (d)	Include details of the particular relevant values and sensitivities (if any) of that environment.	Section 5
5A (5) (e)	Set out the environmental performance outcomes for the project.	Sections 6 and 7
5A (5) (f)	Describe any feasible alternative to the project, or an activity that is part of the project, including: (i) a comparison of the environmental impacts and risks arising from the project or activity and the alternative	Section 4

OPGGS (E) Regulations	Requirements	Relevant Section of OPP
	(ii) an explanation, in adequate detail, of why the alternative was not preferred.	
5A (6)	Requirement to address particular relevant values and sensitivities [as defined in the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)].	Section 5
5A (7)	The proposal must: a) describe the requirements, including legislative requirements, that apply to the project and are relevant to the environmental management of the project b) describe how those requirements will be met.	Sections 2 and 3
5A (8)	The proposal must include: a) details of the environmental impacts and risks for the project b) an evaluation of all the impacts and risks, appropriate to the nature and scale of each impact or risk.	Sections 7 and 8
Regulation 11A Consultation with relevant authorities, persons and organisations, etc		
11A	Consultation with relevant authorities, persons and organisations.	Section 10

1.4.3 Scope

For the purpose of the OPP, the scope of the activity is limited to construction and operation of Scarborough concept in Commonwealth waters only. This includes:

- site preparation surveys (geophysical and geotechnical surveys) at the FPU site and the well locations
- drilling of development wells
- installation of subsea infrastructure, including umbilicals, risers and flowlines from wells to an FPU
- installation, commissioning and operation of a new FPU, with the ability for gas dehydration and compression to transport the gas to shore
- maintenance of all infrastructure for the life of the project
- installation, commissioning and operation of a new approximately 430 km trunkline transporting Scarborough gas from the FPU to shore – the scope of the OPP will be limited to the Commonwealth jurisdiction and as such cover installation and operation activities up to the State water limits (for approximately 400 km of the trunkline) at which point jurisdiction is under the EP Act and EPBC Act
- decommissioning activities at the end of the Scarborough resource life
- the sourcing of marine sediments from a borrow ground located in Commonwealth waters to be used in trunkline stabilisation activities (in both Commonwealth and State waters).

The development of Scarborough will also require both vessel and helicopter-based support activities for all phases of the offshore development.

The State waters and onshore components of the Project are assessed and approved under other regulatory mechanisms (via the EP Act and EPBC Act), and are not in scope of this OPP.

1.4.4 Structure of the OPP

The structure of this OPP is summarised as follows:

- **Section 1** introduces Scarborough, and outlines the purpose and structure of the OPP.
- **Section 2** describes the Woodside Management System which provides the framework for management, governance and assurance to implement commitments made in the OPP.
- **Section 3** summarises legislative requirements, standards and guidelines relevant to the development of Scarborough.
- **Section 4** describes Scarborough and details key activities (from development drilling through to decommissioning) relevant to environmental impact and risk assessment. This section also provides an assessment of the alternative development concepts and key activities considered in the project development process.
- **Section 5** describes the existing environment for key physical, ecological and socioeconomic values and sensitivities of the Project Area.
- **Section 6** describes the criteria Woodside have used to evaluate the acceptability of the impacts and risks and summarises the EPOs and justifications for the acceptability limits for each receptor.
- **Section 7** evaluates in detail all impacts and risks associated with Scarborough, from both planned and unplanned activities.
- **Section 8** provides an assessment of cumulative impacts.
- **Section 9** outlines the environmental performance framework for the development of Scarborough and describes how commitments made in the OPP will be implemented.
- **Section 10** summarises Woodside’s stakeholder consultation methodology, including identification of stakeholders, preliminary engagement undertaken to date, and approach to address feedback received during the public comment process and other future consultation.
- **Section 11** provides citations for all the references used throughout the OPP.

2 WOODSIDE HEALTH, SAFETY AND ENVIRONMENTAL MANAGEMENT SYSTEM

2.1 Overview

The Woodside Management System (WMS) defines how Woodside will deliver its business objectives and the boundaries within which all Woodside employees and contractors are expected to work. The WMS consists of a mission statement, policies, decision making committees, framework of authorities and standards required, that when applied, provides management, governance and assurance. Environmental management is one of the components of the overall WMS.

2.1.1 Environment Policy

Within the WMS, the overall direction for Environment is set through Woodside's corporate Health Safety, Environment and Quality Policy (Figure 2-1). The policy provides a public statement of Woodside's commitment to minimising adverse effects on the environment from its activities and to improving environmental performance. It sets out the principles for achieving the objectives for the environment and how these are to be applied. The policy is applied to all Woodside's activities, and employees, contractors and Joint Venture partners engaging in activities under Woodside operational control.

In addition, Woodside Climate Change Policy (Figure 2-2) demonstrates a commitment to be part of a solution to climate change. This includes promoting and pursuing a culture of energy efficiency and improve resources use in designs and operation.

WOODSIDE POLICY

Woodside

Health, Safety, Environment and Quality Policy

OBJECTIVES

Strong health, safety, environment and quality (HSEQ) performance is essential for the success and growth of our business. Our aim is to be recognised as an industry leader in HSEQ through managing our activities in a sustainable manner with respect to our workforce, our communities and the environment.

At Woodside we believe that process and personal safety related incidents, and occupational illnesses, are preventable. We are committed to managing our activities to minimise adverse health, safety or environmental impacts, incorporating a right first time approach to quality.

PRINCIPLES

Woodside will achieve this by:

- implementing a systematic approach to HSEQ risk management
- complying with relevant laws and regulations and applying responsible standards where laws do not exist
- setting, measuring and reviewing objectives and targets that will drive continuous improvement in HSEQ performance
- embedding HSEQ considerations in our business planning and decision making processes
- integrating HSEQ requirements when designing, purchasing, constructing and modifying equipment and facilities
- maintaining a culture in which everybody is aware of their HSEQ obligations and feels empowered to speak up and intervene on HSEQ issues
- undertaking and supporting research to improve our understanding of HSEQ and using science to support impact assessments and evidence based decision making
- taking a collaborative and pro-active approach with our stakeholders
- requiring contractors to comply with our HSEQ expectations in a mutually beneficial manner
- publicly reporting on HSEQ performance

APPLICATION

Responsibility for the application of this policy rests with all Woodside employees, contractors and joint venturers engaged in activities under Woodside operational control. Woodside managers are also responsible for promotion of this policy in non-operated joint ventures.

This policy will be reviewed regularly and updated as required.

Reviewed by the Woodside Petroleum Ltd Board on 7 December 2018

Figure 2-1: Woodside's corporate Health Safety, Environment and Quality Policy

WOODSIDE POLICY

Woodside

Climate Change Policy

OBJECTIVE

Woodside recognises the scientific consensus on climate change and the challenge of providing safe, clean, affordable and reliable energy whilst reducing emissions. Woodside is committed to being part of the solution.

We believe hydrocarbons will continue to be vital in meeting the world's energy needs and that the benefits of natural gas, in particular, will see it play an increasingly important role globally both in the energy mix and in reducing greenhouse gas emissions.

PRINCIPLES

Woodside will achieve the objective by:

- Promoting natural gas in the global energy mix as a means to reduce greenhouse gas emissions, support renewable energy and improve local air quality
- Promoting and pursuing a culture of energy efficiency and improved resource use in designs and operations
- Supporting our host countries in their endeavours to set emission reduction targets in accordance with internationally accepted science and to achieve these targets using efficient and stable policies
- Supporting lowest cost abatement through global carbon pricing
- Evaluating the resilience of our portfolio and investment decisions to potential changes in global climate policy
- Setting and publishing targets to encourage innovation and drive reductions in our carbon footprint and energy use
- Pursuing greenhouse gas emission reduction technologies with our peers and scientific institutions

APPLICABILITY

Responsibility for the application of this policy rests with all Woodside employees, contractors and joint venturers engaged in activities under Woodside operational control. Woodside managers are also responsible for promotion of this policy in non-operated joint ventures.

This policy will be reviewed regularly and updated as required.

Approved by the Woodside Petroleum Ltd. Board on 21 February 2017

Figure 2-2: Woodside's Climate Change Policy

2.2 Woodside HSEMS Standard

The WMS provides a structured framework of documentation to set common expectations governing how all employees and contractors at Woodside will work. WMS documentation, which comprises of four elements: Compass & Policies; Expectations; Processes & Procedures; and Guidelines outlined below (and illustrated in Figure 2-3):

- **Compass & Policies**. Set the enterprise-wide direction for Woodside by governing behaviours, actions and business decisions and ensuring Woodside meet their legal and other external obligations;

- **Expectations.** Set essential activities or deliverables required to achieve the objectives of the Key Business Activities and provide the basis for development of processes and procedures;
- **Processes & Procedures.** Processes identify the set of interrelated or interacting activities which transforms inputs into outputs, to systematically achieve a purpose or specific objective. Procedures specify what steps, by whom and when are required to carry out an activity or a process; and
- **Guidelines.** Provide recommended practice and advice on how to perform the steps defined in Procedures, together with supporting information and associated tools. Guidelines provide advice on how activities or tasks may be performed; information that may be taken into consideration; or, how to use tools and systems.

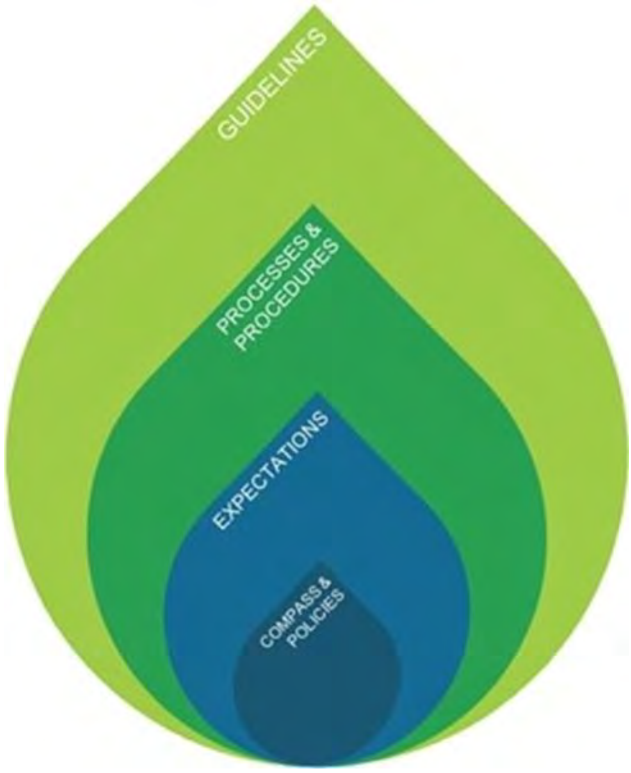


Figure 2-3: The four major elements of the WMS Seed

The WMS is organised within a Business Process Hierarchy based upon Key Business Activities to ensure the system remains independent of organisation structure and is globally applicable and scalable wherever required. These Key Business Activities are grouped into Management, Support and Value Stream activities as shown in Figure 2-4. The Value Stream activities capture, generate and deliver value through the exploration and production (E&P) lifecycle. The management activities influence all areas of the business, while support activities may influence one or more value stream activities.

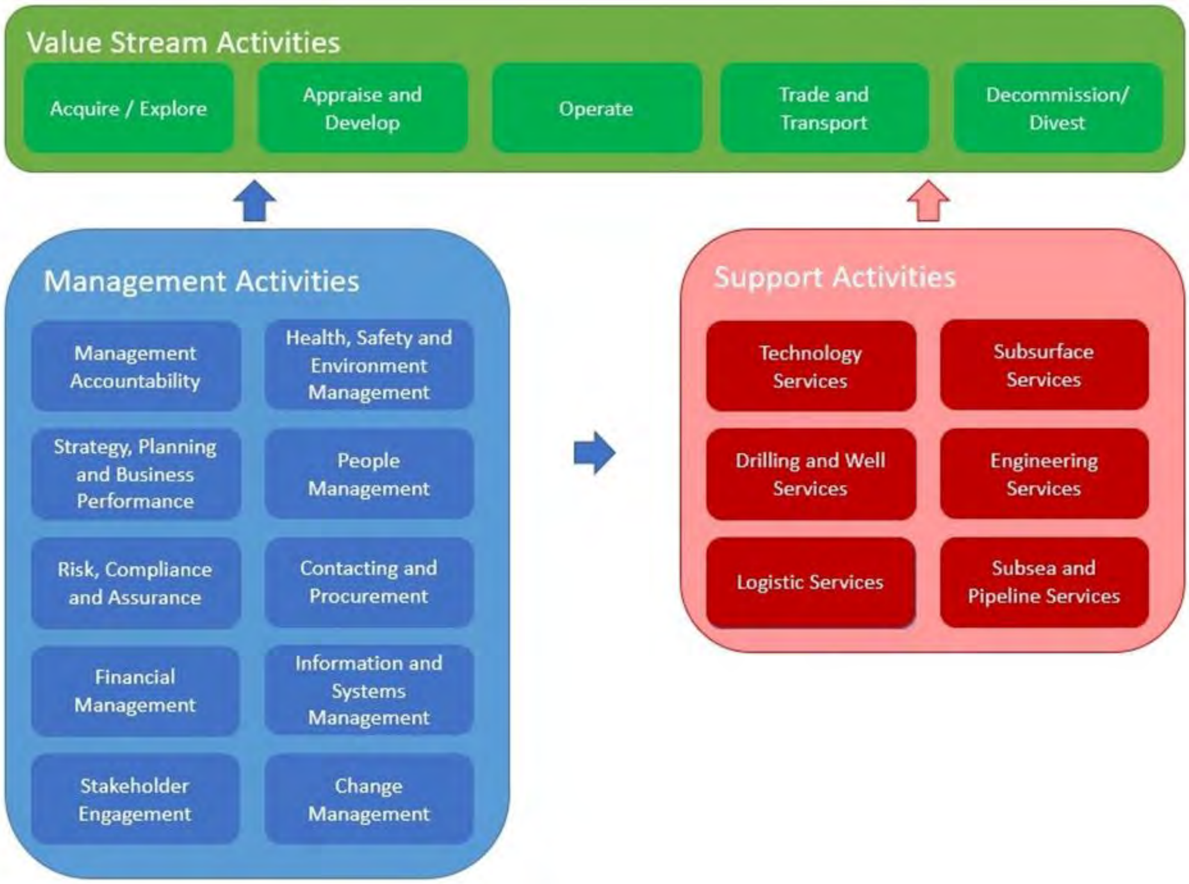


Figure 2-4: The WMS business process hierarchy

2.3 Relationship of the WMS to the OPP

The objectives under the WMS define the mandatory performance requirements that apply to all Woodside activities, and the performance of its employees and contractors within their area of responsibilities. The management commitments made in the Scarborough OPP and subsequent EPs, will be implemented through a management framework specific to Scarborough, but integrated into the WMS.

3 ENVIRONMENTAL LEGISLATION AND OTHER ENVIRONMENTAL MANAGEMENT REQUIREMENTS

Scarborough is located in Commonwealth waters and therefore falls under Commonwealth jurisdiction. An outline of key Commonwealth environmental legislation and its relevance to Scarborough, as an offshore petroleum activity being undertaken in Commonwealth waters, is set out below.

3.1 EPBC Act

The EPBC Act is the Commonwealth Government's primary environmental legislation. This is the principal statute for the protection and management of Matters of National Environmental Significance (MNES).

Under the EPBC Act, any action that is likely to have a significant impact on MNES must not be undertaken without the approval of the Minister. Actions with the potential to impact on MNES trigger the Commonwealth environmental assessment and approval process.

Assessment under the EPBC Act, administered by the Department of Agriculture, Water and the Environment (DAWE) includes an assessment of the impacts of a proposal on matters of NES listed under Part 3 of the EPBC Act.

However, in 2014, NOPSEMA became the sole Commonwealth regulator for environmental management of offshore petroleum activities following streamlining of regulatory processes under the OPGGS Act (see Section 3.2) and the EPBC Act. The effect of streamlining is that offshore petroleum activities are no longer required to be subject to separate authorisation processes under the OPGGS Act and the EPBC Act.

These changes took effect following the approval granted on the 27 February 2014 by the Minister for the Environment under section 146B of the EPBC Act, for the taking of actions in accordance with an endorsed "Program" under the EPBC Act.

The 'Program' is described in "Program Report – Strategic Assessment of the environmental management authorisation process for petroleum and greenhouse gas storage activities administered by the National Offshore Petroleum Safety and Environmental Management Authority under the Offshore Petroleum and Greenhouse Gas Storage Act 2016". The Program, which was endorsed by the Minister for the Environment under section 146 of the EPBC Act on 7 February 2014, outlined the environmental management authorisation process for offshore petroleum and greenhouse gas activities administered by NOPSEMA. The objective of this Program Report was to demonstrate how the Program will ensure activities are conducted in a manner consistent with the principles of ecologically sustainable development and will not result in unacceptable impacts to matters protected under Part 3 of the EPBC Act. Specifically, the report outlined the commitments and undertakings of NOPSEMA to ensure adequate protection of Part 3 protected matters.

The endorsement of the Program, and the final approval decision had the effect that certain actions can be undertaken in accordance with the endorsed program without further approval under the EPBC Act. This includes referral of a proposal, or further assessment under the EPBC Act. The class of actions covered by this approval are petroleum and greenhouse gas activities taken in Commonwealth waters and in accordance with the endorsed Program.

The approved class of actions excludes actions which are petroleum and greenhouse gas activities that:

- have, will have or are likely to have a significant impact on the environment on Commonwealth land
- are taken in any area of sea or seabed that is declared to be a part of the Great Barrier Reef Marine park under the Great Barrier Reef Marine Park Act 1975 (Cth)

- have, will have or are likely to have a significant impact on the work heritage values of the Great Barrier Reef National Heritage place
- are taken in the Antarctic
- are injection and/or storage of greenhouse gas.

Additionally, actions taken in state or territory waters are also noted to not be covered by the approved class of actions. The scope of this OPP does not include any of the excluded actions.

To allow for streamlining to occur, several changes to the Environment Regulations administered by NOPSEMA were made. This included introducing the OPP authorisation process to allow for public scrutiny and comment on offshore petroleum developments early in the project lifecycle. The OPP process reflects the level of transparency and opportunity for public comment that is provided for as part of the 'Environmental Impact Statement/Public Environmental Review' assessment process under the EPBC Act.

Unlike the EPBC Act assessment process previously applicable to offshore petroleum activities, the OPP assessment process applies to all offshore petroleum activities regardless of the potential level of impact or risk to the environment that the proposal may present.

3.2 OPGGS Act

The OPGGS Act is the principal Act governing offshore petroleum exploration and production in Commonwealth waters. Specific environmental, resource management and safety obligations are set out in associated Regulations:

- Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009
- Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011
- Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Environment Regulations).

Assessment under the OPGGS Act, administered by NOPSEMA, aims to ensure all impacts and risks of a petroleum activity are acceptable and as low as reasonably practicable.

3.2.1 EPBC Act Policy Statement 2.1 – Interaction between Offshore Seismic Exploration and Whales

Assessment of Scarborough has identified the potential for interaction with whales and other marine fauna. This policy encourages the goal of minimising the likelihood of injury or hearing impairment of whales, based on current scientific understanding. The aim of the policy is to:

- provide practical standards to minimise the risk of acoustic injury to whales in the vicinity of seismic survey operations
- provide a framework that minimises the risk of biological consequences from acoustic disturbance from seismic survey sources to whales in biologically important habitat areas or during critical behaviours
- provide guidance to both proponents of seismic surveys and operators conducting seismic surveys about their legal responsibilities under the EPBC Act.

While this policy is applicable to the control of exploration seismic activities, it can be used to control noise from other sources.

3.2.2 Environment Plans

Beyond the OPP, other approvals required under the OPGGS Act and associated regulations include Environment Plans (EPs) and Oil Pollution Emergency Plans (OPEPs).

Under the Environment Regulations, a titleholder is required to have in place an accepted EP before commencing a petroleum activity. The EP must be appropriate for the nature and scale of the activity and describe the activity, the existing environment, details of environmental impacts and risks and the control measures for the activity. In addition, the EP must include an implementation strategy to demonstrate that the impacts and risks can be managed to ALARP and an acceptable level and to describe how appropriate environmental performance outcomes, standards and measurement criteria outlined in the EP will be met. The EP must also provide a summary of all consultation undertaken with relevant persons. The EPs required in support of Scarborough will address activities related to:

- drilling development wells
- installing subsea infrastructure
- installing, commissioning and operating the FPU
- installing, commissioning and operating a new trunkline from the FPU to the State water limits
- decommissioning activities at the end of Scarborough resource life.

EPs will be supported with appropriate OPEPs and OSMPs, which are required as a part of an EP's implementation strategy, noting that these may be developed to support a range of activities or phases of a project. The EPs will be submitted and accepted by NOPSEMA before the activities listed above can commence.

Unless an offshore petroleum activity has prior approval under the EPBC Act (pre-2014), an OPP must be accepted by NOPSEMA before the proponent can submit EPs, and other related approvals for activities that make up the project.

3.2.3 Other Petroleum Activity Approvals

In addition to environmental approvals as discussed, the Resource Management and Administration Regulations also require that a Safety Case and a Well Operations Management Plan (WOMP) are assessed and accepted by NOPSEMA for petroleum facilities, along with any relevant licences to support pipelines, infrastructure and production.

Woodside will prepare and submit the required permit applications, Safety Cases and WOMPs to NOPSEMA as the project is developed.

3.3 Other Relevant Commonwealth Legislation

Other Commonwealth legislation that may applicable to the environmental management of the project is outlined in Table 3-1.

Table 3-1: Other relevant Commonwealth legislation

Commonwealth Legislation	Legislation Summary	Relevance to Scarborough
Air Navigation Act 1920 • *Air Navigation Regulations 1947* • *Air Navigation (Aerodrome Flight Corridors) Regulations 1994* • *Air Navigation (Aircraft Engine Emissions) Regulations 1995* • *Air Navigation (Aircraft Noise) Regulations 1984* • *Air Navigation (Fuel Spillage) Regulations 1999*	This Act relates to the management of air navigation.	Applies to helicopter activities undertaken during all phases of the project. Not linked to the control of any impacts and risks under this OPP.
Australian Radiation Protection and Nuclear Safety Act 1998	This Act relates to the protection of the health and safety of people, and the protection of the environment from the harmful effects of radiation.	Radioactive traces may be used during formation evaluation. These sealed radioactive sources are lowered into the well as a part of the well logging tools and removed. Any use of radioactive materials must comply with this Act. Not linked to the control of any impacts and risks under this OPP.
Environment Protection (Sea Dumping) Act 1981 *Environment Protection (Sea Dumping) Regulations 1983*	This Act and associated regulations provide for the protection of the environment by regulating dumping matter into the sea, incineration of waste at sea and placement of artificial reefs.	Sea Dumping Permits will be in place where required. Sea dumping activities will be undertaken in accordance with the act and under permit as required.
Industrial Chemicals (Notification and Assessment Act) 1989	This Act creates a national register of industrial chemicals. The Act also provides for restrictions on the use of certain chemicals which could have harmful effects on the environment or health.	All chemicals used in association with this project will consider the requirements of this act. Not linked to the control of any impacts and risks under this OPP.
National Environment Protection Measures (Implementation) Act 1998 *National Environment Protection Measures (Implementation) Regulations 1999*	This Act and associated Regulations provide for the implementation of National Environment Protection Measures (NEPMs) to protect, restore and enhance the quality of the environment in Australia and ensure that the community has access to relevant and meaningful information about pollution. The National Environment Protection Council has made NEPMs relating to ambient air quality, the movement of controlled waste between states and territories, the national pollutant inventory, and used packaging materials.	Woodside will meet any requirements of this Act including submission of a greenhouse and energy report as required. Not linked to the control of any impacts and risks under this OPP.

Commonwealth Legislation	Legislation Summary	Relevance to Scarborough
Navigation Act 2012	This Act regulates navigation and shipping including Safety of Life at Sea (SOLAS). Although the Act does not apply to the operation of petroleum facilities, it may apply to some activities of operations support vessels.	Vessel operations undertaken as a part of this activity will adhere to MARPOL and the various Marine Orders (as appropriate to vessel class) enacted under this Act. Applicable requirements are specified as controls to relevant impacts and risks.
Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 *Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995*	This Act and associated regulations provide for measures to protect ozone in the atmosphere by controlling and ultimately reducing the manufacture, import and export of ozone depleting substances (ODS) and synthetic greenhouse gases, and replacing them with suitable alternatives. The Act will only apply to Woodside if it manufactures, imports or exports ozone depleting substances.	Activities undertaken as a part of this project will adhere to the requirements of this Act including restrictions on import and use of Ozone Depleting Substances (ODS) (in refrigeration and air conditioning equipment) through control measures in procurement. Applicable requirements are specified as controls to relevant impacts and risks.
Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (MARPOL) *Protection of the Sea (Prevention of Pollution from Ships) (Orders) Regulations 1994* • *Marine Orders – Marine Pollution Prevention (Oil)* • *Marine Orders – Marine Pollution Prevention (Noxious liquid substances)* • *Marine Orders – Marine Pollution Prevention (Packaged harmful substances)* • *Marine Orders – Marine Pollution Prevention (Sewage)* • *Marine Orders – Marine Pollution Prevention (Garbage)*	This Act implements into Australian law Australia's obligations under the International Convention for the Prevention of Pollution from Ships (MARPOL Convention). This Act and associated Regulations relate to the protection of the sea from pollution by oil and other harmful substances discharged from ships. Under this Act, discharge of oil or other harmful substances from ships into the sea is an offence. There is also a requirement to keep records of the ships dealing with such substances. The Act applies to all Australian ships, regardless of their location. It applies to foreign ships operating between 3 nautical miles (nm) off the coast out to the end of the Australian Exclusive Economic Zone (200 nm). It also applies within the 3 nm of the coast where the State/Northern Territory does not have complementary legislation.	Vessel operations undertaken as a part of this activity will adhere to MARPOL and associated Marine Orders (as appropriate to vessel class) enacted under this Act. Applicable requirements are specified as controls to relevant impacts and risks.
Protection of the Sea (Harmful Antifouling Systems) Act 2006	This Act implements Australia's obligations under the International Convention on the Control of Harmful Anti-Fouling Systems on Ships (Harmful Anti-Fouling Systems Convention) This Act relates to the protection of the sea from the effects of harmful anti-fouling systems. It prohibits the application or reapplication of harmful anti-fouling compounds on Australian ships or foreign ships that are in an Australian shipping facility.	Vessel operations undertaken as a part of this project will comply with anti-fouling system requirements in accordance with this Act. Applicable requirements are specified as controls to relevant impacts and risks.

Commonwealth Legislation	Legislation Summary	Relevance to Scarborough
Biosecurity Act 2015 *Quarantine Regulations 2000*	This Act provides the Commonwealth with powers to take measures of quarantine, and implement related programs as are necessary, to prevent the introduction of any plant, animal, organism or matter that could contain anything that could threaten Australia's native flora and fauna or natural environment. The Commonwealth's powers include powers of entry, seizure, detention and disposal. This Act includes mandatory controls on the use of seawater as ballast in ships and the declaration of sea vessels voyaging out of and into Commonwealth waters. The Regulations stipulate that all information regarding the voyage of the vessel and the ballast water is declared correctly to the quarantine officers.	The project will comply with biosecurity requirements in accordance with this Act. This will include biofouling and ballast water requirements for vessels, offshore facilities and associated in-water equipment. Applicable requirements are specified as controls to relevant impacts and risks.
Australian Heritage Council Act 2003	This Act identifies areas of heritage value, including those listed on the World Heritage List, National Heritage List and the Commonwealth Heritage List. The Act also establishes the Australian Heritage Council and its functions.	The project will take into consideration any heritage values in the area.
Underwater Cultural Heritage Act 2018 (Underwater Heritage Act)	The Act came into effect on 1 July 2019, replacing the Historic Shipwrecks Act 1976. This new Underwater Heritage Act continues the protection of Australia's shipwrecks, but has also broadened to include protection to sunken aircraft and other types of underwater cultural heritage.	There are no planned activities associated with this project which will result in any interference with a shipwreck or underwater cultural heritage sites listed under the act.
Hazardous Waste (Regulation of Exports and Imports) Act 1989	This Act regulates the export and import of hazardous waste to ensure that hazardous waste is disposed of safely so human beings and the environment, both within and outside Australia, are protected from the harmful effects of the waste.	Project will comply with the requirements of this act with regard to export of hazardous waste.

3.4 Commonwealth Policies and Guidelines

The following are Commonwealth Government policies and guidelines that are relevant to petroleum activities in Commonwealth waters.

3.4.1 Greenhouse Gas Legislation

The United Nations Framework Convention on Climate Change (UNFCCC) came into force in 1994 and has been ratified by 197 countries. The UNFCCC established a goal of preventing dangerous anthropogenic interference with the climate system. Subordinate treaties and agreements have been ratified by parties to the UNFCCC, including the Paris Agreement in 2015. The Paris Agreement establishes a series of targets including:

- keeping "global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit temperature increase to 1.5°C" (Article 2.1(a))
- "reach global peaking of GHG emissions as soon as possible…achieve a balance between anthropogenic emissions by sources and removals by sinks in the second half of this century" (Article 4.1).

The adoption of the Paris Agreement under decision 1/CP.21 (UNFCCC, 2016) acknowledged that the Nationally Determined Contributions (NDCs) made by countries as commitments under the Paris Agreement were insufficient to meet the goals of the Paris Agreement. To manage this, the Paris Agreement includes a process to update, or 'ratchet-up' NDCs every 5 years.

Australia has ratified the Paris Agreement and has set a target to reduce emissions by 26-28 per cent below 2005 levels by 2030. The primary policy mechanisms to implement this target, and therefore Australia's current commitments under the Paris Agreement, are the *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 (Cth)* (SGM) made under the *National Greenhouse and Energy Reporting Act 2007 (Cth)* (NGERS) and administered by the Clean Energy Regulator (CER). The SGM was developed to ensure that emission reductions implemented through the Emissions Reduction Fund (ERF) are not offset or exceeded by significant GHG emissions (above 'business-as-usual levels') emanating from other industrial or economic sectors. The purpose of the SGM has more recently been communicated to measure, report and manage greenhouse gas emissions for industrial facilities. The SGM currently applies to facilities which emit greater than 0.1 MtCO2-e per annum, requiring annual covered emissions to be reported against a designated emissions 'baseline'.

In March 2019, modifications to the SGM were introduced to transition facilities from current 'reported' baselines (an absolute value based on the historical high-point of emissions) to a 'calculated' baseline (set based on production forecasts and emissions intensity). There is now an expectation that existing facilities will transition to calculated baselines within the next two years.

This change to the SGM, also requires that calculated baselines which are valid for a fixed period, to transition to 'production adjusted' baselines which adjusts for any difference between production forecasts used to apply for a calculated emissions baseline and actual production. In some cases, production adjusted baselines will adjust with annual production.

New facilities after 1 July 2020 will be subject to a 'benchmark baseline' which is expected to be defined by the DAWE and be based on leading-practice emissions intensities (top 10% of comparable facilities).

At the time of writing three schedules within the SGM remain unpublished. These will include the a) benchmark parameters, b) production adjusted production variables and emissions intensities and c) fixed production variables and emissions intensities (Schedules 1, 2 and 3 respectively). Schedule 2 and 3 were subject to significant consultation through 2019 and are expected to be published in early 2020. Schedule 1 content, including whether the leading-practice approach will be retained, is subject to greater uncertainty. The publication of this data is intrinsic to determining a baseline emissions figure under the SGM amendments.

3.4.2 Australian Offshore Petroleum Development Policy

This policy encourages petroleum exploration in Australia's offshore areas and is administered by the Commonwealth Government. Commonwealth and State Government agencies issue titles to the private sector to facilitate exploration and development of petroleum reserves within Australia. The titleholders have an obligation to undertake exploration and/or development of their titles. They also have an obligation to certify the nature and the extent of the reserves. Following the discovery of a petroleum resource, the titleholder may apply for a licence to produce the resource and to construct pipelines and other infrastructure. The environmental regulatory framework for offshore petroleum development is principally provided by the OPGGS Act and associated regulations, as described in Section 3.2.

3.4.3 Australia's Ocean Policy

Australia's Oceans Policy, introduced in 1998, is a framework for integrated and ecosystem-based planning and management for Australia's marine jurisdictions. Building on the existing effective sectoral and jurisdictional mechanisms, the policy promotes ecologically sustainable development (ESD) of the resources of our oceans and the encouragement of internationally competitive marine industries, while ensuring the protection of marine biological diversity. The policy also promotes Integrated Planning and Management. The policy's aims are to:

- exercise and protect Australia's rights over its marine jurisdictions
- meet its obligations under the United Nations Convention on the Law of the Sea 1982 (UNCLOS)
- understand and protect the marine environment.

The core of Australia's Oceans Policy is the development of Marine Bioregional Plans, based on large marine ecosystems, which are binding on all Commonwealth Government agencies and relevant to the environmental impact assessment process as set out below.

3.4.4 Marine Bioregional Plans

The Marine Bioregional Plans aim to strengthen the operation of the EPBC Act to help ensure that the marine environment remains healthy and resilient. The Plans provide information on conservation values and the current and emerging pressures within each region, as well as describing conservation priorities and measures for the region. The Marine Bioregional Plans are a source of information for Government and industry to improve the way the marine environment is managed and protected (Commonwealth of Australia 2012b). The Marine Bioregional Plans:

- support strategic, consistent and informed decision-making under Commonwealth environment legislation in relation to Commonwealth marine areas
- support efficient administration of the EPBC Act to promote the ecologically sustainable use of the marine environment and its resources
- provide a framework for strategic intervention and investment by Government to meet policy objectives and statutory responsibilities.

The Marine Bioregional Plans improve the understanding of Australian oceans by providing a consolidated picture of the biophysical characteristics and the diversity of marine life (Commonwealth of Australia 2012b). The four Marine Bioregional Plans that have been developed are South-west, North-west, North and Temperate East. Scarborough lies within the North-west Marine Region.

3.4.5 Australian Ballast Water Management Requirements 2017

Scarborough will make use of vessels deployed from both Australian and international ports. The Australian Ballast Water Management Requirements (DAWR, 2017, version 7), provide guidance on how vessel operators should manage ballast water when operating within Australian seas in order to comply with the Biosecurity Act 2015. They also align to the International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004 (the Ballast Water Management Convention), which entered into force internationally on 8 September 2017. The Ballast Water Convention aims to prevent the spread of IMS from one region to another, by establishing standards and procedures for the ballast water management, including phasing out the use of ballast water exchange in favour of other approved methods of ballast water management, including:

- use of a Ballast Water Management System
- ballast water exchange conducted in an acceptable area
- use of low risk ballast water (such as fresh potable water, high seas water or fresh water from an on-board fresh water production facility)

- retention of high-risk ballast water on board the vessel
- discharge to an approved ballast water reception facility.

3.4.6 National Biofouling Management Guidance for the Petroleum Production and Exploration Industry 2009

This guidance document aims to assist the operators of the petroleum production and exploration industry to minimise the amount of biofouling accumulating on vessels, infrastructure and submersible equipment and thereby to minimise the risk of spreading marine pests around the Australian coastline.

3.4.7 Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000

These Guidelines are intended to provide Government, industry, consultants and community groups with a comprehensive set of tools that will enable the assessment and management of ambient water quality in a wide range of water resource types, and according to designated environmental values. The Guidelines are the recommended limits to acceptable change in water quality that will continue to protect the associated environmental values.

3.5 Western Australian Legislation

Western Australian specific legislation is described, where impacts from Scarborough in Commonwealth waters may impact State jurisdiction.

3.5.1 Greenhouse Gas

The Western Australian Government released a GHG Emissions Policy for Major Projects on 28 August 2019. The Policy included an aspirational target of net zero greenhouse gas emissions by 2050. The Minister for Environment will consider how the Policy relates to major proposals assessed under Part IV of the EP Act (Government of Western Australia, 2019) including onshore facilities processing Scarborough gas.

The EPA's current Environmental Factor Guideline for Air Quality describes the EPA's role in assessing greenhouse gas emissions within the State environmental impact assessment process if the proposal's expected total greenhouse gas emissions are deemed to be significant. The EPA released its updated Draft Environmental Factor Guideline for Greenhouse Gas Emissions on 9 December 2019 following public consultation earlier in 2019. The final guidance is due to be published in March 2020.

3.5.2 Dredging

Dredging activities occurring in WA will be assessed under the EP Act which is WA's primary environmental legislation for assessing and seeking approval for any activities likely to have a significant impact. The Act sets out to prevent, control, and abate pollution and environmental harm, for the conservation, preservation, protection, enhancement, and management of the environment. The EPA's current Environmental Factor Guideline for Air Quality describes the EPA's role in assessing greenhouse gas emissions within the State environmental impact assessment process if the proposal's expected total greenhouse gas emissions are deemed to be significant. The EPA released its updated Draft Environmental Factor Guideline for Greenhouse Gas Emissions on 9 December 2019 following public consultation earlier in 2019. The final guidance is due to be published in March 2020.

3.6 EPBC Management Plans

3.6.1 Listed Threatened Species Management/Recovery Plans and Conservation Advices

While unlikely to be significant, the development of Scarborough may trigger risks or impacts on listed threatened species. The requirements of the species recovery plans and conservation advices have been considered to identify any requirements that may be applicable to the impact and risk assessment of the OPP. Recovery plans are enacted under the EPBC Act and remain in force until the species is removed from the threatened species list. Conservation advice provides guidance on immediate recovery and threat abatement activities that can be undertaken to facilitate the conservation of a listed species or ecological community.

Table 3-2 outlines the management/recovery plans and conservation advices relevant to those species identified as potentially occurring or having habitat within the Scarborough Project Area. The table also summarises the key threats to those species, as described in relevant management/recovery plans and conservation advices.

The management/recovery plans and conservation advices have been taken into consideration in assessing the impacts and risks associated with the project (Section 7) and will be further incorporated into implementation planning in activity-specific EPs.

Table 3-2: Summary of EPBC management/recovery plans and conservation advices relevant to the project

Species/ Sensitivity	Recovery plan/ conservation advice (date issued)	Key threats identified in the recovery plan/ conservation advice	Relevant Conservation Actions
All Vertebrate Fauna			
All Vertebrate Fauna	Threat abatement plan for the impacts of marine debris on vertebrate marine life (DEWHA, 2009)	Marine debris	No explicit management actions for non-fisheries related industries (note that management actions in the plan relate largely to management of fishing waste (e.g. “ghost” gear), and state and Commonwealth management through regulation).
Marine Mammals			
Sei Whale	Conservation advice *Balaenoptera borealis* sei whale (TSSC, 2015a)	Noise interference	Once the spatial and temporal distribution (including biologically important areas) of sei whales is further defined an assessment of the impacts of increasing anthropogenic noise (including from seismic surveys, port expansion, and coastal development) should be undertaken on this species
		Vessel disturbance	Ensure all vessel strike incidents are reported in the National Vessel Strike Database.
Blue Whale	Conservation management plan for the blue whale: *A recovery plan under the Environment Protection and Biodiversity Conservation*	Noise interference	Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury and is not displaced from a foraging area.

Species/ Sensitivity	Recovery plan/ conservation advice (date issued)	Key threats identified in the recovery plan/ conservation advice	Relevant Conservation Actions
	Act 1999 2015–2025 (Commonwealth of Australia, 2015a)		EPBC Act Policy Statement 2.1—Interaction between offshore seismic exploration and whales is applied to all seismic surveys.
		Vessel disturbance	Ensure all vessel strike incidents are reported in the National Ship Strike Database
			Ensure the risk of vessel strikes on blue whales is considered when assessing actions that increase vessel traffic in areas where blue whales occur and, if required, appropriate mitigation measures are implemented
Fin Whale	Conservation advice *Balaenoptera physalus* fin whale (TSSC, 2015b)	Noise interference	Once the spatial and temporal distribution (including biologically important areas) of fin whales is further defined, assess the impacts of increasing anthropogenic noise (including seismic surveys, port expansion, and coastal development).
		Vessel disturbance	Develop a national vessel strike strategy that investigates the risk of vessel strikes on fin whales and identifies potential mitigation measures.
			Ensure all vessel strike incidents are reported in the National Vessel Strike Database.
Humpback Whale	Approved Conservation Advice for *Megaptera novaeangliae* (humpback whale) (TSSC, 2015c)	Noise interference	For actions involving acoustic impacts (example pile driving, explosives) on humpback whale calving, resting, feeding areas, or confined migratory pathways, undertake site-specific acoustic modelling (including cumulative noise impacts).
		Vessel disturbance	Ensure the risk of vessel strike on Humpback Whales is considered when assessing actions that increase vessel traffic in areas where humpback whales occur and, if required appropriate mitigation measures are implemented to reduce the risk of vessel strike.
Reptiles			
Loggerhead Turtle, Hawksbill Turtle, Green Turtle, Olive Ridley Turtle, Flatback Turtle and Leatherback Turtle	Recovery plan for marine turtles in Australia (DoEE, 2017)	Vessel disturbance	Vessel interactions identified as a threat; no specific management actions in relation to vessels prescribed in the plan.
		Light pollution	Minimise light pollution.
			Identify the cumulative impact on turtles from multiple sources of onshore and offshore light pollution.
		Acute chemical discharge (oil pollution)	Ensure spill risk strategies and response programs include management for turtles and their habitats.

Species/ Sensitivity	Recovery plan/ conservation advice (date issued)	Key threats identified in the recovery plan/ conservation advice	Relevant Conservation Actions
Leatherback Turtle	Approved conservation advice for *Dermochelys coriacea* (Leatherback Turtle) (TSSC, 2008a)	Vessel disturbance	No explicit relevant management actions; vessel strikes identified as a threat.
Short-nosed Seasnake	Approved Conservation Advice for *Aipysurus apraefrontalis* (Short-nosed Seasnake) (DSEWPaC, 2011).	Habitat loss, disturbance and modification	Monitor known populations to identify key threats. Ensure there is no anthropogenic disturbance in areas where the species occurs, excluding necessary actions to manage the conservation of the species.
Sharks and Rays			
Great White Shark	Recovery plan for the White Shark (*Carcharodon carcharias*) (DSEWPaC 2013a)	No additional threats identified (ex. marine debris)	None applicable.
Dwarf Sawfish, Queensland Sawfish	Approved conservation advice for *Pristis clavata* (Dwarf Sawfish) (TSSC, 2009)	Habitat degradation/ modification	No explicit relevant management actions; habitat loss, disturbance and modification identified as threats.
	Sawfish and river shark multispecies recovery plan (Commonwealth of Australia, 2015b)		Identify risks to important sawfish and river shark habitat and measures needed to reduce those risks.
Green Sawfish, Dindagubba, Narrowsnout Sawfish	Approved conservation advice for Green Sawfish (TSSC, 2008b)	Habitat degradation/ modification	No explicit relevant management actions; habitat loss, disturbance and modification identified as threats.
	Sawfish and river shark multispecies recovery plan (Commonwealth of Australia, 2015c)		Identify risks to important sawfish and river shark habitat and measures needed to reduce those risks.
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish	Approved Conservation Advice for *Pristis* (Largetooth Sawfish) (DoE, 2014).	Habitat degradation/ modification	Implement measures to reduce adverse impacts of habitat degradation and/or modification.
Whale Shark	Conservation advice *Rhincodon typus* (Whale Shark) (TSSC, 2015d)	Vessel disturbance	Minimise offshore developments and transit time of large vessels in areas close to marine features likely to correlate with Whale shark aggregations and along the northward migration route that follows the northern Western Australian coastline along the 200 m isobath.
	Whale Shark (*Rhyncodon typus*) recovery plan 2005–2010 (DEH, 2005)	Habitat degradation/ modification	No explicit relevant management actions; seasonal aggregations of Ningaloo recognised as important habitat.
Grey Nurse Shark (west coast population)	Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*) (DoEE, 2014)	No additional threats identified (ex. marine debris)	None applicable.

Species/ Sensitivity	Recovery plan/ conservation advice (date issued)	Key threats identified in the recovery plan/ conservation advice	Relevant Conservation Actions
Seabirds			
Red Knot	Conservation advice *Calidris canutus* (Red Knot) (TSSC, 2016a)	Habitat degradation/ modification	No explicit relevant management actions; oil pollutions recognised as a threat.
Curlew Sandpiper	Conservation advice *Calidris ferruginea* (Curlew Sandpiper) (TSSC, 2015f)	Habitat degradation/ modification (oil pollution)	No explicit relevant management actions; oil pollutions recognised as a threat.
Bar-tailed Godwit (Western Alaskan)	Conservation advice *Limosa lapponica baueri* (Bar-tailed Godwit (Western Alaskan)) (TSSC, 2016b)	Habitat degradation/ modification	No explicit relevant management actions; oil pollutions recognised as a threat.
Bar-tailed Godwit (Northern Siberian)	Conservation advice *Limosa lapponica menzbieri* (Bar-tailed Godwit (Northern Siberian)) (TSSC, 2016c)	Habitat degradation/ modification	No explicit relevant management actions; oil spills recognised as a threat.
Australian Fairy Tern	Conservation advice for *Sterna nereis* (Fairy Tern) (TSSC, 2011)	Habitat degradation/ modification (oil pollution)	Ensure appropriate oil-spill contingency plans are in place for the subspecies' breeding sites which are vulnerable to oil spills.
Eastern Curlew, Far Eastern Curlew	Conservation Advice for *Numenius madagascariensis* (Eastern Curlew) (DotE, 2015)	Habitat loss, disturbance and modification	Manage disturbance at important sites when the species is present.
Australian Painted Snipe	Approved Conservation Advice for *Rostratula australis* (Australian Painted Snipe). (DSEWPaC, 2013a)	Habitat loss, disturbance and modification	Ensure there is no disturbance in areas where the species is known to breed.
Greater Sand Plover, Large Sand Plover	Conservation Advice for *Charadrius leschenaultii* (Greater Sand Plover). (TSSC, 2016e)	Habitat loss and degradation Pollution and contamination impacts	Manage disturbance at important sites which are subject to anthropogenic disturbance when the species is present.
Great Knot	Conservation Advice for *Calidris tenuirostriss* (Great Knot) (TSSC, 2016d)	Habitat loss, disturbance and modification	Manage disturbance at important sites which are subject to anthropogenic disturbance when the species is present.
Common Sandpiper, Red Knot, Oriental Plover, Oriental Pratincole, Bar-tailed Godwit, Common Greenshank	Wildlife conservation plan for migratory shorebirds (DoEE, 2015a)	Habitat degradation/ modification (oil pollution)	No explicit relevant management actions; oil spills recognised as a threat.

3.6.2 Australian Marine Parks

Under the EPBC Act, Australian Marine Parks (AMPs), formally known as Commonwealth Marine Reserves, are recognised for the purpose of conserving marine habitats and the species that live and rely on these habitats.

The AMPs that occur within or near the Project Area, include those listed in Table 3-3.

Table 3-3: Marine Parks that occur within or near the Project Area

Marine Park	Distance from Project Area (km)	IUCN Protected Area Category
Montebello	Overlap	VI (Multiple Use Zone)
Dampier[3]	Adjacent to Borrow Ground Project Area (at 250 m distance)	II (National Park Zone), IV (Habitat Protection Zone) & VI (Multiple use Zone)
Gascoyne	87	II (National Park Zone), IV (Habitat Protection Zone) & VI (Multiple use Zone)
Ningaloo	186	IV (Habitat Protection Zone)

Scarborough will include construction of approximately 80 km of pipeline through the Montebello Marine Park Multiple Use Zone, as well as inspection maintenance and repair (IMR) activities along the pipeline once operational. Mining operations may be undertaken in the Montebello Multi Use Zone (MUZ) (VI) if authorised by a policy, plan or program endorsed under Part 10 of the EPBC Act ("strategic assessment") and conducted in accordance with that authorisation and a class approval issued under the North-West Marine Parks Network Management Plan (Plan). A class approval permitting mining operations and greenhouse gas activities was issued specifically under this Plan dated 28 June 2018 https://parksaustralia.gov.au/marine/pub/class-approvals/North-west_Marine_Parks_Network.pdf, which includes the Montebello Marine Park MUZ as an Approved Zone.

As these activities will be covered within a future environment plan(s), they do not require any further assessment by the Director of National Parks (DNP). However, the DNP will still be a relevant person for consultation under an OPP/EP with regard to activities in a marine park.

In addition to the identified Management Principles, activities must be undertaken in a manner that is consistent with the objectives of the zone, and the values of the marine park (including natural, cultural, heritage and socio-economic values) (Director of National Parks, 2018):

- The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible.
- The objective of the Habitat Protection Zone (IV) is to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while allowing activities that do not harm or cause destruction to seafloor habitats.
- The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species.

Australian IUCN Reserve Management Principles for each category are set out in the Environment Protection and Biodiversity Conservation (EPBC) Regulations and are summarised in Table 3-4.

The values of the marine parks are described in Section 5.6.

[3] Currently included to support option to use adjacent borrow ground. Reference to this AMP will be removed if option is not carried forward.

Table 3-4: Australian IUCN reserve management principles

Category II: National Park: Protected Area managed mainly for ecosystem conservation and recreation	Category IV: Habitat/Species Management Area: Protected Area managed mainly for conservation through management intervention	Category VI: Managed Resource Protected Areas: Protected Area managed mainly for the sustainable use of natural ecosystems
3.01 The reserve or zone should be protected and managed to preserve its natural condition according to the following principles. 3.02 Natural and scenic areas of national and international significance should be protected for spiritual, scientific, educational, recreational or tourist purposes. 3.03 Representative examples of physiographic regions, biotic communities, genetic resources, and native species should be perpetuated in as natural a state as possible to provide ecological stability and diversity. 3.04 Visitor use should be managed for inspirational, educational, cultural and recreational purposes at a level that will maintain the reserve or zone in a natural or near natural state. 3.05 Management should seek to ensure that exploitation or occupation inconsistent with these principles does not occur. 3.06 Respect should be maintained for the ecological, geomorphologic, sacred and aesthetic attributes for which the reserve or zone was assigned to this category. 3.07 The needs of indigenous people should be taken into account, including subsistence resource use, to the extent that they do not conflict with these principles. 3.08 The aspirations of traditional owners of land within the reserve or zone, their continuing land management practices, the protection and maintenance of cultural heritage and the benefit the traditional owners derive from enterprises, established in the reserve or zone, consistent with these principles should be recognised and taken into account.	5.01 The reserve or zone should be managed primarily, including (if necessary) through active intervention, to ensure the maintenance of habitats or to meet the requirements of collections or specific species based on the following principles. 5.02 Habitat conditions necessary to protect significant species, groups or collections of species, biotic communities or physical features of the environment should be secured and maintained, if necessary, through specific human manipulation. 5.03 Scientific research and environmental monitoring that contribute to reserve management should be facilitated as primary activities associated with sustainable resource management. 5.04 The reserve or zone may be developed for public education and appreciation of the characteristics of habitats, species or collections and of the work of wildlife management. 5.05 Management should seek to ensure that exploitation or occupation inconsistent with these principles does not occur. 5.06 People with rights or interests in the reserve or zone should be entitled to benefits derived from activities in the reserve or zone that are consistent with these principles. 5.07 If the reserve or zone is declared for the purpose of a botanic garden, it should also be managed for the increase of knowledge, appreciation and enjoyment of Australia's plant heritage by establishing, as an integrated resource, a collection of living and herbarium specimens of Australian and related plants for study, interpretation, conservation and display.	7.01 The reserve or zone should be managed mainly for the sustainable use of natural ecosystems based on the following principles. 7.02 The biological diversity and other natural values of the reserve or zone should be protected and maintained in the long term. 7.03 Management practices should be applied to ensure ecologically sustainable use of the reserve or zone. 7.04 Management of the reserve or zone should contribute to regional and national development to the extent that this is consistent with these principles.

3.7 International Agreements

Australia is a signatory to several international conventions and agreements relevant to environmental protection. Those relevant to Commonwealth legislation that may apply to Scarborough include:

- International Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal 1989 (Basel Convention)
- Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and Their Environment (commonly referred to as the China Australia Migratory Bird Agreement or CAMBA)
- International Convention on the Conservation of Migratory Species of Wild Animals 1979 (Bonn Convention)
- International Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
- Convention on the International Maritime Organisation 1948
- International Convention for the Prevention of Pollution from Ships, London, 1973/1978 (commonly known as MARPOL 73/78)
- International Convention on Harmful Anti Fouling Systems 2001 (AFS Convention)
- International Convention on Civil Liability for Oil Pollution Damage, 1969 and 1992 (CLC 69; CLC 92)
- Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and Their Environment (commonly referred to as the Japan Australia Migratory Bird Agreement or JAMBA)
- Kyoto Protocol 1997
- Montreal Protocol on Substances that Deplete the Ozone Layer 1987
- Protocol to International Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter, 7 November 1996 (previously known as the London Dumping Convention)
- Rotterdam Convention a multilateral treaty to promote shared responsibilities in relation to importation of hazardous chemicals
- Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds (commonly referred to as the Republic of Korea Australia Migratory Bird Agreement or ROKAMBA)
- The Convention on the International Regulations for Preventing Collisions at Sea 1972 (COLREGS)
- UNCLOS
- United Nations Framework Convention on Climate Change 1992.

4 DESCRIPTION OF THE PROJECT AND ALTERNATIVES ANALYSIS

4.1 Project Overview

The Scarborough and North Scarborough gas fields are located 375 km west-north-west of the Burrup Peninsula in the northwest of Australia within offshore petroleum permits WA-1-R and WA-62-R. The Thebe and Jupiter fields, which may provide opportunities for future tie-back options, are located to the north and north-east of the Scarborough and North Scarborough gas fields, within offshore permits WA-63-R and WA-61-R respectively (Figure 4-1). These potential future field tie-back options are included as part of the overall Scarborough Offshore Project Proposal. As the proposed trunkline route crosses the Carnarvon Basin, in close proximity to other undeveloped fields, Woodside is also engaging with other resource owners to explore opportunities for future development. Any future development opportunities will be undertaken in accordance with the environmental legislative requirements in force at that time.

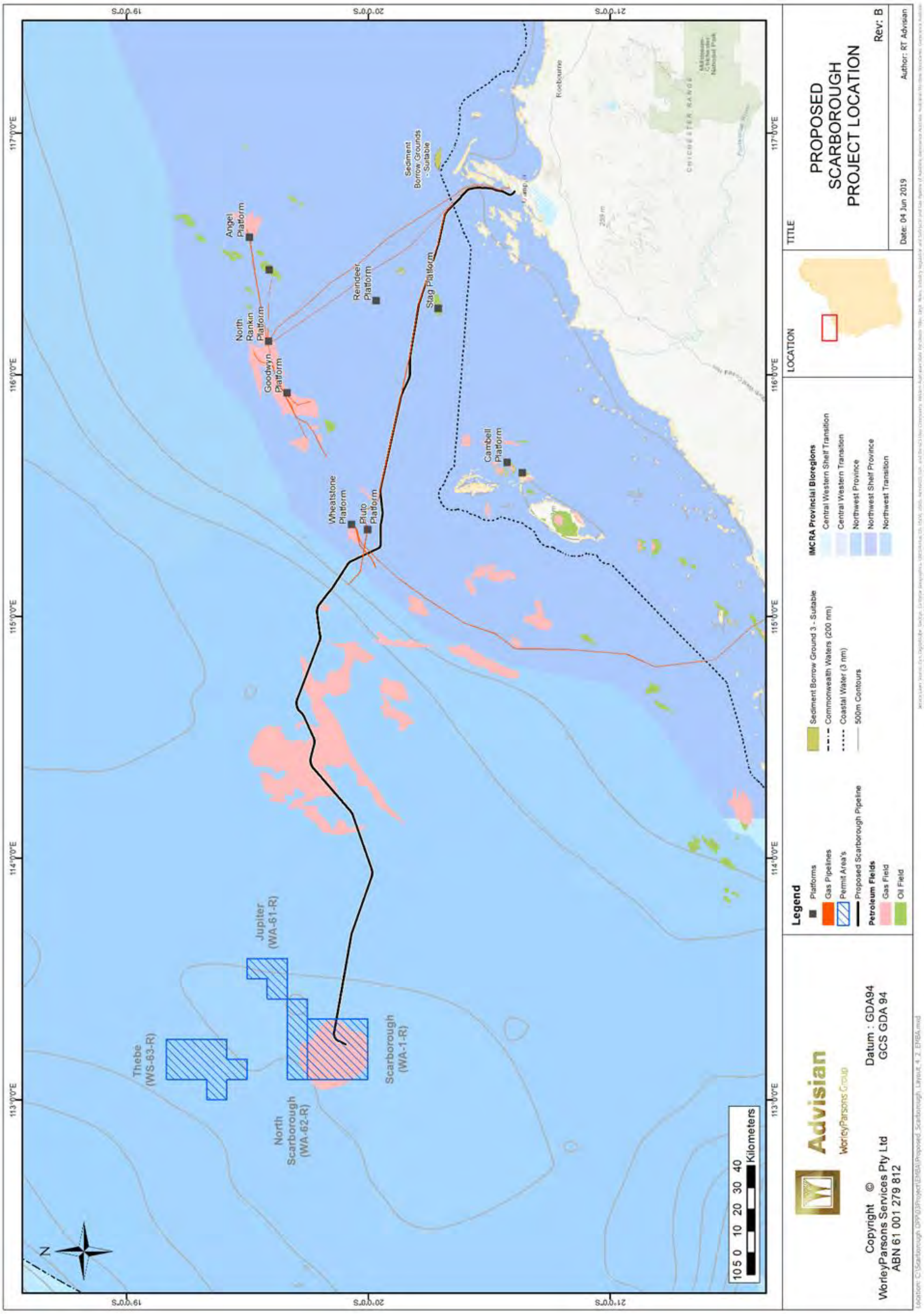


Figure 4-1: Proposed Scarborough and trunkline location

The proposed development of Scarborough includes drilling of multiple subsea gas wells (which includes wells in the Scarborough, North Scarborough, Thebe and Jupiter gas fields). Wells will be tied back to an FPU moored in about 900 m of water, over the Scarborough field. Woodside proposed that the FPU topsides has processing facilities for gas dehydration and compression to transport the gas through an approximately 430 km long trunkline to a proposed brownfield expansion of the existing Pluto LNG onshore facility (Pluto Train 2) (outside the scope of this Proposal).

The key characteristics of Scarborough are outlined in Table 4-1.

Table 4-1: Key project characteristics for Scarborough

Criteria	Key Characteristics of the Development
Proponent	Woodside Energy Ltd (Woodside) for and on behalf of the Scarborough Joint Venture (SJV) consisting of Woodside and BHP Billiton Petroleum (North West Shelf) Pty Ltd (BHP NWS)
Field Location	375 km WNW of the Burrup Peninsula in the North West of Australia
Offshore Permits	WA-1-R (Scarborough field) WA-62-R (North Scarborough field) WA-63-R (Thebe field) WA-61-R (Jupiter field) With potential for other future tie-ins in the vicinity of these permits
Anticipated Hydrocarbon	Dry gas (i.e. trace or no condensate expected) No detectable hydrogen sulphide (H_2S) and extremely low reservoir CO_2 (~0.1 mol%) compared with other oil and gas reservoirs.
Key Project Phases	Development and infill drilling Subsea infield infrastructure installation FPU and installation Trunkline installation (including crossing of existing trunklines) Commissioning activities Operation Decommissioning
Proposed Number of Wells	Anticipated that a number of wells will be drilled in two phases in the Scarborough reservoir. As an estimate only, this may include up to 20 wells: • proposed seven wells at start up • up to 13 future wells (including wells for subsequent tiebacks of other reservoirs including Thebe (8 wells) and Jupiter (2 wells). • While not currently planned, the assessment carries a contingency of 10 additional wells should this be required for the development.
Subsea Infrastructure	Infield infrastructure, including; wellheads, manifolds, flowlines and umbilicals, trunkline and communications lines.
Surface Infrastructure	Minimally manned FPU in approximately 900 m of water to the southeast of the WA-1-R permit area
Trunkline Installation Techniques	Trenching and backfill
Final Investment Decision – Woodside target	2020
First cargo – Woodside target	2023
Project life[1]	2055 (estimation only)

[1] *If additional or third-party reservoirs have been tied into Scarborough infrastructure, this could increase the project's economic life.*

4.1.1 Project Schedule

Woodside is proposing to conduct FEED activities in 2019 to support the Operator's targeted Final Investment Decision (FID) in 2020. Woodside's target schedule for Scarborough is included in Table 4-2.

Table 4-2: Woodside's target preliminary schedule

Phase	Timing
Select/Definition (Pre-FEED)	2018
Front End Engineering Design (FEED)	FEED activities will be conducted in 2019 to be ready for FID in 2020
Final Investment Decision (FID)	2020
Drilling	2020 Phase 1 2025 Phase 2 (potentially including Thebe and Jupiter) ***Note that timing will be dependent on reservoir performance***
FPU Installation	2023
Trunkline Installation	2022
First Cargo	2024
Decommissioning[1]	2055 (estimation only)

[1] Note decommissioning may occur in stages, and if additional or third-party reservoirs have been tied into Scarborough infrastructure, this could increase the project's economic life and thus postpone decommissioning.

4.1.2 Definition of Project Area

For the purpose of this OPP, the Project Area has been defined to consist of the Offshore Project Area (for the Scarborough, North Scarborough, Thebe and Jupiter fields i.e. the area covered by WA-1-R, WA-62-R, WA-61-R, and WA-63-R), the Trunkline Project Area to the State water limits (the proposed trunkline route with a 1.5 km buffer either side inclusive of Spoil Ground 5A) and the Borrow Ground Project Area, as shown in Figure 4-3. This Project Area has been considered to include the extent of all planned activities described in this proposal with sufficient buffer.

The Project Area will accommodate the movement of vessels around the offshore facilities during installation, commissioning and operation. However, the OPP does not include the transit of vessels to or from the offshore locations. These activities are undertaken in accordance with maritime legislation including the Commonwealth *Navigation Act 2012*.

The OPP does not consider any activities undertaken in State waters or onshore. These activities will be assessed under the relevant State and Commonwealth legislation.

4.2 Project Location

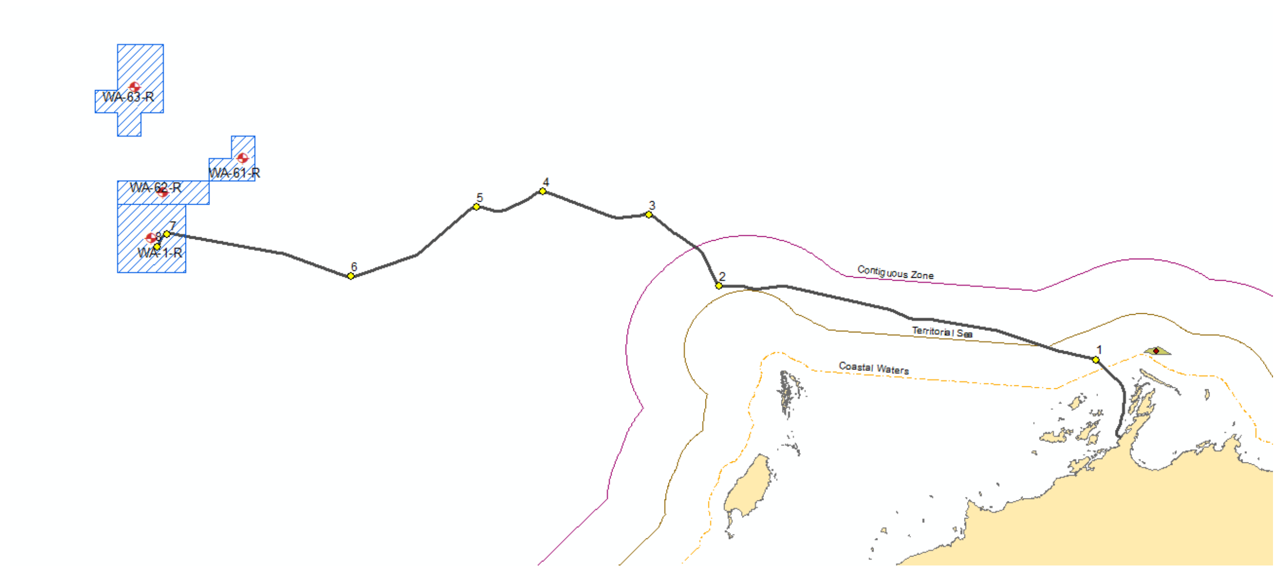
The proposed Scarborough and North Scarborough fields are located in permit area WA-1-R and WA-62-R, in Commonwealth waters approximately 375 km north west off the Burrup Peninsula in the North West of Australia. Water depths within WA-1-R range between 900 m to 1000 m. Wells may also be drilled and tied back to the FPU from the Thebe and Jupiter fields, located in petroleum permits WA-63-R and WA-61-R respectively.

All subsea and subsurface infield infrastructure and wells are located in Commonwealth waters. The trunkline from the FPU to shore will be the only part of the proposed development which traverse into State waters. The proposed trunkline route is shown in Figure 4-1. The location at which the trunkline will cross into State waters is about 20 km north-west from the shore and in water depths of 31 m.

Table 4-3 presents the location of the key Scarborough infrastructure.

Table 4-3: Approximate location details for key infrastructure

Site/Location	Coordinates (MGA94(50))	
	Longitude	***Latitude***
FPU	113.242°E	-19.926°S
WA-1-R Centre point	113.210°E	-19.874°S
WA-61-R Centre point	113.543°E	-19.582°S
WA-62-R Centre point	113.251°E	-19.707°S
WA-63-R Centre point	113.147°E	-19.322°S
Trunkline Point 1	116.669°E	-20.321°S
Trunkline Point 2	115.291°E	-20.050°S
Trunkline Point 3	115.034°E	-19.789°S
Trunkline Point 4	114.642°E	-19.704°S
Trunkline Point 5	114.399°E	-19.761°S
Trunkline Point 6	113.939°E	-20.016°S
Trunkline Point 7	113.264°E	-19.860°S
Trunkline Point 8	113.230°E	-19.906°S
Sediment Borrow Grounds - Suitable	116.769°E	-20.468°S



4.3 Hydrocarbon Characteristics

The Scarborough gas resource contains gas which is classified as 'dry' with only trace levels of condensate, and 'sweet' with no detectable H_2S and <0.01 mol% of CO_2.

Understanding of the Scarborough gas composition was supported by information collected from reservoir samples and well tests obtained from the SC-4 and SC-5 appraisal wells, and compositional analysis undertaken in 2018. The Scarborough gas composition is provided in Table 4-4.

Table 4-4: Scarborough gas composition

Component	Composition Range (mol%)
Carbon dioxide	0.01 to 0.06
Nitrogen	4.3 to 5.6
Methane	94.2 to 95.5
Ethane	0.06 to 0.1
Propane +	0.002 to 0.01

Table 4-5: Scarborough contaminants [S1, S4, S8]

Contaminant	Maximum Concentration	Units
BTEX	<1	ppm
Hydrogen Sulphide (H_2S)	<0.2	ppm
Mercaptans	<0.2	ppm
Mercury (Hg)	30	ug/m³
Arsenic (As)	<0.005	mg/m³
Helium (He)	0.025	mol %
Hydrogen (H_2)	0.018	mol %
Radon (Rn)	300	Bq/m³

The development of Scarborough considers future tie-in to adjacent fields including the Thebe and Jupiter fields. These fields are expected to be of a similar composition to the Scarborough gas resource.

4.4 Development Infrastructure

The key infrastructure components of Scarborough include wells, subsea infrastructure, the FPU and trunkline. These are discussed in Section 4.4.2.

4.4.1 Future Development

The project is designed to accommodate future tie-back opportunities including Thebe and Jupiter gas fields and potentially other resources owned either by Woodside or other resource owners. Any future development opportunities will be undertaken in accordance with the environmental legislative requirements in force at that time.

Provision for tie-in to the FPU, such as spare riser slots and preinstalled tees in the export pipeline, is part of the current design of Scarborough. The infrastructure to support Thebe and Jupiter field development is likely to comprise development wells and subsea infrastructure such as manifolds, possibly subsea compression and flowlines. While the design of these facilities is not yet matured, consideration of the activities is within the scope of the assessment in this OPP.

4.4.2 Current Infrastructure Design

4.4.2.1 Wells

It is anticipated that Scarborough will require a number of development wells to be drilled in the target reservoirs over the life of the project. The number and location of these wells will depend on reservoir target areas, seabed bathymetry and features to optimise reservoir recovery. Pressure and saturation changes in the reservoir will be monitored over the life of the Project. Data will be used to inform decisions regarding reservoir management.

Each well will be topped by a wellhead, which provides means of hanging the production well casing, and installing the christmas tree and well flow control facilities. Each well is then fitted with a christmas tree which enables reservoir fluids to flow from the well to the flowlines. Christmas trees are used to:

- manage chemical injection
- control production, whereby hydraulically controlled valves on the christmas trees are used to control flow rates and provide a well shut-off mechanism.

Wells will be grouped into drill centres, thereby optimising the layout of wells. For future tie-ins of the Thebe and Jupiter gas fields, it is likely that one drill centre for each field will be required. While the exact location of the wells has not yet been determined, they are proposed be located with the permit areas as identified in Figure 4-1.

4.4.2.2 Subsea Infrastructure

The drill centres are connected to manifolds by well jumpers to allow reservoir fluids to be carried. Connection between the flowlines and the FPU is achieved using flexible risers through a riser base manifold.

Subsea infrastructure is powered, monitored and controlled from the FPU facilities using a network of electro-hydraulic control umbilicals and subsea distribution units (SDUs). Wells are serviced by static umbilicals likely to follow the same route as the infield flowlines, the static umbilicals are tied back to the FPU using a dynamic umbilical. A telecommunications fibre optic cable will connect the FPU and associated subsea infrastructure to shore. This line would most likely follow the path of the Trunkline, though details regarding installation and operation will be determined during detailed engineering design.

Other subsea infrastructure includes FPU mooring anchors and the riser base manifold.

All subsea infrastructure types described above will be located in Commonwealth waters.

The total extent of seabed required for the installation of subsea infrastructure for Scarborough is estimated at about 0.234 km^2. This total area is subject to refinement during the design process, but a 50% contingency has been added to represent a conservative maximum extent (Table 4-6).

Table 4-6: Approximate extent of seabed disturbance for infield subsurface disturbance[4]

Infrastructure	Area (km²)
Scarborough Field	
FPU and infield infrastructure (flowlines, umbilicals, in-line tees (ILTs), risers and anchors, flowlines)	0.038
Jupiter and Thebe fields (flowlines and interfield lines)	0.027
Jupiter and Thebe Field	
Flowlines and interfield lines	0.090
Total Disturbance	***0.156***
Total Disturbance with 50% contingency	***0.234***

4.4.2.3 Floating Production Unit

The FPU will be a semi-submersible platform installed over the Scarborough field, in approximately 900 m water depth. Table 4-7 presents preliminary main characteristic of the FPU. The FPU will provide all necessary systems and utilities to support gas compression and exporting to shore. MEG will be continuously injected into the subsea gathering system to prevent hydrate formation. The MEG will be regenerated and stored on the FPU and pumped to the subsea and topsides injection points as required.

The Scarborough FPU is currently being designed so that the facility would be manned by the minimum number of personnel required to operate safely, with the ability for remote control operations. If required, additional personnel would be transferred to the FPU to complete maintenance on the facility.

The FPU is envisaged as a production hub for other resources in the area. The Thebe and Jupiter gas fields provide opportunities for future tie backs via subsea flowlines to the Scarborough FPU.

Table 4-7: Floating Production Unit (FPU) preliminary main characteristics[5]

Characteristic	Unit	Value
Hull type		Conventional semi-submersible
Deck Dimensions (L x W x H)	m-m-m	2 @ 70 x 70 x 13
Draft	m	28
Mooring radius	m	1,400
Maximum POB	persons	75

The FPU will be maintained on location by a semi-taut mooring system. The mooring lines will be preferentially secured to the seabed by suction piles. The suction piles will typically be 6 to 10 m in diameter and about 30 m in length, with each weighing about 400 tonnes. It is anticipated that up to 20 piles may be required. While the base case is for the use of suction piles, the option to use driven piles will be carried depending on seabed conditions.

[4] Note that this will be subject to change during FEED

[5] Note these may be subject to change during FEED

The topsides process configuration has been selected in line with the current minimum manning and remote control of FPU operation philosophies. The FPU topsides process functionality will include:

- inlet reception facilities for wet well fluids
- gas/liquid separation
- gas conditioning (dehydration and hydrocarbon dew-pointing)
- dry gas export compression
- MEG Recovery Unit including regeneration and reclamation, storage and pumping
- MEG solids treatment and disposal
- produced water treatment and disposal
- contaminants removal and disposal – sand, mercury, oil
- gas back flow from the trunkline
- production flowline re-pressurisation
- process support utilities (including power generation and flare)
- temporary flowline pigging facilities.

The topsides will be designed to be operated remotely from shore, including shut-down, start-up and steady state operation with minimal manning requirements.

4.4.2.4 Trunkline

Woodside proposes that gas will be exported from the FPU via a 32-inch carbon steel trunkline that runs approximately 430 km from the FPU to a proposed and approved brownfield expansion of the existing Pluto LNG onshore facility (Pluto Train 2). Under this proposal the trunkline will extend from the FPU site to the Pluto platform and then run parallel to the existing Pluto trunkline, within the existing trunkline corridor and come ashore on the Burrup Peninsula adjacent to the existing Pluto trunkline shore crossing. Trunkline construction is anticipated to begin in 2022.

4.4.2.5 Onshore Development (out of scope)

Woodside's preferred development for Scarborough proposes to transport feed gas to the existing Woodside-operated Pluto LNG facility on the Burrup Peninsula for processing, where a second LNG train will be built (known as Pluto Train 2). However, Train 2 is subject to separate State and Commonwealth environmental approval mechanisms, and is out of scope of this OPP.

4.4.3 Drilling Activities

The proposed production wells will be drilled using a moored or semi-moored MODU, or dynamically positioned (DP) MODU or drill ship.

The location of wells and associated subsea facilities will be influenced by reservoir targets, general bathymetry, seabed features and hydraulic performance of subsea production systems.

A phased development drilling program is proposed with infill drilling as required. While the final number and location of operating wells is not yet known, it is anticipated that seven wells will be available at first cargo in 2024, and up to 13 wells (including eight wells in the Thebe field and two wells in the Jupiter field) during a potential second future phase, that may begin in 2025. An additional 10 wells are proposed to be carried in this assessment as contingency. While the exact location of the wells has not yet been determined, they are proposed be located with the permit areas as identified in Figure 4-1.

Each operating well is anticipated to take approximately 2-3 months from the start of drilling to completions. Table 4-8 provides an estimate of Scarborough operating wells, noting that this is an estimate only.

Table 4-8: Estimates for the Scarborough wells

Drilling Phase	Anticipated Timeframes	Reservoir	Anticipated number of wells
1	2020	Scarborough (Phase 1)	7
2	2025	Scarborough (Phase 2)	3
		Thebe	8
		Jupiter	2
Contingency wells (50%)			10
TOTAL			**30**

4.4.3.1 Drilling Method Overview

Several vessel types will be required to complete production drilling, including:

- semi-submersible moored MODU or DP MODU
- support vessels, required for activities such as to run and set anchors and support the MODU, during operations.

Development wells will be drilled to depths of about 3000 m beneath sea level to intersect the reservoirs. Wells will be spaced out optimising the layout of subsea infrastructure and bottom hole targets.

Typically, the drilling process starts with the drilling of the largest size hole, and a smaller diameter conductor will be cemented inside this hole. Next, a smaller diameter hole section will be drilled, and an intermediate casing will be run in and cemented. Intermediate casings provide structural support for the hole walls, isolate geological formations and allow pressure management that may be experienced during drilling.

A blow-out preventer (BOP) and riser system will then be installed. With the BOP in place, a hole will then be drilled to the top of the reservoir and a liner cemented over this hole section. The final hole section is then drilled through the reservoir as required based on reservoir targets.

Once drilling and completion of the well is completed, the well is then flowed to the MODU. Once stable flow is achieved the produced fluids are sent to tanks for separation onboard the MODU. The produced hydrocarbons are flared while the water is treated to meet regulatory requirements and then discharged overboard. This first production to the MODU is known as unloading and typically lasts approximately 12 hours per well. Once unloading activities are completed, the wells are then isolated until they are connected to the FPU.

Well construction activities are conducted in the stages described below. Detailed well designs will be submitted to the Well Integrity department of NOPSEMA as part of the Approval to Drill and the accepted Well Operation Management Plan (WOMP) as required under the *Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011*.

4.4.3.2 Top Hole Section Drilling

Drilling commences with the top-hole section of the well as follows:

1. The MODU arrives and establishes position over the well site.
2. A pilot hole or holes may be drilled close to the intended well location. Pilot holes are used when confirmation of geology and shallow hazards or further understanding of the

structural integrity of the rock is required. Pilot holes are drilled riserless, as described below, and result in additional cuttings, sweeps and potentially deposition to seabed.

3. Top hole sections are drilled riserless using seawater with pre-hydrated bentonite sweeps/ (XC) Polymer sweeps or drilling fluids to circulate drill cuttings from the wellbore.
4. Once each of the top-hole sections are drilled, steel casings are inserted into the wellbore to form the surface casing and secured in place by pumping cement into the annular space back to about 300 m above the casing shoe, which may involve a discharge of excess cement at the seabed.

Cuttings generated during drilling of the top-hole sections are discharged at the seabed. Discharged volumes for each well have been estimated in Table 7-63.

4.4.3.3 Blowout Preventer and Marine Riser Installation

After setting the surface casing, a BOP is installed on the wellhead to provide a means for sealing, controlling and monitoring the well during drilling activities. The BOP components are operated using open hydraulic systems (utilising water-based BOP control fluids). Each time the BOP is operated, the maximum volume of BOP control fluid released to the marine environment per well is 1320 – 2250 L of water-based fluid containing about 40 – 68 L of control fluid additive. BOP operation includes pressure testing approximately every 21 days and a function test approximately every seven days, excluding the week a pressure test is conducted.

Following installation of the BOP, a marine riser is installed to provide a physical connection between the well and MODU. This enables a closed circulation system to be maintained, where weighted water-based muds (WBM) and cuttings can be circulated from the wellbore back to the MODU via the riser.

4.4.3.4 Bottom Hole Section Drilling

Bottom hole drilling involves drilling of the lower section of the well. Bottom hole drilling requires a bottom hole assembly (BHA) that provides the force for the drill bit to break the rock in what can be a more challenging mechanical environment.

Bottom-hole section drilling uses a closed system (post installation of marine riser) to the planned wellbore total depth (TD). Bottom hole sections may be drilled using a combination of water-based and non-water-based drilling fluids.

Protective steel tubulars (casings and liners) are inserted as required. After a string of casing/liner has been installed into the wellbore and the cement holding it in place has hardened, the casing/liner is pressure-tested.

Cementing operations are also undertaken to:

- maintain well control and structural support of the casing as required
- set a plug in an existing well in order to sidetrack
- plug a well so it can be abandoned.

Cements are transported as dry bulk to the MODU by support vessels, mixed as required by the cementing unit on the MODU and are pumped by high pressure pumps to the surface cementing head then directed down the well.

Once well operations are completed, excess cement (dry bulk), is either held on-board and used for subsequent wells; provided to the next operator at the end of the program; or discharged to the marine environment along with cement that does not meet technical requirements (least likely option).

Cuttings and drilling fluids circulated back to the MODU are separated from the drilling fluids by the solids control equipment (SCE). The SCE comprises shale shakers to remove coarse cuttings from the drilling fluid. After processing by the shale shakers, the recovered fluids from the cuttings may be directed to centrifuges, which are used to remove the finer solids (4.5 to 6 μm). The cuttings are usually discharged below the water line and the fluids are recirculated into the fluid system. Volumes of drill cuttings and fluids discharged per well are summarised in Table 7-63.

4.4.3.5 Well Clean-up

Prior to installing the drill stem test (DST) string, wells will generally be displaced from the drilling fluid system to brine. A chemical cleanout fluids train will be circulated between the two fluids, then seawater or brine circulated until operational cleanliness specifications are met. This will be in line with Woodside's Reservoir, Drilling and Completions Fluids Guideline. Brine is typically a filtered brine with <70 NTU and/or <0.05% total suspended solids (TSS). This results in a brine and seawater discharge after this operation. Should there be clean-up brine contaminated with base oil, it will be captured and stored on the MODU for treatment prior to discharge or returned to shore if treatment is not possible.

4.4.3.6 Well Flow-back

Upon successfully drilling the production wells, Woodside may conduct well testing or well flowback activities. The types of tasks associated with well testing and flowback may include:

- reservoir gas flaring
- reservoir gas venting.

During flowback, initial unloading of the well displaces the suspension fluids. These are discharged overboard – the gas content makes it too dangerous to filter or treat them. Once the suspension fluids are unloaded, the gas stream is sent to flare via the production separator.

After the objectives of the well testing and flowback are achieved, the flow is stopped and the well may be cleaned using a brine that can include several chemicals, such as biocide and surfactant.

4.4.3.7 Completion

Once a well has been drilled, well completion activities will be undertaken including installation of sand control screens, production tubing and the christmas tree, followed by well suspension. Lower completions will require down-hole sand control to manage the potential for formation failure during operation.

Installation of well infrastructure will consist of deploying the horizontal christmas tree and lock it to the wellhead, followed by verification testing of the connector, flowline connector and subsea control module (SCM) as required. The installation will be supported by remotely operated vehicles (ROVs) with installation by wire from the MODU or vessel.

4.4.3.8 Subsea Equipment Preservation Chemicals

Following well completion activities, the wells may be left with subsea equipment (such as christmas trees) installed, awaiting connection to the FPU. All subsea equipment will contain preservation fluids to prevent corrosion and any other deterioration of the equipment before production. Such fluids will be flushed back to the FPU when production from the well commences.

Prior to leaving the subsea equipment flooded and ready for start-up, pre-commissioning and final hydrotests of the subsea infrastructure will result in discharge of treated seawater.

4.4.3.9 Drilling Fluids

Drilling fluids are used to lubricate the drill string, resist any pressure from the well stream and return cuttings to surface. They are formulated according to the well design, the expected reservoir geological conditions and the surrounding formations.

Drilling fluids are comprised of a base fluid, weighting agents and chemical additives used to give the fluid the exact properties required to make the drilling as efficient and safe as possible. The selection of fluid types will not be finalised until the detailed design phase when well design is more confirmed.

All wells will be drilled using Water Based Muds (WBMs) for the top-hole sections and either WBMs or Non-Water Based Muds (NWBMs) for the lower sections. The selection of mud types is dependent on technical aspects of the drilling program that will not be known until completion of detailed design:

- WBM is typically used as the first preference when planning to drill a well, consistent with the requirements of Woodside's Environmental Performance Standard. WBM is mainly comprised of water (salt or fresh). Some basic additives such bentonite/guar gum may be added to the water. All WBM chemicals selected for use will be assessed under the Woodside Chemical Selection and Assessment Environment Guideline.
- NWBM may also be used subject to the development of a "business case deviation" that details environment, technical, health and waste management considerations. The requirement to use NWBM is typically based on a need for improved management of the technical and safety aspects of drilling technically complex wells. All NWBM chemicals selected for use will be assessed under the Woodside Chemical Selection and Assessment Environment Guideline.

Given the shallow depth of the target reservoir in the Scarborough, Thebe and Jupiter reservoirs, a combination of horizontal and high angle wells is required with maximum well lengths of approximately 2000 m.

4.4.3.10 Vertical Seismic Profiling

As a part of ongoing field evaluation, Woodside may undertake vertical seismic profiling (VSP) once total depth is reached.

VSP is used to generate a high-resolution seismic image of the geology in the well's immediate vicinity. It uses a small airgun array, typically comprising either a system of three 250 inch^3 airguns with a total volume of 750 inch^3 of compressed nitrogen at about 1800 psi (12,410 kPa) or two 250 inch^3 airguns with a total volume of 500 inches^3. During VSP operations, four to five receivers may be positioned in a section of the wellbore (station) and the airgun array is discharged approximately five times at 20 second intervals. The generated sound pulses are reflected through the seabed and are recorded by the receivers to generate a profile along 60 to 75 m section of the wellbore. This process is repeated as required for different stations in the wellbore and it may take up to 24 hours to complete, depending on the wellbore's depth and number of stations being profiled.

4.4.4 Installation of Subsea Infrastructure

Subsea infrastructure required for start-up will be installed prior to the installation of the FPU, with further infrastructure, including temporary infrastructure to support commissioning activities, installed throughout the life of the project as required (e.g. for wells drilled in Phase 2 and in the Thebe and Jupiter fields). Subsea infrastructure such as riser-based manifolds, risers, flowlines, umbilicals and mooring system will be transported to site by a combination of installation vessels and cargo barges. Subsea installation of equipment will be performed by subsea installation vessels (ISV). These will be equipped with submersible ROVs, which will aid in the installation, hook-up and commissioning processes.

With the riser based manifolds in place, the subsea well jumpers, infield flowlines and umbilicals will be installed on the seabed. The infield flowlines will be installed progressively within a defined corridor using a pipe-lay vessel, whereby each flowline is lowered to the seabed as the vessel moves forward. The flowlines and MEG lines will be laid directly on the seabed following seabed preparation (if required) and umbilicals will be laid alongside the flowlines.

4.4.5 Installation of Flexible Risers

The flexible risers will be installed using an ISV. Each of the flexible risers will be installed, already filled with MEG or freshwater/seawater. To achieve the final riser design configuration, buoyancy modules will be installed directly onto the riser during the installation. Once each riser has been laid, the subsea end will be installed to the riser base manifold. Diverless connectors are likely to be used to connect each riser to the manifold. The installation of the flexible umbilical risers will follow the same methodology; however, the umbilicals will be connected to the Subsea Distribution Unit (SDU).

4.4.6 Installation of FPU

The FPU components will be assembled and pre-commissioned as much as reasonably possible at onshore fabrication/pre-assembly sites before transportation to its final offshore location.

The anchor piles and mooring legs will be installed in advance and laid on the seabed.

The FPU will most likely be dry towed to a sheltered location for offloading and wet towed to site. Once at site, the mooring lines will be connected to the FPU.

Riser connection and offshore commissioning will then be completed. A marine spread will be at site supporting anchor and riser connection.

Where suction piling is to be used, piles will be installed by gently lowering the pile onto the seabed and using gravity to lower the pile into the soft substrate. The preferred installation method is to pump out the entrapped water inside the pile, with the resulting differential pressure drawing the pile deeper into the seabed. Should driven piling be required, current options being assessed are drilling and cementing or impact piling, which involves the application of force to drive the pile into the seabed.

4.4.6.1 FPU Utilities

The FPU will likely include utilities as described below.

Power Generation and Distribution: Power generation is likely to be supplied by gas turbine driven generators that have the capacity to use diesel if gas is not available (such as during start-up operations). The need for separate emergency power generation equipment will be determined during FEED.

Fuel Gas Treatment: Gas would be the main source of fuel for power generation. A fuel gas treatment system usually consists of pressure reduction, filtering, dew pointing and metering equipment prior to use by turbines and other fuel gas users.

Diesel System: A diesel storage and distribution system may be required to provide a fuel source for emergency power generation systems, materials handling cranes, firewater pumps, and as a back-up fuel source for the main power generation system. Diesel would be transported to the FPU by supply vessel.

Emergency Flare System: An emergency depressuring (flare) system, also referred to as a ‘safety flare system’, will be installed on the FPU. The safety flare will be designed to provide a safe means of rapidly disposing pressurised gas from process equipment in the event of an emergency or process upset. The flare system is also required during commissioning, initial production, process shutdowns and restarts, maintenance, and equipment downtime. A pilot flare will keep the emergency flare lit.

Chemical Storage and Injection Facilities: Chemicals may need to be stored on the FPU for injection into the subsea systems (flowlines/wellheads/manifolds) and trunkline and for production purposes. A wide variety of chemicals and other materials may be stored and used on the FPU, including:

- acids and solvents
- hydrate and corrosion inhibitors
- surface active agents
- lubricating fluids and greases
- hydraulic oils and fluids
- paints
- specialised cleaning fluids
- seawater system treatment chemicals.

MEG will be continuously injected into the subsea gathering system to prevent hydrate formation. The MEG will be regenerated and stored on the FPU and pumped to the subsea and topsides injection points as required. Produced and condensed water extracted from the reservoir and separated from the MEG during regeneration will be treated to acceptable quality and routinely disposed of overboard, with volumes expected to be below 100 m^3/day.

Subsea Controls Support System: The subsea equipment will be controlled by an electro-hydraulic system. The hydraulic fluid, power and controls communications functions will be transported to the manifolds via an umbilical. This umbilical may also transport some of the production chemicals required at the field. The FPU will house all the equipment needed to support these functions, including a hydraulic pressure maintenance system, power supply and uninterrupted power supply system, a master controls station and the umbilical initiation point.

Seawater Treatment: Seawater may be required for various purposes, including cooling of wellstream fluids, process equipment, fire protection systems, and freshwater production. Seawater treatment systems may include coarse filters to strain debris from the seawater and injection of hypochlorite (or similar biocide) to prevent the build-up of marine fouling growth on the internal surfaces of the system. Hypochlorite is the most widely used material and is normally produced onboard by electrolysis of seawater.

Seawater used for cooling purposes will be routinely discharged overboard from either the surface or at a point below sea level (depending on final FPU design) at a temperature less than 60°C and rates up to 175,000 m^3/d.

Accommodation Facilities: A project objective is to design the FPU to achieve minimally manned operation. Accommodation facilities will be provided for core crew as well as increased manning during maintenance or other activities.

Safety Systems: Safety systems will include escape equipment, fire/gas/smoke detection and protection systems, and back-up power systems. The fire protection system will consist of passive systems (such as equipment coatings) and active systems possibly including deluge, water, foam, CO^2 and extinguishers. The most appropriate system for each area will be selected based on detailed risk assessments. Ozone-depleting substances will not be used for these systems. Safety equipment including fire pumps, emergency lighting and communications equipment, are generally designed to be completely independent and with appropriate levels of redundancy. Independent fuel or energy sources, such as diesel, may be used.

Communication Systems: Standard offshore communications systems will be in place. Additional safeguards will also be implemented such as the gazetting of the platform onto navigational charts and the creation of a safety exclusion zone.

Flowline and Trunkline Pigging Facilities: For operational and inspection reasons, it may be necessary to run 'pigs' through the flowlines and/or trunkline. The FPU may include launchers/receivers for these activities.

Drains: The FPU drainage and disposal systems will include closed drains, open drains and liquid hydrocarbon recovery systems. Deck drainage consists mainly of deck washdown water and rainwater.

4.4.7 Gas Trunkline

The base case design is a dry gas trunkline between the FPU and the shore. The nominal size is 32-inch with a total route length of approximately 430 km.

The proposed route for the trunkline between the FPU and Pluto LNG is shown in Figure 4-1.

In deep water, the key routing drivers for the trunkline are:

- minimising environmental impact
- avoiding any identified geohazards
- finding an optimum route up the continental slope (1000 m to 300 m water depth) which minimises intervention requirements and long-term integrity issues
- minimising the number of third-party trunkline crossings.

Figure 4-1 shows the preliminary trunkline route. At KP 200, about 20 km north-west of the Pluto Riser Platform, the trunkline deviates to the south to avoid the existing facilities and manage environment, technical and safety risks. From KP 160, about 20 km south-east of the platform, the trunkline will be routed alongside the existing Pluto gas trunkline, within the same corridor as the Pluto trunkline (about 100 m to the south) until it reaches Mermaid Sound.

4.4.7.1 Pre-lay Survey

A pre-lay survey of the trunkline will be undertaken prior to commencement of the trunkline installation. This survey is aimed to identify debris and other hazards prior to laying the trunkline and is not considered a full geophysical/geotechnical survey.

The pre-lay survey will be performed by a dedicated pre-lay survey vessel (which is typically similar in size to support vessels) or potentially the ISV. The survey usually utilises a side scan sonar fish towed behind the pre-lay survey vessel. The survey methods are non-intrusive and the equipment, under planned operation, will not disturb the seabed. Information is transferred to the survey vessel via an umbilical. The pre-lay survey may also be undertaken with ROV or autonomous underwater vehicle (AUV) using side scan sonar.

A multi-beam echo sounder, a common survey tool for offshore surveys, may also be deployed to establish the profile of the seabed, using sound pulses.

Geotechnical surveys typically involve in-situ testing and piston/push sampling. Following sampling, all equipment is withdrawn from the seabed. A small hole (<1 m^2) will remain, which will eventually collapse and infill with the movement of surface sediments in ocean current

4.4.7.2 Trunkline Installation

The trunkline will be installed from a conventional pipelay vessel (Figure 4-2). The pipelay vessel may be required to temporarily moor on location via an anchor.

The trunkline is built up from pipe lengths, each being welded to the previous section. Following completion of each weld, a Non-Destructive Examination (NDE) technique will be employed to inspect the weld, and weld repairs will be performed if required. An anti-corrosion heat shrink sleeve or cold tape will then be applied to the weld area, and the void between adjacent concrete coatings may then be filled with a suitable infill. Upon completion of this process, the pipe is laid over a pipe support ramp (stinger) on the stern of the lay barge and laid onto the seabed.

Laying the trunkline near existing trunklines (e.g. the Pluto trunkline, TSEP trunkline, etc.) will need to be considered, and appropriate measures established to protect these trunklines.

Figure 4-2: Conventional pipelay vessel

4.4.7.3 Trunkline Stabilisation

During FEED, the trunkline dredging, protection and stabilisation design will be refined to provide an optimum solution in terms of environmental impact, safety, cost and schedule. However, it is anticipated that stabilisation is generally required in water depths shallower than 40 m, which corresponds to a location about 50 km offshore. Accordingly, it is anticipated that for the section of trunkline from shore to the State waters boundary (approximately KP32) out to KP50 (Figure 4-3), there may be a requirement for some trenching and back fill to stabilise the export trunkline in both state and Commonwealth waters.

The pre-lay dredging works associated with the trunkline installation involves the dredging of an approximately 2.5–3.5 m deep trench along the trunkline route within an indicative trunkline corridor of 30 m width.

Trailing suction hopper dredgers (TSHD) have been proposed for the pre-lay dredging works in Commonwealth waters. Material will be dredged, placed alongside the trunkline route. This stabilisation will be done using coarse sand. Trenched material will be disposed at existing spoil grounds within the region. In Commonwealth waters this is Spoil Ground 5A, which lies within the Trunkline Project Area and is approximately 300 m wide and runs ~17km between the State waters boundary and KP 50. While backfill will be sourced from one of the pre-identified borrow ground locations. Estimated maximum volumes for trenching and backfill activities are presented in Table 4-9.

Table 4-9: Estimated maximum dredge and backfill volumes

Activity	Estimated maximum volumes
Commonwealth waters trenching	1.2 Mm^3
Commonwealth waters backfill	1.5 Mm^3

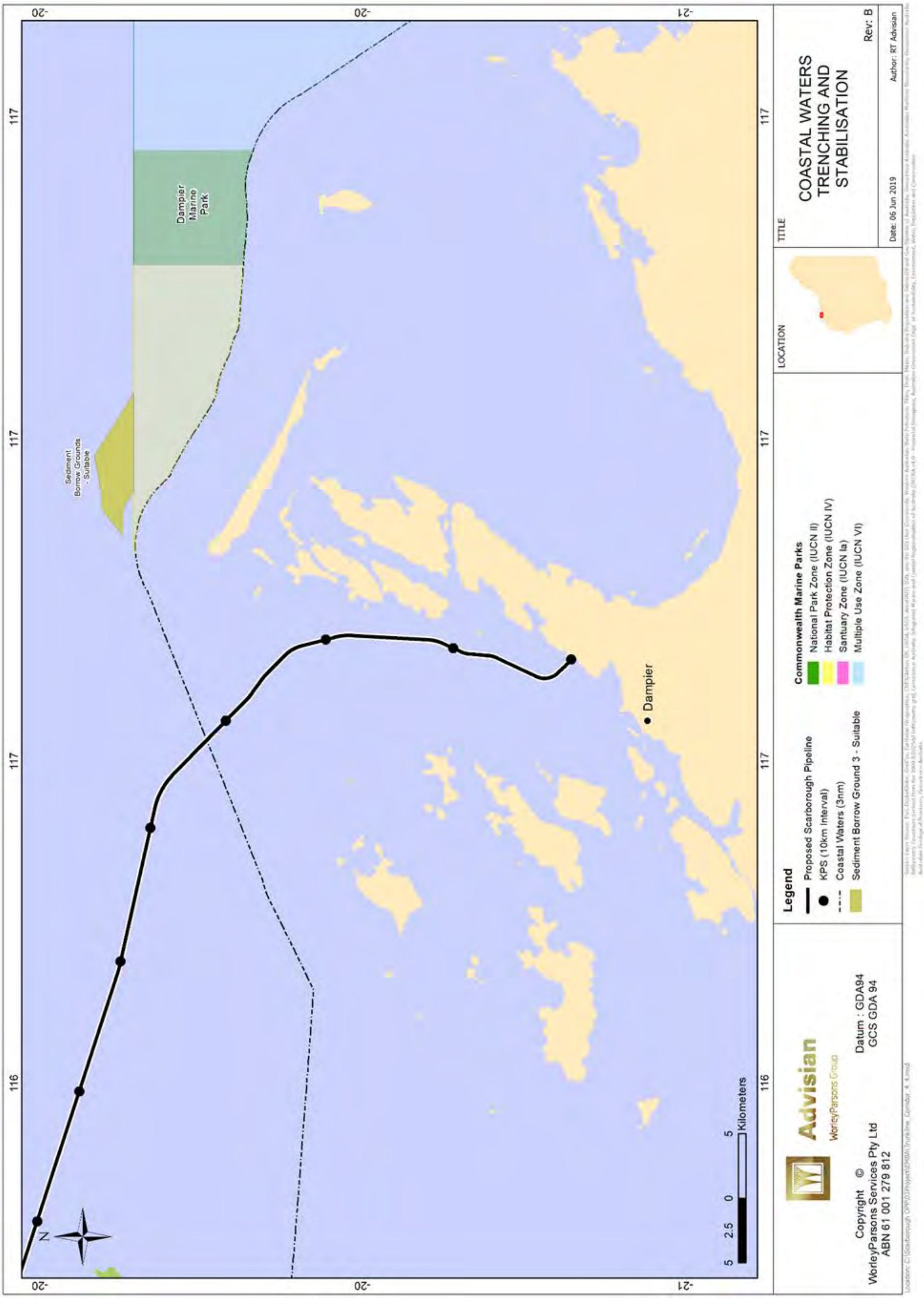


Figure 4-3: Trunkline Corridor within Commonwealth Waters and Potential Borrow Ground Project Area

In the vicinity of KP 209 , about 2500 m³ to 15,000 m³ of material may be displaced to allow safe pipelay operations to be conducted as the Trunkline crosses the continental slope in approximately 580 m water depth. This seabed material relocation will be completed using a potential combination of ROV or other subsea equipment based methods, such as mass flow excavation, heavy duty grab, jetting or a grader. Any displaced material would not be recovered to the surface (except for small samples for testing purposes) and could be placed in vicinity of the pipeline route (within a radius of approximately 250 m), and/or relocated along the pipeline corridor.

4.4.7.4 Borrow Ground

Sand may be required to assist with trunkline stabilisation in some of the trunkline sections in shallower water. This sand is proposed to be obtained from borrow ground locations in either State or Commonwealth waters. The location of the pre-identified borrow ground in Commonwealth waters is shown in Figure 4-3.

The sand would be dredged from the borrow ground using a TSHD. The volumes required, and duration of the dredging activities is to be confirmed during detailed engineering design.

Consideration was given to the potential re-use of materials from existing Spoil Grounds to negate the requirement to use a new borrow ground, however the geotechnical properties of the materials in existing spoil grounds are not suitable for pipeline stabilisation (refer to Section 4.5 for additional discussion regarding borrow ground selection).

4.4.8 Pre-Commissioning and Commissioning

Once installation and hook up of subsea infrastructure are complete, the subsea infrastructure, including the subsea umbilicals, risers and flowlines (SURF) and the trunkline will be subject to pre-commissioning activities, required to test the integrity of the subsea infrastructure. For SURF, this will be conducted using hydrotest fluids, whereby the subsea infrastructure pressures will be monitored to detect leaks. There will be a number of associated discharges. Fluids in the flowlines will be left in place to provide corrosion protection prior to dewatering, at which time hydrotest fluids will be discharged. The likely highest individual discharge volume of hydrotest fluids used for SURF pre-commissioning is 5300 m³ with a 10% contingency, for flowline hydrotest dewatering, resulting in a maximum likely volume of 5800 m³.

The preferred option for trunkline pre-commissioning does not involve the use of hydrotest fluids. “Dry commissioning” relies on data gathered during fabrication and installation to provide assurance of trunkline integrity. There is a possibility, however, that hydrotesting may still be required and as such this has been included in the scope of activities under the OPP. Potential volume of pre-commissioning fluid for the trunkline is 190,000 m³ of chemically treated seawater with a 20% contingency, resulting in a maximum likely volume of 223,000 m³.

The location and timing of the pre-commissioning fluid discharge is unknown; however, it is assumed it will be discharged from a single point on the seabed in the vicinity of the proposed location of the FPU at any time of the year. For the purpose of undertaking this assessment, the discharge rate is estimated at around 1500 m³/hr for the trunkline and 85 m³/hr for flowlines. Residual biocide may be present in the hydrotest water at the time it is discharged at concentrations in the order of 500 to 1500 ppm.

FPU will be pre-commissioned at the fabrication site prior to transportation to the offshore location. Commissioning will include checking, inspection, cleaning, tightness testing, drying and inerting and first fill of process chemicals and adsorbents for the gas treatment system.

Commissioning of the overall production system will be conducted from the FPU once on location. Commissioning will include testing, adjusting and monitoring of all systems.

4.4.9 Operations

4.4.9.1 Hydrocarbon Extraction

Hydrocarbons from the reservoir will flow via the subsea infrastructure to the FPU for processing.

Control of the subsea system is via the umbilical which transports electrical power, control fluids and chemicals to the required subsea locations. Other chemicals including MEG will be injected into the gas at the wellhead to prevent the formation of gas hydrate in the flowlines and risers and to assist in corrosion inhibition.

4.4.9.2 Processing

Well fluids are processed on the FPU to meet the trunkline gas specification. MEG, water and any salt, sand and scale are removed for further processing and disposal. The gas will then be compressed to meet the requirements of the trunkline and metered prior to export via the trunkline.

Due to the temperature difference between the reservoir fluids and the FPU process, mercury contained in reservoir fluids is expected to condense and collect in the topside process. The mercury will be removed from the FPU process for onshore treatment and disposal.

Condensed water, resulting from the vapour in the gas stream which condenses out during gas processing, will be produced throughout the life of the project at rates of about 285 bbl/day. This water will be treated and discharged from the FPU to the marine environment.

Wells are not expected to produce formation water until they start to water out toward the end of well life. Once they start to water out, about 200 bbl/day of formation water may be produced. At that time, daily discharge of up to approximately 485 bbl/day (combined condensed water and formation water) will be generated for a limited duration prior to watering out, at which point the well will be shut-in.

The condensed water and produced formation water will also contain residual salt, MEG, scale, corrosion inhibitors and sands. The condensed water and produced formation water will be separated by distillation in the MEG unit and will contain a small amount of residual MEG and corrosion inhibitors but no salt, scale, or fines. These streams will be directed to the produced water treatment system for processing prior to discharge overboard either from the surface, or from a point below the surface depending on the final design of the FPU.

Any solids will be recovered, dissolvable salts may be re-dissolved or slurried using treated water and discharged overboard. Other solids will be recovered and transported to shore for treatment and disposal.

4.4.9.3 Gas Export

Gas is to be exported from the FPU to shore via the 430 km long trunkline. The trunkline will operate dry and liquids free. Any future hydrocarbon liquids from future field tie-backs will be exported separately to the gas to avoid trunkline liquid management issues.

4.4.10 Decommissioning

At the end of Scarborough's life, the facilities will be decommissioned in accordance with good oilfield practice and relevant legislation and practice at the time. Decommissioning will occur once the Scarborough, North Scarborough, Thebe and Jupiter fields have reached the end of their economic life and may occur in stages. If additional or third-party reservoirs have been tied into Scarborough infrastructure, this could increase the project's economic life and thus postpone decommissioning.

The OPGGS Act (Section 572(3)) outlines that a titleholder "must remove from the title area all structures that are, and all equipment and other property that is, neither used nor to be used in connection with the operations". However, this obligation is subject to other provisions of the Act and allows titleholders to identify and seek approval for alternative arrangements. Subsequently, decommissioning may include:

- plugging of production wells and removal of christmas trees and wellheads down to 5 m below the seabed
- removal of manifolds
- removal of umbilicals
- cut off mooring and remove the FPU
- anchor piles and mooring legs remain at location, within the seabed
- removal of subsea infrastructure, (subject to other provisions of the OPGGS Act).

Given the expected life of the project, the decommissioning of Scarborough is not likely for many years. While it is not possible to fully scope the decommissioning strategy that will be employed at that time, and given the possible improvements in technology that may occur between now and the time of decommissioning, it is intended within this OPP to identify the broad environmental performance outcomes for decommissioning, and demonstrate how these will be met through activity-specific Environment Plans to be developed closer to the time.

4.4.10.1 Well Abandonment

Once no longer required for use, wells must be abandoned in accordance with the requirements of the OPGGS Act and industry best practice.

On abandonment, the surface casing, conductor, and wellhead may be cut off below the seabed and recovered.

Well plug and abandonment include activities such as:

- install and pressure test BOP
- bullhead the well
- isolate the reservoir (deep set slick line plug)
- cut/perforate casing/production tubing
- install permanent reservoir barrier
- perforate the well casing/tubing
- install permanent surface barrier
- Remove BOP stack
- sever and remove surface casing and wellhead
- conduct post operation ROV survey.

4.4.11 Inspection, Maintenance and Repair Activities

All facilities supporting Scarborough, both subsea and topsides, will be subject to Inspection, maintenance and repair activities. For the FPU this will be undertaken during campaign maintenance periods to reduce the number of personnel onboard during normal production periods. For the subsea systems activities will be conducted using ROVs.

Inspection, maintenance and repair activities may need to occur during the operational life of the field to:

- prevent deterioration and/or failure of infrastructure

- maintain reliability and performance of infrastructure.

4.4.11.1 Inspections

For Scarborough, wellheads, pipelines, trunkline umbilicals and subsea structures will be inspected by an ROV from a vessel. Inspections may monitor:

- anode wastage
- coating damage
- cathodic protection measurements
- non-destructive testing
- external corrosion
- lack of integrity (missing components, broken loose or damaged appurtenances)
- marine growth
- damage (impact, environment or third party)
- scour
- variation of inspected components or operating conditions
- leaks (gas or liquid).

The frequency and duration of inspections is dependent in the issue however could take place at any time of the year for a duration of a few hours to a few days.

4.4.11.2 Maintenance and Repair

Maintenance and repair activities may need to occur during the operational life of the field to:

- prevent deterioration and/or failure of infrastructure
- maintain reliability and performance of infrastructure.

Maintenance and repair activities are typically conducted in response to inspection findings, engineering analyses, and/or external events. The activities are typically performed by ROV from a vessel or may be undertaken by divers from a dive support vessel in shallower sections of the trunkline.

Typical maintenance and repair activities include:

- cathodic protection system maintenance
- leak testing
- marine growth and hard deposit removal
- removal of debris or fishing net
- rectification of electrical or hydraulic fault
- pipeline/trunkline repair
- pipeline/trunkline stabilisation
- general subsea infrastructure servicing
- general topsides servicing.

4.4.11.3 Well Intervention

Well intervention generally occurs within the wellbore and includes activities such as:

- slickline/wireline/coil-tubing operations
- well testing and flowback
- well workovers (mechanical or hydraulic).

The frequency of well intervention activities depends on well performance.

During intervention activities, local control of the Christmas trees may be required. Valve actuation of the trees may be required, which will result in small releases of subsea control fluids to be released to the environment. Intervention activities also include removing marine fouling by mechanical or acid soaking, resulting in the release of marine-fouling debris and small amounts of acid to the environment. When retrieving intervention tooling, small volumes of wellbore fluids may be displaced back into the well.

In addition, various other activities (described in Section 4.4.3 Drilling Activities) may also be conducted during well intervention activities.

4.4.12 Support Activities

Support Vessels

The drilling, installation, commissioning and operation phases of the project will be supported by a variety of vessels including barges, tugs, heavy lift vessels, accommodation support vessels, survey vessels and supply vessels (thereafter referred to as support vessels) and installation (ISV) and pipelay vessels. Vessels used during these phases may be sourced from international or Australian based location, depending on the time of vessel needed and availability. Regional ports such as Dampier and Exmouth are proposed for use during different phases of the project (including but not limited to mobilisation/resupply/equipment transfer activities). Port based activities associated with these vessels, are subject to all applicable maritime regulations and other requirements (including Woodside's *Marine Operations Operating Procedure (WM0000PG10120467)*.

While in the Project Area, support vessels will be required for transporting stores and equipment. Support vessels also backload materials and segregated waste for transportation back to shore, as well as carrying out standby duties where required. Standby duties may include but are not limited to periods of helicopter operations and working over the side activities while in the field. During the operations phase supply vessels will travel between the supply chain and logistics support facility (or facilities) and the FPU.

During drilling activities, several different materials required for the campaign will be transferred from vessels to the MODU in bulk. Cement, barite and bentonite are transported as dry bulk to the MODU by support vessels and pneumatically blown to the MODU storage tanks using compressed air.

Vessels may also be employed to undertake various inspection, maintenance and repair activities, both in-field of the subsea facilities, and along the trunkline.

While use of anchors by support vessel in deeper waters is unlikely due to depth constraints, there may be occasions for example to conserve fuel, where support vessels anchor in shallower waters, within the Project Area while working on the trunkline route.

Vessel requirements during the decommissioning phase are unknown at this stage due to uncertainty regarding the methodology to be applied, but it can be expected that decommissioning will use similar vessels to those engaged for installation activities.

Helicopter Operations

Helicopters are the primary means of transporting passengers and/or urgent freight to/from during drilling, installation, commissioning and operation phases of the project. They are also the preferred means of evacuating personnel in an emergency. Helicopter support is principally supplied from the Karratha and Exmouth Airports.

Remotely Operated Vehicles

All phases may be supported by remotely operated vehicles (ROV). These may be used during drilling operations, inspection and maintenance and in decommissioning

The ROV can be fitted with various tools and camera systems that can be used to capture permanent records (both still images and video) of the operations and immediate surrounding environment.

The ROV may also be used in the event of an incident to deploy the Subsea First Response Toolkit.

4.4.13 Key Aspects Associated with the Project

A summary of the project stages, the activities and identified environmental aspects based on the activity as described in this section is provided in Table 4-10. This forms the framework for the impact assessment undertaken in Section 7 of this OPP.

Table 4-10: Relationship between the project phases, activities and aspects

Aspect Name	Drilling				Installation and Commissioning						Operations				Decommissioning			Inspection, Maintenance and Repair			Support Operations			
	Drilling Operations	Well flow-back	Completion	Vertical Seismic Profiling	Pre-Lay Survey	Installation of FPU	Installation of subsea infrastructure	Trunkline installation	Trunkline stabilisation	Commissioning	FPU Operations	Hydrocarbon extraction	Hydrocarbon processing	Gas Export	Removal of subsea infrastructure	Leaving flowlines in place	Well Abandonment	Inspection	Maintenance and Repair	Well Intervention	MODU Operations	Vessel Operations	ROV Operations	Helicopter Operations
Planned																								
Routine light emissions											✓		✓								✓	✓		
Routine atmospheric emissions affecting air quality		✓									✓		✓								✓	✓		
Routine greenhouse gas emissions		✓									✓		✓								✓	✓		
Routine acoustic emissions	✓			✓	✓	✓					✓	✓			✓						✓	✓		✓
Physical presence (routine): Displacement of Other Users					✓	✓	✓	✓			✓				✓						✓	✓		✓
Physical presence (routine): Seabed disturbance	✓				✓	✓	✓	✓	✓						✓						✓	✓	✓	
Routine and non-routine discharges: Sewage and Greywater											✓										✓	✓		
Routine and non-routine discharges: Food Waste											✓										✓	✓		
Routine and non-routine discharges: Chemicals and Deck Drainage											✓										✓	✓		
Routine and non-routine discharges: Brine and Cooling Water											✓										✓	✓		
Routine and non-routine discharges: Operational Fluids												✓	✓											
Routine and non-routine discharges: Subsea installation, and commissioning						✓	✓			✓														
Routine and non-routine discharges: Drilling	✓																✓			✓				
Unplanned																								
Unplanned Discharges: Chemicals	✓										✓										✓	✓	✓	✓
Unplanned Discharges: Solid Waste											✓										✓	✓		
Physical presence (unplanned): Seabed disturbance								✓			✓										✓	✓		
Physical presence (unplanned): IMS						✓	✓	✓													✓	✓		
Physical presence (unplanned): Collision with Marine Fauna																						✓		
Unplanned hydrocarbon release	✓									✓	✓	✓	✓	✓	✓		✓				✓	✓		✓

4.5 Assessment of Alternatives

4.5.1 Background

In 2018, Woodside acquired an additional 50% interest in WA-1-R containing the majority of the Scarborough field, taking the Company's interest at the time to 75% in WA-1-R and a 50% interest in WA-61-R, WA-62-R and WA-63-R [6]. Prior to this acquisition, the previous Operator had evaluated and selected as a concept the development of the Scarborough field via Floating Liquefied Natural Gas (FLNG) technology. This Proposal was referred under the EPBC Act (reference no. 2013/6811) by ExxonMobil to the Commonwealth in 2013 and was set a level of assessment as “assessed by preliminary documentation”. The Proposal was approved the same year with conditions and varied in 2015 to allow for changes resulting from the streamlining arrangements set in place for the assessment of petroleum activities under the OPGGS Act and EPBC Act. Woodside is proposing to bring Scarborough gas onshore to existing LNG facilities through an approximately 430 km trunkline.

4.5.2 Proposal Need and Alternatives Considered

The Scarborough field was discovered in 1979 with the drilling of the Scarborough-1 well. Since discovery, various development options have been considered.

The previous Operator evaluated two concept themes, a tieback to a shore-based LNG site and Floating LNG (FLNG). Given high costs for developing a greenfield LNG site and the limited commercial solutions for expanding existing LNG facilities at the time, the previous Operator selected FLNG as the preferred development concept. The FLNG concept included proprietary technologies of the previous Operator. Woodside’s view of the concept was that it would take several years to fully mature the technology prior to being ready for deployment.

Woodside has further considered development options and undertaken a comparative assessment (including a ‘no development’ option) to identify the benefits, risks and impacts of each. A summary of the evaluation outcome is presented in Table 4-11, with environmental aspects potentially resulting from different activities undertaken for each concept summarised in Table 4-12. A more detailed evaluation against the key drivers of the concepts one to four is provided in Table 4-13.

[6] Current equity participation of the joint venture is described in Section 1.1

Table 4-11: Woodside assessment of alternative concepts for the development of Scarborough

Concept	Summary of Woodside evaluation
1. Semi-submersible to Pluto LNG Semi-submersible platform with trunkline to Pluto LNG. Includes infield processing and compression at ready for start-up (RFSU).	*Preferred approach* – Pre-investment made during construction of Pluto LNG (including the trunkline corridor, tanks and jetty infrastructure) for future expansion, and existing primary environmental approvals for a second LNG train, has provided cost benefits and reduced risk. Processing Scarborough gas through Pluto LNG will maximise use of existing infrastructure, extend the life of the facility and supply domestic and export markets from mid-2020 for decades. Lower environmental impact as area has previously been developed and no additional onshore clearing or significant dredging required.
2. Subsea Tieback to Shore Various subsea focussed development options with initial free flow and later installation of floating or subsea compression facilities.	There is negligible difference in environmental impacts/risks between this option and the preferred option (i.e. both have an infrastructure footprint, and both require an export pipeline from the field site to the onshore location). Weakness in the concept are complexity in delivering design rate, technology development risk and complex liquids management in the trunkline.
3. Subsea Tieback via Pluto Upstream Subsea development tieback to existing offshore Pluto Platform.	Carries similar weaknesses to the above Subsea Tieback to Shore option and presents higher technical risks and value impacts associated with the offshore brownfield integration (i.e. integration of new platform with existing riser platform, complex liquids management in the trunkline, shut-down implications during offshore installation and integration).
4. FLNG Concept As proposed by previous Operator, includes immature proprietary gas processing, storage and cryogenic offloading technology.	Higher technical risk including unproven technology in Scarborough conditions. Higher cost, longer schedule and risks to predictable delivery. Does not support use of existing onshore LNG infrastructure
5. No Development	Titleholder is required to undertake certain petroleum exploration and production related activities towards commercialising the Scarborough gas resource.

Table 4-12: Environmental Aspects related to Activities associated with each Concept

Activity	Related Concept	Ecological Services Impacts		IMS Risk	Emissions and Discharge Impacts				
		Physical Presence	Vessel movements	IMS	Underwater noise emissions	Atmospheric emissions (including GHG)	Light emissions	Planned liquid and solid discharges and waste	Unplanned Discharges
Installation and Commissioning									
Pre-lay survey	1, 2, 3, 4		✓	✓	✓				
Installation of semi-submersible platform (FPU)	1, (2)	✓	✓	✓	✓				
Installation of moorings for FLNG	4	✓	✓	✓					
Installation of subsea infrastructure	1, 2, 3, 4	✓	✓	✓					
Trunkline installation	1, 2, 3	✓	✓	✓					
Trunkline stabilisation	1, 2, 3	✓	✓	✓					
Installation of floating or subsea compression facilities	(2), 3	✓	✓	✓					
Commissioning	1, 2, 3, 4							✓	✓
Operations									
FPU Operations	1, (2)	✓	✓	✓		✓	✓	✓	✓
FLNG Operations	4	✓	✓	✓	✓	✓	✓	✓	✓
Infield hydrocarbon processing	1, 4					✓		✓	
Subsea Compression Facilities	(2), 3				✓				
Production via FLNG	4		✓	✓		✓			
Gas Export	1, 2, 3, 4								x
Support Operations									
Vessel Operations	1, 2, 3, 4		✓	✓	✓	✓	✓	✓	✓

Note – Concept 2 may involve either floating or subsea compression facilities. Potentially related activities are marked (2).

4.5.3 Comparative Assessment Process

To provide a broad comparison of the merit of the different alternative concepts that were determined to be feasible for Scarborough, a qualitative assessment is presented in Table 4-15. This reflects key considerations of safety, environment, technical and economic drivers and stakeholder/society expectations. Specific details regarding the assessment criteria has been provided in Table 4-13. These criteria were considered by Woodside as part of the decision-making process to identify the optimal concept for the development of the Scarborough gas resource.

Criteria have been assessed against a rating system relevant to each of the options. Environmental drivers and criteria described in Table 4-13 refer to relevant environmental aspects triggered by activities undertaken for each concept. Where an environmental aspect is not triggered, low or no risk is determined.

Table 4-13: Key criteria used in the assessment of alternatives (as relevant)

Driver		Criteria
ECONOMIC DRIVERS	Schedule Risk	• Ability to meet the development timeline
	Cost Risk	• Economic viability
	Future Flexibility Risk	• Ability to accommodate future development including ties-ins of other fields
TECHNICAL FEASIBILITY AND SAFETY DRIVERS	Safety Risk	• In line with industry standards and good practice
	Operability Risk	• Technically feasible to meet the field life requirements
	Technical Readiness	• Project considers an acceptable technology readiness level (TRL). TRL is a method of estimating technology maturity of Critical Technology Elements (CTE)
ENVIRONMENTAL DRIVERS	Ecological Services Impacts	• Physical presence (i.e. seabed disturbance) • Vessel movements
	IMS Risk	• IMS
	Emissions and Discharge Impacts	• Underwater noise emissions • Atmospheric emissions • Light emissions • Planned liquid and solid discharges and waste • Unplanned discharges
SOCIAL DRIVERS	Socioeconomic Impacts	• Avoidance/minimisation of impacts to other industry • Avoidance/minimisation of impacts to fishery resources

Table 4-14: Ranking scale for comparative assessment of the options

Preference	Risk/Impact/Significance Ranking			
	Technical, Economic, Safety and Environment (Risk) [1]	Environment (Impact) [2]	Socioeconomic Risk (Significance) [2]	
Least preferred	Severe	Catastrophic	-	6
	Very High	Major	Major	5
	High	Moderate	Moderate	4
	Moderate	Minor	Minor	3
	Low	Slight	Slight	2
	-	Negligible	-	1
Most preferred	No risk	No impact	No risk	0

Notes:
1. Woodside's risk levels defined in Figure 6.3
2. Woodside's impact significance levels defined in Section 6.4.2.1

Table 4-15: Woodside assessment against key drivers of alternative concepts for the development of Scarborough

Driver		Criteria	Evaluated Concepts							
			1. Semi-submersible to Pluto LNG		*2. Subsea Tiebacks to Shore*		*3. Subsea Tieback via Pluto Upstream*		*4. FLNG Concept*	
			Ranking	*Risk/Impact*	*Ranking*	*Risk/Impact*	*Ranking*	*Risk/Impact*	*Ranking*	*Risk/Impact*
ECONOMIC DRIVERS	Schedule Risk	Ability to meet the development timeline	2	Able to meet development timeframe based on greater schedule certainty due to low technology risks.	3	Risks to meeting schedule as higher technical risks introduces risks of schedule slippage.	3	Risks to meeting schedule based on the technical risks associated with the offshore brownfield component.	4	High risk to meeting schedule due to technical uncertainties.
	Cost Risk	Economic viability	2	Economically viable as offshore gas processing and compression improves trunkline efficiency (such as flow rate and assurance).	3	Higher costs associated with the requirements for installation of late subsea compression and the lower production rates.	2	Reduced costs due to there being no requirement for shallow water trunkline, and in any other opportunities to share infrastructure/ activities with Pluto.	3	Higher costs associated with new technology.
	Future Flexibility Risk	Ability to accommodate future development including ties-ins of other fields	1	Able to provide future risers and adjust for low reservoir pressure with compression facilities.	2	Able to adjust subsea compression but likely that this will be costlier to implement in a subsea environment.	3	Low reservoir pressure support would compromise capacity.	3	High degree of complexity and higher costs associated with future tie backs to the FLNG facility.

Driver		Criteria	Evaluated Concepts							
			1. Semi-submersible to Pluto LNG		*2. Subsea Tiebacks to Shore*		*3. Subsea Tieback via Pluto Upstream*		*4. FLNG Concept*	
			Ranking	*Risk/Impact*	*Ranking*	*Risk/Impact*	*Ranking*	*Risk/Impact*	*Ranking*	*Risk/Impact*
TECHNICAL FEASIBILITY AND SAFETY DRIVERS	Safety Risk	In line with industry standards and good practice	3	Simple topsides processing and compression. Minimal manned and presents a moderate risk due to POB.	1	Safest option given unmanned, however there is still potential requirements for subsea intervention which would contribute to safety risks.	3	Comparable POB to Semi-sub option. Additional safety risks during Brownfield construction and integration.	4	High manning and new technology introduce safety risks. Challenging metocean conditions for FLNG design.
	Operability	Technically feasible to meet the field life requirements	1	Known operation, i.e. topsides compression and gas dehydration.	3	Complex liquids management in the trunkline.	3	Complex liquids management in the trunkline. Uncertain shutdown implications during offshore brownfield integration.	3	Unproven technology in Scarborough conditions
	Technical Readiness	Technology readiness levels (TRL) (Note TRL are a method of estimating technology maturity of Critical Technology Elements (CTE) of a program.	1	Proven facility concept, trunkline operation, multiple suppliers available.	4	Novel subsea compression and power, 1 or 2 suppliers of the technology, uncertain trunkline capacity.	4	Some novel subsea elements, uncertain trunkline capacity, Pluto brownfield modifications.	4	Many novel design components which are not ready for full field application. No line of sight to technology deployment ahead of potential Scarborough use.
ENVIRONMENTAL DRIVERS	Ecological services	Physical Presence (i.e. seabed disturbance)	3	Seabed disturbance is greatest based on subsea infrastructure, FPU moorings and trunkline to shore.	2	Seabed disturbance is slightly lower given no moored FPU, however other infrastructure including trunkline remains.	2	Low level of seabed disturbance as gas is exported to Pluto over the further shoreline options.	1	Lowest level of seabed disturbance as gas is not transferred but processed closer to the location.

Driver		Criteria	1. Semi-submersible to Pluto LNG – Ranking	1. Semi-submersible to Pluto LNG – Risk/Impact	2. Subsea Tiebacks to Shore – Ranking	2. Subsea Tiebacks to Shore – Risk/Impact	3. Subsea Tieback via Pluto Upstream – Ranking	3. Subsea Tieback via Pluto Upstream – Risk/Impact	4. FLNG Concept – Ranking	4. FLNG Concept – Risk/Impact
		Vessel movements	2	Moderate level of vessel movements due to minimally manned status during operation.	1	Low level of vessel movements due to subsea infrastructure. Limited to construction and inspection activities.	1	Low level of vessel movements due to subsea infrastructure. Limited to construction and inspection activities.	2	Moderate level of vessel movements due to manned status during operation.
	IMS risk	IMS	3	Risk of invasive marine species is likely to be similar for all options, noting that water depths are not favourable for introduction to region. Although noting that the mobilisation of the FPU to the region introduces an additional potential pathway.	2	Risk of invasive marine species is likely to be similar for all options, noting that water depths are not favourable for introduction to region.	2	Risk of invasive marine species is likely to be similar for all options, noting that water depths are not favourable for introduction to region.	3	Risk level may be slightly higher due to vessel movements to support the manned offshore facility.
	Emissions and discharges	Underwater noise emissions	2	Underwater noise may be slightly higher during construction phase only due to requirement for piling during mooring of the FPU.	2	Underwater noise is likely to be lowest, however there are some technical uncertainties with noise emissions associated with subsea compression (if undertaken).	2	Underwater noise is likely to be lowest, however there are some technical uncertainties with noise emissions associated with subsea compression (if undertaken).	2	Underwater noise may be higher due to operation of the FLNG and presence of offtake vessels.

Driver	Criteria	Evaluated Concepts							
		1. Semi-submersible to Pluto LNG		*2. Subsea Tiebacks to Shore*		*3. Subsea Tieback via Pluto Upstream*		*4. FLNG Concept*	
		Ranking	*Risk/Impact*	*Ranking*	*Risk/Impact*	*Ranking*	*Risk/Impact*	*Ranking*	*Risk/Impact*
	Atmospheric emissions	2	Emission levels slightly higher due to topside machinery/plant and vessel movements.	1	Emissions lowest due to subsea infrastructure and minimal surface activities.	1	Emissions lowest due to subsea infrastructure and minimal surface activities.	3	Emission levels highest due to topside machinery/plant and vessel movements.
	Light emissions	2	Moderate light levels to support the topsides. Noting all offshore facilities and vessels must meet minimum requirements for navigation and safety.	1	Minimal lighting due to lower surface infrastructure. Noting all offshore facilities and vessels must meet minimum requirements for navigation and safety.	1	Minimal lighting due to lower surface infrastructure. Noting all offshore facilities and vessels must meet minimum requirements for navigation and safety.	2	Highest level of light emissions to support the FLNG. Noting all offshore facilities and vessels must meet minimum requirements for navigation and safety.
	Planned liquid and solid discharges and wastes	2	Moderate level of discharges based on domestic discharges from minimally manned facility, and cooling water/PW discharge.	1	Lowest level of discharge based given subsea infrastructure.	1	Lowest level of discharge based given subsea infrastructure.	3	Highest levels of discharge based on domestic wastes, cooling waters, etc.

Driver		Criteria	Evaluated Concepts							
			1. Semi-submersible to Pluto LNG		2. Subsea Tiebacks to Shore		3. Subsea Tieback via Pluto Upstream		4. FLNG Concept	
			Ranking	Risk/Impact	Ranking	Risk/Impact	Ranking	Risk/Impact	Ranking	Risk/Impact
		Unplanned discharges	3	Credible spill risk highest due to topside inventories. Credible spill risk from the loss of well control will be similar across the options.	2	Lowest risk of spill risk due to no surface infrastructure and associated chemical/hydrocarbon inventories. Credible spill risk from the loss of well control will be similar across the options.	2	Lowest risk of spill risk due to no surface infrastructure and associated chemical/hydrocarbon inventories. Credible spill risk from the loss of well control will be similar across the options.	3	Credible spill risk highest due to topside inventories. Credible spill risk from the loss of well control will be similar across the options.
SOCAL DRIVERS	Socio-economic Impacts	• Avoidance/ minimisation of impacts to other oil and gas activities • Avoidance/ minimisation of impacts to fishery resources	1	Processing Scarborough through Pluto LNG will extend the life of the facility and the supply of gas for domestic and export markets.	1	Processing Scarborough through Pluto LNG will extend the life of the facility and the supply of gas for domestic and export markets.	3	Processing Scarborough through Pluto upstream and LNG will extend the life of the facility and the supply of gas for domestic and export markets. Noting that production capacity and expansion options will be more limited in the initial phases of operation.	3	Does not support extension of the life of the Pluto LNG Facility.

In consideration of all the assessment drivers listed in Table 4-15, Concept 1 is Woodside's preferred development option, whereby Scarborough gas would be processed through a brownfield expansion of Pluto LNG, where additional LNG processing capacity and domestic gas infrastructure will be installed. The composition of Scarborough gas is well suited to the Pluto LNG Facility, which is designed for lean gas and nitrogen removal.

In the context of the environmental impacts and risks associated with each of the options, the following conclusions have been drawn:

- Option 1, based on FPU and trunkline to shore, results in additional seabed disturbance; however, for onshore development (outside the scope of the OPP) there are benefits in the use of the existing brownfield site and the promotion of the Pluto LNG hub.
- Although Options 2 and 3 would result in lower discharges and potential for unplanned events, due to the lack of surface infrastructure and minimal vessel movements during the operations phase, there are significant technical and economic disadvantages to these options.
- For Option 4, FLNG would result in less seabed disturbance, technical uncertainties and lower opportunities for social benefits (contribution to the domestic gas market), making this option less favourable.

4.5.4 Design/Activity Alternatives

As part of Woodside's preferred concept of a brownfield expansion of the existing Woodside-operated Pluto LNG Facility to process Scarborough gas, Woodside is considering and assessing a range of options for facilities, activities, installation and construction methods. At the current development phase, these are concepts which may eliminate or substitute risks or impacts and are listed in Table 4-16. Further consideration of controls will be provided as part of demonstration that risks and impacts are reduced to as low as reasonably practicable in subsequent project Environment Plans.

Table 4-16: Alternatives considered that eliminate or substitute aspects of the project

Planned Aspects	Alternatives Considered
Routine light emissions	None identified that eliminate/substitute
Routine atmospheric emissions	None identified that eliminate/substitute
Routine greenhouse gas emissions	• Energy efficiency opportunities • Geosequestration of CO_2
Routine acoustic emissions	• Mooring of vessels • Piling techniques • MODU design
Physical presence (routine): Displacement of other users	None identified that eliminate/substitute
Physical presence (routine): Seabed disturbance	• Mooring of vessels • Trunkline route • Post-lay stabilisation and protection

	• Borrow ground location • MODU design
Routine and non-routine discharges: Sewage and greywater	• Manning of FPU • Sewage treatment on FPU • Transport of sewage to shore for disposal • Discharge of sewage overboard
Routine and non-routine discharges: Food waste	• Manning of FPU
Routine and non-routine discharges: Chemicals and deck drainage	None identified that eliminate/substitute
Routine and non-routine discharges: Brine and cooling water	None identified that eliminate/substitute
Routine and non-routine discharges: Operational fluids	• Produced water reinjection • Onshore treatment of produced water • Treatment and discharge of produced water
Routine and non-routine discharges: Subsea installation, and commissioning	• Trunkline dry commissioning
Routine and non-routine discharges: Drilling	• Onshore disposal of cuttings or fluids • Drilling fluid type • Drilling discharge management
Unplanned	
Unplanned Discharges: Chemicals	None identified that eliminate/substitute
Unplanned Discharges: Solid Waste	None identified that eliminate/substitute
Physical presence (unplanned): Seabed disturbance	None identified that eliminate/substitute
Physical presence (unplanned): IMS	None identified that eliminate/substitute
Physical presence (unplanned): Collision with marine fauna	None identified that eliminate/substitute
Unplanned hydrocarbon release	None identified that eliminate/substitute

The following sections describe the alternatives for these key elements where they are evident at the current phase of engineering maturity, with each alternative assessed against the criteria for the respective drivers (Table 4-12). The criteria that are used for each decision are those that demonstrate a material difference between the options under consideration.

4.5.4.1 Energy Efficiencies

While the majority of decisions that will influence the energy efficiency of the development will be made during the design phase of the project, a number of alternatives which will benefit energy efficiency have been included in the development base case as preferred options. These include:

- Allowance in design for future installation of a battery energy storage system (BESS) to reduce the fuel gas consumption (and emissions) for power generation in steady state operation, in the event additional design work and collection of operational data determines that a BESS is ALARP for the facility.
- Selection of a minimally manned concept which provides benefits in the form of reduced electrical load for the living quarters, reduced helicopter and vessel use and associated philosophy of simplifying topsides process as much as possible. This enables the facility to be operated with fewer personnel, but also reduces electrical load associated with ancillary systems
- Use of waste heat from turbine exhaust to provide heating duty on the FPU, removing the need for fired boilers for heating medium
- Providing pre-cooling of incoming gas using a gas-gas heat exchanger rather than refrigeration
- Internally flow coated trunkline which reduces pressure drop along the length and therefore requires lower compression on the FPU, and
- Turbine and equipment selection

Alternatives that have not been selected include:

- Alternative power sources such as offshore renewables or a cable from shore. These options were not selected for implementation due to technical constraints associated with the infrastructure and significant cost which was considered grossly disproportionate to the emissions reduction
- Free flow to shore. This concept involves removing the hydrocarbon dewpointing process on the FPU, and therefore the necessity to recompress the gas before export using gas powered turbines. It was not considered technically feasible to implement this option due to risk of liquid build-up in sections of the trunkline

A FEED phase energy efficiency workshop has been held to identify additional opportunities which can be investigated during design. The workshop was facilitated by specialist consultants and was attended by key discipline engineers to enable comprehensive opportunity identification. Opportunities will be screened and implemented according to ALARP principles and in alignment with the framework defined by the WMS including expected benefit, economic, technical and health, safety and environment drivers.

These opportunities which reduce greenhouse gas emissions or intensity reflect the design decisions taken to date based on ALARP principles. Demonstrations that greenhouse gas emissions have been reduced to ALARP levels in future design decisions will be submitted to NOPSEMA for approval as part of the regular Environment Plan process following approval of this OPP (see section 3.2.2).

4.5.4.2 Geosequestration of CO_2

Geosequestration involves the long-term capture of greenhouse gases associated with processing and storage in a suitable underground reservoir, rather than emitting them to the atmosphere, thereby reducing contribution to climate change. In gas processing, there are two main emission streams that could be considered for geosequestration – CO_2 that exists with hydrocarbon gas in the reservoir which is removed from the product stream during processing (reservoir CO_2) and the exhaust stream from gas turbines. Capturing emissions from flares is not possible because the flare produces widely variable heat and emissions and is required to be unimpeded and physically separate from process equipment.

For Scarborough, emissions of reservoir CO_2 will occur from the onshore processing and not from the FPU and is therefore not assessed under this Proposal. As described in section 0, onshore greenhouse gas emissions from downstream processing are subject to other approvals and regulations, which includes the requirement to offset reservoir CO_2 emitted from the Pluto Gas Plant, which Scarborough gas processed at Pluto will also be subject to.

Geosequestration of CO_2 emitted from gas turbines on the FPU would require further processing to strip the CO_2 from the exhaust stream, compress and reinject. This technology is significantly complex and prohibitive on an offshore facility where space is restrictive. Gas projects that employ geosequestration are onshore and typically capture reservoir CO_2 only. It is not considered to be technically feasible for the Scarborough project.

4.5.4.3 *Mooring of Construction Vessels*

Three options for the mooring of construction vessels were considered:

- Option 1: Anchoring (drag anchors)
- Option 2: Mooring at location – using suction piles
- Option 3: Mooring at location – using driven piles
- Option 4: Dynamically positioned vessels.

The criteria considered when reviewing the type of mooring for construction vessels for the development of Scarborough were as shown in Table 4-17. Evaluation of the applicable environment drivers is provided in Table 4-18.

Table 4-17: Criteria considered when reviewing the type of mooring for construction vessels

Driver Category	Criteria
Economic	• Economic viability
Technical feasibility and safety	• In line with industry standards and good practice
Environment	• Physical presence: Seabed disturbance
Socioeconomic	• Avoidance/minimisation of impacts to other industry • Avoidance/minimisation of impacts to fishery resources • Avoidance/minimisation of risk to public health and safety

Table 4-18 Woodside assessment against key environment drivers of alternatives mooring of construction vessels

Criteria	Evaluated Concepts							
	1. Anchoring (drag anchors)		*2. Mooring at location – using suction piles*		*3. Mooring at location – using driven piles*		*4. Dynamically positioned vessels*	
	Ranking	*Risk/Impact*	*Ranking*	*Risk/Impact*	*Ranking*	*Risk/Impact*	*Ranking*	*Risk/Impact*
Physical Presence: Seabed disturbance	2	Slightly higher level of impact due to the potential number of anchors during construction, noting that this is the least feasible option due to water depth.	1	There will be seabed disturbance at the Project Area where the piles are installed, however as area does not intersect environmentally sensitive habitats, this impact is low.	1	There will be seabed disturbance at the Project Area where the piles are driven, however as area does not intersect environmentally sensitive habitats, this impact is low.	0	No impact to the seabed. Lowest level of seabed disturbance

Other than the trunkline installation for which piling is not currently planned, activities will occur offshore in waters of about 900 m, and as such anchoring at this depth is unlikely to be suitable for construction vessels. There will potentially be installed mooring facilities in the Offshore Project Area, while other vessels may use dynamic positioning systems. For vessels being used to support the trunkline installation, there will be a need for temporary anchor moorings at various locations within the Trunkline Project Area.

The final decision for mooring will be determined during the FEED phase of the project. Although DP vessels provided the lowest environmental impact / risk ranking, given that the Project Area does not intersect environmentally sensitive habitats, the decision will be based mainly on technical feasibility and economic criteria. The environmental impact assessment however considers the worst-case impacts associated with each of the options. For example, driven piles for installing moorings offshore are assessed in terms of the potential underwater noise impacts (note that the alternatives of suctions versus driven piles is considered further in the following sections).

4.5.4.4 Piling Techniques

Two options for the installation of the FPU are under consideration:

- Option 1: Suction piles
- Option 2: Driven piles.

The criteria considered when reviewing the piling techniques for the installation of the FPU for the development of Scarborough were as shown in Table 4-19. Evaluation of the applicable environment drivers is provided in Table 4-20.

Table 4-19: Criteria considered when reviewing the piling techniques for installing the FPU

Driver Category	Criteria
Economic	• Ability to meet the development timeline • Economic viability • Ability to accommodate future development including ties-ins of other fields
Technical feasibility and safety	• In line with industry standards and good practice • Technically feasible to meet the field life requirements
Environment	• Underwater noise emissions

Table 4-20: Woodside assessment against key environment drivers of alternatives for piling techniques

Criteria	Evaluated Concepts			
	1. Suction piles		*2. Driven piles*	
	Ranking	Risk/Impact	Ranking	Risk/Impact
Underwater noise emissions	1	Some noise during construction however this will be comparable to typical vessel driven noise.	3	Piling is likely to generate underwater noise during the construction period that will have the potential for minor short-term impacts up to approximately 40 km from the Project Area (Marshall Day Acoustics, 2019).

The preferred option for piling is Option 1 given the associated costs, safety and environmental impacts are likely to be much less. However, there are potentially technical constraints for this option based on the geotechnical conditions at the location of the FPU. On this basis, Woodside are carrying both options until further investigative studies are undertaken including geophysical and geotechnical assessment at the FPU location.

When compared on environmental drivers, suction piling presents the lowest potential impact and risk to receptors. However, given final decisions will be determined in the FEED phase of the project, the environmental impact assessment considers the worst-case impacts associated with each of the options. For example, driven piles for installing moorings offshore are assessed in terms of the potential underwater noise impacts.

4.5.4.5 Trunkline Route

An assessment of options associated with the Scarborough trunkline route have been divided into two sections. The deepwater trunkline route (i.e. West of the existing Pluto platform) and the shallower water trunkline route (i.e. East of the existing Pluto platform). The criteria considered when reviewing the trunkline route for the development of Scarborough were as shown in Table 4-21.

Table 4-21: Criteria considered when reviewing the trunkline route

Driver Category	Criteria
Economic	• Ability to meet the development timeline • Not impact economics of other projects • Economic viability
Technical feasibility and safety	• In line with industry standards and good practice • Technically feasible to meet the field life requirements • Crossing angle of other pipelines

	• Avoidance of challenging seabed features such as rocky outcrops • Approach angle to bathymetric features such as sand waves
Environment	• Physical presence: Seabed disturbance
Socio economic	• Avoidance/minimisation of impacts to other industry (including future development)

Deepwater trunkline route (i.e. West of the existing Pluto platform)

A summary of the evaluation of the applicable environment drivers for the base case and three alternative deepwater trunkline routes is provided in Table 4-22.

Table 4-22: Woodside assessment against key environment drivers of alternatives for the deepwater trunkline route

Criteria	Evaluated Concepts							
	1. Base case		*2. Alternative 1*		*3. Alternative 2*		*4. Alternative 3*	
	Ranking	Risk/Impact	Ranking	Risk/Impact	Ranking	Risk/Impact	Ranking	Risk/Impact
Physical Presence: Seabed disturbance	2	Pipeline length of 430km. Lower seabed intervention given the location of the scarp crossing. While the route traverses the Marine park surveys show sand waves at this location with little habitat.	3	Greatest pipeline length at 455km. Limited crossing with other infrastructure however, the increased pipeline length and seabed intervention required for scarp crossing results in greatest area of seabed disturbance.	2	Lowest pipeline length at 415km. However additional crossings with infrastructure which increases the potential risks.	2	425km pipeline length however there are unknowns with respect to environmental sensitivities and increases in crossings with infrastructure

The base case for the trunkline has an overall length of about 430 km. It traverses from the Offshore Project Area to the north of the existing Io/Jansz subsea infrastructure before approaching the continental slope to the north of the Pluto field.

A key driver for trunkline routes is to minimise risks associated with geohazards and abrupt bathymetry features such as submarine landslide deposits, debris flows, turbidite flows, sand waves and steep sections. Previous work undertaken by Woodside has identified an area of the continental scarp that can be crossed without significant slope crossing construction (including deepwater trenching and rock dumping) and avoidance of intolerable pipe spans and geohazards and as such this is preferred for the base case. The route does not follow the same corridor as the Pluto flowlines up the slope because there is no space for the Scarborough trunkline to pass through a narrow ‘choke’ area between canyon features at the Pluto flowline crossing. It also ensures that the trunkline runs parallel to the sand wave features in this location which is important for a rigid trunkline (relative to the more flexible Pluto flowline). This is depicted on Figure 4-4. Crossing the scarp in this location places the trunkline within the far north-western corner of the Montebello Multiple Use Zone.

The base case route brings the trunkline to the south of the Pluto Platform and Pluto trunkline and avoids an area of rocky outcrops to the south of Pluto Platform, as depicted on Figure 4-4.

This is also on the same side as the shore crossing (which is restricted due to spatial constraints). If the route took the Scarborough trunkline to the north of the Pluto trunkline, it would require a crossing to bring it to the south side, a challenging sharp turn at the top of the scarp and an additional crossing of the Pluto flowline. No alternative sites at which the trunkline could safely cross the continental scarp further to the north of the Pluto Platform were identified.

Once at the top of the slope, the pipeline will follow existing Woodside infrastructure before heading into the south-easterly direction and crossing the Pluto, Julimar and Wheatstone pipeline and umbilical systems. All route options have to cross existing pipelines, and since crossings present technical challenge and safety/environment risk associated with damage to the existing pipelines, the number of pipelines to be crossed is a key differentiator between the options. The base case route is then located to the south of the Pluto platform comes into close proximity to the existing Pluto trunkline (within about 100 m) and then follows the it to shore.

Alternative Route 1 with the greatest route length of 455 km, follows the base case route from the Offshore Project Area for the first 190 km, before deviating southwards, avoiding areas proposed for future development, and limiting the number of pipeline crossings. This option however presents some challenges for scarp crossing, which would require significant engineering and construction based on industry experience for this area. The seabed intervention required for this crossing would increase physical disturbance in the area (including generation of turbidity from dredging and stabilisation), and associated presence of deepwater construction vessels. As such and based on the potential implications to schedule and cost, this option was not considered further.

Alternative Route 2 has a total length of 415 km and follows the base case route from the Offshore Project Area for the first 75 km. It then deviates in an easterly direction and crosses the continental slope at the same location as the base case route. The main point of difference is that this alternative saves around 15 km of pipeline length by crossing the Io/Jansz pipeline system in waters approximately 1200 m deep. Other crossings are in much shallower areas (120 to 150 m) and this crossing therefore carries more technical risk. There is also a potential for other deepwater developments at some time in the future, and therefore based on the uncertainty and risks surrounding this deepwater crossing, this route was not considered further, despite having an overall route slightly shorter than the base case.

Alternative Route 3 has a total route length of 425 km and follows the base case route from the Offshore Project Area for the first 75 km. It then deviates in a south-easterly direction and crosses the continental slope in an area for which high quality survey data is not available. For example, it is unknown as to whether there are environmental sensitivities (i.e. deepwater sponges or corals) on the slope in this area. The route will also result in a number of pipeline crossings including the possible future developments and the existing Io/Jansz pipelines. Even though this alternative offers some savings in total length (5 km), based on the above factors, it has not been considered further.

The option selected by Woodside is the base case route, as shown in Figure 4-4, for the deepwater section of the trunkline.

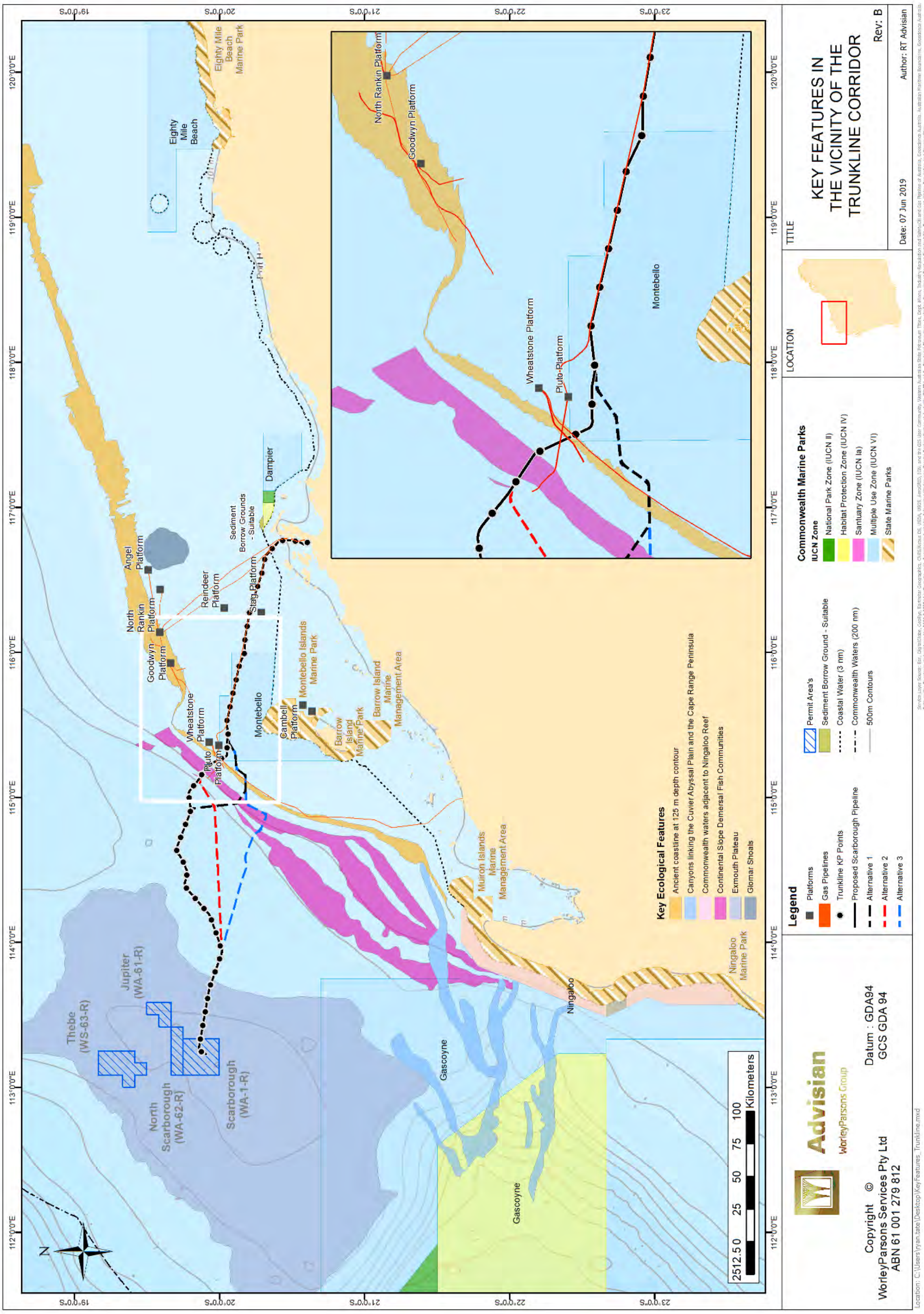


Figure 4-4: Alternative alignments for the deepwater trunkline

Shallow water trunkline route (i.e. East of the existing Pluto platform)

A summary of the evaluation of the applicable environment drivers (Table 4-23) for the proposed option and alternatives for the Trunkline route east of the Pluto platform.

Table 4-23: Woodside assessment against key environment drivers of alternatives for the trunkline route east of the Pluto platform

Criteria	Evaluated Concepts							
	1. Base Case - Along existing Pluto trunkline from shore then deviate to the South.		***2. Alternative A - Along existing Pluto trunkline from shore for longer period then deviate to the North prior to Pluto platform.***		***3. Alternative B - Use of Existing Pluto Trunkline and then extension past platform in deeper waters.***		***4. Alternative C – New Route to North which completely avoids Montebello AMP.***	
	Ranking	Risk/Impact	Ranking	Risk/Impact	Ranking	Risk/Impact	Ranking	Risk/Impact
Physical Presence: Seabed disturbance	3	Level of seabed disturbance equivalent to other trunkline options. Route avoids rocky outcrop features to the north. Route allows trunkline to align at optimum angle to traverse sand waves and other pipelines.	3	Risky scarp crossing location. Level of seabed disturbance equivalent to other trunkline options. This was not a preferred alternative for the Scarborough trunkline as this would have required further crossings of existing infrastructure (including the existing Pluto trunkline) that introduces additional technical and integrity risk and costs.	2	Risky scarp crossing location. Not preferred due to differences in fluid composition between Pluto and Scarborough, flow on impacts (processing complexity) for the onshore facilities and as capacity of that line is already accounted for with existing and planned future projects.	3	Risky scarp crossing location. Not preferred as going to the north would require crossing the existing Pluto trunkline due to the configuration of the existing shore crossing. A new trunkline route in this location would be traversing through less understood bathymetry and seabed data. Seabed disturbance not within a pre-disturbed footprint and is of a longer distance (i.e. greater seabed disturbance.

When considering Woodside's preferred Scarborough trunkline route and Alternative Route A, following the existing Pluto trunkline corridor within the northern extent of the AMP Multiple Use Zone provides technical benefits including using well understood bathymetry and seabed data. This approach of following an existing disturbance corridor also reduces the cumulative physical footprint impacts a result of multiple trunkline corridors and related seabed preparation (where required).

Deviating to the North around the Pluto Platform (i.e. outside the Montebello AMP Multiple Use Zone) before meeting the Pluto trunkline (i.e. Alternative Route A) was considered, however this route would have required further crossings of existing infrastructure (including the existing Pluto trunkline) that introduces additional technical and integrity risk and costs. In addition, this route is less technically feasible as it would involve traversing an area of large sand wave features found on the continental slope at a less than optimal traversing angle which would reduce stability and increase span risk in this section. Crossing the sand waves on this different angle would have also required seabed intervention and stabilisation that was not required for the Pluto flowlines due to its greater pipe inherent flexibility when compared with a trunkline. As highlighted within the deepwater section above, this alternative route would have been traversing the scarp through less understood bathymetry and seabed data (i.e. similar to Alternative Route C). At present no alternative sites at which the trunkline could safely cross the continental scarp further to the north of the Pluto Platform have been identified.

Meeting the Pluto trunkline offshore on the southern side avoids an additional crossing which is particularly sensitive for the Pluto trunkline due to the chemical supply pipe which is located on top of the main Pluto trunkline. Since crossing risks are reduced by perpendicular approach angles, a crossing of the Pluto trunkline would also require a loop to be introduced to achieve this and therefore result in additional seabed disturbance. In addition, seabed surveys (Keesing, 2019) indicate that seabed sensitivity is likely higher in the Trawl Fishery Area to the North/West of the Montebello AMP Multiple Use Zone than within it. This includes a biomass of habitat forming filter feeders 5.5 times greater than that within the Montebello AMP Multiple Use Zone.

Tie in to the existing Pluto trunkline (i.e. Alternative Route B on Figure 4-5) does not meet the economic drivers listed in Table 4-23. The existing Pluto project and trunkline is expected to continue operating at full capacity for a number of years. Therefore, use of this trunkline for Scarborough would either mean significant delay to project start up (potentially making it non-viable), or limiting production from existing Pluto wells to create space in the trunkline which impacts the economics of the Pluto project. Additionally, due to different reservoir pressures significant infrastructure would be required on either the Scarborough or Pluto platforms to reduce Scarborough pressure and allow tie in at the Pluto platform. This is not considered feasible due to space and weight constraints on both facilities.

Construction of a separate dry gas pipeline for Scarborough rather than co-mingling with the “wet” Pluto trunkline also allows a simpler onshore gas plant design which does not have to separate liquids, MEG condensate and heavy hydrocarbon gases. This represents both a cost saving and reduction of onshore physical footprint

An option was also considered where the new Scarborough trunkline route avoids the Montebello AMP Multiple Use Zone completely and extends to the north (Alternative Route C on Figure 4-5). A new trunkline route in this location would be traversing through less understood bathymetry and seabed data with the same challenges related to scarp crossing described above. In addition, this route would be longer overall compared to other options causing a greater overall increase of seabed disturbance. As described above spatial constraints at the shore crossing location mean that the Scarborough trunkline must cross the coastline on the southern side of the existing Pluto trunkline, so use of this route would require an additional pipeline crossing to bring it back to the south side of the Pluto trunkline. Seabed surveys (described above) also indicate that seabed sensitivity to the North/West of the Montebello AMP Multiple Use Zone (Keesing, 2019) is also higher, suggesting greater potential for disturbance to habitats from this route.

Trunkline shallower waters

In shallow water (east of the Pluto Platform beyond the Montebello AMP Multiple Use Zone) it is preferred that the trunkline follows the alignment of the Pluto trunkline to the entrance of Mermaid Sound. Justifications regarding this selection are similar to the Base Case above where following the existing Pluto trunkline corridor provides technical benefits including well understood bathymetry and seabed data, but also reduces the cumulative physical footprint impacts a result of multiple trunkline corridors. In addition, when the route gets closer to Mermaid South this course also provides the advantage of known environment and geology, and the availability for use of the pre-investment work (dredging and seabed preparation) undertaken for Pluto LNG.

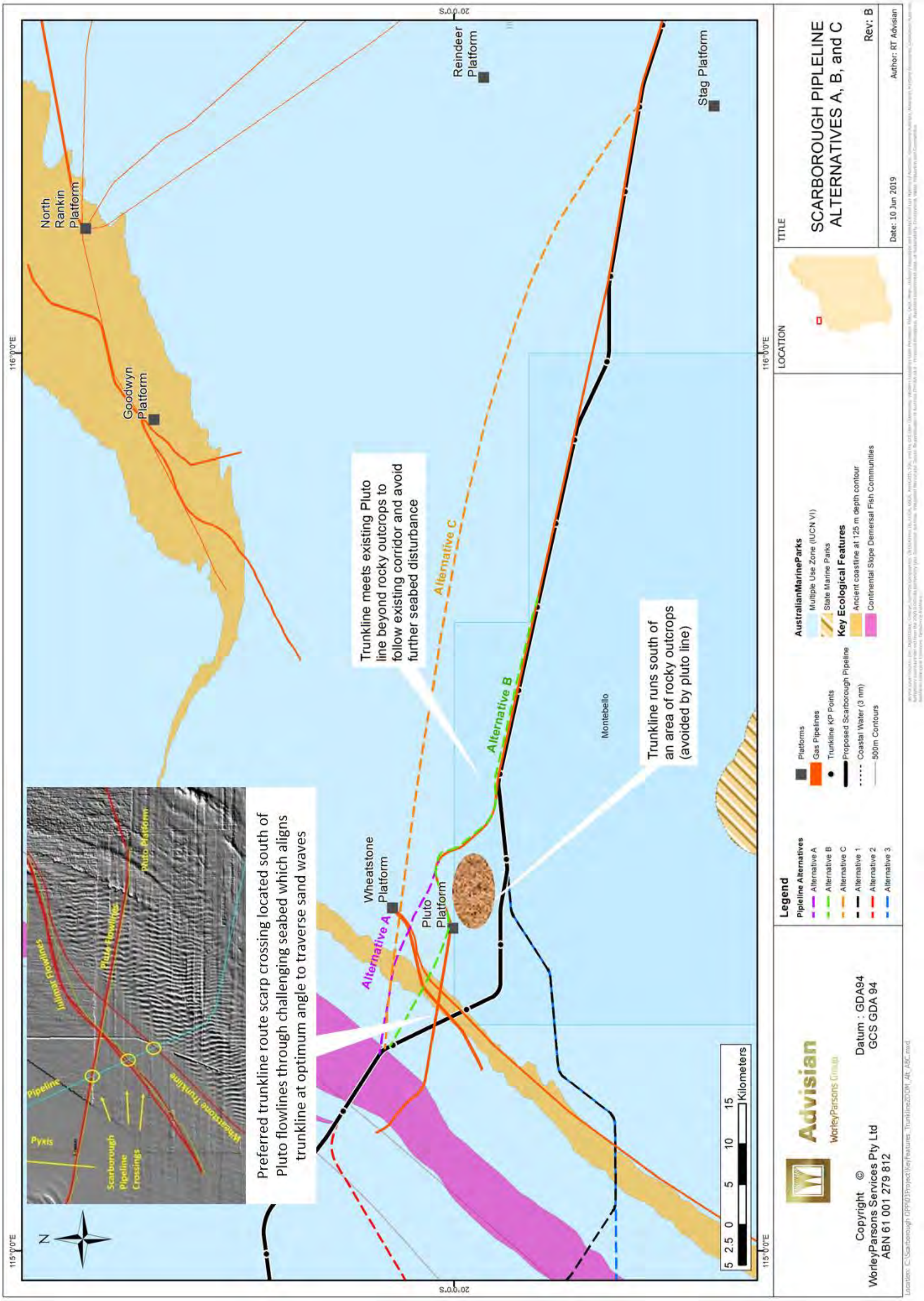


Figure 4-5: Shows the location of key features that influenced the preferred trunkline corridor adjacent to the Pluto platform.

4.5.4.6 Post Lay Stabilisation and Protection and Borrow Ground Location

Considerations when assessing trunkline stabilisation in Commonwealth waters included:

- Necessity to stabilise the trunkline
- Use of rock dumping or sand to stabilise the trunkline
- Source of rock or sand used to stabilise the trunkline

The criteria considered when assessing these options are summarised in Table 4-24.

Table 4-24: Criteria considered when reviewing the trunkline post lay stabilisation and protection

Driver Category	Criteria
Economic	• Economic viability • Proximity of borrow ground to pipeline
Technical feasibility and safety	• In line with industry standards and good practice • Stabilisation performance and protection
Environment	• Physical presence: Seabed disturbance

As described in Section 4.4.7.3, it is anticipated that trunkline stabilisation will be required in water depth shallower than 40 m. Use of rock for stabilisation may be required in some areas, however sand is preferentially used due to its local availability which reduces cost and risk associated with bringing rock from onshore locations. Woodside considered a range of stabilisation options as presented in Table 4-25.

Table 4-25: Summary of assessment of stabilisation options

Stabilisation Option	Feasible?	Justification
Use of Sand Material Sourced from Borrow Ground >250 m from the Commonwealth Marine Park	**Woodside's Preferred Option**	Location contains substantial amounts of highly suitable material of a quality and quantity to undertake stabilisation activities for the Scarborough Scope. A 250 m buffer will be maintained from the Dampier Marine Park.
Use of Sand Material Sourced from Borrow Ground adjacent to Commonwealth Marine Park	Feasible	Location contains substantial amounts of highly suitable material of a quality and quantity to undertake stabilisation activities for the Scarborough Scope.
Use of Rock Material for whole trunkline (no sand stabilisation)	Feasible	While this option is feasible, trench and backfill is valued as a superior solution over stabilisation rock berms (no cover over the pipeline) for the following reasons: • Higher Health and Safety Exposure associated with rock handling (onshore quarrying, transport over public roads, stockpiling, load out to vessel) compared to the TSHD only option. • Costs impact associated with only using rock for trunkline stabilisation would be significant compared to a combination of rock and sand. • Vessel time would be significantly increased over TSHD trench and backfill option
Use of Sand Material Sourced from within Dampier Commonwealth Marine Park	Not Feasible	Commonwealth Marine Park Area – Marine Habitat Protected Area. There is a higher potential impact to the values of the marine park, and as such Woodside's preferred position is to focus on areas adjacent to the Marine Park where suitable sediment is located.

Stabilisation Option	Feasible?	Justification
Use of Sand Material Sourced from Borrow Ground within Mermaid Sound	Unknown	Additional work would need to be undertaken to prove material suitability and quantity. Location is expected to contain only marginally suitable material of a quality to undertake stabilisation activities for the Scarborough Scope. The areas with of acceptable material are thin and spread across the area making dredging potentially inefficient. Possible areas within Mermaid Sound contain higher proportions of fine sediment, potentially increasing dredging times and turbidity. Given the overlap with the PPA approved anchorages on the west and the new Scarborough pipeline on the eastern side, the practical access to the areas and the actual available volume may be less than required.
Use of Sand Material sourced from alternative/new Borrow Ground at a greater distance from the Commonwealth Marine Park	Unknown	Comprehensive geotechnical investigations were undertaken in 2001, covering a very large area both east and west of the pipeline corridor. It was identified that the sand layer thins significantly to the north and west of the proposed borrow area, making those areas unsuitable for TSHD work. Based on the investigative work done in the past no other prospective areas were identified outside of Mermaid Sound. An open ended search for alternative borrow grounds will lead to significant delivery risk for Scarborough.
Use of Sand Material Sourced from existing Spoil Grounds	Not Feasible	Testing of this material undertaken during Pluto LNG demonstrated that the material is of inconsistent quality with a majority of the volume not meeting minimum backfill requirements. Not suitable.
Use of Sand Material Sourced from Onshore	Not Feasible	Suitable backfill sand is only available in limited quantities and from a significant distance away from the point of load out. The cost associated with using onshore quarried sand would be significant due and likely impacting the local sand (and concrete) trade.
Use of Sand Material Sourced from TSEP Borrow Ground	Not Feasible	Borrow Ground was used during TSEP and subsequently for the Pluto Foundation Project. As a result, it no longer contains adequate suitable material to undertake stabilisation activities for the Scarborough Scope.

For the assessment of stabilisation options, consideration was given to the suitability of stabilisation material, proximity to the pipeline and proposed backfill and the environmental sensitivity of the borrow ground and surrounding area when selecting suitable borrow ground locations.

A geotechnical survey was conducted in four distinct areas for the TSEP project to characterise potential suitable borrow grounds. These surveys identified the most suitable location as that identified in Figure 4-3.

Consideration was given to the potential re-use of materials from existing Spoil Grounds to negate the requirement to use a new borrow ground, however the geotechnical properties of the materials in existing spoil grounds are not suitable for pipeline stabilisation (refer to Section 4.5 for additional discussion regarding borrow ground selection).

A benthic habitat survey of the potential borrow ground and surrounding areas within the Dampier Marine Park was commissioned (Advisian, 2019c) to support the assessment of the suitability of the borrow ground. Evaluation of the applicable environment drivers for the technically feasible options is provided in Table 4-26.

Table 4-26: Woodside assessment against key environment drivers of feasible alternatives for trunkline stabilisation

Criteria	Evaluated Concepts					
	1. Borrow ground >250 m from Dampier Marine Park		***2. Only rock material used for stabilisation***		***3. Borrow ground within Mermaid Sound***	
	Ranking	*Risk/Impact*	*Ranking*	*Risk/Impact*	*Ranking*	*Risk/Impact*
Physical Presence: Seabed disturbance	2	Options presents some potential for seabed disturbance however a buffer from the Dampier Marine Park will be maintained, and the area was surveyed to show that bare sandy substrate dominates the area identified for suitable borrow.	2	Options presents less seabed disturbance as the rock is likely to be sourced onshore. However, there is additional onshore impacts, including clearance, transport and additional vessel movements required.	2	Area has had prior disturbance, as such the impacts may be less, however there are increased technical challenges and the potential for impacts to social receptors within the Port. Higher level of fines in Mermaid Sound has potential to increase dredging times and turbidity.
	New/alternative borrow ground greater distance from marine park					
	2	An open ended search for appropriate material carries material safety and environment risks and impacts. Modelling has shown that borrow ground operations directly adjacent to the Marine Park are below threshold levels predicted to result in impacts to BCH. Therefore, increasing distance from the Park is not expected to provide any reduction in impact.				

Bare sandy substrate dominated most of the locations where towed/drop camera transects were conducted. Where biota was observed, it typically consisted of invertebrates such as anemones and crinoids at densities no greater than 10% and typically less than 5% cover. Of the 24 survey locations within the potential borrow ground, sparse invertebrate cover was observed at only two locations. Of the 51 survey locations within the habitat protection zone of the Dampier Marine Park immediately adjacent to the proposed borrow ground, sparse invertebrate cover was observed at 12 locations.

Additional survey work completed by CSIRO shows that benthic cover in the habitat protection zone of the Dampier AMP, adjacent to the proposed borrow ground, is not regionally significant and that benthic cover in the habitat protection zone of the Dampier AMP, adjacent to the proposed borrow ground, is lower than that identified regionally (Keesing, J.K. (Ed.) 2019).

It is feasible that suitable material in sufficient quantities could be located at a greater distance from the Dampier AMP than the borrow ground currently selected. However, Woodside has sufficient data to provide assurance that the proposed borrow ground meets the required criteria, whereas further field investigation would be required to qualify a new area further afield, noting the geotechnical investigation already undertaken to the north and west of this site did not identify areas of sufficient size containing suitable material . Conducting a new investigation over a wider area would include a bathymetric survey and geotechnical investigation. These field activities present safety risk, and increase environmental risks and impacts associated with light emissions, acoustic emissions, physical presence, displacement of users, seabed disturbance, routine discharges and unplanned chemical or hydrocarbon spills. Undertaking such an investigation also carries risk to the project schedule and material cost. Additionally, modelling has shown that elevations in turbidity as a result of operations at the borrow ground adjacent to the Dampier AMP will remain below the intensity-duration thresholds predicted to cause impact to benthic communities and habitats of the Dampier AMP, and that the activities are consistent with the objectives of zoning in the marine park (see section 7.1.6.2). The known risk and impact associated with investigating new borrow ground areas is not considered justified.

Based on an assessment of the existing environment at and surrounding the borrow ground and the geotechnical properties of the regional seabed the borrow ground identified in Figure 4-3 is considered the most suitable for the project.

4.5.4.7 Manning of FPU

Three options for the manning the FPU were considered:

- Option 1: Manned FPU
- Option 2: Minimally manned FPU
- Option 3: Unmanned facilities.

The criteria considered when reviewing the manning philosophy for the FPU as part of the development of Scarborough were as shown in Table 4-27.

Table 4-27: Criteria considered when reviewing the manning philosophy for the FPU

Driver Category	Criteria
Technical feasibility and safety	• In line with industry standards and good practice • Technically feasible to meet the field life requirements
Environment	• Planned waste discharges

Environmental criteria are not a major consideration in the decision of manning the FPU as the location of the FPU is at a sufficient distance offshore and from areas of environmental sensitivity that the reduction in environmental impacts associated with domestic discharges and activities (such as sewage, greywater and food waste discharge) from reduction in manning is minimal.

The key drivers for the manning philosophy are technical feasibility and safety criteria. Unmanned facilities are viable for the subsea focused development options; however, these options were not selected in the concept evaluation based on the technical feasibility and readiness of such options. Offshore manning will be minimised through design of the facilities for minimal offshore maintenance and remote control and operation.

As such Option 2: Minimally manned FPU is the preferred option, and it is a project objective to design the Scarborough FPU so a minimally manned operation (aiming for potential future unmanned activities) with campaign maintenance strategy can be achieved.

The final decision for manning will be determined during the FEED phase of the project. Given the Project Area does not intersect environmentally sensitive habitats, the decision will be based mainly on the technical feasibility and safety criteria. The environmental impact assessment however considers the worst-case impacts associated with a manned option – i.e. to assess the potential domestic discharges associated with up to 75 persons on board.

4.5.4.8 *Sewage Management*

Three options were considered for sewage management from the FPU during operations:

- Option 1: Treat using an onboard sewage treatment plant, then dispose overboard
- Option 2: Transport to shore for treatment and disposal

- Option 3: Discharge overboard

The criteria considered when reviewing the management of sewage generated from the FPU during operations are shown in Table 4-28.

Table 4-28: Criteria considered when reviewing sewage management on the FPU during operations

Driver Category	Criteria
Technical feasibility and safety	• Industry standards and good practice • Introduction of other risks • Maintenance requirements (in minimum manning philosophy)
Environment	• Planned waste discharges

Woodside's experience with sewage treatment plants onshore is that they are operationally intensive (which would impact manning levels), require special skills and health controls to manage and are difficult to design and operate with fluctuating waste levels which will be the case for the FPU, considering minimum manning during normal operations and significant increases during maintenance campaigns. None of Woodside's offshore facilities currently have a sewage treatment plant, and it is industry standard for offshore facilities far from sensitive receptors to discharge untreated sewage. For these reasons, inclusion of a sewage treatment plant on the FPU is not a preferred option.

It would be possible to store sewage and transport it via support vessels to shore for treatment and disposal/irrigation, however this option introduces the requirement for additional FPU to vessel transfers, dedicated tanks or hoses and risk of personnel exposure to biologically hazardous materials. It also introduces a requirement to manage storage and avoid exceeding capacity and requiring discharge to ocean.

Options one and two would reduce or mitigate environmental impact associated with sewage discharge to the environment. However, due to the open offshore water location and distance from environmental or social receptors, it is considered environmentally appropriate to discharge sewage from the FPU and therefore option three has been selected as the preferred alternative.

4.5.4.9 Produced Water Disposal

Two options were considered for disposal of produced water:

- Option 1: Reinjection into the reservoir
- Option 2: Transport and onshore treatment/disposal
- Option 3: Treatment and overboard disposal

The criteria considered in this decision are summarised in Table 4-29. Evaluation of the applicable environment drivers for the options is provided in Table 4-30.

Table 4-29: Criteria considered when reviewing the disposal of produced water

Driver Category	Criteria
Economic	• Economic viability • Impact on reservoir performance • Maintenance requirements (in minimum manning philosophy)
Technical feasibility and safety	• In line with industry standards and good practice
Environment	• Planned liquid and solid discharges and wastes

Table 4-30: Woodside assessment against key environment drivers of alternatives for produced water disposal

Criteria	Evaluated Concepts					
	1. Reinjection into the reservoir		*2. Transport and onshore treatment/disposal*		*3. Treatment and overboard disposal*	
	Ranking	*Risk/Impact*	*Ranking*	*Risk/Impact*	*Ranking*	*Risk/Impact*
Planned liquid and solid discharges and wastes	2	Would require drilling of an additional well, with potential for additional impacts.	2	Requires either dedicated pipeline or additional vessel trips, and discharge into more sensitive nearshore environment.	2	Very low volumes for disposal anticipated. Modelling demonstrated that impacts are localised and will not result in any significant impact.

The volume of water expected to be produced from Scarborough, Thebe and Jupiter is expected to be very low in comparison with other offshore facilities where treated produced water is discharged overboard, usually at a rate up to approximately 285 bbl/day with a maximum of 400 bbl/day (see Section 4.4.9). This rate is considered small in comparison with other offshore facilities, as shown below:

- Scarborough: 400 bbl/day
- Barossa: 20,500 bbl/day (OPP)
- Ichthys: 31,400 bbl/day (EIS)
- Browse: 36,000 bbl/day (ERD)

Option 1 would require drilling of an additional well, additional subsea and topsides infrastructure, has considerations for reservoir performance and is not considered feasible. Drilling and completions activities carry material associated health and safety risk, and environment impact associated with acoustic emissions, seabed disturbance, discharges of cuttings and drilling fluids, and unplanned discharges of chemicals and hydrocarbons. This is not considered justified to offset the relatively small rate of produced water which will be treated to meet ecological thresholds. Reinjection also incurs significant additional cost (estimated $300 million) associated with drilling activities which is considered grossly disproportionate to the impact reduction offered.

Option 2, transport to onshore for processing and disposal is not considered feasible. Getting the water to shore would require either a separate pipeline to be constructed, or transport by support vessel. Both of these options require additional infrastructure on the FPU, either large pumps to supply the pressure needed to pump water over 400 km to shore or holding tanks to store water in between supply vessel visits. This is not considered appropriate for a weight constrained floating facility. Additional safety and environmental risks and impacts are also presented by either construction of a separate pipeline or increased number of supply vessel transits. The onshore Pluto LNG Facility has specialised equipment to treat process effluent and could potentially receive additional water from offshore. However, discharge of treated produced water into a more sensitive nearshore environment from the onshore treatment plant is a worse environmental outcome than an open water offshore environment.

Since modelling indicates that suitably treated produced water can be discharged with acceptable environmental impact (see Section 4.4.9.2) the decision has been made to progress Option 3, treatment and overboard disposal of produced water. Treatment options to manage the impact of discharging produced water including tertiary treatment, comingling with seawater return and discharge depth are currently being investigated with a goal of reducing the impact to ALARP.

4.5.4.10 *Trunkline Commissioning*

Two options for trunkline pre-commissioning were considered:

- Standard or typical commissioning, including hydrotesting
- Partial dry commissioning – no flooding or hydrotesting, but with post installation cleaning and gauging
- Full dry commissioning

The criteria considered for trunkline commissioning alternatives are shown in Table 4-31.

Table 4-31: Criteria considered when reviewing trunkline commissioning alternatives

Driver Category	Criteria
Technical feasibility and safety	• Industry standards and good practice • Introduction of other risks • Verification to ensure same level of safety and integrity
Environment	• Subsea commissioning discharges

Standard trunkline commissioning practice involves filling the trunkline with seawater dosed with chemicals to mitigate corrosion, pumping to achieve a desired pressure and then holding at pressure. This is done to provide assurance that there are no leaks in the trunkline (which would result in pressure loss) and is known as hydrotesting. Following this process, the trunkline is de-watered and the chemically treated seawater is discharged to the environment. For the Scarborough trunkline, this is expected to be 190,000 m³ of chemically treated seawater with a 20% contingency, resulting in a maximum likely volume of 223,000 m³. It is not considered feasible to dispose of such a large volume of saltwater onshore.

As described in Section 4.4.8, the preferred option for pre-commissioning of the trunkline is dry commissioning, which does not require hydrotesting and subsequent discharge of fluid. Instead, the appropriate level of assurance over trunkline integrity is provided by gathering of data during manufacture and installation which are demonstrated to provide the same level of safety and integrity. This option is expected to provide environment and safety benefits. Despite dry commissioning being the preferred option, there are certain occurrences during installation which may trigger hydrotesting of the trunkline so the fall-back position of standard pre-commissioning is being carried as an option.

4.5.4.11 *Drilling Fluid Type*

Two options for drilling fluids were considered:

- Option 1: Water Based Mud (WBM)
- Option 2: Non-Water Based Mud (NWBM).

The criteria considered when reviewing the type of drilling fluids for the development of Scarborough were as shown in Table 4-32.

Table 4-32: Criteria considered when reviewing the type of drilling fluids

Driver Category	Criteria
Technical feasibility and safety	• In line with industry standards and good practice • Technically feasible to meet the field life requirements

The selection of drilling fluid types is dependent on technical aspects of the drilling program that will not be known until completion of detailed design. WBM drilling fluids systems are used as the first preference when planning to drill a well, consistent with the requirements of Woodside's

Environmental Performance Standard. NWBM may also be used subject to the development of a "business case deviation" that details environment, technical, health and waste management considerations. The requirement to use NWBM is typically based on a need for improved management of the technical and safety aspects of drilling technically complex wells.

Where NWBMs are used these will be selected in accordance with the Woodside Chemical Selection and Assessment Environment Guideline. Therefore, the key criterion for selection is technical feasibility and safety and as such both Option 1: WBM and Option 2: NWBM are being progressed.

4.5.4.12 Drilling Discharge Management

Options considered for the management of drilling discharge of cuttings and drilling fluids (mud) include:

- Option 1: Transport to shore and onshore disposal
- Option 2: Transport and disposal at an alternative offshore location
- Option 3: Discharge overboard

The criteria considered when reviewing drilling discharge options are shown in Table 4-33. Assessment against environment drivers is provided in Table 4-34.

Table 4-33: Criteria considered when reviewing drilling discharge options

Driver Category	Criteria
Technical feasibility and safety	• In line with industry standards and good practice • Introduction of other risks and impacts
Economic	• Economic viability
Environment	• Planned solids and liquids discharges

Table 4-34: Woodside assessment against key environment drivers of alternatives for drilling discharge options

Criteria	Evaluated Concepts – Drilling Discharges					
	1. Onshore disposal		*2. Alternate offshore disposal*		*3. Overboard discharge*	
	Ranking	Risk/Impact	Ranking	Risk/Impact	Ranking	Risk/Impact
Planned liquid and solid discharges and wastes	2	Requires additional supply vessels to transport to shore, then disposal onshore with associated risks and impacts.	2	Requires additional supply vessels to transport. Impacts from discharge similar to overboard discharge.	2	Due to location and water depth, receptor sensitivity is low and discharge will have only slight affect.

As summarised above, due to the offshore and deepwater location of the drilling locations, the level of environment impact associated with alternatives available for cuttings and fluid disposal are not materially differentiated.

Option 1 involves transport of cuttings and/or fluids to shore via support vessels. Transfer operations and additional vessels required increase the risks and impacts associated with vessel operations (see Table 4-10). This option also introduces onshore risks and impacts related to transfer of material from vessels to trucks, transport to waste management facilities, processing and disposal onshore in landfill. Given that this option does not present material environment benefit over other options considered, introduces other risks and impacts and is significantly more expensive, it is not currently the preferred option.

Option 2 also increases risks and impacts associated with vessel operations as Option 1, however not to the same extent because the cuttings/fluids would be discharged at an alternative offshore location rather than transported all the way to shore. For Option 2 to be attractive environmentally, an alternative offshore disposal location must be found with environmental sensitivity materially lower than that of the drilling location – with enough of a difference to offset the risks and impacts associated with increased vessel activity and cost. Because the drilling locations are already in deepwater and away from sensitive receptors, this is not considered feasible.

Option 3 is expected to present a similar level of environmental risk/impact as the other alternatives, lower safety risks (due to comparatively fewer vessel transfers) and lower cost. It is also aligned with standard industry practice in offshore drilling locations that are not close to sensitive receptors. Therefore, Option 3 is currently preferred.

4.5.4.13 *Compression Facilities*

Three options for the compression facilities were considered:

- Option 1: Conventional compression on a floating semi-submersible
- Option 2: Subsea compression at RFSU
- Option 3: Future platform or subsea compression.

The criteria considered when reviewing the type of compression facilities for the development of Scarborough were as shown in Table 4-35.

Table 4-35: Criteria considered when reviewing the type of compression facilities

Driver Category	Criteria
Economic	• Ability to meet the development timeline • Economic viability • Ability to accommodate future development including ties-ins of other fields
Technical feasibility and safety	• In line with industry standards and good practice • Technically feasible to meet the field life requirements • Project considers an acceptable technology readiness levels (TRL)

Option 1 is a known mode of operation. Woodside is experienced with the use of topsides for compression facilities, and this option provides schedule certainty.

Subsea compression (Option 2) is a novel technology. The adoption of this option would incur significant schedule risk and costs to pursue.

Option 3 would not support the required production capacity at commencement, and as such does not meet the project requirements.

4.5.4.14 MODU Design

Three options were considered for MODU design:

- Option 1: Jack-up MODU
- Option 2: Anchored floating MODU
- Option 3: DP floating MODU.

The criteria considered in this decision are summarised in Table 4-36. Evaluation of the applicable environment drivers for the options is provided in Table 4-37.

Table 4-36: Criteria considered when reviewing MODU design options

Driver Category	Criteria
Economic	• Ability to meet the development timeline • Economic viability
Technical feasibility and safety	• In line with industry standards and good practice
Environment	• Physical presence: Seabed Disturbance • Underwater noise emissions

Table 4-37: Woodside assessment against key environment drivers of alternatives for MODU design

Criteria	Evaluated Concepts					
	1. Jack-up MODU		*2. Anchored floating MODU*		*3. DP floating MODU*	
	Ranking	Risk/Impact	Ranking	Risk/Impact	Ranking	Risk/Impact
Physical presence: Seabed disturbance	-	Option not technically feasible.	3	Seabed disturbance footprint dependent on anchor spread. Anchor handling required.	1	Footprint minimised due to lack of anchor spread. No anchor handling required.
Underwater noise emissions	-	Option not technically feasible.	0	No underwater noise emissions generated from positioning.	2	Thrusters generate underwater noise emissions.

Due to the water depth in the Scarborough Project area, it is not technically feasible to use a jack-up MODU. Option 1 was therefore screened out, with no further consideration undertaken.

The use of a DP MODU (Option 3) is considered the best option as it does not require the subsea layout to accommodate mooring locations for anchors and provides lower risk as no anchor handling is required, minimizing the potential to damage the infrastructure being laid on location if an anchor is dropped. Having no anchors also minimises the potential environmental impact on the seabed. The more mobile nature of using a DP MODU allows for more dynamic and efficient well sequencing, reducing the total duration of the drilling activity.

Although the DP MODU (Option 3) is favourable with regards to minimising seabed impact and well sequence flexibility, they generate more underwater noise when compared to an anchored MODU. Additionally, DP MODUs generate more atmospheric emission due to the additional fuel consumption associated with the use of DP thrusters.

Although Option 3 is the currently preferred option, Option 2 (Anchored MODU) has not been ruled out as it is still a potential option and will depend on regional and local rig availability.

5 DESCRIPTION OF THE ENVIRONMENT

5.1 Overview

Scarborough occurs in Commonwealth waters off the northwest coast of Western Australia (WA) (Figure 5-1), located in the North West Marine Bioregion (NWMR) (IMCRA 4.0). The target fields occur within the Northern Carnarvon Basin on the Exmouth Plateau, and are about 375 km offshore from Dampier, in water depths of 900–970 m, with the proposed trunkline ultimately crossing into State waters along the same alignment as the Pluto Gas Export Pipeline (Figure 5-1).

For the purpose of describing the environmental context relevant to the development of Scarborough, two zones have been developed:

- The Project Area, which is divided further into the Offshore Project Area (the area covered by WA-1-R, WA-62-R, WA-61-R and WA-63-R), the Trunkline Project Area (the proposed trunkline route with a 1.5 km buffer either side) and the Borrow Grounds Project Area (the proposed location for the borrow grounds).
- The environment that may be affected (EMBA) by Scarborough, which is the largest spatial extent where unplanned events could have an environmental consequence on the surrounding environment (Figure 5-2). The maximum extent of area that may be affected is driven by the potential area that may be exposed to hydrocarbons in the event of a worst-case spill scenario. (i.e. a 2,000 m^3 vessel fuel tank rupture; refer to Section 7.2.6). The EMBA has been derived by merging the maximum spatial extent for all stochastic modelling results, that is the result of 100 single trajectories run for each scenario. While the EMBA considers all hydrocarbon phases, it is characterised by the low exposure zone for entrained hydrocarbons. The EMBA has been set with some buffer (approximately a minimum of 50 km) to accommodate exposure below these levels (noting that below these levels any biological impacts are not expected to occur). The EMBA also extended inshore to accommodate for a spill scenario occurring anywhere along the trunkline route and simplified to a rectangular shape for ease of use. The modelling that was used to derive the EMBA is detailed in the report provide in Appendix I.

For planned and unplanned emissions and discharges, numerical modelling was undertaken as outlined in Section 5.2.

This EMBA forms the basis of the EPBC Protected Matters search and Woodside has undertaken an assessment of all the environmental values and sensitivities within this EMBA. Noting that the thresholds at which impacts to biological and social impacts will vary, the level of detail provided on each of the receptor will reflect this difference.

The key characteristics of the environment of the Project Area and EMBA have been summarised in the sections below.

In addition, the key characteristics of the closest protected marine places outside the EMBA have also been summarised. This is to provide additional regional context in consideration of potential in the unlikely event of the worse-case spill scenario, for these protected places to be exposed to hydrocarbon levels below the low exposure threshold used to define the EMBA (noting that biological impacts are not expected as they are outside the EMBA).

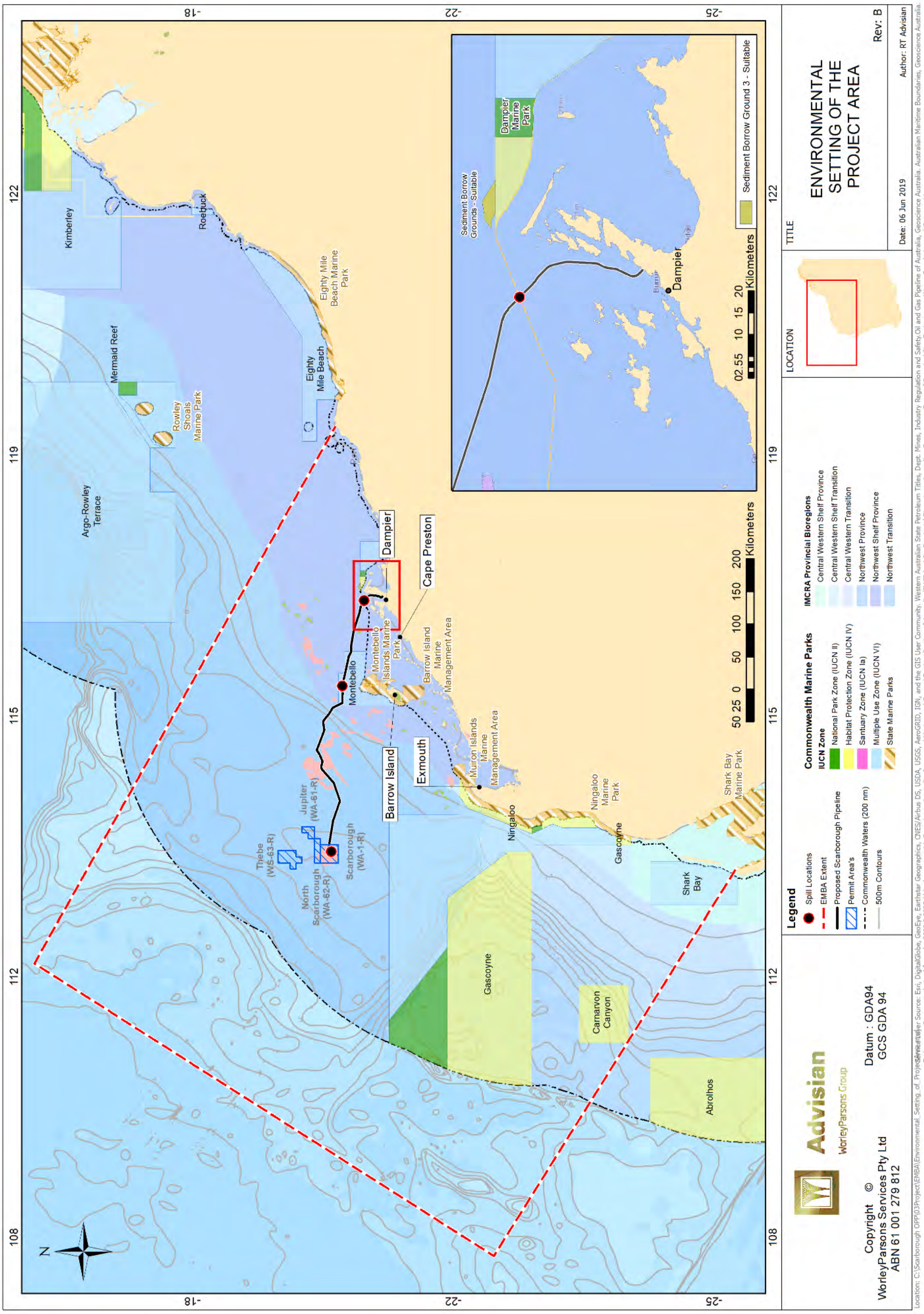


Figure 5-1: Environmental setting of the Project Area

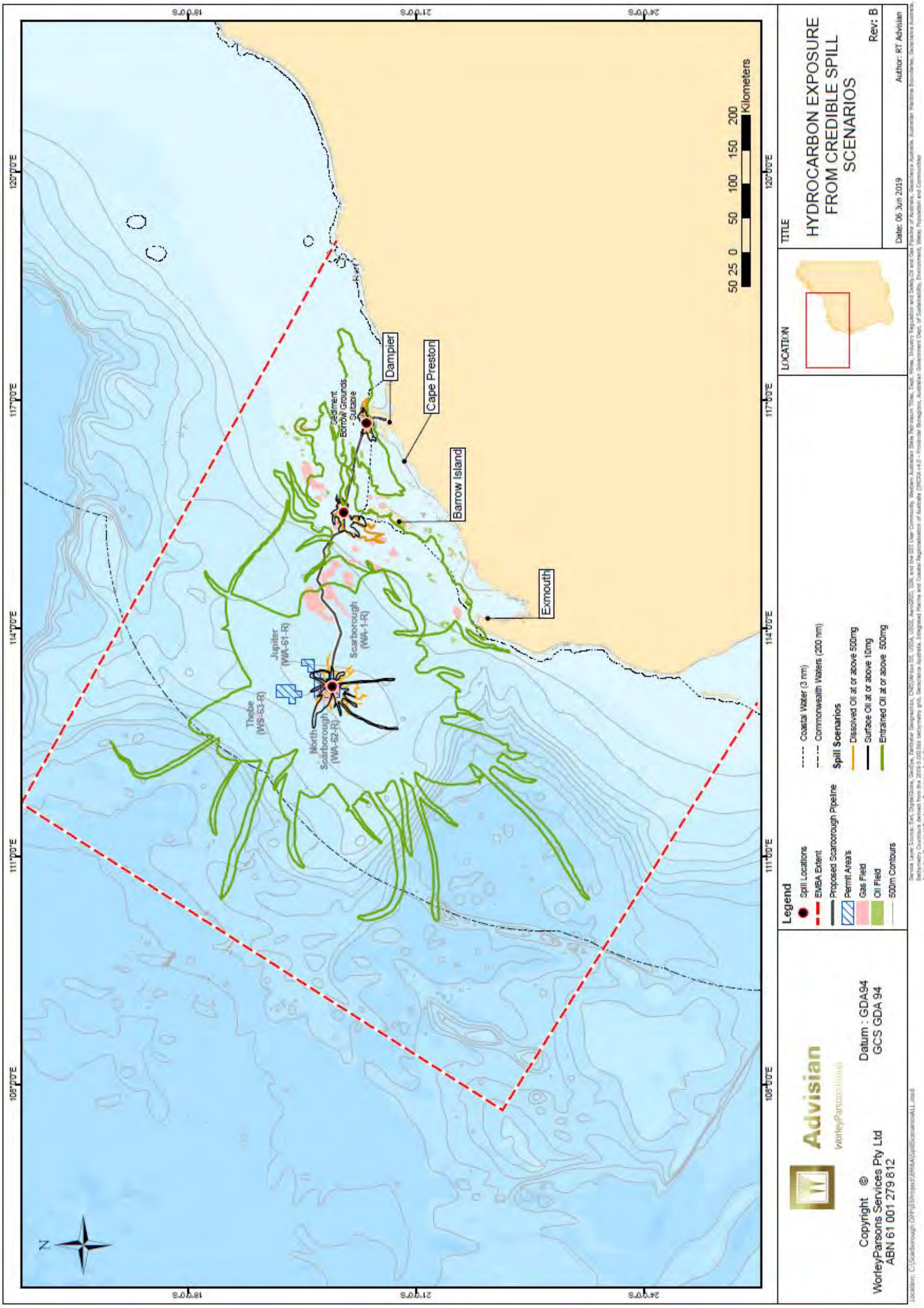


Figure 5-2: Results from stochastic hydrocarbon spill modelling used to define the EMBA

5.2 Studies and Information Sources

5.2.1 Overview

Studies and reviews of the Exmouth Plateau and North West Shelf have been compiled and/or undertaken to provide an understanding of the physical, biological and socio-economic environmental conditions within the Scarborough Project area.

These studies contribute to long-term datasets for the region and the majority have been made available in the public domain. Information on the existing environment gathered through these studies has been supplemented by information from:

- peer reviewed journals
- industry and government technical reports
- standards and guidelines
- Department of Agriculture, Water and the Environment (DAWE) resources and published literature including the Species Profile and Threats (SPRAT) database
- search tools such as the Department of Parks and Wildlife (DPaW) NatureMap and an EPBC Act Protected Matters database search to identify listed species and communities potentially occurring in the vicinity of Scarborough.

Baseline databases available for searching and accessing studies and scientific literature for the NWS region include:

- Industry-Government Environmental Meta-database (IGEM): http://www.igem.com.au
- CSIRO MarLIN Metadata System: http://www.marlin.csiro.au
- CSIRO Data Access Portal (DAP): https://data.csiro.au
- WAMSI research access, Pawsey Data Portal: https://data.pawsey.org.au/
- Australian Ocean Data Network (AODN): https://catalogue.aodn.org.au
- AIMS Data Centre: https://www.aims.gov.au/docs/data/data.html
- North West Access: https://maps.northwestatlas.org/.

5.2.2 Completed Studies

In the broader NWMR, many studies have been conducted by both petroleum titleholders (e.g. studies undertaken by Woodside for the Pluto LNG development) and independent research agencies (e.g. Brewer et al. (2007) reviewed trophic systems of the Northwest Marine Region). Existing specialist studies that have been completed specifically for and have been made available to support the assessment and management of the development of Scarborough include those presented in Table 5-1.

Table 5-1: Studies undertaken to support Scarborough

Organisation	Study
Sinclair Knight Merz	Pluto LNG Development Offshore Marine Environmental Survey (2006) (and other associated technical studies). Available from: http://www.epa.wa.gov.au/sites/default/files/PER_documentation/1632-PER-Technical%20Report%20-%20combined.pdf
Woodside Energy Limited	Pluto LNG Development: Draft Public Environment Report/Public Environment Review (2006), and associated studies. Available from: http://www.epa.wa.gov.au/sites/default/files/PER_documentation/1632-PER-PLUTO%20LNG%20PER.pdf
	Advisian. 2019a. Scarborough Offshore Benthic Marine Habitat Assessment. Prepared for Woodside Energy Ltd. Advisian WorleyParsons Group. (Appendix A)
	Advisian. 2019b. Montebello Marine Park Benthic Habitat Survey. Prepared for Woodside Energy Ltd. Advisian WorleyParsons Group. (Appendix C)
	Advisian. 2019c. Dampier Marine Park Benthic Habitat Survey. Prepared for Woodside Energy Ltd. Advisian WorleyParsons Group. (Appendix B)
Marshall Day Acoustics	Underwater noise modelling for the Scarborough Project (Marshall Day, 2019; Appendix E)
RPS/APASA	Scarborough Gas Development Cooling Water Discharge Modelling Study (RPS, 2019a; Appendix F)
	Scarborough Gas Development Produced Water Discharge Modelling Study (RPS, 2019b; Appendix G
	Scarborough Gas Development Hydrotest Discharge Modelling Study (RPS, 2019c; Appendix H)
	Scarborough Gas Development Quantitative Spill Risk Modelling (RPS, 2019d; Appendix I)
	Scarborough Dredge Dispersion Modelling – Offshore Borrow Ground (RPS, 2019e; Appendix J)

5.3 Marine Regional Characteristics

5.3.1 Introduction

The Project area and EMBA occur within the North-West Marine Region (NWMR), which encompasses waters from the WA/Northern Territory (NT) border to Kalbarri (Figure 5-1). The NWMR covers a large area of continental shelf and slope, with a range of bathymetric features such as canyons, plateaus, terraces, ridges, reefs, banks and shoals.

The Offshore Project Area, and the western part of the Trunkline Project Area, is in the Northwest IMCRA Province. As the trunkline traverses the continental shelf it crosses into the Northwest Shelf IMCRA Province (Figure 5-1). These provinces are the start of a transition between tropical and temperate marine areas; and include migration routes and breeding locations for some important whale and bird species (DEWHA, 2008a). The provinces are known to be important areas for the petroleum and commercial fishing industries (DEWHA, 2008a). No additional IMCRA Provinces occur in the EMBA.

The continental shelf in the vicinity of the Project Area is wide, with a change of slope at about the 20 m bathymetric contour (IMCRA Technical Group, 1998). Inside this contour there is a series of limestone islands (South and North Muiron, Serrurier, Bessieres, Thevenard, Rosily, Barrow and the Montebello islands); with fringing coral reefs typically occurring on the seaward side of most of these islands (IMCRA Technical Group, 1998).

Further offshore from the continental slope is the Exmouth Plateau. The Exmouth Plateau is a deep-water plateau, with a narrow, steep southern slope and a wider, less steep northern slope. The

Montebello Trough along the south-east edge of this plateau drains into the Cape Range Canyon; while the northern portion of the plateau comprises the Dampier Ridge and Swan Canyon.

5.3.2 Oceanographic Environment and Coastal Processes

5.3.2.1 Currents

The NWMR is influenced by a complex system of ocean currents that can change between seasons and between years. The major surface currents in the region flow away from the equator, and include the Indonesian Throughflow, Leeuwin Current, South Equatorial Current and the Eastern Gyral Current. These surface currents are typically warm, low salinity and oligotrophic (DEWHA, 2008a). There are also a series of subsurface currents that influence the area, the most important of which are the Leeuwin Undercurrent and the West Australian Current (Figure 5-3). These subsurface currents are typically cooler, with higher salinity and dissolved oxygen content (DEWHA, 2008a).

The Exmouth Plateau is known to influence the region’s currents due to its topography. The plateau obstructs the flow of the warm surface currents and forces upwelling of the cold nutrient-rich waters underneath, influencing the physical and biological properties of the environment.

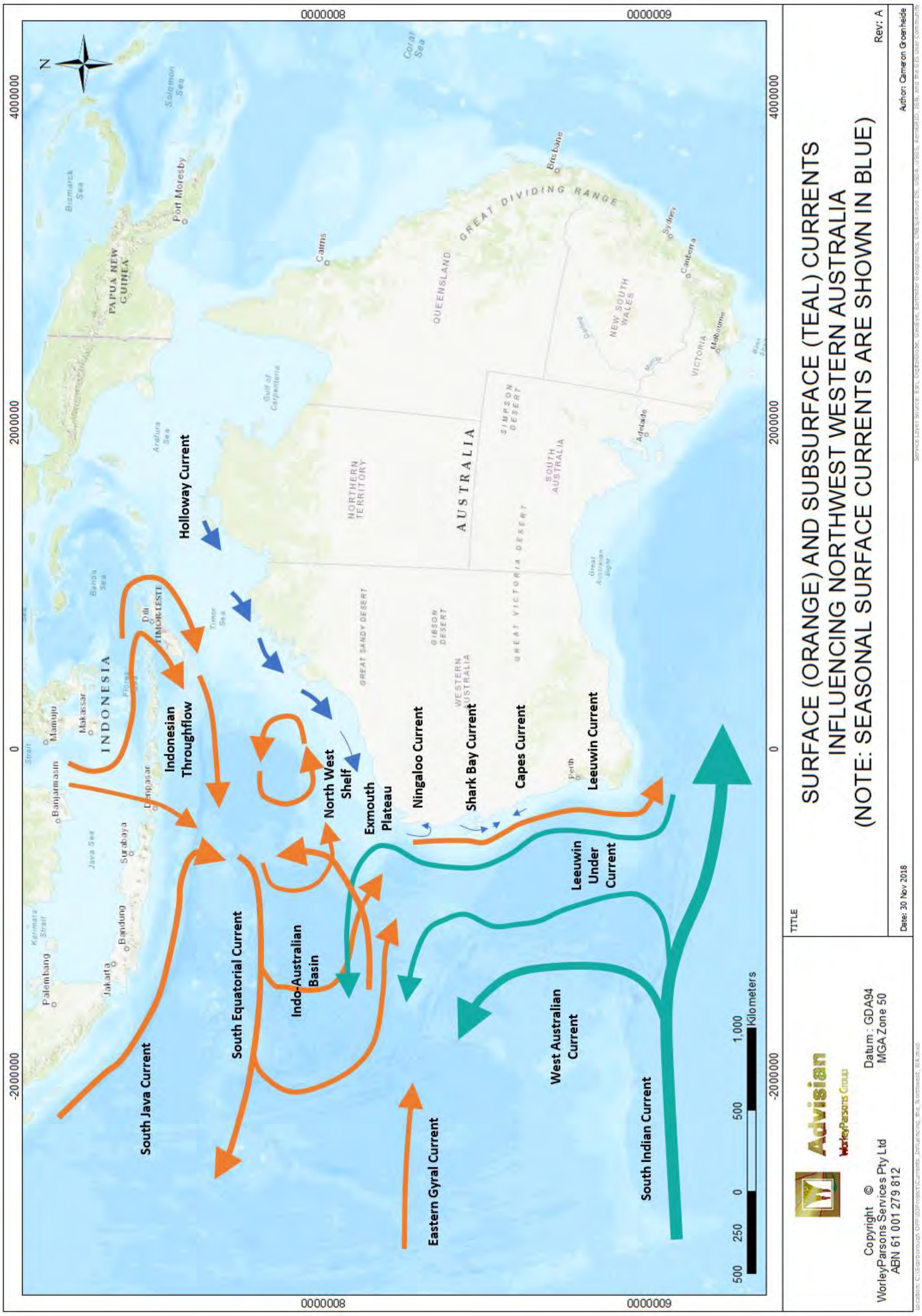


Figure 5-3: Surface (orange) and subsurface (teal) currents influencing the northwest Western Australia (Note: seasonal surface currents are shown in blue)

5.3.2.2 Tides

The NWMR experiences highly variable tidal regimes but can be broadly categorised as semi-diurnal (two highs and two lows per day) with a diurnal inequality (difference between successive highs and successive lows). Tides and winds strongly influence water flow in the coastal zone and over the inner to mid shelf, whereas flows over the outer shelf, slope, rise and deeper waters are influenced by large-scale regional circulation (DEWHA, 2008a). The interaction of the semi-diurnal tides with the Exmouth Plateau generates internal tides, also known as barotropic tides (Holloway, 1988). These internal tides can subsequently generate internal waves, which are dynamic, episodic events strongly influenced by topography and caused by pronounced temperature differences in the water column and the interaction between currents and the seafloor (DEWHA, 2008a). Internal waves are large in amplitude (up to 75 m high) and encourage the mixing of surface waters with deeper, more nutrient-rich waters, which is important for biological productivity in the region (DEWHA, 2008a). Internal waves are considered to occur more frequently and to be stronger during the wet season than the dry season when the water column is more stratified (Brewer et al., 2007; DEWHA, 2008a).

5.3.2.3 Waves and Wind

The wave climate of open waters of the NWMR is influenced by locally generated wind waves (seas) and remotely generated swells. Swell directions can vary widely in the region, depending on wind direction, locations of major storms, and local bathymetric effects. Fugro (2012) measured wave height in the Offshore Project Area throughout the year and recorded a maximum of 9.2 m in December.

Winds vary seasonally, with a tendency for winds from the south-west quadrant during summer months (September–March) and the north-east quadrant in autumn and winter months (April–August). The summer south-westerly winds are driven by high pressure cells that pass from west to east over the Australian continent. During winter months, the relative position of the high-pressure cells moves further north, leading to prevailing south-easterly winds blowing from the mainland (Pearce et al., 2003). Winds typically weaken and are more variable during the transitional period between the summer and winter regimes, generally between April and August.

5.3.2.4 Tropical Cyclones

Tropical cyclones are relatively frequent in the NWMR, with the Pilbara coast experiencing more cyclonic activity than any other region of the Australian mainland coast (Bureau of Meteorology, n.d.). Tropical cyclone activity can occur between November and April and is most frequent during December to March (i.e. considered the peak period), with an annual average of about one storm per month. Cyclones are less frequent in the months of November and April. Based on 47 years of historical weather data from 1970 until 2016, 34 tropical cyclones have occurred in the region of the Offshore Project Area (Bureau of Meteorology, n.d.). The likelihood of a tropical cyclone during the first 28 days of November is far less than could be expected for the remainder of tropical cyclone season.

5.3.2.5 Water Temperature and Salinity

Variation in surface salinity along the North West Shelf (NWS) (in the vicinity of the Trunkline Project Area) throughout the year is minimal (between 35.2 and 35.7 Practical Salinity Units), with slight increases occurring during the summer months due to intense coastal evaporation (Pearce et al., 2003; James et al., 2004). This small increase in salinity during summer is countered by the arrival of the lower salinity waters of the Leeuwin Current and Indonesian Throughflow in autumn and winter (James et al., 2004). Across Dampier Archipelago waters, surface salinity closer to the mainland coast is higher than outer archipelago waters throughout the year. In winter, denser (cooler and more saline) water forms within the archipelago and wedges seaward beneath open shelf waters. In summer, salinity increases in shallow coastal waters due to the localised effects of evaporation (Pearce et al., 2003).

In the Offshore Project Area, temperatures of about 25°C and salinity of about 35 ppt were recorded in surface waters; while deeper waters recorded temperatures of about 5°C and salinity of about 34.5 ppt (ERM, 2013a). Presence of both a thermocline and halocline were recorded; the level of these varied by about 50 m seasonally.

5.3.3 Seabed Characteristics

5.3.3.1 Region and EMBA

The EMBA overlaps both the Northwest Shelf IMCRA Province and the Northwest IMCRA Province.

The Northwest Shelf IMCRA Province is located almost entirely on the continental shelf. The shelf slopes gradually from the coast to the shelf break with a number of banks, shoals and valleys, examples including Rankin Bank (Section 5.3.13) and Glomar Shoals (Section 5.5.6).

The Northwest Province occurs entirely on the continental slope and comprises muddy sediments. There are many distinguishable topographic features, such as the Exmouth Plateau (Section 5.5.1), as well as deep holes and valleys on the inner slope. The Montebello Trough occurs on the eastern side of the Exmouth Plateau and represents more than 90 per cent of the area of troughs in the NWMR (Baker et al., 2008).

The seafloor of the EMBA is strongly affected by cyclonic storms, long-period swells and large internal tides, which can resuspend sediments within the water column as well as move sediment across the shelf (Margvelashvili et al., 2006). The North West marine bioregion includes a variety of geomorphological features (Figure 5-3).

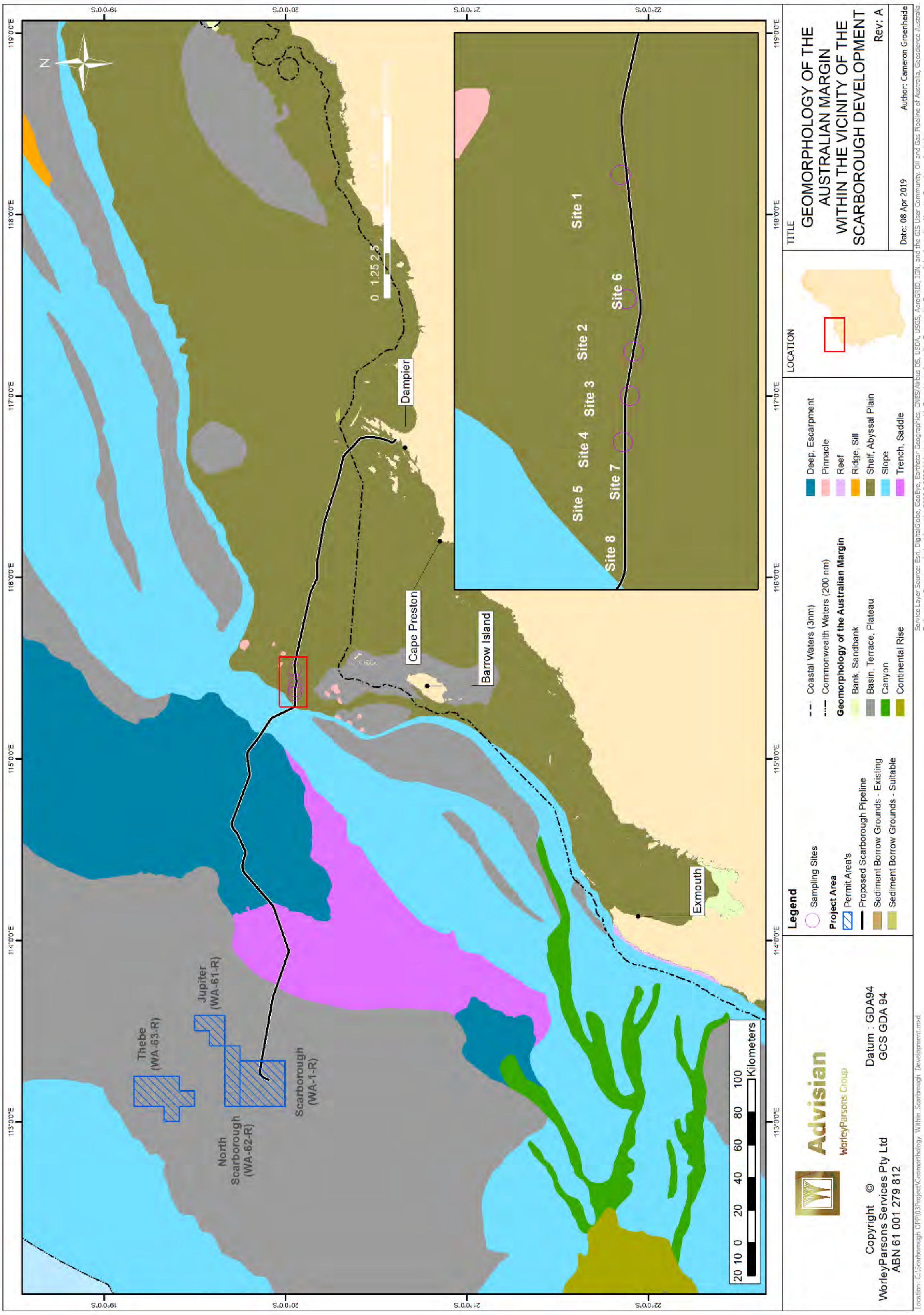


Figure 5-4: Geomorphology of the Australian margin within the vicinity of the development of Scarborough

5.3.3.2 Trunkline Project Area

The Trunkline Project Area, in the context of this OPP, extends from the State-Commonwealth boundary on the inner continental shelf, onto the continental slope where it traverses the continental slope westwards to the Offshore Project Area on the Exmouth Plateau. The eastern half of the Trunkline Project Area is adjacent to the existing Pluto trunkline.

The inner continental shelf is the area from the coast to about 30 m water depth, and the middle continental shelf is the area between 30 and 120 m water depth. At about 120 m depth, a terrace (start of the outer shelf) of gradients of between 5° and 20° represents a paleo-shoreline and marks an important divide between the continental shelf and the continental slope (SKM, 2006).

The continental slope in proximity of the Pluto field is the narrowest part of the continental slope in the NWS. Assessment of geophysical and ROV data of this area confirmed that it is traversed by several canyon systems where water depth ranges from 160 m to 1220 m (Geoconsult, 2005). The continental slope can be characterised into three sub-divisions, namely:

- dendritic channel areas
- channel areas
- continental slope areas (between channels).

A total of six major and nine minor dendritic channel areas were recorded that are up to 200 m deep and with gradients of 1:1. Major channels were well spaced through the site: in 300 m to 750 m water depth: between 500 m to 1500 m wide and up to 5 km in length.

The minor channels are prevalent in 320 m to 550 m water depths: 500 m to 900 m wide and up to 2.4 km in length. They are formed by the gradual erosion of the continental slope as numerous small, localised slumps, which trigger turbidity currents. It is suspected that dendritic channel areas act as a focus for seafloor currents (Advisian, 2019a).

Geophysical data has been collected and is used to support the description of the seabed features/characteristics identified from the State waters boundary to the the intersection of the trunkline route with the North Western limit of the Montebello Islands Marine Park. A detailed description of seabed features along this section of the trunkline route is provided in Table 5-2. Where more complex seabed features are identified from the geophysical data, studies are used to validate the presence of the features and the benthic communities and habitats associated with the features.

Sediments previously disposed at Spoil Ground 5A from the Pluto trunkline route are expected to be broadly similar to those noted in the original drop camera survey of the spoil ground, given the proximity of sourced materials (<1km).

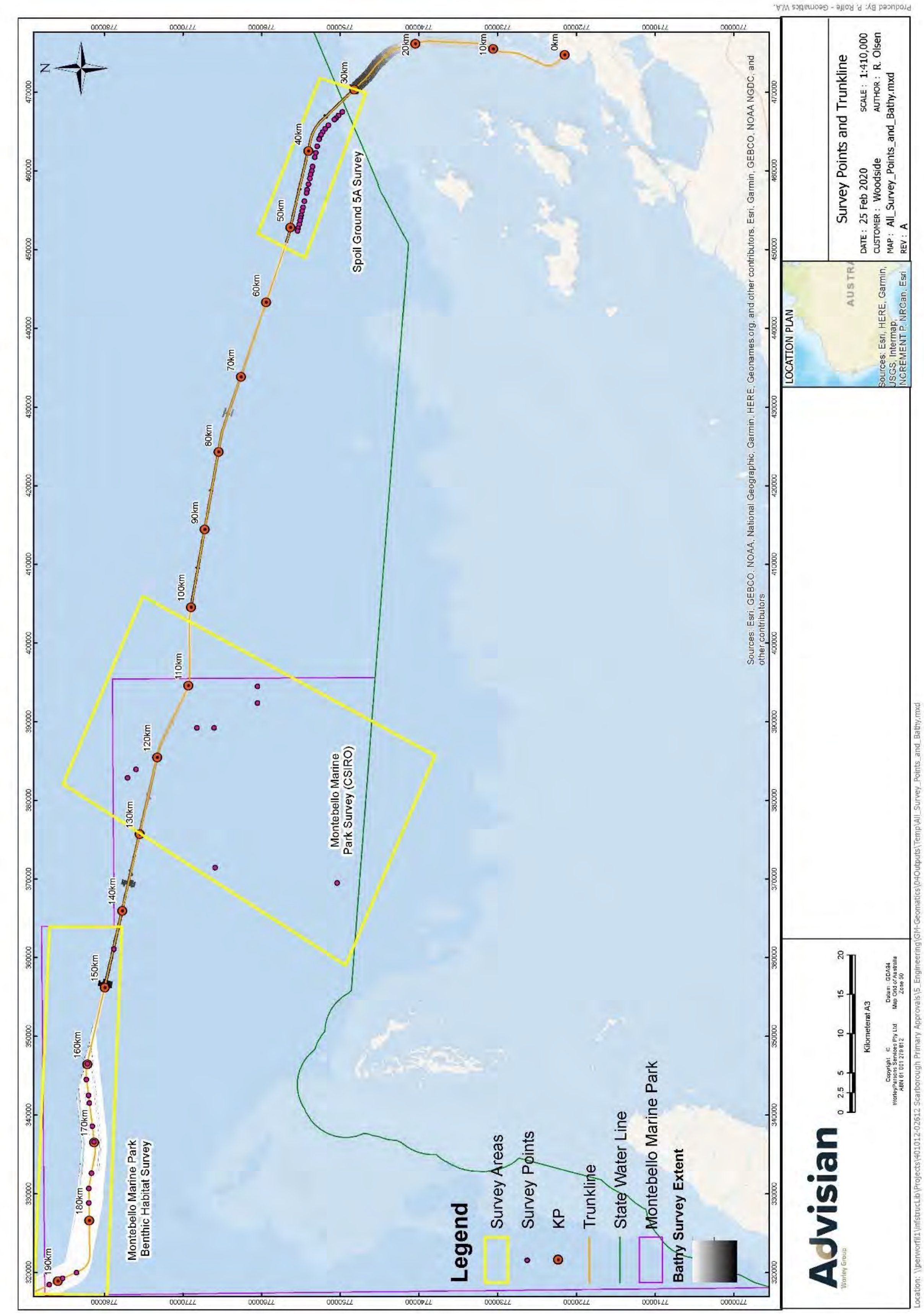
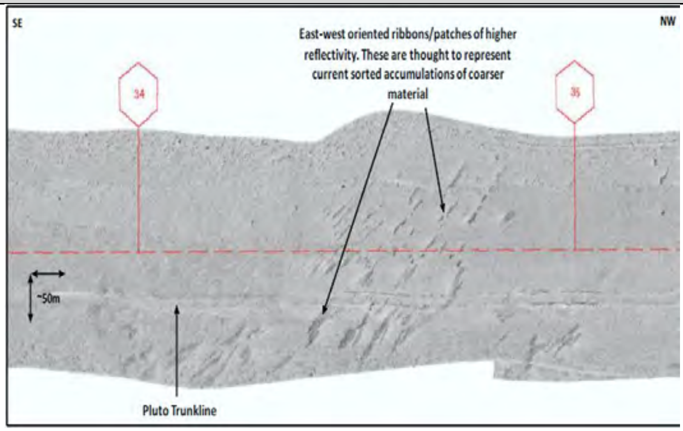
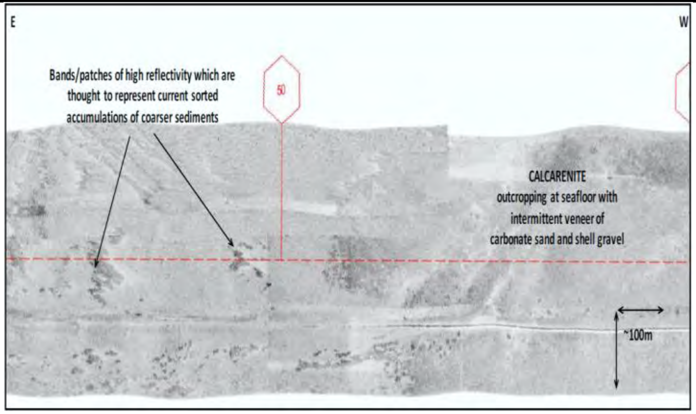
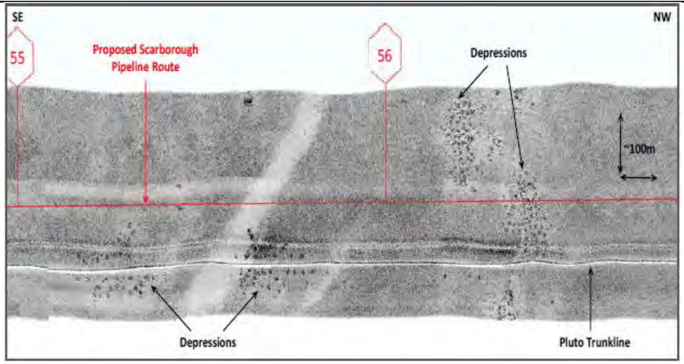


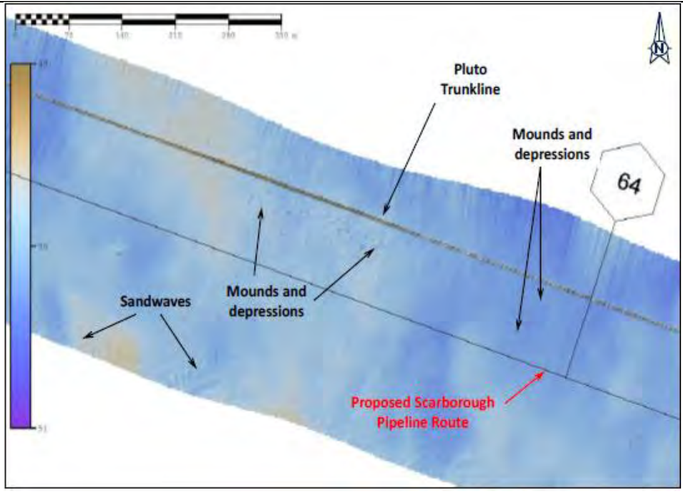
Figure 5-5: Seabed features ground truthing data

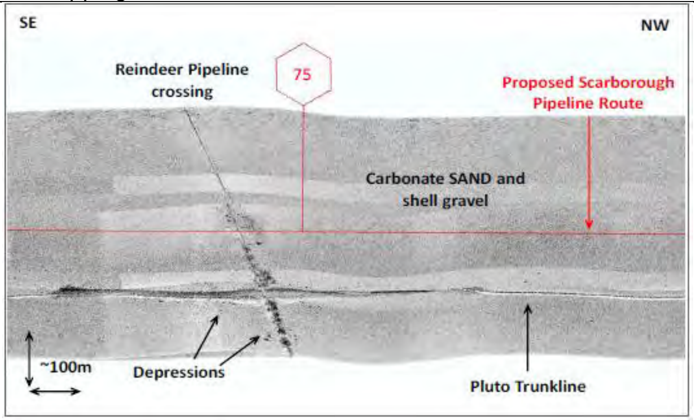
Table 5-2: Summary of seabed features along the proposed trunkline route

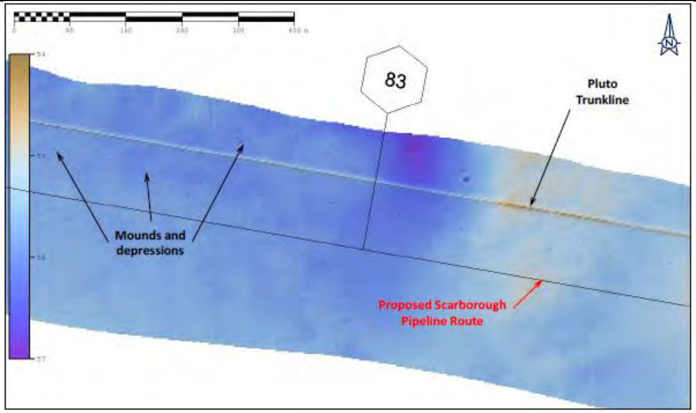
Section of Trunkline Project Area	**Geophysical Data**	**Environmental Sensitivity**	**Supporting Studies**	**Conclusions**
State waters boundary to KP 50 (the end of the proposed trunkline trenching operations)				
KP 32 – KP 43.1	 The seabed is predominantly flat, smooth and featureless between KP 32 and KP 43.1. From KP 32 to approximately KP 35 there are some minor east-west oriented ribbons/patches of higher reflectivity. These are thought to represent current sorted accumulations of coarser sediment. Sediments comprise carbonate sands with some finer components.	This area of the proposed trunkline may be trenched and backfilled to ensure the stability of the trunkline during higher energy metocean conditions. These activities have the potential to disturb a wider area of seabed and will temporarily increase suspended sediment concentrations above background.	A geophysical and geotechnical survey of the proposed trunkline route has been completed with key seabed features described in this table. A drop camera survey has been completed between KP 33 and KP 50.3 adjacent to the proposed trunkline route (Figure 5-14).	The seabed substrate observed on the drop camera footage was representative of the area (predominantly fine to coarse sand) and is consistent with the geophysical and geotechnical data collected along the trunkline route. Sparse ascidians, sponges, invertebrate communities, burrowing organisms and octocorals were observed from the drop camera study. This benthos is considered representative of the area and is similar to that observed in other regional studies (Keesing 2019, Advisian 2019b). Given the similarity in the seabed substrate observed from the geophysical and geotechnical data collected along the trunkline route and the drop camera footage, and the proximity of the drop camera footage to the proposed trunkline route, benthic communities and habitats along the proposed trunkline route are expected to be similar to those observed in the drop camera study.

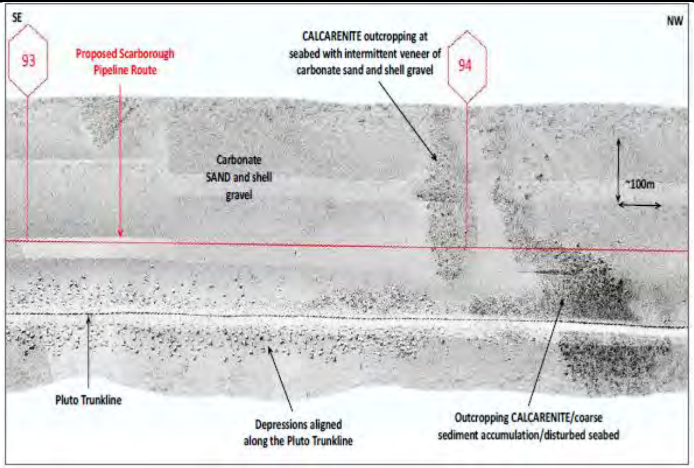
Section of Trunkline Project Area	Geophysical Data	Environmental Sensitivity	Supporting Studies	Conclusions
KP 43.1 – KP 52.5	 The seabed is predominantly flat and featureless between KP 43.1 and KP 52.5. The exhibited low reflectivity correlates with a seabed expected to comprise carbonate sand and shell gravel which was confirmed by geotechnical sampling within this section of the proposed route. Between KP 43.9 and KP 44.9 a number of small patches of higher reflectivity are apparent. These are thought to represent minor accumulations of coarser sediments. From KP 47.1 to approximately KP 50.0 the seabed displays numerous bands/patches of high reflectivity. These bands/patches tend to show an east-west orientation and are thought to represent current sorted accumulations of coarser sediments. From KP 50.3 to KP 52.4 calcarenite outcrops at seabed. This appears characteristically highly reflective with some smooth, less reflective areas which are expected to be due to a sediment veneer which masks the position of the outcrop in some areas.			

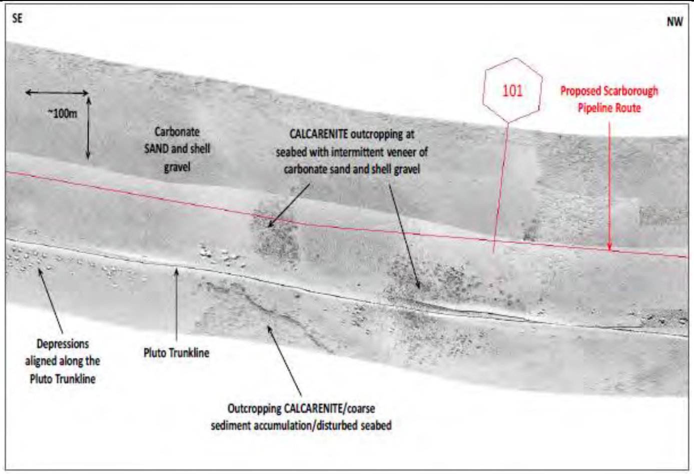
Section of Trunkline Project Area	Geophysical Data	Environmental Sensitivity	Supporting Studies	Conclusions
	From approximately KP 50 to KP 52 there are a number of isolated depressions visible on the seafloor. These are representative of depressions observed along the trunkline route.			
End of the proposed trenching and backfill operations to the boundary of the Montebello Islands Marine Park				
KP 52.5 – KP 61.9	 Some localised increases in the acoustic reflectivity are observed along this section of the trunkline route. The increases in reflectivity tend to be associated with the presence of numerous depressions and exposure of the underlying calcarenite unit. Seabed sediments are expected to comprise carbonate sands with shell gravel which has been confirmed by geotechnical sampling within this section. From KP 52.4 to KP 52.5 the seabed appears moderately reflective with some small isolated depressions. Between KP 52.5 and KP 52.7 the underlying calcarenite outcrops at the seabed. The seafloor exhibits a higher reflectivity and appears slightly mottled due to the presence of an intermittent veneer of sediment. Whilst isolated depressions appear throughout the route corridor it seems that the clusters of depressions mostly occur when the	The predominantly featureless seabed is not expected to support abundant or diverse benthic communities and is considered typical of the North West Shelf. The calcarenite outcrops are typical of those found across the North West Shelf (Wilson 2013) and generally run perpendicular to the trunkline limiting the intersection of the trunkline with areas of harder seabed substrate.	A geophysical and geotechnical survey of the proposed trunkline route has been completed with key seabed features described in this table.	The predominantly featureless seabed is not expected to support abundant or diverse benthic communities and is considered typical of the North West Shelf. The calcarenite outcrops identified in the Trunkline Project Area are common across the North West Shelf (Wilson 2013) and generally run perpendicular to the trunkline. The intersection of any exposed calcarenite would not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat given that the habitat is widespread across the North West Shelf (Wilson 2013) and only a very small area of the habitat will be intersected by the trunkline route. The presence of oil and gas infrastructure may artificially increase habitat complexity in areas of featureless seabed, resulting in higher species richness and abundance of fish species and epifauna associated with infrastructure, compared to adjacent natural habitats (McLean et al., 2020, McLean et al., 2018; McLean et al., 2017; Bond et al., 2018).

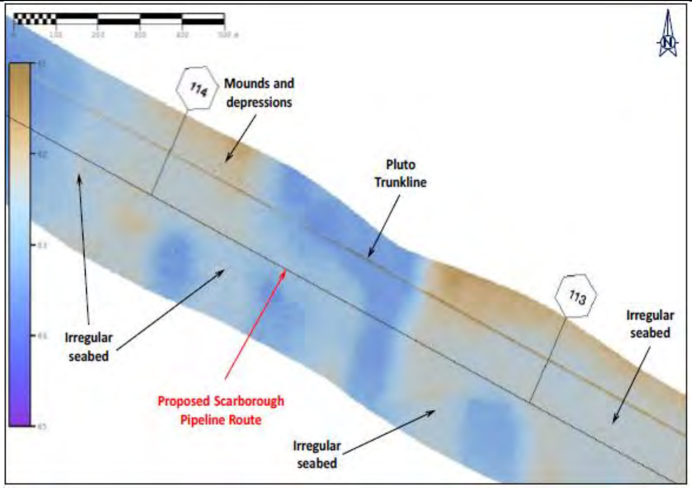
Section of Trunkline Project Area	Geophysical Data	Environmental Sensitivity	Supporting Studies	Conclusions
	calcarenite is outcropping at seafloor. These depressions run perpendicular to the proposed trunkline route.			
KP 61.9 – KP 71.2	 From KP 61.8 until KP 71.2, the seabed appears predominantly moderately reflective. Localised increases in reflectivity tend to be associated with the presence of numerous depressions and exposure of the underlying calcarenite unit. Seabed sediments are expected to comprise carbonate sands with shell gravel. Geotechnical sampling within this section recovered carbonate sands with some silt content. The underlying calcarenite is expected to outcrop at the seabed within this area, however apart from appearing marginally less smooth and slightly mottled the seafloor otherwise appears, visually, very similar to the rest of the corridor. This is thought to be due to the intermittent veneer of sediment on top of the calcarenite.			

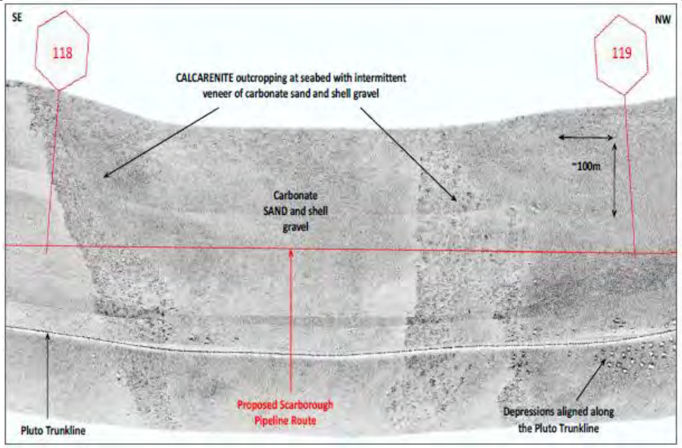
Section of Trunkline Project Area	Geophysical Data	Environmental Sensitivity	Supporting Studies	Conclusions
	Whilst isolated depressions appear throughout the route corridor the clusters of depressions mostly occur when the calcarenite is outcropping at the seafloor.			
KP 71.2 – KP 80.6	 From KP 71.1, until KP 80.6, the seabed appears predominantly moderately reflective. Localised increases in reflectivity tend to be associated with the presence of numerous depressions and exposure of the underlying calcarenite unit. Seabed sediments are expected to comprise carbonate sands with shell gravel. Geotechnical sampling within this section recovered carbonate sands with some silt content. The underlying calcarenite is expected to outcrop at seabed within this area, however apart from appearing marginally less smooth and slightly mottled the seafloor otherwise appears, visually, very similar to the rest of the corridor. This is thought to be due to the intermittent veneer of sediment expected on top of the calcarenite.			

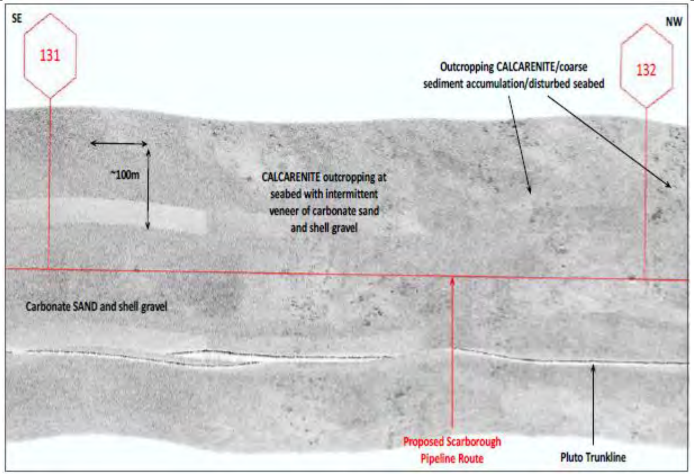
Section of Trunkline Project Area	Geophysical Data	Environmental Sensitivity	Supporting Studies	Conclusions
KP 80.6 – KP 89.8	 From KP 80.3, until KP 89.8, the seabed appears predominantly moderately reflective. Localised increases in reflectivity tend to be associated with the presence of numerous depressions. Seabed sediments are expected to comprise carbonate sands with shell gravel which was confirmed by geotechnical sampling within this section.			

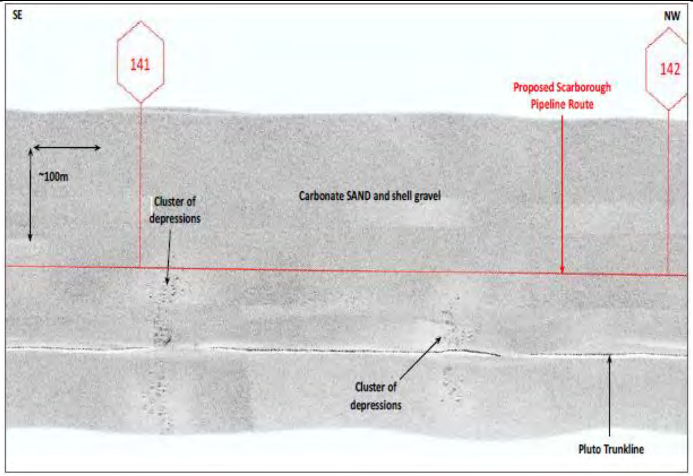
Section of Trunkline Project Area	Geophysical Data	Environmental Sensitivity	Supporting Studies	Conclusions
KP 89.8 – KP 99.1	 From KP 89.7, until KP 99.1, the seabed appears predominantly moderately reflective. Localised increases in reflectivity tend to be associated with the presence of numerous depressions and exposure of the underlying calcarenite unit. Where the Calcarenite unit is exposed it runs generally perpendicular to the proposed trunkline route. Seabed sediments are expected to comprise carbonate sands with shell gravel which was confirmed by geotechnical sampling within this section. The seabed depressions occur almost entirely within the northern half of the route corridor, alongside the Pluto trunkline. There is however a small group of isolated features expected to be calcarenite outcropping or an accumulation of coarser sediments which extend across to the southern side of the corridor around approximately KP 94.2. From KP 93.9 to KP 99.1 the seabed alternates between areas of moderately reflective sand cover and more highly reflective outcrops of calcarenite. The calcarenite outcrops are not extensive but do occasionally occur on the route centerline.			

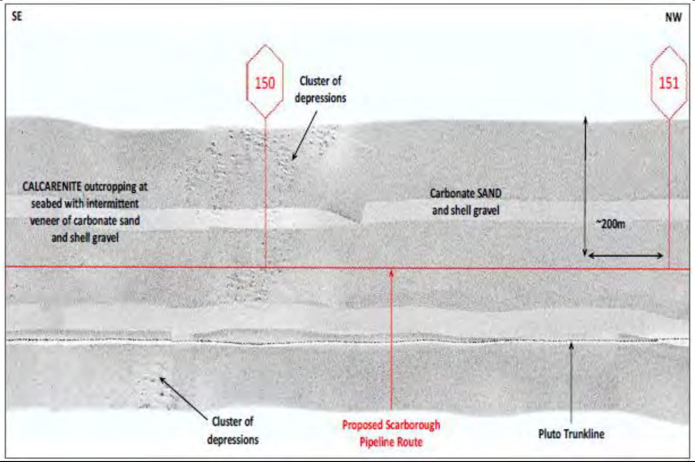
Section of Trunkline Project Area	Geophysical Data	Environmental Sensitivity	Supporting Studies	Conclusions
KP 99.1 – KP 108.4	 From KP 98.9, until the end of this chart section at KP 108.4, the seabed appears predominantly moderately reflective. Localised increases in reflectivity tend to be associated with the presence of numerous depressions and exposure of the underlying calcarenite unit. Seabed sediments are expected to comprise carbonate sands with shell gravel. This was confirmed by geotechnical sampling in this section which recovered carbonate sands and gravels with some silts. The seabed depressions occur entirely within the northern half of the route corridor, alongside the Pluto trunkline. One isolated feature occurs on the route centreline at KP 104.8 whilst one cluster extends onto the route at KP100.9. The seabed within this section of the route is expected to predominantly represent a cover of sand. However, calcarenite outcrops occasionally along the route centerline, however the outcrops run perpendicular to the trunkline route limiting the intersection of the trunkline with these areas of outcropping.			

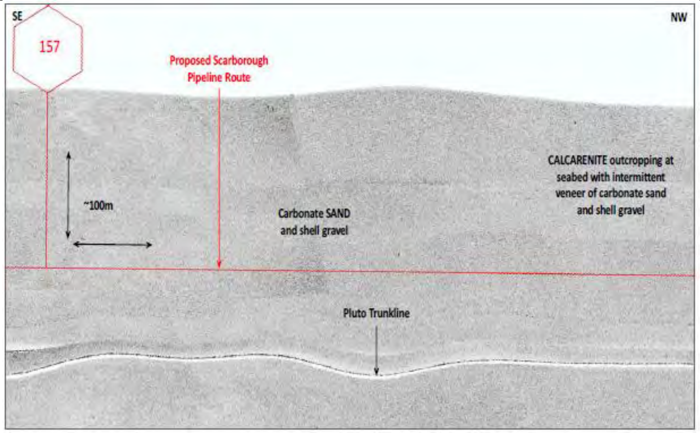
Section of Trunkline Project Area	Geophysical Data	Environmental Sensitivity	Supporting Studies	Conclusions
Montebello Islands Marine Park				
KP 108.4 – KP117.6	 From KP 108.2, until KP 117.67, the seabed appears predominantly moderately reflective. Localised increases in reflectivity tend to be associated with the presence of numerous depressions and exposure of the underlying calcarenite unit. Seabed sediments are expected to comprise carbonate sands with shell gravel which was confirmed by geotechnical sampling in this section.The seabed depressions occur almost entirely within the northern half of the route corridor, alongside the Pluto trunkline. The seabed within this section of the trunkline route is expected to predominantly represent a cover of sand. However, areas of higher reflectivity similar to those observed as calcarenite outcrops were observed along the route centreline at the following locations; KP 112.00 to KP 112.07, KP 113.36 to KP 113.44 and KP 115.75 to KP 115.91. An area of outcropping calcarenite/coarse sediment/disturbed seabed occurs along the route between	This section of the trunkline intersects with the Montebello Islands Marine Park (Multiple Use Zone)	A geophysical and geotechnical survey of the proposed trunkline route has been completed with key seabed features described in this table. The CSIRO study (Keesing 2019) is used to validate the geophysical data in the South East Section of the Marine Park Multiple Use Zone (Figure 5-5). The ROV survey (Advisian, 2019b) is used to validate the geophysical data in the North West Section of the Marine Park Multiple Use Zone (Figure 5-5, Figure 5-15 and Figure 5-40).	Data used to describe benthic substrates and biota from the 2017 CSIRO RV Investigator voyage (Keesing 2019) in the South East section of the Marine Park were principally derived from still camera images. Camera sites 79, 80, 81 and 82 being the closest to the Scarborough trunkline route (Figure 5-15) showed that topography in the vicinity of the Scarborough trunkline was predominantly flat bottom with some occasional bioturbated areas which is consistent with the interpretation of the geophysical data. Substrate was typically fine sands although site 81 was predominantly rock. These sites within the vicinity of the Scarborough trunkline had low numbers of sponges, whips and gorgonians and as a result, complex benthic filter feeder communities were largely absent in this area of the Marine Park. An ROV survey of the trunkline route within the North West section of the Montebello AMP was undertaken in 2019 (Advisian, 2019b). This survey predominantly targeted areas where the Scarborough trunkline deviates from the existing Pluto trunkline (i.e. the northwestern extent). Bathymetry data was analysed to select areas that could be expected to support benthic communities, including areas of potential harder substrate, the ancient coastline KEF (see also Section 5.5.2), areas of sub-cropping calcarenite with shallow sediment

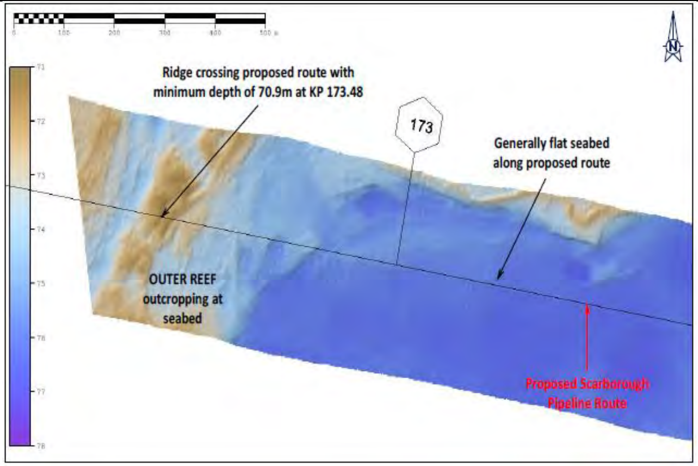
Section of Trunkline Project Area	Geophysical Data	Environmental Sensitivity	Supporting Studies	Conclusions
	approximately KP 112.6 and KP 113.2. Similar areas also appear along the outer edges of the corridor, in the vicinity of KP 112.6, KP 116.3, KP 116.8 and KP 117.3. The shallow soils isopach in these areas shows a cover of sand which suggests that these areas are more likely to represent accumulations of coarse material or disturbed seabed rather than calcarenite outcrop.			cover, and areas of potential turtle foraging habitat. The results of previous benthic studies in the Montebello AMP are largely in alignment with the geophysical data (i.e. typically low relief sandy seafloor (with various bedforms) with occasional rubbly areas increasing at sites more inshore) and dominant benthic organisms identified (which varied in diversity and density within and between survey areas, but typically included a wide variety of sponges and soft corals including whips and gorgonians, hydroids, seapens and crinoids) (Advisian, 2019b). The benthic communities and habitats of the marine park are considered representative of the region. Substrate type and topography of the seabed within the Marine Park were similar to those in the adjacent trawl fishery area (Keesing 2019) with predominantly flat bottom with fine sand substrate. Similar biota types (sponges, gorgonians, whips and other soft corals, hydroids, crinoids and sea pens) were present in the marine park and adjacent trawl fishery. The exception to this was that sponge and whips were more abundant in trawel fishery than the South Eastern Section of the Marine Park, making up more than 50% of biota scored in images from 6 sites, while only one site in the South Eastern Section of the Montebello AMP had more than 10% of biota scored as sponges or whips (Keesing 2019). The biomass of habitat forming filter feeder communities was also much greater (5.5 times
KP 117.6 – KP 126.8	 From KP 117.4, until KP 126.8, the seabed appears predominantly moderately reflective. Localised increases in reflectivity tend to be associated with the presence of numerous depressions and exposure of the underlying calcarenite unit. Seabed sediments are expected to comprise carbonate sands with shell gravel. This was confirmed by geotechnical sampling in this section which recovered carbonate sands and silts. The seabed depressions occur almost entirely within the northern half of the route corridor, alongside the Pluto trunkline. However, a number of isolated depressions were found on the route centerline at KP 118.6, KP 118.8, KP 119.6, KP 122.4 and KP 123.9.			

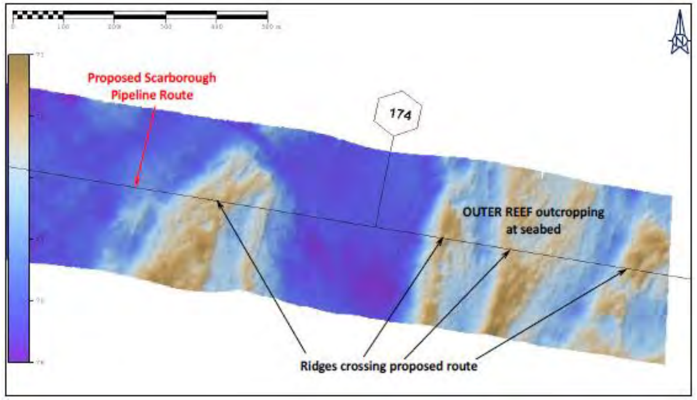
Section of Trunkline Project Area	**Geophysical Data**	**Environmental Sensitivity**	**Supporting Studies**	**Conclusions**
	The seabed within this section of the trunkline route is expected to predominantly represent a cover of sand. However, calcarenite outcrops along the route centreline at the following locations; KP 117.70 to KP 117.74, KP 118.06 to KP 118.19, KP 118.63 to KP 118.81, KP 119.89 to KP 119.96 and KP 120.82 to KP 120.92. These outcrops extend in an approximate north-northeast - south-southwest orientation across the corridor. Three small areas of outcropping calcarenite/coarse sediment/disturbed seabed occur along the outer edges of the corridor, in the vicinity of KP 118.67, KP 118.79 and KP 119.28. From KP 122.38 until KP 126.85 the seabed remains predominantly featureless with the exception of a few minor isolated depressions which themselves peter out after KP 124.			higher) at sites in the trawel fishery than in the South Eastern Section of the Montebello AMP. The intersection of the trunkline with ~~isolated~~ areas of denser sponges associated with the outer reef area identified from the geophysical data is not expected to fragment the community given that any loss of sponges will be localised to the trunkline footprint and that sponge communities are well represented in the Marine Park and adjacent traw~~e~~l fishery area. The pipeline alignment was selected to ensure the intersections with harder more complex areas of seabed are minimised with the pipeline generally running perpendicular to these areas. Given the small footprint of the trunkline, and subsequent percentage disturbance to the Montebello AMP (0.07%) the project activities are not expected to modify, destroy, fragment, isolate or disturb important or substantial areas of habitat important to turtles, whale sharks or whales in the Montebello AMP.
KP 126.7 – KP 136.2	 From KP 126.75, until KP 136.2, the seabed appears predominantly moderately reflective. Localised increases in reflectivity tend to be associated with the presence of numerous depressions and exposure of the underlying calcarenite unit. Seabed sediments are expected to comprise carbonate sands with			

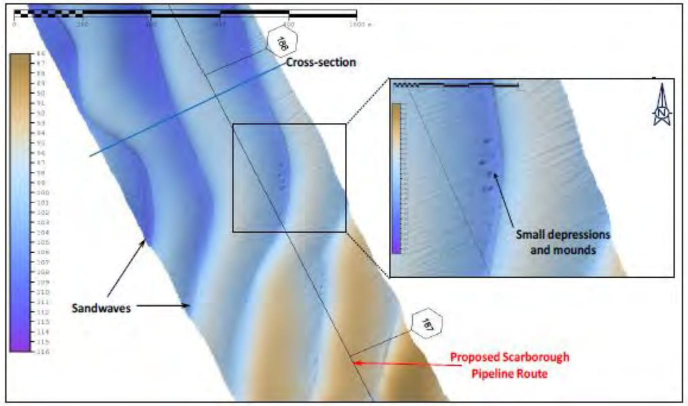
Section of Trunkline Project Area	**Geophysical Data**	**Environmental Sensitivity**	**Supporting Studies**	**Conclusions**
	shell gravel which was confirmed by geotechnical sampling in this section. The seabed within this section of the route is expected to represent a cover of sand. However, calcarenite does outcrop at seabed along the route centreline between KP 131.38 and KP 131.61. A number of areas interpreted as outcropping calcarenite/coarse sediment/disturbed seabed occur along the route. The shallow soils isopach in these areas tends to show a cover of sand which suggests that these areas are more likely to represent accumulations of coarse material or disturbed seabed rather than outcrop.			
KP 136.09 – KP 145.5	 From KP 136.1, until KP 145.5, the seabed appears predominantly moderately reflective and generally quite featureless. Localised increases in reflectivity tend to be associated with the presence of small depressions. Seabed sediments are expected to comprise carbonate sands with shell gravel which was confirmed by geotechnical sampling in this section.			

Section of Trunkline Project Area	**Geophysical Data**	**Environmental Sensitivity**	**Supporting Studies**	**Conclusions**
	A number of small depressions, present as both isolated features and clusters, are the only seabed feature noted in this section of the route. Two isolated depressions appear on the route at KP 137.53 and KP 137.57. Elsewhere, a number of clusters extend from the Pluto trunkline, southwards, to occur on the route centreline.			
KP 145.4 – KP 164.3			Montebello Marine Park Survey (Advisian 2019)	

Section of Trunkline Project Area	**Geophysical Data**	**Environmental Sensitivity**	**Supporting Studies**	**Conclusions**
	 From KP 145.4, until KP 154.9, the seabed appears predominantly moderately reflective and generally quite featureless. Localised increases in reflectivity tend to be associated with the presence of small depressions. Seabed sediments are expected to comprise carbonate sands with shell gravel which was confirmed by geotechnical sampling in this section. The underlying calcarenite is expected to outcrop at seabed within this area, however apart from appearing marginally less smooth the seafloor otherwise appears, visually, very similar to the rest of the corridor. This is thought to be due to the intermittent veneer of sediment on top of the calcarenite. A number of small depressions, present as both isolated features and clusters, are the only seabed feature noted in this section of the route.			

Section of Trunkline Project Area	Geophysical Data	Environmental Sensitivity	Supporting Studies	Conclusions
KP 164.3 – KP173.6	 From KP 164.1, until KP 173.5, the seabed appears predominantly moderately reflective and featureless. The underlying calcarenite is expected to outcrop at seabed within the majority of this area, however, apart from appearing marginally less smooth and sometimes slightly mottled, the seafloor otherwise appears very uniform without any noticeable increase in reflectivity. This is thought to be due to the intermittent veneer of sediment expected on top of the calcarenite. At approximately KP 173.0 the calcarenite exhibits subtle northeast-southwest oriented lineations which is thought to mark the edge of the outer reef. Seabed sediments are expected to comprise carbonate sands with shell gravel. This was confirmed by geotechnical sampling in this section which recovered silty carbonate gravels and gravelly carbonate sands.			

Section of Trunkline Project Area	Geophysical Data	Environmental Sensitivity	Supporting Studies	Conclusions
KP 173.6 – KP 182.8	 From KP 173.4, until KP 182.9, the seabed appears moderately reflective and predominantly featureless. The underlying calcarenite outcrops at seabed within this area. Between KP 173.4 and KP 178.1 the seafloor appears more irregular and slightly mottled. Lineations in the calcarenite are oriented approximately northeast-southwest and this area is thought to represent the outer reef which is characterised by linear ridges and relict sandwaves. Between KP 178.1 and KP 182.9 the seafloor appears smoother though still represents outcropping calcarenite. Very little variation in reflectivity is noted across this change which may be due to variations in the intermittent veneer of sediment expected on top of the calcarenite. Surficial seabed sediments are expected to comprise carbonate sands with shell gravel. The seabed is featureless from KP 173.4 to KP 180.9. From KP 180.9 to KP 182.9 a number of small depressions, present as both isolated features and clusters, are noted. These depressions often show associated small mounds.			

Section of Trunkline Project Area	**Geophysical Data**	**Environmental Sensitivity**	**Supporting Studies**	**Conclusions**
KP 182.8 – KP 191.6	 From KP 182.7, until KP 191.6, the seabed appears moderately reflective. From KP 183.6 to KP 190.6 the calcarenite outcropping at seabed is thought to represent the outer reef. This is an area characterised by relict sandwaves and numerous linear, northeast southwest oriented ridges. Relict sandwaves are defined as having been immobile over a geological timescale and being cemented or indurated. Here they are present along the proposed route from approximately KP 184.7 to KP 190.6. The sandwaves exhibit an approximate north-south orientation, have wavelengths of between 150m to 300m and measure up to 10m in height. Surficial seabed sediments are expected to comprise carbonate sands with shell gravel. Between approximately KP 183.1 and KP 187.7 a number of small depressions, present as both isolated features and clusters.			

5.3.3.3 Offshore Project Area

The Offshore Project Area is situated on the Exmouth Plateau. The seascapes of the Exmouth Plateau are not considered unique (Falkner et al. 2009), and consistent with the seascape of the broader area at this depth range.

The seafloor is generally flat and uniform with water depths ranging from 900 m to 970 m within the Scarborough permit, with a gradual increase from the north/north-west to the south/south-east of the area (Figure 5-6 and Figure 5-8; Fugro, 2010). Water depths in the North Scarborough and Jupiter fields are similar to Scarborough; however, Thebe is slightly deeper (1,000 m to 1,400 m) with a south-east to north-west gradient.

To the south-west of the Offshore Project Area, craters (up to 400 m across and 10 m deep) and smaller pockmarks (metres to tens of metres across) have been identified through geophysical surveys (Fugro, 2010). The seafloor exhibits gradients less than 1° but extends to about 15° on the edge of craters (Fugro, 2010). These crater and pockmark formations may be associated with hydrocarbon seeps and associated authigenic carbonate formations (Fugro, 2010).

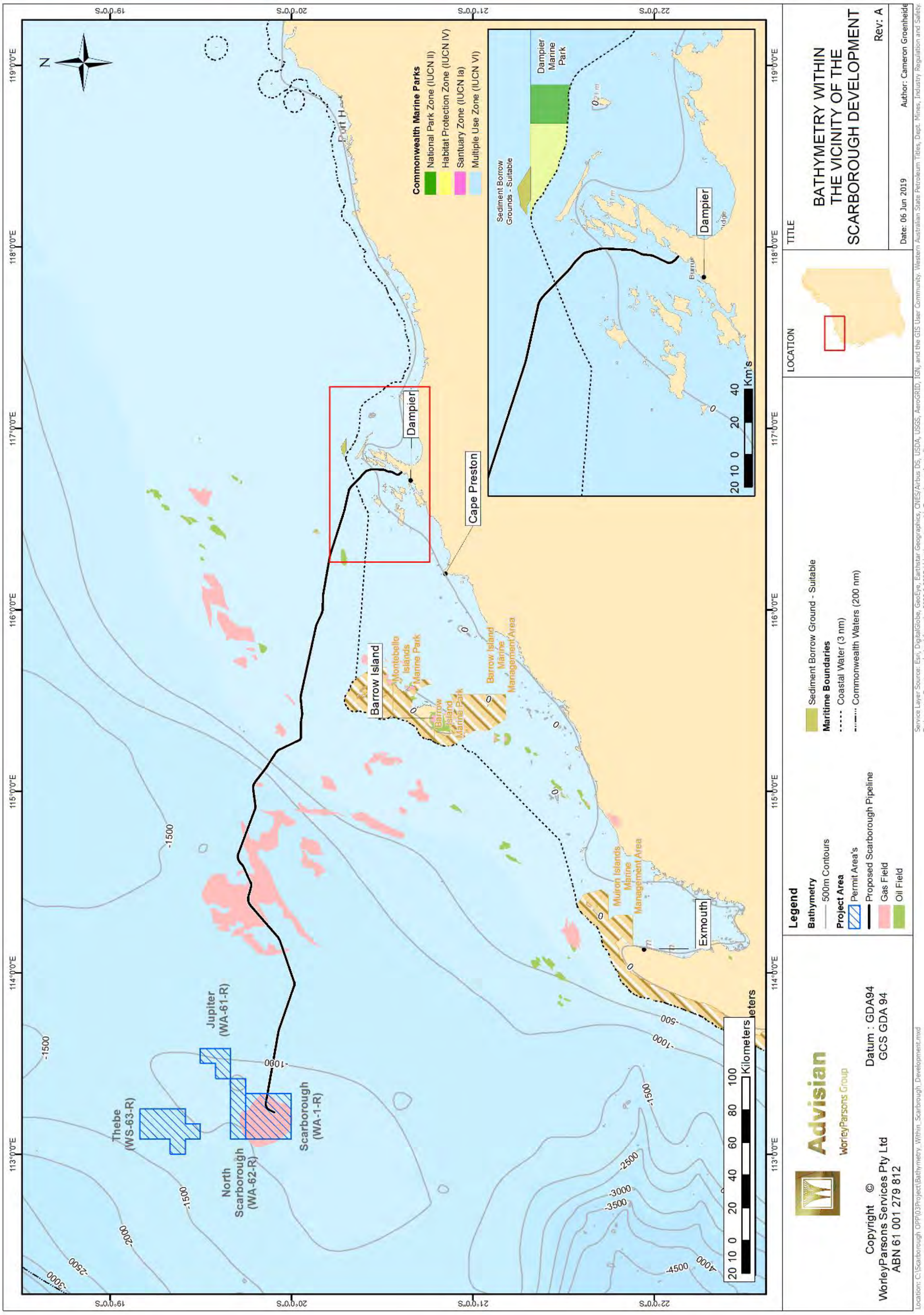


Figure 5-6: Bathymetry showing the 500 m depth contour in the vicinity of Scarborough

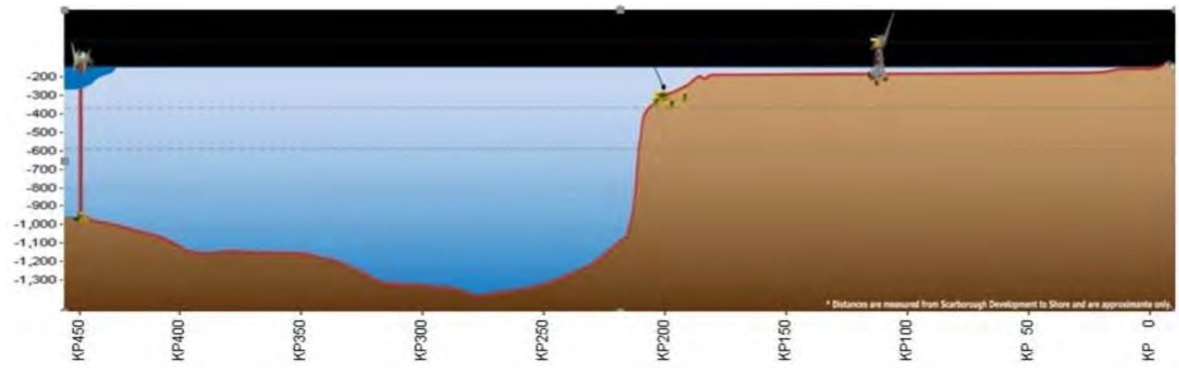


Figure 5-7: Depth profile along the proposed Scarborough deep water trunkline route

5.3.3.4 Borrow Ground Project Area

The Borrow Ground Project Area lies just outside the State marine boundary to the NNE of the Dampier Archipelago (~15 km). Water depths in this area are shallow (~35-45 m), increasing gradually in a N/ NW direction. The Borrow Grounds Project Area lies within the continental shelf and is characterised by a generally flat/ undulating and uniform seabed with no important submerged features (i.e. pinnacles).

5.3.4 Marine Sediments

5.3.4.1 Region and EMBA

Marine sediments are the deposits of insoluble material found on the sea floor. These deposits can include rock and soil particles originating from adjacent land masses (terrigenous) or the remains of marine organisms (pelagic). They can also originate from volcanic sources beneath the surface of the ocean or from chemical precipitation processes that occur in the water column.

The composition, distribution and movement of marine sediments is an important component of a marine ecosystem. These sediments can influence the primary biological production in the water column as well as the evolution and distribution of marine habitats.

Sediments in the outer NWS are relatively homogenous and are typically dominated by sands and a small portion of gravel (Baker et al., 2008). Fine sediment size classes (e.g. muds) increase with proximity to the shoreline and the shelf break but are less prominent on the continental shelf (Baker et al., 2008). Carbonate sediments typically account for the bulk of sediment composition, with both biogenic and precipitated sediments present on the outer shelf (Dix et al., 2005). Beyond the shelf break, the proportion of fine sediments increases along the continental slope towards the Exmouth Plateau and the abyssal plain (Baker et al., 2008). The predominant seabed type at the Offshore Project Area is mud and calcareous clay, and along the Trunkline Project Area is calcareous gravel, sand and silt (Figure 5-8).

Hard substrates occur in the region and can host more diverse benthic communities. Hard substrate may be associated with the Ancient coastline at 125 m depth contour KEF (Section 5.5.2).

The NWMR comprises bio-clastic, calcareous and organogenic sediments deposited from relatively slow and uniform sedimentation rates (Baker et al., 2008). Sediments in the region generally become finer with increasing water depth, ranging from sand and gravels on the continental shelf to mud on the continental slope and abyssal plain (Brewer et al., 2007).

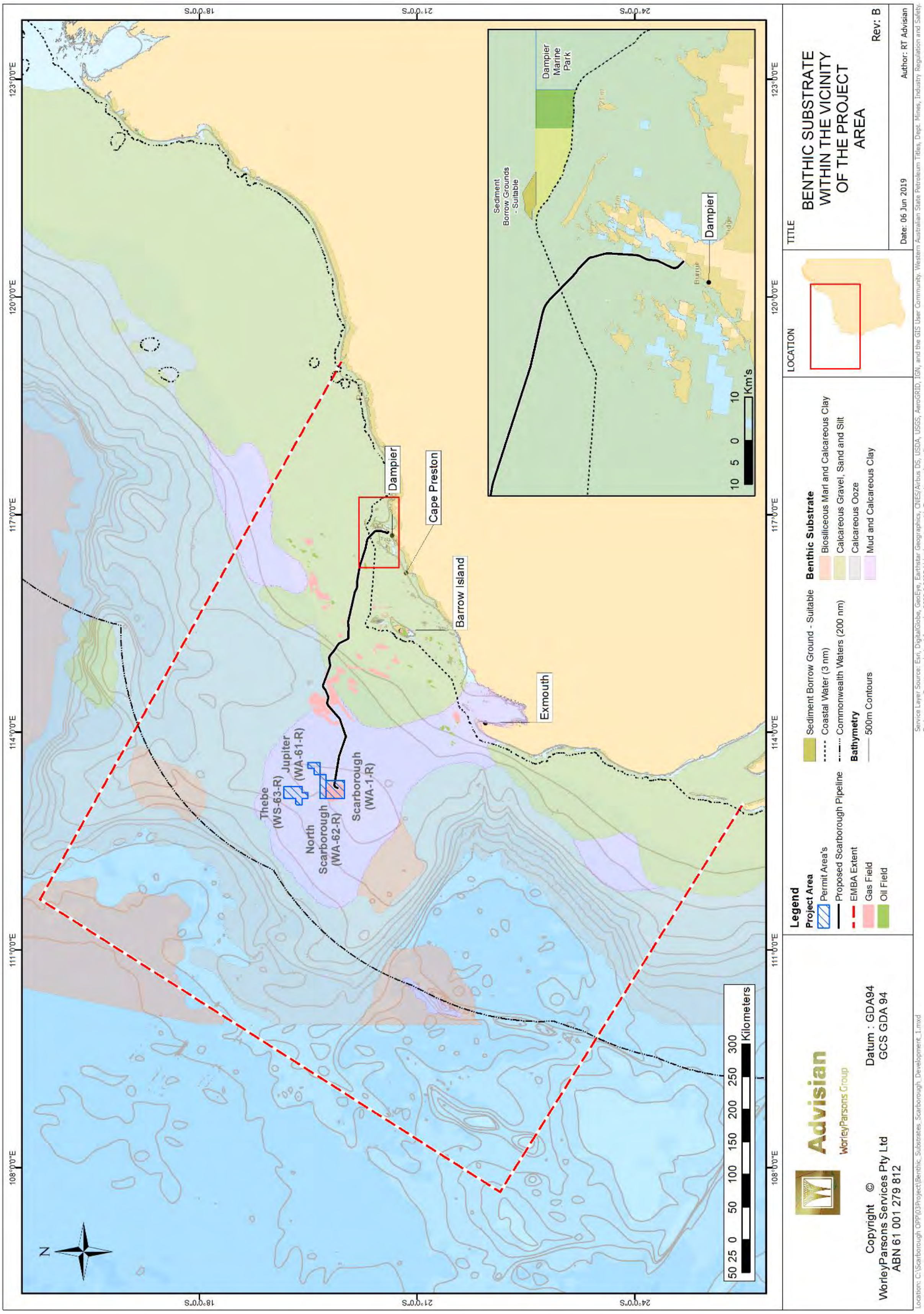


Figure 5-8: Benthic substrate within the vicinity of Scarborough

5.3.4.2 Trunkline Project Area

Sediments along the Trunkline Project Area are expected to be dominated by sand as is typical of the continental slope in the Northwest Transition bioregion (DEWHA, 2008a). These sediments will be further characterised during the baseline survey of the Trunkline Project Area. Sediments on the continental slope are expected to comprise very soft sandy clay/silt.

Six major and nine minor complete channels were identified on an area of the continental slope traversed by the Trunkline Project Area (SKM, 2006). The presence of sand in the channels was confirmed by drop cores and within the channel base current driven bedforms or erosive “back stepping” of bedding planes were observed. ROV stills show current driven bedforms and rounded cobble sized clasts and sediment clumps in the channel base. Channels are not only developed by seafloor currents but have in the past been conduits for large scale turbidity currents. Present day sedimentary processes are observed to be significant, with active seafloor currents. The area of continental slope between channels undulates and deepens from the SE to the NW over a series of linear and steep scarps from water depths of approximately 250 m to 1100 m (SKM, 2006).

Spoil Ground 5A lies within the Trunkline Project Area between approximately KP 32 to KP 50 and has been previously subject to spoil disposal from the Pluto Foundation trunkline. Given the relocation of sediments from nearby, it is expected that marine sediments will be consistent.

5.3.4.3 Offshore Project Area

The Offshore Project Area is located on the Exmouth Plateau which is characterised by a thick Triassic sequence overlain by a Jurassic, Cretaceous and Cainozoic sediment sequence; and fine-grained carbonate ooze (Fugro, 2010). Sediment transport on the outer shelf/slope of the Exmouth Plateau is influenced by a combination of slope processes and large ocean currents.

Marine sediment quality surveys within the Scarborough (WA-1-R) permit were undertaken during the 2012/2013 wet and dry seasons (ERM, 2013). The ERM marine investigation included sampling at a number of sampling sites, as shown in Figure 5-9, to:

- provide a broad characterisation of the habitats within WA-1-R
- achieve spatial coverage across WA-1-R
- provide a representative selection of the various topographic features and corresponding benthic habitats (i.e. crater/pockmark versus non-crater areas).

While no specific sediment sampling was undertaken within the North Scarborough, Thebe or Jupiter permit areas, given the relatively close distance (<50 km), similar water depths, and exposure to similar oceanographic conditions, the sediment characteristics of the Scarborough field are considered to be representative of the Offshore Project Area.

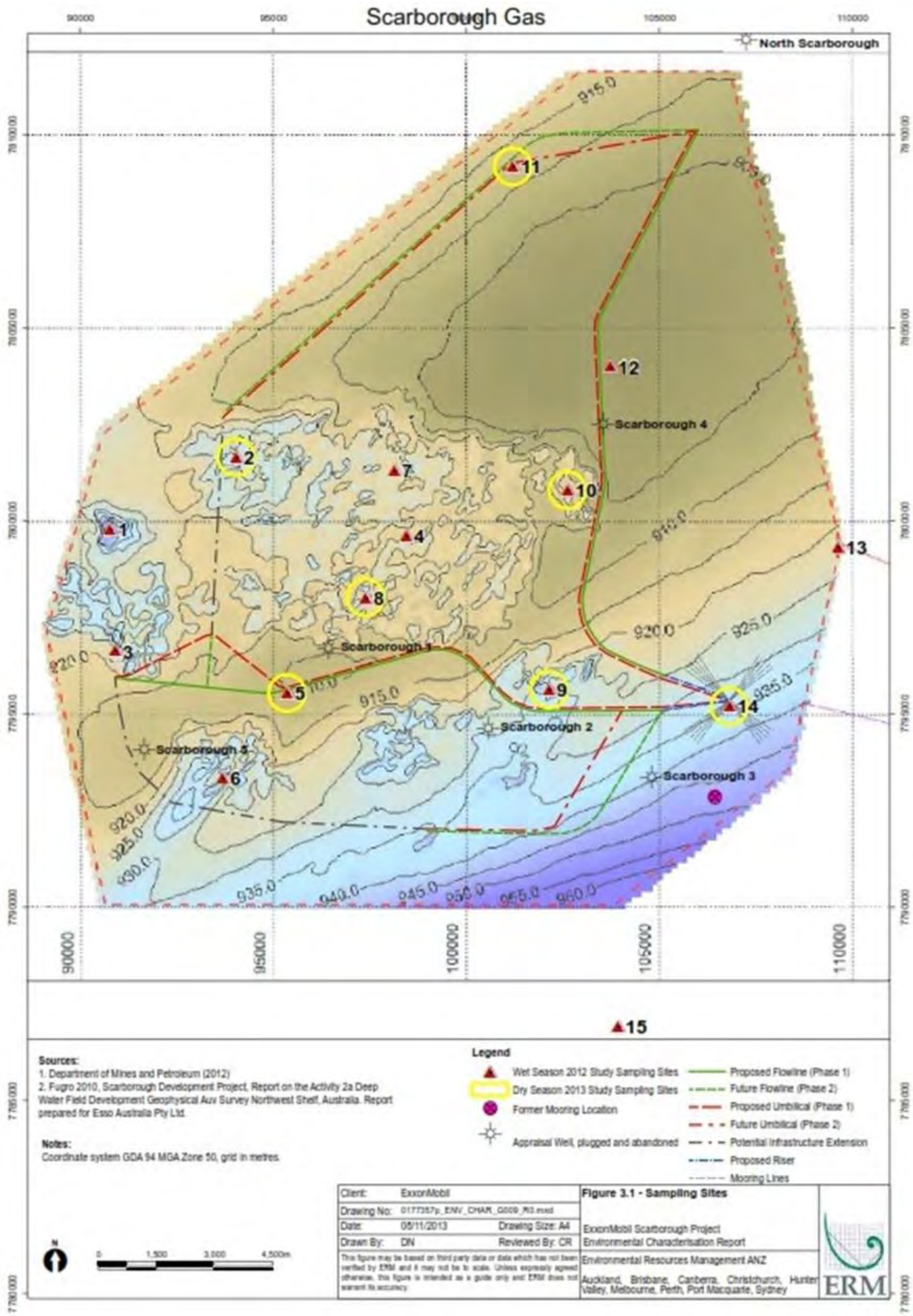


Figure 5-9: Sampling sites in the Permit Area WA-1-R on the Exmouth Plateau, undertaken by ERM in the wet and dry seasons of 2012/2013 (Source: ERM, 2013)

Key results included:

- All the sediment samples collected were predominantly (≥97% w/w) composed of clay and silt; and only small amounts (1–3% w/w) of sand and shell were detected (Figure 5-10).
- Generally, low concentrations of metals and nutrients were detected.
- No hydrocarbons were detected.

Although crater and pockmark formations have been identified in the Offshore Project Area, which have been associated with hydrocarbon seeps and authigenic carbonate formations (Fugro, 2010), the absence of hydrocarbons in sediment samples indicates the lack of recent hydrocarbon seep activity in the locations sampled (ERM, 2013).

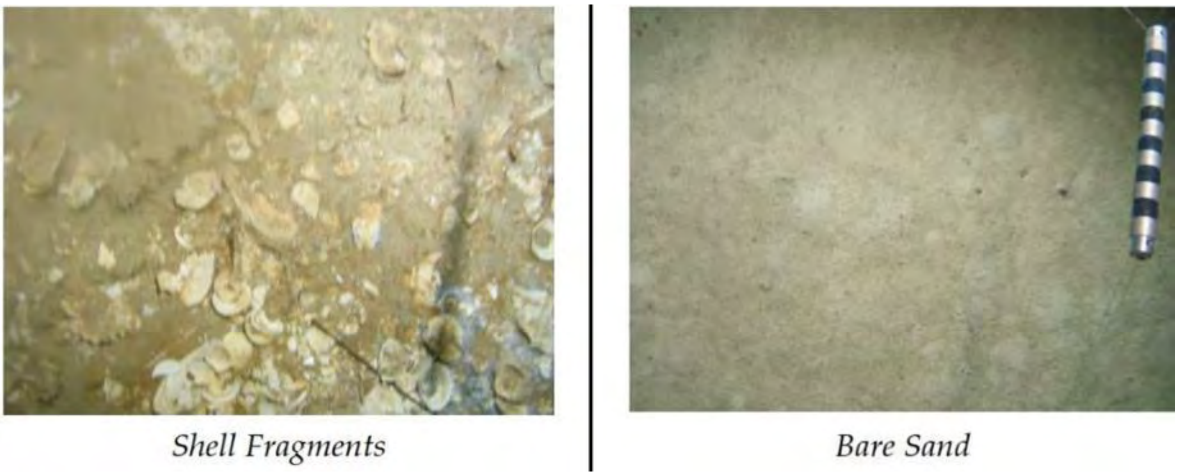


Figure 5-10: Sediment types of Permit Area WA-1-R collected as still imagery during Habitat Characterisation Survey (ERM, 2013)

5.3.4.4 Borrow Ground Project Area

The Borrow Ground Project Area lies within close proximity to the Dampier Archipelago (~15 km to the NNE) within the Lampert Shelf. The Lampert Shelf is dominantly comprised of Cretaceous-Cenozoic sedimentary rocks of up to 2000 m thick. The sediment formation of the offshore area surrounding the Archipelago, including the Borrow Grounds is known as the Delambre Formation which predominantly comprises of calcium carbonate skeletal remains or marine organisms ranging in particle size from millimetres to a few microns.

5.3.5 Water Quality

5.3.5.1 Region and EMBA

Marine water quality considers chemical, physical and biological characteristics with respect to its suitability to support marine life, or for a purpose such as swimming or fishing. Marine water quality can be measured by several factors, such as the concentration of dissolved oxygen, the salinity, the amount of material suspended in the water (turbidity or total suspended solids) as well as the concentration of contaminants such as hydrocarbons and heavy metals.

In the NWMR, water quality is regulated by the Indonesian Throughflow, which plays a key role in initiating the Leeuwin Current and brings warm, low-nutrient, low-salinity water to the NWMR. It is the primary driver of the oceanographic and ecological processes in Western Australia. Water quality is expected to reflect the offshore oceanic conditions of the Western Australian coast wider region which has high water quality, with the exception of water quality in ports and harbours that can be locally influenced by industry effluent.

Coastal waters of the Pilbara are turbid due to a combination of high tidal ranges and terrestrial run-off from rainwater, peaking during summer months (Human and McDonald 2009). Cyclones are a prevalent meteorological feature during summer that adds to the turbidity (DEWHA, 2008a).

The water quality is influenced by tidal conditions and pre-existing disturbances that cause increased turbidity levels (MScience, 2018b). Karratha is a major hub with existing infrastructure including the Port of Dampier, Karratha Gas Plant and Pluto Trunkline. Mermaid Sound off Dampier was exposed to elevated turbidity conditions during the Mermaid Sound dredging projects in 2004, and dredging of Woodside Pluto Trunkline in 2009 (MScience, 2018a, 2018b). Increased turbidity and reduced water quality were restricted to the dredging sites. Increased turbidity has been recorded within 500 m of the dredge site and turbidity outside 500 m of the dredge site was below the 80th percentile of turbidity at two reference sites (MScience, 2018a).

In coastal waters off Dampier, dissolved concentrations of a range of heavy metals (e.g. cadmium, copper, and mercury) and organic chemicals (e.g. petroleum hydrocarbons) are generally of very high quality with little or no organic chemical detected in any of the samples and heavy metal levels approaching those in the open ocean (DEWHA, 2008). Sediment quality in nearshore waters of the NWMR is regarded as very good. Studies showed slight elevations of some metals in inner Dampier port (DoE, 2006).

5.3.5.2 Trunkline Project Area and Borrow Ground Project Area

Water quality along the Trunkline Project Area portion of the Project area and the Borrow Grounds Project Area is expected to be typical of an unpolluted tropical offshore environment. The nearshore coastal waters of the Pilbara are turbid due to a combination of high tidal ranges and terrestrial runoff from rainwater, peaking during summer months (Human and McDonald, 2009). Cyclones are a prevalent meteorological feature during summer that adds to the turbidity (DEWHA, 2008a). Off Dampier Archipelago, dissolved concentrations of a range of heavy metals (e.g. cadmium, copper, and mercury) and organic chemicals (e.g. petroleum hydrocarbons) are generally of very high quality with little or no organic chemical detected in any of the samples and heavy metal levels approaching those in the open ocean (DEWHA, 2008a).

5.3.5.3 Offshore Project Area

Water quality in the Offshore Project Area is typical of an unpolluted tropical offshore environment. Much of the surface water in this area is nutrient poor, transported from the Indonesian Throughflow and has low primary productivity.

The marine water quality of the offshore environment of the Exmouth Plateau was measured by collecting triplicate water samples at three stations per 15 sampling sites (across two seasons) (ERM, 2013a). Key results from the water profiling and water quality sampling undertaken in the 2012/2013 wet and dry seasons are summarised in Figure 5-11 and Figure 5-12. Key results include:

- The deeper waters had significantly lower dissolved oxygen concentrations (about 23%) compared to the oxygen-saturated (≥100%) surface waters.
- Generally low concentrations of metals, nutrients and chlorophyll-a were detected.
- Total suspended solid mean concentrations were higher during the wet season (22,450 µg/L) than the dry season study (4000 µg/L) and showed variability across sites and throughout the water column.
- No hydrocarbons were detected.

Results from the studies indicated that the water quality within the WA-1-R permit area is generally typical of the North-west Marine Bioregion's tropical deep-water environment (ERM, 2013a).

Depth	Season Study	Temperature (°C)	Conductivity (mS/cm)	Turbidity (FTU)	pH	DO (%SAT)
Full Water Column	Wet	12.7 (5.0 - 26.1)	41.0 (32.3 - 54.0)	5.2 (0.0 - 124.3)	8.0 (7.8 - 8.6)	52.9 (22.1 - 106.7)
	Dry	11.8 (5.0 - 25.2)	40.0 (33.6 - 52.6)	0.0 (0.0 - 1.8)	8.0 (7.7 - 8.3)	53.9 (21.8 - 104.2)
Surface (Top 10 m)	Wet	25.6 (23.1 - 25.9)	53.6 (0 - 54.0)	5.7 (0.0 - 120.0)	8.2 (8.0 - 8.8)	113.0 (96.5 - 128.7)
	Dry	24.8 (24.7 - 25.2)	52.1 (51.6 - 52.6)	0.2 (0.1 - 0.8)	8.2 (8.2 - 8.3)	101.6 (100.8 - 104.2)
Bottom (Bottom 10 m)	Wet	5.1 (5.0 - 5.2)	33.8 (33.6 - 34.0)	5.0 (4.6 - 6.8)	7.8 (7.8 - 7.9)	22.7 (22.2 - 23.8)
	Dry	5.1 (5.0 - 5.3)	33.7 (33.6 - 33.8)	0.3 (0.0 - 1.7)	7.8 (7.7 - 7.9)	23.0 (22.4 - 25.1)

Parameter readings are shown as mean with total range in brackets.

Figure 5-11: Water profiling results summary from marine surveys undertaken in permit area WA-15-R (ERM, 2013)

Depth	Season Study	Ammonia	Nitrate (as NO3−)	Nitrogen (total oxidised)	Total Nitrogen	Phosphorus	Reactive Phosphorus (as P)
Full Water Column	Wet	12 (<5-75)	711 (<50-2400)	160 (<5-530)	251 (<50-650)	40 (<10-130)	27 (<5-86)
	Dry	11 (<5-18)	680 (<50-2400)	153 (<5-<550)	367 (210-750)	28 (<10-90)	28 (<5-91)
Surface (Top 10 m)	Wet	11 (<5-49)	25 (<50-<50)	2.50 (<5-<5)	86 (<50-190)	13 (<10-80)	2.50 (<5-<5)
	Dry	15 (12-17)	25 (<50-<50)	5.30 (<5-11)	240 (210-260)	5 (<10-<10)	5.50 (<5-7)
30 m	Wet	8.20 (<5-30)	56 (<50-400)	9.70 (<5-110)	114 (<50-340)	13 (<10-30)	3.50 (<5-17)
	Dry	5.70 (<5-18)	55 (<50-110)	13 (<5-24)	230 (210-250)	6.70 (<10-10)	4.80 (<5-6)
150 m	Wet	9 (<5-34)	456 (<50-600)	103 (<5-140)	201 (80-420)	40 (<10-130)	16 (<5-21)
	Dry	11 (<5-17)	243 (120-440)	55 (28-99)	270 (240-310)	12 (<10-20)	12 (7-19)
Bottom (Bottom 10 m)	Wet	18 (<5-73)	2,307 (2,100-2,400)	523 (470-530)	601 (530-680)	95 (70-120)	85 (83-86)
	Dry	11 (<5-16)	2,400 (2,400-2,400)	540 (530-550)	727 (710-750)	87 (80-90)	89 (86-91)

Parameter readings are shown as mean with total range in brackets.

Nitrite was not detected in the samples.

Figure 5-12: Water quality nutrients key results summary (µg/L) from marine surveys undertaken in permit area WA-15-R (ERM, 2013)

5.3.6 Air Quality

There is a lack of air quality data for the NWP and greater offshore NWMR air shed. However, the area is very remote relative to other areas of Australia and globally and therefore air quality in nearshore and offshore waters of the Pilbara area is considered high.

While vessels and industry developments contribute to emissions in the area, results from previous monitoring (e.g. DEP, 2002; CSIRO, 2008) around the Burrup Peninsula suggest that concentrations of measured air quality parameters remain low (ERM, 2012). For example, nitrogen dioxide (NO_2) concentrations during the early Pilbara air quality study were below NEPM standards (DEP, 2002; ERM, 2012). Similarly, during the rock art air quality studies, concentrations of NO_2 were higher at sites closer to industrial sources (e.g. monthly average of 3.5–3.8 ppb) but was still considered as a low concentration (CSIRO, 2008).

Due to the extent of the open ocean area and the activities that are currently undertaken within the NWS, it is considered the ambient air quality in the EMBA and wider offshore NWMR will be high.

5.3.7 Ambient Light

The Project Area is offshore and remote from urban or industrial areas; as such local light emissions via anthropogenic sources are limited to vessel traffic, particularly within fisheries zones and shipping fairways (Figure 5-56) and oil and gas infrastructure (Figure 5-57). At the eastern end of the Trunkline Project Area (KP 32.7 – KP 50), anthropogenically generated light is likely to increase due to the proximity to industrial activity. Heavy vessel traffic exists within the Pilbara Port Authority management area which recorded 10,521 vessel movements in the 2018/19 annual reporting period (PPA, 2019). Twenty-six designated anchorages for bulk carriers, petroleum and gas tankers, drilling rigs, offshore platforms, and pipe lay vessels are located offshore of Rosemary Island.

5.3.8 Ambient Noise

Physical and biological processes contribute to natural background sound. Physical processes include that of wind and waves while biological noise sources include vocalisations of marine mammals and other marine species.

Underwater noise surveys in the region detected fauna noise (Antarctic blue whales; pygmy blue whales; dwarf minke whales; Bryde's whales; sperm whales; humpback whales; Antarctic minke whales; dolphins; and one fish chorus) and artificial noise (vessel noise; seismic survey signals; mooring noise artefacts) (McCauley, 2011).

5.3.9 Planktonic Communities and productivity

EMBA

Plankton within the EMBA is expected to reflect the conditions of the NWMR. Primary productivity of the NWMR is generally low and appears to be largely driven by offshore influences (Brewer et al., 2007), with periodic upwelling events and cyclonic influences driving coastal productivity with nutrient recycling and advection.

Seasonal weather patterns also influence the delivery of nutrients from deep-water to shallow water. Cyclones and north-westerly winds during the north-west monsoon (approximately November–March) and the strong offshore winds of the south-east monsoon (approximately April–September) facilitate the upwelling and mixing of nutrients from deep-water to shallow water environments (Brewer et al., 2007). Aggregations of marine life, high primary productivity and species richness on the reefs are likely due to the steep rise of the reef from the seabed. On the shelf within the nearshore waters, the plankton abundance and diversity are considered relatively low.

Zooplankton and may include organisms that complete their lifecycle as plankton (e.g. copepods, euphausiids) as well as larval stages of other taxa such as fishes, corals and molluscs. Peaks in zooplankton such as mass coral spawning events (typically in March and April) (Rosser and Gilmour, 2008; Simpson et al., 1993) and fish larvae abundance (Department of Conservation and Land Management, 2005) can occur throughout the year.

Within the region, peak primary productivity occurs in late summer/early autumn, along the shelf edge of the Ningaloo Reef. It also links to a larger biologically productive period in the area that includes mass coral spawning events, peaks in zooplankton and fish larvae abundance (Department of Conservation and Land Management, 2005) with periodic upwelling throughout the year.

Trunkline Project Area and Borrow Ground Project Area

Primary productivity in the NWMR is generally low, with boom and bust cycles driven by monsoonal seasonality. Seasonal weather patterns also influence the delivery of nutrients from deep water to shallow water. Cyclones and north-westerly winds during the north-west monsoon (approximately November–March) and the strong offshore winds of the south-east monsoon (approximately April–September) facilitate the upwelling and mixing of nutrients from deep-water to shallow water environments (Brewer et al., 2007). Aggregations of marine life, high primary productivity and species richness on the reefs and in the surrounding Commonwealth waters are likely due to the steep rise of the reef from the seabed. This causes nutrient-rich waters from below the thermocline (about 100 metres) to mix with the warmer, relatively nutrient-poor tropical surface waters via the action of internal waves and from mixing and higher productivity in the lee of emergent reefs (Brewer et al., 2007). For this reason, in general, within the NWMR shallower, nearshore environments are more productive, decreasing in productivity with increasing depth.

Offshore Project Area

Productivity is generally considered to be low in the region and on the Exmouth Plateau, with upwelling events and peaks in primary productivity occurring during both the wet and dry seasons (Brewer et al., 2007; DEWHA, 2008a). Satellite observations indicate that productivity is enhanced along the northern and southern boundaries of the plateau and along the shelf edge (Figure 5-13). This in turn suggests that despite the region's productivity being low, the plateau is a significant contributor to that productivity (Brewer et al., 2007).

Sampling within the Offshore Project Area returned low phytoplankton densities (ERM, 2013). Seasonal variation was observed in the samples with total recorded taxa, species richness and species diversity (Shannon-Weiner) being significantly greater in the dry season than in the wet season (ERM, 2013). Dinoflagellates were the most abundant group within wet season study, and diatoms were generally the most abundant group in dry season study (ERM, 2013).

Similarly, greater species abundance and diversity was recorded in zooplankton samples during the dry season compared to the wet season (ERM, 2013). Copepods were the most dominant taxonomic group during both studies in terms of abundance and concentrations, with other zooplankton including ostracods, molluscs (pteropods), euphausiids (krill) and larvaceans also being identified in relatively abundant amounts (ERM, 2013).

Concentrations of fish larvae were similar in both wet and dry season samples. For both seasons ichthyoplankton communities largely comprised the larvae of meso-pelagic fishes (Myctophidae (lantern fishes) and Gonostomatidae (bristlemouths)) (ERM, 2013).

It is noted that these survey findings do not reflect the productivity trends reported in scientific literature for the region (DEWHA, 2008a; Brewer et al., 2007), whereby productivity is typically greater during the wet season when the weakening of surface currents allows for increased upwelling. However, the findings do indicate that productivity remains low across the seasons and that while seasonal variations in plankton species composition potentially occurs, variations in abundance are likely to be overall minor (ERM, 2013).

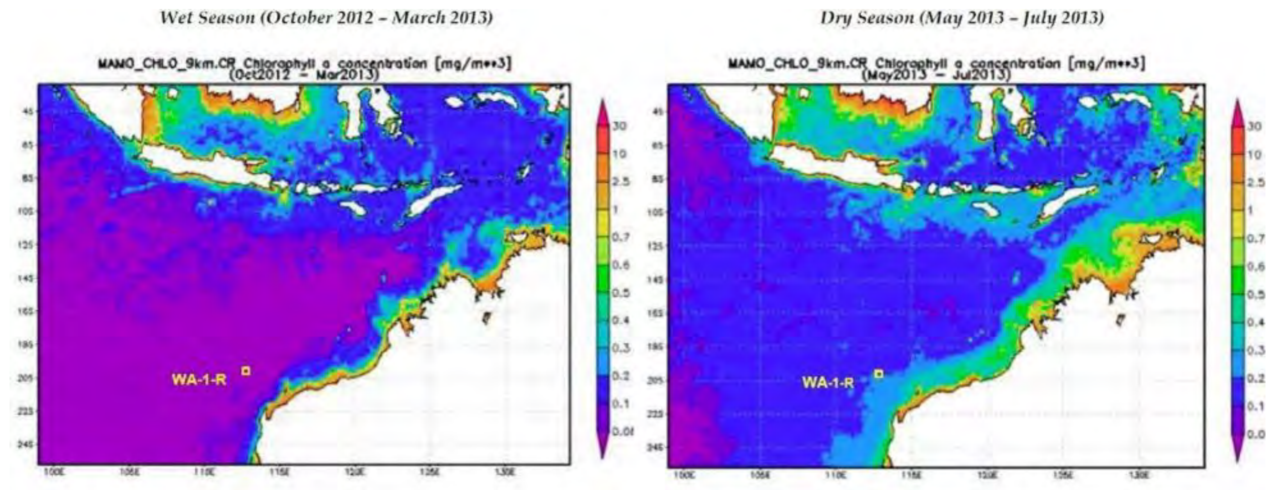


Figure 5-13: Seasonal satellite primary productivity imagery (Source: ERM, 2013a)

5.3.10 Epifauna and Infauna

Region and EMBA

Studies completed within the region indicate that benthic composition in deep water habitats is generally lower in abundance than shallow water habitats of the region (DEWHA, 2008a; Brewer et al., 2007). Gage (1996) reported that the density of benthic fauna tends to be lower in deep water sediments (>200 m) than in shallower coastal sediments, but the diversity of communities may be similar.

The area of shallower waters between Dampier and Port Hedland is a hotspot for sponge biodiversity. There is a high species richness of sponges within the region. A total of 275 species have been recorded through three studies (Fromont, 2004, 2017) that looked at the biodiversity (distribution and habitat) of sponges in the Damper Archipelago. This biodiversity in the Dampier AMP (see Section 5.6.1.4) may reflect short pelagic stages for sponge larvae, resulting in minimal larval exchange and high population differentiations between sponge communities (Director of National Parks, 2018).

Trunkline Project Area

From the State waters boundary to approximately KP 50 the geophysical and geotechnical survey results showed that the seabed was generally flat and featureless comprising carbonate sand and shell gravel. There were some areas of sorted accumulations of coarser sediments and some small depressions but these are not expected to support significant benthic communities. As part of the Pluto LNG Foundation Project, surveys were completed to determine the presence and extent of any sessile benthic assemblages adjacent to the proposed trunkline route. The survey was completed between the State waters boundary and to a point adjacent KP 50.3 to determine the suitability of the area for an offshore spoil disposal ground (Woodside, 2009). Twenty-nine sites were surveyed with a drop camera (Figure 5-14). The seabed was characterised as fine to coarse sand with low species abundance and diversity with sparse sponges and soft corals typical of habitat on the North West Shelf. The seabed substrate observed on the drop camera footage was representative of the area (predominantly fine to coarse sand) and is consistent with the geophysical and geotechnical data collected along the trunkline route. Sparse ascidians, sponges, invertebrate communities, burrowing organisms and octocorals were observed from the drop camera study. This benthos is considered representative of the area and is similar to that observed in other regional studies (Keesing 2019, Advisian 2019b). Given that the seabed substrate observed in the drop camera study aligns with the geophysical and geotechnical data collected along the trunkline route and that the drop camera study was within 1km of the proposed trunkline route, benthic communities and habitats along the proposed trunkline route are expected to be similar to those observed in the drop camera study.

The drop camera surveys completed in Spoil Ground 5A prior to its use for the Pluto foundation project showed that benthic communities and habitats were sparse. Sediments disposed at the spoil ground from the Pluto trunkline route and are expected to be broadly similar to those noted in the original drop camera survey, given the proximity of sourced materials (<1km). Further given that the spoil ground is expected to contain sediments that are similar to those observed prior to its original use and that the area has been previously disturbed during the Pluto foundation project, epifauna is expected to be sparse within Spoil Ground 5A.

Figure 5-14: Benthic habitat survey from KP 32 to KP 50

Between KP 52.5 and KP 109 the seabed is generally featureless with the exception of some depressions noted from the geophysical data that appear to expose the underlying calcarenite and areas where the underlying calcarenite is intermittently exposed at the seabed (Table 5-2). The areas of calcarenite are often overlain with a thin veneer of sediments which limits the spatial area of hard exposed substrate. Seabed sediments were confirmed from the geotechnical survey as comprising carbonate sands with some silt and shell gravel. The calcarenite outcrops generally run perpendicular to the trunkline and are spread widely over the North West Shelf (Wilson, 2013). Any intersections of the isolated calcarenite outcropping identified from the geophysical data represent a very small area (<0.01km^2), given the 32 inch diameter of the pipeline. Given the small area of disturbance from the trunkline, the isolated nature of the calcarenite outcrops along the trunkline route and the wide distribution of these outcrops across the North West Shelf (Wilson 2013), no significant impacts to filter feeder communities that may colonise the outcrops along the trunkline route are predicted.

The trunkline route intersects the Montebello Islands Marine Park between KP 109 and KP 191.7. The seabed along the South East corner of the Montebello Islands Marine Park between KP 109 and KP 145 is generally featureless with the exception of some depressions noted from the geophysical data that appear to expose the underlying calcarenite (Table 5-2). From KP 117.7 some calcarenite outcrops intersect the trunkline route. The CSIRO study (Keesing 2019) summarised in Section 5.6.1.3 showed that the topography in the vicinity of the Scarborough trunkline is predominantly flat bottom with some occasional bioturbated areas, and the substrate is typically fine sands, although site 81 is predominantly rock (Figure 5-43). These sites within the vicinity of the Scarborough trunkline had low numbers of sponges, whips and gorgonians (Figure 5-44) and as a result, complex benthic filter feeder communities were largely absent.

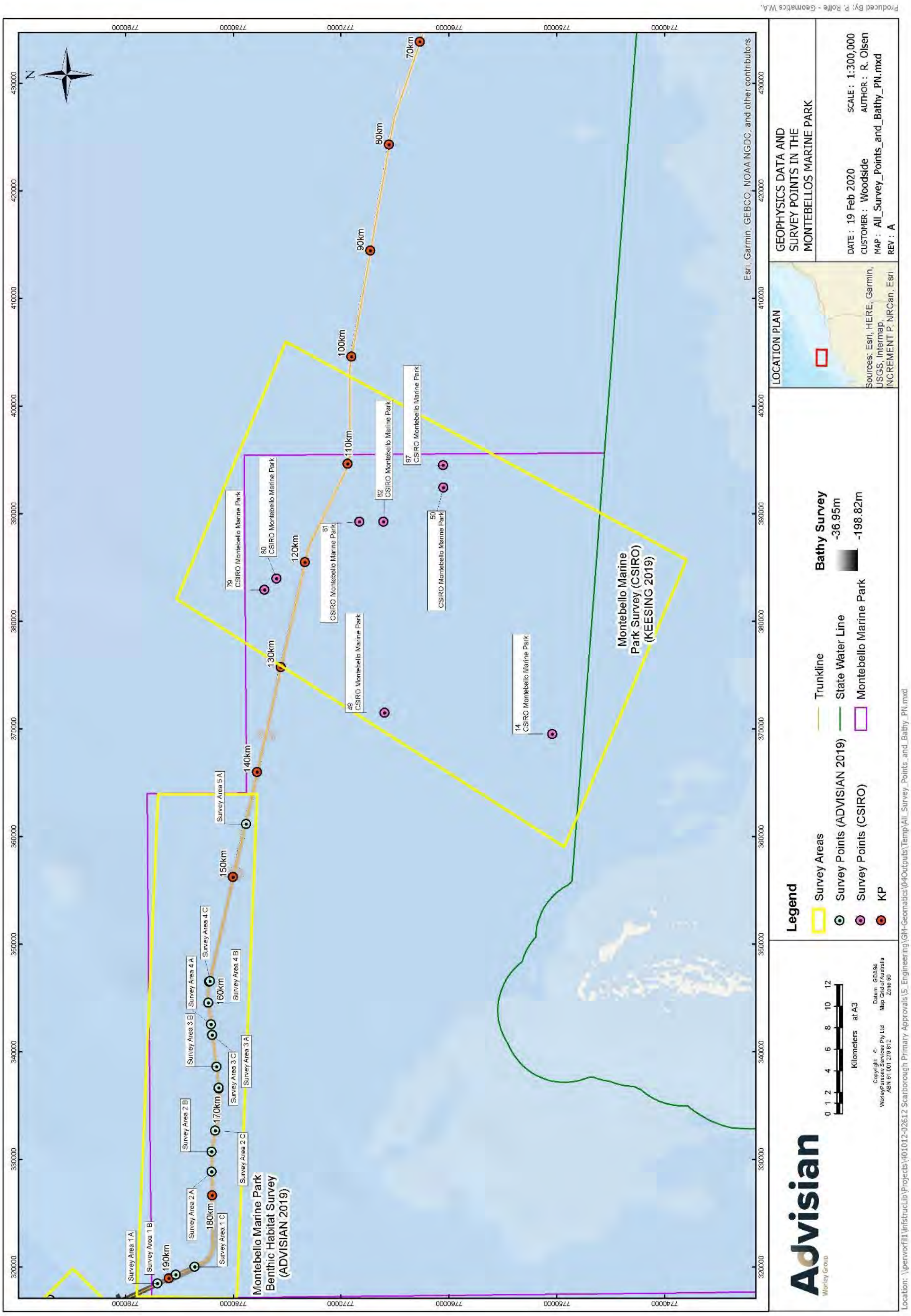


Figure 5-15: Montebello Survey Sites

From KP 145 to KP 192 the seabed starts off generally featureless with the exception of some small depressions. From approximately KP 173 the calcarenite exhibits subtle northeast-southwest oriented lineations observed in the bathymetry, but a veneer of sediment is thought to cover these outcrops. From approximately KP 185 relict sandwaves are observed from the geophysics data. Due to the increased complexity in this area of the Montebello Islands Marine Park additional survey work was completed (Section 5.6.1.3). Analysis of the high definition ROV video data (Advisian, 2019b) found that the area in which the trunkline intersects the North West section of the Montebello AMP is characterised by bare sandy sediments, interspersed with predominantly sparse benthic communities and epifauna (Table 5-10, Figure 5-41). Denser areas of sponges were observed in areas identified from the bathymetry as having a more complex seabed structure. Further description of the epifaunal communities in the Montebello Islands Marine Park is provided in Section 5.6.1.3.

From KP 192 to the continental slope the seabed is generally featureless. Epifauna was most abundant on the continental shelf compared to the slope and the abundance of the fauna appeared to be inversely associated with depth, with distinct differences in the fauna on the shelf and slope. The assessment of the offshore habitats that occur on the continental shelf (<300 m water depth), have been based on ROV footage collected as part of subsea facility inspections around the Pluto field within Permit Area WA-34-L and WA-48-L. While the Pluto platform itself is located within WA-48-L, in 83 m water depth, much of the subsea infrastructure including pipelines and wellheads are in WA-34-L in ~190 m water depth. The seabed composition through these areas has been previously described as being predominantly flat and featureless and comprises thick, unconsolidated fine-grained sands. The sediments support soft sediment benthic communities dominated by infauna (including molluscs, crustaceans and worms) and isolated larger fauna (free swimming cnidarian, demersal fish and benthic crustaceans). Interestingly, the habitats containing the greatest biodiversity in these offshore environments are the habitats formed by colonising invertebrates on oil and gas subsea infrastructure including the well heads and pipelines. These habitats and the species present on these structures in the NWS of Western Australia have been recently subject to detailed quantitative and qualitative assessment (McLean et al., 2017, 2018, 2020 Bond et al., 2018a, b).

The bathymetry of the seabed increases in complexity over the continental slope and thus additional survey data has been collected over this area (Figure 5-16 and Figure 5-17).

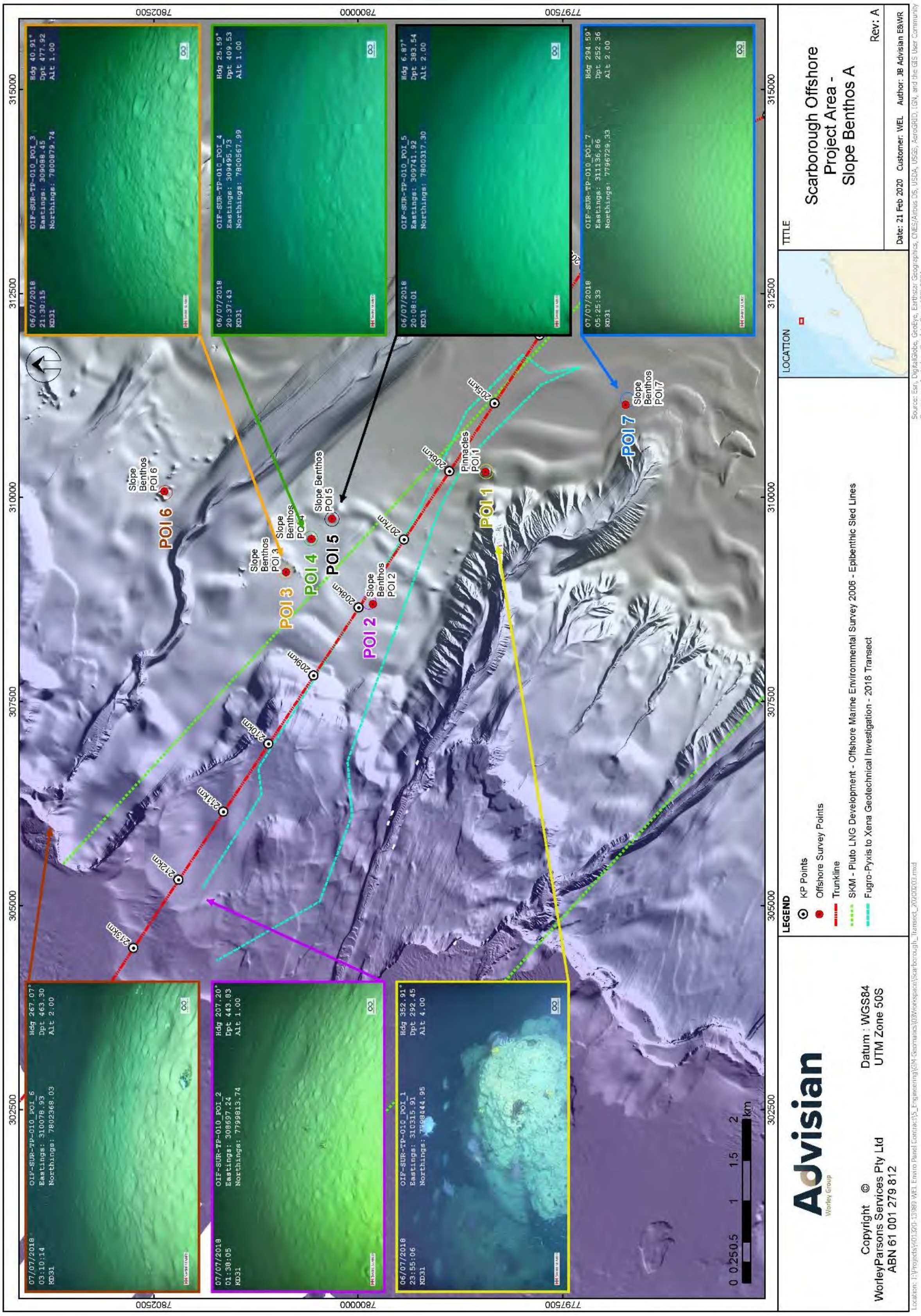


Figure 5-16: North West Shelf and Continental Slope Survey Sites

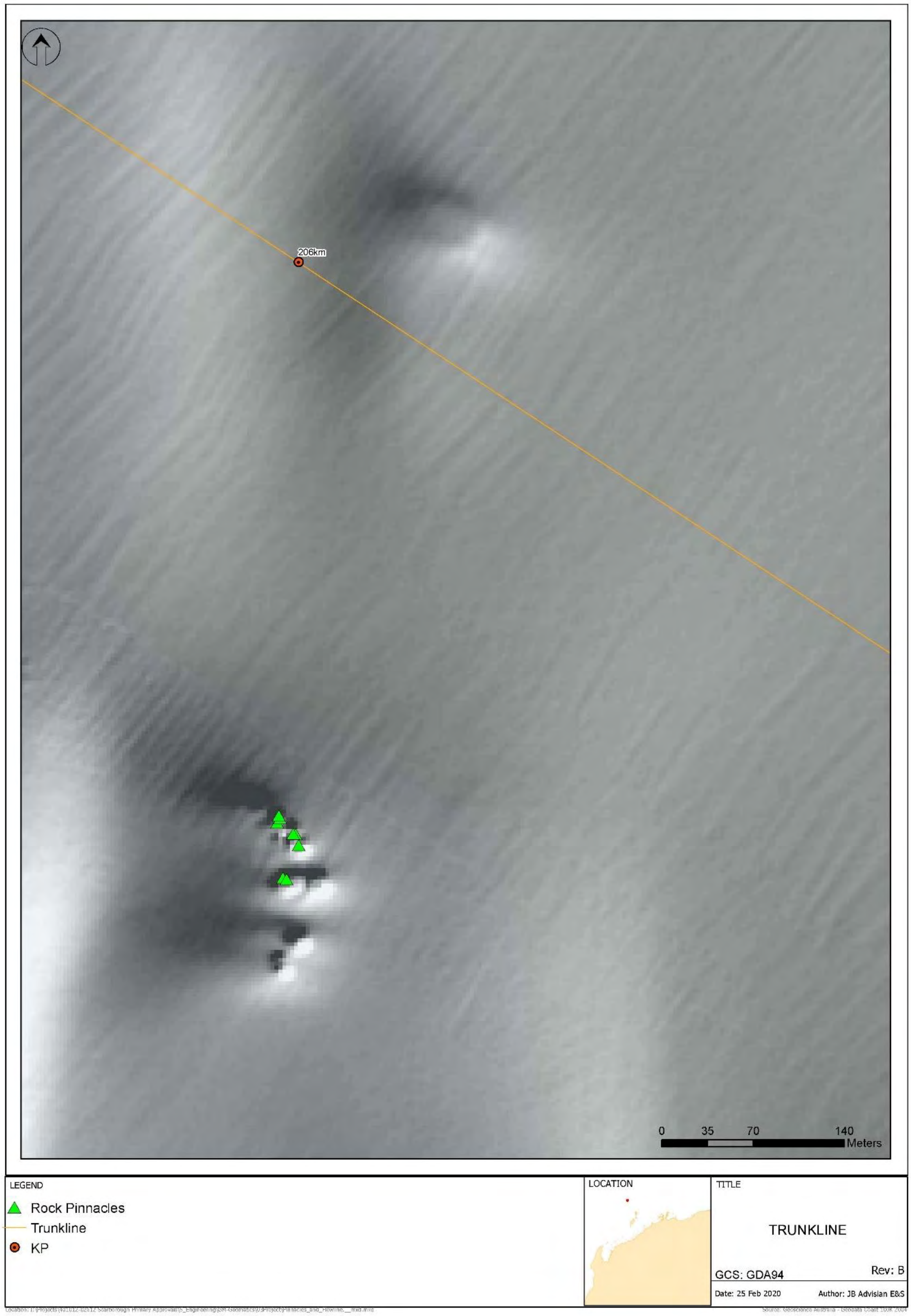


Figure 5-17: Distribution of Pinnacles

A desktop study was undertaken summarising all known information and new survey data on benthic habitats from the offshore slope and deeper development area which the trunkline will pass through and is based on survey work previously completed in the Offshore Project Area (>950 m water depth), on the escarpment of the continental shelf (i.e. slope) (300 to 950 m water depth) and on the shelf (<300 m water depth) (Advisian, 2019a). This included a review of recent marine surveys, including geophysical and ROV surveys that filmed the proposed trunkline route from the Scarborough field such as the Base Case Slope ROV Investigation Field Report Scarborough development Export Pipeline Route Survey (Ocean Affinity, 2018) that conducted ROV inspections along the slope section of the trunkline route between Scarborough and Pluto. An ROV survey of benthic habitats within the Montebello Marine Park was also undertaken and results have been described in Sections 5.5.2 and 5.6.1.3.

The infauna of the continental slope, (as based on data collected from the Pluto field) was very sparse with a maximum density of 167 individuals per m² from a sample collected in 400 m water depth. Infauna was generally more abundant in sites located in shallow water, although this trend with depth was somewhat obscured because three samples contained no infauna, both samples from 800 m and one sample from 1000 m. A total of 47 individuals, representing 32 nominal species, were collected from the 12 samples. The fauna was dominated by polychaetes, which comprised 79% of the fauna by abundance and 75% of the fauna by species richness. Some crustaceans, sipunculids and nemerteans were also recorded but no molluscs or echinoderms were collected in any of the box core samples. Box core samples found the sediments to be silt below about 400 m and fine sand above this depth (SKM, 2006). The infauna recorded was sparse but highly diverse (given the limited number of individuals collected). While a number of epifaunal species had not been recorded previously in Australia, Western Australia or the NWS region, this is attributed to the limited number of previous studies of the continental slope rather than the rarity of the fauna (SKM, 2006).

A survey of the outer shelf and slope habitats (SKM, 2006) included transects within and outside of canyon systems observed from geophysical data along the slope. Over forty hours of ROV footage was collected and twenty-five sled tows completed.

Approximately 1200 specimens were collected from 25 sled tows. Cnidarians, mostly free-living deep water solitary corals, were the most abundant phyla, followed by malacostracan crustaceans, mostly decapods, bony fish, and sponges. Together, these groups accounted for 70% of the fauna by abundance and are typical of those found on the North West Shelf.

The fauna was most abundant along the 200 m contour but this was largely a result of the distribution of the free-living deep water, solitary corals. Seventy percent of the corals collected occurred in samples collected from the 200 m sites. Crustaceans were most abundant at 400 m. Sponges were most abundant in the deeper stations (600 m and 800 m).

The Western Australian Museum identified the sponges, fish, molluscs, echinoderms, cnidarians and most of the crustaceans and made comparisons with existing deepwater collections. Identification of the samples by staff of the Western Australian Museum found that the fauna was consistent with what would be expected to be found at the surveyed depths on the North West Shelf.

The greatest proportion of images analysed from around the Pluto field survey (SKM, 2006) consisted of soft sediments supporting a typically sparse deep-water fauna. The fauna was typical of the fauna expected on the North-West Shelf (NWS) and slope. A total of 231 epifaunal species a species were identified during the SKM (2006) survey. The only natural habitat on the continental slope that is not classified as soft sediment is the rock pinnacle field that lies in about 300 m water depth. Investigations in the vicinity of the pinnacle field covered an area about 1km long x 4 km wide (Figure 5-16), but the pinnacles are isolated forms restricted to an area about 100m long x 75m wide (Figure 5-17), and do not constitute continuous reef. It remains unclear what the rock pinnacles are constructed from, however the structures provide habitat for a diverse range of epifaunal and demersal species that commonly occur elsewhere in the NWS. Many tens of fish were observed gathered around these pinnacles, most probably belonging to either the Glaucosomidae or Pricanthidae families. Crinoids, hydroids and ophiuroids were also common. Other species visible on the mounds include anemones, soft corals, small crustacean like shrimp and some larger brachyurans, possibly Cyrtomaia suhmii (Advisian, 2019a).

Regional and site-specific studies reviewed indicate that seabed material along the proposed Trunkline Project Area (and around the gas field) is predominantly flat and featureless and comprises thick, unconsolidated fine-grained sands (Geoconsult, 2005, SKM, 2006, ERM, 2013).

Where the trunkline would be located within the deeper waters beyond the slope, epifauna and infauna communities would be similar to those described for the Offshore Project Area. The low energy, soft bottom seafloor around Scarborough supports sparse marine fauna as reported for the Exmouth Plateau. Sediments are calcareous, fine-grained and low in nutrients. Benthic communities are dominated by motile organisms, including shrimp, sea cucumbers, demersal fish and small, burrowing worms and crustaceans. No threatened species/ecological communities or migratory species were identified in the previous studies (as defined under the EPBC Act).

Offshore Project Area

Habitat characterisation studies undertaken in the Offshore Project Area included benthic habitat assessment using towed video and stills. At each of the 15 sites, a minimum of 15 minutes of video and 25 stills at three stations were collected (ERM, 2013).

The seafloor composition within the Offshore Project Area is expected to primarily be mud and clay material (Figure 5-8; see also Section 5.3.3). The seafloor in the Offshore Project Area is characterised by sparse marine life dominated by motile organisms (ERM, 2013). Such motile organisms included shrimp, sea cucumbers, demersal fish and small, burrowing worms and crustaceans. This soft bottom habitat also supports patchy distributions of mobile epibenthos, such as sea cucumbers, ophiuroids, echinoderms, polychaetes and sea-pens (DEWHA, 2008). The dominant types of epifauna were arthropods and echinoderms (especially shrimp and sea cucumbers, respectively), while the dominant infauna groups were crustaceans and polychaetes (ERM, 2013). Bioturbation traces are common in the Offshore Project Area (Figure 5-18) and represent presence of benthic infauna including echinoderms and biota including foraminifera, echiurans and annelids (ERM, 2013).

Benthic communities in the Offshore Project Area are representative of the Exmouth Plateau and of deep-water soft sediment habitats reported in the region (e.g. BHP Billiton, 2004; Woodside, 2005; Woodside, 2006; Brewer et al., 2007; RPS, 2011; Woodside, 2013; Apache, 2013). No organisms identified to species level for the ERM (2013) studies were listed as Threatened or Migratory under the EPBC Act according to the Species Profile and Threats (SPRAT) database.

Figure 5-18: Example of typical benthic habitat and bioturbation traces observed in Permit Area WA-1-R (ERM, 2013)

Hydrocarbon Seep-Associated Benthic Communities

Hydrocarbon seeps are the seeping of gaseous or liquid hydrocarbons (including oil and methane) to the surface of the seabed from fractures and fissures in the underlying rock, resulting in possible hydrocarbons and other chemicals in the water column (DEWHA, 2008). It is possible that these formations may host thiotrophic (sulphur-based metabolism) or methanotrophic (methane-based metabolism) benthic communities and chemosymbiotic benthic fauna reliant on methane-oxidising bacteria, which usually aggregate in the form of mats over the seafloor (Barry et al., 1996).

Naturally occurring hydrocarbon seeps are known to be present in the region; however, no indication of active seeps was observed during marine surveys (ERM, 2013). Bivalve shell debris and bacterial mats (both with low percent cover, Figure 5-19) were the only identified features that may be indicative of historic hydrocarbon seep activity. The benthic infauna analysis provided no evidence of the presence of unique hydrocarbon seep chemosynthetic benthic communities, which are typically characterised by species from the family Dorvilleidae (ERM, 2013; Thornhill et al., 2012).

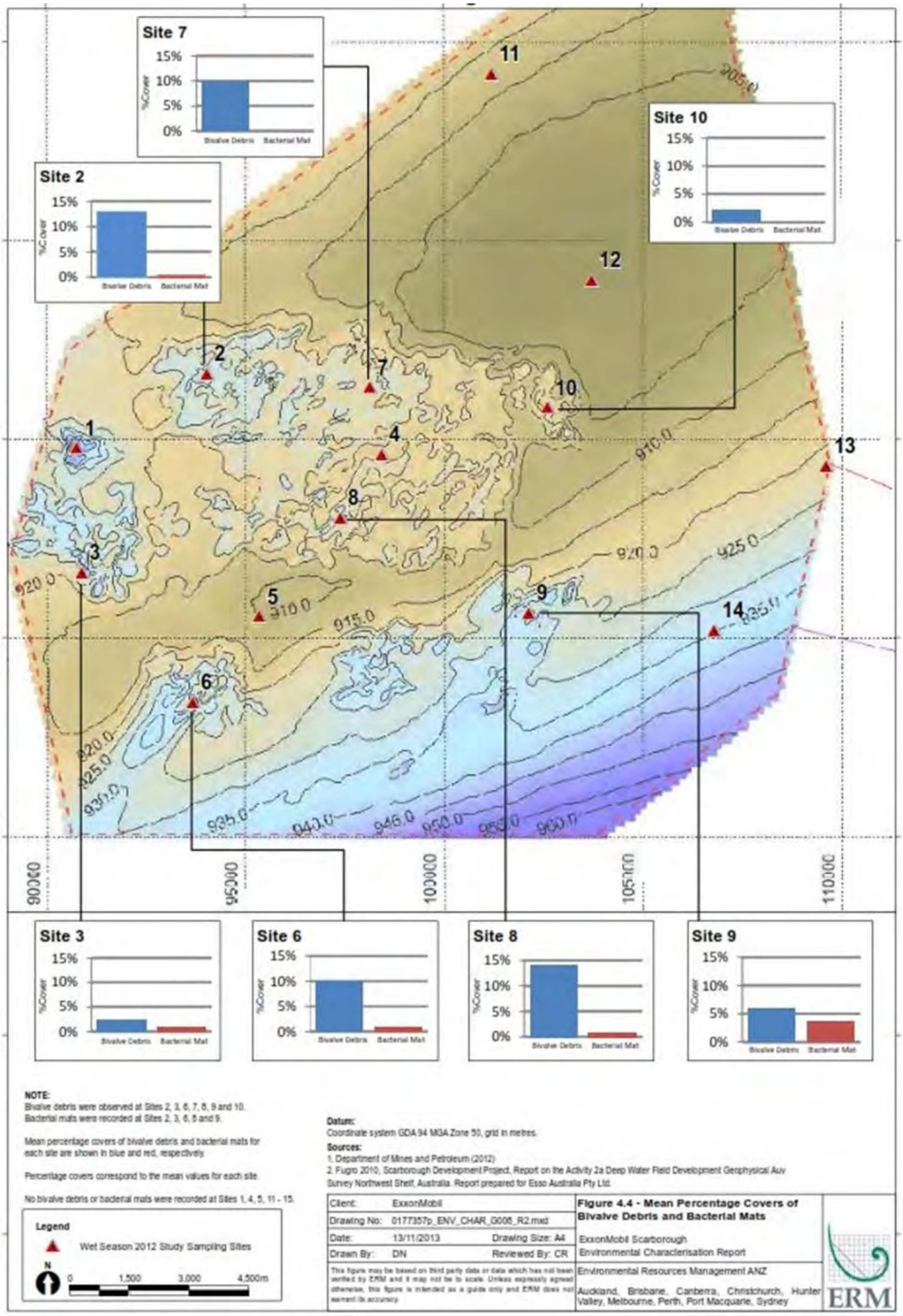


Figure 5-19: Mean percentage cover of bivalve debris and bacterial mats at study sites samples in the permit area WA-15-R (source: ERM, 2013)

Borrow Ground Project Area

Preliminary findings from the benthic habitat survey completed in the Borrow Ground Project Area and adjacent areas of the Dampier AMP suggest that the benthic habitat is dominated by sandy bottom and with little to no biota (Advisian, 2019c). Data captured included high resolution still images and video footage at 24 drop camera locations outside the marine park and 51 drop camera locations within the marine park. Within and outside the marine park little or no invertebrates were observed (<10% coverage) (Figure 5-20 and Figure 5-21).

Figure 5-20: Example image of typical sand habitat with no biota observed within the Dampier Marine Park area of interest

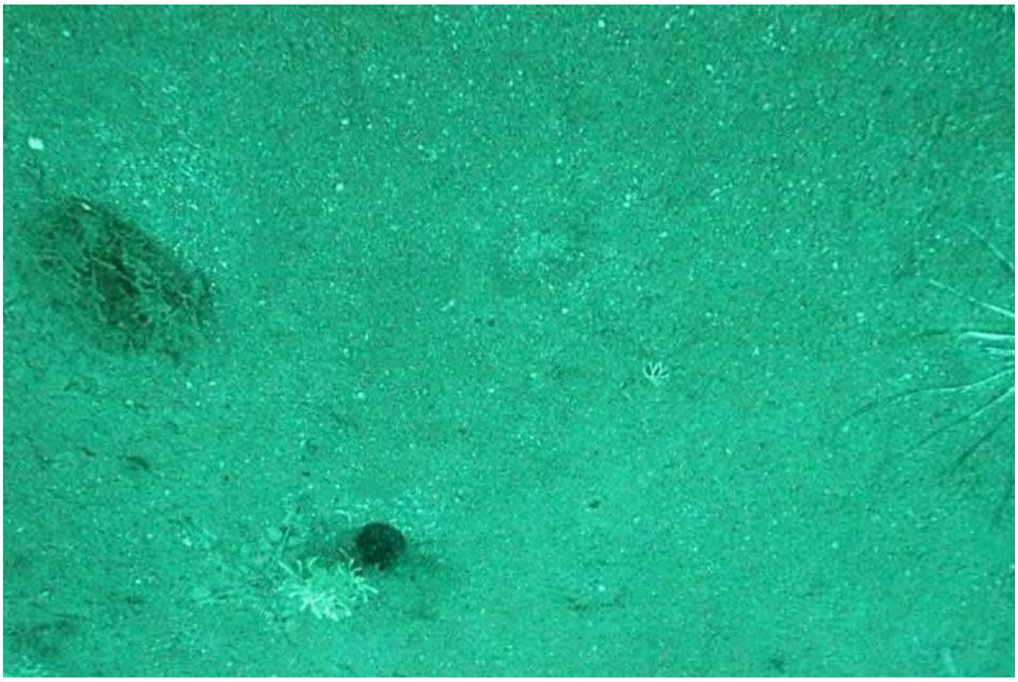


Figure 5-21: Example image of sand habitat with sparse invertebrates (<10%) observed within the Dampier Marine Park area of interest

5.3.11 Coral

EMBA

Corals are generally divided into two broad groups: the zooxanthellate ('reef-building', 'hermatypic' or 'hard') corals, which contain symbiotic microalgae (zooxanthellae) that enhance growth and allow the coral to secrete large amounts of calcium carbonate; and the azooxanthellate ('ahermatypic' or 'soft') corals, which are generally smaller and often solitary (Tzioumis and Keable, 2007). Hard corals are generally found in shallower (<50 m) waters while the soft corals are found at most depths, particularly those below 50 m (Tzioumis and Keable, 2007).

Both zooxanthellate and azooxanthellate corals are found throughout the Dampier Archipelago, including a total of 229 species from 57 hermatypic coral genera (Woodside, 2006; Griffith, 2004), representing a large proportion of the 318 hermatypic species from 70 genera known to occur in Western Australia (URS, 2004). The most diverse coral assemblages of the Dampier Archipelago are on the seaward slopes of outer islands such as Delambre Island, Legendre Island, Rosemary Island and Kendrew Island (Jones, 2004; CALM, 2005). A recent survey of Legendre Island showed that coral cover was 5.7%. Coral cover has been historically low at Legendre compared to other reefs in the Dampier Archipelago (MScience 2019). All hard coral categories were represented at the Legendre survey site with *Porites* being the most abundant. Areas supporting a broad variety of corals are also found at Madeleine Shoal, Hamersley Shoal, Sailfish Reef and north-west Enderby Island (Woodside, 2006). Madeleine Shoals are approximately 15-30m below sea level.The shoal is has mainly encrusting hard corals, faviids and plates, with many small Dendronepthyea sponges either large mounds or cups and extensive encrustations (Fromont, 2004).

The coral communities along the mainland Burrup Peninsula coast show little evidence of reef development; rather they grow by encrusting solid substrata such as Precambrian rock (URS, 2004; Jones, 2004). Coral reefs have been recorded near King Bay, between Phillip Point and the Dampier Public Wharf; however, water conditions in this area are extremely turbid and the reef is patchy (Water Corporation, 2000). URS (2003) has recorded various species of coral along the western coast of the Burrup Peninsula, with the most dominant genera being *Favities*, *Favia*, *Platygyra*, *Goniastrea* and *Caulastrea*, as well as *Turbinaria* colonies. Other common corals recorded include *Porites*, *Pavona*, *Acropora*, *Lobophyllia*, *Symphyllia*, *Goniopora*, *Montipora* and *Pectinia* species (URS, 2003).

Other significant areas of coral reef in the EMBA include Ningaloo Reef, and those fringing the Muiron Islands, Barrow Island and Montebello Islands.

Trunkline Project Area

Due to the water depths of the majority of the Trunkline Project Area in Commonwealth waters, no zooxanthellate corals are expected to occur. However, free-living soft solitary corals were an abundant phylum observed during sled tow sampling (SKM, 2006). The only natural habitat within the Offshore Project Area and Trunkline Project Area that is not classified as soft sediment is the rock pinnacle field that lies in about 300 m water depth, on the continental slope (Figure 5-16). Investigations of the pinnacle field covered an area about 1km long and 4km wide, but found the the pinnacles are isolated forms restricted to an area about 100m long x 75m wide (Figure 5-17), and do not constitute continuous reef. It remains unclear what the rock pinnacles are constructed from, however the structures provide habitat for a diverse range of epifaunal and demersal species that commonly occur elsewhere in the NWS, including a very low percentage cover of live coral with only a few live specimens of coral observed growing on top of the pinnacles. Professor Murray Roberts (University of Edinburgh) was provided footage of ROV surveys of the rock pinnacles and determined the coral species was "at first glance *Dendrophyllia cornigera* (well known in the Mediterranean Sea), but perhaps more likely a Leptosammia species (same family: Dendrophylliidae)" *(*Advisian, 2019a).

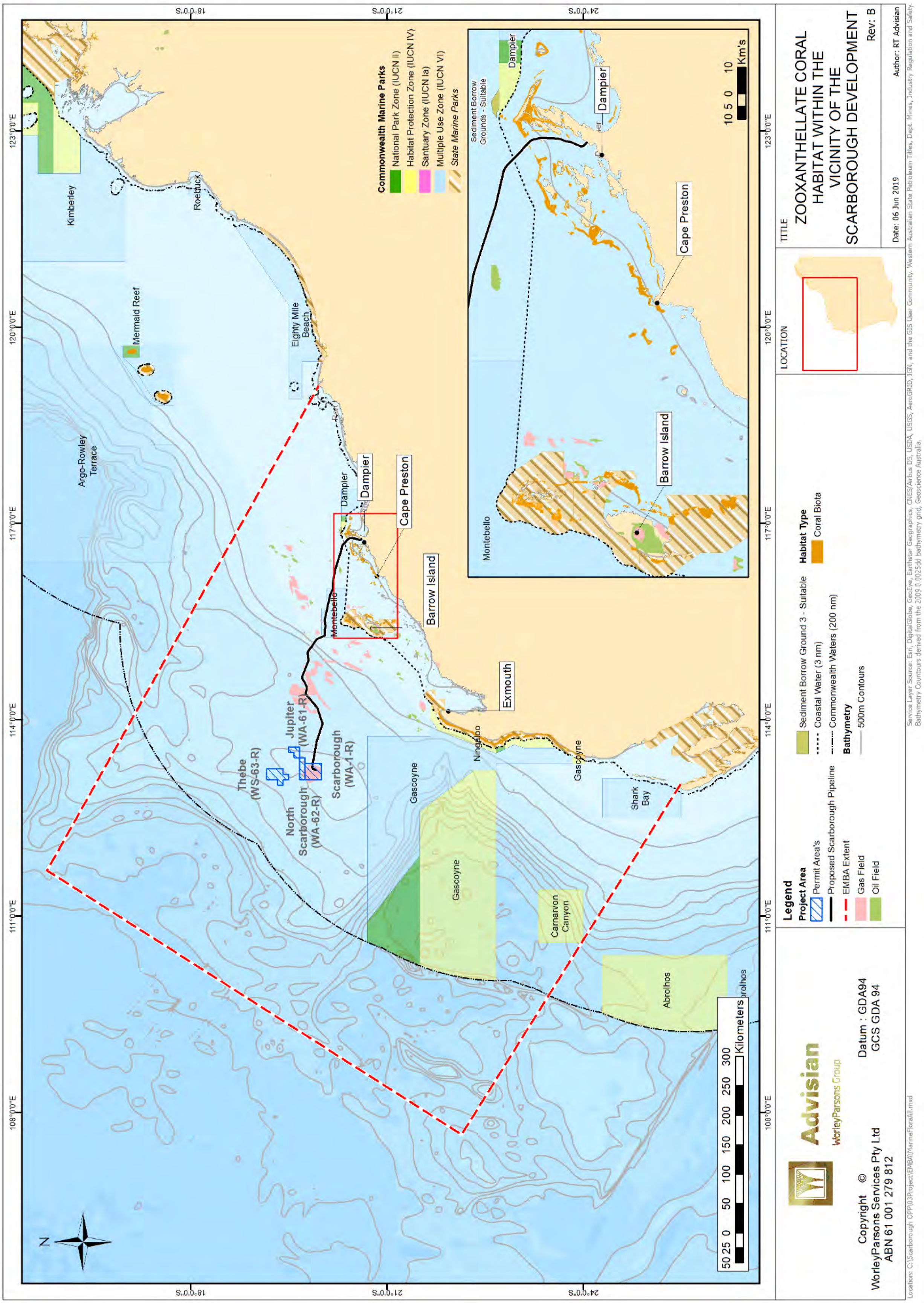


Figure 5-22: Zooxanthellate coral habitat within the vicinity of Scarborough

Offshore Project Area

Given the water depths of the Offshore Project Area, no zooxanthellate corals are expected to occur in this region. Soft corals were observed during surveys in the Offshore Project Area, though were not dominant. Most sites where soft coral was identified were found outside of the seafloor crater areas (ERM, 2013) (see 'Epifauna and Infauna').

Borrow Ground Project Area

As outlined above for epifauna and infauna, preliminary findings from the benthic habitat survey completed in the Borrow Ground Project Area and adjacent areas of the Dampier AMP found that benthic habitat within the Borrow Grounds Project Area consisted of sand with little to no biota throughout the area. No Coral species were identified.

5.3.12 Seagrass and Macroalgae

EMBA

Seagrass beds and benthic macroalgae reefs are a main food source and provide key habitats and nursery grounds for many marine species (Heck Jr. et al., 2003; Wilson et al., 2010). In the northern half of Western Australia, these habitats are restricted to sheltered and shallow waters due to large tidal movement, high turbidity, large seasonal freshwater run-off and cyclones.

Within the EMBA, significant seagrass and macroalgae communities are found in waters surrounding islands of the Dampier Archipelago, Barrow Island and the Montebello Islands.

Seagrasses in the Dampier Archipelago are generally sparse, occurring in low abundance on shallow sandy sediments in sheltered areas such as flats and larger bays (CALM, 2005; Jones, 2004). Surveys in the region have identified the following nine species: *Cymodocea angustata*, *Enhalus acoroides*, *Halophila decipiens*, *Halophila minor*, *Halophila ovalis*, *Halophila spinulosa*, *Halodule uninervis*, *Thalassia hemprichii,* and *Syringodium isoetifolium* (Woodside, 2006). Recorded occurrences of *Halophila* species in the Dampier Archipelago fluctuate depending on a variety of factors such as salinity, success of seed set and colonisation, temperature and grazing by dugongs (Woodside, 2006).

Macroalgae are most commonly found on shallow limestone pavements located throughout the Dampier Archipelago (Figure 5-23). Large expanses of macroalgae are prevalent along the seaward side of West Intercourse Island, extending south-west along the coast to Cape Preston and beyond. Large macroalgal platforms are also evident at Rosemary Island, Nelson Rocks, Legendre Island, West Lewis and East Lewis Islands, Enderby Island, Gidley Island, Eaglehawk Island, Malus Island and Angel Island; these platforms generally occur on the northern and western sides of the islands (Woodside, 2006). The most abundant group of algae in the region is brown algae; species from the genus *Sargassum*, *Dictyopteris* and *Padina* are very common (Woodside, 2006). The most common species of green algae in the Dampier Archipelago include *Caulerpa* species and calcareous *Halimeda* species (CALM, 2005; Jones, 2004). A variety of red algae are also found in the Dampier Archipelago including corallines, calcified red algae and algal turf (Jones, 2004).

In waters surrounding Barrow Island and the Montebello Islands, extensive subtidal macroalgal and seagrass communities are important primary producers and refuge areas for fishes and invertebrates. Macroalgae communities are most commonly found on shallow limestone pavement in depths of 5 to 10 m. The macroalgal assemblage is typically dominated by species of brown algae, particularly of the genera *Sargassum*, *Turbinaria* and *Pandina*. Green algae from the genera *Caulerpa*, *Cladophora* and *Rhodophyta* are also quite common. Other abundant taxa include *Halimeda*, *Dictyopterus*, *Dictyota*, *Cystoseira*, *Codium* and *Laurencia*.

In the vicinity of the Montebello Islands, seagrasses do not appear to form extensive meadows but instead are sparsely interspersed between the macroalgae assemblages. Seagrasses typically extend from the intertidal zone to approximately 15 m water depth. A total of seven seagrass species have been recorded to date, these being *Cymodocea angustata*, *Halophila ovalis*, *Halophila spinulosa*, *Halodule uninervis*, *Thalassia hemprichi*, *Thalassodendron ciliatum* and *Syringodium isoetifolium*.

Offshore Project Area/Trunkline Project Area/Borrow Ground Project Area

Seagrasses and macroalgae are generally found in coastal waters at depths of <10 m, although they have been recorded at 50 m in some Australian waters. Therefore, it is highly unlikely that seagrasses are present within the Offshore Project Area (900 – 970 m depth).

The shallowest water depths in Trunkline Project Area and Borrow Ground Project Area are in the order of 35 m. Seagrasses may occur in areas of the Trunkline Project Area where water depths are less than 50 m. However, extensive areas of seagrass are not expected given distribution is typically limited to water depths shallower than the Trunkline Project Area.

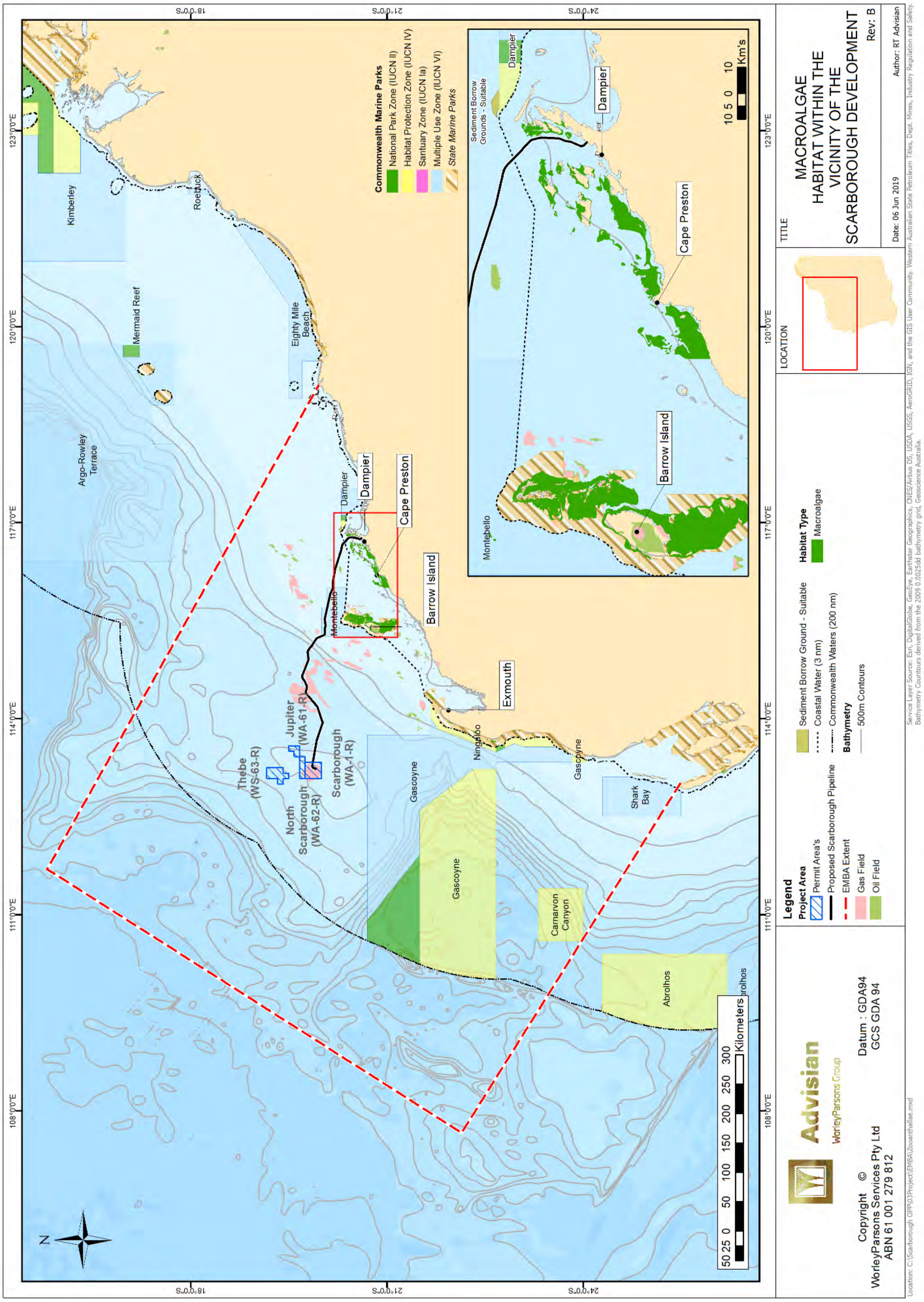


Figure 5-23: Macroalgae habitat within the vicinity of Scarborough

5.3.13 Regionally Important Shoals and Banks

As outlined in Section 5.3.3, no shoals or banks occur in the Project Area. However, regionally important shoals occur within the EMBA, namely Glomar shoals and Rankin Bank. Glomar Shoals is a designated Key Ecological Feature (KEF) and is described further in Section 5.5.6.

Rankin Bank is on the continental shelf, about 40 km from the Project Area. While Rankin Bank is not protected and is not a KEF, it is the only large, complex bathymetrical feature on the outer western shelf of the West Pilbara and represents habitats that are likely to play an important role in the productivity of the Pilbara region (AIMS, 2014). Rankin Bank consists of three submerged shoals delineated by the 50 m depth contour with water depths of about 18–30.5 m (AIMS, 2014).

Rankin Bank was surveyed by AIMS in 2013 as part of a co-investment project between Woodside and AIMS to better understand the habitats and complexity of the submerged shoal ecosystems. Rankin Bank represents a diverse marine environment, predominantly composed of consolidated reef and algae habitat (~55% cover), followed by hard corals (~25% cover), unconsolidated sand/silt habitat (~16% cover), and benthic communities composed of macroalgae, soft corals, sponges and other invertebrates (~3% cover) (AIMS, 2014). Hard corals are a significant component of the benthic community of some parts of the bank, with abundance in the upper end of the range observed elsewhere on the submerged shoals and banks of north-west Australia (Heyward et al., 2012). Indeed, in a comparison between Glomar Shoals and Rankin Bank, Rankin Bank had both higher cover of hard corals, and higher abundance of fish compared to Glomar Shoals (Abdul Wahab et al., 2018).

Rankin Bank has been shown to support a diverse fish assemblage (AIMS 2014). This is consistent with studies showing a strong correlation between habitat diversity and fish assemblage species richness (Gratwicke and Speight, 2005; Last et al., 2005).

5.3.14 Coastal Habitats

Given the offshore location of the Project Area, coastal habitats occur in neither the Offshore Project Area nor Trunkline Project Area. However, coastal habitats may occur within the EMBA and are discussed below.

The coastline within the northwest of Western Australia is varied, but predominantly includes tidal flats with smaller areas of rocky shores and sandy beaches (described in Section 5.3.15). Tidal flats are shorelines exposed to high tidal variation; includes both sandy and muddy sediments. This shoreline type can often be associated with mangrove or saltmarsh environments.

5.3.14.1 Saltmarshes

Saltmarshes are terrestrial halophytic (salt-adapted) ecosystems that mostly occur in the upper-intertidal zone. They are typically dominated by dense stands of halophytic plants such as herbs, grasses and low shrubs. The diversity of saltmarsh plant species increases with increasing latitude (in contrast to mangroves). The vegetation in these environments is essential to the stability of the saltmarsh, as they trap and bind sediments. The sediments are generally sandy silts and clays and can often have high organic material content. Saltmarshes provide a habitat for a wide range of both marine and terrestrial fauna, including infauna and epifaunal invertebrates, fish and birds.

There are no saltmarshes within the Project Area. However, saltmarshes are known to occur at locations along the Pilbara coast and islands of the Dampier Archipelago as shown in Figure 5-24.

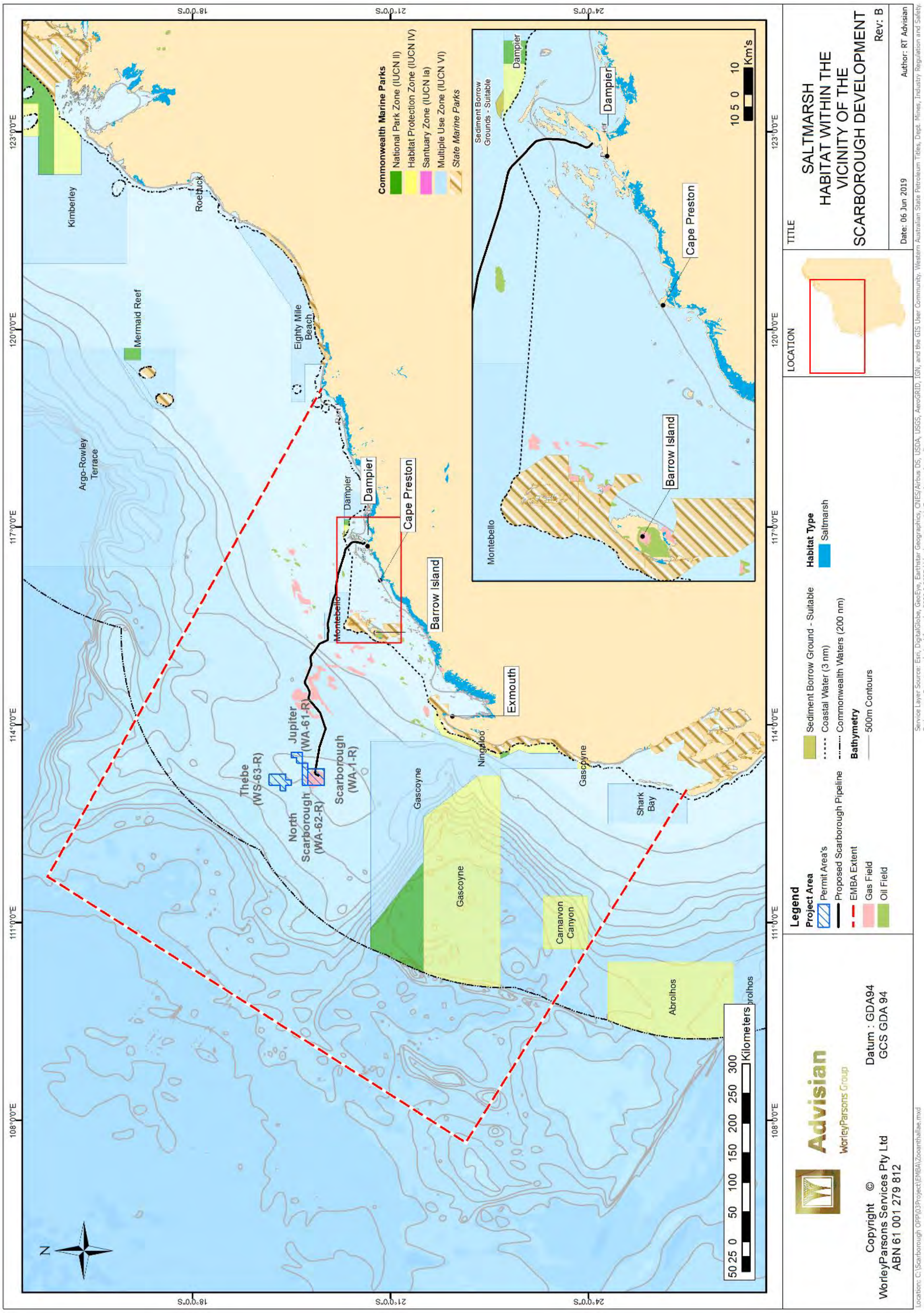


Figure 5-24: Saltmarsh habitat within the vicinity of Scarborough

5.3.14.2 Mangroves

Mangroves grow in intertidal mud and sand, with specially adapted aerial roots (pneumatophores) that provide for gas exchange during low tide (McClatchie et al., 2006). Mangrove forests can help stabilise coastal sediments, provide a nursery ground for many species of fish and crustacean, and provide shelter or nesting areas for seabirds (McClatchie et al., 2006).

There are no mangroves within the Project Area. However, mangrove presence is known at locations along the Pilbara coast and islands of the Dampier Archipelago as shown in Figure 5-25.

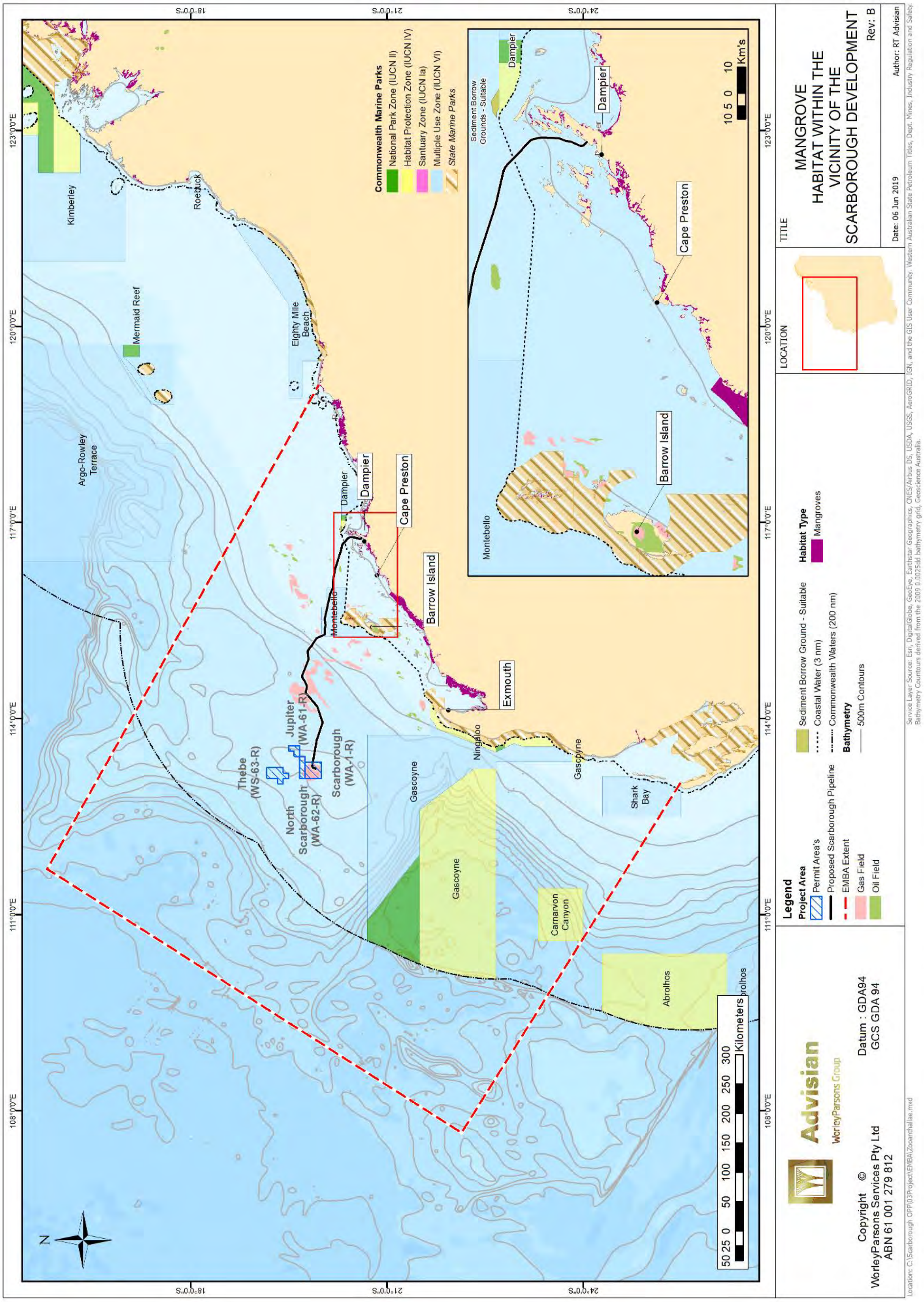


Figure 5-25: Mangrove habitat within the vicinity of Scarborough

5.3.15 Shoreline Habitats

Given the offshore location of the Project Area, shoreline habitats occur in neither the Offshore Project Area nor Trunkline Project Area. However, shoreline habitats may occur within the EMBA and are discussed below.

The shoreline within the northwest of Western Australia is varied, but predominantly includes tidal flats (described in Section 5.3.14) with smaller areas of rocky shores and sandy beaches (Table 5-3). Each of these shoreline types has the potential to support different flora and fauna assemblage due to the different physical factors (e.g. waves, tides, light, etc.) influencing the habitat.

Table 5-3: Description of shoreline types

Shoreline Type	Description
Rocky	Hard and soft rocky shores, including bedrock outcrops, platforms, low cliffs (less than five metres), and scarps. Depending on exposure, rocky shores can be host to a diverse range of flora and fauna, including barnacles, mussels, sea anemones, sponges, sea snails, starfish and algae. Australian fur-seals are also known to use rocky shores for haul-out and/breeding.
Sandy	Beaches dominated by sand-sized (0.063–2 mm) particles; also includes mixed sandy beaches (i.e. sediments may include muds or gravel, but sand is the dominant particle size). Sandy beaches are dynamic environments, naturally fluctuating in response to external forcing factors (e.g. waves, currents, etc). Sandy beaches can support a variety of infauna and provide nesting and/or foraging habitat to shorebirds and seabirds and pinnipeds. Sand particles vary in size, structure and mineral content; this in turn affects the shape, colour and inhabitants, of the beach.

5.3.16 Listed Threatened Ecological Communities

The Project Area does not intersect any Threatened Ecological Communities (TEC) as designated under Section 181 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). However, the EMBA intersects with the Subtropical and Temperate Coastal Saltmarsh TEC.

5.3.16.1 Subtropical and Temperate Coastal Saltmarsh

The Subtropical and Temperate Coastal Saltmarsh is listed as a vulnerable TEC under the EPBC Act. The TEC is predominantly distributed in southern Australia, however an area in the vicinity of Carnarvon is known to occur (Figure 5-26).

The Subtropical and Temperate Coastal Saltmarsh ecological community occurs within a relatively narrow margin along the coast, within the subtropical and temperate climatic zones; and includes coastal saltmarsh occurring on islands within these climatic zones (DSEWPaC, 2013b). The physical environment for the ecological community is coastal areas under regular or intermittent tidal influence (DESWPaC, 2013b).

The ecological community consists mainly of salt-tolerant vegetation (halophytes) including grasses, herbs, sedges, rushes and shrubs (DESWPaC, 2013b). Many species of non-vascular plants are also found in saltmarsh, including epiphytic algae, diatoms and cyanobacterial mats (TSSC, 2013a). The ecological community is inhabited by a wide range of infaunal and epifaunal invertebrates, and temporary inhabitants such as prawns, fish and birds (and can often constitute important nursery habitat for fish and prawn species) (DESWPaC, 2013b). Insects are also abundant and an important food source for other fauna, with some species being important pollinators (DESWPaC, 2013b). The dominant marine residents are benthic invertebrates, including molluscs and crabs that rely on the sediments, vascular plants, and algae, as providers of food and habitat across the intertidal landscape (DESWPaC, 2013b).

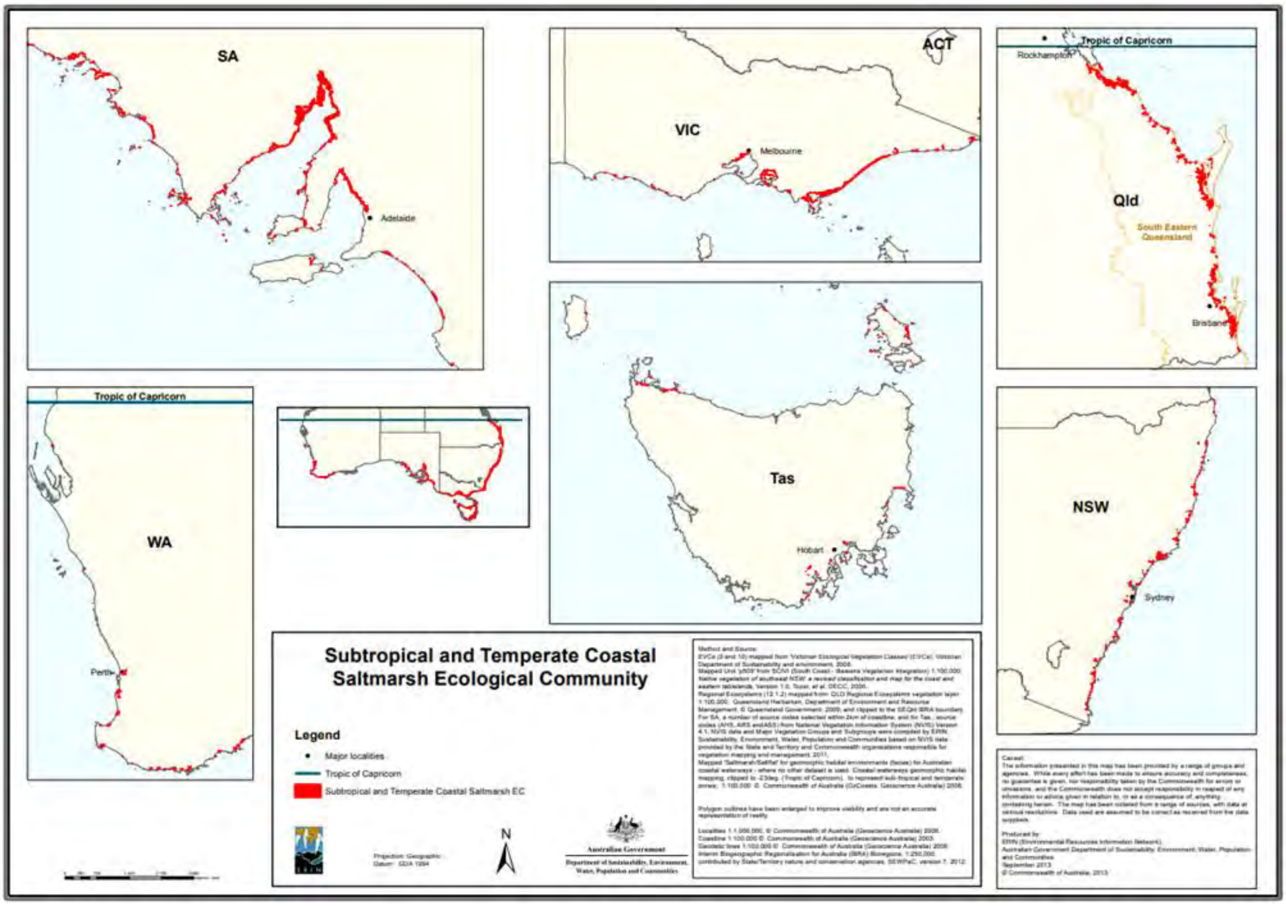


Figure 5-26: Distribution of Subtropical and Temperate Coastal Saltmarsh TEC

5.4 Marine Fauna of Conservation Significance

Under Part 13 of the EPBC Act, species can be listed as one, or a combination, of the following protection designations:

- threatened (further divided into categories; extinct, extinct in the wild, critically endangered, endangered, vulnerable, conservation-dependent)
- migratory
- whale or other cetaceans
- marine.

Additionally, the *Western Australia Wildlife Conservation Act 1950* (WA Wildlife Conservation Act) provides for species or subspecies of native animals (fauna) to be specially protected and listed as 'threatened' in Western Australia because they are:

- under identifiable threat of extinction
- rare
- otherwise in need of special protection.

The EPBC Act Protected Matters Search Tool was used to identify protected species that may occur within the Project Area and EMBA. Four separate EPBC Act Protected Matters Reports were generated for the Offshore Project Area, Trunkline Project Area, Borrow Grounds Project Area and EMBA.

Details of listed fauna and their likely presence in the Project Area and EMBA are provided in the following sections and appendices. Results of the EPBC Act Protected Matters Search Tool were cross-checked against the Threatened and Priority Fauna List, downloaded from the Department of Biodiversity, Conservation and Attractions website.

For the purpose of the OPP, only species listed as threatened or migratory under the EPBC Act likely to occur in the Project Area are considered to have conservation significance warranting further discussion. Likely occurrence was determined by the EPBC Act Protected Matters Reports or through designation of important habitat (e.g. BIA).

5.4.1 Biologically Important Areas and Habitat Critical to the Survival of a Species

Biologically Important Areas (BIAs) are areas that are particularly important for the conservation of protected species and where aggregations of individuals display biologically important behaviour such as breeding, foraging, resting or migration. Their designation is based on expert scientific knowledge about species' distribution, abundance and behaviour. The presence of the observed behaviour is assumed to indicate that the habitat required for the behaviour is also present.

BIAs and habitat critical to the survival of a species which overlap the Project Area and EMBA have been identified for the following EPBC Act listed species using the Conservation Values Atlas and are summarised in Table 5-4. Further details about the BIAs and critical habitat are included in the relevant species sections below.

Table 5-4: Designated biologically important areas and habitat critical to the survival of a species for protected species occurring in the Project Area and EMBA

Receptor		Distance/overlap with BIA				Type	Description
		Offshore Project Area	*Trunkline Project Area*	*Borrow Ground Project Area*	*EMBA*		
Seabirds and shorebirds	Australian Fairy tern	>216 km	Overlap	Overlap	Overlap	Breeding	Birds from South West Marine Region (SWMR) dispersing northwards in winter – July to late September. BIA located around islands of Dampier Archipelago, Barrow Island, Montebello Islands and Pilbara coast
	Brown booby	>525 km	>215 km	>200 km	Overlap	Breeding	Breeding February to October (but mainly in autumn). BIA located around Bedout Island
	Lesser crested tern	>211 km	>34 km	114 km	Overlap	Breeding	Breeding March to June. BIA located around Lowendal Islands
	Roseate tern	>206 km	>25 km	Overlap	Overlap	Breeding	Breeding from mid-March to July, birds from SWMR dispersing north in winter. BIAs located around Lowendal Islands, Pilbara islands and Dampier Archipelago
	Wedge-tailed shearwater	>106 km	Overlap	Overlap	Overlap	Breeding	Breeding visitor arriving in mid-August and leaving in April. Large BIA covering large proportions of

Receptor		Distance/overlap with BIA				Type	Description
		Offshore Project Area	Trunkline Project Area	Borrow Ground Project Area	EMBA		
							Commonwealth and State waters
Marine mammals	Humpback whale	>153 km	Overlap	Overlap	Overlap	Migration	Migration routes, including timing, provided in Section 5.4.4
		>198 km	>198 km	>286 km	Overlap	Resting	Resting area in Exmouth Gulf
	Pygmy blue whale	>35 km	Overlap	>160 km	Overlap	Migration	Migration routes, including timing, provided in Section 5.4.4
		>186 km	>186 km	>344 km	Overlap	Possible Foraging Area	Relatively small area off Ningaloo Reef, activity could occur year-round
	Dugong	>198 km	>198 km	>284 km	Overlap	Nursing and foraging	BIA for year-round breeding, nursing and foraging in proximity to Ningaloo Reef and Exmouth Gulf
Marine turtles	Flatback turtle	>164 km	Overlap	Overlap	Overlap	Internesting	80 km buffer around nesting beaches, including Montebello Islands, Barrow Island, Dampier Archipelago and the Pilbara coast, October to March
		>222 km	>10 km	>8 km	Overlap	Nesting	Smaller BIA restricted to a few kilometres from key nesting beaches at the Montebello Islands, Barrow Island and Dampier Archipelago, October to March
		>200 km	>10 km	>8 km	Overlap	Foraging	Nearshore waters off some islands of the Dampier Archipelago.
		>224 km	>10 km	>10 km	Overlap	Mating	Nearshore waters surround Montebello Islands, Barrow Island and Dampier Archipelago, October to March
		>165 km	Overlap	Overlap	Overlap	Habitat Critical	Barrow Island, Montebello Islands, 60 km internesting buffer, October to March
	Green turtle	>188 km	Overlap	Overlap	Overlap	Internesting	20 km buffer around nesting beaches, including Muiron Islands, North West Cape, Montebello Islands, Barrow Island and Dampier Archipelago, November to March
		>226 km	>10 km	>8 km	Overlap	Nesting	Smaller BIA restricted to a few kilometres from key nesting beaches at the Montebello

Receptor		Distance/overlap with BIA				Type	Description
		Offshore Project Area	Trunkline Project Area	Borrow Ground Project Area	EMBA		
							Islands, west coast of Barrow Island, Muiron Islands and North West Cape and Dampier Archipelago, November to March
		>200 km	>10 km	~9 km	Overlap	Foraging	Nearshore waters off some islands of the Dampier Archipelago.
		>188 km	Overlap	Overlap	Overlap	Habitat Critical	Nearshore waters surround Montebello Islands, Barrow Island and Dampier Archipelago, 20 km internesting buffer, November to March
	Hawksbill turtle	>203 km	Overlap	Overlap	Overlap	Internesting	20 km buffer around nesting beaches, including North West Cape, Ningaloo Reef, Montebello Islands, Barrow Island, Serrurier Island and the Dampier Archipelago, October to February
		>222 km	>9 km	>6 km	Overlap	Nesting	Smaller BIA restricted to a few kilometres from key nesting beaches at the North West Cape, Ningaloo Reef, Montebello Islands, Barrow Island, Serrurier Island and the Dampier Archipelago, October to February
		>200 km	>10 km	>9 km	Overlap	Foraging	Nearshore waters off some islands of the Dampier Archipelago.
		>203 km	Overlap	Overlap	Overlap	Habitat Critical	Dampier Archipelago (particularly Rosemary Island), Montebello Islands and Lowendal Islands. 20 km internesting buffer, October to February
	Loggerhead turtle	>192 km	Overlap	Overlap	Overlap	Internesting	20 km buffer around nesting beaches, including North West Cape, Ningaloo Reef, Muiron Islands, Montebello Islands and the Dampier Archipelago, November to March
		>192 km	>172 km	>172 km	Overlap	Habitat Critical	Exmouth Gulf and Ningaloo coast; 20 km internesting buffer; November to May

Receptor		Distance/overlap with BIA				Type	Description
		Offshore Project Area	Trunkline Project Area	Borrow Ground Project Area	EMBA		
Fish	Whale shark	>165 km	Overlap	~18 km	Overlap	Foraging	Broad BIA encompassing migration and foraging post aggregation at Ningaloo Reef (see below) March to November
		>208 km	>193 km	>337 km	Overlap	Foraging (high density prey)	Upwelling of nutrients result in high primary production, mass spawning of corals also brings about increased zooplankton production in April to June. BIA smaller than Foraging BIA

5.4.2 Listed Threatened Species Recovery Plans

Listed threatened species recovery plans (Recovery plans) and Conservation advices may be in place for species of marine fauna of conservation significance. Recovery plans are enacted under the EPBC Act and remain in force until the species is removed from the threatened list. Conservation advice provides guidance on immediate recovery and threat abatement activities that can be undertaken to facilitate the conservation of a listed species or ecological community.

Table 3-2 outlines the recovery plans and conservation advices relevant to those species identified as potentially occurring within or utilising habitat in the Project Area and EMBA and summarises the key threats to those species, as described in relevant recovery plans and conservation advices.

5.4.3 Seabirds and Migratory Shorebirds

5.4.3.1 Overview

Birds in the marine environment can include seabirds and shorebirds. Seabirds refers to those species of bird whose normal habitat and food sources are derived from the ocean (both coastal and pelagic); pelagic seabirds include such species as shearwaters and petrels, coastal seabirds include species such as cormorants. Shorebirds (sometimes referred to as wading birds) refers to those species of bird commonly found along sandy or rocky shorelines, mudflats, and shallow waters; shorebirds include such species as plovers and sandpipers

Seabirds spend most of their lives at sea, ranging over large distances to forage over the open ocean. Many of these species also breed in and adjacent to the NWMR, including populations of terns and shearwaters (DEWHA, 2008). Based on the results of two survey cruises and other unpublished records, Dunlop et al. (1988) recorded the occurrence of 18 species of seabirds over the NWS. Seabird distributions were generally patchy, except near islands (Dunlop et al., 1988).

Migratory shorebirds may be present in or fly through the region between July and December and again between March and April as they migrate between Australia and offshore locations (Bamford et al., 2008; DoE, 2015a). During their migration, shorebirds use several staging areas, typically wetland habitat, as intermediate feeding sites to rest and restore energy reserves. Where wetland habitat has been assessed as provided significant ecological value, including utilisation by shorebirds, they are designated ‘Ramsar wetlands of international importance’. As outlined in Section 5.6.8.1, there are no Ramsar wetlands of international importance located in the Project Area or EMBA.

There are numerous important habitats for seabirds and migratory shorebirds including key breeding/nesting areas, roosting areas and surrounding waters important foraging and resting areas within the NWMR. These include:

- Muiron Islands (186 km from Project Area)
- Montebello/Barrow/Lowendal Islands group (41 km from Project Area)
- Pilbara Islands (North, Middle and South groups) (>50 km from Project Area)
- Rowley Shoals (420 km from Project Area)
- Ashmore Reef (>1000 km from Project Area)
- Kimberley coast (>1000 km from Project Area)
- Shark Bay (607 km from Project Area)
- Houtman Abrolhos Islands (>1000 km from Project Area).

Other species may also utilise the marine environment, and are listed as marine under the EPBC Act, but have distributions that also extend into freshwater or terrestrial environments. Such species include passerines or raptors.

There are 19 seabird and shorebird species (or species habitat) that may occur within the Project Area and an additional 60 seabirds or shorebirds that could occur in the EMBA. These include species classified as threatened, migratory and marine under the EPBC Act (Table 5-5); however no additional species are protected under the WA Wildlife Conservation Act. The type of presence varies between species and location and includes important behaviours (e.g. breeding, foraging) for a small number of species within the Trunkline Project Area (Table 5-5).

Breeding BIAs for seabirds and shorebirds are primarily restricted to within tens of kilometres of emergent features, except the wedge tailed shearwater, as described in Table 5-4.

Table 5-5: Bird species or species habitat that may occur within the Project Area and EMBA

Species		Specially Protected Fauna	Threatened Species	Migratory Species	Listed Marine Species	Biologically Important Area	Offshore Project Area	Trunkline Project Area	Borrow Grounds Project Area	EMBA
Seabirds										
Anous stolidus	Common noddy			✓(M)	✓		MO	MO	MO	LO
Ardenna carneipes	Flesh-footed shearwater			✓(M)	✓					LO
Ardenna pacifica	Wedge-tailed shearwater			✓(M)	✓	✓(b)				BKO
Calonectris leucomelas	Streaked shearwater			✓(M)	✓			LO	LO	LO
Catharacta skua	Great skua				✓					MO
Diomedea amsterdamensis	Amsterdam albatross		E	✓(M)	✓					MO
Diomedea exulans	Wandering albatross		V	✓(M)	✓					MO
Fregata ariel	Lesser frigatebird			✓(M)	✓		MO	LO	LO	KO
Fregata minor	Great frigatebird			✓(M)	✓					MO
Larus novaehollandiae	Silver gull				✓					BKO
Larus pacificus	Pacific gull				✓					BKO
Macronectes giganteus	Southern giant petrel		E	✓(M)	✓		MO	MO	MO	MO
Macronectes halli	Northern giant petrel		V	✓(M)	✓					MO
Onychoprion anaethetus	Bridled tern			✓(M)	✓					BKO
Papasula abbotti	Abbott's booby		E		✓					MO
Pterodroma mollis	Soft-plumaged petrel		V		✓					FLO
Sterna caspia	Caspian tern			✓(M)	✓					BKO
Sterna dougallii	Roseate tern			✓(M)	✓	✓(b)		FLO	BKO	BKO
Sterna fuscata	Sooty tern				✓					BKO
Sterna nereis	Fairy tern				✓					BKO
Sternula nereis	Australian fairy tern		V			✓(b)		FLO	BKO	BKO
Sula leucogaster	Brown booby				✓	✓(b)				BKO

Species		**Specially Protected Fauna**	**Threatened Species**	**Migratory Species**	**Listed Marine Species**	**Biologically Important Area**	**Offshore Project Area**	**Trunkline Project Area**	**Borrow Grounds Project Area**	**EMBA**
Thalassarche carteri	Indian yellow-nosed albatross		V	✓(M)	✓					FMO
Thalassarche cauta	Tasmanian shy albatross		V	✓(M)	✓					MO
Thalassarche impavida	Campbell albatross		V	✓(M)	✓					MO
Thalassarche melanophris	Black-browed albatross		V	✓(M)	✓					MO
Thalassarche	White-capped albatross		V	✓(M)	✓					FLO
Thalasseus bengalensis	Lesser crested tern				✓	✓(b)				BKO
Thalasseus bergii	Crested tern				✓					BKO
Shorebirds										
Actitis hypoleucos	Common sandpiper			✓(W)	✓		MO	MO	MO	KO
Ardea alba	Great egret				✓					BKO
Ardea ibis	Cattle egret				✓					MO
Arenaria interpres	Ruddy turnstone			✓(W)	✓					KO
Calidris acuminata	Sharp-tailed sandpiper			✓(W)	✓		MO	MO	MO	KO
Calidris alba	Sanderling			✓(W)	✓					KO
Calidris canutus	Red knot		E	✓(W)	✓		MO	MO	MO	KO
Calidris ferruginea	Curlew sandpiper		CE	✓(W)	✓			MO	MO	KO
Calidris melanotos	Pectoral sandpiper			✓(W)	✓		MO	MO	MO	KO
Calidris ruficollis	Red-necked stint			✓(W)	✓					KO
Calidris subminuta	Long-toed stint			✓(W)	✓					KO
Calidris tenuirostris	Great knot		CE	✓(W)	✓					KO
Charadrius leschenaultii	Greater sand plover		V	✓(W)	✓					KO
Charadrius mongolus	Lesser sand plover		E	✓(W)	✓					KO
Charadrius ruficapillus	Red-capped plover				✓					KO

Species		Specially Protected Fauna	Threatened Species	Migratory Species	Listed Marine Species	Biologically Important Area	Offshore Project Area	Trunkline Project Area	Borrow Grounds Project Area	EMBA
Charadrius veredus	Oriental plover			✓(W)	✓					KO
Gallinago megala	Swinhoe's snipe			✓(W)	✓					RLO
Gallinago stenuar	Pin-tailed snipe			✓(W)	✓					RLO
Glareola maldivarum	Oriental pratincole			✓(W)	✓					KO
Himantopus	Pied stilt				✓					KO
Limicola falcinellus	Broad-billed sandpiper			✓(W)	✓					KO
Limosa lapponica	Bar-tailed godwit	IA		✓(W)	✓					KO
Limosa lapponica baueri	Bar-tailed godwit (baueri)		V							KO
Limosa lapponica menzbieri	Northern Siberian bar-tailed godwit		CE							LO
Limosa	Black-tailed godwit			✓(W)	✓					KO
Numenius madagascariensis	Eastern curlew		CE	✓(W)	✓			MO	MO	KO
Numenius minutus	Little curlew			✓(W)	✓					KO
Numenius phaeopus	Whimbrel			✓(W)	✓					KO
Phalaropus lobatus	Red-necked phalarope			✓(W)	✓					KO
Pluvialis fulva	Pacific golden plover			✓(W)	✓					KO
Pluvialis squatarola	Grey plover			✓(W)	✓					RKO
Recurvirostra novaehollandiae	Red-necked avocet				✓					RKO
Rostratula australis	Australian painted snipe		E		✓					MO
Rostratula benghalensis (sensu lato)	Painted snipe		E		✓					MO
Stiltia isabella	Australian pratincole				✓					KO
Thinornis rubricollis	Hooded plover				✓					KO
Tringa brevipes	Grey-tailed tattler			✓(W)	✓					KO

Species		Specially Protected Fauna	Threatened Species	Migratory Species	Listed Marine Species	Biologically Important Area	Offshore Project Area	Trunkline Project Area	Borrow Grounds Project Area	EMBA
Tringa glareola	Wood sandpiper				✓					RKO
Tringa nebularia	Common greenshank			✓(W)	✓					KO
Tringa stagnatilis	Marsh sandpiper			✓(W)	✓					KO
Tringa totanus	Common redshank			✓(W)	✓					KO
Xenus cinereus	Terek sandpiper			✓(W)	✓					KO
Other Species										
Apus pacificus	Fork-tailed swift			✓(M)	✓			LO	LO	LO
Chrysococcyx osculans	Black-eared Cuckoo			✓(M)	✓			LO		KO
Haliaeetus leucogaster	White-bellied sea-eagle				✓					BKO
Hirundo rustica	Barn swallow			✓(T)	✓			MO		KO
Merops ornatus	Rainbow bee-eater				✓			MO		MO
Motacilla cinerea	Grey wagtail			✓(T)	✓			MO		MO
Motacilla flava	Yellow wagtail			✓(T)	✓			MO		KO
Pandion haliaetus	Osprey			✓(W)	✓			MO	MO	BKO

Specially Protected Fauna:
IA Migratory birds protected under an international agreement
Threatened Species:
V Vulnerable
E Endangered
CE Critically Endangered
Migratory Species:
M Marine
W Wetland
T Terrestrial

Biologically Important Area:
(b) Breeding
(f) Foraging

Type of Presence:

MO	Species or species habitat may occur within area
LO	Species or species habitat likely to occur within area
KO	Species or species habitat known to occur within area
FMO	Foraging may occur within the area
FLO	Foraging likely to occur within the area
BKO	Breeding known to occur within area
RLO	Roosting likely to occur within area

Species	Specially Protected Fauna	Threatened Species	Migratory Species	Listed Marine Species	Biologically Important Area	Offshore Project Area	Trunkline Project Area	Borrow Grounds Project Area	EMBA
		RKO	Roosting known to occur within area						

EMBA

A total of 61 seabirds or shorebirds (or habitat) of conservation significance may occur in the EMBA (Table 5-5). Furthermore, five breeding BIAs (Australian Fairy tern, Brown booby, Lesser crested tern, Roseate tern and Wedge-tailed shearwater) overlap the EMBA (Table 5-4, Figure 5-27).

Given the presence of emergent features and coastlines within the EMBA, seabirds and shorebirds are likely to occur. Significant areas for seabirds and shorebirds in the EMBA include the Montebello Islands, Barrow Island and the islands of the Dampier Archipelago (see Section 5.6.1.4 for further details). Although some species may be resident year-round, peak occurrence of many species will be associated with breeding and nesting, the timing of which will vary between species. Species may breed in the area or be non-breeding visitors.

Trunkline Project Area and Borrow Ground Project Area

A total of 18 conservation significant seabirds or shorebirds (or habitat) occur in the Trunkline Project Area (Table 5-5). In addition, two BIAs also overlap the Trunkline Project Area; a breeding BIA for the Australian fairy tern, and breeding BIA for the wedge-tailed shearwater (Table 5-4, Figure 5-27). A total of 14 conservation significant seabirds or shorebirds (or habitat) may occur in the Borrow Ground Project Area (Table 5-5). Within the Borrow Ground Project Area, three breeding BIAs (Australian Fairy tern, Roseate tern and Wedge-tailed shearwater) overlap the Borrow Grounds Project Area (Table 5-4,Figure 5-27). Since the BIAs are associated with breeding, the designated areas will not represent important habitat for the species year-round.

Since the majority of species identified in Table 5-5 are migratory, their presence would only be expected in the Trunkline Project Area and Borrow Grounds Project Area during part of the year. Breeding sites are often associated with conditions of prey availability nearby. For seabirds, which are further constrained by the need to provision their young with whole or macerated prey, parents would be expected to forage as near to the colony as prey conditions and energetic requirements allow (McLeay et al., 2010).

Offshore Project Area

A total of seven conservation significant seabirds or shorebirds (or habitat) may occur in the Offshore Project Area (Table 5-5). Given the offshore location and distance from emergent habitats (e.g. Montebello Islands, 230 km; Dampier Archipelago, 330 km), coastal seabirds or migratory shorebirds are unlikely to occur, other than transitory individuals during migration.

Pelagic seabirds may occur more frequently given the wide-ranging distribution of these species. However, no critical habitats (including feeding) for any species are known to occur and therefore high numbers of individuals are unlikely.

5.4.3.2 Conservation-Significant Birds in the Project Area

Seabirds

Wedge-tailed Shearwater

The wedge-tailed shearwater (*Ardenna pacifica*, previously known as *Puffinus pacificus*) is listed Migratory under the EPBC Act. The species is common off the Western Australian coast from August to April (DEWHA, 2012a). Known breeding locations in the NWMR include Dampier Archipelago and the Montebello, Lowendal and Barrow islands. During chick provision, the chick is fed approximately every one to two days, though longer periods have been recorded. Diet is variable but commonly consists of squid, fish and crustaceans (DEWHA, 2012a).

A BIA for breeding extends throughout the NWMR (Figure 5-27), overlapping with the Trunkline Project Area. Although the species has a large pelagic distribution, individuals are likely to occur in the Trunkline Project Area rather than the Offshore Project Area, particularly in the vicinity of breeding colonies during incubation and chick rearing.

Streaked Shearwater

The Streaked shearwater (*Calonectris leucomelas,* previously known as *Puffinus leucomelas)* is listed as Migratory under the EPBC Act. Following its winter migration from the northern hemisphere, the Streaked shearwater occurs frequently in northern Australia from October to March, with some records as early as August and as late as May (Marchant & Higgins, 1990). While it does not breed in Australia, it is known to forage in the North Marine Region (NMR), in particular north-west of the Wellesley Islands (over 1000 km south-east of the Offshore Project Area) (DSEWPaC, 2012a). In Australia, its distribution ranges from the North West Cape across to North Queensland. Streaked shearwaters feed mainly on fish and squid which are caught by surface-seizing and shallow plunges (DSEWPaC, 2012b).

Considering the distribution for this species, individuals are not expected to occur in the Offshore Project Area, although presence is likely in the eastern portions of the Trunkline Project Area. While presence in the Trunkline Project Area is likely, the lack of known habitat for foraging or breeding in Trunkline Project Area suggests that large numbers or aggregations are unlikely.

Lesser Frigatebird

The Lesser frigatebird (*Fregata ariel)* is listed as Migratory under the EPBC Act. They are usually observed in tropical waters around the coast of northern Western Australia, Northern Territory, Queensland and New South Wales (DSEWPaC, 2012a). Breeding typically occurs on remote offshore islands, such as Bedout island, Ashmore Reef, Lacepede Islands and Adele Island in the NWMR, between March and November. They are often found foraging far offshore, especially during the non-breeding season where some large movements have been recorded (DSEWPaC, 2012a). During the breeding season (March–November), the Lesser frigatebird’s range remains close to the breeding colonies (DSEWPaC, 2012a).

Due to the large distances potentially travelled, individuals may occur across the Project Area, however, are only likely to occur within the Trunkline Project Area. No important breeding or forging areas have been identified in the Project Area. Furthermore, breeding sites are remote to the Project Area meaning that aggregations of foraging birds are unlikely to occur.

Australian Fairy Tern

The Australian fairy tern (*Sternula nereis nereis*) is listed vulnerable under the EPBC Act. It is a widely distributed coastal seabird and occurs mainly on sandy beaches within sheltered coasts of New South Wales, Victoria, Tasmania, South Australia and Western Australia (TSSC, 2011a). In

Western Australia, the species occurs along the coast as far north as the Dampier Archipelago and offshore islands Barrow/Montebello/Lowendal Islands Group (TSSC, 2011b, 2011a). The Australian fairy tern is listed as vulnerable under the EPBC Act and occurs. Dampier Archipelago is the northern extent of known habitat for the species (DEWHA, 2012a). Australian fairy terns nest above the high-water mark in sandy substrates where vegetation is low (TSSC, 2011a). Breeding in the region is typically July to September (Johnstone and Storr, 1998). Fairy terns will feed predominantly on fish, foraged in inshore waters around island archipelagos and on the Australian mainland (DEWHA, 2012a).

Due to the preferences for coastal habitats, presence in the Offshore Project Area is not expected. However, the proximity of the Trunkline Project Area to breeding sites at the Montebello, Lowendal and Barrow islands, and the Dampier Archipelago suggest occurrence is likely. Indeed, BIAs for breeding at around the Dampier Archipelago are overlapped by the Trunkline Project Area (Figure 5-27). Additional BIAs are located around the Montebello, Lowendal and Barrow Island, although these do not overlap the Trunkline Project Area. Usage of these BIAs is seasonal, with the species typically found in the region during July, August and September (Department of Conservation and Land Management, 2005; Environment Australia, 2002).

<u>Roseate Tern</u>

The Roseate tern (*Sterna dougalii*) is listed Migratory under the EPBC Act. It is common in waters off northern Australia. Northern populations of the Roseate tern breed on offshore islands, cays and banks; breeding populations are known to occur within the Dampier Archipelago (DEWHA, 2012a). Throughout the year the species often rests and forages in sheltered estuaries, creeks, inshore waters. They have been found to feed primarily in the open sea and at a greater distance from the colony than other similar species of inshore terns (DSEWPaC, 2012a). For the northern population, breeding has been observed between April and June–July, but most between September and December–January (DSEWPaC, 2012a). Roseate terns predominantly eat small pelagic fish; although are also known to consume insects and marine invertebrates such as crustaceans (DEWHA, 2012a).

Although Roseate terns forage at greater distances from land compared to other tern species, presence in the Offshore Project Area is not expected given the distance offshore. Presence in the Trunkline Project Area is likely, particularly during the breeding season in the area closest to Dampier Archipelago where the Trunkline Project Area overlaps the BIA (Figure 5-27).

<u>Caspian Tern</u>

The Caspian tern (*Sterna caspia*) is listed as Migratory under the EPBC Act. It has a widespread occurrence in coastal and inland habitat. Within Western Australia, breeding is known to occur from the Recherche Archipelago to Dirk Hartog Island and Faure Island in Shark Bay, and in the Pilbara region from around Point Cloates to North Turtle Island, and more rarely, in the Kimberley (DoE, 2018a). The main breeding period in the southern hemisphere is September to December. The Caspian tern forages in open wetlands, including lakes and rivers, but can also be found in open coastal waters (Higgins & Davies, 1996). Diet predominantly comprises small fish species, with aquatic invertebrates, insects and carrion also occurring.

Due to the preferences for coastal habitats, presence in the Offshore Project Area is not expected. Although no BIAs have been designated in the vicinity of the Project Area, breeding is expected in proximity to the Trunkline Project Area and therefore presence in expected.

5.4.3.3 Shorebirds

Since shorebird presence is strongly associated with coastal habitat, occurrence of any shorebird species listed in Table 5-5 in the Offshore Project Area is unlikely. Occurrence in the Trunkline Project Area is more likely, given the relative proximity of this area to emergent features with coastal habitats. The following sections provide details of shorebirds which are likely to occur in the Trunkline Project Area. However, no BIAs, Ramsar sites or other protected areas for shorebirds occur in the Trunkline Project Area, which is located 12 km from the nearest shoreline, and as such, large numbers of individuals are not expected. Any individuals encountered will most likely be flying through the area as they move between foraging or roosting areas.

Bar-tailed Godwit

The Bar-tailed godwit (*Limosa lapponica*) is listed as Migratory under the EPBC Act. In addition, the Western Alaskan bar-tailed godwit (*L. lapponica bauera*), a subspecies of *L. lapponica* is listed Vulnerable under the EPBC Act.

The Bar-tailed godwit, including subspecies, are found in all states of Australia, preferring coastal habitats such as intertidal sandflats, banks, mudflats, estuaries and bays. They are known to forage near the edge of tidal estuaries and harbours, feeding mainly on worms, molluscs, crustaceans, insects and some plant material. The large waders commonly roost on sandy beaches, sandbars, spits and in near-coastal saltmarsh. In hotter environments, waders may choose roost sites where a damper substrate lowers the local temperature (DoE, 2018b).

Eastern Curlew

The Eastern curlew (*Numenius madagascariensis*) is listed as Migratory and Critically Endangered under the EPBC Act. The bulk of the global population spend non-breeding periods, between September and November, in Australia (Bamford et al., 2008). Within Australia, it has a primarily coastal distribution. It does not breed in Australia and is found foraging on soft sheltered intertidal sandflats or mudflats, open and without vegetation or covered with seagrass, often near mangroves, on salt flats and in saltmarsh, rockpools and among rubble on coral reefs, and on ocean beaches near the tideline (DoEE, 2015).

Common Greenshank

The Common greenshank (*Tringa nebularia*) is listed as Migratory under the EPBC Act. This wader does not breed within Australia; however, the species is widely distributed in wetland habitats of varying salinities throughout Australia, arriving from breeding grounds in August. Northward migration back to breeding sites occurs predominantly in April. These carnivorous birds commonly forage at the edges of wetlands, in soft mudflats, in channels, or in shallows around mangroves (DoE, 2018c).

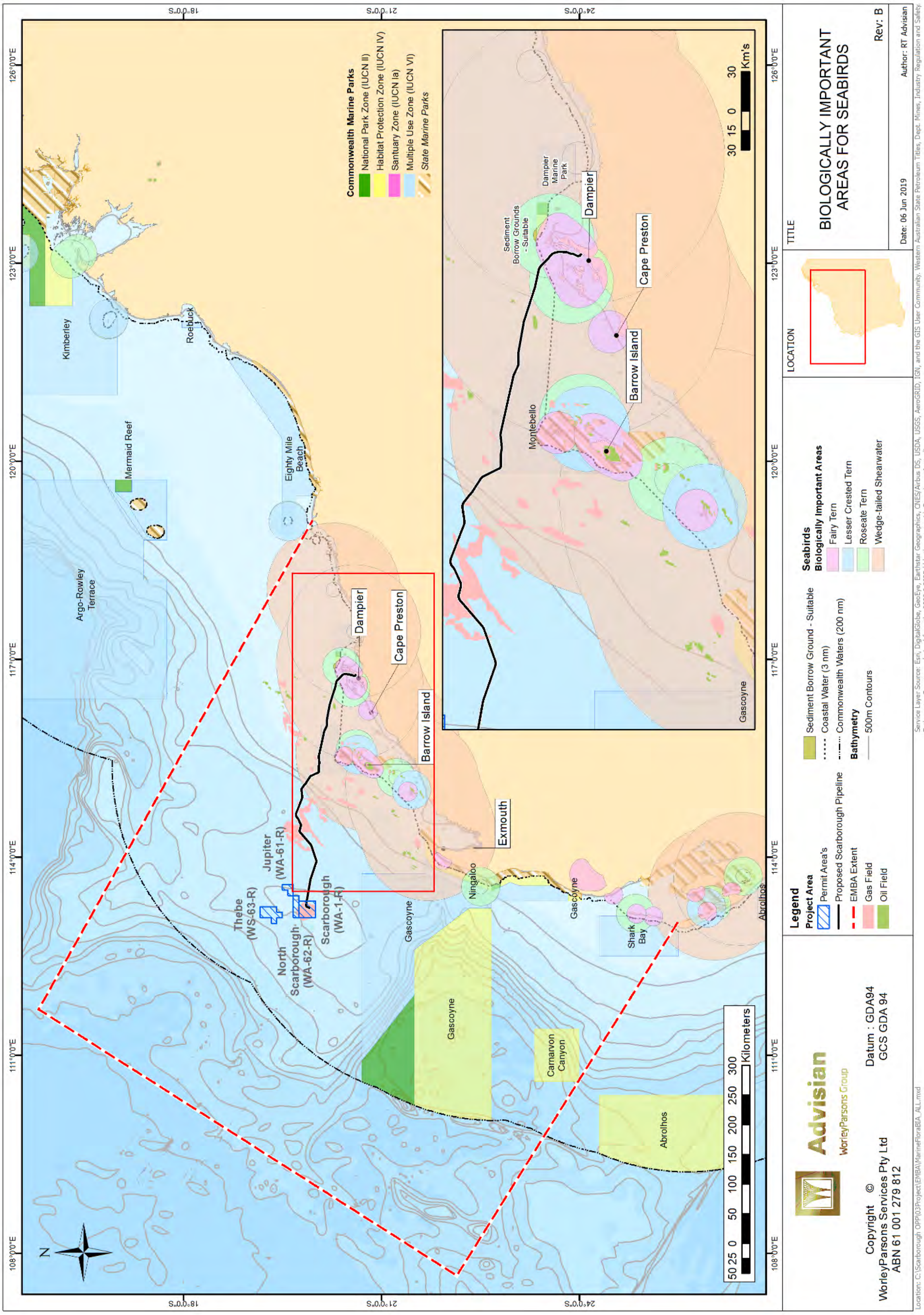


Figure 5-27: Biologically important areas (breeding) for the Fairy tern, Lesser crested tern, Roseate tern, Wedge-tailed shearwater and Brown booby

5.4.4 Fish

5.4.4.1 Overview

The NWMR supports a diversity of fish species. For the purpose of this OPP, fish species have been split into the following groups:

- sharks, sawfish and rays
- syngnathids (seahorses and pipefish)
- pelagic and demersal fish.

Habitat preferences and distribution of sharks and rays can vary depending on the species; from large pelagic distributions, to coastal habitat preferences, and can be migratory. Sawfish, however, are generally restricted to inshore coastal, estuarine and riverine environments.

Within the NWMR, syngnathids may be encountered in a wide variety of shallow habitats, including seagrass meadows, reefs and sandy substrates around coastal islands and shallow reef areas. They are uncommon in deeper continental shelf waters (50–200 m). Data collected using Baited Remote Underwater Video Stations (BRUVS) at Rankin Bank and Glomar Shoals did not record any Syngnathids (Australian Institute of Marine Science, 2014).

Both demersal and pelagic fish communities of the NWMR appear to be closely associated with different depth ranges (DEWHA, 2008a), with fish assemblage species richness decreasing with depth (Last et al., 2005) as well as being positively correlated with habitat complexity (Gratwicke & Speight, 2005). Subsea oil and gas infrastructure in the NWMR provide areas of hard substrate in an otherwise predominantly soft sediment habitat (see Sections 5.3.3 and 5.3.4). Accordingly, the presence of oil and gas infrastructure may artificially increase habitat complexity, resulting in higher species richness and abundance of fish species associated with infrastructure compared to adjacent natural habitats (Mclean et al., 2020; McLean et al., 2018; McLean et al., 2017; Bond et al., 2018).

The NWMR supports both large and small pelagic fish species. Small pelagic fish inhabit a range of marine habitats, including inshore and continental shelf waters. They feed on pelagic phytoplankton and zooplankton and represent a food source for a wide variety of predators including large pelagic fish, sharks, seabirds and marine mammals (Mackie et al., 2007). Large pelagic fish include commercially targeted species such as mackerel, wahoo, tuna, swordfish and marlin. Large pelagic fish are typically widespread, found mainly in offshore waters (occasionally on the shelf) and often travel extensively.

High levels of endemism in demersal fish communities on the continental slope are known to occur within the region. The North West Cape region is cited as a transition between tropical and temperate demersal and continental slope fish assemblages (Last et al., 2005). Demersal fish are associated with more complex habitats; the Continental Slope Demersal Fish Communities KEF (see Section 5.5.3), has been identified as one of the most diverse slope assemblages in Australian waters. Additionally, the Ancient Coastline at 125 m Depth Contour (‘Ancient Coastline’) KEF (see Section 5.5.2) provides areas of hard substrate in an area of predominantly soft sediment, providing sites for higher diversity and species richness for epifauna, and consequently, demersal and pelagic fish. The Montebello Australian Marine Park (AMP) (see Section 5.6.1) also supports high demersal fish richness and abundance, despite their isolated location.

On the Exmouth Plateau, also a designated KEF (see Section 5.5.1), strong tidal activity and internal waves cause upwellings of deep-water and increased productivity, as observed from satellite images of chlorophyll concentrations (Brewer et al., 2007). As a result, these areas have been shown to support high catch rates of pelagic and demersal commercial fish, although evidence suggests these high production events are sporadic (Brewer et al., 2007).

There are 35 syngnathids, five sharks, three sawfish and two ray species (or species habitat) that may occur within the Project Area and an additional 4 syngnathids, one shark and one sawfish that could occur in the EMBA. These includes species classified as Threatened or Migratory under the EPBC Act (Table 5-6). The type of behaviour is predominantly a presence (i.e. may, likely or known to occur), with a foraging BIA identified for a single species, the Whale shark, within the Trunkline Project Area (Table 5-4).

Table 5-6: Fish species or species habitat that may occur within the Project Area and EMBA

Species		Specially Protected Fauna	Threatened Species	Migratory Species	Listed Marine Species	Biologically Important Area	Offshore Project Area	Trunkline Project Area	Borrow Grounds Project Area	EMBA
Sharks										
Carcharias taurus (west coast population)	Grey nurse shark (west coast population)		V					LO	LO	KO
Carcharodon carcharias	Great white shark		V	✓			MO	MO	MO	KO
Isurus oxyrinchus	Shortfin mako			✓			LO	LO		LO
Isurus paucus	Longfin mako			✓			LO	LO		LO
Lamna nasus	Porbeagle shark			✓						MO
Rhincodon typus	Whale shark		V	✓		✓(f)		FKO	MO	FKO
Sawfish										
Anoxypristis cuspidata	Narrow sawfish			✓				LO	LO	KO
Pristis clavata	Dwarf sawfish		V	✓				KO	KO	KO
Psristis pristis	Freshwater sawfish		V	✓						LO
Pristis zijsron	Green sawfish		V	✓				KO	KO	KO
Rays										
Manta alfredi	Reef manta ray			✓				KO	KO	KO
Manta birostris	Giant manta ray			✓			MO	LO	LO	KO
Seahorse and Pipefish										
Acentronura larsonae	Helen's pygmy pipehorse				✓			MO	MO	MO
Bulbonaricus brauni	Braun's pughead pipehorse				✓			MO	MO	MO
Campichthys galei	Gale’s pipefish				✓					MO

Species		Specially Protected Fauna	Threatened Species	Migratory Species	Listed Marine Species	Biologically Important Area	Offshore Project Area	Trunkline Project Area	Borrow Grounds Project Area	EMBA
Campichthys tricarinatus	Three-keel pipehorse				✓			MO	MO	MO
Choeroichthys brachysoma	Pacific short-pipehorse				✓			MO	MO	MO
Choeroichthys latispinosus	Muiron Island pipehorse				✓			MO	MO	MO
Choeroichthys suillus	Pig-snouted pipehorse				✓			MO	MO	MO
Corythoichthys flavofasciatus	Reticulate pipehorse				✓			MO		MO
Cosmocampus banneri	Roughridge pipehorse				✓			MO		MO
Doryrhamphus dactyliophorus	Banded pipehorse				✓			MO	MO	MO
Doryrhamphus excisus	Bluestripe pipehorse				✓			MO		MO
Doryrhamphus janssi	Cleaner pipehorse				✓			MO	MO	MO
Doryrhamphus multiannulatus	Many-banded pipehorse				✓			MO	MO	MO
Doryrhamphus negrosensis	Flagtail pipehorse				✓			MO	MO	MO
Festucalex scalaris	Ladder pipehorse				✓			MO	MO	MO
Filicampus tigris	Tiger pipehorse				✓			MO	MO	MO
Halicampus brocki	Brock's pipehorse				✓			MO	MO	MO
Halicampus grayi	Mud pipehorse				✓			MO	MO	MO
Halicampus nitidus	Glittering pipehorse				✓			MO	MO	MO
Halicampus spinirostris	Spiny-snout pipehorse				✓			MO	MO	MO
Haliichthys taeniophorus	Ribboned pipehorse				✓			MO	MO	MO
Hippichthys penicillus	Beady pipehorse				✓			MO	MO	MO
Hippocampus angustus	Western spiny seahorse				✓			MO	MO	MO

Species		Specially Protected Fauna	Threatened Species	Migratory Species	Listed Marine Species	Biologically Important Area	Offshore Project Area	Trunkline Project Area	Borrow Grounds Project Area	EMBA
Hippocampus histrix	Spiny seahorse				✓			MO	MO	MO
Hippocampus kuda	Spotted seahorse				✓			MO	MO	MO
Hippocampus planifrons	Flat-face seahorse				✓			MO	MO	MO
Hippocampus spinosissimus	Hedgehog seahorse				✓			MO		MO
Hippocampus trimaculatus	Three-spot seahorse				✓			MO	MO	MO
Lissocampus fatiloquus	Prophet's pipefish				✓					MO
Micrognathus micronotopterus	Tidepool pipefish				✓			MO	MO	MO
Nannocampus subosseus	Bonyhead pipefish				✓					MO
Phoxocampus belcheri	Black rock pipefish				✓			MO	MO	MO
Solegnathus hardwickii	Pallid pipehorse				✓			MO	MO	MO
Solegnathus lettiensis	Gunther's pipehorse				✓			MO	MO	MO
Solenostomus cyanopterus	Robust ghostpipefish				✓			MO	MO	MO
Stigmatopora argus	Spotted pipefish				✓					MO
Syngnathoides biaculeatus	Double-end pipehorse				✓			MO	MO	MO
Trachyrhamphus bicoarctatus	Bentstick pipefish				✓			MO	MO	MO
Trachyrhamphus longirostris	Straightstick pipefish				✓			MO	MO	MO

Threatened Species:

V Vulnerable

Biologically Important Area:

(f) Foraging

Type of Presence:

MO	Species or species habitat may occur within area
LO	Species or species habitat likely to occur within area
KO	Species or species habitat known to occur within area

Species	Specially Protected Fauna	Threatened Species	Migratory Species	Listed Marine Species	Biologically Important Area	Offshore Project Area	Trunkline Project Area	Borrow Grounds Project Area	EMBA
		FKO	Foraging known to occur within area						

5.4.4.2 EMBA

A total of 12 conservation significant species (or habitat) may occur in the EMBA. Foraging (including high density prey) BIAs for the Whale Shark overlap with the EMBA. Areas where increased biodiversity may occur include:

- Dampier AMP (see Section 5.6.1.4): presence of various habitats, particularly coral reefs and seagrasses, provide habitat for a variety of fish fauna, including Syngnathids.
- Gascoyne AMP (see Section 5.6.2.4): diverse continental slope habitats, evidenced by the presence of three KEFs (described below)
- Ningaloo AMP (see Section 5.6.2.2): diverse continental slope habitats, evidenced by the presence of three KEFs (described below)
- Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula (KEF) (see Section 5.5.4): aggregations of whale sharks, manta rays, sharks and large predatory fish are known to occur in this area, the hard substrates of the canyons' sides provide habitat for deepwater snappers and other species
- Commonwealth waters adjacent to Ningaloo Reef (KEF) (see Section 5.5.5): benthic and pelagic habitats create high productivity and aggregations of marine species, including fish fauna
- Glomar Shoals (KEF) (see Section 5.5.6): known to be an important area for a number of commercial and recreational fish species
- Rankin Bank (see Section 5.3.13): varied marine environment supporting a diverse fish assemblage.

5.4.4.3 Trunkline Project Area

A total of ten conservation significant fish species (or habitat) may occur in the Trunkline Project Area: five sharks, three sawfish and two rays. A designated BIA for Whale Shark foraging traverses the Trunkline Project Area, where seasonal peaks in whale shark presence is likely.

In addition to habitat for conservation significant species, the Trunkline Project Area overlaps other significant area for fish habitat, namely the Continental Slope Demersal Fish Communities KEF (see Section 5.5.3), Ancient Coastline KEF (see Section 5.5.2) and the Montebello AMP (see Section 5.6.1.3) which support higher demersal fish richness and abundance.

5.4.4.4 Offshore Project Area

Four conservation-significant fish species (or habitat) may occur in the Offshore Project Area: the Longfin mako, Shortfin mako, Great white shark and Giant manta ray. No threatened or migratory rays or sawfish are likely to occur in the Offshore Project Area, due to the absence of key habitat for these species.

The deep water and predominantly featureless, flat soft sediment seabed of low complexity (see Section 5.3.3) in the Offshore Project Area reduces the species diversity and richness of Syngnathids, pelagic and demersal fish species. Although sporadic upwelling events associated with the Exmouth Plateau and associated KEF, may temporarily increase fish diversity, overall, fish fauna is not expected to be abundant in the Offshore Project Area.

5.4.4.5 Borrow ground Project Area

A total of eight conservation significant fish species may be present within the Borrow Grounds project Area: three sharks, three sawfish species and two ray species. No BIAs overlap the Borrow Ground Project Area, however a foraging BIA for whale sharks lies ~20km to the north, extending from west to east (Figure 5-28).

Sharks, Sawfish and Rays

<u>Whale Shark</u>

The Whale shark (*Rhincodon typus*) is listed as Vulnerable and Migratory under the EPBC Act (TSSC, 2015j). The species is widely distributed in Australian waters, most commonly aggregating at Ningaloo Marine Park in WA (between March and July), and to a lesser extent at Christmas Island in the Coral Sea. The seasonal aggregation of Whale sharks at Ningaloo Reef is estimated at 300–500 individuals, although the status of the population is unknown (DEWHA, 2012d). The species is generally encountered close to or at the surface, although whale sharks are known to dive to depths of at least 980 m (Wilson et al., 2006), and as single individuals or occasionally in schools or aggregations of up to hundreds of sharks. Aggregations around Ningaloo Reef are generally greatest during La Niña years rather than El Niño years due to an intensification of the Leeuwin current (DEWHA, 2008a).

The NWMR is considered important to Whale sharks for foraging. Key foraging areas include: (1) the Ningaloo Marine Park and adjacent commonwealth waters (depths of 60–100 m) in March to July; and (2) northward from Ningaloo Marine Park along the 200 m isobath in July to November (DEWHA, 2012d). Satellite tracking of whale sharks from the Ningaloo Reef area have shown movement in a northerly, north-easterly and north-westerly direction towards or into Indonesian waters (Wilson et al., 2006). Anecdotal evidence from sightings data collected from the Woodside offshore facilities on the NWS indicate whale sharks are present on the NWS in the months of April, July, August, September and October, corresponding with the Whale shark's seasonal migration to and from Ningaloo Reef.

Two foraging BIAs have been identified in the NWMR, one for high prey density at Ningaloo Reef, and the other along the continental shelf for post aggregation foraging and migration, with the latter overlapping the Trunkline Project Area (Figure 5-28). Whale sharks are likely to be present in the Trunkline Project Area, particularly during the months of July to November, as they migrate north east within the BIA. Whale sharks are unlikely to occur in the Offshore Project Area.

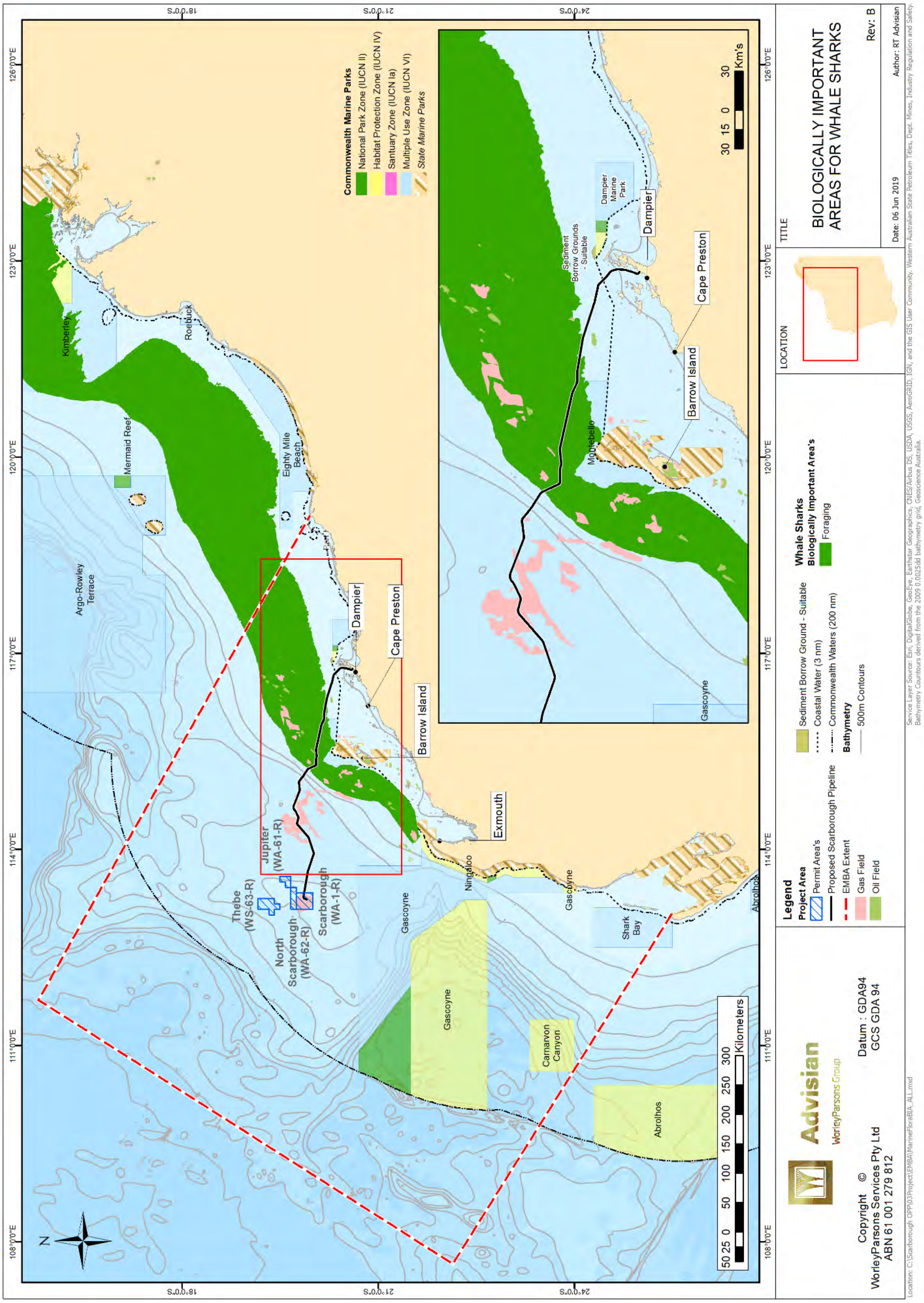


Figure 5-28: Biologically important area for whale sharks

Grey Nurse Shark (West Coast Population)

The Grey nurse shark (*Carcharus taurus*) is listed Vulnerable under the EPBC Act and has a broad distribution in inner continental shelf waters, primarily in sub-tropical to cool temperate waters (DoE, 2014). The species occurs primarily in south-west coastal waters between 20 and 140 m depth off Western Australia (Chidlow et al., 2006). Grey nurse sharks have been documented as aggregating in specific areas (typically reefs), however no clear aggregation sites have been identified off WA (Chidlow et al., 2006).

Given the species' preference for relatively shallow temperate waters, Grey nurse sharks are not expected to occur in the Offshore Project Area. Although at the northern most limit of their distribution, individuals may be present in the Trunkline Project Area, particularly where it crosses the continental shelf. No BIAs have been identified for this species.

Shortfin Mako

The Shortfin mako (*Isurus oxyrinchus*) is listed as Migratory under the EPBC Act (TSSC, 2014). It is a pelagic species with a circumglobal, wide-ranging oceanic distribution in tropical and temperate seas (Mollet et al., 2000). Little is known about the population size and distribution of Shortfin mako sharks in WA; however, the species is commonly found in water with temperatures greater than 16 °C and can grow to almost 4 m. The Shortfin mako shark is an apex and generalist predator that feeds on a variety of prey, such as teleost fish, other sharks, marine mammals and marine turtles (Campana et al., 2005). Tagging studies indicate Shortfin mako sharks spend most of their time in water less than 50 m deep but with occasional dives up to 880 m (Abascal et al., 2011; Stevens et al., 2010).

Although tagging has indicated a preference for shallower waters, their migratory nature and oceanic distribution suggest they could occur in the Project Area and EMBA in low numbers. No BIAs have been identified for this species in the NWMR.

Longfin Mako

The Longfin mako (*Isurus paucus*) is listed as Migratory under the EPBC Act. It is a widely distributed, but rarely encountered, oceanic shark species. The species can grow to just over 4 m long and is found in northern Australian waters, from Geraldton in Western Australia to at least Port Stephens in New South Wales and is uncommon in Australian waters relative to the shortfin mako (Bruce, 2013; DEWHA, 2010). There is very little information about these sharks in Australia, with no available population estimates or distribution trends. A study from southern California, documented juvenile longfin mako sharks remaining near surface waters, while larger adults were frequently observed at greater maximum depths of about 200 m (Sepulveda et al., 2004).

Given its large distribution oceanic distribution, the longfin mako may occur in the Project Area and EMBA, but in low numbers. No BIAs have been identified for this species in the NWMR.

Narrow Sawfish

The Narrow sawfish (*Anoxypristis cuspidate*) is listed Migratory under the EPBC Act. It occurs from the northern Arabian Gulf to Australia and north to Japan. The species inhabits inshore and estuarine waters and offshore waters up to depths of 100 m (IUCN 2015) and are most commonly found in sheltered bays with sandy bottoms. They are not currently listed as Threatened but are commonly caught as bycatch and constituted over half of sawfish bycatch in the Northern Prawn Fishery in 2013 (DoEE, 2015c; Morgan et al., 2010).

They are unlikely to occur in the Offshore Project Area but may be present one the shallower waters of the Trunkline Project Area and EMBA. No BIAs for this species occur in the NWMR.

Dwarf Sawfish

The Dwarf sawfish (*Pristis clavata)* is listed Vulnerable and Migratory under the EPBC Act. They are found in Australian coastal waters extending north from Cairns around the Cape York Peninsula in Queensland to the Pilbara coast (DotE, 2013b). Dwarf sawfish typically inhabit shallow (2 to 3 m) silty coastal waters and estuarine habitats, occupying relatively restricted areas and moving only small distances (Stevens et al., 2008). Juvenile Dwarf sawfish utilise estuarine habitats in north-western Western Australia as nursery areas (Thorburn et al., 2008; TSSC, 2009) and migrate to deeper waters as adults. Most capture locations for the species in Western Australian waters have occurred within King Sound (>1000 km from the Project Area) and the lower reaches of the major rivers that enter the sound, including the Fitzroy, Mary and Robinson rivers (Morgan et al., 2010). Individuals have also been recorded at Eighty Mile Beach, and occasional individuals have also been taken from considerably deeper water from trawl fishing (Morgan et al., 2010). Coastal waters around Eighty Mile Beach have been identified as a possible pupping area for this species, with a BIA designated accordingly.

The Dwarf sawfish is not expected to occur in the Offshore Project Area due to the deep, offshore environment. They may occur infrequently in the shallower waters of the Trunkline Project Area, and in coastal habitats of the EMBA. No BIAs for this species occur in the Project Area or EMBA.

Green Sawfish

The Green sawfish (*Pristis zijsron*) is listed as Vulnerable and Migratory under the EPBC Act. They were once widely distributed in coastal waters along the northern Indian Ocean, although it is believed that northern Australia may be the last region where significant populations exist (Stevens et al., 2005). Within Australia, Green sawfish are currently distributed from about the Whitsundays in Queensland across northern Australian waters to Shark Bay in Western Australia (DoEE, 2015a). Green sawfish are present in coastal waters, tidal creeks, the north eastern parts of the Ashburton Lagoon (Chevron Australia Pty Ltd, 2014). Despite records of the species in deeper offshore waters, Green sawfish typically occur in the inshore fringe with a strong associated with mangroves and adjacent mudflat habitats (Commonwealth of Australia, 2015b; Stevens et al., 2005). Movements within these preferred habitats is correlated with tidal movements (Stevens et al., 2008).

The species is known to occur in offshore waters of the NWS, with known pupping areas in coastal waters north of Port Hedland to Roebuck Bay; pupping is likely to occur south of Port Hedland, Exmouth Gulf and North West Cape (Commonwealth of Australia, 2015b; DoEE, 2017f). However, BIAs for pupping, nursing and foraging have only been designated in coastal waters of Eighty Mile Beach.

The Green sawfish is not expected to occur in the Offshore Project Area due to the deep, offshore environment. They may occur infrequently in the shallower waters of the Trunkline Project Area, and in coastal habitats of the EMBA. No BIAs for this species occur in the Project Area or EMBA.

Reef Manta Ray

The Reef manta ray (*Manta alfredi)* is listed as Migratory under the EPBC Act. The species is commonly sighted inshore, but also found around offshore coral reefs, rocky reefs and seamounts (Marshall et al., 2009). In contrast to the giant manta ray, long-term sighting records of the reef manta ray at established aggregation sites suggest that this species is more resident in tropical waters and may exhibit smaller home ranges, philopatric movement patterns and shorter seasonal migrations than the giant manta ray (Deakos et al., 2011; Marshall et al., 2009). A resident population of reef manta rays has been recorded at Ningaloo Reef, and the species has been shown to have both resident and migratory tendencies in eastern Australia (Couturier et al., 2011).

Given the lack of coral reef habitat within and in the vicinity of the Offshore Project Area, reef manta rays are not expected to occur in the Offshore Project Area. Presence in the Trunkline Project Area and EMBA is more likely given the water depths and proximity to preferred habitat. No BIAs for this species occur in the NWMR.

<u>*Giant Manta Ray*</u>

The Giant manta ray (*Manta birostris*) is listed as Migratory under the EPBC Act and is broadly distributed in tropical waters of Australia. The species primarily inhabits nearshore environments along productive coastlines with regular upwelling, but they appear to be seasonal visitors to coastal or offshore sites including offshore island groups, offshore pinnacles and seamounts (Marshall et al., 2011). Ningaloo Reef is an important area for Giant manta rays in autumn and winter (Environment Australia, 2002; Preen et al., 1997).

Occurrence of Giant manta rays in the Offshore Project Area is unlikely given the deep offshore waters and featureless seafloor. Presence in the Trunkline Project Area is more likely as they migrate through the area, but aggregations are unlikely. The species is known to forage within the EMBA, at Ningaloo Reef, however no BIAs have been identified for this species in the NWMR.

5.4.5 Marine Mammals

5.4.5.1 Overview

Marine mammals in the NWMR can include cetacean (whales and dolphins) and dugongs. The NWMR is thought to be an important migratory pathway for large truly pelagic whales (such as humpback whale and pygmy blue whale) between feeding grounds in the Southern Ocean and breeding grounds in tropical waters (DEWHA, 2012b). In addition, foraging whales have been observed in areas of upwelling in NWMR. Dolphins and dugongs are typically found in nearshore waters.

There are 15 whale, 14 dolphin and one dugong species (or species habitat) that may occur within the Project Area, and an additional three whales could occur in the EMBA; this includes species classified as Threatened and Migratory under the EPBC Act or specially protected under the WA Wildlife Conservation Act (Table 5-7). The type of behaviour is predominantly a presence (may, likely or known to occur), with some important behaviours (e.g. migrating) for a small number of species within the Trunkline Project Area (Table 5-4).

Two species, the Pygmy blue whale and Humpback whale, have BIAs for migration overlapping the Project Area (Table 5-4, Figure 5-31). Although foraging BIAs for Pygmy blue whales, and foraging and nursing BIAs for Dugongs, are present in the EMBA, these do not overlap the Project Area (Table 5-4).

Table 5-7: Mammal species or species habitat that may occur within Project Area and EMBA

Species		Specially Protected Fauna	Threatened Species	Migratory Species	Listed Cetacean Species	Biologically Important Area	Offshore Project Area	Trunkline Project Area	Borrow Ground Project Area	EMBA
Whale										
Balaenoptera acutorostrata	Minke whale				✓		MO	MO	MO	MO
Balaenoptera bonaerensis	Antarctic minke whale			✓	✓		LO	LO		LO
Balaenoptera borealis	Sei whale		V	✓	✓		LO	LO		FLO
Balaenoptera edeni	Bryde's whale			✓	✓		LO	LO	MO	LO
Balaenoptera musculus brevicauda	Pygmy blue whale		E	✓	✓	✓(m,d)	LO	MrK		MrK
Balaenoptera musculus intermedia	Blue whale		E	✓	✓	✓(m,d)	LO	MrK	LO	MrK
Balaenoptera physalus	Fin whale		V	✓	✓		LO	LO		FLO
Eubalaena australis	Southern right whale		E	✓	✓					LO
Globicephala macrorhynchus	Short-finned pilot whale				✓		MO	MO		MO
Indopacetus pacificus	Longman's beaked whale				✓					MO
Kogia breviceps	Pygmy sperm whale				✓		MO	MO		MO
Kogia simus	Dwarf sperm whale				✓		MO	MO		MO
Megaptera novaeangliae	Humpback whale	S	V	✓	✓	✓(m)	MO	KO	KO	AKO
Mesoplodon densirostris	Blainville's beaked whale				✓		MO	MO		MO
Mesoplodon ginkgodens	Gingko-toothed beaked whale									MO

Species		Specially Protected Fauna	Threatened Species	Migratory Species	Listed Cetacean Species	Biologically Important Area	Offshore Project Area	Trunkline Project Area	Borrow Ground Project Area	EMBA
Peponocephala electra	Melon-headed whale				✓		MO	MO		MO
Physeter macrocephalus	Sperm whale			✓	✓		MO	MO		MO
Ziphius cavirostris	Cuvier's beaked whale				✓		MO	MO		MO
Dolphin										
Delphinus delphis	Common dolphin				✓		MO	MO	MO	MO
Feresa attenuata	Pygmy killer whale				✓		MO	MO		MO
Grampus griseus	Risso's dolphin				✓		MO	MO	MO	MO
Lagenodelphis hosei	Fraser's dolphin				✓		MO	MO		MO
Orcinus orca	Killer whale			✓	✓		MO	MO	MO	MO
Pseudorca crassidens	False killer whale				✓		LO	LO		LO
Sousa chinensis	Indo-Pacific humpback dolphin			✓	✓			MO	MO	KO
Stenella attenuata	Spotted dolphin				✓		MO	MO	MO	MO
Stenella coeruleoalba	Striped dolphin				✓		MO	MO		MO
Stenella longirostris	Long-snouted spinner dolphin				✓		MO	MO		MO
Steno bredanensis	Rough-toothed dolphin				✓		MO	MO		MO
Tursiops aduncus	Indian Ocean bottlenose dolphin				✓			MO	LO	LO
Tursiops aduncus (Arafura/Timor Sea populations)	Spotted bottlenose dolphin (Arafura/Timor Sea populations)			✓	✓			LO	LO	KO
Tursiops truncatus s. str.	Bottlenose dolphin				✓		MO	MO	MO	MO

Species		Specially Protected Fauna	Threatened Species	Migratory Species	Listed Cetacean Species	Biologically Important Area	Offshore Project Area	Trunkline Project Area	Borrow Ground Project Area	EMBA
Dugong										
Dugong	Dugong	S		✓	✓			LO	LO	BKO

Specially Protected Fauna:	
S	Other specially protected fauna
Threatened Species:	
V	Vulnerable
E	Endangered
Biologically Important Area:	
(d)	Distribution
(m)	Migration

Type of Presence:	
MO	Species or species habitat may occur within area
LO	Species or species habitat likely to occur within area
KO	Species or species habitat known to occur within area
FLO	Foraging likely to occur within area
AKO	Congregatin or aggregation known to occur
BKO	Breeding known to occur within area
MrK	Migration route known to occur within area

EMBA

A total of 13 conservation significant marine mammals (or habitat) may occur in the EMBA (Table 5-5). BIAs for three significant marine mammals overlap the EMBA: Humpback whale migration and resting; Pygmy blue whale migration, distribution and foraging; and Dugong nursing and foraging (Table 5-4).

Since the EMBA covers offshore, continental shelf and coastal habitats, the presence of whales, dolphins and dugongs may occur.

Shallower waters in proximity to shorelines of the mainland and islands provide habitat for a number of dolphin species. Additionally, seagrass habitat around the Montebello, Lowendal and Barrow islands, Dampier Archipelago and the Exmouth Gulf provides foraging habitat for dugongs. Upwelling off the Ningaloo coast may provide foraging habitat for the Pygmy blue whale in addition to other whale species.

Trunkline Project Area and Borrow Ground Project Area

A total of 12 conservation significant marine mammals (or habitat) may occur in the Trunkline Project Area and seven conservation significant species within the Borrow Ground Project Area (Table 5-5). In addition, BIAs for two significant marine mammals overlap the Trunkline Project Area and Borrow ground Project Area: Humpback whale migration and Pygmy blue whale distribution and migration (Table 5-4, Figure 5-27). Numbers of migrating individuals in the Trunkline Project Area and Borrow Ground Project Area will be higher during peak migration periods which differs between species.

Nevertheless, these BIAs will only represent important habitat for Humpback and Pygmy blue whales for discreet periods of the year.

Since the Trunkline Project Area and Borrow Ground Project Area traverses the continental shelf and is in relative proximity to shorelines, dolphins are more likely to occur in the Trunkline Project Area compared to the Offshore Project Area, although no BIAs or other significant habitat or aggregations were identified. The Dugong is also more likely to occur in shallower waters of the Trunkline Project Area.

Offshore Project Area

A total of nine conservation significant marine mammals (or habitat) may occur in the Offshore Project Area (Table 5-7). Although some dolphin species may have distributions that extend into offshore waters, their presence is not considered likely given their preference for coastal or continental shelf waters. The exception is the False killer whale, which is more likely to occur in the Offshore Project Area.

Only one BIA, for the Pygmy blue whale, overlaps the Offshore Project Area. However, this BIA is designated for distribution only, rather than more sensitive behaviours such as foraging and migration.

5.4.5.2 Conservation Significant Marine Mammals in the Project Area

Whales

Blue Whale and Pygmy Blue Whale

Blue whales are listed as Endangered and Migratory under the EPBC Act. There are two subspecies of blue whales found in the southern hemisphere and known to occur in Australian waters: the Antarctic blue whale (or “true” blue whale, *Balaenoptera musculus intermedia*) and the pygmy blue whale (*Balaenoptera musculus brevicauda*). Antarctic blue whales are uncommon north of 60°S (DotE, 2019), while pygmy blue whales have been recorded in northern waters of the Kimberley region and are assumed to breed in the tropical north.

Blue whales are generally associated with deep water beyond continental shelves, though can be found in shallow-water regions with narrow continental shelves (Branch et al., 2007). Pygmy blue whales are found along the western and southern coasts of Australia, from as far north as Indonesia down to SW Australia and east across the Great Australian Bight and Bonney Upwelling, and into waters as far east as Tasmania (Gill et al., 2011; McCauley, 2011; Double et al., 2014; Möller et al., 2015). They have been found to aggregate reliably and have shown longer periods of occupancy within certain regions (Commonwealth of Australia (2015), Figure 5-29).

Seasonally important areas in Australia include the Peth Canyon and the Bonny Upwelling, which represent two distinct feeding areas (Gill, 2002b; Rennie et al., 2009). In the Bonny Upwelling, pygmy blue whales have been sighted in this region from November to June (Gill, 2002; Gill et al., 2011, 2015; Möller et al., 2015) and acoustically detected off Portland from November, though predominantly from March to June (Tripovich et al., 2015). In the Perth Canyon, visual and acoustic surveys have shown pygmy blue whales arriving as early as November and numbers increasing to a peak in the following March to May (McCauley et al., 2000, 2004; Balcazar et al., 2015). Satellite tracking of these whales as they migrate north has indicated lower rates of travel and relatively longer occupancy within the Perth Canyon/Naturaliste Plateau region (Double et al., 2014). The number of pygmy blue whales present at any one time in this region is highly variable throughout the season and between years (Balcazar et al., 2015). Based on aerial line transect surveys from 2000-2004, an average of 30 (95% CI: 15-58) individuals were present within the peak season (McCauley et al., 2004). Most whales leave by late June, although a small number of acoustic detections have still been made into July (McCauley et al., 2004; Balcazar et al., 2015).

Outside of these recognised aggregation areas, satellite tracking has indicated rates of relatively higher occupancy around North West cape/Ningaloo Reef region in WA (Double et al., 2014; Möller et al., 2015). At this location, primary production rates are equal to those recorded in upwelling systems (Furnas, 2007) and is therefore likely to support blue whale feeding.

Limited and currently unpublished observations suggest areas of relatively higher occupancy may include Scott Reef to the far NW of Australia during October (Commonwealth of Australia, 2015). Further research is needed to confirm blue whale occupancy within these areas.

Branch et al. (2007b) hypothesised that pygmy blue whales occurring in Australian waters migrate between Australia and Indonesia along the Australian west coast. Acoustic data collected in December 2014–January 2015 on the Exmouth Plateau was used to evaluate the corridor of the southbound migration of pygmy blue whales of the eastern Indian Ocean population (Gavrilov and McCauley, 2018). The study reported pygmy blue whale travel southward much further away from the Western Australian coast than expected from data on their northbound migration, at distances of up to 400 km from shore.

Acoustic recordings collected from south-west Australia (McCauley et al., 2004; Stafford et al., 2004, 2011; Gavrilov and McCauley, 2013) showed whale detections increasing from November to June and peaking between February and March. These migration patterns are also supported by satellite telemetry data for pygmy blue whales, which indicates that whales feeding at both the Perth canyon (Gales et al., 2010; Double et al., 2014) and Bonney Upwelling (Möller et al., 2015) travel north along the west Australian coast into Indonesian waters. Assuming these tagged individuals are representative of the animals that feed off Australia as a whole, these data suggest whales feeding of the Perth Canyon migrate north in March–May reaching Indonesia by June–July where they remain until at least September (Double et al., 2014; Möller et al., 2015). They may then migrate south from Indonesia from September, reaching the subtropical frontal zone in December before returning to the Perth Canyon the following March (Double et al., 2014). A single tagged whale travelling north along southwest Australia over the course of a week was found to make consistently shallow dives while migrating, on average to a depth of 14 m for 5.2 min, unrelated to local bathymetry (Owen et al., 2016).

Acoustic detections of Indo-Australian pygmy blue whales around Scott Reef in the far north-west have shown that at least some migrating whales transit in the vicinity of the reef, and an increase in detections was found between 2007–2009 (McCauley, 2011). South-bound migrating whales were detected from October to January with a peak in November, and those travelling north were detected from April to August (McCauley, 2011). Preferred transit routes were west of Scott reef, though whales were also found to pass to the east. Approximately half of the blue whales detected around Scott Reef were estimated to pass through the channel separating the north and south lagoons, but few ventured far into the southern lagoon. Overall, it is estimated that between 6-40% of whales passing by Exmouth pass by Scott Reef (McCauley, 2011).

Indo-Australian type calls have also been recorded far to the west in the SW Indian Ocean subtropical frontal zone between January and June (Samaran et al., 2010; 2013), and two detections have been made in the Prydz Bay region during the austral summer representing the farthest south this population has been recorded (Gedamke and Robinson, 2010). This suggests plasticity in migratory behaviour or multiple migration routes, with some longitudinal movements from east to west in the Indian Ocean. Varying migration paths have also been suggested by McCauley and Jenner (2010) due to the large interannual variation in vocal activity detected off south-west Australia

Based on acoustic data, pygmy blue whales are likely to travel alone or in small groups. Typically, solitary whales have been recorded calling on noise loggers, although larger groups of calling animals were occasionally detected (McCauley & Duncan, 2011). For example, 78% of pygmy blue whale calls recorded around Scott Reef between 2006 and 2009 were from lone whales, 18% were from two whales and 4% were from three or more whales (McCauley & Duncan, 2011). The maximum number of individuals calling at one time was five (McCauley & Duncan, 2011).

Two BIAs for the pygmy blue whale overlap the Project Area (Figure 5-30); a BIA for distribution overlaps the Offshore Project Area and Trunkline Project Area, and a BIA for migration overlaps the Trunkline Project Area only. Although the migration BIA doesn't overlap the Offshore Project Area, based on recent findings (Gavrilov and McCauley, 2018), it is possible that migrating individuals will also traverse the Offshore Project Area.

Therefore, it is likely that individuals will occur in both the Offshore Project Area and Trunkline Project Area, with a peak in numbers during the migration season; May and June for northbound, and October and December for southbound.

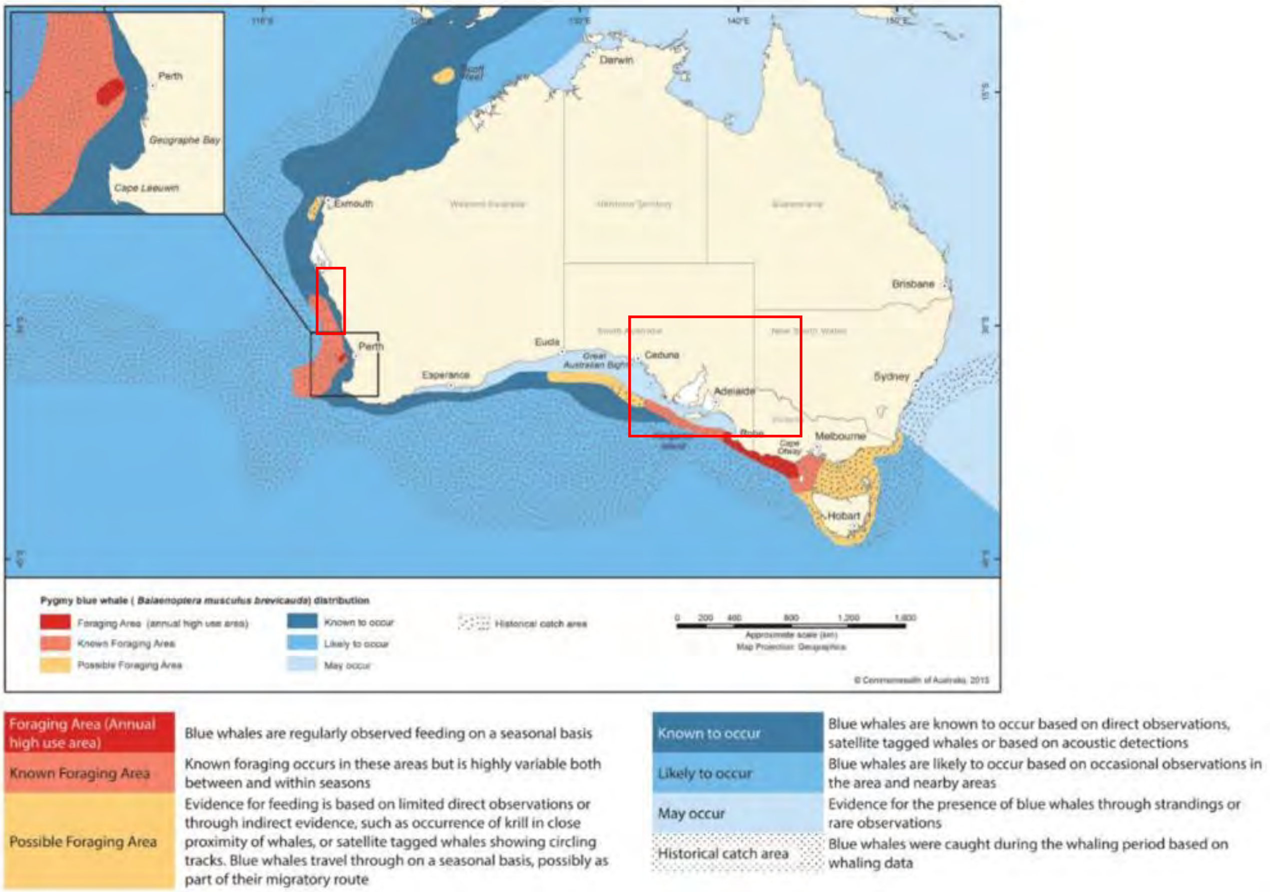


Figure 5-29: An overview of the distribution of pygmy blue whales around Australia (Commonwealth of Australia, 2015)

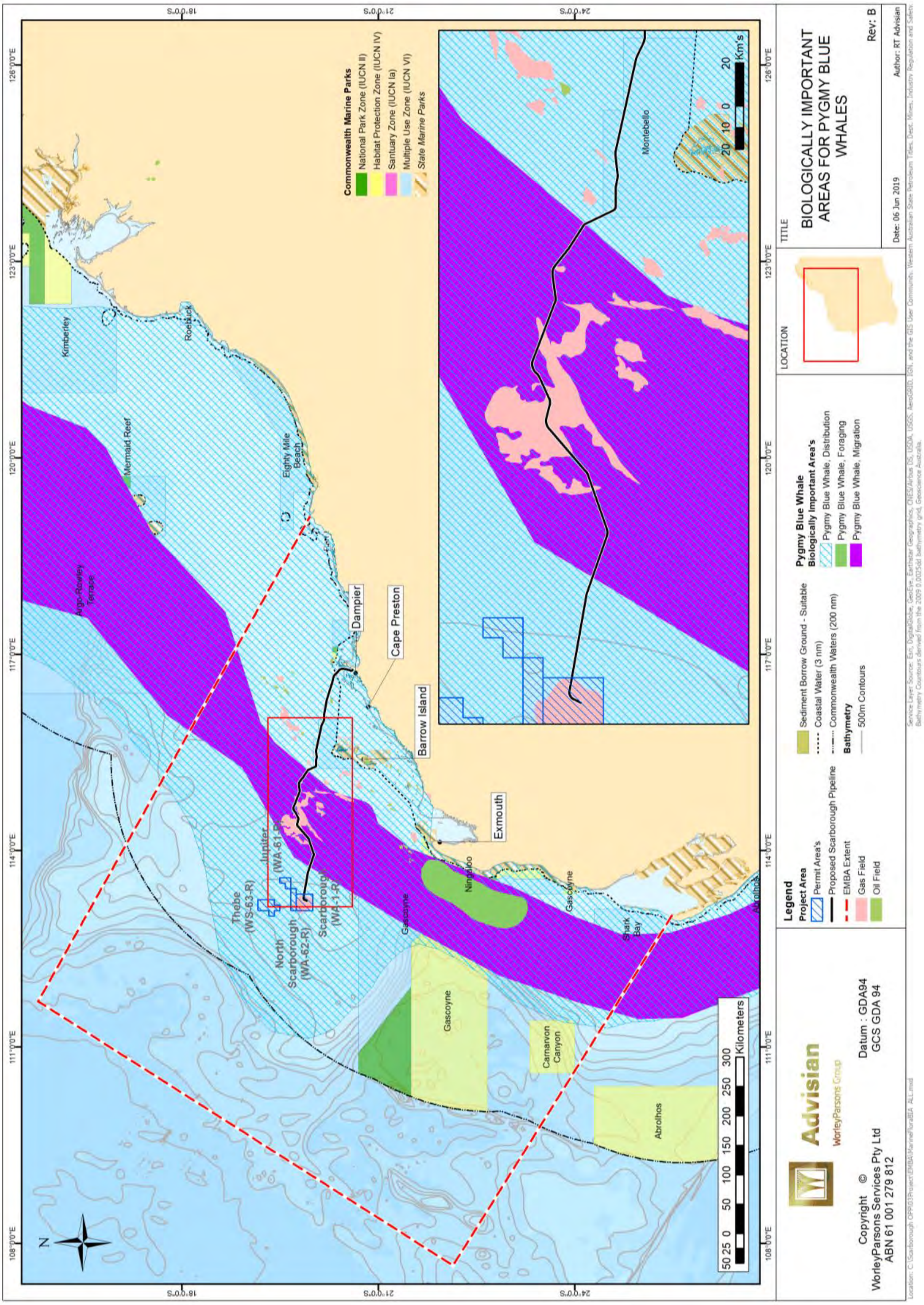


Figure 5-30: Biologically important areas for pygmy blue whales

<u>Humpback Whale</u>

The humpback whale (*Megaptera novaeangliae*) is listed as Vulnerable and Migratory under the EPBC Act, and specially protected under the WA Wildlife Conservation Act. Humpback whales occur throughout Australia, with two genetically distinct east and west subpopulations. The distributions of both subpopulations are influenced by migratory pathways and aggregation areas for resting, breeding and calving. The western subpopulation of Humpback whale was estimated to be as large as 33,300 in 2008 (Bejder et al., 2016). Previous estimates of the Western Australian population of humpback whales saw an increase from ~7000 individuals in 2000 to ~26,000 in 2008 (Salgado Kent et al., 2012).

Humpback whales of the west coast subpopulation migrate north from their Antarctic feeding grounds between May and November each year, to calving grounds which extend south from Camden Sound in the Kimberley (15°S) to at least North West Cape (22°43′S) (Irvine et al., 2018).

Young adults and lactating females arrive first in the mating and calving grounds, followed by non-pregnant mature females and adult males, with pregnant females arriving last (DEWHA, 2012b). The exact timing of the migration period can vary from year to year dependent upon water temperature, sea ice, predation risk, prey abundance and the location of the feeding ground last used (DEWR, 2007). Breeding and calving typically occurs between August and September (DEWHA, 2012b).

From the North West Cape, northbound Humpback whales travel along the edge of the continental shelf passing to the west of the Muiron, Barrow and Montebello Islands, peaking in late July (Jenner et al., 2001). The southern migratory route follows a relatively narrow track between the Dampier Archipelago and Montebello Islands. Southbound migration is more diffuse and irregular, lacking an obvious peak. An increase in migrating individuals may be observed between the North West Cape and the Montebello Islands between August and November (Jenner et al., 2001). Exmouth Gulf and Shark Bay are known resting/aggregation areas for southbound Humpback whales. Cow/calf pairs may stay in Exmouth Gulf for up to two weeks during September (Jenner et al., 2001).

Woodside has conducted marine megafauna aerial surveys that have confirmed that the temporal distribution of migrating Humpback whales off the North West Cape have remained consistent since baseline surveys were first conducted in 2000 to 2001 (RPS, 2010). Most Humpback whales occurred in depths less than 500 m, with the greatest density of whales concentrated in water depths of 200 to 300 m. Only a small proportion of the population were observed to occur in the deeper offshore waters (RPS, 2010). These survey results are consistent with satellite tagging studies (Double et al., 2010, 2012a).

One BIA for migration overlaps the Trunkline Project Area only (Figure 5-31). While individuals may occur in the Offshore Project Area, presence is much likely in the Trunkline Project Area, particularly during peak migration in the area. Presence is expected to be highest during the northbound migration peak in mid-July, and to a lesser extent between August and November for southbound migrating individuals.

No foraging or resting areas occur within the Project Area or EMBA, with the closest resting BIAs located in the Exmouth Gulf 198 km from the Project Area at the closest point.

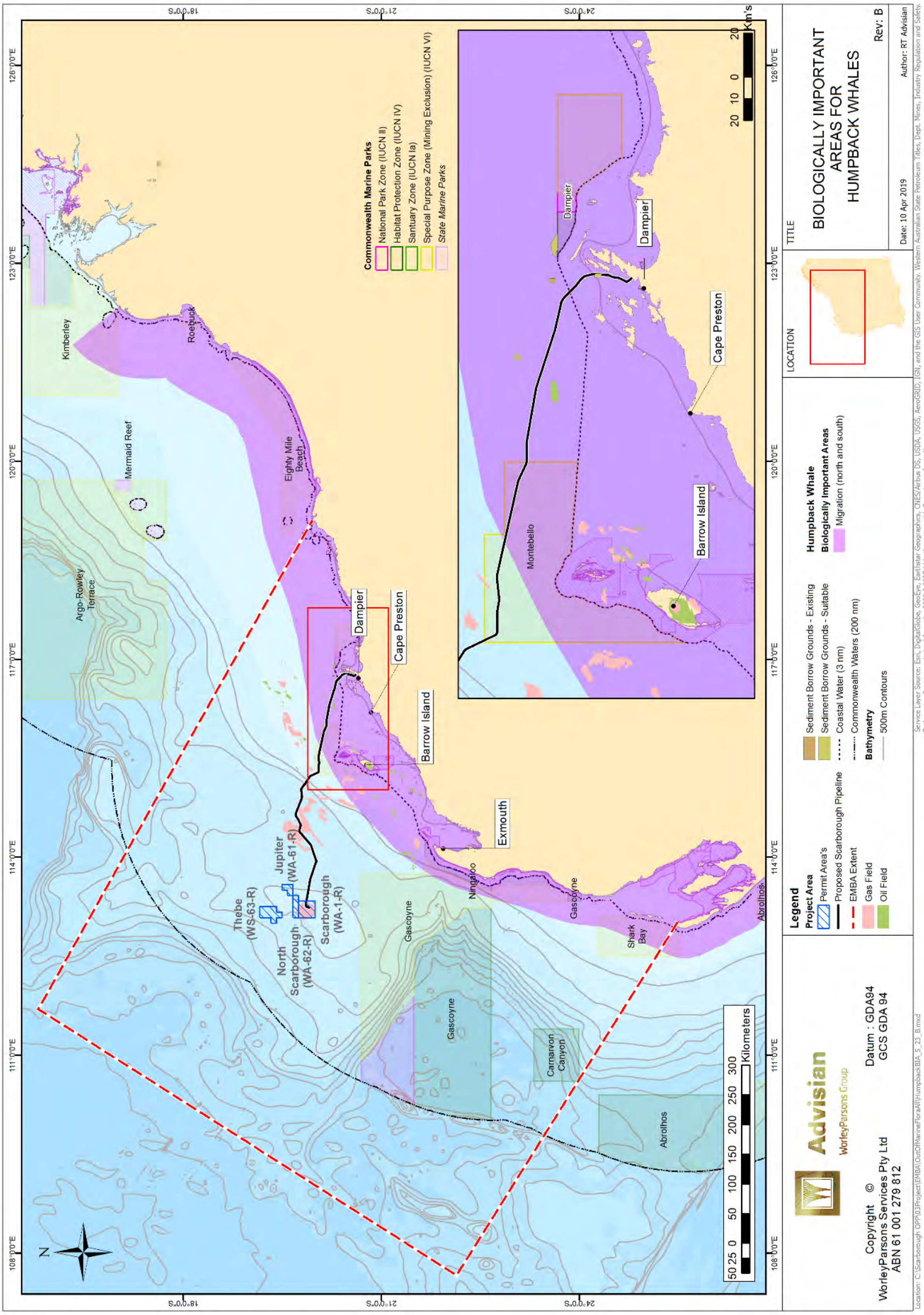


Figure 5-31: Biologically important areas for humpback whales

Antarctic Minke Whale

The Antarctic minke whale (*Balaenoptera bonaerenis*) is listed Migratory under the EPBC Act. It has a global distribution and inhabits all oceans in the Southern Hemisphere. Their summer range is close to Antarctica, but they move further north in winter, including along the Australian east and west coasts (Bannister et al., 1996). Antarctic minke whales have only been observed as far north as 21°S along the east coast of Australia (equivalent to Karratha on the west coast) and it is thought the species follows a similar migration on the Western Australian coast, migrating up to about 20 °S to feed and possibly breed (Bannister et al., 1996). However, detailed information on timing and location of migrations and breeding grounds in Western Australia is not well known.

Antarctic minke whale calls were recorded near Scott Reef on a logger deployed to the south-east of South Scott Reef. Calls were detected for a few days each year in 2006 to 2008 between July and October (McCauley & Duncan, 2011). No calls from this species were identified on other loggers set inside and outside of the reef.

Given the large, oceanic distribution of Antarctic minke whale, and the absence of defined migration pathways, the Project Area is unlikely to represent an important habitat for this species. While individuals may occur, they are unlikely to do so in large numbers, or be undertaking a behaviour critical to their survival. There are no known BIAs for Antarctic minke whales in the NWMR.

Sei Whale

The Sei whale (*Balaenoptera borealis*) is listed Vulnerable and Migratory under the EPBC Act. Like many baleen whale species, the population of Sei whales was significantly reduced in numbers by commercial whaling operations. The species has a worldwide oceanic distribution and is expected to undertake seasonal migrations between low latitude wintering areas and high latitude summer feeding grounds (Bannister et al., 1996; Prieto et al., 2012). Sei whales have been infrequently recorded in Australian waters (Bannister et al., 1996) which could be due to the similarity in appearance of Sei whales and Bryde’s whales leading to incorrect recordings. There are no known mating or calving areas in Australian waters (DoE, 2016a). The species prefers deep waters, and typically occurs in oceanic basins and continental slopes (Prieto et al., 2012); records of the species occurring on the continental shelf (<200 m water depth) are uncommon in Australian waters (Bannister et al., 1996).

Given the large, oceanic distribution of the Sei whale, and the absence of defined migration pathways or foraging areas, the Project Area is unlikely to represent an important habitat for this species. Occurrence within the Offshore Project Area is more likely than the Trunkline Project Area given their preference for deep water habitats, however, they are unlikely to do so in large numbers. There are no known BIAs for Sei whales in the NWMR.

Bryde's Whale

The Bryde’s whale (*Balaenoptera edeni*) is listed Migratory under the EPBC Act, with a wide distribution throughout tropical, sub-tropical and temperate waters from the equator to about 40 °S (Bannister et al., 1996; DoE, 2015a). Bryde’s whales have been identified as occurring in both oceanic and inshore waters, with the only key localities recognised in Western Australia being in the Abrolhos Islands and Shark Bay (Bannister et al., 1996). Data suggests offshore whales may migrate seasonally through a broad area of the continental shelf, heading towards warmer tropical waters during the winter, however, information on migration is not well known (McCauley & Duncan, 2011; RPS Environment and Planning, 2012). This species has been detected on the North West Shelf from mid-December to mid-June, peaking in late February to mid-April (RPS Environment and Planning, 2012).

In 2008, Bryde’s whales were recorded in low numbers across a large survey area between the mainland and Scott Reef (Woodside, 2014b). During aerial and vessel-based surveys in 2009, one

Bryde's whale was recorded 10 km west of Coulomb Point on the Kimberley coast (Woodside, 2014b). Calls attributed to Bryde's whales have been recorded year-round in low numbers on sea noise loggers deployed inside and outside of Scott Reef, between September 2006 and June 2008 (outside the Region) (McCauley, 2009). In Shark Bay, Bryde's whales are present foraging between November and April (Department of Environmental Protection, 2001).

Due to the large, oceanic distribution of Bryde's whale, the Project Area is unlikely to represent an important habitat for this species. Foraging areas have been identified in Shark Bay, 607 km from the Project Area and outside the EMBA. Since they have been observed in offshore and nearshore waters (Bannister et al., 1996), individuals may occur in the Offshore Project Area and Trunkline Project Area, however, they are unlikely to do so in large numbers. There are no known BIAs for Bryde's whales in the NWMR.

Fin Whale

The Fin whale (*Balaenoptera physalus*) is listed Vulnerable and Migratory under the EPBC Act. Fin whales have a cosmopolitan distribution in all ocean basis between 20 and 75 °S (Department of the Environment and Heritage, 2005a). Fin whales have been recorded off all states in Australia except New South Wales and the Northern Territory (Bannister et al., 1996). The global population of Fin whales was reduced significantly by commercial whaling, with the species being targeted due to its large size and broad distribution.

Like other baleen whales, Fin whales undertake annual migrations between high latitude summer feeding grounds and lower latitude over-wintering areas (Bannister et al., 1996). Fin whales are thought to follow oceanic migration paths and are uncommonly encountered in coastal or continental shelf waters. The Australian Antarctic waters are important feeding grounds for Fin whales, however there are no known mating or calving areas in Australian waters (Morrice et al., 2004).

Due to the large, oceanic distribution of the Fin whale, like other large baleen whales, the Project Area is unlikely to represent an important habitat for this species. Given they are uncommonly observed in coastal or continental shelf waters, they are more likely to occur in the Offshore Project Area compared to the Trunkline Project Area, however, they are unlikely to occur in the Offshore Project Area in large numbers. There are no known BIAs for Fin whales in the NWMR.

Sperm Whale

The sperm whale has a worldwide distribution in deep waters (greater than 200 m) off continental shelves and sometimes near shelf edges, averaging 20–30 nautical miles offshore (Bannister et al., 1996a). The species tends to inhabit offshore areas at depths of 600 m or more and is uncommon in waters less than 300 m deep (Ceccarelli et al., 2011). Females and young appear to be restricted generally to warmer waters of low latitudes, in water depths ≥ 1000 m. Inter-oceanic movements are more prevalent among males, with older individuals (4-21-years) travelling to and from colder waters and to Antarctica. Concentrations tend to be found where the seabed rises steeply from great depth, in areas associated with concentrations of major prey and upwelling activity (Ceccarelli et al., 2011).

There is limited information about sperm whale distribution in Australian waters, however, they are usually found in deep offshore waters, with more dense populations close to continental shelves and canyons (DotE, 2019). The species may occur in severely fragmented populations. Key localities in Australia include; the southern coastline between Cape Leeuwin and Esperance, WA (Bannister et al., 1996a); south-west of Kangaroo Island, SA; deep waters off the Tasmanian west and south coasts; southern NSW; and deep waters off Stradbroke Island, Qld (Ceccarelli et al., 2011). There are no known BIAs for sperm whales in the NWMR. In the open ocean, there is a generalised movement of sperm whales southwards in summer, and corresponding movement northwards in winter, particularly for males (DotE, 2019). Detailed information about the distribution and migration patterns of sperm whales off the WA coast is not available.

Females with young may reside within the NWMR all year round, males may migrate through the region and the species may be associated with canyon habitats (Ceccarelli et al., 2011). Sperm whales have been recorded in deep waters off North West Cape (Jenner et al., 2010) and appear to occasionally venture into shallower waters in other areas. Twenty-three sightings of sperm whales (variable pod sizes, ranging from one to six animals) were recorded by marine mammal observers (MMOs) during the North West Cape MC3D marine seismic survey conducted between December 2016 and April 2017. These animals were observed in deep, continental slope waters of the Montebello Saddle (maximum distance of approximately 90 km from North West Cape), and the waters overlying the Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula KEF.

The deep waters above the gully/saddle on the inner edge of the plateau (the Montebello Saddle) are thought to be important for sperm whales that may feed in the region (based on 19th century whaling records; Townsend 1935). The reasons for this aggregation are not known. Other cetaceans are also believed to use northward flowing currents through the Montebello Saddle to assist in their northward migration, similar the northward flowing offshoot of the Eastern Gyral Current (DEWHA, 2008b).

Dolphins

<u>Spotted Bottlenose Dolphin (Arafura/Timor Sea Population)</u>

The spotted bottlenose dolphin (*Tursiops aduncus*) is listed as Migratory under the EPBC Act. It is generally considered to be a warm water subspecies of the common bottlenose dolphin and its distribution is primarily inshore waters, often in depths of less than 10 m (Bannister et al., 1996). They are known to occur from Shark Bay, north to the western edge of the Gulf of Carpentaria.

Given the distribution of Spotted bottlenose dolphins and their preference for shallow coastal waters they are not expected to occur in the Offshore Project Area. Occurrence in the Trunkline Project Area is more likely, given the relative proximity to shorelines; however, the Trunkline Project Area is still 375 km from the shoreline and therefore unlikely to represent an important habitat for this species. BIAs overlap neither the Project Area nor EMBA.

Dugong

The Dugong (*Dugong dugong*) is listed Migratory under the EPBC Act. The species is distributed along the Western Australian coast throughout the Gascoyne, Pilbara and Kimberley, with notable populations in Ningaloo Reef, Exmouth Gulf and Shark Bay. Dugong distribution is correlated with seagrass habitats which Dugong feed on, although water temperature has also been correlated with Dugong movements and distribution (Preen et al., 1997; Preen, 2004). Dugongs are known to migrate between seagrass habitats (hundreds of kilometres) (Sheppard et al., 2006).

Given the lack of seagrass habitat in the Project Area, Dugong are not expected to occur, particularly in the Offshore Project Area when considering the distance offshore. Presence is more likely in the Trunkline Project Area given the shallower water depths; however, individuals would be limited to a very low number potentially transiting the area on migration between areas of seagrass habitat. No BIAs overlap the Project Area. A BIA for foraging and nursing occur in the Exmouth Gulf, however this is outside the EMBA.

5.4.6 Marine Reptiles

5.4.6.1 Overview

Marine reptiles of the NWMR include turtles and seasnakes. Six of the seven marine turtle species are present in Australia, predominantly occurring in the waters off Queensland, Northern Territory and north Western Australia. Marine turtles are highly migratory during some life phases, but during others show high site fidelity. They require both terrestrial and marine habitats to fulfil different life history stages (DoEE, 2017x).

The waters of the NWMR provides marine turtle habitat or a variety of behaviours including; foraging, mating and internesting. Additionally, a number of important nesting beaches occur, including:

- Ningaloo coast
- Muiron Islands
- Montebello, Lowendal and Barrow islands
- Pilbara island chain, including Serrurier Islands
- Dampier Archipelago
- locations along the Pilbara mainland coast.

Many of these locations have been identified as BIAs or 'habitat critical to the survival of a species' (Table 5-4).

The Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017) identifies areas 'habitat critical to the survival of a species' (habitat critical) for marine turtle stocks under the EPBC Act. Habitat critical is defined by the EPBC Act Significant Impact Guidelines 1.1 – Matters of National Environmental Significance as areas necessary:

- for activities such as foraging, breeding or dispersal
- for the long-term maintenance of the species (including the maintenance of species essential to the survival of the species)
- to maintain genetic diversity and long term evolutionary development
- for the reintroduction of populations or recovery of the species.

Nesting and internesting habitats have been identified, described and mapped for the green turtle, loggerhead turtle, flatback turtle, hawksbill turtle, olive ridley turtle and the leatherback turtle (Commonwealth of Australia, 2017).

The areas of habitat critical that overlap with the Trunkline Project Area and Borrow Grounds Project Area are described in Table 5-4. It is noted that habitat critical differs from 'Critical Habitat' as defined under Section 207A of the EPBC Act (Register of Critical Habitat). No 'Critical Habitat' has been identified and listed for marine turtles.

Seasnakes occur along the North West Shelf and are reported to occur in offshore and nearshore waters. They occupy diverse habitats including coral reefs, turbid water habitats and deeper water (Guinea et al., 2004). Species exhibit habitat preferences depending on water depth, benthic habitat, turbidity and season (Heatwole & Cogger, 1993). The majority of information on the occurrence of seasnakes has been sourced from by-catch logs maintained by the Northern Prawn Fishery (DEWHA, 2008a).

A total of five marine turtles and 17 seasnakes species (or species habitat) may occur within the Project Area and an additional seasnake species that could occur within the EMBA. Species include those that are classified as Threatened and Migratory under the EPBC Act, or specially protected under the WA Wildlife Conservation Act (Table 5-8). Seasnake presence is not expected to be linked to a particular behaviour. However, of the five marine turtle species expected to occur, four (flatback, green, loggerhead and hawksbill turtle) have BIAs or habitat critical for breeding (nesting, internesting or mating) overlapping the Project Area. Additional foraging BIAs for those four species also occur within the EMBA.

Table 5-8: Marine reptile species or species habitat that may occur within the Project Area and EMBA

Species		Specially Protected Fauna	Threatened Species	Migratory Species	Listed Marine Species	Biologically Important Area	Offshore Project Area	Trunkline Project Area	Borrow Grounds Project Area	EMBA
Turtles										
Caretta	Loggerhead Turtle		E	✓	✓	✓(i)	LO	AKO	KO	BKO
Chelonia mydas	Green Turtle		V	✓	✓	✓(i,n,m, f,mr)	LO	AKO	KO	BKO
Dermochelys coriacea	Leatherback Turtle		E	✓	✓		LO	LO	LO	FKO
Eretmochelys imbricata	Hawksbill Turtle		V	✓	✓	✓(i,n,m, f,mr)	LO	AKO	KO	BKO
Natator depressus	Flatback Turtle		V	✓	✓	✓(i,n,m, f,mr)	LO	AKO	AKO	BKO
Seasnakes										
Acalyptophis peronii	Horned seasnake				✓			MO	MO	MO
Aipysurus apraefrontalis	Short-nosed seasnake		CE		✓			LO	MO	KO
Aipysurus duboisii	Dubois' seasnake				✓			MO	MO	MO
Aipysurus eydouxii	Spine-tailed seasnake				✓			MO	MO	MO
Aipysurus laevis	Olive seasnake				✓		MO	MO	MO	MO
Aipysurus pooleorum	Shark Bay seasnake				✓					MO
Aipysurus tenuis	Brown-lined seasnake				✓			MO	MO	MO
Astrotia stokesii	Stokes' seasnake				✓			MO	MO	MO
Disteira kingii	Spectacled seasnake				✓		MO	MO	MO	MO
Disteira major	Olive-headed seasnake				✓			MO	MO	MO
Emydocephalus annulatus	Turtle-headed seasnake				✓			MO	MO	MO
Ephalophis greyi	North-western mangrove seasnake				✓			MO	MO	MO

Species		Specially Protected Fauna	Threatened Species	Migratory Species	Listed Marine Species	Biologically Important Area	Offshore Project Area	Trunkline Project Area	Borrow Grounds Project Area	EMBA
Hydrelaps darwiniensis	Black-ringed seasnake				✓			MO	MO	MO
Hydrophis czeblukovi	Fine-spined seasnake				✓			MO	MO	MO
Hydrophis elegans	Elegant seasnake				✓			MO	MO	MO
Hydrophis mcdowelli	(unnamed)				✓			MO	MO	MO
Hydrophis ornatus	Spotted seasnake				✓			MO	MO	MO
Pelamis platurus	Yellow-bellied seasnake				✓		MO	MO	MO	MO

Threatened Species:
V Vulnerable
E Endangered
Biologically Important Area:
(i) Internesting
(n) Nesting
(m) Mating
(f) Foraging
(mr) Migration

Type of Presence:

MO	Species or species habitat may occur within area
LO	Species or species habitat likely to occur within area
KO	Species or species habitat known to occur within area
FKO	Foraging known to occur within area
AKO	Congregatin or aggregation known to occur
BKO	Breeding known to occur within area

5.4.6.2 EMBA

Six conservation significant marine reptile species (or habitat) may occur in the EMBA; five marine turtles and one seasnake (Table 5-5). BIAs for the Flatback turtle, Green turtle, Hawksbill turtle and Loggerhead turtle overlap with the EMBA as described in (Table 5-7).

The shallower waters and shorelines of the EMBA are likely to provide more significant internesting, mating and nesting habitat for the marine turtle species compared to the Project Area. Greater presence of primary producers in the EMBA compared to the Project Area, such as coral reefs or seagrasses, provide additional foraging areas for marine turtles and habitat for a wider range of seasnake species.

5.4.6.3 Trunkline Project Area and Borrow Ground Project Area

A total of six conservation significant marine reptile species (or habitat) may occur in both the Trunkline Project Area and Borrow Ground Project Area; five marine turtles and one seasnake.

In addition, overlapping the Trunkline Project Area and Borrow Grounds Project Area are BIAs for internesting hawksbill, flatback, loggerhead and green turtles, and habitat critical for internesting hawksbill, flatback and green turtles. These areas are associated with nesting beaches at the North West Cape, Muiron Islands, Montebello, Lowendal and Barrow islands, and the islands of the Dampier Archipelago (Commonwealth of Australia, 2017; Environment Australia, 2003; Limpus, 2007, 2008a, 2008b, 2009). Significant nesting and aggregation areas for marine turtles within the Dampier Archipelago were reported by CALM (2005). Presence of marine turtles in the Trunkline Project Area are expected to peak during breeding periods.

5.4.6.4 Offshore Project Area

A total of five conservation significant marine turtle species (or habitat) may occur in the Offshore Project Area. Since the Offshore Project Area is located in deep offshore waters, and is devoid of primary producers and emergent features, the area does not represent important habitat, such as foraging or breeding for marine reptiles. However, given the large distribution of marine turtles, particularly the Leatherback turtle, transient individuals may occur infrequently.

No conservation significant seasnake species are likely to occur in the Offshore Project Area. While some seasnake species inhabit deep offshore habitats, none of the species listed in the EPBC Protected Matters report are listed Threatened or Migratory under the EPBC Act, or likely to occur in the Offshore Project Area.

Marine Turtles

Leatherback Turtle

Leatherback turtles (*Dermochelys coriacea*) are listed Endangered and Migratory under the EPBC Act. They have a broad distribution worldwide but are uncommon within their Australian range, particularly within the NWMR (DoEE, 2017c). Leatherback turtles are rarely recorded breeding within Australia with no large recorded rookeries, however they are known to regularly forage within tropical and temperate continental shelf waters. The leatherback turtle is an oceanic, pelagic species that feeds primarily on jellyfish, sea squirts and other soft-bodied invertebrates (DEWHA, 2012c).

Given their broad distribution the leatherback turtle could occur in the Offshore Project Area and Trunkline Project Area, but in low numbers. No BIAs for this species have been identified in the NWMR.

Flatback Turtle

Flatback turtles (*Natator depressus*) are listed Vulnerable and Migratory under the EPBC Act. They are endemic to the northern Australia/southern New Guinea continental shelf. Flatback turtles differ from other marine turtles in that they do not have a pelagic phase to their lifecycle; instead, hatchlings grow to maturity in shallow coastal waters thought to be close to their natal beaches. They also prefer soft bottom habitats away from rock and reef systems. Flatback turtle foraging areas have been found to occur in waters shallower than 130 m and within 315 km of the shore, with many areas located in 50 m water depth and 66 km from shore (Whittock et al., 2016b). Their main diet comprises algae and a variety of invertebrates (e.g. molluscs, soft corals, sea cucumbers and jellyfish).

There are two breeding stocks within the NWMR, one of which (the Pilbara stock [F-Pil]) has significant rookeries on Thevenard Island, Barrow Island, the Montebello Islands, Varanus Island, the Lowendal Islands, islands of the Dampier Archipelago (particularly Delambre Island), and coastal areas around Port Hedland (DoEE, 2017a). The trend of the F-Pil genetic stock is currently unknown (Commonwealth of Australia, 2017). Nesting begins in late November–December, peaks in January, and finishes by February–March.

Although track data confirmed presence of flatback turtles only at Legendre Island (Pendoley et al., 2016), a tagging program conducted in 2008 demonstrated that flatbacks, hawksbill and green turtles nested in notable numbers at this island (Biota, 2009). Delambre Island has been recognised as the largest flatback turtle rookery in Australia with an estimated 3500 nesting females per year (Chaloupka, 2018).

Both BIAs and habitat critical for flatback turtles have been identified within the Trunkline Project Area around the Montebello, Lowendal and Barrow islands and the Dampier Archipelago (Table 5-4). Compared to other turtles identified in the NWMR, internesting behaviours exhibited by flatback turtles extend further offshore, with the BIA and habitat critical for flatback turtles extending 80 km and 60 km from nesting beaches, respectively (Figure 5-32; Table 5.3). However, tracking data indicates that flatback turtles in the NWMR travel and forage in relatively shallow coastal waters less than 70 m deep (Chevron Australia Pty Ltd, 2015). Furthermore, while internesting distances of up to 70 km have been recorded, these were either in a longshore direction or from islands to mainland, rather out into open water. A number of individuals, from four different rookeries, remained within 10 km of the nesting site (Whittock et al., 2014). These distances are less than previous studies which showed flatback turtles travelled at least 26 km and up to 48 km in all directions from nesting beaches on the Lacepede Islands, during internesting (Waayers et al. 2011), although water depths are not reported.

It is likely that flatback turtles will occur in the Project Area. Although individuals may transit through the Offshore Project Area, the distance offshore, water depths, and lack of primary producers and nesting beaches, prevents the Offshore Project Area from providing habitat that encourages aggregation of this species. The proximity of the Trunkline Project Area to known nesting sites, and the overlap with areas designated as internesting habitat (BIAs and habitat critical), increases the likely presence of flatback turtles in the Trunkline Project Area compared to within the Offshore Project Area. Nevertheless, given the water depths and distance from the Trunkline Project Area to known nesting beaches at the Montebello, Lowendal and Barrow islands, and islands of the Dampier Archipelago, the number of internesting females potentially occurring is unlikely to comprise a significant portion of the Western Australian population. Within the EMBA, the internesting BIA is expected to be utilised more frequently as distance to nesting sites decreases. Additional breeding BIAs for mating and nesting also occur in the EMBA. No foraging areas were identified in the Project Area, although a foraging BIA overlaps the EMBA.

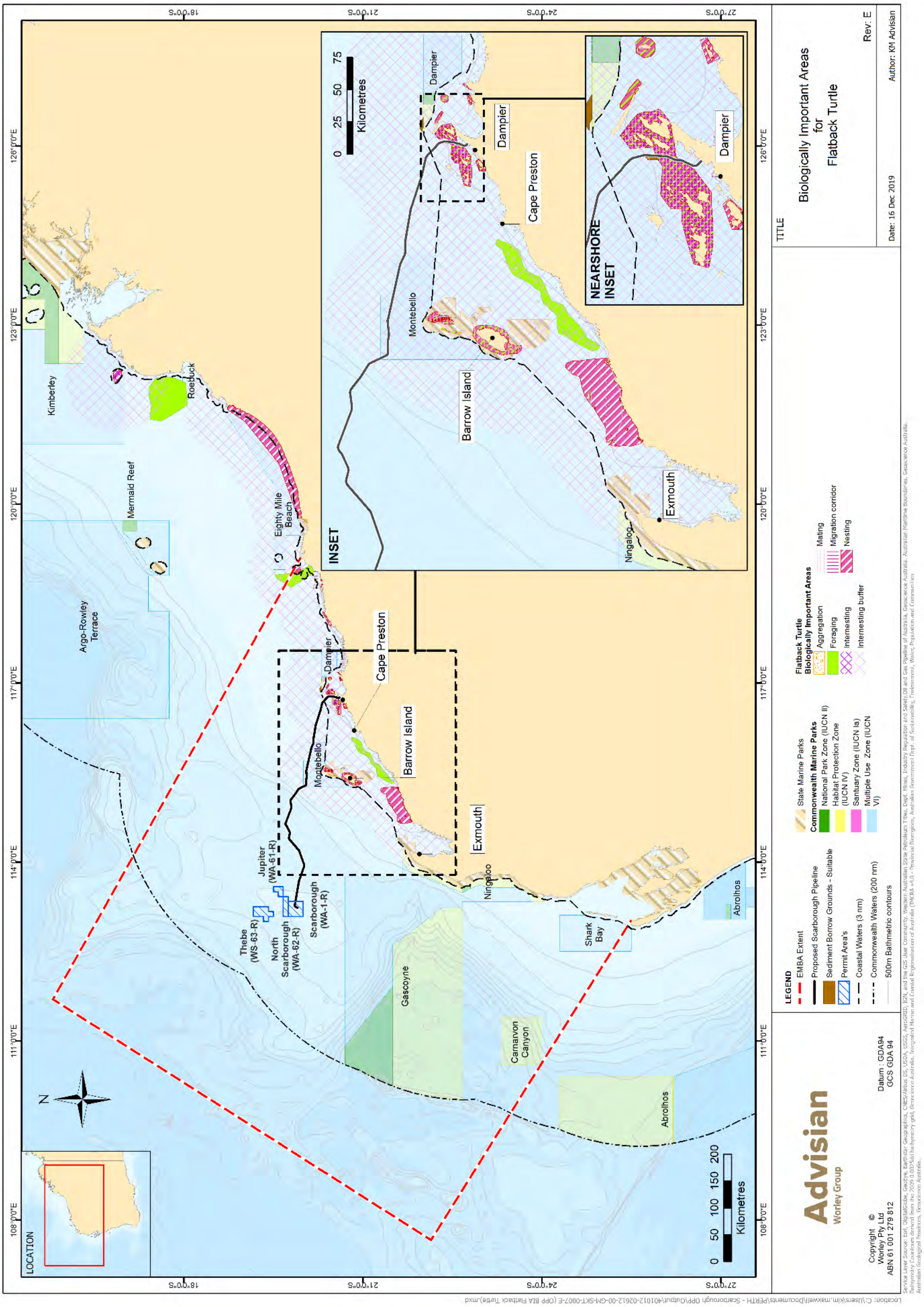


Figure 5-32: Biologically important areas for flatback turtles

Green Turtle

Green turtles (*Chelonia mydas*) are listed as Vulnerable and Migratory under the EPBC Act. They are the most common marine turtle breeding in the NWMR (DEWHA, 2012c). Three distinct breeding stocks of green turtles occur in the region: the North West Shelf (G-NWS) stock, the Scott Reef - Browse Island (G-ScBr) stock and the Ashmore Reef (G-AR) stock. The trend for the G-NWS stock is reported as stable (Commonwealth of Australia, 2017). Locations of key nesting beaches for the G-NWS stock include the Montebello Islands, west coast of Barrow Island, Muiron Islands and North West Cape and Dampier Archipelago (Table 5-4).

Habitat distribution of the species varies depending on their life stage, with general distribution from the ages of five to ten within offshore pelagic environments, followed by a retreat to shallow nearshore tropical – subtropical benthic habitats including seagrass pastures, rocky reef and coral reef systems. The nesting period for the NWS stock is expected to begin in November, peak in January-February, and end in April (DoEE, 2017c). Seasonality of nesting for green turtles in The Dampier Archipelago was not well defined from the available data (Whiting, 2018). Given the discrete duration of surveys at Legendre Island (Biota, 2009), insufficient data is available to refine seasonality for this location.

During non-breeding, green turtles typically occupy nearshore, coastal bays, feeding on seagrasses and macroalgae (Bjorndal, 1997; Bolten, 2003). They are herbivorous for the majority of their life history; however, post-hatching green turtles are omnivorous in their pelagic stage, and recent findings point to an oceanic diet including jellyfish for some populations (Arthur et al., 2008; Bolten, 2003).

Both BIAs and habitat critical for green turtles have been identified overlapping the Trunkline Project Area around the Dampier Archipelago (Figure 5-33; Table 5.4). However, while information on internesting turtle movement in Western Australia is limited, tracking data has shown that during nesting periods, female green turtles typically inter-nest in shallow, nearshore waters between 0 and 10 m deep (Pendoley, 2005) and remain <5 km nesting beaches on Barrow Island, Varanus Island, and Rosemary Island (Pendoley, 2005) and within 10 km of nesting beaches on the Lacepede Islands (Waayers et al. 2011). These conclusions for green turtles internesting are also supported by other international scientific studies that suggest internesting grounds are located close to nesting beaches, in 10–18 m of water (Stoneburner, 1982; Mortimer & Portier, 1989; Maylan, 1995; Tucker et al., 1995; Starbird & Hills, 1992).

It is likely that green turtles will occur in the Project Area. Although individuals may transit through the Offshore Project Area, large numbers are not expected given the distance offshore, water depths, and lack of primary producers and nesting beaches. The proximity of the Trunkline Project Area to known nesting sites, and the overlap with areas designated as internesting habitat (BIAs and habitat critical), increases the likely presence of green turtles compared to the Offshore Project Area. However, given the water depths and distance from the Trunkline Project Area to known nesting beaches at the Montebello, Lowendal and Barrow islands, and islands of the Dampier Archipelago, the number of internesting females potentially occurring is expected to be a small proportion of the NWS stock. Within the EMBA, the internesting BIA is expected to be utilised more frequently as distance to nesting sites decreases. Additional breeding BIAs for nesting also occur in the EMBA. No foraging areas were identified in the Project Area, although a foraging BIA overlaps the EMBA.

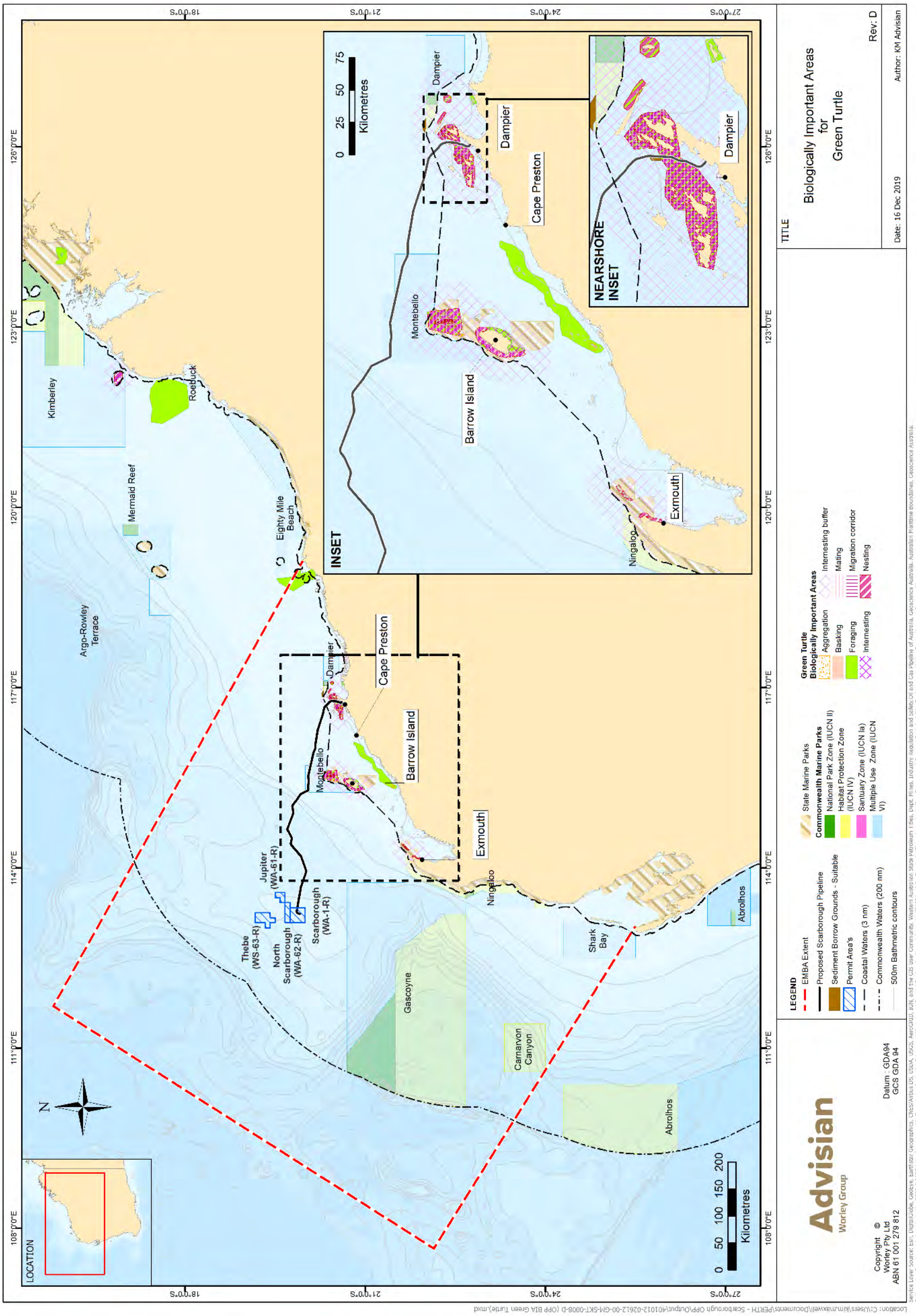


Figure 5-33: Biologically important areas for green turtles

Hawksbill Turtle

Hawksbill turtles (*Eretmochelys imbricata*) are listed Vulnerable and Migratory under the EPBC Act. They typically occupy tidal and subtidal tropical to warm temperate waters around the northern coast Australia from New South Wales to Shark Bay. Hawksbill turtles are the most tropical of all sea turtle species and are found within rock and reef habitats, coastal areas and lagoons (DoEE, 2017g). The species is omnivorous and is known to forage amongst vertical underwater cliffs, on coral reefs and on gorgonian (soft coral) flats, as well as seagrass or algae meadows (Bjorndal, 1997). Hawksbills feed primarily on sponges, but will also consume shrimp, squid, anemones, algae, seagrass, sea cucumbers and soft corals (Bjorndal, 1997). In Fog Bay, Joseph Bonaparte Gulf, hawksbills feed primarily on algae and sponges (Whiting, 2000) and on the reefs of Cocos Islands it feeds on algae, seagrass and sponges (Whiting, 2004).

Juvenile hawksbill turtles appear to dive to relatively shallow depths when foraging. Blumenthal et al. (2009) reported mean diurnal dive depths of 8 ± 5 m, and a range of 2 – 20 m for juveniles on a Caribbean coral reef. Similarly, von Brandis et al. (2010) recorded average foraging dives in water depths < 15 m, for juvenile hawksbills on a coral reef at D'Arros Island, Seychelles. Data on foraging dive depths for adult hawksbill turtles in Australian waters is limited. Hoenner et al. (2016) recorded a maximum dive depth of 45 m in a study of seven adult females nesting on Groote Eylandt, western Gulf of Carpentaria.

There is a single breeding stock in the region, the Western Australian (H-WA) stock, which is centred on the Dampier Archipelago and is one of the largest stocks in the world. The trend for the H-WA stock is unknown (Commonwealth of Australia, 2017). The most significant breeding areas of the species within the NWMR include Rosemary Island in the Dampier Archipelago, Varanus Island in the Lowendal group, Barrow Island and some islands in the Montebello group (DEWHA, 2012c). Nesting in the region can occur year-round, but with a peak between October and January (DoEE, 2017g). Whiting (2018) provided defined seasonality specific nesting data for Rosemary Island, and this study found that hawksbill turtles have a much earlier peak (October/November) compared to flatback turtles (December/January peak).

Rosemary Island has the most significant nesting beaches for the H-WA stock, determined as mean number of turtle tracks per day (Pendoley et al., 2016), and is recognised as an internationally significant rookery for hawksbill turtles (Limpus, 2009). On Rosemary Island, the majority of hawksbill nesting occurs on the north-western (NW) beaches (Pendoley, 2020a) with lower density flatback and green nesting occurring at beaches on the east of the island. An analysis of turtle track data from these beaches on Rosemary Island between 1990 and 2017 has been undertaken (Whiting, 2018), which concluded that nest counts were dominated by hawksbill turtles (9860 nesting events, or 92.1%), with lower flatback and green nests counts at 366 (3.4%) and 478 (4.5%), respectively. These results corroborate other conclusions that the nesting population of hawksbill turtles at Rosemary Island is one of the largest populations in Australia and globally (Limpus, 2009).

Internesting BIAs and habitat critical for hawksbill turtles have been identified within the Trunkline Project Area around the Dampier Archipelago (Figure 5-34; Table 5.3). Information on hawksbill turtles nesting on Varanus and Rosemary Islands suggests females remain within several (less than ten) kilometres of their nesting beaches on Varanus Island and within 1 km of nesting beaches on Rosemary Island (Pendoley, 2005).

It is likely that hawksbill turtles will occur in the Project Area. Although individuals may transit through the Offshore Project Area, large numbers are not expected given the distance offshore and lack of coral reef or rocky shore and nesting beaches. The proximity of the Trunkline Project Area to known nesting sites, and the overlap with areas designated as internesting habitat (BIAs and habitat critical), increases the likely presence of hawksbill turtles compared to the Offshore Project Area. However, given the distance from the Trunkline Project Area to known nesting beaches at the Montebello, Lowendal and Barrow islands, and islands of the Dampier Archipelago, the number of internesting females potentially occurring is expected to be a small proportion of the Western Australian stock.

Within the EMBA, the internesting BIA is expected to be utilised more frequently as distance to nesting sites decreases. Additional breeding BIAs for nesting also occur in the EMBA. No foraging areas were identified in the Project Area, although a foraging BIA overlaps the EMBA.

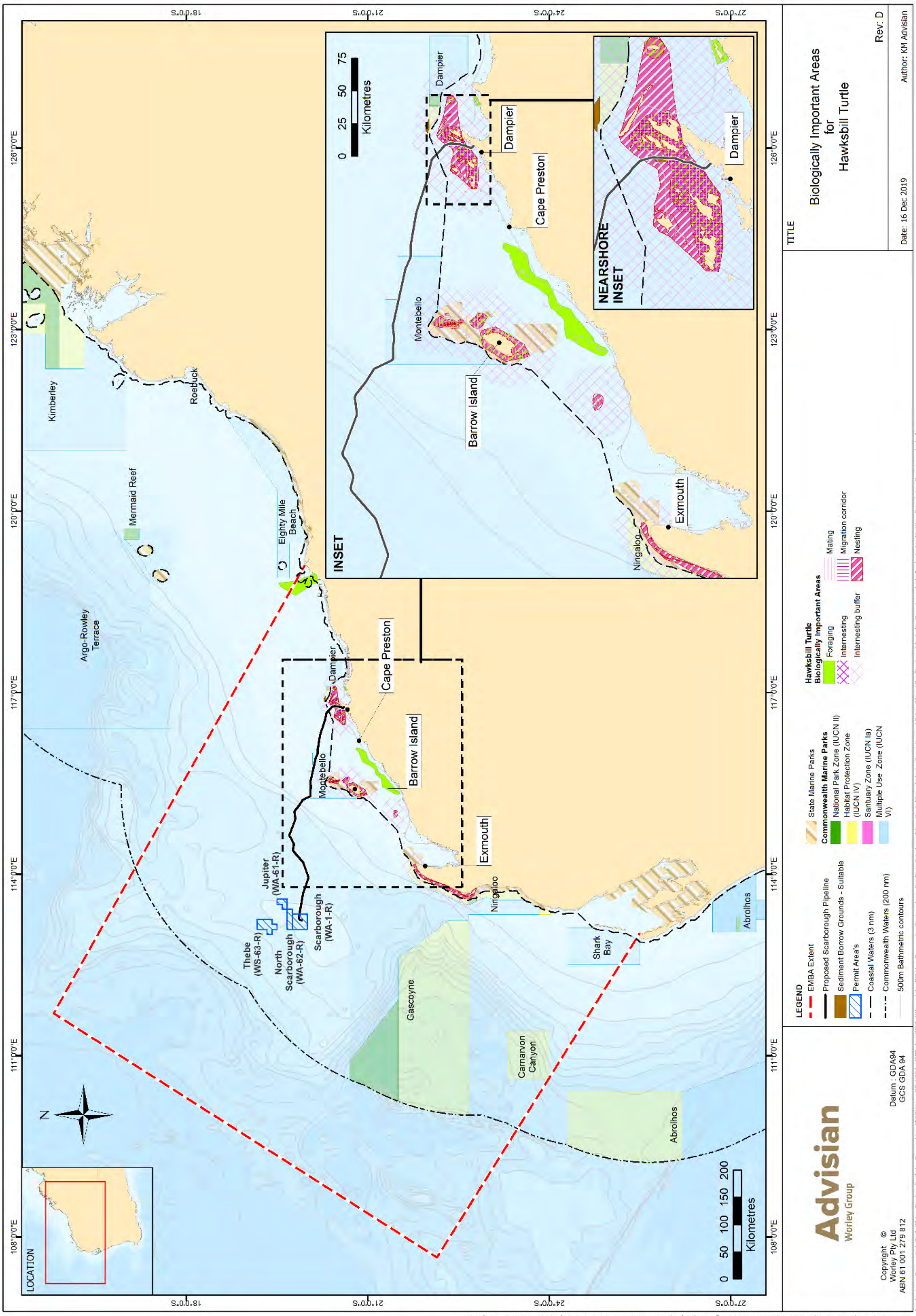


Figure 5-34: Biologically important areas for hawksbill turtles

Loggerhead Turtle

Loggerhead turtles (*Caretta caretta*) are listed Endangered and Migratory under the EPBC Act. Within Australia two breeding stocks exist, with the western breeding stock being the larger of the two stocks. Loggerhead turtles occur throughout the NWMR and forage across a wide range of habitats including rocky and coral reefs, seagrass pastures, estuaries, muddy bays and open ocean environments (DoEE, 2017b).

In the NWMR, loggerhead turtles breed from November to March and require sandy beaches to nest. Nesting occurs principally from Shark Bay to the North West Cape with Dirk Hartog Island in the south being a major nesting site for the species (typically 800–1500 breeding females annually). Other key breeding spots include Gnaraloo Bay, the Muiron Islands and beaches along the North West Cape; with occasional records from Varanus and Rosemary islands, Barrow Island, Lowendal Islands (WA DEC, 2009) and Ashmore Reef (Guinea, 1995).

Although CALM (1990) reports loggerhead turtle nesting activity on Cohen Island, Pendoley et al. (2016) did not find any evidence of loggerhead nesting activity in over 20 years of track data. The northernmost key loggerhead nesting areas include the North West Cape and Muiron Islands and any nesting activity by loggerhead turtles in the Dampier Archipelago will not represent significant rookeries for this species (Pendoley, 2020a).

An internesting BIA for loggerhead turtles overlaps the Trunkline Project Area (Figure 5-35); habitat critical for loggerhead turtles occurs within the EMBA but does not intersect with the Trunkline Project Area (Table 5-4). During internesting periods, female loggerhead turtles generally remain within 10 km of nesting beaches (DoEE, 2017b). Movement patterns during internesting are generally short forays of 4 to 8 km, with distance increasing towards the end of the internesting period. Larger movements (~10 km) were mainly longshore, rather than directed offshore, and confined to water depths of less than 15 m (Tucker et al., 1995).

It is likely that loggerhead turtles will occur in the Project Area. Although individuals may transit through the Offshore Project Area, large numbers are not expected given the lack of habitats that would promote aggregating behaviours, such as breeding or foraging. The proximity of the Trunkline Project Area to known nesting sites, and the overlap with an internesting BIA, increases the likely presence of hawksbill turtles compared to within the Offshore Project Area. However, given the distance from the Trunkline Project Area to known nesting beaches at the North West Cape, Ningaloo Reef, Muiron Islands, Montebello Islands and the Dampier Archipelago, the number of internesting females potentially occurring is expected to be a small proportion of the western breeding stock. Within the EMBA, the internesting BIA is expected to be utilised more frequently as distance to nesting sites decreases. Additional internesting BIAs and habitat critical for loggerhead turtles occurs around Ningaloo Reef and the North West Cape within the EMBA. No foraging areas were identified in the Project Area or EMBA.

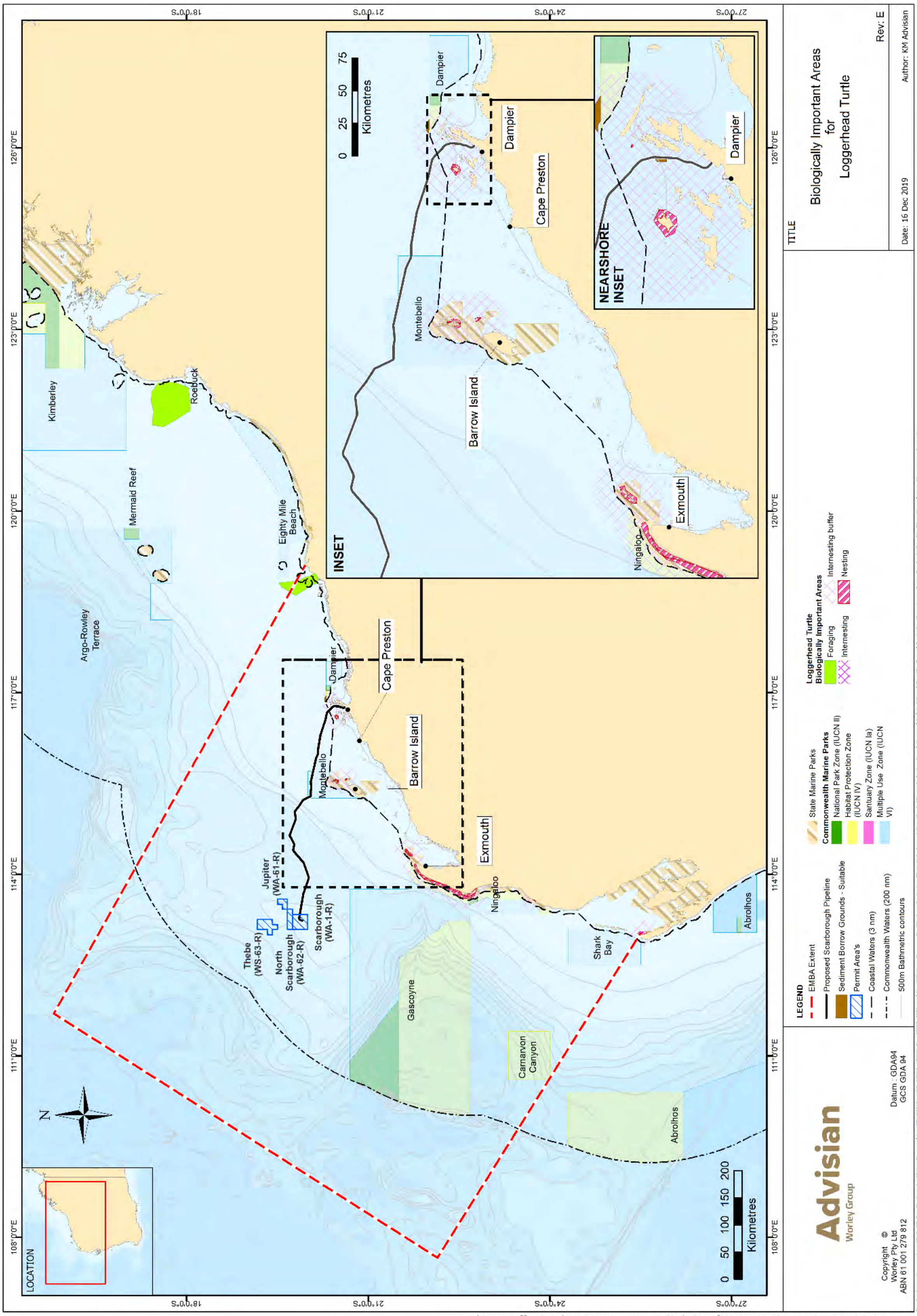


Figure 5-35: Biologically important areas for loggerhead turtles

Seasnakes

<u>*Short-nosed Seasnake*</u>

The short-nosed seasnake (*Aipysurus apraefrontalis*) is listed as Critically Endangered under the EPBC Act. With the NWMR, it has been recorded at Ashmore and Hibernia reefs. However, despite a fivefold increase in survey effort, the species has not been identified at Ashmore since the late 1990s (DoEE, 2017e). Guinea and Whiting (2005) reported that very few short-nosed sea snakes moved as far as 50 m from the reef flat.

Given the coral reef habitat preferences for this species, it does not occur in Offshore Project Area. Although the Trunkline Project Area passes in closer proximity to coral reefs, for example, fringing the Montebello Islands or islands of the Dampier Archipelago, no corals are expected to occur in the Trunkline Project Area. Given the small distances that Short-nosed seasnakes have been observed straying from reef habitat, likely presence in the Trunkline Project Area is limited. It is possible that the Short-nosed seasnake would occur in coral reefs found in the EMBA. No BIAs have been identified for this species in the NWMR.

5.5 Key Ecological Features

Key ecological features (KEFs) are not MNES and have no legal status in their own right; however, they are considered as components of a Commonwealth marine area. KEFs are parts of the marine ecosystem that are considered to be important for a marine region's biodiversity or ecosystem function and integrity. KEFs have been identified by the Australian Government based on advice from scientists identifying regions with important attributes associated with ecosystem function and biodiversity.

The Project Area intersects with the following three KEFs (Figure 5-37):

- Exmouth Plateau (Offshore Project Area and Trunkline Project Area)
- ancient coastline at 125 m depth contour (Trunkline Project Area)
- continental slope demersal fish communities (Trunkline Project Area).

Additional KEFs within the EMBA include:

- canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula (~175 km from Offshore Project Area and ~21 km from the Trunkline Project Area)
- Commonwealth waters adjacent to Ningaloo Reef (~20 km from the Offshore Project Area and 22 km from the Trunkline Project Area)
- Glomar Shoals (5 km from the Trunkline Project Area and ~34 km from the Offshore Project Area).

All KEFs are distributed in offshore areas within Commonwealth waters. Details of the above KEFs are outlined below.

5.5.1 Exmouth Plateau (Offshore Project Area and Trunkline Project Area)

The Exmouth Plateau is a large, mid-slope, continental margin plateau that lies off the north-west coast of Australia. It ranges in depth from about 500 to more than 5000 m and is a major structural element of the Carnarvon Basin (DNP, 2013; Miyazaki and Stagg, 2013). The plateau is bordered by the Rankin Platform and the Exmouth sub-basin of the Northern Carnarvon Basin to the east, the Argo Abyssal Plain to the north, and the Gascoyne and Cuvier Abyssal Plains to the north-west and south-west.

The Exmouth Plateau is defined as a KEF as it is a unique seafloor feature with ecological properties of regional significance, which apply to both the benthic and pelagic habitats within the feature (Figure 5-37; DoEE, 2018b). The KEF lies offshore within Commonwealth waters, starting at about 110 km and extending to as far as about 370 km from the shore, occupying an area of 49,310 km² within water depths of 800–4000 m (Exon & Willcox, 1980, cited in Falkner et al., 2009; Heap & Harris, 2008).

Although the seascapes of this plateau are not unique (Falkner et al., 2009), it is believed that the large size of the Exmouth Plateau and its expansive surface may modify deep water flow and be associated with the generation of internal tides; both of which may subsequently contribute to the upwelling of deeper, nutrient-rich waters closer to the surface (Brewer et al., 2007). Satellite observations suggest that productivity is enhanced along the northern and southern boundaries of the plateau (Brewer et al., 2007). The waters of the Exmouth Plateau are a mixture of waters from the Indonesian Throughflow and the Indian Ocean Central Water; and therefore, can display significant temporal variations due to the fluctuations in the Indonesian Throughflow (and other climatic factors). Internal tides are known to be strongest during January–March (Brewer et al., 2007).

The topography of the plateau (with valleys and channels), in addition to potentially providing a range of benthic environments, may provide conduits for the movement of sediment and other material from the plateau surface through the deeper slope to the abyss. The northern margin is steep and intersected by large canyons (e.g. Montebello and Swan canyons); whereas the western margin is moderately steep and smooth, and the southern margin is gently sloping and virtually free of canyons (Falkner et al., 2009). Sediments on the plateau suggest that biological communities include scavengers, benthic filter feeders and epifauna (DotE, 2018b). Fauna in the pelagic waters above the plateau are likely to include small pelagic species and nekton attracted to seasonal upwellings, as well as larger predators such as billfish, sharks and dolphins (Brewer et al., 2007). Protected and migratory species are also known to pass through the region including Whale sharks and cetaceans.

As described in Section 5.4.5.2, the eastern edge of the Exmouth Plateau KEF overlaps a very small portion of the migration BIA for the pygmy blue whale, and nearly all of the KEF is overlapped by the distribution BIA for this species. Hence, it is possible that pygmy blue whales may occur across the Exmouth Plateau during the peak of the southbound migration in November to December and the peak of the northbound migration in May to June. The Exmouth Plateau KEF does not overlap any other whale BIAs, marine turtle habitat critical to the survival of a species or the foraging BIA for the whale shark.

No pressures were assessed as ‘of concern’ for this KEF; one pressure, ocean acidification as a result of climate change, was assessed as ‘of potential concern’ (DotE, 2018b).

The Offshore Project Area lies entirely within the Exmouth Plateau KEF. Additionally, the Trunkline Project Area partially overlaps the KEF. The Trunkline Project Area enters the KEF at the eastern boundary ~208 km offshore (north of the North West Cape) and extends ~45 km west from the KEF boundary before reaching the Offshore Project Area. The Trunkline Project Area and Offshore Project Area occupy a relatively small portion of the entire KEF (<1.7%).

5.5.2 Ancient Coastline at 125 m Depth Contour (Trunkline Project Area)

The ancient coastline at 125 m depth contour is defined as a KEF (“Ancient Coastline”) as it is a unique seafloor feature with ecological properties of regional significance (Figure 5-37; DotE, 2018b). The feature is defined by a depth range of between 115–135 m. This KEF extends along the NW coast from the North West Cape to within the offshore Kimberley region occupying an area of 16,190 km², spanning approximately 2,910 km end-to-end.

The ancient submerged coastline provides a hard benthic substrate, and therefore may provide sites for higher diversity and species richness relative to surrounding areas of predominantly soft sediment (DotE, 2018b). Little is known about fauna associated with the hard substrate of the escarpment, but it is expected to include sponges, corals, crinoids, molluscs, echinoderms and other benthic invertebrates representative of hard substrate fauna in the North West Shelf bioregion (DotE, 2018b).

The submerged coastline may also facilitate increased availability of nutrients off the Pilbara by interacting with internal waves and enhancing vertical mixing of water layers. Enhanced productivity associated with the sessile communities and increased nutrient availability may attract larger marine life such as whale sharks and large pelagic fish (DEWHA, 2008b). It has been suggested that humpback whales, whale sharks and other migratory pelagic species may use the rocky escarpment as a guide to navigate through the region (DNP, 2013).

No pressures[7] were assessed as 'of concern' for this KEF; one pressure, ocean acidification as a result of climate change, was assessed as 'of potential concern' (DotE, 2018b).

There is no overlap between the Ancient Coastline KEF and the Offshore Project Area. Only a very small portion (5 km² or <0.03%) of this KEF transects the Trunkline Project Area, approximately 132 km offshore, 46 km north-northwest of the Montebello Islands. A benthic habitat survey along the trunkline through this KEF area did not identify the potential features of the KEF (i.e. areas of hard substrate with high biodiversity) (Advisian, 2019b). The area was observed to be predominantly bare sand habitat (Figure 5-36). While no hard substrate or rocky features were identified, the soft sediment habitat was observed to support sparse (<15%) coverage of benthic organisms including epifauna, sponges and soft corals (Advisian, 2019b).

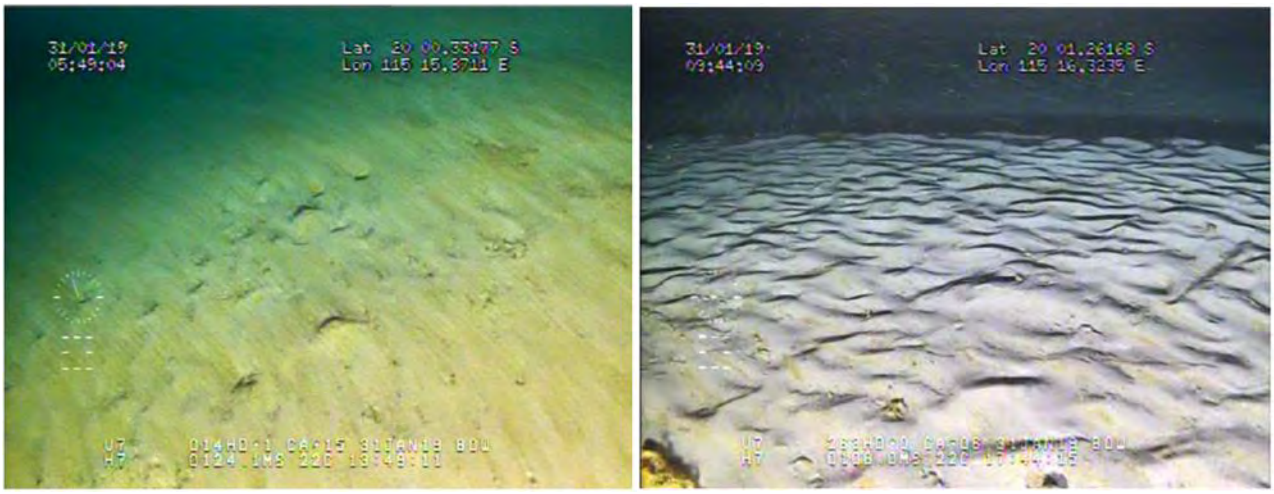


Figure 5-36: Example of ROV footage from benthic habitat survey within trunkline corridor within the ancient coastline at 125 m depth KEF

5.5.3 Continental Slope Demersal Fish Communities (Trunkline Project Area)

This species assemblage is recognised as a KEF because of its biodiversity values, including high levels of endemism (Figure 5-37; DotE, 2018b).

The diversity of demersal fish assemblages on the continental slope in the Timor Province, the Northwest Transition and the Northwest Province is high compared to elsewhere along the Australian continental slope (DotE, 2018b). The continental slope between North West Cape and the Montebello Trough has more than 500 fish species, 76 of which are endemic, which makes it the most diverse slope bioregion in Australia (Last et al., 2005). The slope of the Timor Province and the Northwest Transition also contains more than 500 species of demersal fish of which 64 are considered endemic (Last et al., 2005), making it the second richest area for demersal fish throughout the whole continental slope. The demersal fish species occupy two distinct demersal

[7] During the development of marine bioregional plans, pressures (defined as human-driven processes or events) that do or could detrimentally impact conservation values were identified for each KEF.

biomes associated with the upper slope (225–500 m water depths) and the mid-slope (750–1000 m). Although poorly known, it is suggested that the demersal-slope communities rely on bacteria and detritus-based systems comprised of infauna and epifauna, which in turn become prey for a range of teleost fish, molluscs and crustaceans (Brewer et al., 2007). Higher-order consumers may include carnivorous fish, deepwater sharks, large squid and toothed whales (Brewer et al., 2007). Pelagic production is phytoplankton based, with hot spots around oceanic reefs and islands (Brewer et al., 2007).

No pressures were assessed as of concern for this KEF; three pressures, (i) changes in sea temperature and ocean acidification as a result of climate change, and (ii) physical habitat modification, and (iii) bycatch were assessed as of potential concern (DotE, 2018b).

The Trunkline Project Area intersects a small, narrow portion of the KEF near its northwest-most extent. The KEF mostly lies further south extending about 300 km from the Trunkline Project Area past the North West Cape, splitting from a single corridor into three. Only a small extent (16 km^2 or <0.05%) of this KEF transects the Trunkline Project Area.

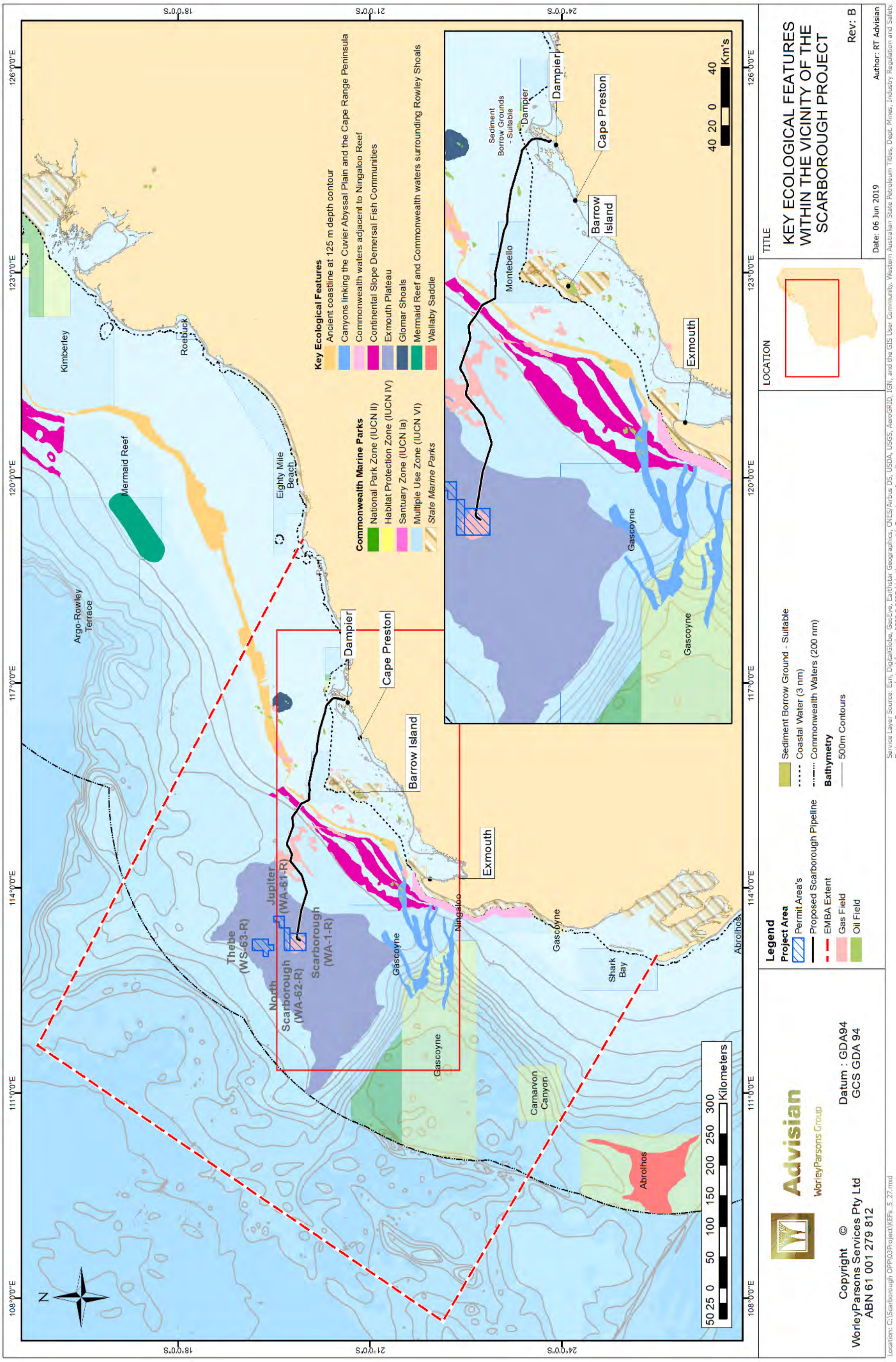


Figure 5-37: Key Ecological Features within the vicinity of Scarborough

5.5.4 Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula Key Ecological Feature (EMBA)

The canyons that link the Cuvier Abyssal Plain with the Cape Range Peninsula KEF ('Canyons KEF') lie off the northwest coast of Australia and are believed to support the productivity and species richness of Ningaloo Reef (DSEWPaC, 2012a). In relation to the Project Area, the Canyons KEF is about 130 km south of the Offshore Project Area at its nearest point. Interactions with the Leeuwin current and strong internal tides are thought to result in upwelling at the canyon heads, thus creating conditions for enhanced productivity in the region (Brewer et al., 2007). As a result, aggregations of Whale sharks, Manta rays, Humpback whales, sea snakes, sharks, predatory fish and seabirds are known to occur in the area due to its enhanced productivity (Sleeman et al., 2007).

Woodside commissioned a literature review of the Cape Range Canyon, supported by an environmental survey of the Enfield Canyon (BMT Oceanica, 2016). This survey examined several sections of the canyon (approximately 365–870 m water depth) and sampled a range of physical and biological parameters, including water, sediments, epifauna and mobile invertebrates, infauna and fish assemblages. Benthic habitats within and surrounding the canyon surveyed were similar in nature to those observed elsewhere in the NWMR and were characterised by flat unconsolidated sediments composed of sand- and mud-sized particles (BMT Oceanica, 2016; Falkner et al., 2009). Epifauna and mobile invertebrate communities associated with these habitats were considered to be similar to those observed elsewhere in the region, as well as other continental slopes in the Indo-Pacific region (BMT Oceanica, 2016, Heyward et al., 2010). The fish assemblages associated with the canyon observed during the survey were considered to be high, and consistent with data recorded during other investigations (Last et al., 2005; Williams et al., 2001). The fish assemblage at the foot of the canyon (the deepest area surveyed) was more diverse than those observed in higher sections of the canyon, with Angulliform (eels) and Scorpaeniform (*Paraliparis* spp.) species present that were not observed in the main section of the canyon.

In reviewing KEFs in the NWMR, Falkner et al. (2009) concluded that the canyons occurring in the region exhibited habitat heterogeneity (although noted that such habitat was not restricted to canyon features) and were representative of the region. These conclusions were based on a review of existing physical and biological data from a range of sources. The observations made during the survey of the Enfield Canyon were not consistent with these conclusions, finding that the habitat at different locations within the canyon comprised flat unconsolidated sediments composed of sand- and mud-sized particles (BMT Oceanica, 2016).

5.5.5 Commonwealth Waters Adjacent to Ningaloo Reef (EMBA)

The spatial boundary of this KEF, as defined in the Conservation Values Atlas, is defined as the waters contained in the existing Ningaloo AMP, provided in Section 5.6.2.

5.5.6 Glomar Shoals (EMBA)

The Glomar Shoals are a submerged littoral feature located about 150 km north of Dampier and about 56 km east of the Trunkline Project Area on the Rowley shelf at depths of 33–77 metres (Falkner et al., 2009). The shoals consist of a high percentage of marine-derived sediments with high carbonate content and gravels of weathered coralline algae and shells (McLoughlin & Young, 1985). The area's higher concentrations of coarse material in comparison to surrounding areas are indicative of a high-energy environment subject to strong seafloor currents (Falkner et al., 2009). Cyclones are also frequent in this area of the north-west and stimulate periodic bursts of productivity because of increased vertical mixing. Studies by Abdul Wahab et al. (2018) found a number of hard coral and sponge species in water depths less than 40 m. 170 different species of fish were detected with greatest species richness and abundance in shallow habitats (Abdul Wahab et al., 2018). Fish species present include a number of commercial and recreational species such as Rankin cod, Brown striped snapper, Red emperor, Crimson snapper, Bream and Yellow-spotted triggerfish

(Falkner et al., 2009; Fletcher & Santoro, 2009). These species have recorded high catch rates associated with the Glomar Shoals, indicating that the shoals are likely to be an area of high productivity. The Glomar Shoals are defined as a KEF for their high productivity and aggregations of marine life.

5.6 Protected Places

Protected places of the NWMR and adjacent State waters include:

- World Heritage Properties
- National Heritage Properties
- Commonwealth-managed Australian Marine Parks (AMPs)
- State-managed Marine Parks (MPs)
- State-managed Marine Management Areas (MMAs)
- Ramsar wetlands of international importance
- Nationally important wetlands.

Distances between these protected places and the Project Area are provided in Table 5-9 (for those with any overlap with the EMBA) and shown in Figure 5-38 and Figure 5-39. Further details are provided in sections that follow. AMPs in north western Australia are managed under the Australian Marine Parks North-west Marine Parks Network Management Plan 2018 (Director of National Parks, 2018).

Table 5-9: Protected places in and bounding the EMBA

	Distance from Project Area to Values/Sensitivity boundaries (km)	IUCN Protected Area Category *	Section Ref.	
Australian Marine Parks (Commonwealth-managed) within the EMBA				
Montebello	Overlap	VI	Montebello and Barrow Islands	5.6.1
Dampier	<1^	II, IV & VI	Dampier Coast	5.6.1
Gascoyne	77	II, IV & VI	Ningaloo Coast and Gascoyne	5.6.2
Ningaloo	182	IV	Ningaloo Coast and Gascoyne	5.6.2
Carnarvon Canyon	405	IV	Shark Bay	5.6.3
Shark Bay	475	VI	Shark Bay	5.6.3
Australian Marine Parks (Commonwealth-managed) bounding the EMBA				
Eighty Mile Beach	218	VI	Eighy-Mile Beach	5.6.5
Abrohlos	552	IV [#]	Abrohlos	5.6.6
Argo-Rowley Terrace	280	VI [#]	Argo-Rowley	5.6.7
Marine Parks (State managed)				
Montebello Islands	25	IA, II & IV	Montebello and Barrow Islands	5.6.1
Barrow Island	73	IA & VI	Montebello and Barrow Islands	5.6.1
Ningaloo	186	IA, II & IV	Ningaloo Coast and Gascoyne	5.6.2
Shark Bay	550	IA, II, IV	Shark Bay	5.6.3
Marine Management Areas (State managed)				
Barrow Island	40	1A & VI	Montebello and Barrow Islands	5.6.1
Muiron Islands	177	1A & VI	Ningaloo Coast and Gascoyne	5.6.2
World Heritage Properties				
Ningaloo Coast	186	N/A	Ningaloo Coast and Gascoyne	5.6.2
Shark Bay	525	N/A	Shark Bay	5.6.3
National Heritage Properties				
Ningaloo Coast (natural)	186	N/A	Ningaloo Coast and Gascoyne	5.6.2
Dampier Archipelago (indigenous)	8	N/A	Dampier Coast	5.6.1
Shark Bay (natural)	525	N/A	Shark Bay	5.6.3
Dirk Hartog Landing - Cape Inscription (historic)	615	N/A	Shark Bay	5.6.3
Ramsar Wetlands of International Importance				
-	-	-	Protected Wetlands	5.6.8

	Distance from Project Area to Values/Sensitivity boundaries (km)	IUCN Protected Area Category *	Section Ref.	
Nationally Important Wetlands				
Exmouth Gulf East	160	N/A	Protected Wetlands	5.6.8
Hamelin Pool	635	N/A	Protected Wetlands	5.6.8
Learmonth Saline Coastal Flats	255	N/A	Protected Wetlands	5.6.8
Shark Bay East.	545	N/A	Protected Wetlands	5.6.8

**Conservation objectives for IUCN categories include:*

- *IA: Strict nature reserve – Area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring.*
- *II: National park – Natural area of land and/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for this and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area, and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.*
- *IV: Habitat/species management area – Area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species.*
- *VI: Protected area with sustainable use of natural resources – Area containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs.*

^ The proposed sediment borrow ground is immediately adjacent to (north of) Dampier Marine Park's Habitat Protection Zone (IUCN IV).
[#] The Argo-Rowley Terrace Marine Park also includes zones of IUCN Category II and VI (Special Purpose (Trawl)). Due to the distance of these zones from the EMBA boundary, the values of these zones are not described here. The Abrolhos Marine Park also includes zones of IUCN Category II and VI (Special Purpose and Multiple Use). Due to the distance of these zones from the EMBA boundary, the values of these zones are not described here.

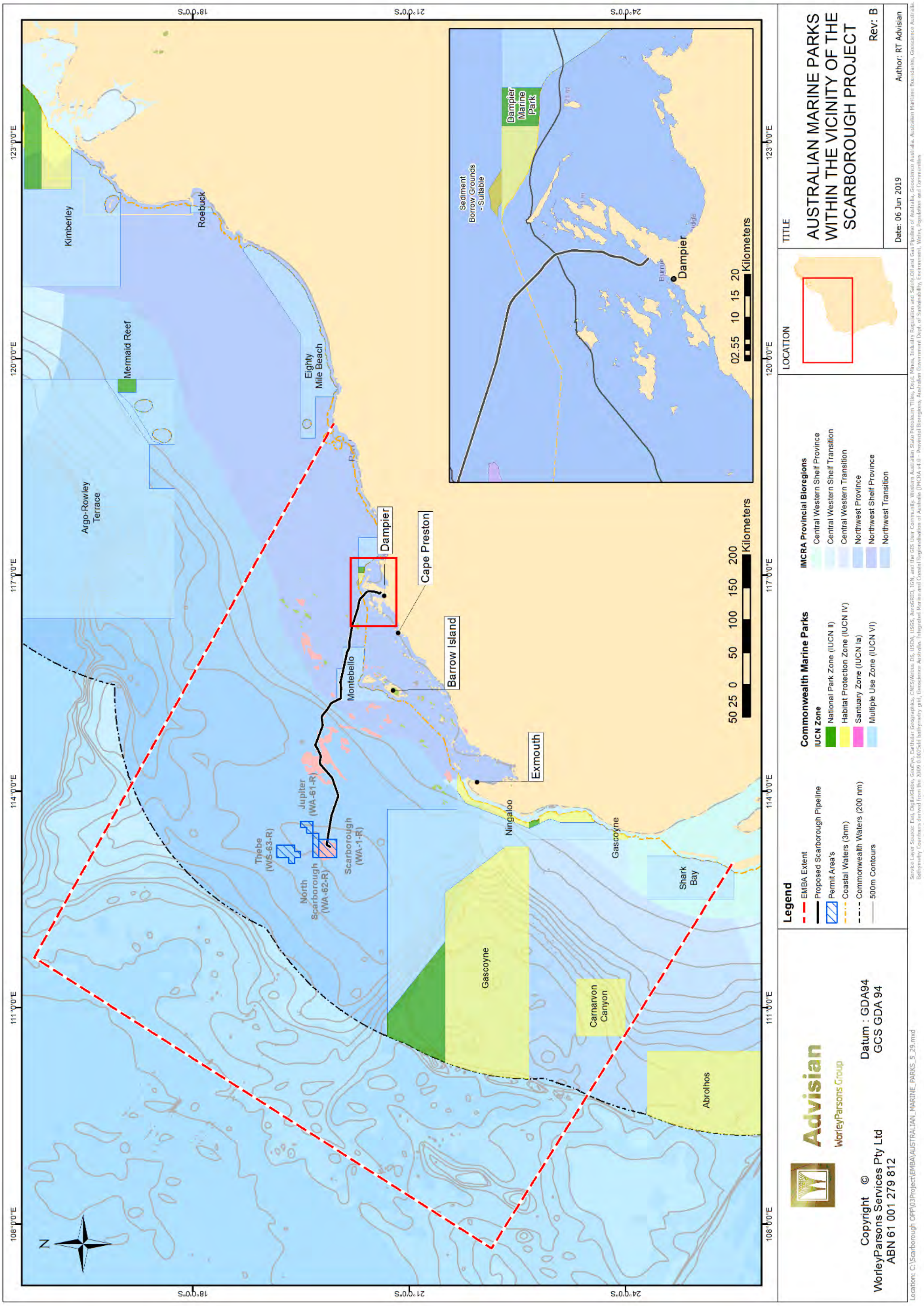


Figure 5-38: Australian Marine Parks within the vicinity of Scarborough

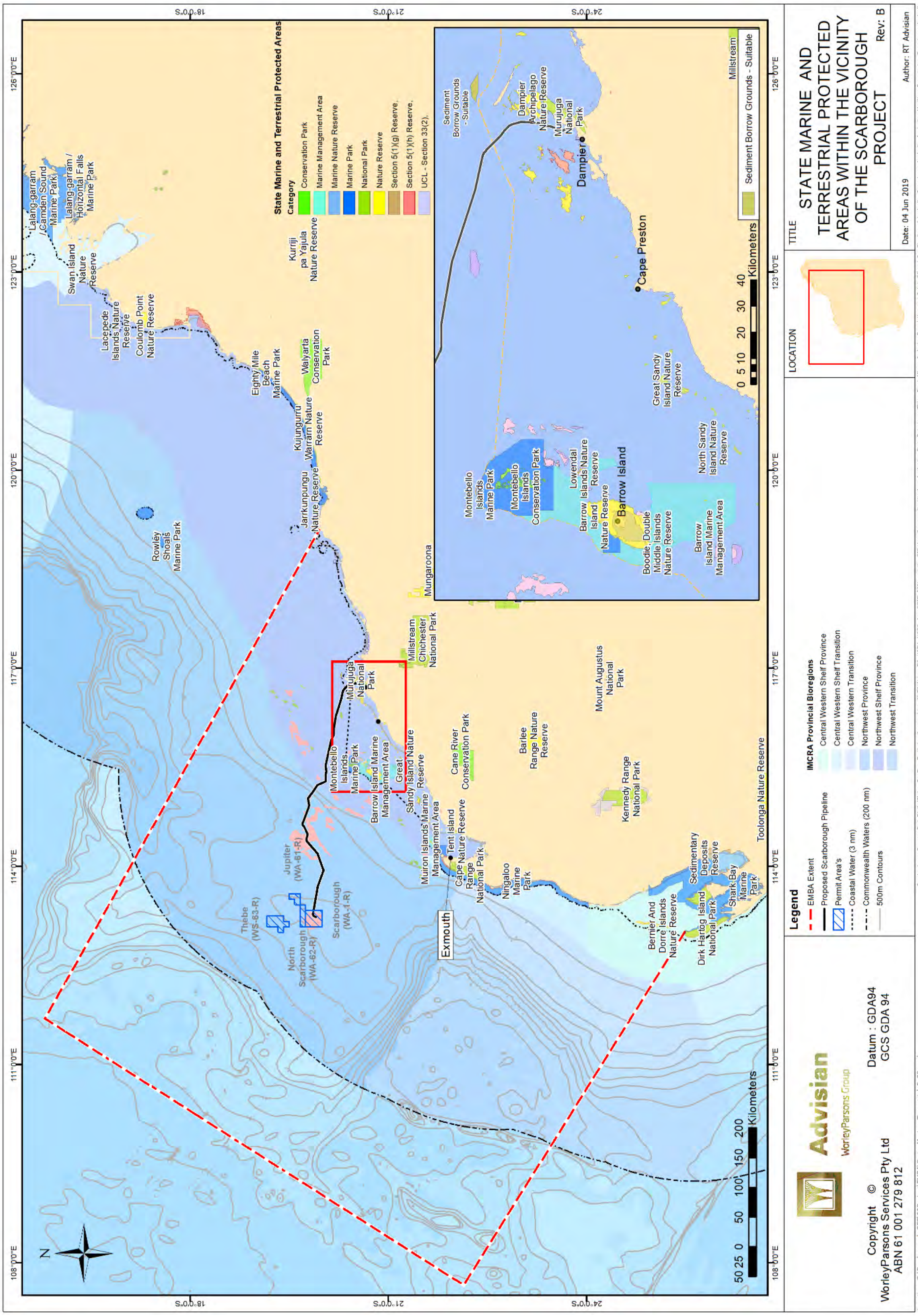


Figure 5-39: State marine and terrestrial protected areas within the vicinity of Scarborough

5.6.1 Montebello, Barrow Islands and Dampier

5.6.1.1 Montebello Marine Park/Barrow Island Marine Park/Barrow Island Marine Management Area

The marine and coastal environments of the Montebello/Barrow Islands region represent a unique combination of offshore islands, intertidal and subtidal coral reefs, mangroves, macroalgal communities and sheltered lagoons, and are considered a distinct coastal type with very significant conservation values (DEC, 2007; Director of National Parks, 2018).

The Montebello Islands Marine Park, Barrow Island Marine Park and Barrow Island Marine Management Area are jointly managed and cover a combined area of 1770 km², located about 25 km south of the Project Area at the closest point. A sanctuary zone covers the entire 4100 ha Barrow Island Marine Park. The Barrow Island Marine Management Area covers 114,500 ha and includes most of the waters surrounding Barrow Island and Lowendal Islands, except for the port areas around Barrow and Varanus Islands. Key conservation and environmental values within the protected areas include (DEC, 2007; Director of National Parks, 2018):

- a complex seabed and island topography consisting of subtidal and intertidal reefs, sheltered lagoons, channels, beaches, cliffs and rocky shores
- pristine sediment and water quality, supporting a healthy marine ecosystem
- undisturbed intertidal and subtidal coral reefs and bommies with a high diversity of hard corals
- important mangrove communities, particularly along the Montebello Islands, which are considered globally unique as they occur in offshore lagoons
- extensive subtidal macroalgal and seagrass communities
- important habitat for cetaceans and dugongs
- nesting habitat for marine turtles
- important feeding, staging and nesting areas for seabirds and migratory shorebirds
- rich finfish fauna with at least 456 species
- culture of the pearl oyster (*Pinctada maxima*) in the area produces some of the highest quality pearls in the world.

These islands support significant colonies of Wedge-tailed shearwaters and Bridled terns. The Montebello Islands support the biggest breeding population of Roseate terns in WA. Ospreys, white-bellied sea-eagles, eastern reef egrets, Caspian terns, and lesser crested terns also breed in this area. Observations suggest an area to the west of the Montebello Islands may be a minor zone of upwelling in the NWMR, supporting large feeding aggregations of terns. There is also some evidence that the area is an important feeding ground for Hutton’s shearwaters and Soft-plumaged petrels. Barrow Island is ranked equal tenth among 147 sites in Australia that are important for migratory shorebirds. Barrow, Lowendal and Montebello islands are internationally significant sites for six species of migratory shorebirds, supporting more than 1% of the East Asian-Australasian Flyway population of these species (DSEWPaC, 2012a).

The Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island Marine Management Area are contiguous with the Montebello Australian Marine Park. The intertidal habitats of the Montebello/Barrow/Lowendal Islands region are influenced by the passage of tropical cyclones that shape sandy beaches (RPS Bowman Bishaw Gorham, 2007). The dominant habitats on the exposed west coasts of islands in the area are sandy beaches, rocky shores and cliffs. The predominant physical habitats of the sheltered east coasts of islands are sand flats, mud flats, rocky pavements and platforms (RPS Bowman Bishaw Gorham, 2007).

5.6.1.2 Barrow Island Nature Reserve

The Barrow Island Nature Reserve is a Class A Nature Reserve covering about 235 km^2 and extends to the low water mark adjacent to the Montebello Islands/Barrow Island Marine Parks. It is about 73 km from the Project Area at the closest point. The islands surrounding Barrow Island including Boodie, Double, and Middle Islands make up the Boodie, Double, and Middle Islands Nature Reserve, covering 587 ha (DPaW, 2015; Director of National Parks, 2018). Together, these two nature reserves are commonly referred to as the Barrow Group Nature Reserves (DPaW, 2015).

The Barrow Island coastline consists of dry creek beds, beaches, clay and salt flats, mangroves, intertidal flats and reefs and is bordered by high cliffs on the western side. Key conservation values within the reserves include (DPaW 2015; Director of National Parks, 2018):

- the second largest island off the WA coast
- important biological refuge site because of isolation from certain threatening processes on the mainland
- contains flora that are restricted in distribution and at or near the limit of their range
- high number of fauna species with high conservation value
- extensive hydrogeological karst system that supports a subterranean community of high conservation significance
- regionally and nationally significant rookeries for green and flatback turtles
- important habitat for migratory shorebirds and also used by these species as a staging and destination terminus
- significant habitat values, such as intertidal mudflats, rock platforms, mangroves, rock piles and cliffs, clay pans and caves
- a significant fossil record that indicates local historical biodiversity and evolution
- a history of Aboriginal and other Australian use including 13 registered Aboriginal cultural heritage sites.

5.6.1.3 Montebello Australian Marine Park

The Trunkline Project Area traverses the northern border of the Montebello Marine Park (Multiple Use Zone). Approximately 80 km of pipeline will extend into the park, equating to approximately 2.4 km^2 overlap (allowing for a 30 m disturbance area on the trunkline). This conservative disturbance area would result in approximately 0.07% of the Montebello Marine Park, including the area intersecting the Ancient Coastline KEF.

An ROV survey of the trunkline route within the Montebello AMP was undertaken in 2019 (Advisian, 2019b). This survey predominantly targeted areas where the Scarborough trunkline deviates from the existing Pluto trunkline (i.e. the northwestern extent). Bathymetry data was analysed to select areas that could be expected to support benthic communities, including areas of potential harder substrate, the ancient coastline KEF (see also Section 5.5.2), areas of sub-cropping calcarenite with shallow sediment cover, and areas of potential turtle foraging habitat. Video imagery was collected from between one and three transects from five separate sites along the trunkline route through the Montebello Marine Park (Figure 5-40). Area 1 was located in the vicinity of the ancient coastline KEF; and Areas 4 and 5 were in the vicinity of the existing Pluto trunkline. Benthic habitat from the videos was described and classified in accordance with the CATAMI Classification System.

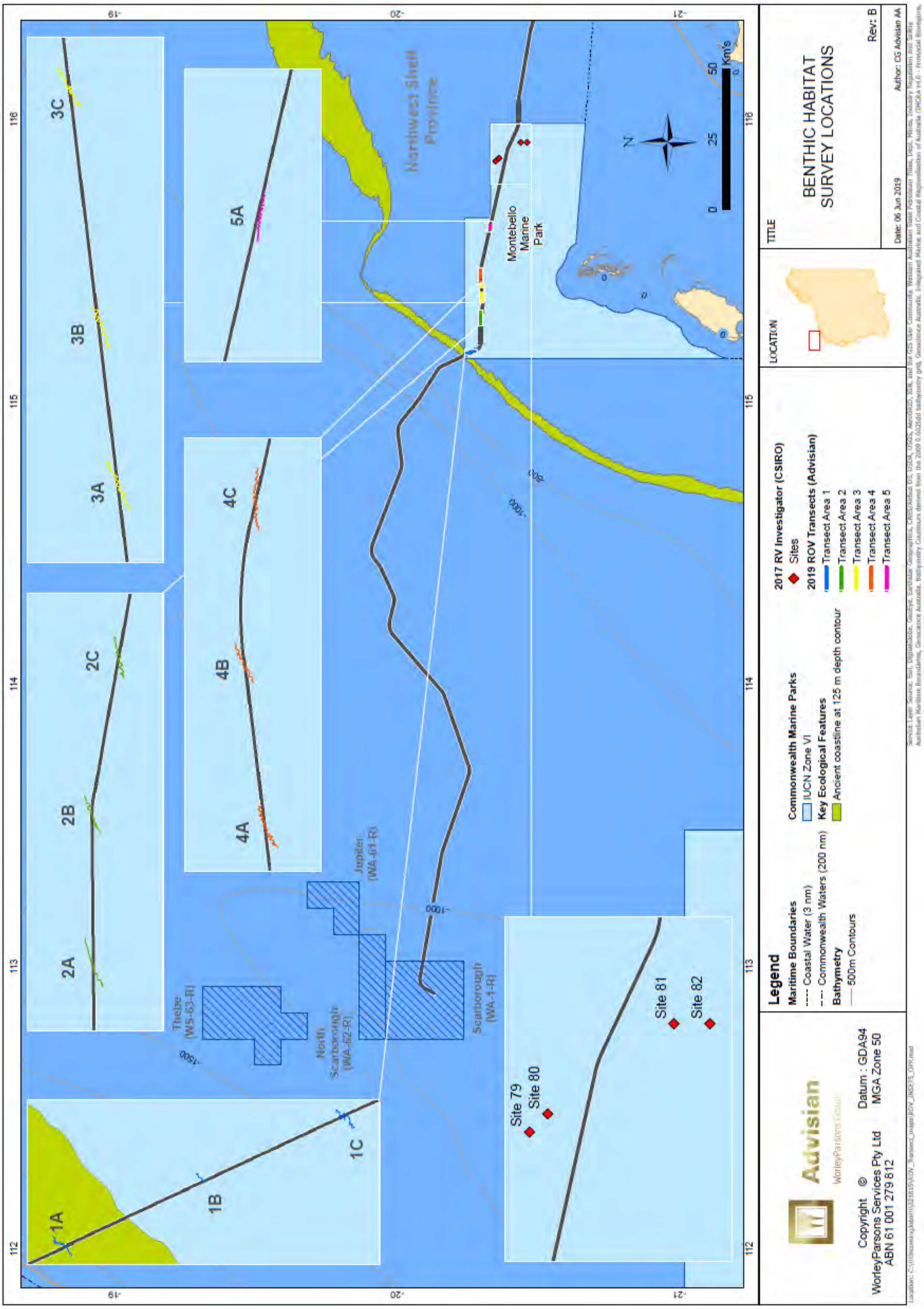


Figure 5-40: Location of survey areas and transects from the trunkline benthic habitat survey within the Montebello AMP

Analysis of the high definition ROV video data (Advisian, 2019b) found that the area in which the trunkline intersects the Montebello AMP is characterised by bare sandy sediments, interspersed with predominantly sparse benthic communities and epifauna (Table 5-10, Figure 5-41). Denser areas of sponges were observed in areas identified from the bathymetry as having a more complex seabed structure.

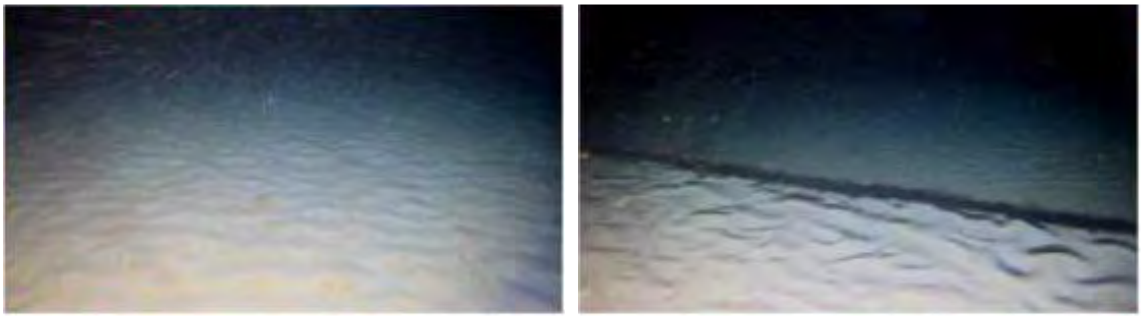
Area 1 which was the deepest and located in the vicinity of the KEF was most different, with a much lower cover of benthic organisms than Areas 2 to 5 (Advisian, 2019b). Transects which were centred on the ancient coastline KEF and surrounding area at the 125 m depth contour did not identify any areas of rocky escarpments, thought to provide biologically important habitat in areas otherwise dominated by soft sediments (Table 5-10;see also Section 5.5.2). Areas 2 to 5 were quite similar in depth (typically 70–80 m) and in nature, with some small differences in the density and occurrence of benthic organisms and in substrate type (e.g. variants of soft sediment bedforms and cover of biologenic gravel) (Table 5-10; Advisian, 2019b).

Table 5-10: Summary of benthic habitat analysis of ROV footage within the Montebello AMP

Survey Area	Summary
1	• Transect 1a was located within the KEF; Transects 1b and 1c were not. No potential features of the KEF (i.e. areas of hard substrate with high biodiversity) were seen along any of the transects surveyed. • Benthic habitat along all transects were typically bare sand with various bedforms including flat bare sand, small ripples (of 2D and 3D forms) and small 'steps' (<50 cm). • Some areas of seafloor were bare, while others were covered in a light bacterial mat and others were seen to have a cover of biologenic gravel (of unidentified origin). The cover of biologenic gravel changed continuously over the course of the transects. • No moderate or high relief features or areas of consolidated hard substrate were present within any transect. • Benthic organisms (including sponges and soft corals) were present on occasion and generally occurred as single or low density aggregations of individuals. The cover of benthic organisms in ranged from 0% to ~15% (highest in Transect 1c). • Bioturbation of the seafloor was evident in all three transects indicating the presence of mobile organisms living on and within the seabed. Mobile organisms including fish, echinoderms and jellies, were also noted on the video.
2	• The seafloor was relatively flat and sandy with a light to high cover of unconsolidated biologenic gravel and/or organic material. Small undulations of the seabed were seen but no other regular bedforms such as sand ripples or sand waves were apparent. • No significant high relief habitat features, or areas of consolidated hard substrate, were observed in any transect. • Some areas of seafloor were relatively bare while others included a low (~5%) to high (~80%) density cover of benthic organisms. This benthic cover changed continually and often (within m's) over each transect. Benthic fauna comprised a diverse array of sponges and corals with varying forms, sizes and colours. Hydroids and cnidarians were also apparent on occasion. • Bioturbation of the seafloor in the form of small cones, craters, burrows, small and large trails was also apparent. Mobile organisms including fish, echinoderms and jellies, were also noted on the videos.
3	• The seafloor in Area 3 was relatively flat and sandy with a light to high cover of biologenic gravel and/or organic material over its entire length (continually changing). Small undulations of the seabed and some small sand waves were present on occasion, but no other regular bedforms such as sand ripples or sand waves were apparent. • No significant moderate or high relief habitat features were observed on the video or can be seen on the transect maps with detailed bathymetry. Any features seen are in the order of ~1 m and occur over relatively large scales. • The seabed was a mosaic of bare substrate and low (~5%) to high (~75%) density cover of benthic organisms (e.g. sponges, corals). Benthic fauna comprised a diverse array of sponges and corals with varying forms, sizes and colours. Hydroids and cnidarians were also apparent on occasion along the transect length.

Survey Area	Summary
	• Bioturbation of the seafloor in the form of small cones, craters, burrows and small and large trails was apparent. Mobile organisms including fish, echinoderms and jellies, were also noted on the videos. Fish fauna diversity was quite high, and varying sizes of fish were seen amongst the aggregations of corals and sponges and also over bare sandy seafloor.
4	• The seafloor within Area 4 was typically flat sand with a high level of biologenic gravel of unknown origin. Small mounds, waves and undulations all < 50 cm in height were seen on occasion and mainly occurred around aggregations of benthic epifauna (i.e. sponges and corals). • No significant moderate or high relief features, or significant areas of consolidated hard substrate, were present in Area 4 as could be seen on the video or transect maps. • The seafloor in Area 4 was scattered with sponges and corals of varying forms and sizes; occurring as individuals with a low-density cover (~5%) up to more dense clusters (~50%). Other benthic epifauna included echinoderms (e.g. feather stars) and cnidaria (e.g. seapens). Mobile fauna (mainly small bony fishes) were most common around the larger clusters of sponges and corals. • Areas of bare sand were present amongst the patches of epifauna; and the switch between bare sand to benthic cover changed constantly and over short distances. • Bioturbation of the seafloor in the form of small mounds and craters was evident along the entire transect length.
5	• The seafloor consisted of flat sand, often with an organic cover (likely bacterial or algae) or a biologenic gravel component. The seafloor showed some slight undulation in places and scour marks commonly occurred around small 'clusters' of benthic epifauna (i.e. sponges and corals). No regular bedforms such as sand ripples or sand waves were present. • No significant moderate or high relief features were present. • Benthic epifauna occurred sporadically along the entire transect length and generally occurred as diverse 'clusters' of sponges and corals. These organisms were often large and were very diverse in form. The percentage cover of benthic organisms ranged from 5% to ~40%. • Mobile fauna were common around these clumps of sponges and corals; including echinoderms (e.g. sea stars, feather stars and sea cucumbers) and small bony fishes. • Bioturbation of the seafloor was common over the entire transect length and usually occurred in the form of thin trails, small mounds or craters.

Area 1



Area 2

Area 3

Area 4

Area 5 (note: transect does not cross the trunkline)

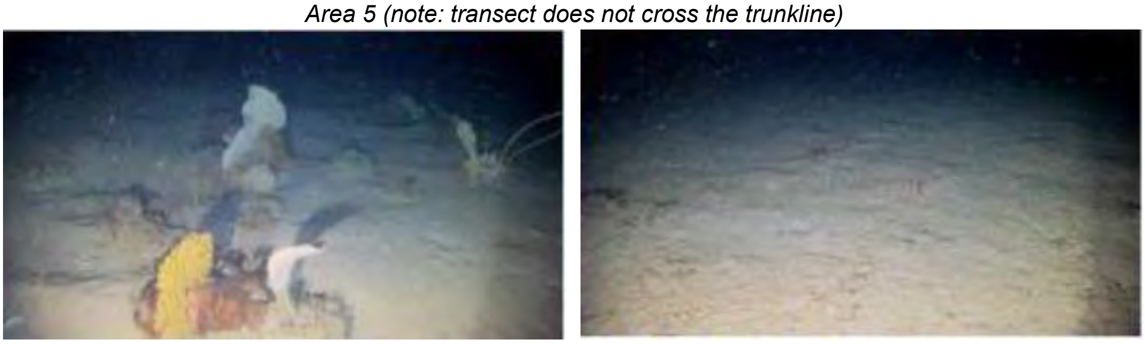
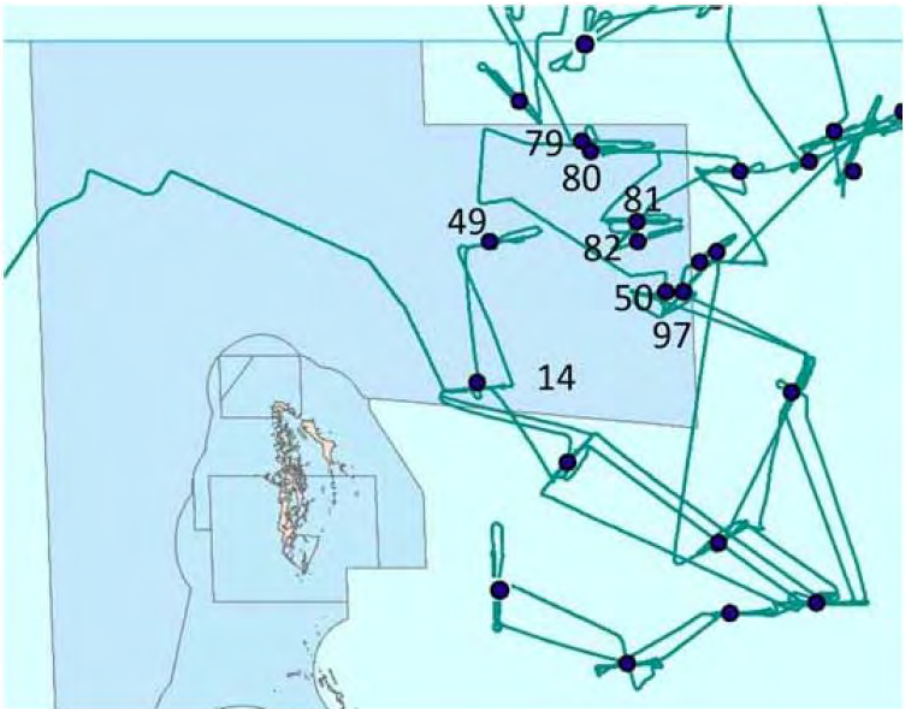


Figure 5-41: Example of ROV footage from the benthic habitat survey of the trunkline corridor within the Montebello Marine Park (photos selected from near the trunkline route)

Relatively recent previous surveys of benthic habitat data from areas on the North West Shelf (including the Montebello AMP) include the 2017 CSIRO *RV Investigator* voyage (Keesing, 2019) and the 2013 Pilbara Marine Conservation Partnership (PMCP) surveys (Pitcher et al., 2016). General findings of these studies are provided below.

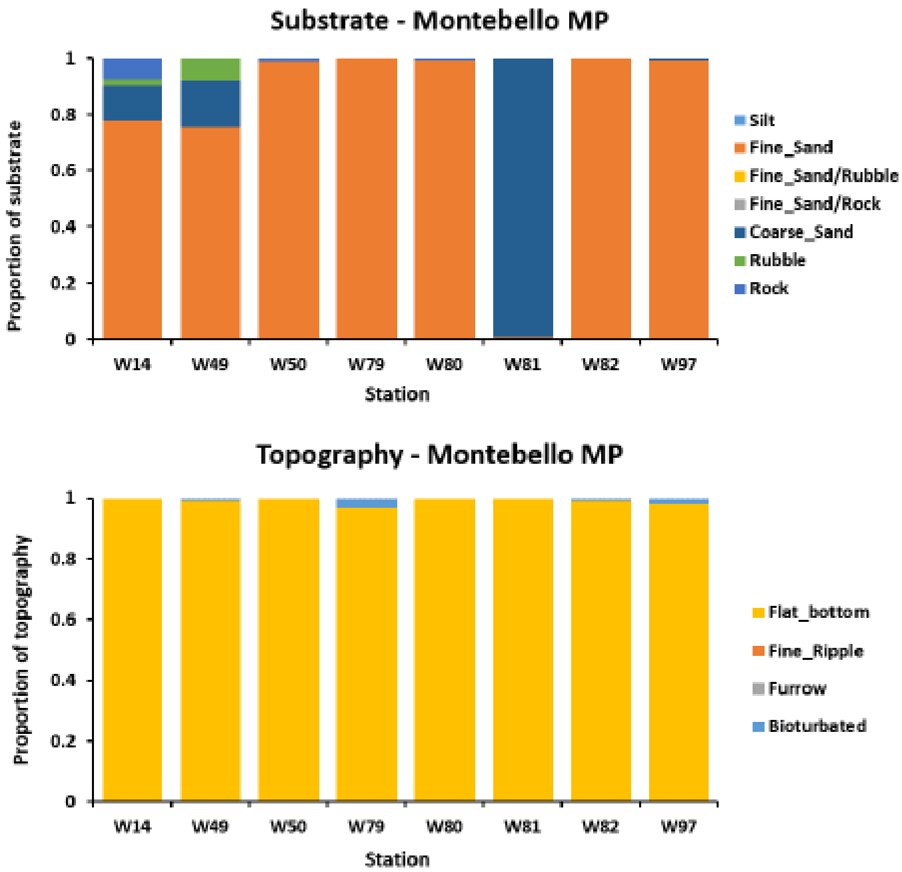
Data used to describe benthic substrates and biota from the 2017 CSIRO *RV Investigator* voyage were principally derived from still camera images. This study was predominantly undertaken in the eastern region of the AMP (Figure 5-42); with sites 79, 80, 81 and 82 being the closest to the Scarborough trunkline route (Figure 5-40). This study showed that topography in the vicinity of the Scarborough trunkline was predominantly flat bottom with some occasional bioturbated areas, and that the substrate was typically fine sands although site 81 was predominantly rock (Figure 5-43). These sites within the vicinity of the Scarborough trunkline had low numbers of sponges, whips and gorgonians (Figure 5-44) and as a result, complex benthic filter feeder communities were largely absent. The dominant filter feeders were hydroids, seapens and crinoids. The most commonly recorded crinoid was *Comatula rotalaria* which is free living on sand rather than associated with other filter feeders like gorgonians. Only site (81) had more than 50% of images with no biota however most sites had large areas characterised by soft sediment dwelling crinoids or hydroids and seapens.

The Keesing (2019) report did note that no imagery or biological samples had been collected in the northwestern part of the Montebello AMP as part of their study (or the previous 2013 PMCP study). Acoustic data was collected on a single swath path through part of the northwest region of the AMP (Figure 5-42), which did indicate rocky bottomed areas. However, this swath path is located south of the Scarborough trunkline. The substrate type and benthic habitat results from the Advisian (2019b) survey work towards filling this gap in data and are considered representative of habitats expected to be encountered by the Scarborough trunkline through the northwestern part of the Montebello AMP.



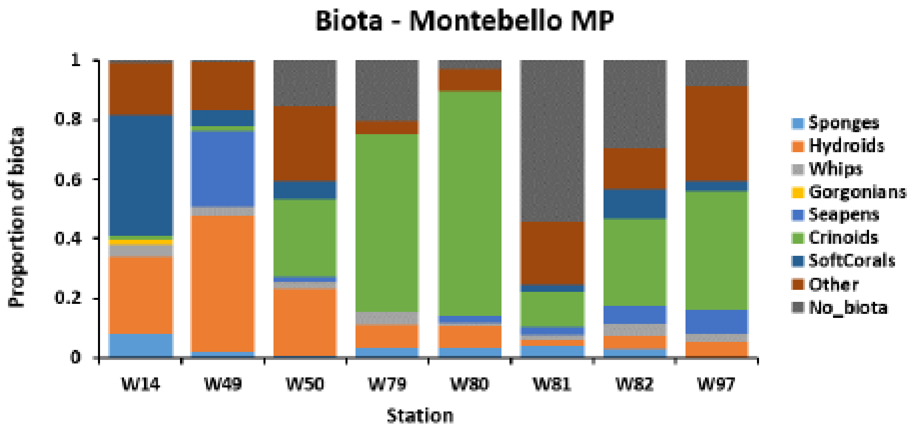
(Source: Keesing, 2019)

Figure 5-42: Location of sites surveyed swath mapping within the Montebello AMP during the 2017 study



(Source: Keesing, 2019)

Figure 5-43: Proportion of substrate and topography types in seabed images from the RV Investigator survey



(Source: Keesing, 2019)

Figure 5-44: Proportion of benthic biota types in seabed images from the 2017 RV Investigator survey

The 2013 PMCP project included habitat and biodiversity mapping in the region between North West Cape and Barrow Island and the Montebello Islands; one of the studies included sites in what is now the Montebello AMP (Pitcher et al., 2016). All sites in the PMCP study were located much further south within the Montebello AMP than the Scarborough trunkline (Figure 5-45). Substrate type recorded by video at the 2013 survey sites was either fine or coarse sand at four sites and rippled at two sites located in the south-western section of the AMP. The towed video sites surveyed in the south-western part of the AMP had large proportions of video transects where no biota was evident. Dense sponges occurred at shallower sites on the central southern and south western section of the MP, west of the islands and a site also in the south-western section had a large proportion of gorgonian habitat.

(Source: Keesing, 2019)

Figure 5-45: Location of sites surveyed within the Montebello AMP during the 2013 study

The results of previous benthic studies in the Montebello AMP are largely in alignment with the findings of the current study in terms of the benthic habitat recorded (i.e. typically low relief sandy seafloor (with various bedforms) with occasional rubbly areas increasing at sites more inshore) and dominant benthic organisms identified (which varied in diversity and density within and between survey areas, but typically included a wide variety of sponges and soft corals including whips and gorgonians, hydroids, seapens and crinoids) (Advisian, 2019b). While the presence of benthic biota (e.g. sponge and soft corals) may provide a food source for marine turtles, given the variation in cover, the water depth, and lack of any significant high relief habitat features, the region in proximity to the Scarborough trunkline route is not considered to be representative of a significant turtle foraging habitat.

Details of the Montebello Marine Park values are provided below. These are taken directly from the North-west Marine Parks Network Management Plan 2018 (Director of National Parks, 2018).

The Montebello Marine Park is located offshore of Barrow Island and 80 km west of Dampier extending from the Western Australian state water boundary and is adjacent to the Western Australian Barrow Island and Montebello Islands Marine Parks (refer to Section 5.6.1). The Marine Park covers an area of 3413 km² and water depths from less than 15 m to 150 m.

The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Montebello Marine Park on 9 October 2017. The Marine Park is assigned IUCN category VI and includes one zone assigned under this plan: Multiple Use Zone (VI).

The Montebello Marine Park is significant because it contains habitats, species and ecological communities associated with the Northwest Shelf Province. It includes one key ecological feature: the ancient coastline at the 125 m depth contour (valued as a unique seafloor feature with ecological properties of regional significance).

The Marine Park provides connectivity between deeper waters of the shelf and slope, and the adjacent Barrow Island and Montebello Islands Marine Parks. A prominent seafloor feature in the Marine Park is Trial Rocks consisting of two close coral reefs. The reefs are emergent at low tide.

Comparison of Montebello AMP and the adjacent Trawl Fishery Area

The Keesing (2019) report also completed a comparison between the Montebello AMP and the adjacent Trawl Fishery area as part of their study. This study notes that both the Pilbara Fish Trawl Fishery (PFTF) Area 1 and the Montebello AMP had a similar history of fishing effort up until about 1985, however there has been little or no trawling in the area that is now the Montebello AMP since that time.

Substrate type and topography of the seabed were similar between the two areas with predominantly flat bottom with fine sand substrate. Similar biota types (sponges, gorgonians, whips and other soft corals, hydroids, crinoids and sea pens) were present in the two areas. The exception to this was that sponge and whips were more abundant in PFTF Area 1, making up more than 50% of biota scored in images from 6 sites, while only one site in the Montebello AMP had more than 10% of biota scored as sponges or whips. The biomass of habitat forming filter feeder communities was also much greater (5.5 times higher) at sites in the PFTF Area 1 than in the Montebello MP.

Fish species diversity also differed between PFTF Area 1 sites and Montebello AMP sites and it was concluded that this could probably be attributable to the lesser availability of complex benthic filter feeder habitat in the AMP. There was also found to be a strong association between habitat forming benthic filter feeder biomass and fish biomass for most families of fish. In general fish biomass was much greater at stations within the PFTA Area 1 than in the Montebello AMP.

Natural Values

The Marine Park includes examples of ecosystems representative of the Northwest Shelf Province – a dynamic environment influenced by strong tides, cyclonic storms, long-period swells and internal tides. The bioregion includes diverse benthic and pelagic fish communities, and ancient coastline thought to be an important seafloor feature and migratory pathway for humpback whales. A key ecological feature of the Marine Park is the ancient coastline at the 125 m depth contour where rocky escarpments are thought to provide biologically important habitat in areas otherwise dominated by soft sediments.

The Marine Park supports a range of species including species listed as threatened, migratory, marine or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding habitat for seabirds, internesting, foraging, mating, and nesting habitat for marine turtles, a migratory pathway for humpback whales and foraging habitat for whale sharks.

Cultural Values

Sea country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for tens of thousands of years. At the commencement of the North-west Marine Parks Network Management Plan 2018 (Director of National Parks, 2018), there is limited information about the cultural significance of this Marine Park. The Yamatji Marlpa Aboriginal Corporation is the Native Title Representative Body for the Pilbara region.

Heritage Values

No international, Commonwealth or national listings apply to the Marine Park at commencement of the North-west Marine Parks Network Management Plan 2018 (Director of National Parks, 2018), however the Marine Park is adjacent to the Western Australia Barrow Island and the Montebello-Barrow Island Marine Conservation Reserves which have been nominated for national heritage listing (Director of National Parks, 2018).

The Marine Park contains two known shipwrecks listed under the Underwater Cultural Heritage Act 2018: Trial (wrecked in 1622), the earliest known shipwreck in Australian waters and Tanami (unknown date) (Director of National Parks, 2018).

Social and economic values

Tourism, commercial fishing, mining and recreation are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation (Director of National Parks, 2018).

5.6.1.4 Dampier Archipelago National Heritage Property

The Dampier Archipelago (including Burrup Peninsula) is an indigenous class feature on the National Heritage List. The place comprises of parts of the Burrup Peninsula, Islands of the Dampier Archipelago and Dampier Coast. The Dampier Archipelago is sacred and home to Indigenous Australians. According to the Ngarda-Ngarli people ancestral beings created the land during the Dreamtime, and the spirits of Ngkurr, Bardi and Gardi continue to live in the area. The Dampier Archipelago contains one of the largest and most diverse concentrations of rock art (petroglyphs) in the world. The place also contains Indigenous stone features, camp sites, quarries and shell middens which show a rich cultural and spiritual history dating back tens of thousands of years. Indigenous heritage sites range from small scatters to valleys with thousands of engravings which exhibit a degree of creativity that is unusual in Australian rock engravings (DEH, 2007). The Aboriginal Heritage Inquiry System identified about 1700 Registered Aboriginal Sites within the Dampier Archipelago (DPLH, 2018).

5.6.1.5 Dampier Marine Park

The Dampier Marine Park is located 250 m from the Project Area (Borrow Ground). Details of the Park's values are provided below. These are taken directly from the North-west Marine Parks Network Management Plan 2018 (Director of National Parks, 2018).

The Marine Park is located approximately 40 km from Dampier. The Marine Park covers an area of 1252 km² and water depths between less than 15 m and 70 m.

The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Dampier Marine Park on 9 October 2017. The Marine Park is assigned IUCN category VI and includes three zones assigned under this plan: National Park Zone (II), Habitat Protection Zone (IV) and Multiple Use Zone (VI).

The Dampier Marine Park is significant because it contains habitats, species and ecological communities associated with the North West Shelf Province. The Marine Park provides protection for offshore shelf habitats adjacent to the Dampier Archipelago, the areas between Dampier and Port Hedland and is a hotspot for sponge biodiversity. The multi-use zone of the Park includes several submerged coral reefs and shoals including Delambre Reef and Tessa Shoals.

Findings from the benthic habitat survey completed in the Borrow Ground Project Area and adjacent areas of the Dampier Marine Park suggest that the benthic habitat is dominated by sandy bottom with little to no biota (Advisian, 2019). Data captured includes high resolution still images and video footage at 24 drop camera locations outside the marine park and 51 drop camera locations within the marine park. Within and outside the marine park, little or no invertebrates were observed (< 10% coverage) (Figure 5-20 and Figure 5-21). Where biota was observed, it typically consisted of invertebrates such as anemones and crinoids at densities no greater than 10% and typically less than 5% cover. Of the 24 survey locations within the potential borrow ground, sparse invertebrate cover was observed at only two locations. Of the 51 survey locations within the habitat protection zone of the Dampier Marine Park immediately adjacent to the proposed borrow ground, sparse invertebrate cover was observed at 12 locations.

Additional survey work completed by CSIRO shows that benthic cover at the proposed borrow ground and adjacent habitat protection zone is not regionally significant, and that benthic cover is lower than that identified regionally (Keesing, 2019).

Natural Values

The Marine Park includes examples of ecosystems representative of:

- North West Shelf Province – a dynamic environment influenced by strong tides, cyclonic storms, long-period swells and internal tides.

The bioregion includes diverse and pelagic fish communities. There are no KEFs identified within the AMP but the AMP is noted to include ancient coastline thought to be an important seafloor value.

The Marine Park supports a range of species including species listed as threatened, migratory, marine or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding habitat for seabirds (fairy tern, wedge-tailed shearwater and roseate tern), internesting habitat for marine turtles (flatback, hawksbill, loggerhead and green), migratory pathway for humpback whales and distribution for pygmy blue whales.

Cultural Values

Sea country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for tens of thousands of years.

The Ngarluma, Yindjibarndi, Yaburara and Mardudhunera people have responsibilities for sea country in the Marine Park. The native title holders for these people are represented by the Ngarluma Aboriginal Corporation and Yindjibarndi Aboriginal Corporation. These Prescribed Body Corporates represent traditional owners with native title over coastal area adjacent to the Marine Park and are the points of contact for their respective areas of responsibility for sea country in the Marine Park.

The Yamatji Marlpa Aboriginal is the native title representative body for the Pilbara and Yamatji regions.

Heritage Values

No international, Commonwealth or national listings apply to the Marine Park at commencement of this plan, however the Marine Park is approximately 10 km north of the Dampier Archipelago (including Burrup Peninsula) national heritage listing, which has significant Indigenous heritage values including rock art sites.

Social and Economic Values

Port activities, commercial fishing and recreation, including fishing, are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation.

5.6.2 Ningaloo Coast and Gascoyne

5.6.2.1 Ningaloo Coast World and National Heritage Area

The Ningaloo Coast World Heritage Area (WHA) includes North West Cape and the Muiron Islands, and was inscribed, under criteria (vii) and criteria (x) by the World Heritage Committee onto the World

Heritage Register in June 2011. The statement of Outstanding Universal Value for the Ningaloo coast was based on the natural criteria and recognised the following (UNESCO, 2011):

- **Criterion (vii)**: The landscapes and seascapes of the Ningaloo Coast WHA are comprised of mostly intact and large-scale marine, coastal and terrestrial environments. The lush and colourful underwater scenery provides a stark and spectacular contrast with the arid and rugged land. The property supports rare and large aggregations of Whale sharks (*Rhincodon typus*) along with important aggregations of other fish species and marine mammals. The aggregations in Ningaloo following the mass coral spawning and seasonal nutrient upwelling cause a peak in productivity that leads about 300–500 Whale sharks to gather, making this the largest documented aggregation in the world.
- **Criterion (x):** In addition to the remarkable aggregations of Whale sharks, the Ningaloo Reef harbours a high marine diversity of more than 300 documented coral species, over 700 reef fish species, roughly 650 mollusc species, as well as around 600 crustacean species and more than 1000 species of marine algae. The high numbers of 155 sponge species and 25 new species of echinoderms add to the significance of the area. On the ecotone, between tropical and temperate waters, the Ningaloo Coast hosts an unusual diversity of marine turtle species with an estimated 10,000 nests deposited along the coast annually.

The Ningaloo Coast WHA is recognised as being of outstanding conservation value, supporting a rich array of habitats and a diverse and abundant marine life (DoEE, n.d.). The region has a high diversity of marine habitats including coastal mangrove systems, lagoons, coral reef, open ocean, continental slope and the continental shelf (CALM, 2005). The dominant feature of the Ningaloo Coast WHA is Ningaloo Reef, the largest fringing reef in Australia. Ningaloo Reef supports both tropical and temperate species of marine fauna and flora and more than 300 species of coral (CALM, 2005).

The Ningaloo Coast WHA provides important nesting habitat for four species of marine turtle found in Western Australia. The North West Cape and Muiron Islands are major nesting sites for Loggerhead turtles, with about 400 and 600 females nesting annually on the Ningaloo Coast (particularly, North West Cape area) and Muiron Islands, respectively (Department of Environmental Protection, 2001). The North West Cape is also a major nesting habitat for Hawksbill and Green turtles, with an estimated 1000–1500 Green turtles nesting in the area annually (DEC, 2009). The Muiron Islands are minor nesting sites for Flatback and Hawksbill turtles (DEC, 2009).

It is these natural heritage values, iconic wilderness, seascapes, wildlife and biodiversity which are major attractions of the WHA and therefore the main driver for tourism on the North West Cape. All properties inscribed on the World Heritage List must have adequate management to ensure their protection, thus the Ningaloo WHA is managed via the Australian Marine Park and State marine park (see subsections below).

5.6.2.2 Ningaloo Australian Marine Park

The Ningaloo Marine Park is located 186 km from the Project Area. Details of the Ningaloo Marine Park values are provided below. These are taken directly from the North-west Marine Parks Network Management Plan 2018 (Director of National Parks, 2018).

The Ningaloo Marine Park stretches about 300 km along the west coast of the Cape Range Peninsula and is adjacent to the Western Australian Ningaloo Marine Park and Gascoyne Marine Park. The Marine Park covers an area of 2435 km² and a water depth range of 30 m to more than 500 m.

The Marine Park was originally proclaimed under the National Parks and Wildlife Conservation Act 1975 on 20 May 1987 as the Ningaloo Marine Park (Commonwealth waters) and proclaimed under the EPBC Act on 14 December 2013 and renamed Ningaloo Marine Park on 9 October 2017. The

Marine Park is assigned IUCN category IV and includes two zones assigned under this plan: National Park Zone (II) and Recreational Use Zone (IV).

The Ningaloo Marine Park is significant because it contains habitats, species and ecological communities associated with the Central Western Shelf Transition, Central Western Transition, Northwest Province, and Northwest Shelf Province. It includes three key ecological features: canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula (valued for unique seafloor features with ecological properties of regional significance); Commonwealth waters adjacent to Ningaloo Reef (valued for high productivity and aggregations of marine life); and continental slope demersal fish communities (valued for high levels of endemism and diversity).

The Marine Park provides connectivity between deeper offshore waters of the shelf break and coastal waters of the adjacent Western Australian Ningaloo Marine Park. It includes some of the most diverse continental slope habitats in Australia, in particular, the continental slope area between North West Cape and the Montebello Trough. Canyons in the Marine Park are important for their role in sustaining the nutrient conditions that support the high diversity of Ningaloo Reef.

The Marine Park is located in a transition zone between tropical and temperate waters and sustains tropical and temperate plants and animals, with many species at the limits of their distributions.

<u>*Natural Values*</u>

The Marine Park includes examples of ecosystems representative of:

- Central Western Shelf Transition – continental shelf of water depths up to 100 m, and a significant transition zone between tropical and temperate species
- Central Western Transition – characterised by large areas of continental slope, a range of topographic features such as terraces, rises and canyons, seasonal and sporadic upwelling, and benthic slope communities comprising tropical and temperate species
- Northwest Province – an area of continental slope comprising diverse and endemic fish communities
- Northwest Shelf Province – a dynamic environment, influenced by strong tides, cyclonic storms, long-period swells and internal tides. The bioregion includes diverse benthic and pelagic fish communities, and ancient coastline thought to be an important seafloor feature and migratory pathway for humpback whales.

Key ecological features of the Marine Park are:

- canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula –an area resulting in upwelling of nutrient rich water and aggregations of marine life
- Commonwealth waters adjacent to Ningaloo Reef – an area where the Leeuwin and Ningaloo currents interact, resulting in enhanced productivity and aggregations of marine life
- continental slope demersal fish communities – an area of high diversity among demersal fish assemblages on the continental slope.

Ecosystems represented in the Marine Park are influenced by interaction of the Leeuwin Current, Leeuwin Undercurrent and the Ningaloo Current.

The Marine Park supports a range of species including species listed as threatened, migratory, marine or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding and or foraging habitat for seabirds, internesting habitat for marine turtles, a migratory pathway for humpback whales, foraging habitat and migratory pathway for pygmy blue whales, breeding, calving, foraging and nursing habitat for dugong and foraging habitat for whale sharks.

<u>Cultural Values</u>

Sea country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for tens of thousands of years. The Gnulli people have responsibilities for sea country in the Marine Park.

The Yamatji Marlpa Aboriginal Corporation is the Native Title Representative Body for the Yamatji region.

<u>*Heritage Values*</u>

World Heritage

The Marine Park is within the Ningaloo Coast World Heritage Property, recognised for its outstanding universal heritage values, meeting world heritage listing criteria vii and x. In addition to the Marine Park, the world heritage area includes the Western Australian Ningaloo Marine Park, the Muiron Islands, the Western Australian Cape Range National Park and other terrestrial areas. The area is valued for high terrestrial species endemism, marine species diversity and abundance, and the interconnectedness of large-scale marine, coastal and terrestrial environments. The area connects the limestone karst system and fossil reefs of the ancient Cape Range to the nearshore reef system of Ningaloo Reef, to the continental slope and shelf in Commonwealth waters.

National Heritage

The Ningaloo Coast overlaps the Marine Park and was established on the National Heritage List in 2010, meeting the national heritage listing criteria A, B, C, D and F.

Commonwealth Heritage

The Ningaloo Marine Area (Commonwealth waters) was established on the Commonwealth Heritage List in 2004, meeting Commonwealth heritage listing criteria A, B and C. The Ningaloo Marine Area overlaps the Marine Park.

Underwater Cultural Heritage

The Marine Park contains more than 15 known shipwrecks listed under the Underwater Cultural Heritage Act 2018.

<u>Social and Economic Values</u>

Tourism and recreation, including fishing, are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation.

5.6.2.3 Ningaloo Marine Park and Muiron Islands Marine Management Area

The Ningaloo Marine Park (State waters) was established in 1987 and stretches 300 km from the North West Cape to Red Bluff. It encompasses the State waters covering the Ningaloo Reef system and a 40 m strip along the upper shore. The Muiron Islands Marine Management Area is managed under the same management plan as for the Ningaloo State Marine Park (CALM, 2005). The Ningaloo Marine Park is part of the Ningaloo Coast WHA. Whalebone is located within the Muiron Islands Marine Management Area

Ecological and conservation values of the Ningaloo Marine Park and Muiron Islands are summarised below. Generally, all ecological values are presumed to be in an undisturbed condition except for some localised high use areas (CALM, 2005). The ecological and conservation values include:

- Unique geomorphology has resulted in a high habitat and species diversity.

- There is high sediment and water quality.
- Subtidal and intertidal coral reef communities provide food, settlement substrate and shelter for marine flora and fauna.
- Filter feeding communities (sponge gardens) exist in the northern part of the North West Cape and the Muiron and Sunday Islands.
- Shoreline intertidal reef communities provide feeding habitat for larger fish and other marine animals during high tide.
- Soft sediment communities are found in deeper waters, characterised by a surface film of microorganisms that provide a rich source of food for invertebrates.
- Macroalgae and seagrass communities are an important primary producer providing habitat for vertebrate and invertebrate fauna.
- Mangrove communities occur only in the northern part of the Ningaloo Marine Park and are important for reef fish communities (Cassata and Collins, 2008) and support a high diversity of infauna, particularly, molluscs (600 mollusc species).
- There is diverse fish fauna (about 460 species).
- Foreshores and nearshore reefs of the Ningaloo coast and Muiron/Sunday islands provide internesting, nesting and hatchling habitat for several species of marine turtles including the loggerhead, green, flatback and hawksbill turtles.
- Whale sharks aggregate annually to feed in the waters around Ningaloo Reef, from March to July, with the largest numbers being recorded around April and May (Sleeman et al., 2010). The season can be variable, with individual Whale sharks being recorded at other times of the year. Timing of the whale sharks' migration to and from Ningaloo coincides with the mass coral spawning period when there is an abundance of food (krill, planktonic larvae and schools of small fish) in the waters adjacent to Ningaloo Reef.
- Seasonal shark aggregations and Manta rays are commonly found in the area with a permanent population of manta rays (*Manta alfredi*) inhabiting the Ningaloo Reef. Numbers are boosted periodically by roaming and seasonal animals. Small aggregations coincide with small pulses of target prey and the spawning events of many reef inhabitants, while larger aggregations coincide with major seasonal spawning events. The number of species in the Ningaloo Reef area peaks during autumn, which corresponds to coral spawning, and during spring which corresponds with the crab spawning event (McGregor, 2008).
- Annual mass coral spawning on Ningaloo Reef. Synchronous, multi-specific spawning of tropical reef corals occurs during a brief predictable period in late summer/early autumn generally seven to nine nights after a full moon on neap, nocturnal ebb tides March/April each year (Rosser and Gilmour, 2008; Taylor and Pearce, 1999).
- Large coral slicks generally form over shallow reef areas in calm conditions. It is noted that there are minor spawning activities on the same nights after the February and April full moons, and in some years the mass spawning event occurs after the April full moon (Simpson et al., 1993a).
- Marine mammals such as dugong and small cetacean populations frequent or reside in nearshore waters. Dugong numbers in Ningaloo Marine Park are considered to be in the order of around 1000 individuals, with a similar number in Exmouth Gulf (CALM, 2005). The Ningaloo/Exmouth Gulf region supports a significant population

of dugongs which is interconnected with the Shark Bay resident population (which represents less than 10% of the world's dugongs).

- Nesting and foraging habitat is present for seabirds and shorebirds. About 33 species of seabirds are recorded in the Ningaloo Marine Park (13 resident and 20 migratory) and there are five known rookeries as well isolated rookeries on the Muiron and Sunday Islands.

In addition to the ecological and conservation values, the Ningaloo Marine Park has a number of social values including culture heritage and marine based tourism and recreation (water-sports and fishing). The Ningaloo Marine Park (State waters) is contiguous with the Ningaloo Australian Marine Park.

Ningaloo Shoreline, Shallow Subtidal Reef and Intertidal Habitats

The Ningaloo Reef and lagoonal systems comprise a variety of shallow subtidal and intertidal communities that comprise shallow outer reef slope (spur and groove habitat), reef crest (emergent at low tide), reef flat (coralline algae and high cover tabular *Acropora* spp. coral communities), back reef lagoon (coral, soft sediment and macro-algal communities), sublittoral limestone platform (turf algae/molluscs/echinoderm community), and intertidal mangrove, mud flat and salt marsh communities (Cassata and Collins, 2008).

The area seaward of the reef crest is characterised by a coralline algae/coral community (spur and groove reef slope). The area has a series of perpendicular spur and grooves from 5 to 40 m depth range consisting of narrow, deep channels filled with sand and coral rubble and rock spurs with diverse hard coral communities (with dominant tabular *Acropora* spp. growing in small, compact colonies), together with soft corals, *Millepora* (fire coral), sponges and macroalgae. Coralline algae encrust dead corals, rocks and coral rubble. Coral growth is most prolific between 5 and 10 m depth.

On the landward side of the reef crest is a reef flat habitat and back reef lagoon with a number of subtidal and intertidal habitats (Cassata and Collins, 2008) as follows:

- Outer reef flat (very shallow, <1 m depth) at the back of the reef crest: Coralline algae/coral community (spur and groove). Similar morphology to the reef slope.
- Rocky middle/inner reef flat (approximately 1 m depth): Tabular *Acropora* spp. Community.
- Back reef lagoon (>2 m depth): Patchy staghorn, massive and sub-massive coral community.
- Lagoonal sand flat (1–2 m depth): Sparse corals and algae community. This habitat is characterised by sheltered areas of limestone pavement with a veneer of sand and small outcrops of corals (*Porites* spp., *Acropora* spp.) with scattered patches of macroalgae (*Sargassum* spp., *Halimeda* spp., *Caulerpa* spp.) or seagrass (*Halophila* spp.).
- Lagoonal and inter-reef sandy depressions (3–15 m depth): Coral 'bommies' and algal patch community. A distinctive habitat type composed of sandy depressions either found as large deep regions within the lagoon or small depressions/channels inside the reef flat.
- Lagoon, shoreward reef channels (shallow): Macroalgal community. Fleshy algae colonising subtidal limestone pavement that is covered in sand with *Sargassum* spp. up to 0.5 m high and other red and green algal species. There are also small patches of hard and soft corals, sponges and ascidians.
- Sublittoral limestone platform: Turf algae/mollusc/echinoderm community. This habitat is composed of a flat limestone pavement often contiguous with the rocky

shoreline and supports intertidal and subtidal fauna comprising molluscs (limpets, chitons, small mussels, cowries and giant clams) and echinoderms (sea cucumbers, starfish and sea urchins) with isolated hard and soft coral colonies. The limestone pavement also has a ubiquitous coverage of turf algae.

- Mangrove coastal swamps: Although not a common habitat type within Ningaloo Marine Park, there are mangrove stands in the upper intertidal zone on a muddy substrate of carbonate silt and lay. The mangrove communities are located within the Mangrove Sanctuary Zone (where they occupy a large section of coast between Low Point and Mangrove Bay) and sporadically within the Osprey Sanctuary Zone on the Yardie Creek banks. There are three species of mangrove: *Avicennia marina*, *Rhizophora stylosa* and *Bruguiera exaristata*. *Avicennia marina* is most common and widespread. This habitat supports a diverse community of invertebrate fauna including gastropods, crabs and burrowing worms and is also a nursery area for the juveniles of many species of reef fish.
- Intertidal mud flats: Mud flats occur in the lower intertidal zone of the lagoon, formed from the deposition of mud in the sheltered tidal waters.
- Salt marshes: The salt marsh habitat is seaward of the mangroves and is represented by salt tolerant vegetation and sandy patches.

Muiron Islands Subtidal, Intertidal and Shoreline Habitats

Coastal sensitivity mapping identified the onshore sensitivities to be turtle rookeries and turtle nesting occurring from October to April (Joint Carnarvon Basin Operators, 2012). Most of the western coast consists of limestone coastal cliffs interspersed with sandy beaches and intertidal rock platforms. The nearshore sensitivities include the intertidal/nearshore reef (Joint Carnarvon Basin Operators, 2012). Soft coral communities dominate the reefs on the western side of the Muiron Islands. Habitats on the eastern side of the Muiron Islands are more sheltered, consisting of sandy beaches and shallow lagoons with diverse soft and hard coral communities (Cassata and Collins, 2008; Kobryn et al., 2013).

5.6.2.4 Gascoyne Australian Marine Park

The Gascoyne Marine Park is located 77 km from the Project Area. Details of the Gascoyne Marine Park values are provided below. These are taken directly from the North-west Marine Parks Network Management Plan 2018 (Director of National Parks, 2018).

The Gascoyne Marine Park is located approximately 20 km off the west coast of the Cape Range Peninsula, adjacent to the Ningaloo Reef Marine Park and the Western Australian Ningaloo Marine Park and extends to the limit of Australia's exclusive economic zone. The Marine Park covers an area of 81,766 km² and water depths between 15 m and 6000 m.

The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Gascoyne Marine Park on 9 October 2017. The Marine Park is assigned IUCN category IV and includes three zones assigned under this plan: National Park Zone (II), Habitat Protection Zone (IV) and Multiple Use Zone (VI).

- The Gascoyne Marine Park is significant because it contains habitats, species and ecological communities associated with the Central Western Shelf Transition, Central Western Transition, and Northwest Province. It includes four key ecological features: Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula (valued for unique seafloor features with ecological properties of regional significance); Commonwealth waters adjacent to Ningaloo Reef (valued for high productivity and aggregations of marine life); continental slope demersal fish communities (valued for high levels of endemism and diversity); and the Exmouth

Plateau (valued as a unique seafloor feature with ecological properties of regional significance).

The Gascoyne Marine Park includes some of the most diverse continental slope habitats in Australia, in particular the continental slope area between North West Cape and the Montebello Trough. Canyons in the Marine Park link the Cuvier Abyssal Plain to the Cape Range Peninsula and are important for their role in sustaining the nutrient conditions that support the high diversity of Ningaloo Reef.

<u>*Natural Values*</u>

The Marine Park includes examples of ecosystems representative of:

- Central Western Shelf Transition – continental shelf with water depths up to 100 m, and a significant transition zone between tropical and temperate species
- Central Western Transition – characterised by large areas of continental slope, a range of topographic features such as terraces, rises and canyons, seasonal and sporadic upwelling, and benthic slope communities comprising tropical and temperate species
- Northwest Province – an area of continental slope comprising diverse and endemic fish communities.

Key ecological features of the Marine Park are:

- canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula – an area resulting in upwelling of nutrient rich water and aggregations of marine life
- Commonwealth waters adjacent to Ningaloo Reef – an area where the Leeuwin and Ningaloo currents interact resulting in enhanced productivity and aggregations of marine life
- continental slope demersal fish communities – an area of high diversity of demersal fish assemblages on the continental slope
- Exmouth Plateau – a regionally and nationally unique deep-sea plateau in tropical waters.

Ecosystems represented in the Marine Park are influenced by the interaction of the Leeuwin Current, Leeuwin Undercurrent and the Ningaloo Current.

The Marine Park supports a range of species including species listed as threatened, migratory, marine or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding habitat for seabirds, internesting habitat for marine turtles, a migratory pathway for humpback whales, and foraging habitat and migratory pathway for pygmy blue whales.

<u>*Cultural Values*</u>

Sea country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for tens of thousands of years. The Gnulli people have responsibilities for sea country in the Marine Park.

The Yamatji Marlpa Aboriginal Corporation is the Native Title Representative Body for the Yamatji region.

<u>Heritage Values</u>

World Heritage

The Ningaloo Coast was listed as an area of outstanding universal value under the World Heritage Convention in 2011, meeting world heritage listing criteria vii and x. The Ningaloo Coast World Heritage Property is adjacent to the Marine Park.

Commonwealth Heritage

The Ningaloo Marine Area (Commonwealth waters) was established on the Commonwealth Heritage List in 2004, meeting the Commonwealth heritage listing criteria A, B and C. The Ningaloo Marine Area is adjacent to the Marine Park.

National Heritage

The Ningaloo Coast was established on the National Heritage List in 2010, meeting the national heritage listing criteria A, B, C, D, and F and is adjacent to the Marine Park.

Underwater Cultural Heritage

The Marine Park contains more than five known shipwrecks listed under the Underwater Cultural Heritage Act 2018.

<u>Social and Economic Values</u>

Commercial fishing, mining and recreation are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation.

5.6.3 Shark Bay

5.6.3.1 Shark Bay World and National Heritage Areas

Shark Bay is a natural class feature on the World and National Heritage List.

Shark Bay is a large, shallow bay with associated peninsulas and islands on the coast of WA. The place, which has a total area of 22,000 km^2, includes the marine and estuarine areas of the bay, together with the peninsulas and islands projecting into it and adjacent areas of the mainland including the coastal strip along the eastern coast and the region immediately to the south.

Shark Bay has three exceptional natural features: its vast sea-grass beds, which are the largest (4,800 km^2) and richest in the world; its dugong population; and its stromatolites (colonies of algae which form hard, dome-shaped deposits and are among the oldest forms of life on earth). Shark Bay is also home to five species of endangered mammals.

The Shark Bay World Heritage Area (WHA) was inscribed, under criteria (vii), (viii), (ix) and (x) by the World Heritage Committee onto the World Heritage Register in 1991. The statement of Outstanding Universal Value for the Ningaloo coast was based on the natural criteria and recognised the following (UNESCO, 1991):

- **Criterion (vii):** One of the superlative natural phenomena present in this property is its stromatolites, which represent the oldest form of life on Earth and are comparable to living fossils. Shark Bay is also one of the few marine areas in the world dominated by carbonates not associated with reef-building corals. This has led to the development of the Wooramel Seagrass Bank within Shark Bay, one of the largest seagrass meadows in the world with the most seagrass species recorded from one area. These values are supplemented by marine fauna such as dugong, dolphins, sharks, rays, turtles and fish, which occur in great numbers. The hydrologic structure of Shark Bay, altered by the formation of the Faure Sill and a high evaporation, has produced a basin where marine waters are hypersaline (almost twice that of seawater) and contributed to extensive beaches consisting entirely of shells. The profusion of peninsulas, islands and bays create a diversity of landscapes and exceptional coastal scenery.

- **Criterion (viii):** Shark Bay contains, in the hypersaline Hamelin Pool, the most diverse and abundant examples of stromatolites in the world. Analogous structures dominated marine ecosystems on Earth for more than 3,000 million years. The stromatolites of Hamelin Pool were the first modern, living examples to be recognised that have a morphological diversity and abundance comparable to those that inhabited Proterozoic seas. As such, they are one of the world's best examples of a living analogue for the study of the nature and evolution of the earth's biosphere up until the early Cambrian. The Wooramel Seagrass Bank is also of great geological interest due to the extensive deposit of limestone sands associated with the bank, formed by the precipitation of calcium carbonate from hypersaline waters.
- **Criterion (ix):** Shark Bay provides outstanding examples of processes of biological and geomorphic evolution taking place in a largely unmodified environment. These include the evolution of the Bay's hydrological system, the hypersaline environment of Hamelin Pool and the biological processes of ongoing speciation, succession and the creation of refugia. One of the exceptional features of Shark Bay is the steep gradient in salinities, creating three biotic zones that have a marked effect on the distribution and abundance of marine organisms. Hypersaline conditions in Hamelin Pool have led to the development of a number of significant geological and biological features including the 'living fossil' stromatolites. The unusual features of Shark Bay have also created the Wooramel Seagrass Bank. Covering 103,000 ha, it is the largest structure of its type in the world.
- **Criterion (x):** Shark Bay is a refuge for many globally threatened species of plants and animals. The property is located at the transition zone between two of Western Australia's main botanical provinces, the arid Eremaean, dominated by Acacia species and the temperate South West, dominated by Eucalyptus species, and thus contains a mixture of two biotas, many at the limit of their southern or northern range. The property contains either the only or major populations of five globally threatened mammals, including the Burrowing Bettong (now classified as Near Threatened), Rufous Hare Wallaby, Banded Hare Wallaby, the Shark Bay Mouse and the Western Barred Bandicoot. A number of globally threatened plant and reptile species also occur in the terrestrial part of the property. Shark Bay's sheltered coves and lush seagrass beds are a haven for marine species, including Green Turtle and Loggerhead Turtle (both Endangered, and the property provides one of Australia's most important nesting areas for this second species). Shark Bay is one of the world's most significant and secure strongholds for the protection of Dugong, with a population of around 11,000. Increasing numbers of Humpback Whales and Southern Right Whales use Shark Bay as a migratory staging post, and a famous population of Bottlenose Dolphin lives in the Bay. Large numbers of sharks and rays are readily observed, including the Manta Ray which is now considered globally threatened.

5.6.3.2 Dirk Hartog Landing – Cape Inscription National Heritage Area

The Dirk Hartog Landing is a historic class feature on the National Heritage List.

Cape Inscription is the site of the oldest known landings of Europeans on the Western Australian coast and is associated with a series of landings and surveys by notable explorers over a 250-year period. The first known European landing on the west coast of Australia was by Dirk Hartog of the Dutch East India Company's ship the Eendracht at Cape Inscription on 25 October 1616. Hartog left a pewter plate, inscribed with a record of his visit and nailed to a post left standing upright in a rock cleft on top of the cliff. This plate is the oldest extant record of a European landing in Australia.

5.6.3.3 Carnarvon Canyon Australian Marine Park

The Carnarvon Canyon Marine Park is located 405 km from the Project Area. Details of the Carnarvon Canyon Marine Park values are provided below. These are taken directly from the North-west Marine Parks Network Management Plan 2018 (Director of National Parks, 2018).

The Carnarvon Canyon Marine Park is located approximately 300 km north-west of Carnarvon. It covers an area of 6177 km² and a water depth range of 1500–6000 m.

The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Carnarvon Canyon Marine Park on 9 October 2017. The Marine Park is assigned IUCN category IV and includes one zone assigned under this plan: Habitat Protection Zone (IV).

The Carnarvon Canyon Marine Park is significant because it contains habitats, species and ecological communities associated with the Central Western Transition. This includes deep-water ecosystems associated with the Carnarvon Canyon. The Marine Park lies within a transition zone between tropical and temperate species and is an area of high biotic productivity.

Natural values

The Marine Park includes examples of ecosystems representative of the Central Western Transition—a bioregion characterised by large areas of continental slope, a range of topographic features such as terraces, rises and canyons, seasonal and sporadic upwelling, and benthic slope communities comprising tropical and temperate species. It includes the Carnarvon Canyon, a single-channel canyon covering the entire depth range of the Marine Park.

Ecosystems of the Marine Park are influenced by tropical and temperate currents, deep-water environments and proximity to the continental slope and shelf. The soft-bottom environment at the base of the Carnarvon Canyon is likely to support species that are typical of the deep seafloor (e.g. holothurians, polychaetes and sea-pens).

The Marine Park supports a range of species, including species listed as threatened, migratory, marine or cetacean under the EPBC Act. There is limited information about species' use of this Marine Park.

Cultural values

Sea country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for tens of thousands of years.

Heritage values

No international, Commonwealth or national heritage listings apply to the Marine Park at commencement of this plan.

Social and economic values

Commercial fishing is an important activity in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation.

5.6.3.4 Shark Bay Australian Marine Park

The Shark Bay Marine Park is located 475 km from the Project Area. Details of the Shark Bay Marine Park values are provided below. These are taken directly from the North-west Marine Parks Network Management Plan 2018 (Director of National Parks, 2018).

The Shark Bay Marine Park is located approximately 60 km offshore of Carnarvon, adjacent to the Shark Bay world heritage property and national heritage place. The Marine Park covers an area of 7443 km², extending from the Western Australian state water boundary, and a water depth range between 15 m and 220 m.

The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Shark Bay Marine Park on 9 October 2017. The Marine Park is assigned IUCN category VI and includes one zone assigned under this plan: Multiple Use Zone (VI).

The Shark Bay Marine Park is significant because it contains habitats, species and ecological communities associated with the Central Western Shelf Province and Central Western Transition. The Marine Park provides connectivity between deeper Commonwealth waters and the inshore waters of the Shark Bay world heritage property.

<u>Natural values</u>

The Marine Park includes examples of ecosystems representative of:

- Central Western Shelf—a predominantly flat, sandy and low-nutrient area, in water depths 50–100 m. The bioregion is a transitional zone between tropical and temperate species; and
- Central Western Transition—characterised by large areas of continental slope, a range of topographic features such as terraces, rises and canyons, seasonal and sporadic upwelling, and benthic slope communities comprising tropical and temperate species.

Ecosystems represented in the Marine Park are influenced by the Leeuwin, Ningaloo and Capes currents.

The Marine Park supports a range of species including species listed as threatened, migratory, marine or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding habitat for seabirds, internesting habitat for marine turtles, and a migratory pathway for humpback whales. The Marine Park and adjacent coastal areas are also important for shallow-water snapper.

<u>Cultural values</u>

Sea country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for tens of thousands of years. The Gnulli and Malgana people have responsibilities for sea country in the Marine Park.

The Yamatji Marlpa Aboriginal Corporation is the Native Title Representative Body for the Yamatji region.

<u>Heritage values</u>

No international, Commonwealth or national heritage listings apply to the Marine Park at commencement of this plan, but the Marine Park is adjacent to the Shark Bay, Western Australia World Heritage Property and Shark Bay, Western Australia National Heritage Place.

Underwater Cultural Heritage

The Marine Park contains approximately 20 known shipwrecks listed under the Underwater Cultural Heritage Act 2018.

Social and economic values

Tourism, commercial fishing, mining and recreation, including fishing, are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation.

5.6.3.5 Shark Bay Marine Park

The Shark Bay Marine Park was gazetted on 30 November 1990 as A-Class Marine Park Reserve No. 7 and vested in the National Park and Nature Conservation Authority (NPNCA) under the CALM Act. The State Marine Park encompassing an area of 748,725 ha.

Shark Bay is of international significance, having been inscribed on the World Heritage List in 1991 in recognition of the area's outstanding universal natural values (Section 5.6.3.1).

The region contains an outstanding example of Earth's evolutionary history in the stromatolites and hypersaline environment of Hamelin Pool. There are significant ongoing geological and biological processes in both the marine and terrestrial environments of Shark Bay. The Faure Sill and Wooramel Seagrass Bank are examples of the many superlative natural phenomena or features to be found in the World Heritage Area. The World Heritage Area provides the habitat of a number of rare and threatened species with many others at the limit of their range. Shark Bay is also noted for its natural beauty and in particular the diversity of its land and seascapes.

Shark Bay is renowned for its marine fauna, including the dugong which is estimated to be one of the largest populations in the world. Humpback whales use the Bay as a staging area in their migration along the coast. Green and loggerhead turtles occur in the Bay with Dirk Hartog Island providing an important nesting site for loggerheads in Western Australia.

5.6.4 Pilbara Inshore Islands Nature Reserve

The Pilbara Inshore Islands Nature Reserves are mostly small, remote islands that are important breeding and resting places for migratory shorebirds, seabirds and marine turtles. Several threatened species rely on the islands as a refuge protected from disturbance or threats like introduced predators, light/noise pollution, wildfire and vehicles on beaches.

Four species of marine turtle (green, loggerhead, hawksbill and flatback) nest on inshore islands with major nesting beaches on the Muiron, Locker, Thevenard, Serrurier and Sholl Islands.

Around one million wedge-tailed shearwaters migrate to the area each year. They visit the islands (particularly the Muiron and Serrurier) from July onwards in order to prepare a burrow for nesting in when November arrives. During the day the adult birds are out feeding and return to their burrows every evening. Bird species that live on the islands all year round include the Beach Stone-curlew, Pied and Sooty Oystercatcher and Fairy Tern.

5.6.5 Eighty-Mile Beach Australian Marine Park

Eighty Mile Beach AMP is located approximately 218 km north-east of the Borrow Ground Project Area and outside of the EMBA. The Marine Park covers an area of 10,785 km² in water depths between less than 15 m and up to 70 m. The entire AMP is zoned as a Multiple Use Zone (IUCN VI). Ecological and conservation values of the AMP include (Director of National Parks, 2018):

- contains shallow shelf habitats, including terrace, banks and shoals

- supports a range of species including threatened, migratory, marine and cetacean species
- biologically important areas including breeding, foraging and resting habitat for seabirds, internesting and nesting habitat for marine turtles, foraging, nursing and pupping habitat for sawfish and a migratory pathway for humpback whales
- a range of cultural values for the community. Sea country is valued for Indigenous cultural identity, health and wellbeing. The sea country of the Nyangumarta, Karajarri and Ngarla people extends into Eighty Mile Beach Marine Park.

The above list of ecological and conservation values focuses on the far western extent of the AMP. Conservation values located beyond far western extent of the AMP are outside the environmental region relevant to this activity. There are no KEFs identified within the AMP.

The Eighty Mile Beach Ramsar site lies adjacent to the AMP and is recognised as one of the most important areas for migratory shorebirds in Australia.

5.6.6 Abrolhos Australian Marine Park

The Abrolhos AMP is located approximately 552 km south-southwest of the Project Area and outside of the EMBA. The AMP covers a large offshore area of adjacent to the Abrolhos Islands, extending from the State water boundary to the edge of the exclusive economic zone. The Marine Park covers 88,060 km² and includes waters in the depth range of about 15–6000 m (Director of National Parks, 2018). The reserve contains a number of conservation values, including (Director of National Parks, 2018):

- foraging habitat for several species of seabirds
- examples of ecosystems representative of the Central Western Province, Central Western Shelf Province, Central Western Transition, and South-west Shelf Transition
- Several KEFs, including the Wallaby Saddle and demersal slope and associated fish communities of the central western province.

The above list of ecological and conservation values focuses on the northern habitat-protection zone of the AMP. Conservation values of zones located to the south are outside the environmental region relevant to this activity.

5.6.7 Argo-Rowley Terrace Australian Marine Park

The Argo-Rowley Terrace AMP is located approximately 280 km north of the Borrow Ground Project Area and outside of the EMBA. The Marine Park covers an area of 146,099 km², including the Commonwealth waters surrounding the Rowley Shoals. The Argo-Rowley Terrace encompasses water depths from about 220–6000 m.

The ecological and conservation values include (Director of National Parks, 2013):

- support for relatively large populations of sharks (compared with other areas in the region)
- migratory pathway BIA for the pygmy blue whale
- a range of seafloor features such as canyons, continental rise and the terrace, among others

The above list of ecological and conservation values focuses on the south-west extent of the AMP. Conservation values located beyond the south-west extent of the AMP are outside the environmental region relevant to this activity.

5.6.8 Protected Wetlands

5.6.8.1 Ramsar Wetlands of International Importance

The Project Area does not intersect with any wetlands of international importance.

The closest RAMSAR site is Eighty Mile Beach (Site number 480) located about 240 km east of the Project Area and outside the EMBA. Eighty Mile Beach provides continuous intertidal mudflat in excellent condition which supports feeding and stop-over for migratory shorebirds. It also supports the Flatback turtle, which is an IUCN listed species.

5.6.8.2 Nationally Important Wetlands

The Project Area does not intersect with any wetlands of national importance. However, the EMBA overlaps the following Nationally Important Wetlands:

- Exmouth Gulf East
- Hamelin Pool
- Learmonth Saline Coastal Flats
- Shark Bay East.

Exmouth Gulf East is classified as a marine and coastal zone wetland, and occurs within the eastern part of Exmouth Gulf, from Giralia Bay to Urala Creek Locker Point. The wetland has been identified as an outstanding example of tidal wetland systems of low coast of north-west Australia, with well-developed tidal creeks, extensive mangrove swamps and broad saline coastal flats. The site is one of the major population centres for dugongs in Western Australia, and its seagrass beds and extensive mangroves provide nursery and feeding areas for marine fishes and crustaceans in the Gulf (DOEE 2019).

Hamelin Pool is classified as a marine and coastal zone wetland and occurs in the far south-east part of Shark Bay. The wetland has been identified as an outstanding example of a hypersaline marine embayment. Hamelin Pool supports extensive microbialite (subtidal stromatolite or 'layered' and intertidal thrombolite or 'clotted') formations, which are the most abundant and diverse examples of growing marine microbialites in the world. There is no emergent vegetation below the usual high-water mark, though the surrounding land supports tall shrubland.

Very little is known about the Learmonth Saline Coastal Flats site, except that it represents typical saline coastal flats subject to inundation and ponding. This vegetation type typically has low species richness, but its floristic composition and structure is highly distinctive and supports habitat specific fauna.

Shark Bay East is classified as a marine and coastal zone wetland, and occurs on the east arm of Shark Bay, from the mouth of the Gascoyne River south to Hamelin Pool. The wetland is considered to be an outstanding example of a very large, shallow marine embayment, with particularly extensive occurrence of seagrass beds and substantial areas of intertidal mud/sand-flats and mangrove swamp. The site supports what is probably the world's largest discrete population of *Dugong dugon*; it is also a major nursery and/or feeding area for turtles, rays, sharks, other fishes, prawns and other marine fauna; and is a major migration stop-over area for shorebirds. Plant structural formations: Mangrove in low closed-forest, closed-scrub and open-scrub form in periform arrangement on the Carnarvon to Bush Bay coast, at Faure Island and at Guichenault Point; low shrubland (samphire) occurs behind mangroves and in areas not occupied by mangroves, especially in the north-east of the site (DOEE 2019).

5.6.9 Cultural Heritage

5.6.9.1 World Heritage Properties

No World Heritage Properties occur within the Project Area. Ningaloo Coast and Shark Bay World Heritage Area occurs in the EMBA and is described in Section 5.6.2 and 5.6.3.

5.6.9.2 National Heritage Places

No National Heritage Places occur within the Project Area. The Dampier Archipelago, Ningaloo Coast, Shark Bay and Dirk Hartog/Cape Inscription National Heritage Areas occur in the EMBA and is described in Sections 5.6.1, 5.6.2 and 5.6.3 respectively.

5.7 Socio-Economic Values

Socio-economic values in the NWMR include:

- Commercial Fisheries (Commonwealth and State)
- Recreation and Tourism
- Shipping
- Oil and Gas exploration and operation
- Defence.

Potential socio-economic receptors occurring the Project Area and EMBA are detailed in the following sections.

5.7.1 Commonwealth Managed Fisheries

The Australian Fisheries Management Authority (AFMA) manages the Commonwealth-managed commercial fisheries under the Fisheries Management Act 1991. Fisheries typically operate within 3 nm to 200 nm offshore (i.e. to the extent of the Australian Fishing Zone). Commonwealth fisheries generated an estimated gross value of production (GVP) of $403 million in 2016–17, accounting for 23% of wild-catch fisheries GVP in Australia ($1.75 billion) (Patterson et al., 2018).

There are five Commonwealth-managed commercial fisheries that have management areas within the Project Area. No additional Commonwealth fisheries overlap the EMBA. However, one of these fisheries is currently not active (Western Skipjack) and three have actual fishing efforts that have only occurred beyond the Project Area in recent years (Southern Bluefin Tuna, Western Tuna and Billfish and Western Deepwater Trawl) (Patterson et al., 2018). The Northwest Slope Trawl Fishery is likely to be the only fishery that may have active fishing areas intersecting with the Project Area given recent fishing records.

The following commercial fisheries may overlap with the Project Area and are discussed below in further detail:

- Western Skipjack Tuna Fishery (Offshore Project Area and Trunkline Project Area)
- Southern Bluefin Tuna Fishery (Offshore Project Area and Trunkline Project Area)
- Western Deepwater Trawl Fishery (Offshore Project Area and Trunkline Project Area)
- Western Tuna and Billfish Fishery (Trunkline Project Area)
- Northwest slope trawl fishery (Trunkline Project Area).

5.7.1.1 Western Skipjack Tuna Fishery (Offshore Project Area/Trunkline Project Area/Borrow Grounds Project Area)

The Western Skipjack Tuna Fishery (WSTF) extends around the whole of Australia in waters out to 200 nm, using mainly purse seine fishing gear (98%) and some pole-and-line effort (Patterson et al., 2018). There has been no fishing effort in the WSTF since the 2008–09 fishing season (Patterson et al., 2018).

Given the lack of fishing effort across the whole fishery, activity within the Project Area is not expected.

5.7.1.2 Southern Bluefin Tuna Fishery (Offshore Project Area/Trunkline Project Area/Borrow Grounds Project Area)

The southern Bluefin Tuna Fishery (SBTF) extends around the whole of Australia in waters out to 200 nm. The fishery typically uses a mix of purse seine and pelagic longline fishing gear, although since 1992, most of the Australian catch has been taken by purse seine in the Great Australian Bight. The catch, comprising juvenile bluefin tuna, is transferred to aquaculture farming operations off the coast of Port Lincoln, South Australia (SA), where the fish are grown to a larger size to achieve higher market prices (Patterson et al., 2018). A smaller proportion of catch is taken by longline along the east coast of Australia (Patterson et al., 2018).

Although the fishery boundaries encompass the Project Area, the lack of effort outside the Great Australian Bight and the east coast of Australia, activity within the Project Area is not expected.

5.7.1.3 Western Deepwater Trawl Fishery (Offshore Project Area/Trunkline Project Area/Borrow Grounds Project Area)

The Western Deepwater Trawl Fishery (WDTF) operates in Commonwealth waters off the coast of WA with the northern boundary of the fishery adjacent to the western boundary of the North West Slope Trawl Fishery (NWSTF) (see below). Using demersal trawl methods, fishers catch more than 50 species in habitats ranging from temperate–subtropical in the south to tropical in the north (Patterson et al., 2018). Catches in the WDTF were historically dominated by six commercial finfish species or species groups: Orange roughy (*Hoplostethus atlanticus*), Oreos (*Oreosomatidae*), Boarfish (Pentacerotidae), Eteline snapper (Lutjanidae: Etelinae), Apsiline snapper (Lutjanidae: Apsilinae) and Sea bream (*Lethrinidae*). Between 2000 and 2005, deepwater bugs (*Ibacus* spp.) were the most important target species (Patterson et al., 2018). Total fishing effort has been comparatively low since 2005–06; a single vessel was active in the 2016–17 fishing season, resulting in low catches, following two years of no effort (Patterson et al., 2018).

Given the low fishing effort reported for the fishery as a whole, activity within the Project Area is not expected.

5.7.1.4 Western Tuna and Billfish Fishery (Offshore Project Area/Trunkline Project Area/Borrow Grounds Project Area)

The Western Tuna and Billfish Fishery (WTBF) has a wide area of operation, extending from the tip of Cape York around Western Australia to the border of Victoria and South Australia within both the Australian Fishing Zone and further ashore within the high seas, with major landing ports for the fishery being in Fremantle and Geraldton (Patterson et al., 2018). The WTBF targets a range of species including; Bigeye tuna (*Thunnus obesus*), Yellowfin tuna (*Thunnus albacares*), Swordfish (*Xiphias gladius*) and Striped marlin (*Kajikia audax*) using mainly pelagic longline fishing methods and some use of minor-line fishing methods (Patterson et al., 2018). Economic details of the fishery are not available due to confidentiality.

Although the fishery boundaries encompass the Project Area, in recent years, effort has concentrated off south-west WA and SA and therefore activity within the Project Area is not expected.

5.7.1.5 Northwest Slope Trawl Fishery (Offshore Project Area/Trunkline Project Area/Borrow Grounds Project Area)

The Northwest Slope Trawl Fishery (NWSTF) operates off north-western Australia in deep water from the coast of the Prince Regent National Park to Exmouth, roughly between the 200 m depth contour to the outer limit of the Australian Fishing Zone (AFZ). The default fishing season is 12 months, commencing on 1 July each year. Fishers use demersal trawl methods; with major landing ports in Darwin and Point Samson. The NWSTF is managed by limited entry and operators must hold permits to fish. Active vessels are typically one to two each year (Patterson et al., 2018). Recent economic data for this fishery is not available (Patterson et al., 2018).

The NWSTF has predominantly been a scampi fishery in recent years, with the key species being Australian scampi (*Metanephrops australiensis*), with smaller quantities of Velvet scampi (*Metanephrops velutinus)* and Boshma's scampi (*Metanephrops boschmai*). Deepwater prawns, including the Red prawn (*Aristaeomorpha foliacea*), were previously targeted in this fishery. Between 2015 and 2016, total catch of scampi species was 33 tonnes (Patterson et al., 2018).

During 2016–2017, active fishing occurred in two sub-areas of the NWSTF management area; the Trunkline Project Area may intersect with the most southern of these areas (Figure 5-46). In the same period, two fishing vessels were active over 114 days (Patterson et al., 2018).

Given the Trunkline Project Area overlaps with an area of known activity, fishing vessels may occur in the Trunkline Project Area. Fishing effort for the NWSTF does not extend into the Borrow Ground Project Area or the Offshore Project Area.

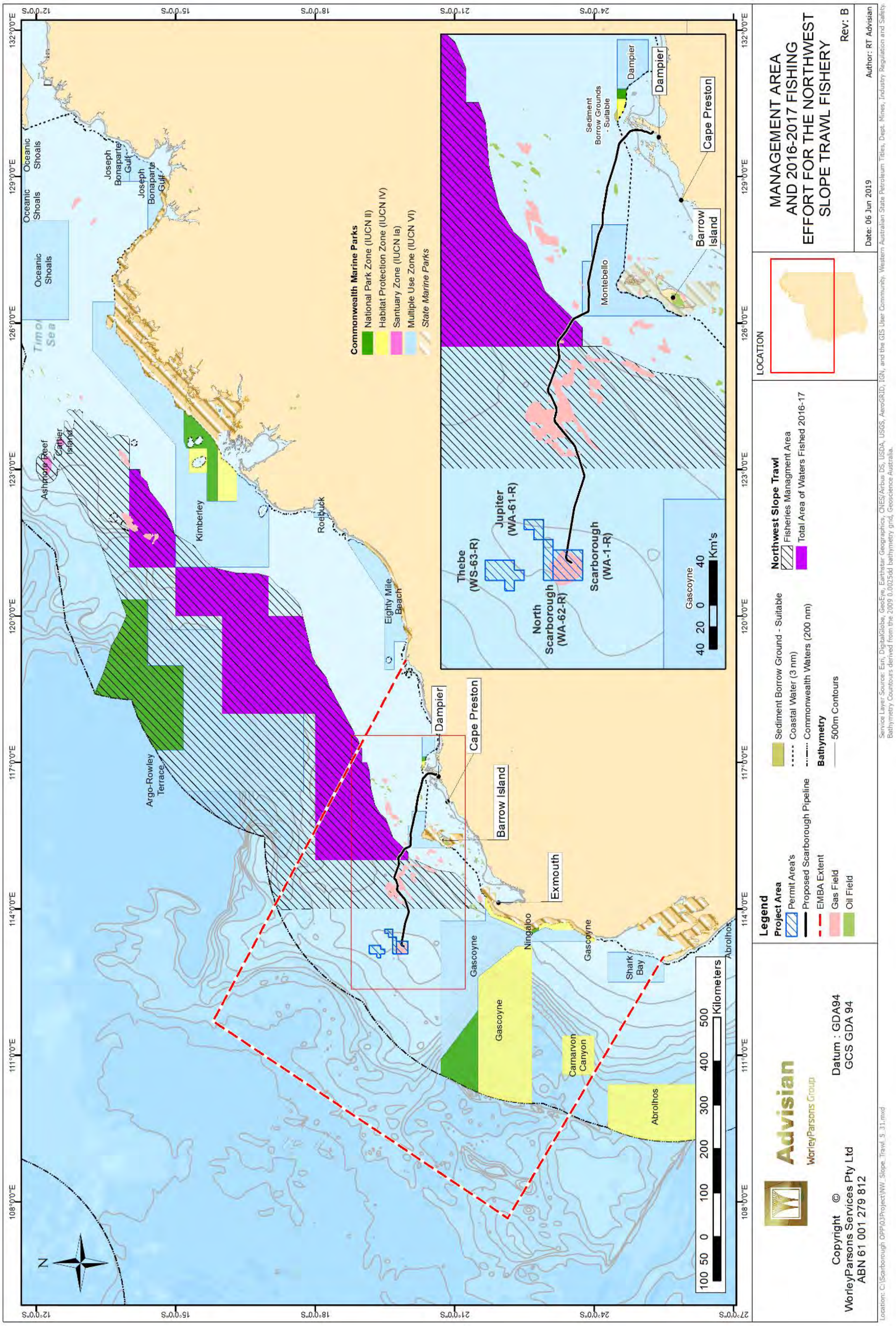


Figure 5-46: Management area and 2016–2017 fishing effort for the Northwest Slope Trawl Fishery

5.7.2 State Managed Fisheries

The WA Department of Primary Industries and Regional and Development (DPIRD) manages the State commercial fisheries under the *Fish Resources Management Act 1994*, Fisheries Resources Management Regulations 1995, relevant gazetted notices and licence conditions and applicable Fishery Management Plans.

The principal State commercial fisheries focus on tropical finfish, particularly the high-value emperors, snappers and cods that are taken by the Pilbara Trap and Trawl Fishery and the Northern Demersal Scalefish Fishery (Gaughan & Santoro, 2018). Other fisheries present within the NWMR also target mollusc, crustacean and echinoderm species. The Project Area lies within the following two defined bioregions:

- Gascoyne Coast
- North Coast.

The Gascoyne Coast bioregion is dominated mainly by invertebrate stock resources, with three fisheries (Shark Bay Prawn, Exmouth Gulf and Shark Bay Scallop fisheries) making an average annual combined value of $40–$50 million. Of the approximately 1400 known species within the bioregion, only a small portion of species are targeted including; scallops, penaeid prawns, blue swimmer crabs and deep-sea crabs. The North Coast bioregion has 15 operating fisheries within its waters targeting a range of organisms including crustaceans, finfish, echinoderms and molluscs.

Of the 15 fisheries that operate within these bioregions in the North Coast bioregion, seven state managed fisheries have the potential to undertake fishing activities within the Project Area. These fisheries include the:

- West Coast Deep Sea Crustacean Managed Fishery (Offshore Project Area and Trunkline Project Area)
- South West Coast Salmon Fishery (Offshore Project Area and Trunkline Project Area)
- Mackerel Managed Fishery (Offshore Project Area and Trunkline Project Area)
- Pilbara Demersal Scalefish Fisheries (Trunkline Project Area)
- Pearl Oyster Managed Fishery (Trunkline Project Area)
- Onslow Prawn Fishery (North Coast Prawn Managed Fisheries) (Trunkline Project Area)
- West Coast Roe’s Abalone Resource (Trunkline Project Area)
- Marine Aquarium Managed Fishery (Trunkline Project Area)
- Specimen Shell Fishery (Trunkline Project Area).

Additional state-managed fisheries which overlap the EMBA include:

- Exmouth Gulf Prawn Managed Fishery
- Nickol Bay Prawn Fishery (North Coast Prawn Managed Fisheries)
- West Coast Rock Lobster Fishery.

5.7.2.1 West Coast Deep Sea Crustacean Managed Fishery (Offshore Project Area/Trunkline Project Area/Borrow Grounds Project Area)

The West Coast Deep Sea Crustacean Managed Fishery (WCDSC) operates along the coast of Western Australia within the Gascoyne Coast bioregion in Commonwealth waters, north of latitude 34° 24' S within water depths >150 m. Fishing is generally concentrated in deeper waters on the continental slope within water depths of 500–800 m (How and Nardi, 2014). Crystal (snow) crab (*Chaceon albus*) stocks support the bulk of this fishery with other species including Giant (king) crabs (*Pseudocarcinus gigas*) and Champagne (Spiny) crabs (*Hypothalassia acerba*) also targeted (How et al., 2015). Fishing methods used for these species are restricted to baited pots on the seafloor (Fletcher and Santoro, 2013). The total landings in 2016 was 153.3 t (Fletcher and Santoro, 2018).

The Project Area is located within the fishery boundaries (Figure 5-47). Furthermore, the Offshore Project Area and deeper waters of the Trunkline Project Area occur in water depths known to be fished (500–800 m). Therefore, fishing effort may occur within the Project Area.

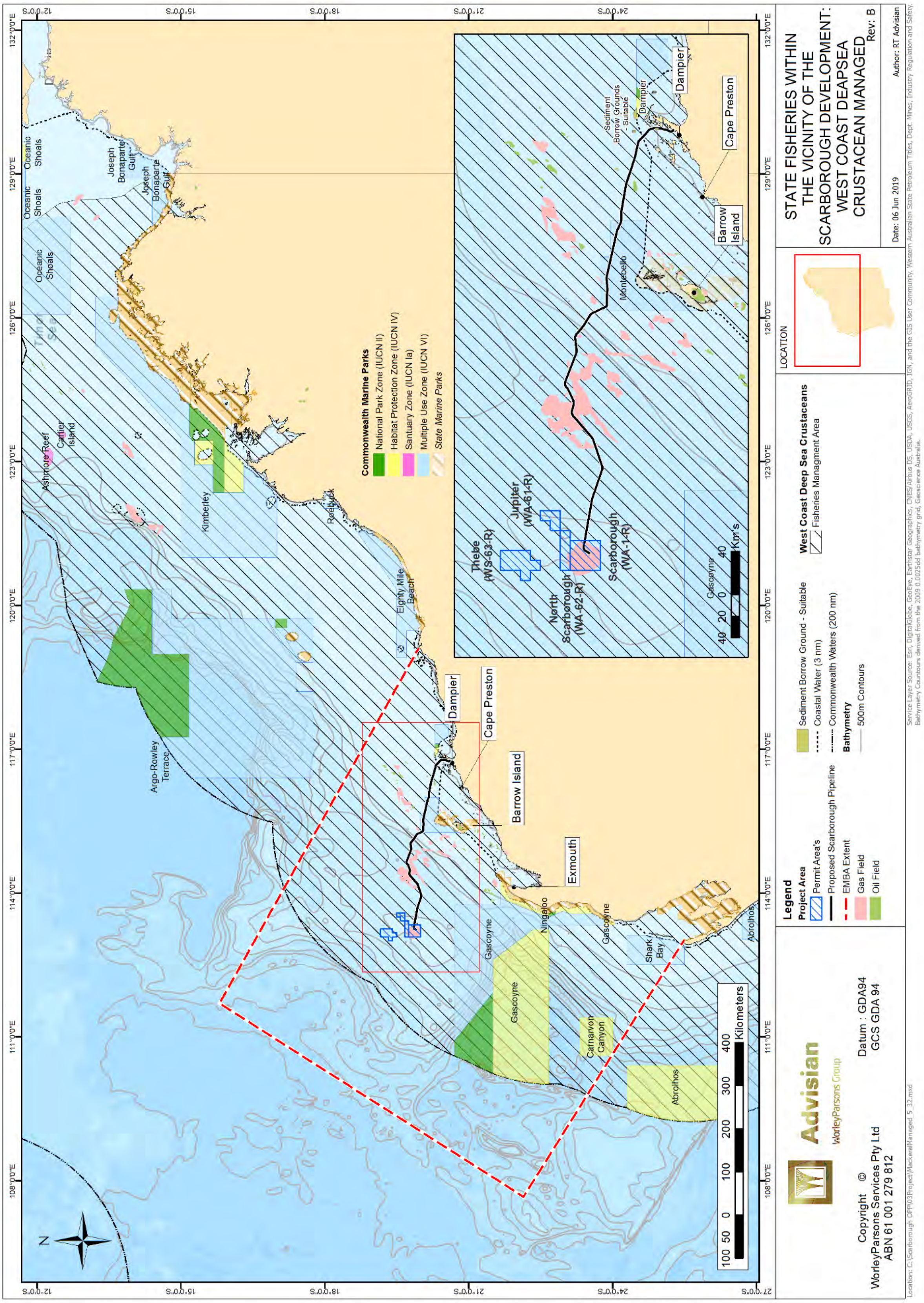


Figure 5-47: West Coast Deep Sea Crustacean Managed Fishery operating area within the vicinity of Scarborough

5.7.2.2 West Coast Salmon Fishery (Offshore Project Area/Trunkline Project Area/Borrow Grounds Project Area)

The South West Coast Salmon Managed Fishery includes all WA waters north of Cape Beaufort (WA/Northern Territory (NT) border) except Geographe Bay. This fishery uses beach seine nets to take salmon (*Arripis truttaceus*). No fishing takes place north of the Perth metropolitan area (Fletcher and Santoro, 2018), and therefore, fishing activities in the Project Area are not expected.

5.7.2.3 Mackerel Managed Fishery (Offshore Project Area/Trunkline Project Area/Borrow Grounds Project Area)

The Mackerel Managed Fishery (MMF) covers much of the WA coast within both Commonwealth and State waters between the Northern Territory border to the north of Augusta with most fishing efforts focused north of Geraldton in Pilbara and Kimberley waters (Fletcher and Santoro, 2018). The MMF mainly relies on near-surface trolling and jig fishing around coastal reefs, shoals and headlands targeting mackerel species including Spanish mackerel (*Scomberomorus commerson*), Grey mackerel (*Scomberomorus semifasciatus*) and other species from the genera Scomberomorus, Grammatorcynus and Acanthocybium (Fletcher and Santoro, 2018).

The Project Area is located within the fishery boundaries (Figure 5-48). Considering the habitats and features that the fishery targets (reefs, shoals and headlands) are absent from the Offshore Project Area, activity is not expected in this part of the Project Area. Fishing effort is likely to be higher in the Trunkline Project Area and borrow Grounds Project Area, particularly in areas close to shorelines and reefs. However, considering the area of overlap in context of the total area available for fishing, interactions with fishing vessels in the Trunkline Project Area are expected to be infrequent.

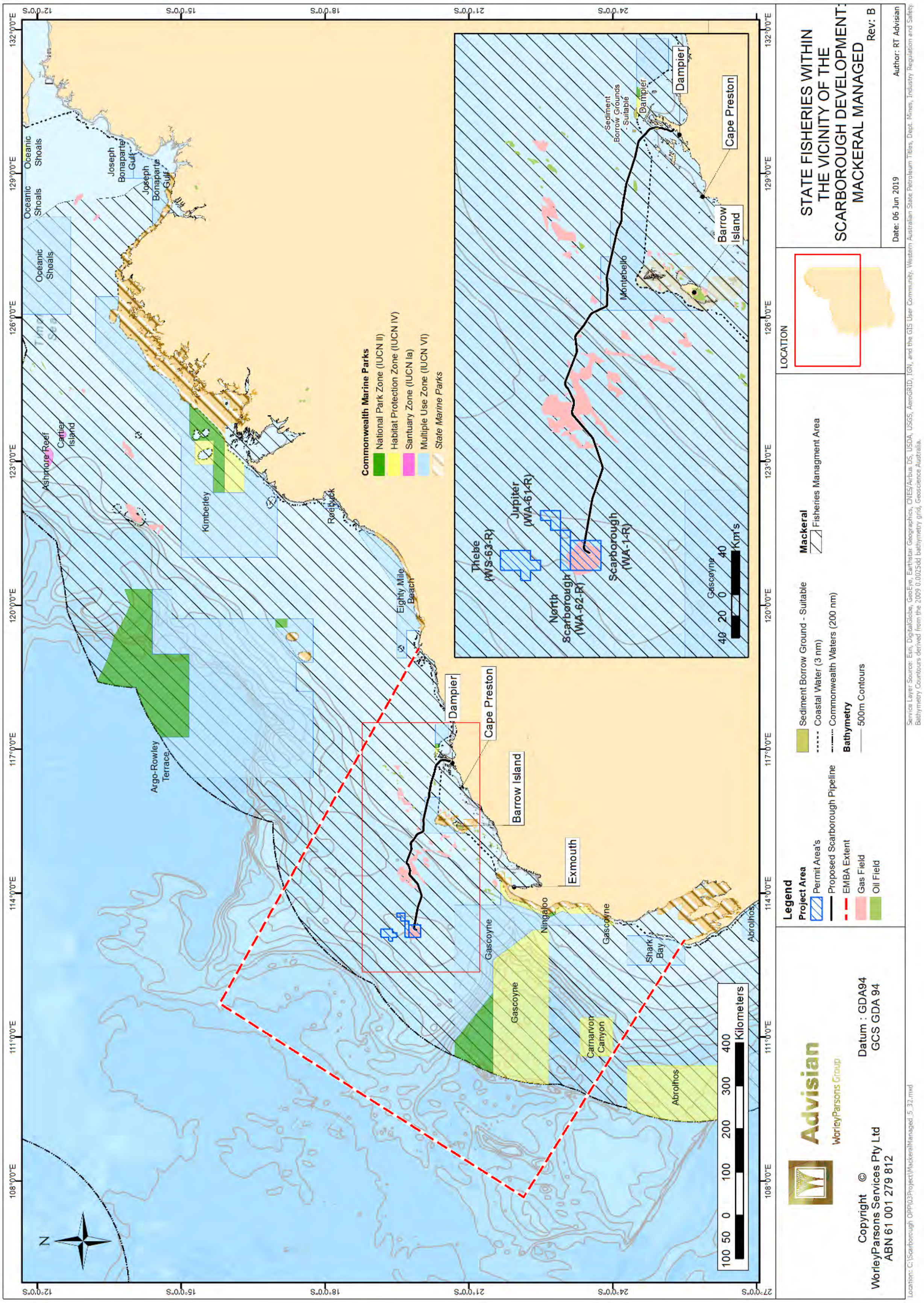


Figure 5-48: Mackerel Managed Fishery operating area within the vicinity of Scarborough

5.7.2.4 Pilbara Demersal Scalefish Fisheries (Trunkline Project Area and Borrow Ground Project Area)

The Pilbara Demersal Scalefish Fisheries include the Pilbara Fish Trawl (Interim) Managed Fishery, the Pilbara Trap Managed Fishery and the Pilbara Line Fishery (Newman et al., 2016). Target species include Goldband snapper (*Pristipomoides multidens*), Crimson snapper (*Lutjanus erythropterus*), Red emperor (*Lutjanus sebae*), Bluespotted emperor (*Lethrinus punctulatus*), Saddletail snapper (*Lutjanus malabaricus*), Rankin cod (*Epinephelus multinotatus*), Brownstripe snapper (*Lutjanus vitta*), Rosy threadfin bream (*Nemipterus furcosus*), Spangled emperor (*Lethrinus nebulosus*) and Moses' snapper (*Lutjanus russelli*). The trawl fishery contributes more than 50 species of scalefish, and the trap and line fisheries contribute 40-50 species, with the line fishery providing additional offshore species such as Ruby snapper (*Etelis carbunculus*) and Eightbar grouper (*Hyporthodus octofasciatus*) (Fletcher and Santoro, 2018).

In 2016, 71% (1,529 t) of the total commercial catches of demersal scalefish in the Pilbara (2,150 t) were landed by the trawl sector, with 23% (495 t) taken by the trap sector and 6% (126 t) taken by the line sector.

The Pilbara Trawl Fishery is of high intensity and is prohibited from certain areas of the fishery, according to Schedules. The Trunkline Project Area traverses Schedule 5 where trawling is permanently prohibited and is immediately south of the border of the Schedule 3 Area 1 which is currently open to trawling (Figure 5-49).

The Pilbara Trap Fishery covers the area from Exmouth northwards and eastwards to the 120° line of longitude, and offshore as far as the 200 m isobath. Like the trawl fishery, the trap fishery is also managed by using input controls in the form of individual transferable effort allocations, monitored with a satellite-based vessel monitoring system (VMS). The fishery operates primarily from Onslow and Schedule 3 of the fishery has been closed to trapping since 1998 (Newman et al., 2015b) (Figure 5-50). Traps are limited in number with the greatest effort in waters less than 50 m depth. This fishery targets high value species such as Red emperor (which spawn October to March) and Goldband snapper (which spawn January to April) (Fletcher and Santoro, 2018).

The Pilbara Line Fishery encompasses all of the 'Pilbara waters' targeting tropical demersal scalefish (Figure 5-51). The Line Fishery is managed under the Prohibition on Fishing by Line from Fishing Boats (Pilbara Waters) Order 2006 with the exemption of nine fishing vessels for any nominated five-month block period within the year (Fletcher and Santoro, 2018).

The Trunkline Project Area overlaps areas open to trap, trawl and line fishing whilst the Borrow Grounds Project Area lies predominantly within the Trap line managed fishery with a small portion entering the line managed fishery. Trap and line fishing are relatively low intensity and therefore interaction with fishing vessels in the Trunkline Project Area and Borrow Ground Project Area is expected to be low. While trawl fishing is of higher intensity, much of the area traversed by the Trunkline Project Area is closed to fishing. Of the areas open to trawling (Schedule 3, Area 1), the Trunkline Project Area traverses a limited area only [HOLD: GIS for actual area], reducing the potential for interaction with trawling vessels. Trap, trawl or line fishing may occur within the Project Area.

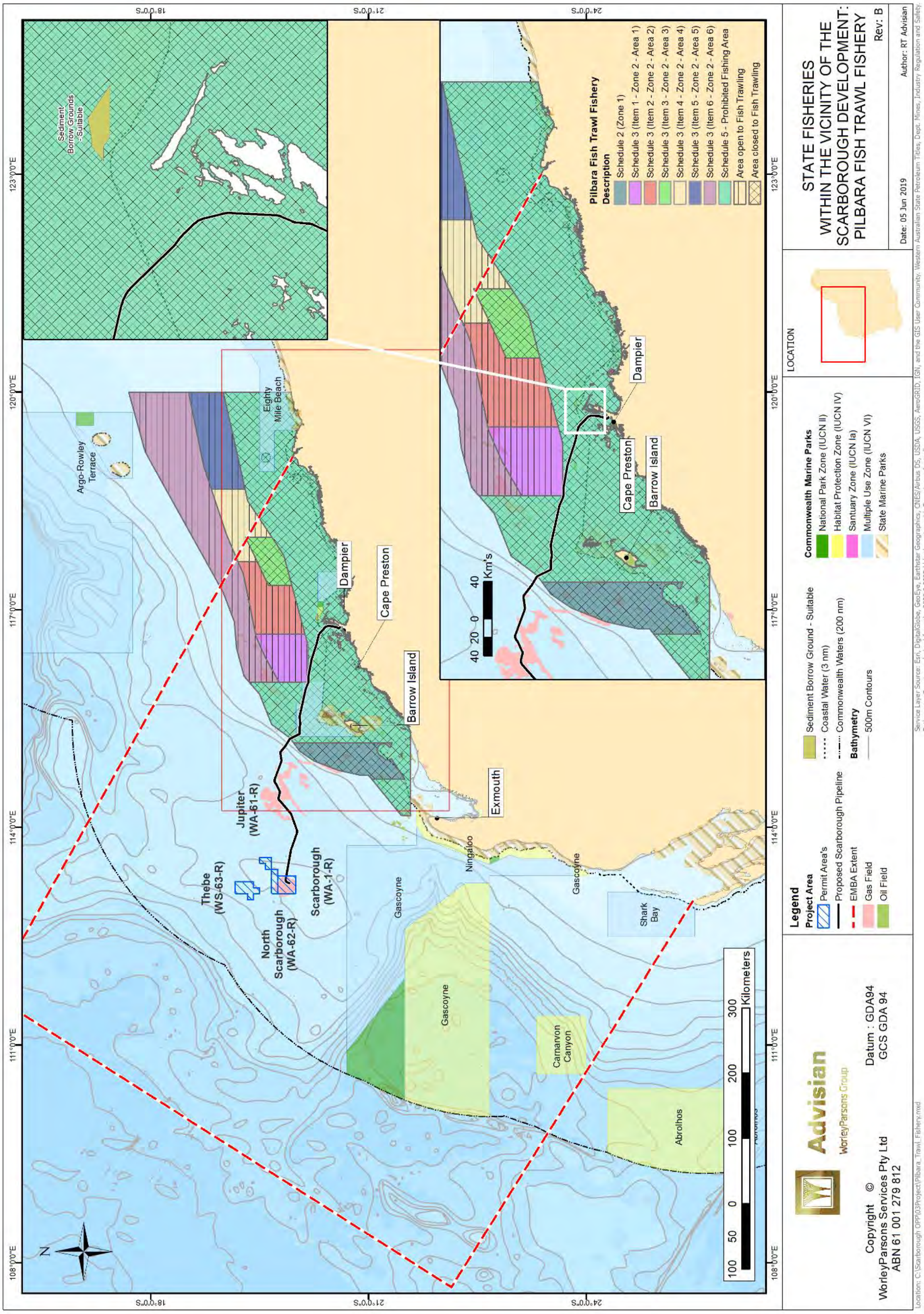


Figure 5-49: Pilbara Trawl Fishery operating within the vicinity of Scarborough

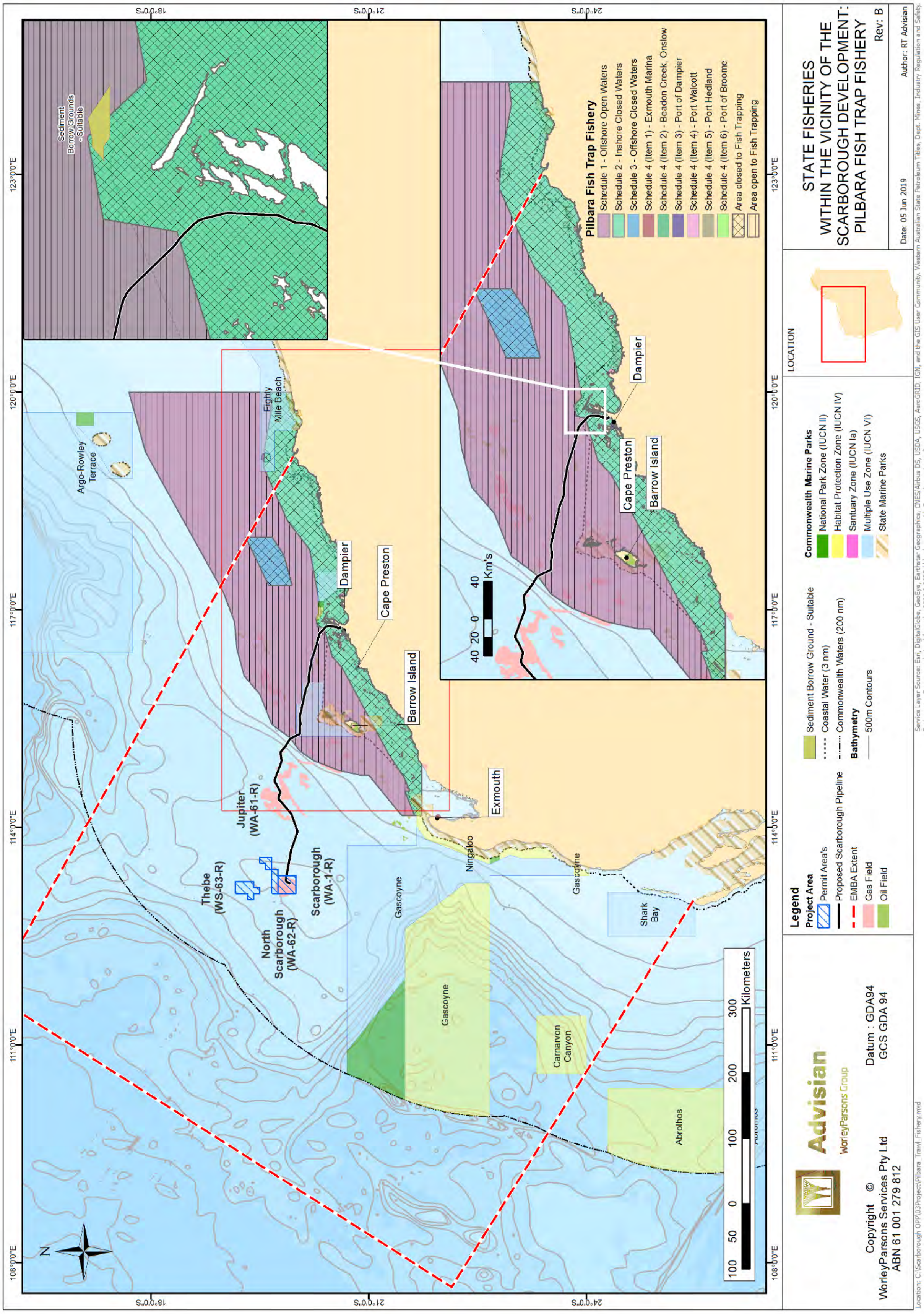


Figure 5-50: Pilbara Trap Fishery operating within the vicinity of Scarborough

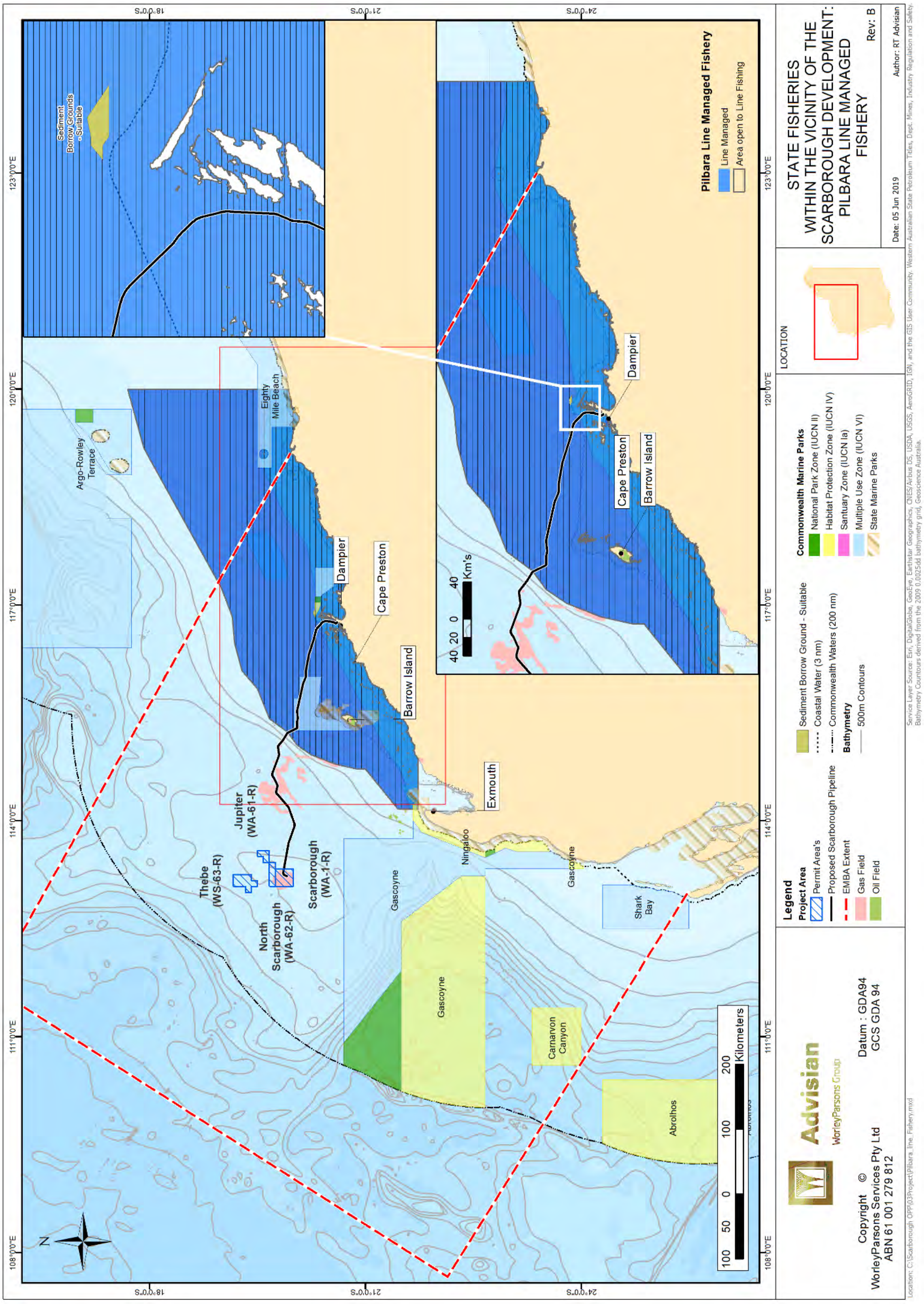


Figure 5-51: Pilbara Line Fishery operating within the vicinity of Scarborough

5.7.2.5 Pearl Oyster Managed Fishery (Trunkline Project Area and Borrow Ground Project Area)

The Pearl Oyster Managed Fishery (POMF) operates in the North Coast bioregion and is the only significant wild stock pearl fishery in the world, using drift diving methods within shallow coastal waters along the NWS (Fletcher and Santoro, 2018). This fishery is separated into four zones, of which the Zone 1 fishing area, running from the North West Cape and Exmouth Gulf to longitude 119°30´ E, lies within the Trunkline Project Area. Although fishing areas extend far offshore from state to Commonwealth waters, fishing effort is focused predominantly close to shore (Fletcher and Santoro, 2018). Other fishing zones located further north may lie within the EMBA. The POMF targets the Indo-Pacific silver-lipped pearl oyster (*Pinctada maxima*) and had an estimated value of $71 million in 2017 (Fletcher and Santoro, 2018).

Although the Trunkline Project Area and Borrow Ground Project Area overlaps the POMF boundaries (Figure 5-52), diving methods of the fishery restrict operations to shallow waters. It is possible fishing activities could occur in the shallowest regions of the Project Area, though effort here is not expected to be high.

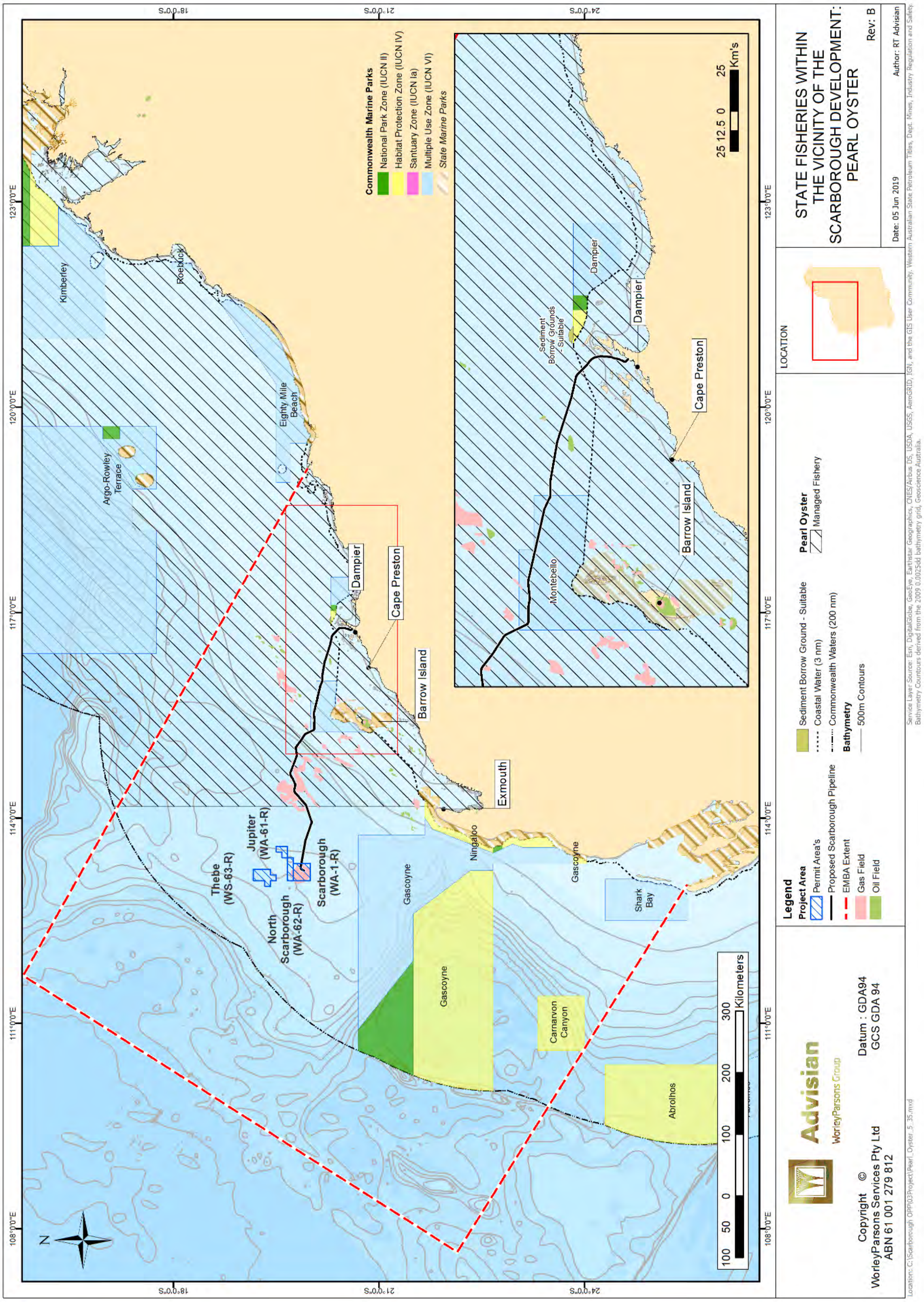


Figure 5-52: Pearl Oyster Managed Fishery operating area within the vicinity of Scarborough

5.7.2.6 North Coast Prawn Managed Fisheries (Offshore Project Area/Trunkline Project Area/Borrow Grounds Project Area)

The North Coast Prawn Managed Fisheries (NCPMF) include the Onslow, Nickol Bay, Broome and Kimberly Prawn Managed Fisheries and operate within the North Coast bioregion on the landward side of the 200 m isobath, east of 114º39.9' within both Commonwealth and State waters. Of the above four prawn fisheries in the North Coast bioregion, the Onslow Prawn Managed Fishery (OPMF) is the only fishery which is transected by the Trunkline Project Area; while the Nickol Bay Prawn Managed Fishery (NBPMF) occurs within the EMBA. The Broome and Kimberley Prawn Managed Fisheries are outside the EMBA.

These fisheries target Western king prawns (*Penaeus latisulcatus*), Endeavour prawns (*Metapenaeus* spp.), Brown tiger prawns (*Penaeus esculentus*) and Banana prawns (*Penaeus merguiensis*) using otter trawl systems (Fletcher and Santoro, 2018).

Effort and catch in the OPMF was minimal for the 2016 season, resulting in 3 t of the 60–180 t Total Allowable Catch (TAC) limit landed. Further, total landings of the NBPMF for the 2016 season were 17 t, the second lowest catch since 1966 (Fletcher and Santoro, 2018).

The Offshore Project Area does not overlap the NCPMF, therefore interactions between planned activities in the permit area and this fishery will not occur. However, the Trunkline Project Area and Borrow Ground Project Area traverses and lies within the OPMF, and fishing activity may occur in the area (Figure 5-53).

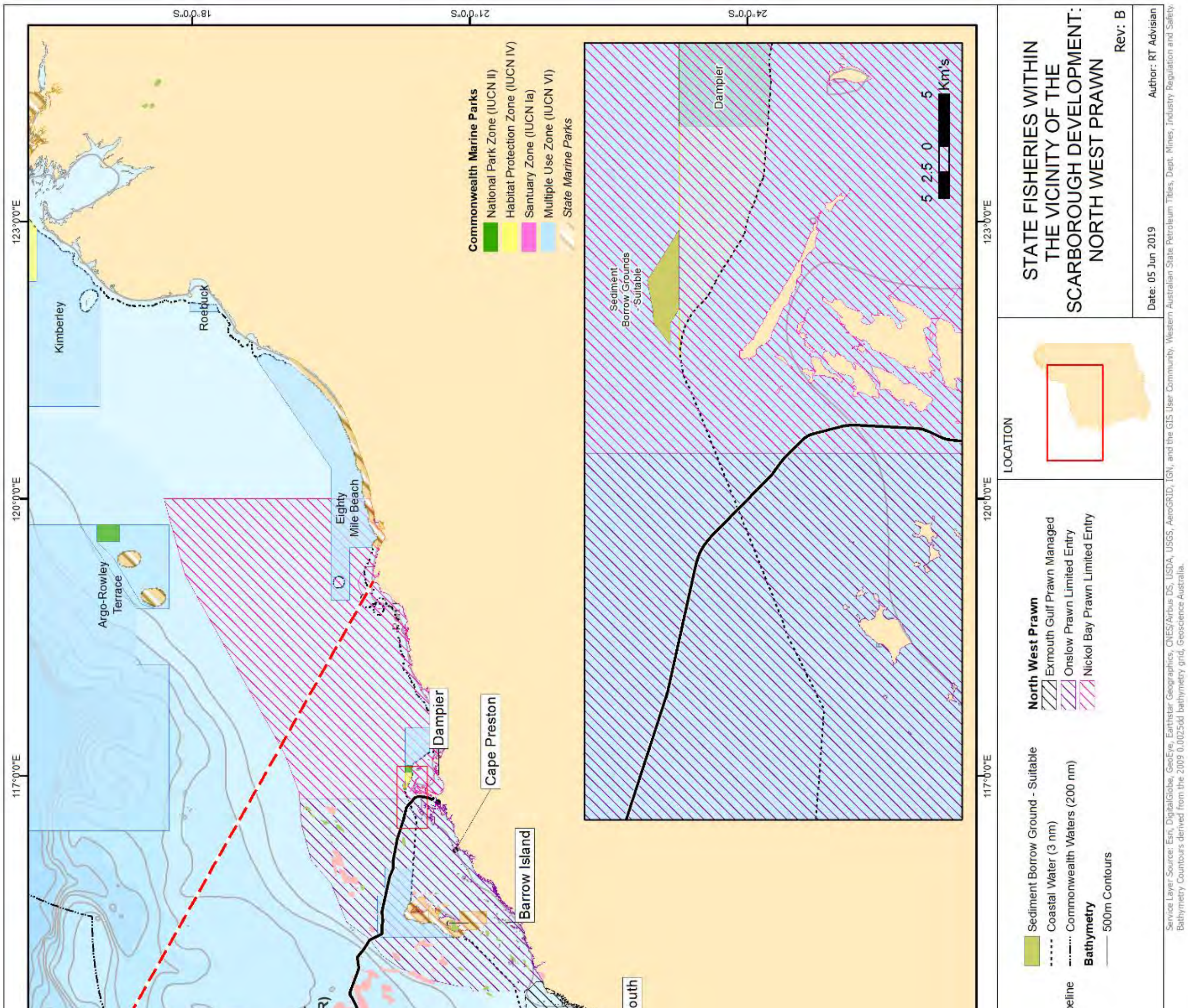


Figure 5-53: North Coast Prawn Managed Fisheries operating area within the vicinity of Scarborough

5.7.2.7 West Coast Roe's Abalone Resource (Trunkline Project Area and Borrow Grounds Project Area)

The WA Abalone Managed fishery boundaries include all waters from the SA border to the NT border. Fishing effort from the dive-based fishery is restricted to shallow coastal waters off the south-west and south coasts of WA, particularly around the Perth metropolitan area (Fletcher and Santoro, 2018). Abalone is harvested by divers, limiting the fishery to shallow waters.

Although the fishery is overlapped by the Project Area, fishing effort is concentrated around the Perth Metropolitan Area and Shark Bay is considered the northern range limit for Roe's abalone. As such, interactions this fishery are not expected in the Project Area.

5.7.2.8 Marine Aquarium Managed Fishery (Trunkline Project Area and Borrow Grounds Project Area)

The Marine Aquarium Fish Managed Fishery operates within all WA State waters. The majority of effort within the fishery occurs in waters between Esperance and Broome, particularly in waters around the Cape region, Perth, Geraldton, Exmouth and Dampier (DoF, 2017). The fishery is diver based, which typically restricts effort to safe diving depths (<30 m).

The Trunkline Project Area traverses the fishery and occurs in water depths where diving can occur. It is possible that fishing effort may occur in the shallowest part of the Trunkline Project Area near Dampier; however, water depths are at the upper limit of safe diving depths and therefore activity is expected to be infrequent.

5.7.2.9 Specimen Shell Fishery (Trunkline Project Area)

The Specimen Shell Managed Fishery (SSF) occurs in all WA State waters. The SSF targets the collection of specimen shells for display, collection, cataloguing and sale. Over 18,000 shells were reported for the fishery for the 2014–15 season (DoF, 2017). Collection is predominantly by hand when diving or wading in shallow, coastal waters though a deeper water collection aspect to the fishery has been initiated with the employment of ROVs operating at depths up to 300 m (Hart and Crowe, 2015). Although the SSF encompasses the entire WA coastline but effort is concentrated in area adjacent to the largest population centres such as: Broome, Karratha, Shark Bay, Mandurah, Exmouth, Cape region, Albany and Perth (Hart and Crowe, 2015).

Although the Trunkline Project Area traverses the fishery, activity is restricted to the shallowest portion of the Trunkline Project Area where the water depths are within safe diving limits. However, high effort in the around Dampier is not expected, and therefore, interactions with this fishery are expected to be infrequent.

5.7.2.10 Western Rock Lobster Fishery (EMBA)

The West Coast Rock Lobster Fishery targets the Western rock lobster (*Panulirus cygnus*) from Shark Bay south to Cape Leeuwin using baited traps (pots) (Fletcher and Santoro, 2018). Although the fishery boundaries fall within the EMBA, the reported northern most limit of the fishery is outside the EMBA and therefore interactions of this fishery with either planned or unplanned events are not expected.

5.7.2.11 Exmouth Gulf Prawn Managed Fishery (EMBA)

The Exmouth Gulf Prawn Managed Fishery (EGPMF) targets Western king prawns (*Penaeus latisulcatus*), Brown tiger prawns (*Penaeus esculentus*), Endeavour prawns (*Metapenaeus endeavouri*) and Banana prawns (*Penaeus merguiensis*) with low opening, otter prawn trawl systems within sheltered waters of Exmouth Gulf (Fletcher and Santoro, 2018). Fishing effort has been in decline since the 1970s but was higher in 2016 compared to the previous four years (Fletcher and Santoro, 2018).

The fishery is not overlapped by the EMBA and therefore interactions with planned activities will not occur.

5.7.3 Aquaculture

As above for state managed fisheries, aquaculture development in the north west is split into two regions; the Gascoyne Coast bioregion and the North Coast bioregion. Aquaculture development in the North Coast region is dominated by the production of pearls. A large number of pearl oysters for seeding are obtained from wild stocks and supplemented by hatchery-produced oysters, with major hatcheries operating at Broome and around the Dampier Peninsula (Gaughan & Santoro, 2018). Aquaculture pearling in the Gascoyne Coast bioregion focuses on predominantly the Blacklip oyster (*Pinctada margaritifera*) and Akoya pearl oyster (*Pinctada imbricate*) which complements the pearling industry which has historically focused on the silver lip pearl (Fletcher and Santoro, 2018).

Other aquaculture developments in the North Coast bioregion include emerging producers of coral and live rock species for aquariums in the Gascoyne Coast bioregion as well as barramundi (*Lates calcarifer*) farms and microalgae culturing for omega-3, biofuels and protein biomass in the North Coast bioregion (Fletcher and Santoro, 2018).

The Project Area does not intersect with any known aquaculture areas (Figure 5-54). The closest is the West Lewis Island (Dampier Archipelago) licence, about 27 km from the Trunkline Project Area.

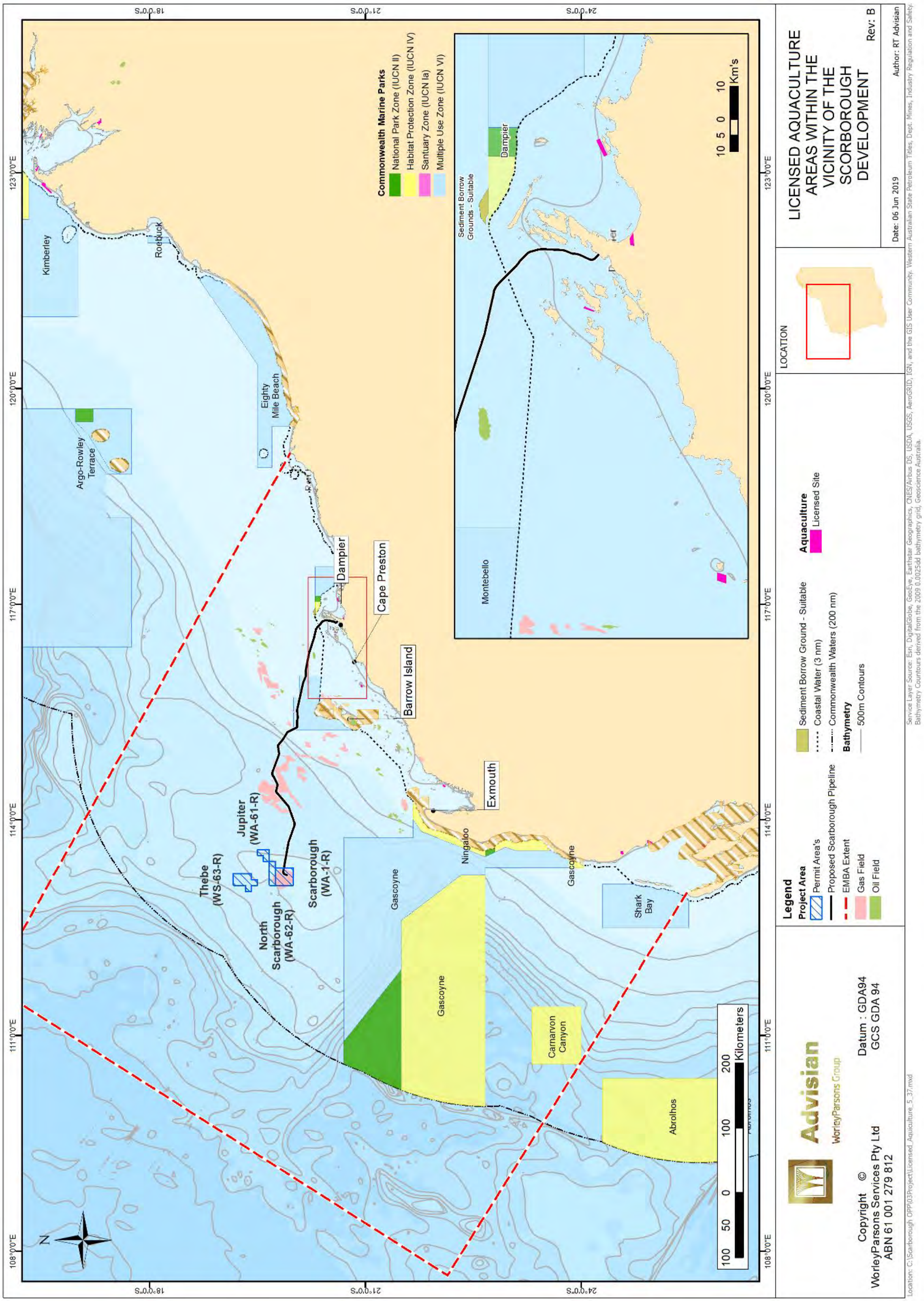


Figure 5-54: Licensed aquaculture areas within the vicinity of Scarborough

5.7.4 Recreation and Tourism

Recreation and tourism activities within the NWMR are of high social value. Recreational and tourism activities include; charter fishing, other recreational fishing, diving, snorkelling, whale, Whale shark, marine turtle and dolphin watching, cruise ship stop overs and yachting.

On a broad scale, recreational fishing within the NWMR tends to be concentrated in State waters adjacent to population centres, with highest records typically in areas such as Point Samson (about 340 km from the Offshore Project Area and 180 km from the Trunkline Project Area), Coral Bay (about 280 km from the Offshore Project Area and 260 km from the Trunkline Project Area) Exmouth (about 255 km from the Offshore Project Area and 225 km from the Trunkline Project Area) and Carnarvon (about 420 km from the Offshore Project Area and 400 km from the Trunkline Project Area) with the addition of charter fishing boats are known to fish further ashore within Commonwealth waters (DEWHA, 2008a). Recreational fishing is known to occur around the Dampier Archipelago with boats launched from boat ramps around Dampier and Karratha (Williamson et al., 2006). Once at sea, charter vessels may also frequent the waters surrounding the Montebello Islands.

Primary dive locations include the State-managed Ningaloo Marine Park (about 400 km from the Offshore Project Area and 120 km from the Trunkline Project Area), the Montebello State Marine Park (25 km from the Trunkline Project Area), the Rowley Shoals, including the Commonwealth marine reserve at Mermaid Reef (about 520 km from the Offshore Project Area and 360 km from the Trunkline Project Area), Scott Reef (approximately 1000 km from the Offshore Project Area and Trunkline Project Area), Seringapatam Reef (about 1000 km from the Offshore Project Area and Trunkline Project Area), Ashmore Reef Australian Marine Park and Cartier Island (about 1500 km from the Offshore Project Area and Trunkline Project Area). The Muiron Islands (about 160 km from the Offshore Project Area and 120 km from the Trunkline Project Area), which are in State waters, are the destination for most of the dive charters operating out of Exmouth.

Whale shark, dolphin and turtle watching tours in the NWMR generally do not extend far ashore. Fauna observation tours often occur around island and reef systems such as Ningaloo Reef (about 160 km from the Offshore Project Area and 120 km from the Trunkline Project Area) and the Dampier Archipelago (about 300 km from the Offshore Project Area and 160 km from the Trunkline Project Area). A range of companies operate in the area specialising in a range of tours that may vary depending on the time of year and/or weather conditions.

Cruise ships that operate in the area, frequently include visits to Exmouth as their primary stop within the NWMR, bringing an added value of $0.7 million to the area (Tourism WA, 2017). Cruise ships are expected to operate within standard shipping lanes and more within State waters and are therefore not discussed further.

Potential presence of these activities within the Scarborough Project Area are outlined below.

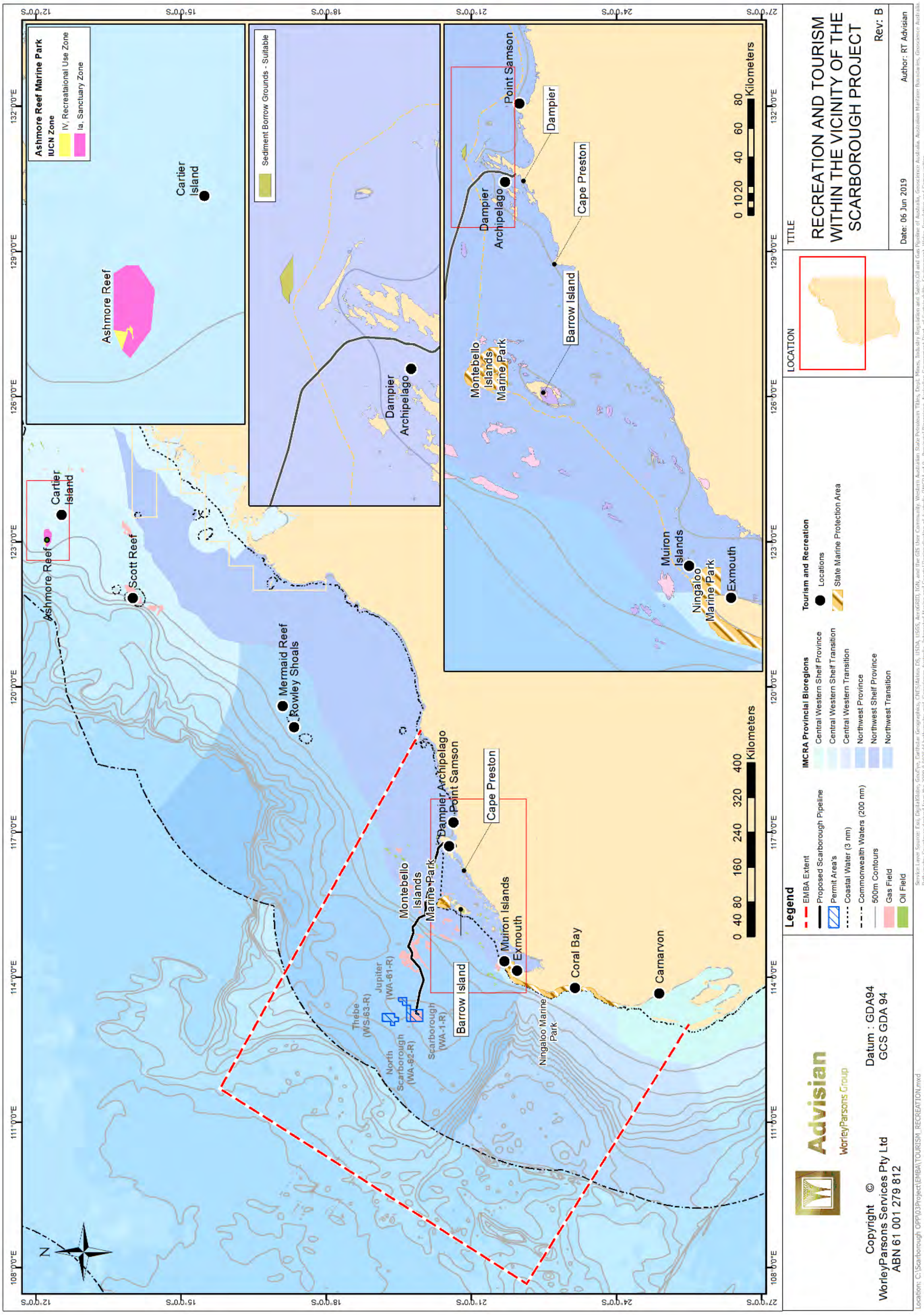


Figure 5-55: Known locations of recreation and tourism activities

5.7.4.1 EMBA

A number of more popular tourism locations occur within the EMBA, including:

- Ningaloo Reef
- Muiron Islands
- Montebello and Barrow islands
- Dampier Archipelago.

Activities within these areas include recreational fishing (including charter fishing), snorkelling, diving and fauna watching, as described in further detail below.

5.7.4.2 Trunkline Project Area and Borrow Ground Project Area

Of the most popular recreational fishing sites outlined above, none lie within the Trunkline Project Area or Borrow Ground Project Area. Trunklines are often popular sites for recreational fishing therefore charter fishing may occur within the Trunkline Project Area within defined fishing areas; however, fish aggregation areas, where charter fishing would be expected to occur, are limited to small areas of increased habitat complexity, such as the Ancient Coastline KEF (Section 5.5.2) or Montebello AMP (see Section 5.6.1). It is possible that interaction with charter vessels could occur within the Montebello AMP; however, given the relative lack of fish aggregation areas (in comparison to other areas in the wider NWMR) and distance offshore from the shoreline and population centres, the level of interaction is considered low.

Subsea infrastructure, such as trunklines, can provide areas of hard substrate which attract a higher species richness and abundance of fish (Bond et al., 2018; Ajemian et al., 2015; Pears and Williams, 2005; Grossman et al., 1997). Anglers visiting offshore oil and gas infrastructure frequently report high catch rates (Grossman et al., 1997). Increased recreational fishing along the Pluto trunkline, which is located adjacent to the continental shelf portion of the Trunkline Project Area, may be observed.

Fauna observation tours generally occur within State waters around areas of high species aggregation. For fauna watching, cetacean species are usually the targeted for viewings. Although not as popular as tours operating out of Exmouth, whale watching tours operate out of Dampier. The Humpback whale migration BIA and Pygmy blue whale distribution BIA (Section 5.4.5, Table 5-4) are transected by the Trunkline Project Area, about 33 km from Dampier. Therefore, it is possible that whale watching tours could occur in the Trunkline Project Area; however, given the distance offshore, frequency is expected to be low.

There are no popular dive or snorkelling sites within the Trunkline Project Area or Borrow Ground Project Area, and given the distance offshore, water depths and lack of coastal habitats, snorkelling and diving is not expected.

In summary, recreational and tourism activities within the Trunkline Project Area and Borrow Ground Project Area will be more common than that experienced in the Offshore Project Area, particularly activities such as whale watching and charter fishing. However, given the water depths and distance offshore and from population centres, interaction with recreational and tourism activities are expected to be infrequent.

5.7.4.3 Offshore Project Area

Recreational and tourism activities within the Offshore Project Area are limited due to its distance offshore. Charter fishing is known to occur within waters very far ashore; however, due to the water depth and lack of hard substrate or habitats promoting fish aggregations, the Offshore Project Area is unlikely to be a consistently preferred area for charter fishing (see Section 5.4.4).

5.7.5 Shipping

Commercial shipping traffic is high within the NWMR (Figure 5-56) with vessel activities including commercial fisheries, tourism such as cruises, international shipping and oil and gas operations. There are 12 ports adjacent to the NWMR, including the major ports of Dampier, Port Hedland and Broome, which are operated by their respective port authorities. These ports handle large tonnages of iron ore and petroleum exports in addition to salt, manganese, feldspar chromite and copper (DEWHA, 2008a).

The eastern most portion of the Trunkline Project Area falls within Pilbara Port Authority waters, with Port of Dampier waters extending from Dampier though State waters out to approximately KP 36.5.

Heavy vessel traffic exists within the Pilbara Port Authority management area which recorded 10,521 vessel movements in Port of Dampier 2018/19 annual reporting period (PPA, 2019). Twenty-six designated anchorages for bulk carriers, petroleum and gas tankers, drilling rigs, offshore platforms, and pipe lay vessels are located offshore of Rosemary Island (inshore of the Trunkline Project Area).

Between 2017 and 2018, annual revenue within the Pilbara Port Authority was $511.9 million with the port of Port Hedland receiving a total of 519.5 Mt of goods and the port of Dampier receiving 177.3 Mt (PPA, 2018).

In 2012, AMSA established a network of shipping fairways off the north-west coast of Australia. The shipping fairways, while not mandatory, aim to reduce the risk of collision between transiting vessels and offshore infrastructure. The fairways are intended to direct large vessels such as bulk carriers and LNG ships trading to the major ports into pre-defined routes to keep them clear of existing and planned offshore infrastructure (AMSA, 2012).

Although the Offshore Project Area is located west of a busy shipping fairway (Figure 5-56), vessel traffic within the Offshore Project Area is relatively low. The majority of vessel movement occurs to the south-east of the Offshore Project Area within the Trunkline Project Area.

In addition to high vessel traffic within the shipping fairway, vessel traffic is high towards the east of the Trunkline Project Area where increased vessel traffic will be associated with ports servicing the resource industry at Barrow Island, Onslow and Dampier.

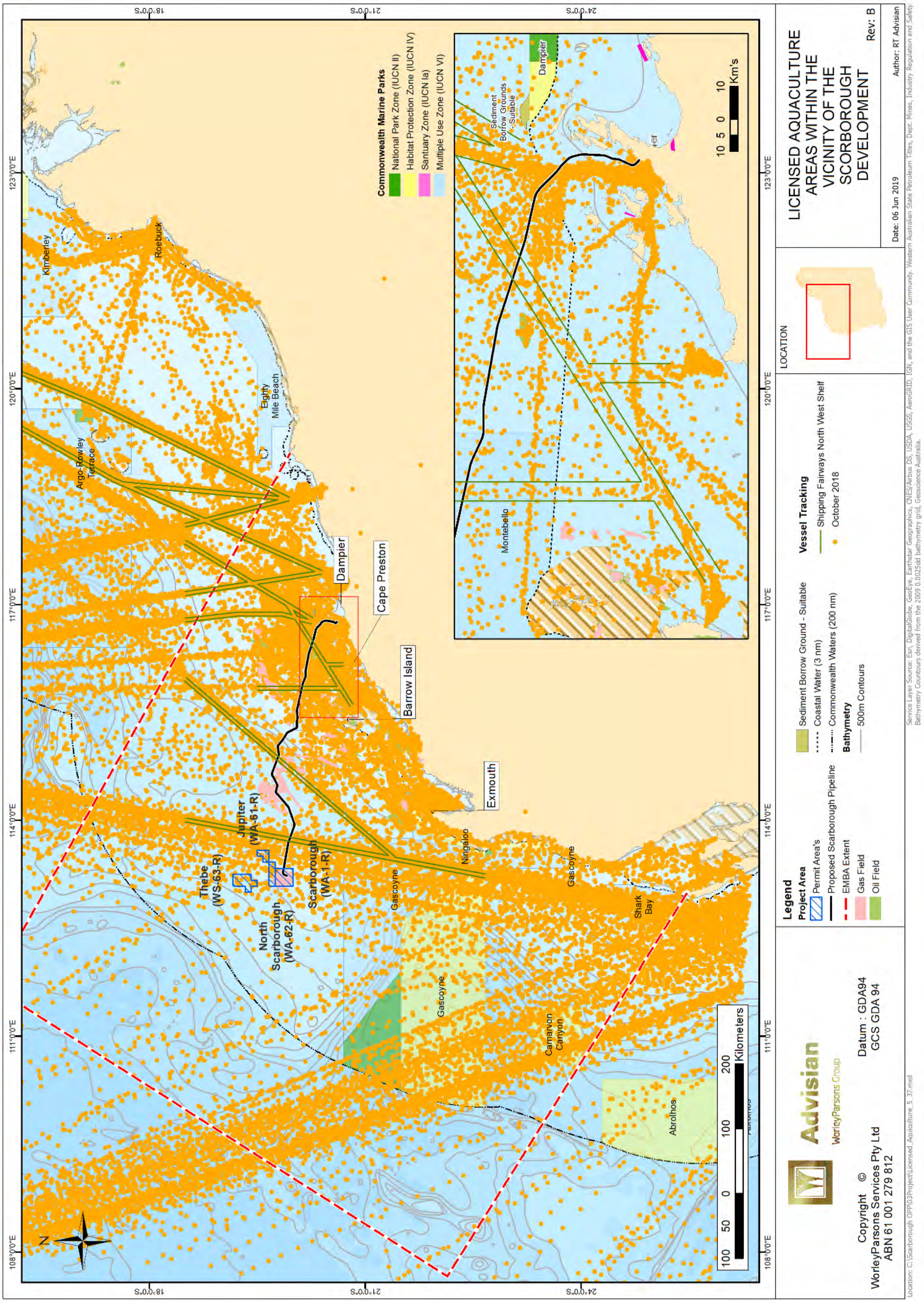


Figure 5-56: Vessel tracking information within the vicinity of Scarborough

5.7.6 Industry

The oil and gas industry is Australia's largest source of energy (gas: 24% and oil: 38%), contributing $34 billion to the Australian economy within the financial year between 2014 and 2015 (APPEA, 2017). Within the NWMR there are seven sedimentary petroleum basins: Northern and Southern Carnarvon basins, Perth, Browse, Roebuck, Offshore Canning and Bonaparte basins. Of these, the Northern Carnarvon, Browse and Bonaparte basins hold large quantities of gas and comprise most of Australia's reserves of natural gas (DEWHA, 2008a), which is reflected by the level of development in the area.

The Project Area is located in the Rankin Platform/Exmouth Plateau area of the Northern Carnarvon Basin.

Oil and gas infrastructure in proximity to the Project Area include that associated with the main producing hubs of the Pluto LNG project, the Wheatstone LNG project and the Greater Gorgon LNG project. As shown in Figure 5-57, the Trunkline Project Area is adjacent to the existing Pluto trunkline and intersects existing subsea infrastructure including:

- Julimar flowlines/pipelines (Woodside)
- Wheatstone flowlines and trunkline (Chevron)
- Reindeer offshore gas supply pipeline (Santos).

The Scarborough trunkline will traverse a number of petroleum titles held by various titleholders. The proposed route, indicating titles traversed is shown in Figure 5-52, with relevant titleholders provided in Table 5-11. As a part of the application process for a pipeline licence (under the OPPGS Act 2006), consultation with the permit holders will be undertaken by Woodside. Details of the consultation will be provided to the National Offshore Petroleum Titles Administrator (NOPTA) as part of the pipeline licence application.

Production facilities within the EMBA are provided in Table 5-12 and shown in Figure 5-57. In addition to existing facilities, there are proposed developments in the region. This includes proposals to develop gas and condensate from a number of nearby fields.

The oil and gas industry is the predominant industry that uses the offshore marine environment in the Project Area for their day-to-day operations. However, other land-based industries depend upon the marine environment in the nearshore area. These include ports (refer to Section 5.7.5), salt mines such as Karratha and Onslow, LNG onshore processing facilities such as Burrup Hub, Thevenard Island, Barrow Island, Varanus Island, and small-scale desalination plants at Barrow Island, Burrup, Cape Preston and Onslow.

Table 5-11: List of Petroleum titles and titleholders along the Scarborough Trunkline

Reference to title shown in Figure 5-57	Title Name	Titleholder
1	WA-1-R	BHP Billiton Petroleum (North Wes t Shelf) Pty. Ltd.; Woods ide Energy Ltd.
2	WA-14-L	Vermilion Oil & Gas Australia Pty Ltd.
3	WA-22-R	Chevron (TAPL) Pty Ltd; Chevron Australia Pty Ltd; Mobil Australia Resources Company Pty Limited; Shell Australia Pty Ltd.
4	WA-23-R	Chevron (TAPL) Pty Ltd; Chevron Australia Pty Ltd; Mobil Australia Resources Company Pty Limited; Shell Australia Pty Ltd.
5	WA-268-P	Chevron (TAPL) Pty Ltd; Chevron Australia Pty Ltd; Mobil Australia Resources Company Pty Limited; Shell Australia Pty Ltd.
6	WA-34-L	Kansai Electric Power Australia Pty Ltd; Tokyo Gas Pluto Pty Ltd; Woodside Burrup Pty. Ltd.

Reference to title shown in Figure 5-57	Title Name	Titleholder
7	WA-356-P	Kufpec Australia (Julimar) Pty Ltd; Woodside Energy Julimar Pty Ltd.
8	WA-36-L	Chevron (TAPL) Pty Ltd; Chevron Australia Pty Ltd; JERA Gorgon Pty Ltd; Mobil Australia Resources Company Pty Limited; Osaka Gas Gorgon Pty Ltd; Shell Australia Pty Ltd; Tokyo Gas Gorgon Pty Ltd.
9	WA-39-L	Chevron (TAPL) Pty Ltd; Chevron Australia Pty Ltd; JERA Gorgon Pty Ltd; Mobil Australia Resources Company Pty Limited; Osaka Gas Gorgon Pty Ltd; Shell Australia Pty Ltd; Tokyo Gas Gorgon Pty Ltd.
10	WA-40-L	Chevron (TAPL) Pty Ltd; Chevron Australia Pty Ltd; JERA Gorgon Pty Ltd; Mobil Australia Resources Company Pty Limited; Osaka Gas Gorgon Pty Ltd; Shell Australia Pty Ltd; Tokyo Gas Gorgon Pty Ltd.
11	WA-474-P	Western Gas (474 P) Pty Ltd.
12	WA-48-L	Chevron (TAPL) Pty Ltd; Chevron Australia Pty Ltd; Kufpec Australia (Wheatstone Iago) Pty Ltd; Kyushu Electric Wheatstone Pty Ltd; PE Wheatstone Pty Ltd.
13	WA-499-P	Santos Offshore Pty Ltd; Santos WA Northwest Pty Ltd.
14	WA-500-P	Finder No 7 Pty Limited.
15	WA-518-P	Western Gas (518 P) Pty Ltd.
16	WA-7-R	BHP Billiton Petroleum (North West Shelf) Pty. Ltd.; BP Developments Australia Pty. Ltd.; Chevron Australia Pty Ltd; CNOOC NWS Private Limited; Japan Australia LNG (MIMI) Pty Ltd; Shell Australia Pty Ltd; Woodside Energy Ltd.
17	WA-70-R	Western Gas (70 R) Pty Ltd.

Table 5-12: Oil and gas facilities in the vicinity of the Project Area

Facility name and Operator	Approximate distance from Project Area (km)
Pluto (Woodside)	5
Stag (Jadestone)	9
Wheatstone Platform (Chevron)	12. 5
Reindeer (Santos)	19
Goodwyn (Woodside)	51
North Rankin Complex (Woodside)	64
Equus Project (Western Gas) - Proposed	70

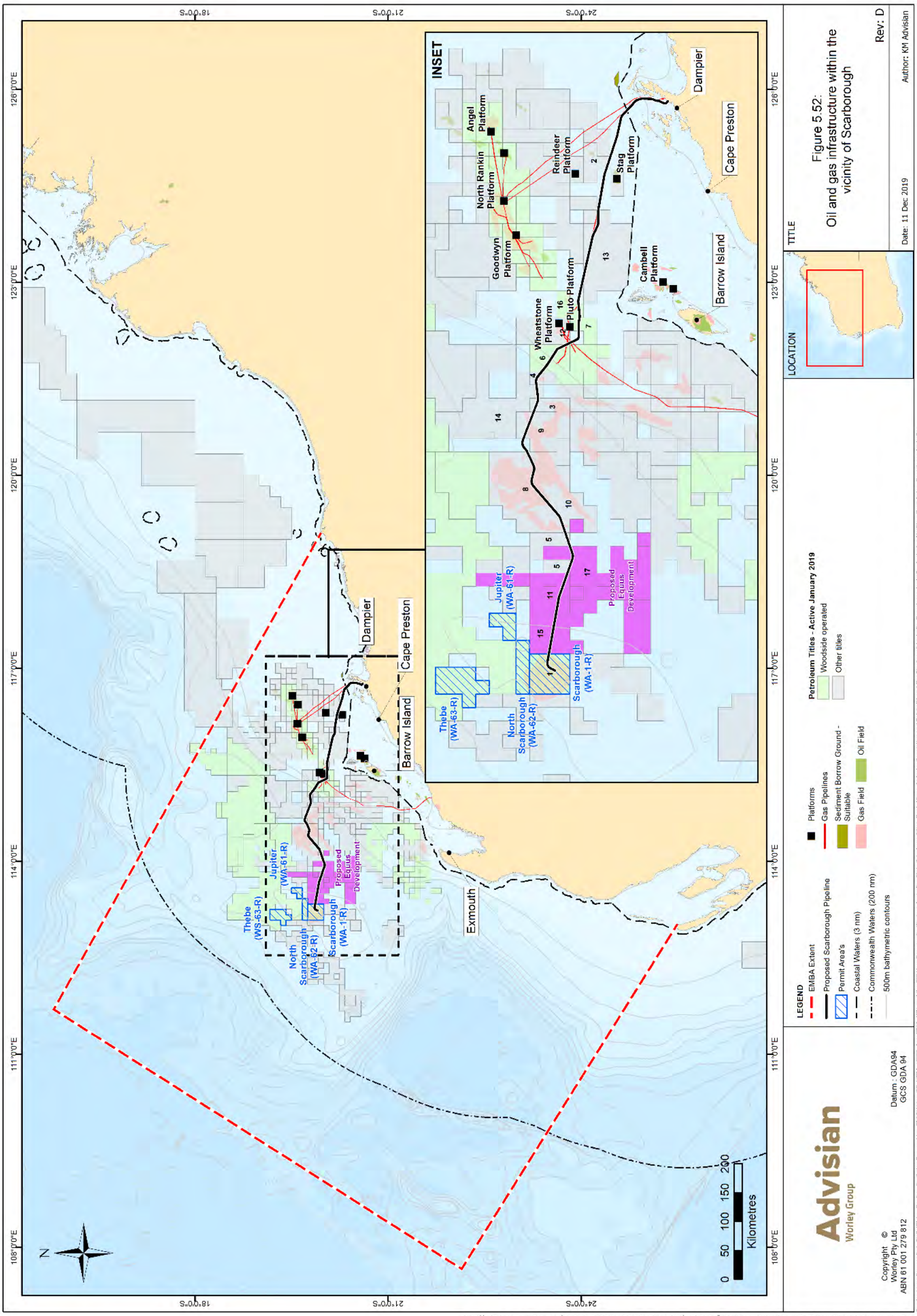


Figure 5-57: Oil and gas infrastructure within the vicinity of Scarborough

5.7.7 Defence

The Australian Defence Forces utilise areas within and adjacent to the NWMR for a range of training and operational activities. These include:

- An operating logistics base has been established in Dampier to support vessels patrolling the waters around offshore oil and gas facilities in the NWMR. A dedicated navy administrative support facility is also being constructed at the nearby township of Karratha.
- The Royal Australian Air Force currently maintains two 'bare bases' in remote areas of Western Australia which are used for military exercises. One of these is the Royal Australian Air Force Base in Learmonth. The Royal Australian Air Force maintains the Commonwealth Heritage listed Learmonth Air Weapons Range Facility, which is located between Ningaloo Station and the Cape Range National Park. The air training area associated with the Learmonth base extends over part of the Project Area (Figure 5.53).
- The Naval Communications Station Harold E. Holt is located ~6 km north of in Exmouth. The main role of the station is to communicate at very low frequencies (19.8 kHz) with Australian and United States submarines and ships in the eastern Indian Ocean and the western Pacific Ocean.

The Offshore Project Area and Trunkline Project Area both intersect Defence Training Areas (Figure 5-58).

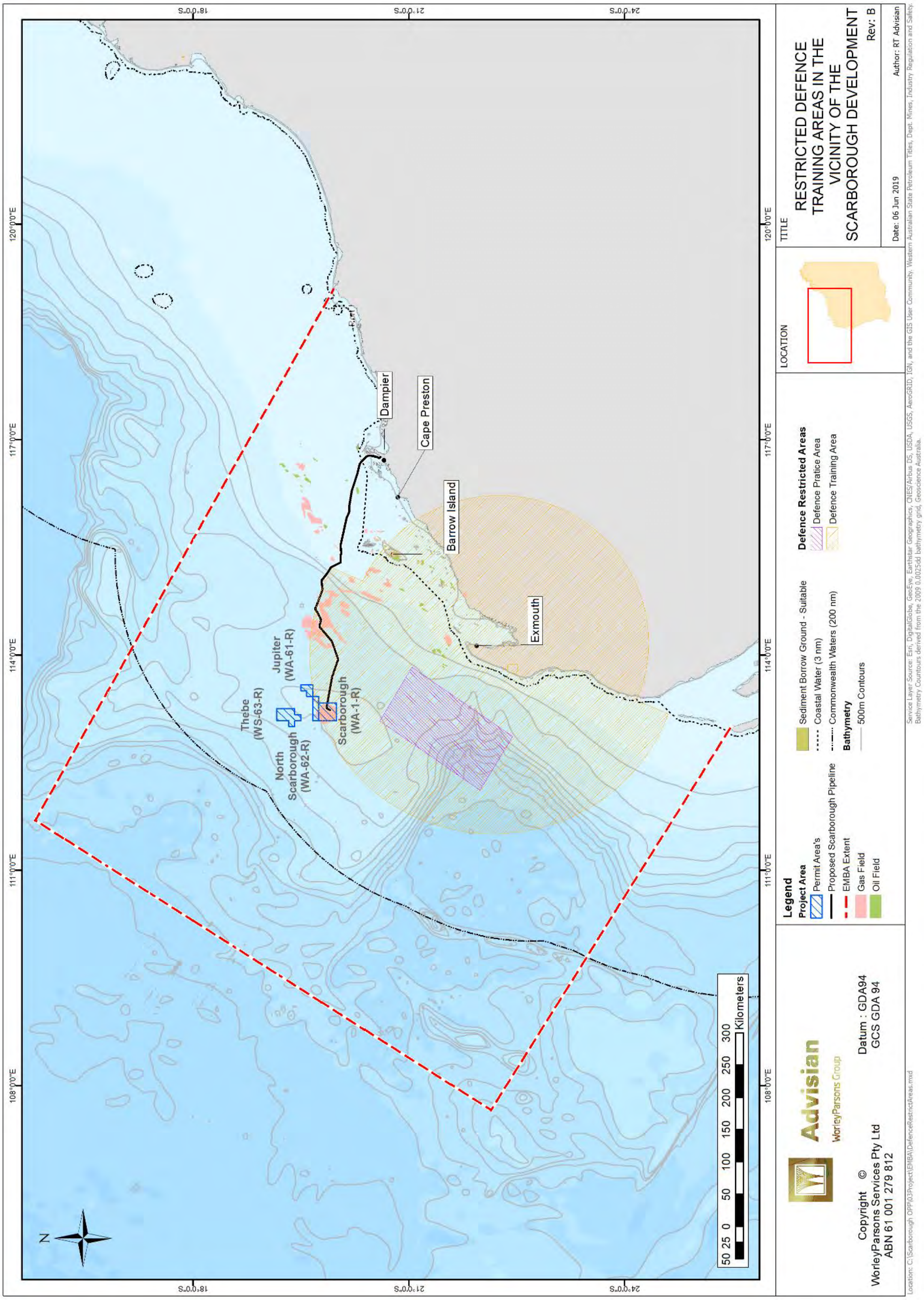


Figure 5-58: Defence training areas

5.7.8 Coastal Settlements

There are no coastal settlements in the Project Area, however the EMBA includes areas of coastline which includes coastal settlements, which are described here.

Coastal settlements in the north-west region range from small towns to larger regional centres such as Exmouth, Onslow, Karratha, Port Hedland and Broome, where the population is concentrated. Smaller towns typically service specific industries, such as mining, fishing and tourism. The population in these larger regional centres are typically transient, with a heavy influence from the mining and offshore sectors where fly-in-fly-out work is common. In the last census, Karratha was the largest centre with a population of 21,473, followed by Port Hedland is 14,469.

6 IMPACT AND RISK ASSESSMENT METHODOLOGY

Under the OPGGS (Environment) Regulations, a titleholder is required to detail and evaluate all the environmental impacts and risks associated with the proposed project, and to demonstrate that the project can be undertaken in such a way that the environmental impacts and risks will be managed to an acceptable level.

An assessment of the impacts and risks associated with Scarborough has been undertaken in accordance with Woodside's Environment Impact Assessment Guideline and Risk Assessment Procedure. This guideline and procedure set out the broad principles and high-level steps for assessing environmental impacts across the lifecycle of Woodside's activities and managing these during project execution.

The key steps of the Woodside impact and risk management process are comprised of:

- the environmental impact and risk assessment
- the communication and consultation that informs the assessment and ongoing performance, and
- the steps required during implementation of the activity including to monitor, review and report.

These steps are shown in Figure 6-1.

Figure 6-1: Woodside's risk management process

For the impact and risk assessment stage of the management process, Woodside's approach to undertaking assessments include the following steps:

1. **CONTEXT SETTING**
    a. Establishing the context based on the proposed activities
    b. Establishing the context for the environment in which the proposal is to take place
    c. Review of the significance/sensitivity of receptors and levels of protection
    d. Environmental legislation and other requirements
    e. External requirements
    f. Internal requirements
2. **IMPACT AND RISK ASSESSMENT**
    a. Impact and Risk Identification
    b. Impact and Risk analysis
    c. Impact and Risk evaluation
    d. Determining Acceptability
3. **IMPACT AND RISK TREATMENT**
    a. Identifying Controls

The Impact and Risk Assessment process as implemented for Scarborough is described in more detail in the following sections. The other key steps of the Woodside Risk Management Process including implementation (which includes the steps to monitor, review and report) and stakeholder consultation, are addressed in Section 9 and 10 respectively.

6.1 Establish the Context

Context is established by considering the proposed activities associated with a project, and the environment in which the project is planned to take place.

6.1.1 Activity Description

This is achieved by describing the key activities associated with the proposal and identifying the environmental **aspects** for each activity (i.e. the elements of the activity (planned or unplanned) that have the potential to impact on the environment). It is important that there is a sufficient level of detail provided for each activity, such that the associated aspects can be adequately quantified and assessed. Information about the activity which does not aid in the assessment of the environmental aspect may be included for context but is not necessary for the assessment.

Section 4 describes all components of the project proposal which are relevant to this assessment. This includes all phases of Scarborough, and activities that will be undertaken under the relevant Petroleum Titles. This section also details the aspects triggered by each activity (Table 4-10).

6.2 Risk Assessment of Key Environmental Impacts and Risks

In accordance with Regulation 5 of the OPGGS Regulations, the potential environmental impacts and risks associated with Scarborough have been identified and evaluated and summarised in this section. The impact and risk evaluations have been conducted as per the methodology described in Section 6. The scoping matrices in Section 6.3 identifies the aspects and impacts/risks to receptors associated with the proposed activities.

This section has been structured so:

- Sections 7.1.1 to 7.1.13 describe potential impacts from planned activities (i.e. routine and non-routine aspects)
- Sections 7.2.1 to 7.2.6 describe potential risks from unplanned activities (i.e. unplanned aspects).

Table 6-1 describes the content and purpose of this Section 7.

Table 6-1: Structure of this section

Content	Purpose
Source of the Aspect	Description of the aspect relative to Scarborough.
Impact or Risk	Description of how this aspect of Scarborough t has the potential to impact/presents a risk on the environment.
Receptors Potentially Impacted	Provides a summary of the receptors potentially impacted which were identified within the Impact or Risk Section. The Receptor/impact matrix which has been provided after the impact/risk evaluation of context contains ticks for receptors which are carried forward to detailed impact evaluation and crosses for those receptors which have not been evaluated further.
Detailed Impact Evaluation	For receptors which have a higher level of impact/risk of being impacted as a result of Scarborough a more details impact evaluation is undertaken. These are also the receptors for which a specific Environmental Performance Objectivise (EPO) have been developed.
Consequence Evaluation and review against acceptability criteria	Provides commentary to the overall consequence of the described aspect, and whether acceptability criteria have been met.
Summary of Impact Assessment	Section provides a summary of impacts, management controls, impact significance ratings and EPOs for the aspect.

6.2.1 Environment Description

This requires a description of the Project Area, and the Environment that May Be Affected (EMBA) by the aspects identified. The description includes all physical, ecological and socioeconomic receptors that may be present, with sufficient detail to inform the impact assessment. Where the impacts and risks are greatest, it is expected that there is more detail and certainty provided in the receptor description.

Section 5 describes the receiving environment. This section addresses the Project Area, which is comprised of the Offshore Project Area, the Trunkline Project Area and Borrow Ground Project Area. It also extends to the broader area that may be impacted in the event of unplanned events such as a hydrocarbon spill.

6.2.2 Review of the significance/sensitivity of receptors and levels of protection.

This step is important for establishing the context of the environment, as it identifies the more significant or sensitive receptors and proposes the level of protection. This is achieved by assessing the **receptor sensitivity** (i.e. the sensitivity/vulnerability/importance of the receptor) as either high, medium or low value, and by stating the **Environmental Performance Outcomes (EPO)** for each receptor in the Project Area and EMBA, and the criteria for determining whether impacts and risks are **acceptable**.

Table 6-3 identifies the sensitivity of each of the receptors, which was determined to be either low, medium or high based on qualitative expert judgement. Key considerations for this determination included:

- **Quality** – Is the receptor considered to be relatively high quality, or is it damaged/degraded?
- **Sensitive to change** – Is the receptor highly sensitive to environmental change and less likely to be able to adapt?
- **Importance** – Is the receptor considered to be of local, regional or international importance?

To determine overall sensitivity, each receptor has been assessed against each of these considerations, and determined to be of high, medium or low sensitivity in accordance with the following:

- **Low**: Highly degraded, low biodiversity value ecosystems or those with a high recovery capacity.
- **Medium**: Natural ecosystem, species, habitat including ecosystems with slight disturbance/ degradation or those with a moderate recovery capacity.
- **High**: Highly valued ecosystems, species, habitats or physical or biological attributes or those with a low recovery capacity

Where one consideration was shown to have a higher level of sensitivity than others, for example where a receptor is of low importance and quality in a region but has a medium sensitivity to change, the highest sensitivity rating has been selected as the overall sensitivity.

Sensitivity considerations should also take into account any relevant legal protection, government policy, stakeholder views or ecosystem service value, and be reflected in the EPOs and acceptability criteria.

6.2.3 Environmental legislation and other requirements.

As part of establishing the context, it is important to know what environment legislation or other requirements are to be considered. This may include legislation that identifies the manner in which specific activities should be undertaken (such as vessel activities), for particular impacts and risks (e.g. greenhouse gas emissions and biosecurity legislation) or management plans, guidelines, or advices that are issued to aid in the protection of significant receptors.

In preparing this OPP, Woodside has ensured the proposed controls and impact and risk levels are consistent with national and international standards, law and policies. This includes applicable plans for management and conservation advices, significant impact guidelines for MNES, and Australia's implementation of the Paris Agreement on climate change through domestic legislation.

This has included developing the project in accordance with all applicable legislation as identified in Section 3, and ensuring the requirements of the species recovery plans and conservation advices have been considered to identify any requirements that may be applicable to the risk assessment.

Recovery plans are enacted under the EPBC Act and remain in force until the species is removed from the threatened list. Conservation advice provides guidance on immediate recovery and threat abatement activities that can be undertaken to facilitate the conservation of a listed species or ecological community. Recovery plans and conservation advices relevant to those species identified as potentially utilising habitat in the Scarborough Project Area by the EPBC Protected Matters search (Appendix D) have been considered in the determination of acceptable levels.

The OPP has also considered the significant impact guidelines for MNES. The MNES potentially impacted or at risk included:

- critically endangered and endangered species
- vulnerable species

- migratory species
- Wetlands of International Importance
- Commonwealth Marine Environment.

The relevant significant impact criteria were identified for each receptor and are reflected in the Environmental Performance Outcomes (EPOs) set for each of the receptors potential impacted or at risk from activities associated with Scarborough.

Additionally, Woodside have given consideration to the Australian Government's *Environmental Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy, October 2012*. This Policy refers to 'environmental offsets' as measures that compensate for all residual adverse impacts of an action on the environment. The policy states that for assessments under the EPBC Act, offsets are only required if residual impacts are significant, with significance to be as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1.*

6.2.4 External requirements

In addition to legal or other requirements, to establish the context for a proposal there is a need to understand stakeholder expectations for the area in which the proposal is to take place. These expectations may be well understood and based on previous experience, consultation or general advice made available by stakeholders. Alternatively, they may be identified during project stakeholder consultation activities, and as such need to be tracked and considered for the impact and risk assessment.

Woodside has a long history of operating in the North West of Australia. Consequently, over the years Woodside has establish strong stakeholder relationships and an appreciation for stakeholder views with respect to oil and gas activities in the region. When establishing acceptable levels for impacts and risks, Woodside considers the expectations of potentially impacted stakeholders, and factors this into decision for the level of potential impact and risk of activities.

Woodside has undertaken preliminary consultation with identified relevant stakeholders (Section 10) incorporating outcomes into the OPP where applicable and will continue to consider the views of stakeholders who provide comment on the Scarborough OPP through the formal consultation process and other means of ongoing consultation.

Consideration of the stakeholder views received via the public review process has been incorporated into this revised Scarborough OPP submitted to NOPSEMA for their assessment following the public comment period.

6.2.5 Internal requirements

As well as legal and external, there are also internal requirements of the proponent that must be implemented when undertaking activities. These may be focussed on the manner in which particular activities are undertaken (for example VSP), for particular impacts or risks (IMS) or in order to protect certain receptors and may be captured under the proponents HSE Management System.

The Woodside Management System (WMS) (described in Section 2) defines how Woodside will deliver its business objectives and the boundaries within which all Woodside employees and contractors are expected to work. The objectives under the WMS define the mandatory performance requirements that apply to all Woodside activities, and the performance of its employees and contractors within their area of responsibilities. Where relevant, Woodside internal requirements have been identified as controls (Section 7).

6.3 Impact and Risk Assessment - Scoping

6.3.1 Impact and Risk Identification

Terminology used for this impact and risk assessment has been taken from the Woodside impact and risk management process, which is aligned with ISO 13001:2018 and the requirements of the OPGGS Regulations.

Environmental impacts and risks include those directly and indirectly associated with the proposed activities and include potential emergency and accidental events.

Planned (routine and non-routine) activities have the potential for inherent changes to the environment, termed environmental 'impacts'.

An environmental risk is an unplanned event which has the potential to result in a change to the environment, positive, negative or neutral. Risks are expressed in terms of the risk source, the event, the consequence of the risk, and the likelihood. In the instance where an environmental risk source leads to an unplanned event, the term 'risk' is used to describe the potential for impact (i.e. changes to the environment) which may affect receptor(s) (should the risk be realised). Risks include an assessment of both likelihood of the impact, and consequence of the change, which is called 'risk consequence' when discussed in terms of a risk.

All impacts and risks of the project are identified in the **scoping phase**. During this phase, the relationships between the environmental aspects identified for the proposed activities and the associated potential impacts and risks for each receptor are established. This sets up the framework for the more detailed impact and risk analysis and evaluation and helps to identify the knowledge gaps which may trigger specific studies and surveys required.

Based upon the context of the project, and known environmental aspects, all relevant risks and impacts were identified in the scoping phase. This was undertaken by considering the receptors identified (Section 5) with the potential to be exposed to or interact with an aspect, then determining the subsequent outcomes of that interaction or exposure (impacts or risks). All impacts and risks identified during the scoping phase are summarised in Table 6-2, which shows two categories of impacts or risks:

- Impacts/risks considered, but not considered credible[8] (shown in grey)
- Impacts/risks considered credible, that are carried through into the environmental risk and impact assessment in Section 7.0 for a detailed evaluation (shown in green).

Section 7.0 provides justification for impacts or risks where application of an EPO for management purposes is warranted (shown in green) and describes the detailed assessment of all identified impacts and risks.

[8] Refer to Section 7 for justification

Table 6-2: Scoping of relationships between Aspects, Associated Impacts and Risks, and Receptors

Key	✓	Detailed Impact / Risk Assessment	✓	Impact / Risk Considered

Aspect	Impact/Risk[9]	Physical		Ecological																Socioeconomic									
		Marine Sediments	Water quality	Air Quality	Climate	Ambient Light	Ambient Noise	Plankton	Epifauna and Infauna	Coral	Seagrass	Macroalgae	Saltmarsh	Mangroves	Shoreline Habitats	Seabirds and Migratory Shorebirds	Fish	Marine Mammals	Marine Reptiles	KEFs	AMPs	Protected Places	Commonwealth Managed Fisheries	State Management Fisheries	Tourism and Recreation	Shipping	Industry	Defence	Coastal Settlements
Planned																													
Routine light emissions	Change in ambient light					✓																							
	Change in fauna behaviour															✓	✓		✓										
	Changes to the functions, interests or activities of other users																						✓	✓	✓				
Routine atmospheric emissions affecting air quality	Change in air quality			✓																									
	Injury/mortality to fauna															✓													
	Climate change				✓																								
	Change in aesthetic value																								✓				✓
Routine greenhouse gas emissions	Climate change				✓																								
	Change in habitat								✓	✓	✓	✓	✓	✓	✓					✓	✓								
	Change in fauna behaviour															✓	✓	✓	✓										
	Injury/mortality to fauna							✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓								
	Change in ecosystem dynamics							✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓								
	Changes to the functions, interests or activities of other users																					✓	✓	✓	✓				
Routine acoustic emissions	Change in ambient noise						✓																					✓	
	Change in fauna behaviour								✓								✓	✓	✓				✓	✓					
	Injury/mortality to fauna							✓	✓								✓	✓	✓										
	Changes to the functions, interests or activities of other users																						✓	✓				✓	
Physical presence: Displacement of other users	Changes to the functions, interests or activities of other users																						✓	✓	✓	✓	✓	✓	
Physical presence: Seabed disturbance	Change in habitat								✓	✓							✓		✓	✓	✓								
	Change in water quality		✓																	✓	✓								
	Injury/mortality to fauna							✓	✓	✓							✓			✓									
	Changes to the functions, interests or activities of other users																						✓						

[9] Note that there is a variation in the identified impacts and risks for each aspect. The basis for the selection of the relevant impacts and risks is provided in Section 7

Aspect	Impact/Risk[9]	Physical		Ecological																Socioeconomic									
		Marine Sediments	Water quality	Air Quality	Climate	Ambient Light	Ambient Noise	Plankton	Epifauna and Infauna	Coral	Seagrass	Macroalgae	Saltmarsh	Mangroves	Shoreline Habitats	Seabirds and Migratory Shorebirds	Fish	Marine Mammals	Marine Reptiles	KEFs	AMPs	Protected Places	Commonwealth Managed Fisheries	State Management Fisheries	Tourism and Recreation	Shipping	Industry	Defence	Coastal Settlements
Routine and non-routine discharges: Sewage and greywater	Change in water quality		✓																	✓									
	Injury/mortality to marine fauna							✓									✓	✓	✓	✓									
	Change in aesthetic value																								✓				✓
	Change to the functions, interests or activities of other users																								✓				✓
Routine discharges: Food waste	Change in water quality		✓																	✓									
	Change in fauna behaviour															✓	✓												
Routine and non-routine discharges: Chemicals and deck drainage	Change in water quality		✓																	✓									
	Change in sediment quality	✓																											
	Injury/mortality to fauna							✓									✓	✓	✓										
Routine and non-routine discharges: Brine and cooling water	Change in water quality		✓																	✓									
	Injury/mortality to fauna							✓	✓								✓	✓	✓										
	Changes to functions, interests or activities of other users																						✓						
Routine and non-routine discharges: operational fluids	Change in water quality		✓																	✓									
	Change in sediment quality	✓																											
	Injury/mortality to fauna							✓	✓								✓	✓	✓										
	Change in habitat																			✓									
	Changes to the functions, interests or activities of other users																						✓	✓					
Routine and non-routine discharges: Subsea installation and commissioning	Change in water quality		✓																	✓									
	Change in sediment quality	✓																		✓									
	Injury/mortality to fauna							✓	✓								✓												
	Changes to the functions, interests or activities of other users																						✓	✓					
Routine and non-routine discharges: Drilling	Change in habitat																			✓									
	Change in water quality		✓																										
	Change in sediment quality	✓																											
	Injury/mortality to fauna							✓	✓								✓	✓	✓										
Unplanned																													
	Change in water quality		✓																										
	Change in sediment quality	✓																											

Aspect	Impact/Risk[9]	Physical						Ecological												Socioeconomic									
		Marine Sediments	Water quality	Air Quality	Climate	Ambient Light	Ambient Noise	Plankton	Epifauna and Infauna	Coral	Seagrass	Macroalgae	Saltmarsh	Mangroves	Shoreline Habitats	Seabirds and Migratory Shorebirds	Fish	Marine Mammals	Marine Reptiles	KEFs	AMPs	Protected Places	Commonwealth Managed Fisheries	State Management Fisheries	Tourism and Recreation	Shipping	Industry	Defence	Coastal Settlements
Unpanned discharges: Chemicals	Injury/mortality to fauna							✓									✓	✓	✓										
Unplanned discharges: Solid waste	Change in water quality		✓																										
	Injury/mortality to fauna															✓	✓	✓	✓										
	Change in aesthetic values																								✓				✓
Physical presence (unplanned): Seabed disturbance	Change in water quality		✓																										
	Change in habitat								✓								✓			✓									
	Injury/mortality to fauna							✓	✓								✓			✓									
Physical presence (unplanned): IMS	Change in ecosystem dynamics								✓	✓	✓	✓																	
	Changes to the functions, interests or activities of other users																						✓	✓		✓	✓	✓	
Physical presence (unplanned): Collision with marine fauna	Injury/mortality to fauna																✓	✓	✓										
Unplanned hydrocarbon release	Change in water quality		✓																										
	Change in sediment quality	✓																											
	Change in habitat									✓	✓	✓	✓	✓	✓					✓	✓	✓							
	Change in fauna behaviour															✓	✓	✓	✓		✓	✓	✓	✓	✓				
	Injury/mortality to fauna							✓								✓	✓	✓	✓		✓	✓	✓	✓	✓				
	Changes to the functions, interests or activities of other users																						✓	✓	✓	✓	✓	✓	✓
	Change in aesthetic value																			✓	✓				✓				✓

6.4 Detailed Impact and Risk Analysis and Evaluation

Following the identification of impacts and risks, analysis and evaluation is undertaken to determine the extent of the impacts and risks, whether they are acceptable or not and to identify any impact and risk treatment (or controls) to be implemented.

6.4.1 Impact and Risk Analysis

Once pathways for impacts or risks on receptors are identified as credible, a more detailed analysis is undertaken to support further evaluation. This may involve detailed consideration of the receptors present, and the exposure levels and impact or risk pathways for each of the environmental aspects.

For Scarborough, the impact and risk analysis were informed by previous experience, literature and expert judgement, but also by project specific surveys and studies of key environmental features (including benthic habitat) and quantitative modelling of discharges and emissions. Where impacts and risks are greatest, the level of detail and certainty of the analysis increased.

6.4.2 Impact and Risk Evaluation

Impact and risk evaluation are undertaken by assessing the **magnitude** (i.e. no lasting effect, slight, minor, moderate, major or catastrophic) of the credible environmental impacts from each aspect based on extent, duration, frequency and scale, and then either

- assigning an **impact significance level** to each credible environmental impact based on the receptor sensitivity and the magnitude of the impact, OR
- assigning an **environmental risk consequence** to each environmental risk based on the receptor sensitivity, magnitude of the impact, and the **likelihood** of occurrence.

6.4.2.1 Impact Evaluation

This process involves determining the magnitude of an impact on the environmental receptor. This is an assessment of the impact in terms of the extent, duration frequency and scale of the impact as follows:

- Extent: The spatial extent of the impact ranges from limited to the location of the activity (e.g. FPU location), localised (e.g. Offshore Project Area, width of Trunkline Project Area), regional (e.g. NW marine region) or widespread (>state-wide up to international).
- Duration: Timeframe of the impact; i.e. if it is short, medium or long term. Linked to duration of the aspect. Temporary effects may last for hours, weeks or months or be from a transient source such as a vessel. E.g. pile driving over a few hours results in sound emissions that will stop once piling is finished. Based on sound levels emitted (high/low), impact (e.g. effects on marine mammals – behavioural or physical) may be lasting beyond the duration of the aspect.
- Frequency: The rate at which an event occurs over a period of time.
- Scale: The degree to which existing environmental conditions are modified as a result of the impact. This could be positive or negative. (e.g. physical disturbance to seabed from presence of subsea infrastructure – small footprint compared to rest of seabed available – but duration would be long-term).

The impact assessment then determines the impact significance of the potential impacts, based on the magnitude and the receptor sensitivity (Figure 6-2). The following impact significant levels may be assigned for the environmental impacts:

- Catastrophic (A) – Applicable limits or standards are substantially exceeded and/or catastrophic or major magnitude impacts are expected to receptors of medium/high or high sensitivity respectively.
- Major (B) – Applicable limits or standards are exceeded and/or moderate, major or catastrophic magnitude impacts are expected to occur to receptors of high, medium or low sensitivity respectively.
- Moderate (C) – Impacts are close to applicable limits or standards, or within standards but with potential for occasional exceedance. Minor, moderate or major magnitude impacts are predicted to occur to receptors of high, medium or low sensitivity respectively.
- Minor (D) – Impact magnitude is within applicable standards but is considered to have significance. Slight, minor or moderate impacts are predicted to occur to receptors of high, medium or low sensitivity respectively.
- Slight (E) – The receptor will experience a noticeable effect, but the impact magnitude is sufficiently small and well within applicable standards, and/or the receptor is of low value.
- Negligible (F) – The receptor will essentially not be affected.

	Receptor Sensitivity		
Magnitude	Low	Medium	High
Catastrophic	B	A	A
Major	C	B	A
Moderate	D	C	B
Minor	E	D	C
Slight	F	E	D
No lasting effect	F	F	E

Significance Level
Catastrophic (A)
Major (B)
Moderate (C)
Minor (D)
Slight (E)
Negligible (F)

Figure 6-2: Impact significance level

6.4.2.2 Risk Evaluation

Environment risk levels are determined slightly differently than impact levels due to the requirement to consider the likelihood that the risk source(s) lead to the event or incident occurring. The likelihood of a risk occurring can be considered remote (0), highly unlikely (1), unlikely (2), possible (3), likely (4) or highly likely (5). Risk consequence, i.e. the consequence of any impacts realised by the risk source leading to an event, is determined using the methodology described in the Impact Evaluation (Section 6.4.2.1), i.e. magnitude and receptor sensitivity are combined to determine the overall consequence of the impact associated with the risk. The likelihood is combined with the risk consequence, to determine the risk level. The following risk levels may be assigned for the environmental risks:

- Severe
- Very High
- High

- Moderate
- Low.

Where consideration of the context, including the nature and scale of the activity and subsequent magnitude of impact, or the sensitivity or value of the receptor resulted in impacts that were either negligible or not credible, this is detailed and that impact or risk on the particular receptor not evaluated further.

For all other impacts and risks, detailed evaluations were undertaken to determine whether or not these were acceptable based on the criteria set in Section 6.4.4. Where the acceptability was contingent on applying particular controls, these were also described in the summary of residual risks, EPOs, etc.

Consequence

	Health & Safety	Environment	Financial	Reputation & Brand	Legal & Compliance	Social & Cultural
A	> 30 fatalities and / or permanent total disabilities	Catastropic, long-term impact (> 50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	> $5B	Catastrophic, long term impact (> 20 years) to reputation and brand. International concern and / or persistent national concern in significant area of operation. Company operations, major ventures, significant or multiple asset operations severely restricted or terminated, and may extend to company at stake	Loss of licence to operate. Potential jail terms for executives, directors or officers. Prolonged litigation / prosecution. Fines (> $100M) and / or civil liability (> $1B)	Catastrophic, long-term impact (> 20 years) to a community, social infrastructure or highly valued areas / items of international cultural significance
B	Multiple fatalities and / or permanent total disabilities	Major, long-term impact (10-50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	> $500M - $5B	National concern and / or international interest. Medium to long-term impact (5-20 years) to reputation and brand. Venture and / or asset operations restricted	Significant restriction on licence to operate. Prolonged litigation / prosecution. Fines (< $100M) and / or civil liability (< $1B)	Major, long-term impact (5-20 years) to a community, social infrastructure or highly valued areas / items of national cultural significance
C	Single fatality and / or permanent total disability	Moderate, medium-term impact (2-10 years) on ecosystems, species, habitat or physical or biological attributes	> $50M - $500M	National concern. Moderate, medium-term impact (2-5 years) to reputation and brand. Venture and / or asset operations restricted or curtailed	Material breach of legislation, regulation, contract or licence condition. Major litigation / prosecution. Fines (< $15M) and / or civil liability (< $150M)	Moderate, medium-term impact (2-5 years) to a community, social infrastructure or highly valued areas / items of national cultural significance
D	Major injury or occupational illness or permanent partial disability	Minor, short-term impact (1-2 years) on species, habitat (but not affecting ecosystems function), physical or biological attributes	> $5M - $50M	Minor, short-term impact (1-2 years) to reputation and brand. Close scrutiny of asset level operations or future proposals	Breach of legislation, regulation, contract or licence condition with investigation and / or report to authority. Litigation / prosecution. Fines (< $5M) and / or civil liability (< $50M)	Minor, short-term impact (1-2 years) to a community or highly valued areas / items of cultural significance
E	Moderate injury or occupational illness or temporary partial disability	Slight, short-term impact (< 1 year) on species, habitat (but not affecting ecosystems function), physical or biological attributes	> $500K - $5M	Slight, short-term local impact (< 1 year) to reputation and brand. Some impact on asset level non-production activities	Breach of legislation, regulation, contract or licence condition. Regulatory action and / or sanction	Slight, short-term impact (< 1 year) to a community or areas / items of cultural significance
F	Minor injury or occupational illness	No lasting effect (< 1 month). Localised impact not significant to environmental receptors	≤ $500K	No lasting effect (< 1 month). Isolated and short-term local concern	Breach of internal standard	No lasting effect (< 1 month). Localised impact not significant to areas / items of cultural significance

Likelihood

	Remote	Highly Unlikely	Unlikely	Possible	Likely	Highly Likely
Experience	Unheard of in the industry	Has occurred once or twice in the industry	Has occurred many times in the industry but not at Woodside	Has occurred once or twice in Woodside or may possibly occur	Has occurred frequently at Woodside or is likely to occur	Has occurred frequently at the location or is expected to occur
Frequency	1 in 100,000 - 1,000,000 years	1 in 10,000 - 100,000 years	1 in 1,000 - 10,000 years	1 in 100 - 1,000 years	1 in 10 - 100 years	> 1 in 10 years
Modelled distribution %* (Probability of event occurrence)	< 1%	1% - 5%	6% - 20%	21% – 50%	51% - 80%	> 80%
LEVEL	0	1	2	3	4	5

* Not to be used for operational Health & Safety or Environment risk assessments.

LEVEL	0	1	2	3	4	5
A	A0	A1	A2	A3	A4	A5
B	B0	B1	B2	B3	B4	B5
C	C0	C1	C2	C3	C4	C5
D	D0	D1	D2	D3	D4	D5
E	E0	E1	E2	E3	E4	E5
F	F0	F1	F2	F3	F4	F5

Risk endorsement table

Current Risk

SEVERE	Risk at this level requires **immediate (no more than 12 hours)** communication to the **CEO & divisional EVP / SVP** via VP Risk & Compliance
VERY HIGH	Risk at this level requires **immediate (no more than 12 hours)** communication to **divisional EVP / SVP** with concurrent communication to VP Risk & Compliance
HIGH	Risk at this level requires timely communication to **SVP / VP of business unit or function**
MODERATE	Risk at this level requires timely communication to **line manager** (i.e. relevant Asset or Project Manager)
LOW	Risk at this level requires timely communication to the relevant **line manager**

Note: All currency stated in $US. The consequence and likelihood categories are not necessarily equal to each other. For example, the financial column is not equal to the remediation costs or consequences described in other columns.

Figure 6-3: Environmental risk levels

6.4.3 Impact and Risk Treatment

In the process of evaluating impacts and risks, any **adopted controls** required to manage the impacts and risks to acceptable levels are identified and captured as commitments to be implemented for the project.

At the OPP phase, the adopted controls reflect the commitments that are required to be implemented in order to meet the criteria for acceptance. This includes any practices that will reduce the impacts and risks in order to meet the identified EPOs, any relevant legal requirements (related specifically to the impact/risk), internal company requirements, and any requirements that are identified through the community consultation process.

Further review and potential adoption of additional controls will be undertaken in subsequent phases of the project, such as during the preparation of EP for activities under the scope of this OPP. While the overarching EPOs will be carried through to the EP, the controls and corresponding environmental performance standards will be implemented to reduce risks to as low as reasonably practicable (ALARP).

6.4.4 Acceptability

In accordance with Regulation 5A, the Scarborough OPP describes the existing environment that may be affected by the project, and the details of the particular relevant values and sensitivities of that environment. It also aims, in accordance with 5D(6), to demonstrate that the proposal meets the criteria for acceptance of the OPP including that it:

(*d) sets out appropriate environmental performance outcomes that:*

(i) are consistent with the principles of ecologically sustainable development; and

(ii) demonstrate that the environmental impacts and risks of the project will be managed to an acceptable level.

Once the impacts and risks are evaluated, it can be determined whether the residual impacts and risks for each of the receptors present are consistent with the EPOs and meet all the criteria for acceptability.

Woodside has determined whether the impacts and risks of Scarborough are acceptable by considering the following evaluation criteria:

- Principles of Ecologically Sustainable Development (ESD) as defined under the EPBC Act (Section 6.4.4.1)
- internal context – the proposed impacts and risk levels are consistent with Woodside policies, procedures and standards (Section 6.2.5)
- external context – consideration of the environment consequence and stakeholder acceptability (Section 6.2.4)
- other requirements – the proposed controls and impact and risk levels are consistent with national and international standards, laws, policies and Woodside Standards (including applicable plans for management and conservation advices, and significant impact guidelines for MNES) (Section 3).

6.4.4.1 Principles of ESD

To define acceptable limits for identified impacts and risks, Woodside has given consideration of the principles of ESD as defined in Section 3A of the EPBC Act. This includes:

- decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations

- if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
- the principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
- improved valuation, pricing and incentive mechanisms should be promoted.

These principles are reflected in the Environmental Performance Outcomes set for the project, which have been set to align with the definitions provided in the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013).

6.5 Significant Impacts

In the assessment of Scarborough, impacts and risks have been demonstrated to be at an acceptable level if they do not result in a 'significant impact' as described in the Matters of National Environmental Significance – Significant Impact Guidelines (DotE, 2013). As described in the Guidelines, whether a not an activity is likely to have a significant impact depends on the sensitivity, value and quality of the environment which is impacted (as described in Section 4) and upon the intensity, duration, magnitude and geographic extent of the impacts (as described in detail for all impacts and risks in Section 7).

The level of significant impact will be specific to the receptor (although may rely on common terminology used in the legislation or guidance to which they relate) and will be determined by whether the receptor species present are listed as an MNES or exist within an area of value.

Levels of significant impact are based on:

- Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)
- OPGGS Act Section 280(2)

The identified level of significant impact for each receptor from Scarborough has been identified and are summarised in Table 6-3.

Table 6-3: Defined level of Significant Impact for Scarborough

Receptor	Regional Context and Receptor Sensitivity	Defined level of Significant Impact
Ambient light	**Receptor Sensitivity - Low value (open water)** Ambient light is typical of an open water environment, with low sensitivity to change. The Offshore Project Area is located 375 km from shore where there are no existing significant sources of artificial light. Existing lighting is limited to transient vessels. The Trunkline Project Area extends from the offshore location, pasting through remote waters where existing lighting sources are limited to transient vessels, other than the point where the route passes the Pluto facility (km distance). As the trunkline gets closer to State waters existing sources of light increase, especially around the islands, shipping channels and on approach to the mermaid sound.	An action is likely to have a significant impact if there is a possibly that is will: • modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. Source: *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013).
Ambient noise	**Receptor Sensitivity - Low value (open water)** Ambient noise is typical of an open water environment, with low sensitivity to change. Anthropogenic noise exists in the region, lowering quality. Large fluctuations in ambient noise levels in the Project Area are expected due to changes in weather systems and seasons, biological events such as whale migrations, and presence of shipping and other industrial activities. Ambient noise is expected to be greater in areas of the Trunkline Project Area which intercept areas of high vessel traffic.	An action is likely to have a significant impact if there is a possibly that is will: • modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. Source: *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013).
Water quality	**Receptor Sensitivity - Low value (open water)** Ambient water quality is typical of an open water environment, with low sensitivity to change. Water quality within the Project Area is typical of an unpolluted tropical offshore environment. Turbidity levels increase during the wet season, especially closer to shore, due to increased runoff, high tidal ranges and increased cyclonic activity. Concentrations of heavy metals and organic chemicals throughout the Project Area are low with concentrations in the Offshore Project Area environment generally lower. Surface water in the Offshore Project Area is nutrient poor. Deeper water has significantly lower concentrations of dissolved oxygen than that of shallower waters, with no detected hydrocarbons.	An action is likely to have a significant impact if there is a possibly that is will: • result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Source: *Matters of National Environmental Significance – Significant impact guidelines*

Receptor	Regional Context and Receptor Sensitivity	Defined level of Significant Impact
Sediment quality	**Receptor Sensitivity - Low value** Sediment quality is typical of the surrounding environment, with low sensitivity to change and no features or species of conservation value. Sediments in the Offshore Project Area are currently of high quality, with low concentrations of metals and nutrients and no hydrocarbons detected during marine sediment quality surveys. Sediments along the Trunkline Project Area are expected to be dominated by sand as is typical of the continental slope in the Northwest Transition bioregion.	An action is likely to have a significant impact if there is a possibly that is will: • result in a substantial change in sediment quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. • result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, social amenity or human health may be adversely affected. Source: *Matters of National Environmental Significance – Significant impact guidelines*
Air quality	**Receptor Sensitivity - Low value (open water)** Air quality is typical of an open water environment, with low sensitivity to change. Due to the extent of the open ocean area and the activities that are currently undertaken within the NWS, it is considered the ambient air quality in the EMBA and wider offshore NWMR will be high.	An action is likely to have a significant impact if there is a possibly that is will: • result in a substantial change in air quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. Source: *Matters of National Environmental Significance – Significant impact guidelines*
Climate	**Receptor Sensitivity - (high value ecosystems)** Ecosystems which are particularly susceptible to adverse effects of climate change include alpine habitats, coral reefs, wetlands and coastal ecosystems, polar communities, tropical forests, temperate forests and arid and semi-arid environments (Department of the Environment and Energy, 2019). In Australia, the most affected ecosystems include coral reefs, alpine regions, rainforests, arid and semi-arid environments, mangroves, grasslands, temperate forests and sclerophyll forests.	It is important to acknowledge that climate change impacts cannot be directly attributed to any one project, as they are instead the result of GHG emissions, minus GHG sinks, that have accumulated in the atmosphere since the industrial revolution started. This means there is no direct link between GHG emissions from Scarborough and climate change impacts. As explained in Section 7.1.3, natural gas from Scarborough is expected to support an overall reduction in net global atmospheric concentration by displacing more emissions-intensive fuels.
Plankton	**Receptor Sensitivity - Low value (open water)**	

Receptor	Regional Context and Receptor Sensitivity	Defined level of Significant Impact
	Plankton are typical of an open water environment, with low sensitivity to change and no species of high importance or quality. Plankton communities have a naturally patchy distribution in both space and time, noting that the NWMR is typically characterised by low planktonic productivity.	An action is likely to have a significant impact if there is a possibly that is will: • have a substantial adverse effect on a population of plankton including its life cycle and spatial distribution. Source: *Matters of National Environmental Significance – Significant impact guidelines*
Fish	**Receptor Sensitivity - High value species** MNES species known to be present. Generally, within the NWMR, fish assemblage and species richness decrease with increasing depth and is positively correlated with habitat complexity. The Offshore Project Area is deep and predominantly featureless resulting in a low abundance of fish fauna. Fish species presence is more likely along the trunkline corridor which overlaps significant fish habitat areas that support higher demersal fish richness and abundance.	An action is likely to have a significant impact if there is a possibly that is will: • have a substantial adverse effect on a population of fish, or the spatial distribution of the population. • substantially modify, destroy or isolate an area of important habitat for a migratory species. • seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species. Source: *Matters of National Environmental Significance – Significant impact guidelines*
Seabirds and Shorebirds	**Receptor Sensitivity - High value species** MNES species known to be present. A range of seabirds and shorebirds are likely to occur with the Project Area and broader region. Breeding BIAs for seabirds and shorebirds are primarily restricted to within tens of kilometres of emergent features however pelagic seabird presence is still likely to occur within the Offshore Project Area. Since the majority of species which have distribution within the Trunkline Project Area are migratory, their presence would only be expected during part of the year. It is expected that species presence in the Trunkline Project Area will be greatest in proximity to emergent features.	An action is likely to have a significant impact if there is a possibly that is will: • have a substantial adverse effect on a population of seabirds or shorebirds, or the spatial distribution of the population. • substantially modify, destroy or isolate an area of important habitat for a migratory species. • seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species. Source: *Matters of National Environmental Significance – Significant impact guidelines*
Marine Reptiles	**Receptor Sensitivity - High value species** MNES species known to be present.	An action is likely to have a significant impact if there is a possibly that is will:

Receptor	Regional Context and Receptor Sensitivity	Defined level of Significant Impact
	There are no sensitive marine turtle habitats near the offshore location for Scarborough. The closest known turtle nesting beach are the islands of the Dampier Archipelago, about 375 km from the Offshore Project Areas associated with Scarborough. The Trunkline Project Area does intercept with BIAs for flatback, green, hawksbill and loggerhead turtles. BIAs and critical habitats for marine turtles are identified for internesting and foraging.	• have a substantial adverse effect on a population of marine reptiles or the spatial distribution of the population • modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. • seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species. Source: *Matters of National Environmental Significance – Significant impact guidelines*
Marine mammals	**Receptor Sensitivity - High value species** MNES species known to be present. The NWMR is thought to be an important migratory pathway for large truly pelagic whales. Foraging whales have been observed in areas of upwelling in NWMR. Dolphins and dugongs are typically found in nearshore waters. Numbers of migrating individuals in the Project Area will be higher during peak migration periods which differs between species. Nevertheless, these BIAs will only represent important habitat for Humpback and Pygmy blue whale. Since the Trunkline Project Area traverses the continental shelf and is in relative proximity to shorelines, dolphins are more likely to occur in the Trunkline Project Area compared to the Offshore Project Area, although no BIAs or other significant habitat or aggregations were identified. The Dugong is also more likely to occur in shallower waters of the Trunkline Project Area. Distribution of cetaceans in the Offshore Project Area are less likely than that experienced along the trunkline corridor, with one BIA for distribution in the area.	An action is likely to have a significant impact if there is a possibly that is will: • have a substantial adverse effect on a population of marine mammals or the spatial distribution of the population. • modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. • seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species. Source: *Matters of National Environmental Significance – Significant impact guidelines*
Epifauna and infauna	**Receptor Sensitivity - Low value** Epifauna and infauna are typical of the surrounding environment, with no species of high importance or quality. Benthic composition in deep water habitats is generally lower in abundance than shallow water habitats of the region. Density of benthic fauna tends to be lower in deep water	An action is likely to have a significant impact if there is a possibly that is will: • modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. Source: *Matters of National Environmental Significance – Significant impact guidelines*

Receptor	Regional Context and Receptor Sensitivity	Defined level of Significant Impact
	sediments (>200 m) than in shallower coastal sediments, but the diversity of communities may be similar. The area of shallower waters between Dampier and Port Hedland is a hotspot for sponge biodiversity.	
Coral	**Receptor Sensitivity - High value habitat** High sensitivity to change. Both hard corals and soft corals are found throughout the Dampier Archipelago, with the species diversity representing a large proportion of the genera known to occur in WA. Other significant areas of coral reef in the EMBA include Ningaloo Reef, and those fringing the Muiron Islands, Barrow Island and Montebello Islands. Due to the water depths of the majority of the Trunkline Project Area in Commonwealth waters, no hard corals are expected to occur, however surveys have shown the presence of soft corals, however they are not a dominant species.	An action is likely to have a significant impact if there is a possibly that is will: • modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. Source: *Matters of National Environmental Significance – Significant impact guidelines*
Seagrass	**Receptor Sensitivity - High value habitat** High sensitivity to change. Within the EMBA, significant seagrass and macroalgae communities are found in waters surrounding islands. Seagrasses and are generally found in coastal waters at depths of <10 m, although they have been recorded at 50 m in some Australian waters. Therefore, it is highly unlikely that seagrasses are present within the Offshore Project Area. The shallowest water depths in Trunkline Project Area are 35 m. Seagrasses may occur in areas of the Trunkline Project Area where water depths are less than 50 m. However, extensive areas of seagrass are not expected given distribution is typically limited to water depths shallower than the Trunkline Project Area.	An action is likely to have a significant impact if there is a possibly that is will: • modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. Source: *Matters of National Environmental Significance – Significant impact guidelines*
Macroalgae	**Receptor Sensitivity - Low value habitat** Macroalgae are homogenous, and therefore have a low sensitivity to change. Macroalgae are most commonly found on shallow limestone pavements.	An action is likely to have a significant impact if there is a possibly that is will: • modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.

Receptor	Regional Context and Receptor Sensitivity	Defined level of Significant Impact
	Macroalgae are generally found in coastal waters at depths of <10 m, although they have been recorded at 50 m in some Australian waters. Therefore, it is highly unlikely that seagrasses are present within the Offshore Project Area.	Source: *Matters of National Environmental Significance – Significant impact guidelines*
Coastal habitats	**Receptor Sensitivity - High value habitat** Habitats with high sensitivity to change, such as mangroves. Given the offshore location of the Project Area, coastal habitats occur in neither the Offshore Project Area nor Trunkline Project Area. However, coastal habitats may occur within the EMBA. The shoreline within the northwest of Western Australia is varied, but predominantly includes tidal flats with smaller areas of rocky shores and sandy beaches. In addition, mangrove and saltmarsh environments also occur along the Pilbara coast and islands of the Dampier Archipelago.	An action is likely to have a significant impact if there is a possibly that is will: • modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. Source: *Matters of National Environmental Significance – Significant impact guidelines*
Industry	**Receptor Sensitivity - Low value** The Project Area is not of extensive use by other Industry. Industry includes oil and gas activities, and defence activities. Oil and gas infrastructure in proximity to the Project Area include that associated with the main producing hubs of the Pluto LNG project, the Wheatstone LNG project and the Greater Gorgon LNG project. There are designated Department of Defence practice areas operating out of the Royal Australian Air Force base located at Learmonth, on North West Cape.	An action is likely to have a significant impact if there is a possibly that is will: • have a substantial adverse effect on water quality such that an adverse impact on industry use occurs. Source: *Matters of National Environmental Significance – Significant impact guidelines* An activity will contravene the OPGGS Act Section 280(2), and therefore result in a Significant Impact, if it is deemed to • interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted.
	Receptor Sensitivity - High value marine user	

Receptor	Regional Context and Receptor Sensitivity	Defined level of Significant Impact
Commonwealth and State Managed Fisheries	Key fishing area, with high importance to stakeholders. Commonwealth and State managed fisheries are present within the EMBA and Trunkline Project Area. The only Commonwealth managed fisheries likely to have active fishing areas intersecting with the Project Area is the Northwest Slope Trawl Fishery. There are seven State-managed fisheries which may undertake fishing activities within the Project Area.	An action is likely to have a significant impact if there is a possibly that is will: • have a substantial adverse effect on the sustainability of commercial fishing. An activity will contravene the OPGGS Act Section 280(2), and therefore result in a Significant Impact, if it is deemed to: • interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted.
Australia Marine Parks	**Receptor Sensitivity - High value** Designated sensitive area. Values protected by legislation. The following AMPs are relevant to the Project Area: • Montebello (Overlaps the Project Area) • Dampier (Adjacent to Borrow Ground Project Area) • Gascoyne (87km from Project Area) Ningaloo (186km from Project Area)	An action is likely to have a significant impact if there is a possibly that is will: • modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. Source: *Matters of National Environmental Significance – Significant impact guidelines*
KEFs	**Receptor Sensitivity - High value** Designated sensitive area. Values protected by legislation. The Project Area intersects with the following three KEFs: • Exmouth Plateau • ancient coastline at 125 m depth contour • continental slope demersal fish communities Additional KEFs within the EMBA include: • canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula • Commonwealth waters adjacent to Ningaloo Reef Glomar Shoals.	An action is likely to have a significant impact if there is a possibly that is will: • modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results. Source: *Matters of National Environmental Significance – Significant impact guidelines*
Shipping		An activity will contravene the OPGGS Act Section 280(2), and therefore result in a Significant Impact, if it is deemed to:

Receptor	Regional Context and Receptor Sensitivity	Defined level of Significant Impact
	Receptor Sensitivity - Medium/high value users Busy shipping area is located outside of Project Area, but shipping traffic still likely to be high. Commercial shipping traffic is high within the NWMR with vessel activities including commercial fisheries, tourism such as cruises, international shipping and oil and gas operations. Although the Offshore Project Area is located west of a busy shipping fairway, vessel traffic within the Offshore Project Area is relatively low. The majority of vessel movement occurs to the south-east of the Offshore Project Area within the Trunkline Project Area. In addition to high vessel traffic within the shipping fairway, vessel traffic is high towards the east of the Trunkline Project Area where increased vessel traffic will be associated with ports servicing the resource industry at Barrow Island, Onslow and Dampier.	• interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted.
Tourism and recreation	**Receptor Sensitivity - Medium/high value users** Seasonally important, unlikely to have activities focused within the Project Area. A number of popular tourism locations occur within the EMBA: • Ningaloo Reef • Muiron Islands • Montebello and Barrow islands • Dampier Archipelago. Activities within these areas include recreational fishing (including charter fishing), snorkelling, diving and fauna watching. Of the most popular recreational fishing sites outlined above, none lie within the Trunkline Project Area.	An activity will contravene the OPGGS Act Section 280(2), and therefore result in a Significant Impact, if it is deemed to: • interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted.
Settlements	**Receptor Sensitivity - Medium value users** Regionally important, low sensitivity to change. There are no coastal settlements in the Project Area, however the EMBA includes areas of coastline which includes coastal settlements. Coastal settlements in the north-west region range from small towns to larger regional centres such as Exmouth, Onslow, Karratha, Port Hedland and Broome, where the population is concentrated.	An activity will result in a Significant Impact, if it is deemed to: • cause significant harm to social surroundings

7 EVALUATION OF ENVIRONMENTAL IMPACTS AND RISKS

7.1 Planned Aspects

7.1.1 Routine Light Emissions

Routine light emissions include light sources that alter the ambient light conditions in an environment.

7.1.1.1 Sources of the Aspect

Activities and facilities associated with Scarborough will require lighting for operational and safety reasons. Light emissions will be produced during:

- vessel operations
- FPU operations
- MODU operations
- hydrocarbon processing.

Light may appear as a direct light source from an unshielded lamp with direct line of sight to the observer or through skyglow. Where direct light falls upon a surface, be it land or ocean, this area of light is referred to as light spill.Skyglow is the diffuse glow caused by light that is screened from view but through reflection and refraction creates a glow in the atmosphere. Scattering of light by dust, salt and other atmospheric aerosols increases the visibility of light as skyglow while the presence of clouds reflecting light back to earth can substantially illuminate the landscape (Kyba et al., 2011). White/blue light scatters more easily and further in the atmosphere compared to yellow-orange light (Kyba et al., 2011). Therefore, the distance at which direct light and skyglow may be visible from the source is dependent on the number, intensity and types of lights, and how such lights are orientated or shielded, in addition to environmental conditions.

Receptors within a 20 km buffer of project light sources were considered based on recommendations of the National Light Pollution Guidelines for Wildlife (Commonwealth of Australia (2020) and references therein). However where project specific information was available, including representative line-of-sight assessments and light modelling, the assessment area for consideration was refined.

FPU and MODU Operations

The FPU and MODU will have external lighting to support safe navigation and safe operations at night. This lighting typically consists of bright white (i.e. metal halide, halogen, fluorescent) lights, and is not dissimilar to lighting used for other offshore activities, including fishing and shipping. Lighting is considered standard and is restricted to safe operations and navigational requirements.

While light emissions from MODU operations will be short-term (about two to three months per well), the lighting from the FPU operations will be long term, that is over the life of the project. The intermittent and transient lighting from vessels (including pipelay, construction and dredging vessels) supporting Scarborough will be greatest during the construction phase of the project but remain ongoing as vessels will provide ongoing support functions for the life of Scarborough.

Woodside (2014) undertook a line-of-sight assessment to determine the maximum distance that light associated with offshore activities may be visible (irrespective of the light source intensity). This study focused on lighting from a MODU which is considered conservative for vessel operations and appropriate for the FPU operations, given the height above sea level for the FPU is similar to that of the MODU used for this study. It showed that the maximum distance direct light may be visible extended up to:

- 20 km for main deck lights
- 35 km for topside modules/cranes lights
- 50 km for the flare (at about 150 m above sea level).

Vessel Operations

Vessels involved in Trunkline installation and stabilisation will be present in the Trunkline Project Area and the Borrow Ground Project Area temporarily (Table 7-1). Once activities are completed and vessels depart the area, no permanent ongoing light emissions will occur. Light emissions in any one area are limited by the transient nature of the works along the trunkline route and the cycling of dredging between loading and unloading locations. In addition, activities are completed sequentially which limits cumulative impacts from multiple light sources in a single area.

Table 7-1 Trunkline installation and stabilisation activities within 20 km of land

Activity	Estimated duration	Location	Vessels
Hydrographic, geophysical and geotechnical surveys	2 months	Trunkline Project Area and Borrow Ground Project Area	Survey vessels
Pre-lay trenching and spoil disposal	8 weeks	Trunkline Project Area (KP 32.7 – KP 54)	Dredging vessel
Pipelay	3.5 weeks	Trunkline Project Area	Pipelay vessel
Pre and post-lay span rectification	2 weeks	Trunkline Project Area (KP 32.7 – KP 54)	Construction Vessel
Post-lay dredging and backfill	8 weeks	Trunkline Project Area (KP 32.7 – KP 54) and Borrow Ground Project Area (cycling between the two project areas over approximately 7 hours with the majority spent in the Trunkline Project Area)	Dredging vessel

ILLUMINA Artificial Light At Night (ALAN) modelling was undertaken for two representative vessel types using methodology presented in Aube et al., (2005) against the nearest turtle nesting habitat to the Trunkline and Borrow Ground Project Areas. The ILLUMINA model is a three-dimensional model that accounts for both line of sight and atmospheric scattering, allowing the attenuation of light over distance and extent of light glow to be modelled. Four scenarios were considered associated with trunkline installation and stabilisation activities (Pendoley 2020a, Appendix L):

Scenario 1: Representative pipelay vessel at the closest point of the Trunkline Project Area to Rosemary Island (point 1, 14.15 km)

Scenario 2: Representative pipelay vessel at the closest point of the Trunkline Project Area to Legendre island (point 2, 12 km)

Scenario 3: Representative dredging vessel at the closest point of the Trunkline Project Area to Rosemary Island (point 1, 14.15 km)

Scenario 4: Representative dredging vessel at the closest point of the Borrow Grounds Project Area to Legendre island (point 3, 6.6 km)

Model outputs were in radiance (W/m^2/sr) and presented as a proportion of the radiance of a full moon as a realistic scale representative of the natural conditions experienced by marine turtles in the field and to provide biological context, where there is potential for behavioural impacts to turtles to occur at more than 0.01, or 1%, radiance of a full moon (Table 7-2).

Table 7-2 Artificial light impact potential criteria (marine turtles) (Aube et al., 2005)

Proportion of radiance of a full moon*	Impact potential to marine turtles (Pendoley, 2020b, Appendix L)
1 - 10	Light or light glow visible and impact likely, represents a very bright light equivalence to up to 10 times the radiance of one moon. This light radiance will override the moderating influence of the ambient full moon at the time of exposure.
0.1 - 1	Light or light glow visible and behavioural impact possible, depending on ambient moon phase at the time of exposure, which will influence the visibility of the artificial light sources, equivalent to the light output. Artificial lights will be more visible to marine turtles under a first quarter moon than under a full moon.
0.01 - 0.1	Light or light glow visible but behavioural impact unlikely (i.e. not biologically relevant). Equivalent to the light output of the first quarter moon.
<0.01	Light or light glow is considered ambient and no impact expected, equivalent to a new moon

Light emissions were greater for the pipelay vessel compared to the dredging vessel. Light emissions of the same vessel differed slightly between scenario locations due to differences in the reflectance values of each location. However, the difference was not detectable when the distance to source is reported in km to one decimal place. Therefore the effect of location was not considered significant and modelled illuminations were applied as potential impact zones across the project areas based on the largest vessel present (Figure 7-1). For the Trunkline Project Area, the pipelay vessel provided the most conservative assessment whereas only the dredging vessel will be undertaking activities at the Borrow Ground Project Area.

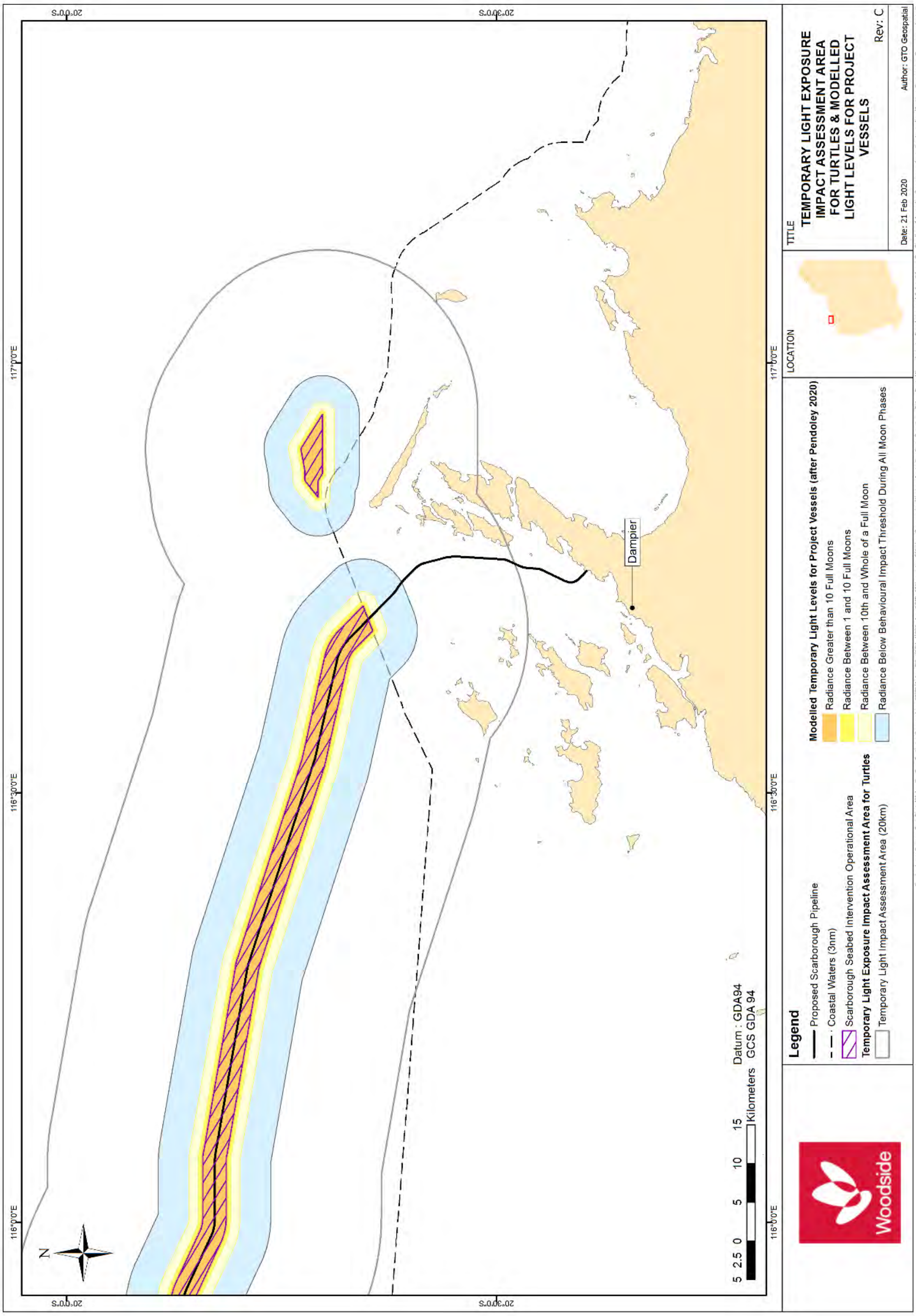


Figure 7-1 Modelled potential light impact radius from representative project vessels within the Trunkline and Borrow Gorund Project Areas

Note: Light exposure from vessel operations would not occur within all these areas simultaneously.

Light emissions were predicted to reduce to ambient levels (0.01, or 1%, radiance of a full moon) at 5.7 km and 4.7 km from the pipelay vessel and dredging vessel, respectively. There is potential for behavioural impacts to turtles to occur (more than 0.01, or 1%, radiance of a full moon) within 1.8 km and 1.5 km from the pipelay and dredging vessel, respectively. Behavioural impacts are more likely (≥ radiance of one full moon) within 0.6 km and 0.5 km of the pipelay and dredging vessel, respectively.

Table 7-3 Distance of equivalent moon radiances for a representative trunkline installation and stabilisation vessels

Proportion of radiance of a full moon*	Equivalent distance from lighting source (m)	
	Pipelay vessel (Scenario 1 and 2)	Dredging Vessel (Scenario 3 and 4)
10	180	150
1	570	470
0.1	1790	1480
0.01	5740	4730

*Where 10 equals the radiance of ten full moons and 0.01 equals 100th the radiance of one full moon

Hydrocarbon Processing

During hydrocarbon processing, flare stacks are used for burning off flammable gas released by pressure release valves (referred to as flaring). Flaring most often takes place during start-ups and shutdowns or in emergency events. The flare tip however may remain lit at all times via the pilot flame, which results in continued emission of light from the FPU.

Flaring will occur during commissioning and operations. During normal operations, intensity will be low comprising of small gas streams and the pilot light (resulting in flame approximately 2 m high). During blowdown events, the intensity will be much higher, and the flame could be as high as 50 m, at which time the light emissions will be greatest (Woodside, 2011). These events are however infrequent at around ten events per year, and will be of a relatively short duration, about 15 minutes depending on the inventory of hydrocarbons to be discharged.

A line of sight assessment was undertaken to support the Browse FLNG Development to identify the maximum distance that light associated with project activities (including a flare stack at 154 m above sea level) was visible (Woodside, 2014). In this assessment, it was determined that under routine operation the flare at the FLNG would be visible at a maximum distance of 47.7 km from the source. In an earlier study, Woodside estimated that a 2 m high flare would be reach a maximum distance of 45.2 km from source, when the flare stack was 137 m, above sea level (Woodside, 2011). These studies are considered comparable to the flare stack proposed on the Scarborough FPU.

7.1.1.2 Impact or Risk

Routine light emissions generated by offshore activities has the potential to result in the following impact(s):

- a change in ambient light.

As a result of a change in ambient light, further impacts may occur, which include:

- a change in fauna behaviour
- a change to the functions, interests or activities of other users.

Change in Ambient Light

The extent of this potential impact for Scarborough is restricted to the line of sight for each activity emitting light (Table 7-4), which based on the previous work undertaken by Woodside is about 30 km from the MODU during drilling activities and 30 km from support vessels. For hydrocarbon operations, specifically flaring, the distance at which the flare will be visible is expected to be less than 50 km from the source, and potentially around 10 km further during emergency flaring (Woodside 2011, 2014). These studies did not take into account the diminishing spatial extent of the light or the decrease in light intensity as distance from the light source increased and this is considered a conservative approach to identifying where impacts to fauna behaviour may occur.

Table 7-4: Estimated extent of potential impact from light sources associated with Scarborough

Activity	Zone of Potential Impact	Project stage	Reference
Offshore Project Area (FPU, MODU and Vessel operations)	30 km	Installation, commissioning and operations	Woodside, 2014
Trunkline Project Area (Vessel operations)	1.8 km	Installation	Pendoley, 2020b (Appendix L)
Borrow Gorund Project Area (Vessel operations)	1.5 km	Installation	Pendoley, 2020b (Appendix L)
Hydrocarbon processing (flaring)	50 km (+ 10 km during emergency flaring)	Commissioning and operations	Woodside, 2011

Existing light sources at the eastern end of the Trunkline Project Area (within 20 km of land) include heavy vessel traffic within the Pilbara Port Authority Management area and 26 designated anchorages for bulk carriers, petroleum and gas tankers, drilling rigs, offshore platforms, and pipelay vessels located offshore of Rosemary Island. These anchorages are located between Rosemary Island and the Trunkline Project Area. Although light monitoring within the Dampier Archipelago has not been undertaken, existing light pollution in this area is expected to be high (DoEE, 2017).

Change in Fauna Behaviour

Routine light emissions have the potential to disrupt ecological processes that rely on natural light for visual cues. The fauna potentially impacted include shorebirds and migratory seabirds, fish and marine reptiles.

Change to the Functions, Interests or Activities of Other Users

Light emissions can result in changes to the ambience of an area, which can potentially impact on values for tourism and recreation. Given the distance from shore of the Offshore Project Area (375 km), and the high vessel traffic already offshore from Dampier, the impact from routine light emissions on changes to the functions, interest or activities of others is likely to be negligible. Therefore, the potential impact from changes to the functions interest of activities of other users, such as Commonwealth and State managed fisheries and tourism and recreation is not evaluated further.

Receptors Potentially Impacted

Routine light emissions have the potential to disrupt ecological processes that rely on natural light for visual cues. Marine fauna receptors that are known to either rely on light for ecological functions or have a sensitivity to light include:

- fish
- seabirds and migratory shorebirds
- marine reptiles.

<u>Fish</u>

Experiments using light traps have found that some fish and zooplankton species are attracted to light sources (Meekan et al., 2001). The concentration of organisms attracted to light may result in an increase in food source for predatory species and marine predators may subsequently aggregate in these areas (e.g. Shaw et al., 2002).

The BIA for whale sharks is about 180 km away from the Offshore Project Area and no whale sharks are expected to be present within the Offshore Project Area. Whilst the trunkline overlaps with the whale shark BIA, potential light disturbance is restricted to vessels during the trunkline construction phase. Presence of other threatened fish species within the Offshore Project Area or pipeline route is expected to be of a transient nature only.

Within the Offshore Project Area, the attraction of transient fish to light emissions will be localised around the source, and not result in a substantial adverse effect on a population of species or its lifecycle. Outside of the Offshore Project Area, vessels undertaking trunkline installation activities will be transient and present for short periods only, and although operating within the BIA will not seriously disrupt the lifecycle of an ecologically significant proportion of whale sharks. Additionally, light emissions from these activities are comparable to other activities in the region. On this basis, the impacts to fish, from light emissions during activities associated with Scarborough, is likely to be negligible. Therefore, the potential impact from lighting to fish is not evaluated further.

Table 7-5 outlines the potential impacts to receptors associated with light emissions.

Table 7-5: Receptor/impact matrix after evaluation of context

	Receptors			
Impacts	***Ambient Light***	***Seabird and Migratory Shorebirds***	***Fish***	***Marine Reptiles***
Change in ambient light	✓			
Change in fauna behaviour		✓	X	✓

Detailed Impact Evaluation

<u>Ambient Light</u>

The introduction of light emissions from activities associated with Scarborough can result in a change to ambient light, by adding temporary lights from vessels as well as ongoing source of light from the FPU which may be visible up to 60 km away during emergency flaring activities.

The area of operation is at a significant distance from coastal sources of light emissions. However, there are existing activities in the region which also currently generate light including offshore facilities and supporting activities, as well as shipping traffic.

Predicted Impact Summary

The contribution of light emissions from the development of Scarborough will be comparable with existing vessels and facilities on the North West Shelf and will not result in a notable increase.

Lighting will be limited to the minimum required for navigational and safety requirements, with the exception of emergency events. Impacts from routine light emissions on ambient light will be slight. Given receptor sensitivity of ambient light (low value, open water), and therefore the Impact Significance Level of routine light emissions on ambient light is **Negligible (F).**

Seabirds and Migratory Shorebirds

High levels of marine lighting can attract and disorient seabird species resulting in species behavioural changes (e.g. circling light sources or disrupted foraging), injury or mortality near the light source (e.g. Longcore and Rich, 2004; Gaston et al. 2014; Rich and Longcore, 2006).

Light emission from Scarborough will be greatest in the Offshore Project Area due to MODU presence and FPU operations. The Offshore Project Area is about 375 km offshore and outside known BIAs for seabirds. Threatened bird species are not expected to be encountered within the Offshore Project Area. The Scarborough Project Area overlaps with BIAs for four seabird species in the Dampier Archipelago, along the pipeline route in Commonwealth waters. Australian fairy terns occupy offshore islands including the Montebello and Lowendal Islands groups and have seasonal presence in the region during July–September (Johnstone & Storr 1998). The lesser crested tern occupies coastal areas, islands and estuary environments. They are short-ranging seabirds with foraging likely to occur near nesting sites. Roseate terns are common in the region and have known breeding sites on islands of the Dampier Archipelago (Higgins & Davies 1996). Throughout the year the species often rests and forages in sheltered estuaries, creeks and inshore waters. Similarly, wedge-tailed shearwaters BIA overlaps with the Trunkline Project Area and are also known to breed on islands of the Dampier Archipelago and forage in nearby coastal waters (Marchant & Higgins 1990). As most of the Project Area, including the trunkline route in Commonwealth waters, is offshore and away from islands or other emergent features, any presence of seabirds or shorebirds is considered likely to be of a transient nature only.

Predicted Impact Summary

Behavioural disturbance to birds from light in the Offshore Project Area is expected to be localised to within the vicinity of the FPU (Figure 7-1) and/or MODU and vessels within the permit areas (Figure 7-3). While the FPU light source is continuous, the interaction with seabirds is expected to be low given the distance offshore and lack of known aggregation areas. The light source from the MODU and vessels within the Offshore Project Area will be temporary and only when operations are occurring; and similar to the FPU source, interaction with seabirds is expected to be low. Therefore impacts, if they did occur, are predicted to be at an individual level and not a population level. Behavioural disturbance to birds from light sources within the Trunkline Project Area are expected to be localised (Figure 7-3) and temporary. These light sources are associated with particular activities and will not occur for the life of the project. The temporary behavioural disturbance of birds will be localised around the light sources, and not result in a substantial adverse effect on a population of species or its lifecycle. Additionally, light emissions will not seriously disrupt the lifecycle of an ecologically significant proportion any migratory birds.

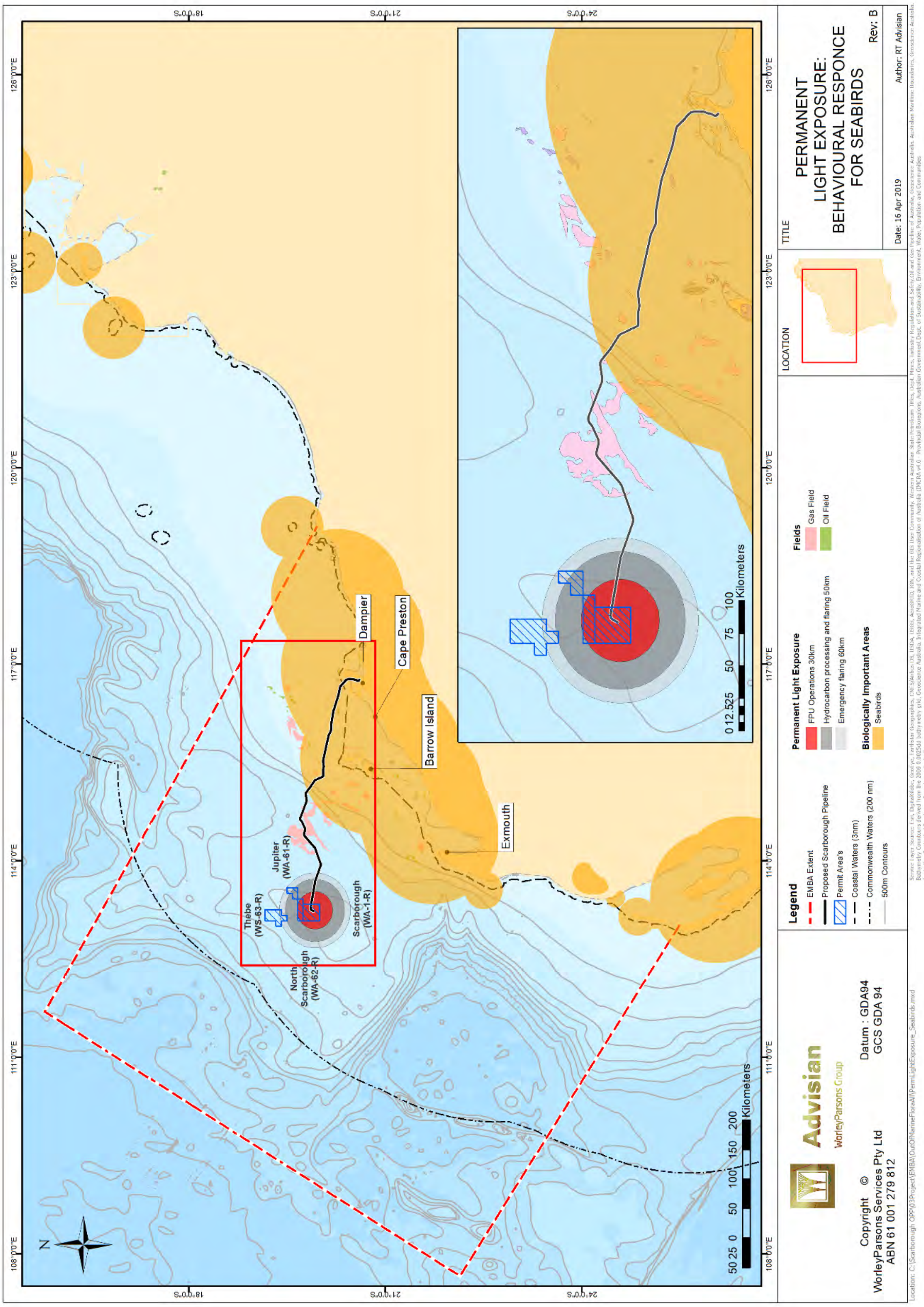
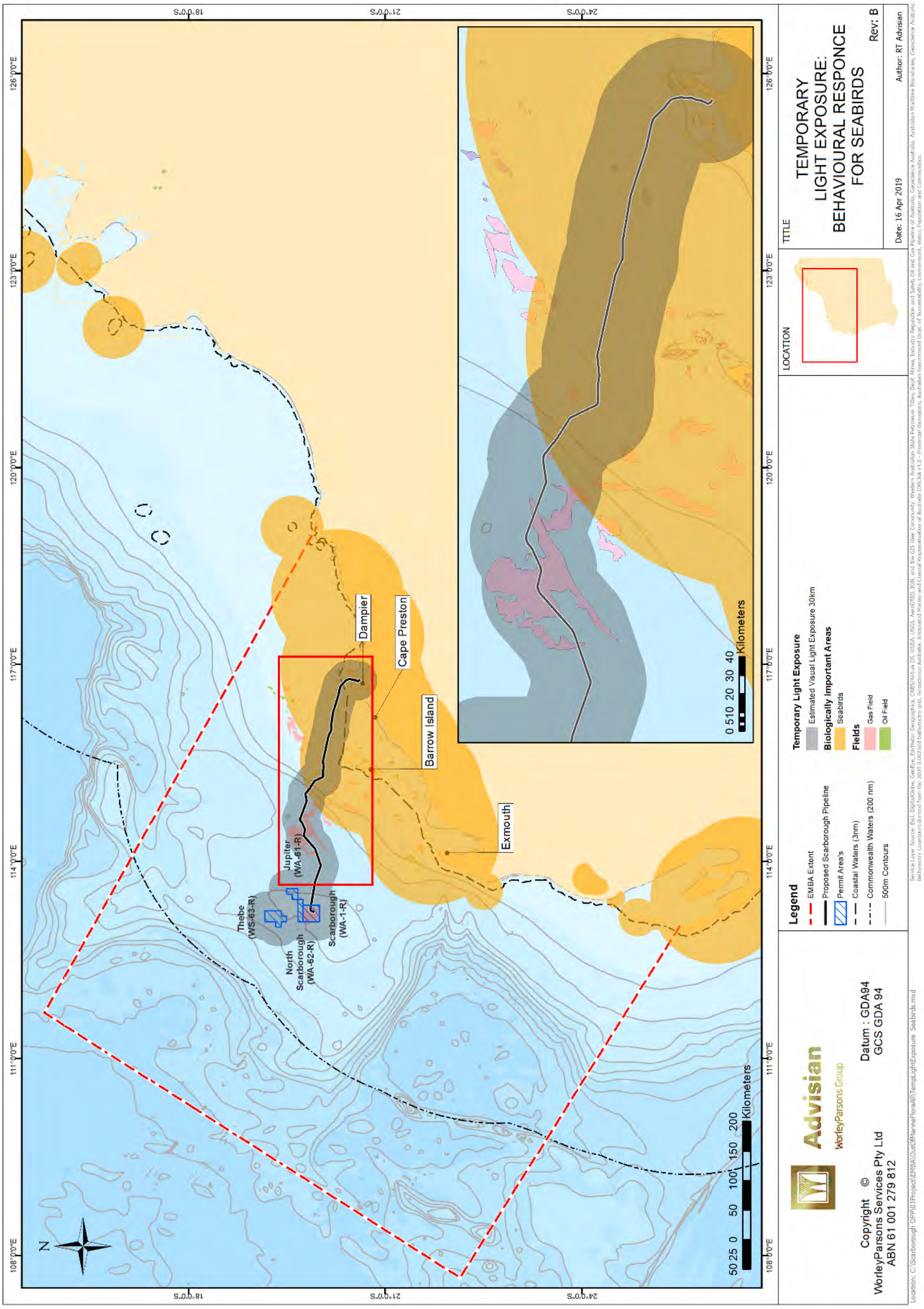


Figure 7-2: Predicted exposure area from continuous (red shading) and intermittent (grey shading) light sources associated with FPU operations and known biologically important areas for seabirds



Note: Light exposure from MODU and vessel operations would not occur within all these areas simultaneously.

Figure 7-3: Environmental impact assessment area for temporary light sources associated with MODU and vessel operations, and known biologically important area for seabirds.

There are no Recovery plans for seabirds and shorebirds in this location, however there are a number of Conservation advices that relate to ensuring protection where certain listed species are known to breed. These are however at significant distance from the Project Area where impacts from lighting are limited.

Light exposure to seabirds within the Offshore Project Area will be continuous for the duration of the operations phase of the project, for a limited area in the vicinity of the FPU. As shown in Figure 7-1, there is no overlap between BIAs for any species of seabird and the Offshore Project Area. Part of the Trunkline Project Area overlaps BIAs for several seabird species, and light exposure from vessel operations during pipeline installation may overlap breeding seasons within these BIAs (Table 5-3). However, pipeline installation activities will have a limited duration (weeks to months) and the areas of overlap between the Trunkline Project Area and the BIAs are located in offshore waters at a considerable distance from the breeding colonies. Consequently, given the limited spatial and temporal overlap with seabird breeding activities any impacts from light exposure will be limited to transient individuals only, and there will be no impacts at a population level.

Lighting will be limited to the minimum required for navigational and safety requirements, with the exception of emergency events. Impacts from routine light emissions on seabirds and migratory shorebirds will have no lasting effect. Receptor sensitivity of seabirds and migratory shorebirds is high (high value species), and therefore the Impact Significance Level of routine light emissions on seabirds and migratory shorebirds is **Slight (E).**

Marine Reptiles

A Desktop Lighting Assessment was performed by Pendoley (2020a, attached as Appendix K) to assess the potential impacts of vessel lighting from the Trunkline Project Area and the Borrow Ground Project Area. A 20 km buffer around vessel activities was considered in the assessment that may result in impacts to turtle behaviour based on recommendations proposed in the National Light Pollution Guidelines (Commonwealth of Australia (2020) and references therein).

Exposure of marine turtles to artificial light can result in changes to their natural behaviour. Witherington and Martin (2003) state that light pollution on nesting beaches is detrimental to marine turtles because it alters critical nocturnal behaviours, namely, how turtles choose nesting sites, how they return to the sea after nesting, how hatchlings find the sea after emerging from their nests and how they disperse once they are in the sea.

Although individuals undertaking internesting, migration, mating or foraging may occur within the operational areas, marine turtles do not use light cues to guide these behaviours. Further, there is no evidence, published or anecdotal, to suggest that internesting, mating, foraging or migrating turtles are impacted by light from offshore vessels. As such, light emissions from the vessels are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages.

Five species of marine turtle may occur in the trunkline and borrow grounds operational area: flatback, green, hawksbill, loggerhead and leatherback turtles.

Although CALM (1990) reports loggerhead turtle nesting activity on Cohen Island, Pendoley et al (2016) did not find any evidence of loggerhead nesting activity in over 20 years of track data. The northern most key loggerhead nesting areas include the North West Cape and Muiron Islands and any nesting activity by loggerhead turtles in the Dampier Archipelago will not represent significant rookeries for this species. No major leatherback turtle rookeries are known to occur in Australia, with scattered nesting reported in Queensland (Limpus & MacLachlan 1979, 1994; Limpus et al. 1984) and the Northern Territory (Hamann et al. 2006; Limpus & MacLachlan 1994) only. As such, loggerhead and leatherback turtles are not considered to be impacted by activities in the Project Area.

There are no sensitive marine turtle habitats near the Offshore Project Area. The closest known turtle nesting beach are the islands of the Dampier Archipelago, about 375 km from the Offshore Project Area. The marine turtle BIAs are predominantly in State waters with some overlap in Commonwealth waters. At the Offshore Project Area, marine turtles are unlikely to occur due to the deep waters (>950 m) and limited habitat for marine turtle foraging. However, they may occur offshore in small numbers.

The Trunkline Project Area and Borrow Ground Project Area overlaps internesting habitat critical and BIAs for the flatback turtle around the Dampier Archipelago and Montebello Islands, and internesting BIAs for green and hawksbill turtles around the Dampier Archipelago.

The Montebello Islands are important nesting beaches for flatback, green and hawksbill turtles (Pendoley et al., 2016), which are located >30 km away from the Trunkline Project Area. Given the significant distance of activities from nesting beaches, impacts to nesting, hatchling emergence or dispersal are not expected. While the Project Area does overlap internesting habitat critical, it is considered unlikely that internesting turtles will occur in the Trunkline Project Area off the Montebello Islands where water depths range from 46 m to 214 m based on the evaluation of internesting habitat preferences made by Pendoley (see Appendix K). Further, internesting behaviours are not likely to be impacted by lighting sources from the Project Area.

Flatback turtles generally demonstrate internesting displacement distances of 3.4 – 62 km from the nesting beach, typically confined to longshore movements in nearshore coastal waters or traveling between island rookeries and the adjacent mainland (Whittock et al. 2014). There is no evidence to date to indicate flatback turtles swim out into deep offshore waters during the internesting period. Incorporating tracking data, along with environmental variables, into a habitat suitability model, Whittock et al. (2016) defined suitable internesting habitat for Flatback turtles as water 0 – 16 m deep and within 5 – 10 km of the coastline, while unsuitable internesting habitat was defined as water >25 m deep and >27 km from the coastline (Whittock et al. 2016). Pendoley (2005) provides details of tracking data for green and hawksbill turtles nesting on Rosemary Island. Results suggested that nesting female hawksbill turtles remained within 1 km of nesting beaches on Rosemary Island (Pendoley, 2005). Female green turtles travelled greater distances, up to 5 km, but typically remained within shallow, nearshore waters between 0 and 10 m deep (Pendoley, 2005).

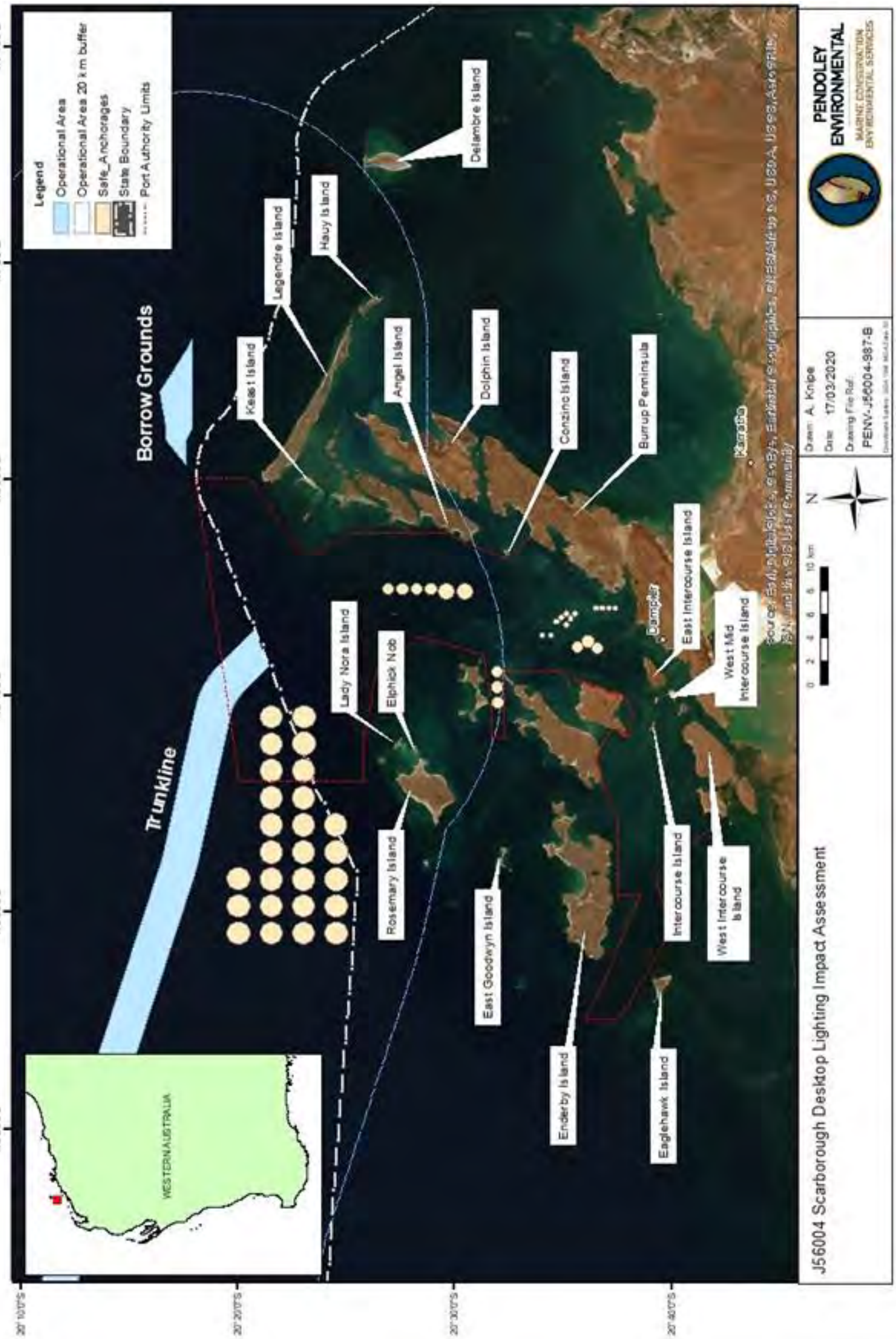


Figure 7-4: Islands of the Dampier Archipelago with Turtle Nesting Beaches and intersection with 20 km impact assessment buffer around the Project Area

Beaches of the Dampier Archipelago within 20 km of the Project Area, where turtle nesting has been identified, include Rosemary Island (14 km south of the Trunkline Project Area), Legendre Island (12 km east of the trunkline operational area and 6.6 km south of the Borrow Ground Project Area), which is considered jointly with Huay Island, and Angel Island (16 km SE of the trunkline operational area). The intersection of the 20 km buffer around the project area with the islands of the Dampier Archipelago is shown in Figure 7-4. Although Delambre Island is located 20 km SE of the borrow grounds operational area, the area within 20 km comprises rocky coastline unsuitable for turtle nesting. The sandy beaches where turtle nesting will occur at higher density are located more than 20 km from the project area (see Figure 7-4). Therefore, potential impacts to nesting habitat of Delambre Islands are not considered further.

Within the Dampier Archipelago, Rosemary Island has the most significant nesting beaches, determined as mean number of hawksbill, green and flatback turtle tracks per day (Pendoley et al 2016) and is recognised as an internationally significant rookery for hawksbill turtles (Limpus, 2009). On Rosemary Island, the majority of hawksbill nesting occurs on the northwestern beaches (K Pendoley, pers comm) with lower density flatback and green nesting occurring at beaches on the eastern end of the Island. An analysis of turtle track data from these beaches on Rosemary Island between 1990 and 2017 has been undertaken (Whiting, 2018). The analysis concluded that nest counts were dominated by hawksbill turtles (9860 nesting events, or 92.1%), with flatback and green nest counts at 366 (3.4%) and 478 (4.5%), respectively. These results corroborate other conclusions that the nesting population of hawksbill turtles at Rosemary Island is one of the largest populations in Australia and globally (Limpus, 2009).

Other islands also with moderate nesting activity (Table 7-6) for all three species, include Delambre Island, Enderby Island, Eaglehawk Island and Angel Island (Pendoley et al 2016). Although track data confirmed presence of flatback turtles only at Legendre Island (Pendoley et al., 2016), a tagging program conducted in 2008 demonstrated that flatbacks, hawksbill and green turtles nested in notable numbers at this island (Biota, 2009).Of these, only Delambre and Angel Islands are located within 20 km of the Project Area.

Table 7-6 Records of nesting behaviour of green, flatback and hawksbill turtles on islands of the Dampier Archipelago (CALM, 1990; Pendoley et al., 2016; Biota, 2009)

	Angel	Burrup Peninsula	Conzinc	Delambre	Dolphin	Eaglehawk	East Goodwyn	East Intercourse	Elphick Nob	Enderby	Hauy	Intercourse	Keast	Lady Nora	Legendre	Rosemary	West Intercourse	West Mid Intercourse
Trunkline Project Area distance (km)	17	22	22	38	17	41	25	32	14	27	27	34	13	12	12	14	36	35
Borrow ground Project Area distance (km)	21	26	28	20	16	57	41	42	32	43	14	45	10	28	6.6	40	48	46
Flatback	X	X	X	M	X	L	X	X	X	M	X	X	X	X	L	M	X	X
Green	-	X	-	L	X	L	-	X	-	L	X	-	-	-	X	M	X	-
Hawksbill	L	-	-	L	-	L	X	-	X	M	-	-	-	-	X	H	-	-

Key	
	Island is within 20 km of the operational areas plus nesting at ‘Low’ or above
	Island is within 20 km of the operational areas, but nesting is less than ‘Low’
	Island is more than 20 km from operational areas
-	Absent
X	Present
L	Low: 1 – 10 tracks per day
M	Moderate: 11 – 100 tracks per day
H	High: 101 – 500 tracks per day

Seasonality of nesting differs between flatback, green and hawksbill turtles;Table 7-7 provides a summary of the generalised seasonality across the North West Shelf region. Whiting (2018) provides defined seasonality specific nesting data for Rosemary Island (indicated in Table 7-7 by *) and found that hawksbill turtles having a much earlier peak (October/November) compared to flatback turtles (December/January peak). Seasonality for green turtles was not well defined from the available data (Whiting, 2018). Given the discrete duration of surveys at Legendre Island (Biota, 2009), insufficient data is available to refine seasonality for this location.

Table 7-7 Peak activity of nesting females and emerging hatchlings of green, flatback and hawksbill turtles in the NWS region

Species	Activity	Jul		Aug		Sep		Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun	
Green	Nesting																								
	Emergence																								
Hawksbill	Nesting							*	*	*	*														
	Emergence											*	*	*	*										
Flatback	Nesting											*	*	*	*										
	Emergence															*	*	*	*						

*Peak nesting reported for Rosemary Island (Whiting, 2018), peak hatchling emergence based on ~two month incubation (Commonwealth of Australia, 2017)

Adult Female Nesting

Adult female marine turtles return to land, predominantly at night, to nest on sandy beaches, relying on visual cues to select, and orient on, nesting beaches. That artificial lighting on or near beaches has been shown to disrupt nesting behaviour is relatively well documented (see Witherington and Martin, 2003 for review.). Beaches with light spill, such as those located adjacent to urban developments, roadways and piers, often have lower densities of nesting females compared to beaches with less development (Salmon, 2003; Hu et al., 2018). Further, on completion of laying, nesting females are thought to use light cues in order to return to open ocean, orientating towards the brightest light (Witherington and Martin, 2003). However, observations of nesting females and emerging hatchlings at the same beach showed that females were disorientated much less frequently than hatchlings (Witherington, 1992a) indicating that nesting females are less vulnerable to impacts of artificial light on sea finding.

Light modelling of representative project vessels has indicated that light will not be at levels likely to impact turtle behaviour at nesting beaches within 20 km of the Trunkline or Borrow Ground Project Areas (Pendoley 2020b, Appendix L). At the closest point to Rosemary Island (14 km), maximum radiance from the project vessels is equal to 0.003 (0.3%) that of a full moon. At the closest point to Legendre Island (6.6 km) the maximum radiance is equal to 0.005 (0.5%) that of a full moon. Therefore, modelled lighting levels at the nearest receiving beaches to project areas are well below levels where possible impacts to turtle behaviour can be expected (Table 7-2).

As such, the vessels light sources are not expected to discourage females from nesting, or effect nest site selection and sea-finding behaviour, and hence will not displace females from nesting habitat or effect biologically important behaviour. Since females are not considered highly vulnerable to disorientation due to artificial light and modelling has indicated light emissions will not be present at levels likely to cause impacts to turtles, the risk of artificial light preventing nesting behaviour at nesting beaches is not predicted.

Hatchling Emergence

Hatchling turtles emerge from the nest, typically at night (Mrosovsky & Shettleworth, 1968), and must rapidly reach the ocean to avoid predation (Salmon 2003). Hatchlings locate the ocean using a combination of topographic and brightness cues, orienting towards the lower, brighter oceanic horizon, and away from elevated darkened silhouettes of dunes and/or vegetation behind the beach (Pendoley & Kamrowski, 2015; Lohmann et al 1997; Limpus & Kamrowski 2013).

Artificial lights interfere with natural light levels and silhouettes disrupt hatchling sea finding behaviour (Withington and Martin, 2003; Pendoley & Kamrowski, 2015; Kamrowski, et al., 2014). Hatchlings may become disorientated - where hatchlings crawl on circuitous paths; or misorientated - where they move in the wrong direction, possibly attracted to artificial lights (Withington and Martin, 2003; Lohmann et al., 1997; Salmon 2003). Hatchling orientation has been shown to be disrupted by light produced at distances of up to 18 km from the nesting beach (Hodge et al. 2007, Kamrowski et al. 2014), although the degree of impact will be influenced by a number of factors including light intensity, visibility (a function of lamp orientation and shielding), spectral power distribution (wavelength and colour), atmospheric scattering, cloud reflectance, spatial extent of sky glow, duration of exposure, horizon elevation and lunar phase. Hatchlings disoriented or misoriented by artificial lighting may take longer, or fail, to reach the sea. This may result in increased mortality through dehydration, predation or exhaustion (Salmon and Witherington, 1995).

Disruption to orientation of emerging hatchlings has been found to occur most often during new moon phases and least frequent during full moon phases (Salmon & Witherington, 1995). Experiments showed that background illumination from the moon (while in phases closer to full moon), restored normal sea-finding behaviour in hatchlings but did not result in attraction in the direction of the moon. It was concluded that background illumination from the moon reduced light intensity gradients of artificial light, reducing, but not eliminating, its effect on hatchling orientation (Salmon & Witherington, 1995).

Light modelling of representative project vessels has indicated that light will not be at levels likely to impact turtle behaviour at nesting beaches within 20 km of the Trunkline or Borrow Ground Project Areas (Pendoley, 2020b, Appendix L). Given the predicted level of light emissions from project activities, the distance to turtle nesting habitat and the temporary nature of the trunkline installation and stabilisation activities, impacts to turtle hatchling sea-finding behaviour resulting from vessel lighting are not predicted.

Hatchling Dispersal

Once in nearshore waters, artificial lights can also interfere with the dispersal of hatchlings. Presence of artificial light can slow down their in-water dispersal (Witherington & Bjorndal, 1991; Wilson et al., 2018), increase their dispersion path, potentially depleting yolk reserves, or even attract hatchlings back to shore (Truscott et al., 2017). In addition to interfering with swimming, artificial light can influence predation rates, with increased predation of hatchlings in areas with significant skyglow (Gyuris 1994; Pilcher et al 2000). Since the nearshore area tends to be predator-rich, hatchling survival may depend on them exiting this area rapidly (Gyuris, 1994). Should this be the case, aggregation of predatory fish occurring in artificially lit areas (e.g. Wilson et al., 2019) may further increase predation of hatchlings.

An internal compass set while crawling down the beach, together with wave cues, are used to reliably guide them offshore (Lohmann & Lohmann 1992, Stapput & Wiltschko 2005; Wilson et al, submitted).

In the absence of wave cues however, swimming hatchlings have been shown to orient towards light cues (Lorne & Salmon 2007, Harewood & Horrocks 2008) and in some cases, wave cues were overridden by light cues (Thums et al. 2013; 2016; Wilson et al., 2018).

The speed and direction of at-sea dispersal is substantially influenced by currents; the offshore trajectory of flatback hatchlings at Thevenard Island was displaced by tidal currents that ran parallel to the beach, an effect that increased as the hatchlings moved further offshore (Wilson et al. 2018, 2019). However, when light was present this effect was diminished, showing that hatchlings actively swam against currents and towards the light source, which slowed their offshore dispersal from 0.5 m/s^{-1} when no light was present, to 0.35 - 0.44 m/s^{-1}, depending on the type of light (Wilson et al., 2018). Wilson et al (2018) demonstrated that when flatback hatchlings were within 150 m of the beach, they were able to swim against currents up to 0.3 m/s^{-1}.

These results suggest that hatchlings can move in any direction when their swimming speed is greater than the speed of the nearshore current, although the speed at which currents can no longer be overcome by hatchlings will be species specific and related to swimming speeds. The mean swimming of flatback hatchlings under natural light conditions (0.5 m/s^{-1}) were similar to speeds of green turtle hatchlings (0.49 $m.s^{-1}$) (Thums et al., 2016), both of which are greater that hawksbill turtle hatchlings (0.21 m/s^{-1}) (Chung et al, 2009). Given the similarities in swim speeds between flatback and green turtles, it is possible that green turtles will have the ability to swim against similar strength currents as reported for flatback turtles (0.3 m/s^{-1}). However, the slower swimming speeds recorded for hawksbill turtles suggest that current speeds at which hawksbill hatchlings could swim against would be weaker than 0.3 m/s^{-1}, though to what extent is currently unknown.

When tidal influences were considered, modelled currents around the Dampier Archipelago and Montebello Islands ranged from <0.1 to 0.5 m/s.-1, with the greatest proportion of records within the 0.1 – 0.2 m/s-1 range (RPS, 2019). These modelling results suggest that flatback and green turtle hatchlings may be able to swim against currents, for at least a proportion of the activity, should they be attracted to artificial light. Hawksbill turtles may be able to swim against currents at the lowest end of the predicted range, which is unlikely to comprise a significant proportion of the activity duration.

In the event that hatchlings are able to swim against current speeds, there is a risk that they could become entrapped in areas of vessel light spill. Project vessels may create light spill where lighting is required for safe visibility of overboard equipment such as the pipelay stinger, dredge suction pipes and crane movements. Wilson et al (2018) observed flatback hatchlings becoming entrapped in the light spill from a small survey vessel for up to 1 hour. Other reports of the duration of time in which hatchlings may be entrapped in direct light spill varies widely; while Thums et al. (2016) found that light trapping was very temporary (minutes), anecdotal observations of hatchlings entrapped by light spill from a pipelay vessel off Barrow Island found hatchlings remained within the light spill in the lee of the barge all night until dawn (K Pendoley pers obs 2003). It is possible that larger vessels, such as the pipelay vessel, provide shelter on the leeward side from tidal currents allowing hatchlings to remain in the light spill longer (K Pendoley pers obs 2003).

The majority of hatchlings emerging from nesting beaches of Rosemary Island are hawksbill turtles, which, given their swimming speeds, are considered less likely to swim against the predominant currents for a significant proportion of the activity duration. Further, the predominant current direction (E or W) are unlikely to carry hatchlings (of any species) from Rosemary Island towards an artificial light source in the Trunkline Project Area. At Legendre

Island, the predominant current direction (E or W) is unlikely to carry hatchlings in the direction of the Borrow Grounds Project Area. Should light emissions be at a level that results in attraction, green and flatback hatchlings may be able to swim against currents towards the vessel light sources. However, given that the vessels will only be present for approximately two hours at a time within the Borrow Grounds Project Area, any attraction will be temporary, and once vessels have left the Project Area, dispersing behaviour under would continue under natural conditions. Since the Trunkline Project Area is W of Legendre Island, it is possible that hatchlings could be carried towards vessels within this area. However, while not tested empirically due to the logistical constraints of tracking large numbers of hatchlings concurrently, the density of hatchlings will decrease with distance from the nesting beach as individuals disperse in open ocean (see ambient treatment results in Thums et al.,2016, Wilson et al., 2016, Wilson et al.,2019). Since the distance between Legendre Island and the Trunkline Project Area is 12 km, the number of hatchlings emerging from Legendre Island occurring within the Trunkline Project Area is likely be a small proportion of the total number emerging from the closest nesting beaches.

In the unlikely event that dispersing hatchlings from Rosemary Island or Legendre Island are carried by currents into the vicinity of the project vessels and become attracted to sources of artificial light, the impact will be temporary in that attraction will only occur during hours of darkness; following sunrise or the vessel departing the area, the attraction will cease hatchling dispersal will return.

Further, light modelling of representative project vessels has indicated that there will be separation between nesting beaches where hatchlings will emerge and the zone which artificial light may cause impacts to turtle behaviour (Pendoley 2020b, Appendix L). The separation between nesting beaches and areas where hatchlings may be attracted to vessel lighting is a minimum of 5 kms from the Borrow Ground Project Area and 12 kms from the Trunkline Project Area (Figure 7-1). Therefore, dispersing hatchlings would first need to move into the zone of elevated radiance before potential behavioural impacts could be considered credible.

Individual variability in swimming speed and direction, combined localised water movements and the continuously moving vessels, will also reduce the proportion of the total number of emerging hatchlings that could be attracted to the vessel light sources. Although attraction to light sources may have consequences at the individual level (e.g. energy depletion and increased predation risk), the numbers that could be impacted is highly unlikely to comprise a significant proportion of the annual number of hatchlings emerging from the nesting beaches.

Although disruption to hatchling dispersal behaviour is credible, following sunrise, any effect of the light sources on hatchlings will be eliminated allowing dispersal behaviour to resume. Attraction to light sources will not result in permanent displacement from their pelagic habitats.

Hatchlings emerging from nesting beaches of the Montebello Islands are expected to be carried east or west by the predominant current direction, and not in the direction of the Trunkline Project Area. Since the light sources are located more than 30 km from the nesting beaches, the risk of dispersing hatchlings becoming attracted to light sources in the operational area is not predicted.

Predicted Impact Summary

Turtles passing through the Offshore Project Area may temporarily alter their normal behaviour if attracted to the light from infrastructure. This impact could extend up to tens of kilometres away from the FPU or MODU which will be visible for up to 50 km during flaring and less than 30 km during routine operations (Figure 7-5). In such instances, the turtles would likely return to their normal behaviour once they have moved away from the area. There are no sensitive locations within 50 km therefore the impact from this source would be minor and short-term at the individual level. Given the wide migratory distribution (i.e. several hundred kilometres) of adult turtles outside of nesting season and their low-density presence within the Offshore Project Area, the attraction from direct lighting is expected to be minor and a temporary disruption to a small portion of the adult turtle population not affecting biologically important behaviours.

Vessel activities within the Trunkline Project Area are likely encounter similar distributions of turtles in offshore waters, except where aggregations are known to occur, such as BIAs or habitat critical (internesting buffer). While vessel lights may be visible to observers as a light point for up to 30 km (Figure 7-6), behavioural disturbance to turtles from lights within the Trunkline Project Area are expected to be localised (Figure 7-1) and temporary. These light sources are associated with particular activities and will not occur for the life of the project. Impacts will not occur to significant proportions of the populations of the species, nor result in the decrease of the quality of the habitat such that the extent of these species is likely to decline.There is no evidence, published or anecdotal, to suggest that internesting, mating, foraging or migrating turtles are impacted by light from offshore vessels. As such, light emissions from the vessels are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages.

A Desktop Lighting Assessment (Pendoley, 2020a, Appendix K) has been conducted for vessel activities within the Trunkline and Borrow Ground Project Areas, focusing on a 20km buffer zone. The assessment was supported by additional modelling of representative vessels involved in trunkline installation and stabilisation activities. The Trunkline Project Area and the Borrow Ground Project Area overlap with BIAs from the Montebello and Dampier Archipelgo islands representing nesting and internesting habitat.

Light modelling (Appendix L) of representative project vessels indicates that light levels at the nearest nesting beaches to the Projects areas is below thresholds where behavioural impacts are possible. Therefore, impacts to nesting female turtles including discouraging females from nesting, or effecting nest site selection and sea-finding behaviour are not predicted. Impacts to hatchling emergence including hatchling mis- or dis-orientation are also not predicted.

Impacts to hatchling dispersal resulting from vessel lighting are possible but will be limited by:

- Separation between nesting beaches that hatchlings commence dispersing from and the zone which modelling indicates impacts to turtle behaviour is possible (minimum 5 km from Legendre Island and 12 km from Rosemary Island).
- Nearshore currents would need to carry hatchlings into the zone where behavioural impacts from vessel lighting are possible. The density of hatchlings will decrease with distance from the nesting beach as individuals disperse in open ocean.
- Nearshore currents in the region must be weaker than hatchling swimming speed in order for hatchlings to override wave cues and successfully swim toward light sources.
- The potential for attraction to vessel lighting is expected to be overridden by the radiance of the moon during full moon periods.
- Project vessels within 20 kms of nesting beaches will be in the area temporarily (months) during trunkline installation and stabilisation, light emissions will not be ongoing.
- Vessels within the project areas will be continuously moving at varying speeds, particularly within the Borrow Ground Project Area where vessel presence is limited to approximately 2 hours at a time.
- Attraction to light sources will not occur during daylight and hatchling dispersal will resume upon sunrise.

Although attraction to light sources may have consequences at the individual level (e.g. energy depletion and increased predation risk), the numbers that could be impacted is likely to be low and undetectable against normal population fluctuations.

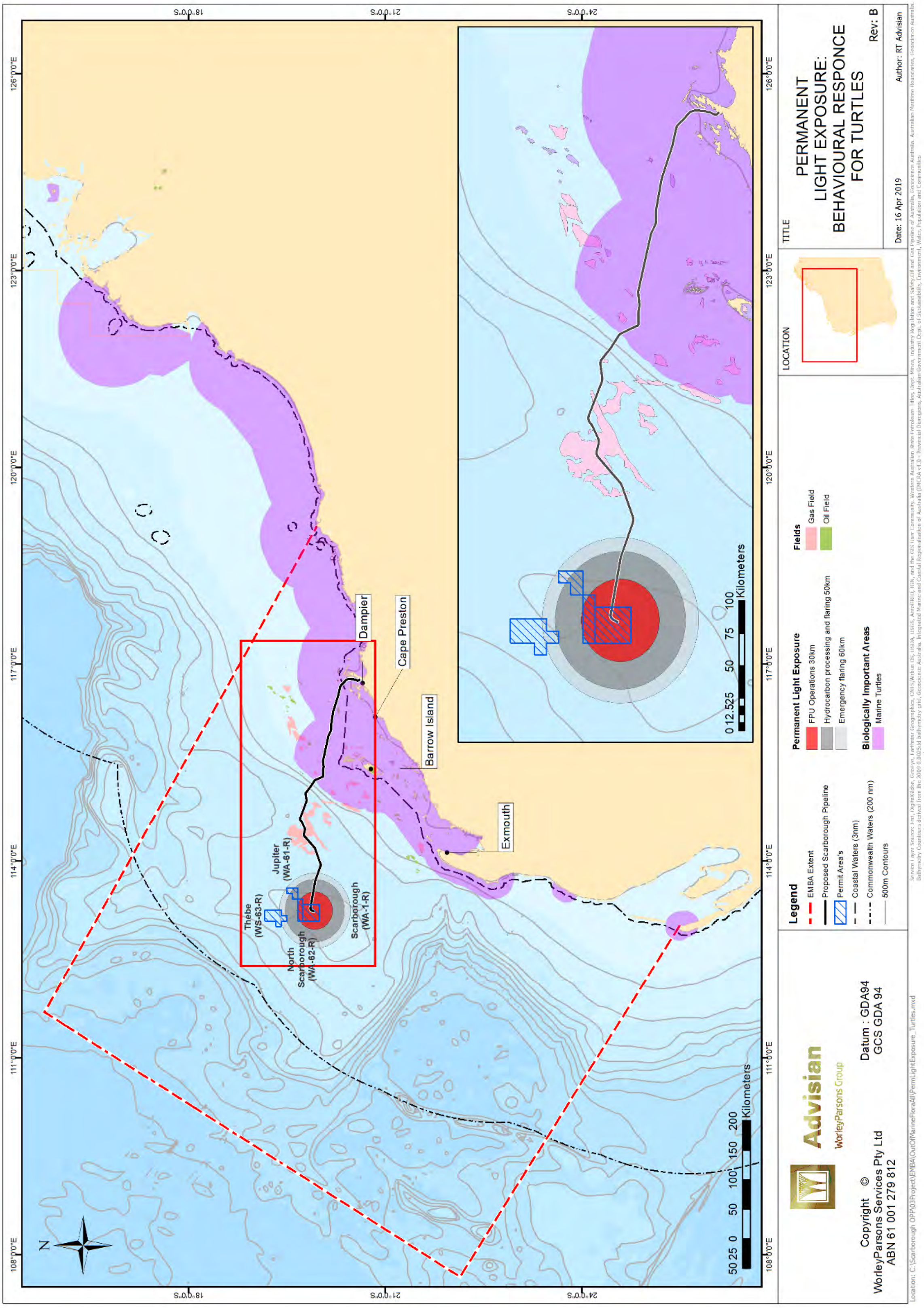


Figure 7-5: Predicted exposure area from continuous (red shading) and intermittent (grey shading) light sources associated with FPU operations and known biologically important areas for turtles

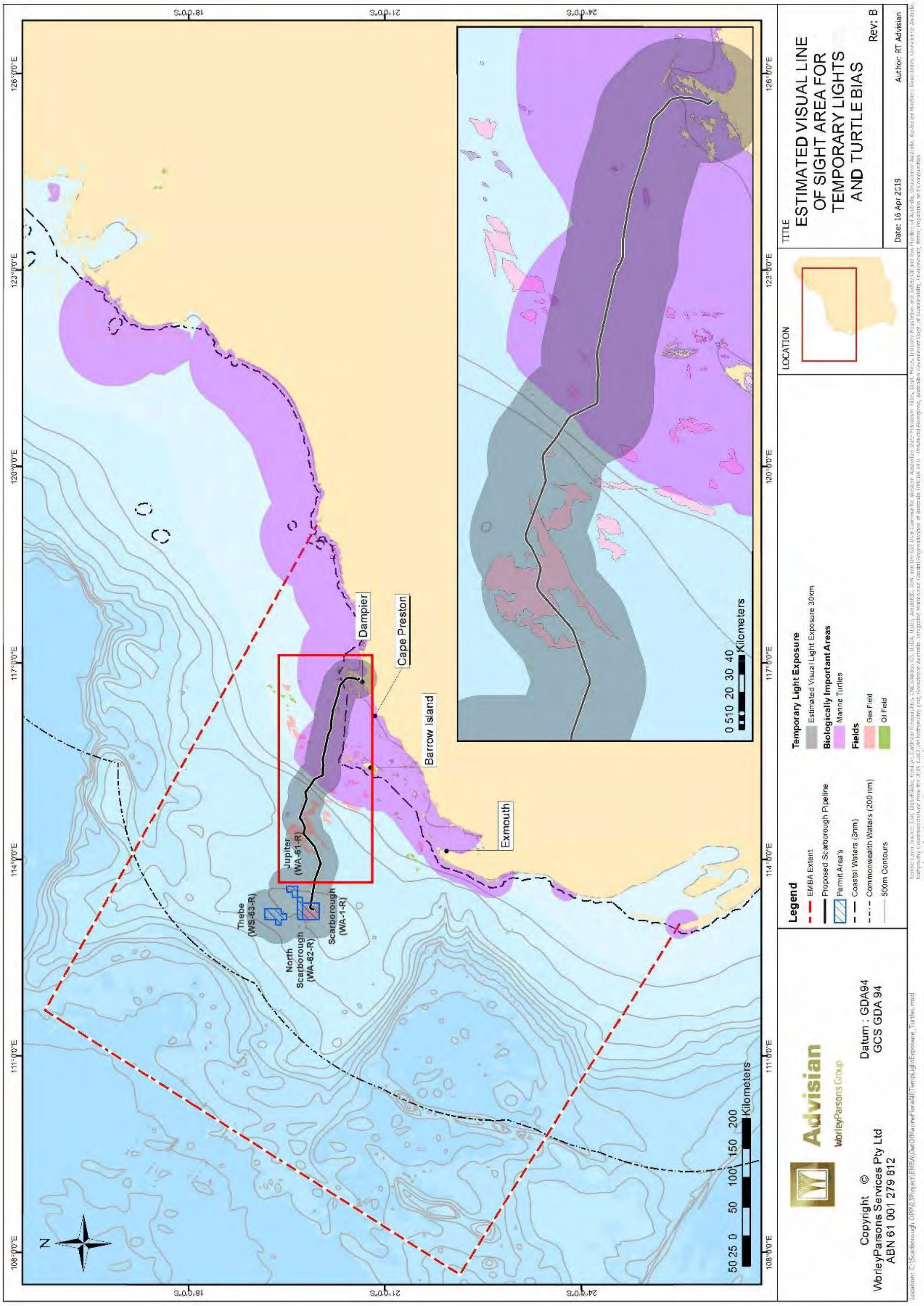


Figure 7-6:. Estimated visual line of sight area for temporary light sources associated with MODU and vessel operations, and known biologically important area for turtles.

Lighting will be limited to the minimum required for navigational and safety requirements, with the exception of emergency events.

In summary, impacts to turtles from light during installation, commissioning and operations are not anticipated to result in impacts at a population level, with the risk to the marine turtle populations from the proposed project considered to be low and undetectable against normal population fluctuations. Receptor sensitivity of marine reptiles is high (high value species), and therefore the Impact Significance Level of routine light emissions on marine reptiles is **Slight (E).**

7.1.1.3 Demonstration of Acceptability

Impact acceptability has been demonstrated for all impacts based on evaluation against the criteria described in Section 6.4.4. The outcomes of this determination are summarised below.

Principles of ESD

The Scarborough development is consistent with the relevant principles of ESD:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making

The Scarborough development will result in no significant impacts to receptors identified as potentially affected. Significant impact definitions for the potentially affected receptors are:

- Ambient Light
  - o To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.
- Seabirds and Migratory Shorebirds:
  - o To not have a substantial adverse effect on a population of seabirds or shorebirds, or the spatial distribution of the population.
  - o To not substantially modify, destroy or isolate an area of important habitat for a migratory species.
  - o To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.
- Marine Reptiles:
  - o To not have a substantial adverse effect on a population of marine reptiles or the spatial distribution of the population
  - o To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat, such that an adverse impact on marine ecosystem functioning or integrity results

- To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

Internal Context

The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards.

External Context

During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on affected receptors from routine light emissions.

Other requirements

The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES, specifically:

- Lighting will be limited the minimum required for navigational and safety requirements, with the exception of emergency events.
- Requirements of the Recovery plan for marine turtles in Australia (DoEE, 2017) and the relevant conservation advices for seabirds / shorebirds have been met. This includes to manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival, and for activities in BIAs to ensure that biologically important behaviour can continue.
- Requirements of the National Light Pollution Guideline for Wildlife (Commonwealth of Australia, 2020), including to undertake a project specific lighting assessment.

Acceptable Levels of Impact

Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013)).

Activities associated with the Scarborough development that cause routine light emissions are not inconsistent with recovery plans or wildlife conservation plans/advice that are in force for a potentially affected species, including the:

- Recovery plan for marine turtles in Australia (DoEE, 2017)

Impacts to turtles from artificial light are to be managed in accordance with the Recovery Plan for marine turtles in Australia (DoEE, 2017). The Recovery Plan identifies minimising light pollution and considering cumulative impacts on turtles from multiple sources of onshore and offshore light pollution (see Section 8).

Table 7-8 Assessment of Key Actions within the Recovery Plan for Marine Turtles in Australia (DoEE, 2017)

Relevant Recovery Plan Actions	Marine Turtle Impact Summary
Manage anthropogenic activities to ensure marine turtles are not	Vessel light sources are not expected to discourage females from nesting, or effect nest site selection, and hence will not displace females from nesting habitat.

Relevant Recovery Plan Actions	Marine Turtle Impact Summary
displaced from identified habitat critical to the survival	There is no evidence to suggest that internesting females are impacted by artificial light and, therefore, internesting females will not be displaced from internesting habitat.
Manage anthropogenic activities in Biologically Important Areas to ensure that biologically important behaviour can continue	Vessel light sources are not expected to discourage females from nesting, or effect nest site selection and sea-finding behaviour, meaning that impacts to nesting behaviour is not expected to occur. There is no evidence, published or anecdotal, to suggest that internesting turtles are impacted by light from offshore vessels and, therefore, changes to internesting behaviour are not expected to occur. Disruption to hatchling emergence is not expected to occur based on modelled levels of light likely to be received at the nearest nesting habitat to the Project Areas. While disruption to hatchling dispersal behaviour (e.g. attraction to or trapping by light at a vessel) of an insignificant proportion of the annual number of hatchlings emerging from a given beach is credible, following sunrise, any effect of the light sources on hatchlings will be eliminated allowing dispersal behaviour to resume. Further, the potential for hatchling dispersal behaviour to be impacted increases with distance to shore and separation from areas where received lighting may affect turtle behaviour. While behavioural impacts to dispersing turtle hatchlings are credible, under a conservative assessment, it is not expected these impacts will impede recovery of the relevant green (G-NWS), flatback (F-Pil) or hawksbill (H-WA) genetic stocks, or result in a decreasing trend in numbers/abundance and, therefore, the project will not impact the measure of success criteria of the Recovery Plan (DoEE, 2017).

Statement of Acceptability

Based on an assessment against the defined acceptable levels, the impacts on affected receptors from Routine Light Emissions is considered acceptable, given that:

- the activity is aligned with the relevant principles of ESD.
  - Behavioural disturbance to birds from light is expected to be localised and temporary, occurring on an individual level only given the transient nature of birds within the Project Area, and distance from sensitive areas.
  - Activities within Biologically Important Areas and habitat critical for the survival of marine turtles are of temporary duration.
  - Vessel light sources are not expected to discourage females from nesting, or effect nest site selection, and hence will not displace females from nesting habitat.
  - There is no evidence to suggest that internesting females are impacted by artificial light and, therefore, internesting females will not be displaced from internesting habitat.
  - Disruption to hatchling emergence is not expected to occur based on modelled levels of light likely to be received at the nearest nesting habitat to the Project Areas.
  - While behavioural impacts to dispersing turtle hatchlings are credible, under a conservative assessment, it is not expected these impacts will impede recovery of the relevant green (G-NWS), flatback (F-Pil) or hawksbill (H-WA) genetic stocks, or result in a decreasing trend in numbers/abundance.

   - Given the wide migratory distribution of adult turtles outside of nesting season and their low-density presence within the Project Area, the attraction from direct lighting is expected to be minor and not a disruption to the adult turtle population.
- the proposed controls are consistent with Woodside's internal policies, procedures and standards
- feedback from stakeholders has been taken into consideration
- legislative requirements/industry standards have been adopted
- the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices:
   - Activities associated with the Scarborough development that cause routine acoustic light emissions are not inconsistent with the Recovery plan for marine turtles in Australia (DoEE, 2017).
   - A project specific lighting assessment has been conducted in accordance with the National Light Pollution Guidelines for Wildlife (Commonwealth of Australia, 2020).
- the predicted level of impact is at or below the defined acceptable levels for all receptors.

Environmental Performance Outcomes

To manage impacts to affected receptors to at or below the defined acceptable levels the following EPO have been applied:

EPO 1.1: Undertake the Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.

EPO 1.2: Undertake the Scarborough development in a manner that will not have a substantial adverse effect on a population of seabirds or shorebirds, or the spatial distribution of the population.

EPO 1.3: Undertake the Scarborough development in a manner that will not substantially modify, destroy or isolate an area of important habitat for a migratory species.

EPO 1.4: Undertake the Scarborough development in a manner that will not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

EPO 1.5: Trunkline installation and borrow ground activities will be undertaken in a manner that aims to avoid the displacement of marine turtles from important foraging habitat or from habitat critical during nesting and internesting periods.

7.1.1.4 Summary of the Impact Assessment

Table 7-9 provides a summary of the risk assessment and acceptability for impacts from routine light emissions on receptors.

Table 7-9: Summary of impacts, management controls, impact significance ratings and EPOs for routine light emissions

Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity level	Magnitude	Impact significance level	Acceptability
Ambient light	Change in ambient light	**EPO 1.1**: Undertake the Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 1.2:** Undertake the Scarborough development in a manner that will not have a substantial adverse effect on a population of seabirds or shorebirds, or the spatial distribution of the population. **EPO 1.3:** Undertake the Scarborough development in a manner that will not substantially modify, destroy or isolate an area of important habitat for a migratory species. **EPO 1.4**: Undertake the Scarborough development in a manner that will not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species. **EPO 1.5**: Trunkline installation and borrow ground activities will be undertaken in a manner that aims to avoid the displacement of marine turtles from important foraging habitat or from habitat critical during nesting and internesting periods	**CM1:** Lighting will be limited the minimum required for navigational and safety requirements, with the exception of emergency events.	Low value (open water)	Slight	Negligible (F)	Acceptable
Seabirds and migratory shorebirds	Change in fauna behaviour			High value species (e.g. wedge-tailed shearwater)	No lasting effect	Slight (E)	Acceptable
Marine reptiles				High value species (e.g. flatback turtle)	No lasting effect	Slight (E)	Acceptable

7.1.2 Routine Atmospheric Emissions affecting Air Quality

Atmospheric emissions affecting air quality refer to the discharges to the atmosphere of gases and particulates from an activity or from a facility or piece of machinery which have a recognised adverse effect on human health and/or flora and fauna. The main emissions responsible for these effects include carbon monoxide (CO), oxides of nitrogen (NO_x), sulphur dioxide (SO_2), particulate matter less than 10 microns (PM10), non-methane volatile organic compounds (VOCs) and BTEX (benzene, toluene, ethylbenzene and xylenes), which are specific VOCs of interest.

7.1.2.1 Sources of the Aspect

Atmospheric emissions affecting air quality will be produced in all phases of the development of Scarborough, as a result of:

- FPU operations
- MODU operations
- vessel operations
- well flowback

FPU, MODU and Vessel Operations

<u>Atmospheric Emissions</u>

MODUs, FPUs and vessels are powered via the use of on-board generators. Operations require the use of diesel to undertake daily activities functions such as transport, desalination, sewage treatment, etc. Emissions produced during vessel, FPU and MODU operations will be emitted to the atmosphere during all project phases.

Atmospheric emissions generated during these operations will include SOx, NOx, particulates and Volatile Organic Compounds (VOCs). SOx and particulate matter emissions are heavily influenced by the fuel used and its relative sulphur content, MGO having a lower sulphite content than marine diesel oil (MDO) or heavy fuel oil (HFO).

NO_2 emissions from routine MODU and production platform power generation for an offshore project were modelled previously by another operator (BP, 2013). NO_2 is the focus of the modelling, on account of the larger predicted emission volumes compared to the other pollutants, and the potential for NO_2 to impact on human health (as a proxy for environmental receptors). The model demonstrated that atmospheric emissions generated by MODU operations may increase ambient NO_2 concentrations by 1 µg/m³ (0.001 ppm) within 10 km of the source and 0.1 µg/m³ (0.0001 ppm) within 40 km of the source. This represents an increase of 2% over typical background concentrations within 40 km, with air quality remaining well below the WHO air quality guideline for NO_2 of 40 µg/m³ annual mean. As NO_2 is the main emission that poses a threat to receptor health, it is considered conservative to use the above studies to justify potential impacts to receptors. As such, studies into the attenuation of other gasses emitted are not evaluated.

Due to the similar functions performed by the production platforms compared to FPUs, the use of this study to predict NO_2 emission attenuation for FPU and MODU operations associated with the development of Scarborough is considered appropriate. MODU and FPU operations will be limited to the Offshore Project Area. Vessels will operate within the Offshore Project Area, the Borrow Grounds Project Area and the Trunkline Project Area although emissions produced from such sources will be substantially less than that of the MODU or FPU.

Well Flowback and Hydrocarbon Processing

Atmospheric Emissions

Wellbore flowback will occur following wellbore clean-up and will result in the venting and/or flaring of hydrocarbons. During wellbore flowback, initial unloading of the well displaces the well fluids (i.e. suspension/completion brine). These are discharged overboard as the gas content makes it too dangerous to filter or treat. Once the brines are unloaded, the gas stream is sent to flare via the production separator. Well flowback activities will be undertaken during drilling operations at the beginning of the proposed development of Scarborough, and for future phases. Well flowback may occur at any time throughout the drilling of wells.

In addition to flowback activities, flaring may occur during hydrocarbon processing from the FPU, where flare stacks are used for burning off flammable gas released by pressure release valves. Flaring most often takes place during start-ups and shutdowns or in emergency events. If flow rate is not sufficient to sustain a flare for MODU operations, venting will occur. Some unburnt fugitive emissions may also be released. Depending on the process selected (venting or flaring) the emissions may vary from methane to carbon dioxide, NO_x, etc. Flaring activities may take place anytime during the drilling and production phase of the project.

During the study undertaken by (BP 2013), NO_2 emissions from flaring were modelled for clean-up flaring on MODUs at a rate of 250 MMscfd for up to two days and emergency flaring on production facilities at full load for up to an hour. This model showed that short-term concentrations of NO_2 from flaring increased by up to about 60 µg/m³ (0.06 ppm) within 10 km of the source and increase of up to 20 µg/m³ (0.02 ppm) at about 40 km from the source. For emergency flaring, modelling showed that NO_x concentrations may increase by up to 10 µg/m³ (0.01 ppm) at 10 km from the source and 4 µg/m³ (0.0004 ppm) at about 40 km from the source. These levels are intermittent and temporary and do not result in exceedances above the WHO air quality guideline for NO_2 of 40 µg/m³ annual mean.

Planned flaring during wellbore clean-up and flowback and hydrocarbon processing will occur at a at typical levels per flaring event therefore the study undertaken by BP (2013) is an appropriately conservative indicator of attenuation of flaring emissions. As stated above, studies into the attenuation of other gasses is not discussed due to the nature of potential impacts of NO_2 to receptors.

7.1.2.2 Impact or Risk

Atmospheric emissions from the sources described above have the potential to result in the following impact(s):

- change in air quality.

As a result of a change in air quality, further impacts may occur, which include:

- injury/mortality to fauna
- climate change (see Section 7.1.3)
- change in aesthetic value.

Change in Air Quality

Atmospheric emissions may result in a decline in local air quality, within the immediate vicinity of the emissions source. As described above, produced emissions throughout the project will include SO_2, NOx, ozone depleting substances, CO_2, particulates and Volatile Organic Compounds (VOCs). Emissions from engines, generators and deck equipment may be toxic, odoriferous or aesthetically unpleasing, and will result in a reduction in air quality.

Injury/Mortality to Fauna

Atmospheric emissions can cause direct impacts to fauna, if they are present in the immediate vicinity of significant releases. Birds, for example, have been shown to suffer respiratory distress and illness when subjected to extended duration exposure to air pollutants (Sanderfoot and Holloway, 2017). Given that atmospheric emissions will be typical of other operating facilities and equipment, and that fauna numbers will be low at the point of discharge. Injury or mortality to fauna a result of atmospheric discharges is negligible and has not been evaluated further.

Change in Aesthetic Value

Atmospheric emissions have the potential to introduce odour and visual amenity issues which can result in changes to the aesthetic value of an area.

Scarborough is located in the open ocean and is well-removed from nearest residential or sensitive populations of the WA coast, with limited interaction with the regional airshed.

Given the distance from shore of the Offshore Project Area (375 km), the potential for a change in air quality from atmospheric emissions associated with Scarborough resulting in a change to aesthetic value for tourism/recreation or settlements is not considered to be credible. As the Offshore Project Area is not directly visible from the nearest landfall, the flare and potential smoke resulting from emissions will not impact visual amenity, and no impacts to visual amenity for settlements are expected. Therefore, a change in aesthetic value from atmospheric emissions associated with Scarborough is negligible and has not been evaluated further.

Receptors Potentially Impacted

Routine atmospheric emissions have the potential to change the local air quality as shown in Table 7-10.

Table 7-10: Receptor/impact matrix after evaluation of context

	Receptor	
Impacts	*Air Quality*	*Climate*
Change in air quality	✓	

Detailed Impact Evaluation

Air Quality

The air quality within the Scarborough Area is typical of an unpolluted tropical offshore environment and the ambient air quality in the offshore NWMR will be of high quality. Atmospheric emissions from Scarborough have the potential to result in a localised reduction in air quality in the immediate vicinity of the release point.

Predicted Impact Summary

Emissions will be limited through the compliance of vessels and MODU with Marine Order 97 (Marine Pollution Prevention – Air Pollution). Additionally, flaring will be optimised to allow for the safe and economically efficient operations of the facility.

Impacts from routine atmospheric emissions effecting air quality will be slight. Receptor sensitivity of air quality is low (low value, open water), and therefore Impact Significance Level of routine atmospheric emissions effecting air quality on air quality is **Negligible (F).**

7.1.2.3 Demonstration of Acceptability

Impact acceptability has been demonstrated for all impacts based on evaluation against the criteria described in Section 6.4.4. The outcomes of this determination are summarised below.

Principles of ESD

The Scarborough development is consistent with the relevant principles of ESD:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making

The Scarborough development will result in no significant impacts to receptors identified as potentially affected. Significant impact definitions:

- Air Quality
    - To not result in a substantial change in air quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.

Internal Context

The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards.

External Context

Stakeholder comment has been submitted with respect to routine atmospheric emissions, or potentially impacted receptors. Woodside has considered these comments and responded accordingly as outlined in .

Other requirements

The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES.

Acceptable Levels of Impact

Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013)).

Statement of Acceptability

Based on an assessment against the defined acceptable levels, the impacts on affected receptors from Routine Atmospheric Emissions affecting Air Quality is considered acceptable, given that:

- the activity is aligned with the relevant principles of ESD.

  - The volumes of routine atmospheric emissions from Scarborough will be relatively low in comparison to existing vessels and facilities on the North West Shelf.
  - There are currently very low background levels of pollutants in the existing environment.
  - The location of Scarborough offshore facilities is at a significant distance from sensitive receptors.
- the proposed controls are consistent with Woodside's internal policies, procedures and standards
- feedback from stakeholders has been taken into consideration
- legislative requirements/industry standards have been adopted
- the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices
- the predicted level of impact is at or below the defined acceptable levels for all receptors.

Environmental Performance Outcomes

To manage impacts to affected receptors to at or below the defined acceptable levels the following EPO have been applied:

EPO 2.1: Undertake the Scarborough development in a manner that will not result in a substantial change in air quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.

7.1.2.4 Summary of the Impact Assessment

Table 7-11 provides a summary of the risk assessment and acceptability for impacts from atmospheric emissions affecting air quality on receptors.

Table 7-11: Summary of impacts, management controls, impact significance ratings and EPOs for atmospheric emissions affecting air quality

Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity level	Magnitude	Impact significance level	Acceptability
Air quality	Change in air quality	**EPO 2.1:** Undertake the Scarborough development in a manner that will not result in a substantial change in air quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	**CM2:** Vessel and MODU compliance with Marine Order 97 (Marine Pollution Prevention – Air Pollution), including: • International Air Pollution Prevention (IAPP) Certificate, required by vessel class • use of low sulphur fuel when available • Ship Energy Efficiency Management Plan (SEEMP), where required by vessel class • onboard incinerator to comply with Marine Order 97. **CM3:** Optimisation of flaring to allow the safe and economically efficient operation of the facility.	Low value (open water)	Slight	Negligible (F)	Acceptable

7.1.3 Routine Greenhouse Gas Emissions

This chapter details the assessment of direct greenhouse gas (GHG) emissions from Scarborough and the indirect GHG emissions from the onshore processing of Scarborough LNG and third party consumption of Scarborough gas. This assessment includes the contribution to global GHG emissions and the potential impacts of climate change on sensitive receptors, including matters of national environmental significance, within Australian jurisdictions.

Climate change is caused by the concentration of GHG emissions in the global atmosphere. As explained below, natural gas from Scarborough is expected to support an overall reduction in net global atmospheric concentration by displacing more emissions-intensive fuels.

It is important to acknowledge that climate change impacts cannot be directly attributed to any one project, as they are instead the result of GHG emissions, minus GHG sinks, that have accumulated in the atmosphere since the industrial revolution started. This means there is no direct link between GHG emissions from Scarborough and climate change impacts.

The more relevant consideration is the contribution that a project makes to net emissions, as it is the overall global atmospheric concentration of emissions that causes climate change. Scarborough gas processing and consumption results in GHG emissions, but these emissions are expected to displace emissions from other sources. If the use of Scarborough gas displaces other sources of gas, then the net emissions impact of Scarborough will be minimal. In the more likely scenario where the use of Scarborough gas displaces energy from more emissions-intensive fuels, then there will be a net reduction in global GHG emissions.

A reduction in global GHG emissions leading to a reduction in net global atmospheric GHG concentrations is required to minimise the risk of temperature increases caused by atmospheric GHGs absorbing infrared radiation and trapping energy as heat. This increase in temperature is predicted to have an adverse effect on natural ecosystems as a result of reductions in the bioclimatic range within which a given species or ecological community exists.

The main categories of human-induced activities that emit GHGs are:

- energy
- industrial processes including use of synthetic gases
- waste emissions
- agriculture
- land use, land use change and forestry.

Ecosystems which are particularly susceptible to adverse effects of climate change include alpine habitats, coral reefs, wetlands and coastal ecosystems, polar communities, tropical forests, temperate forests and arid and semi-arid environments (Department of the Environment and Energy, 2019). In Australia, the most affected ecosystems include coral reefs, alpine regions, rainforests, arid and semi-arid environments, mangroves, grasslands, temperate forests and sclerophyll forests. Future climate change (increased temperature and decreased, but more variable, rainfall) has the potential to have a range of impacts on ecological factors and threaten biodiversity in the Australian Mediterranean ecosystem (CSIRO, 2017).

As already discussed, climate change impacts upon Australian receptors cannot be directly causally linked to Scarborough but are instead the result of the accumulation of GHG emissions in the atmosphere. The accumulation of GHG emissions in the atmosphere is, in turn, influenced by global energy demand and the composition of the global energy mix. It is, therefore, relevant to understand that the crucial role that natural gas can play in supporting the transition to lower-carbon energy is expected to underpin strong demand for natural gas in the decades ahead. Scarborough does not create this demand but can contribute to meeting it. The natural gas that can be produced from the

Scarborough reservoir is a fraction of what will be needed to make up the significant global shortfall that the International Energy Agency (IEA) (2020) has identified by comparing global gas demand in the World Energy Outlook Sustainable Development Scenario (SDS) to current and predicted supply.

The IEA has highlighted the role of gas in enabling the energy transition, reporting that "global energy-related CO_2 emissions flattened in 2019 following two years of increases. This resulted mainly from a sharp decline in CO_2 emissions from the power sector in advanced economies, thanks to the expanding role of renewable sources (mainly wind and solar PV), fuel switching from coal to natural gas, and higher nuclear power output" (https://www.iea.org/articles/global-co2-emissions-in-2019). This demonstrates the contribution gas is making to lowering global GHG emissions and net atmospheric concentrations by providing a dispatchable, transportable energy source to replace higher carbon-intensive fuels, such as coal, and supporting cheap renewables. As Chief Scientist Alan Finkel has noted, "natural gas is already making it possible for nations to transition to a reliable, and relatively low emissions, electricity supply" (https://www.chiefscientist.gov.au/news-and-media/national-press-club-address-orderly-transition-electric-planet).

For the foreseeable future, the total life cycle impact of gas, including Scarborough gas, is expected to result in lower net global atmospheric concentrations of GHGs than would otherwise have been the case. This benefit is enhanced if the emissions associated with Scarborough are minimised, as outlined in Section 4.5.4.1 which includes a range of measures to manage and mitigate direct GHG emissions from Scarborough. This expands on measures that will be undertaken to offset reservoir CO_2 emissions.

The lifecycle impact of gas is well-documented and understood by a range of forecasters, who expect strong demand, particularly as the world increases its efforts to decarbonise energy supply (e.g. the International Energy Agency's SDS). However, Woodside recognises the inherent uncertainty in the outcomes of such energy mix forecasts and in the future evolution of global policy responses to climate change. In light of this, a suite of management measures to address uncertainty is outlined later in this chapter.

In summary, the expected role of Scarborough gas in reducing net global atmospheric concentrations by displacing more emissions-intensive fuels further demonstrates the acceptability of Scarborough. While Woodside is not in a position to control Scarborough Scope 3 emissions, it is committed to implementing a range of initiatives to influence the transition to a low carbon economy. These measures (outlined later in this section) reflect Woodside's level of operational control over these emissions.

7.1.3.1 Sources of the Aspect

Direct GHG emissions attributed to Scarborough will result from:

- FPU operations
- MODU operations
- vessel operations
- well flowback

Indirect GHG emissions attributed to Scarborough will result from:

- hydrocarbon processing (onshore)
- third party transport, regassification, distribution and combustion by the end user

Greenhouse Gas Accounting Principles

GHG emissions are typically characterised by reference to the GHG Protocol Corporate Standard. Originally published in 2001, the GHG Protocol represents a collaboration between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), with the objective of developing an international standard for corporate GHG accounting and reporting. One of the most important outcomes of developing the Protocol has been the widespread recognition of a high-level emissions classification scheme that allows organisations and industries to better define key focus areas for abatement activities. This scheme has been adapted and deployed by national and local regulators and represents a globally accepted subdivision of GHG emissions for evaluation and reporting purposes. The GHG Protocol is aligned to the definitions for Scope 1 and Scope 2 emissions as defined by the *National Greenhouse and Energy Reporting Regulations 2008 (Cth)*.

Direct emissions are most commonly associated with the combustion of fossil fuels manufacturing processes, transportation and intentional or unintentional GHG ('fugitive') emissions. Indirect emissions are most commonly associated with the use of energy in another part of the reporting entity's value chain.

In this context, the GHG Protocol emissions classification scheme is defined in terms of Scope as shown in Figure 7-7.

Emissions type	Scope	Definition	Examples
Direct emissions	Scope 1	Emissions from operations that are owned or controlled by the reporting company	Emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.; emissions from chemical production in owned or controlled process equipment
Indirect emissions	Scope 2	Emissions from the generation of purchased or acquired electricity, steam, heating, or cooling consumed by the reporting company	Use of purchased electricity, steam, heating, or cooling
	Scope 3	All indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions	Production of purchased products, transportation of purchased products, or use of sold products

Figure 7-7: GHG protocol emissions classification scheme

Emissions Classification

Based on the GHG Protocol's emissions classification scheme, the nature and origin of the main sources of GHG emissions from and associated with Scarborough are shown in Table 7-12. GHG sources that are not part of the proposed offshore development (e.g. onshore processing emissions) are included for completeness.

Table 7-12: Classification of GHG emissions according to the GHG Protocol

Description	Location	Jurisdiction	Emissions Source/Process	Scope
Construction & Installation	Upstream	Commonwealth	Indirect GHG emissions generated from activities associated with construction, installation and commissioning* of upstream infrastructure to	Scope 3

Description	Location	Jurisdiction	Emissions Source/Process	Scope
			process Scarborough gas and operations (by third parties)	
Processing	Upstream	Commonwealth	Direct emissions from combustion of hydrocarbon-based fuels required for processing, compression of hydrocarbon gas on the FPU prior to pipeline export and other operational activities	Scope 1
	Onshore	State	Indirect GHG emissions from venting of reservoir CO_2 extracted from the gas exported from the FPU and vented from downstream processing	Scope 3**
	Onshore	State	Indirect emissions from combustion of hydrocarbon-based fuels required for processing of hydrocarbon gas downstream prior to export	Scope 3**
Third Party Consumption	Transit	Subject to consumer location	Indirect emissions from transportation of products to the markets into which they will be sold, including regasification and distribution of LNG in customer markets	Scope 3
	Market	Subject to consumer location	Indirect emissions from combustion of products as part of power generation and other energy solutions within final market environment	Scope 3

Woodside will actively manage and mitigate Scope 1 GHG emissions associated with Scarborough, in accordance with relevant legislation and minimise emissions to ALARP. Examples of how this is being achieved for the FPU are described in Section 4.5.4.1, Energy Efficiencies and Section 7.1.3.6, Greenhouse Gas Management and Mitigation.

GHG emissions associated with onshore processing of Scarborough gas are to be managed separately under relevant onshore environmental approvals, as further described in section 7.1.3.6 for the Pluto LNG Facility and Karratha Gas Plant.

GHG emissions arising from third party consumption of Scarborough gas along with other feed sources are to be managed and mitigated through relevant domestic and international emissions control frameworks. In that regard, all likely target markets for Scarborough domestic gas and LNG have ratified the Paris Agreement. As such, they have agreed to several global targets, including to keeping "global average temperature to well below 2°C above pre-industrial levels" and to set national targets relating to their own emissions. For many countries, greater use of natural gas (both as a lower carbon fossil fuel, and as dispatchable power source to partner with renewables) is likely to be an important option. The IEA's Sustainable Development Scenario, which is aligned with a "well below 2°C" goal, includes significant additional gas supply. Further, as identified above, while Woodside is not in a position to control emissions associated with third party consumption of Scarborough gas, it is committed to support a range of initiatives associated with the transition to a low carbon economy.

7.1.3.2 GHG emissions estimates

Forecast GHG emissions for Scarborough based on the GHG Protocol emissions classification scheme have been estimated, based on the current level of development definition and assumptions regarding commercial arrangements, anticipated controls and inputs associated with the nature of the feed gas and the scale, efficiency, interaction and complexity of the extraction, processing, anticipated production and compression of the product stream.

Key assumptions relate to:

- the timing and phasing of production well commissioning and start-up

- the expected average and maximum production rates from those wells and its decline over life of field
- the type and reliability of equipment used to process Scarborough gas

Given that GHG emission estimates are subject to a range of variables that may change, a range of scenarios have been presented. Explanations for these scenarios are presented below in Table 7-13

Table 7-13: Description of scenarios presented for Scarborough GHG emissions estimates

Scenario	Description
Scope 1	
Annual	Average (mean) GHG emissions produced during processing of Scarborough[1]
Total expected field life	Upstream GHG emissions over expected field life, using mid case reservoir performance estimates and production profile
Scope 3: Onshore Processing (e.g. Pluto and Karratha Gas Plants)	
Annual	Average (mean) GHG emissions from downstream processing of Scarborough gas based on the current rate of Scarborough gas expected to be processed onshore[2] and published Pluto/KGP emissions intensity[3]
Total expected field life	Total downstream GHG emissions from processing of Scarborough gas, based on the current rate of Scarborough gas expected to be processed onshore and published Pluto/KGP emissions intensity. A duration corresponding to the total expected field life of Scarborough has been applied.
Scope 3: Customer Use and Transport	
Annual	Indicative annual GHG emissions produced by product transport, regasification, distribution and combustion by customers using published emissions factors and expected annual production rate of LNG and Domgas
Total expected field life	Indicative GHG emissions over life of field produced by product transport, regasification, distribution and combustion by customers using published emissions factors and expected annual production rate of LNG and Domgas

[1] "Scarborough" is inclusive of Thebe and Jupiter reservoirs.
[2] The proportion of gas from Scarborough reservoirs and Pluto, Xena or other reservoirs processed at onshore facilities will vary over time, but the total gas and emissions will remain within limits set by relevant onshore approvals.
[3] Publicly available Pluto and NWS emissions intensity values are used to describe the downstream GHG emissions from onshore processing of Scarborough gas

Whilst CO_2 accounts for the majority of GHG emissions associated with Scarborough, other GHGs will be produced across the value chain, including methane (CH_4) and nitrous oxide (N_2O). All estimates for GHG include both methane and nitrous oxide, unless otherwise stated. The GWP adopted to determine the amount of CO_2-e contributed from both CH_4 and N_2O aligns to the National Greenhouse and Energy Reporting Regulations (NGER) 2008, which at time of writing reflects the IPCC's Fourth Assessment Report.

Scope 1 emissions

GHG emissions associated with gas extraction, processing and compression activities are typically from three key sources: fuel combustion, flaring and fugitive emissions.

<u>Methodology</u>

Fuel is used to power export compression and associated processing and utilities. An assessment of the quantity of fuel gas required to power Scarborough facilities has been completed. This assessment is based on the estimated efficiency of the equipment that has been selected to provide compression power, electricity generation and heat, which are subject to change. The power and heat demand of the system has been estimated based on the estimated compression demand, electrical load list demand and heating system demand. Using the expected composition of the fuel gas, an emissions factor has been developed in accordance with NGERs Method 2.

Flaring refers to the combustion of hydrocarbons that are not able to be processed. The flare is a safety feature to prevent the risk of creating explosive atmosphere in case of a process blowdown. Flaring from the FPU facilities is expected to be minimal relative to combustion of gas for fuel. An assessment on the average flaring rate per day has also been completed, considering both continuous sources (i.e. pilot gas) and episodic flaring associated with planned and unplanned production system events (start-ups and shutdowns). The assessment of episodic flaring considered both the expected frequency of flaring events and the expected quantity flared during the flaring events. An emissions factor for flaring has been taken from NGERs Method 1.

Fugitive emissions refer to minor leaks of hydrocarbon gases that occur from the process, or uncommuted hydrocarbons that pass through the flare or gas turbines. Fugitive emissions are expected to be minimal relative to flaring and fuel combustion emissions. The expected fugitive emissions have been estimated based on the production rate of the facility, multiplied by a regulatory factor, which reflects an estimated leak rate.

The emissions factors used in determining Scope 1 emissions are shown in Table 7-14.

Table 7-14: Emissions Factors used for Scarborough Scope 1 Processing Emissions

Source/fuel	Energy Content	kg CO_2-e/ GJ (CO_2)	kg CO_2-e/ GJ (CH_4)	kg CO_2-e/ GJ (N_2O)	kg CO_2-e/ kg Product	NGERs Reference
Fuel Gas	34.1 x 10^{-3} (GJ/m^3)	49.5	0.1	0.03	2.52 (per kg fuel gas)	S2.21-2 Method 2
Flaring	N/A	2.7 (per kg flared)	0.1 (per kg flared)	0.03 (per kg flared)	2.83 (per kg flare)	S3.67 Method 1
Fugitives Total	1.2kg CO_2-e (CH_4) Total (per tonne LNG produced)					S3.72 Method 1

Scope 1 Emissions Estimates

The emissions from each of these three sources is shown in Table 7-15.

Table 7-15: Scope 1 emissions

	Annual ($MtCO_2e$)	Total expected field life ($MtCO_2e$)
Emission source		
Fuel Gas	0.41	9.88
Flaring	0.04	1.38
Fugitives	0.01	0.26
Total Scope 1	**0.47**	**11.52**

Scope 3 emissions: Installation, Construction and Decommissioning

Installation, construction and decommissioning are expected to contribute a minor component of the overall emissions associated with Scarborough. Total installation, construction and decommissioning emissions are expected to be approximately 1MtCO_2e over project life, or approximately 1% of Scarborough's lifecycle emissions.

Scope 3 emissions: Onshore processing and reservoir CO_2 venting

Onshore processing emissions are principally from:

- Processing: Fuel combustion, flaring and fugitives
- Venting of reservoir CO_2

Some combustion of fuel and flaring will be associated with onshore processing. It is noted that the emissions for onshore processing, operated on behalf of different joint ventures, are subject to separate onshore approvals, with requirements as described in Section 7.1.3.5.

Methodology

Processing emissions related to fuel, flare and fugitive emissions have been estimated by using emission factors appropriate to each of the likely processing facilities. These factors are sourced from publicly available materials as per Table 7-16.

Table 7-16: Emissions Factors used for Scarborough Processing Emissions

Processing facility	Emission factor
Processing Emissions Downstream - Pluto	0.31 tCO_2e per tonne of LNG produced, Pluto Greenhouse Gas Abatement Programme Rev 2 (note, downstream reservoir CO_2 emissions are added separately)
Processing Emissions Downstream - KGP	0.33 tCO_2e per tonne of LNG produced North West Shelf Project Extension (under assessment), Greenhouse Gas Management Plan (note, downstream reservoir CO_2 emissions are added separately)

Reservoir CO_2 Emissions Methodology and Context

An assessment of the total quantity of reservoir CO_2 likely to be emitted has been completed. The assessment assumed that all reservoir CO_2 must be removed prior to liquefaction of the gas, at the relevant onshore facility. The estimate of vented reservoir CO_2 was based on the expected CO_2 composition of the Scarborough reservoirs. All reservoir CO_2 emissions from the Pluto LNG facility are required to be offset under current onshore approvals.

CO_2 content in the hydrocarbon reservoir is a naturally occurring geological phenomenon that is typically treated as a waste product during LNG liquefaction. It is not influenced by the design of the processing facilities.

Contemporary large operating and proposed developments off the west coast of Australia include a number of developments where the levels of CO_2 in the reservoir are comparatively high (at an average of 10 - 20 mol%) compared to Scarborough. Examples of approximate reservoir CO_2 concentrations for recent developments are given below:

- Barossa Development (proposed): 16–20 mol%
- Gorgon LNG Development (operating): <1-14 mol%
- Ichthys Project (operating): 8-17 mol%
- Prelude FLNG: 9 mol%
- Proposed Browse to NWS Project: 7-12 mol%.
- Scarborough, Thebe and Jupiter: 0.1 mol%

The negligible expected CO_2 concentration in the Scarborough, Thebe and Jupiter reservoirs means that the emissions associated with venting of reservoir CO_2 will be small in comparison with these other projects and not considered to be a major source for Scarborough.

Processing and Reservoir CO_2 Emissions Estimates

Forecast processing and reservoir CO_2 emissions using the emissions factors from Table 7-14 are shown in Table 7-17 below.

Table 7-17: Forecast Scarborough Processing and Reservoir CO_2 GHG emissions summary

	Annual ($MtCO_2e$)	Total expected field life ($MtCO_2e$)
Onshore Processing		
Reservoir Emissions	0.02	0.55
Processing Emissions (fuel and flare)	2.82	87.42
Onshore processing Total	**2.84**	**87.97**

Scope 3 emissions: Customer use and transport

Methodology

An estimate of the quantity of GHG emissions arising from third party consumption of Scarborough has been completed. As described in Section 7.1.3.5, emissions related to third party consumption of gas from Pluto LNG Facility were described in the Pluto PER, Section 5.1.1.6.

For the consumption of LNG anticipated to be produced from Scarborough, which is expected to predominately occur internationally, an emissions factor has been sourced from the Ecoinvent v3.5 database (Table 7-18). This emissions factor considers the transport, regasification, distribution and final combustion of LNG. The factor used in the Pluto PER is also presented for comparison. The difference between these factors is primarily due to the PER factor not considering emissions associated with regasification and distribution.

For the consumption of domestic gas anticipated to be produced from Scarborough, an emissions factor has been developed based on NGERs. This emissions factor considers the distribution and final combustion of natural gas. Fugitive emissions of the gas transmission pipeline have been estimated in accordance with NGERs Measurement Determination s3.76 and are negligible. Therefore, they are not discussed further.

In each instance for Scope 3 Emissions, the estimate of CO_2-e emissions is based on the quantity of product consumed, multiplied by the respective emissions factor.

Table 7-18: Emissions Factors used for Scarborough Gas Transit and Market Emissions

Source/fuel	kg CO_2-e/ kg Product	Reference
Third Party – LNG	3.13	EcoInvent 3.5
Third Party – LNG	2.78	Pluto PER S5.1.1.6
Third Party – Domgas	2.99	NGER Schedule 1 (Consumption) S3.80 (Distribution)

The methodology used by Ecoinvent v3.5 follows the international standards for lifecycle assessment. The Ecoinvent v3.5 emissions factor is based on individual processes which generate GHG emissions, as connected along a production chain to deliver intermediate or final production processes. The methodology includes infrastructure, manufacturing processes, fugitive emissions as well as all energy-related emissions. Allocation between coproducts is done based on physical parameters, where available, such as energy content for coproduced energy products and, where a physical basis cannot be established, allocation is based on relative economic value of coproducts.

Ecoinvent v3.5 represents arguably the largest public collection of inventory data in the world, covering over 5,000 products and containing 17,000 unit processes. It has been recognised as the emission factor source for the European Union Renewable Energy Direction GHG methodology and sits in the background of many of the National Carbon Offset Scheme (NCOS) emission factors. The Ecoinvent factors are therefore aligned in methodology to the principles of the NGERs methodology.

Third Party Consumption Emissions Estimates

Third party consumption emissions, as per the emissions factors used in Table 7-18 reflect emissions associated with the final combustion and use of the product and are shown in Table 7-19. Third party consumption emissions form the largest part of the overall emissions related to Scarborough. Note that Scope 3 emissions associated with LNG are presented using both the factor from the Pluto PER and the more recent EcoInvent factor. For the total Scope 3 estimate, the more recent EcoInvent factor has been used.

Table 7-19 Forecast Third Party consumption GHG emissions summary

CO_2-e MT	Average year	Total expected field life
Third Party Consumption (Scope 3)		
1a. Consumption – LNG using Pluto PER factor (transport, and combustion) – Reference only	18.09	560.77
1b. Consumption – LNG using EcoInvent factor (transport, regasification, distribution, and combustion)	22.12	685.84
2. Consumption – Domgas (distribution and combustion)	2.99	92.69
Total (1b+2)	**25.11**	**778.53**

Emissions Estimate Summary

A summary of emissions from Scarborough is provided in Table 7-20, below.

Table 7-20: Summary of Scope 1 and Scope 3 emissions for Scarborough

	Average year ($MtCO_2e$)	Total expected field life ($MtCO_2e$)
Scope 1 Emissions	0.47	11.52
Scope 3 Emissions - Downstream Processing and Reservoir CO_2 Venting	2.84	87.97
Scope 3 Emissions - Transport and Combustion	25.11	778.53
Total	**28.42**	**878.02**

Scarborough relative to global natural gas use and emissions

The contribution of Scarborough's emissions to global emissions can also be estimated. Table 7-21 shows the estimated average GHG contribution compared to the 2030 emissions levels of each IEA WEO scenario. This table assumes annual scope 1 emissions of 0.47 $MtCO_2e$ and annual lifecycle (scope 1 + scope 3) emissions of 28.4 $MtCO_2e$.

Table 7-21: Scarborough emissions contribution to IEA Scenarios

Lifecycle emissions	Total global GHG ($MTCO_2e$/yr) IEA 2019	Scope 1 (% of global GHG)	Lifecycle (% of global GHG)
2030 (CPS)	37,400	0.001%	0.076%
2030 (STEPS)	34,900	0.001%	0.081%
2030 (SDS)	25,200	0.002%	0.113%

It should be noted that the 2030 emissions forecasts use IEA scenarios (as further explained in Section 7.1.3.7 below) so only cover the energy system. Inclusion of other GHG sources, such as agriculture, would reduce the fraction of global emissions that Scarborough represents.

7.1.3.3 Lifecycle Emissions lifecycle and intensity

A recent ERM study[10] examined the emissions intensity of Scarborough gas, processed through Pluto, and then used to generate electricity in selected markets. An example of the results is shown in Figure 7-8, which shows the results for electricity generated in China from Scarborough LNG. The total lifecycle emissions intensity of this application of Scarborough gas was estimated to be 480 $kgCO_2$-e/MWh[11].

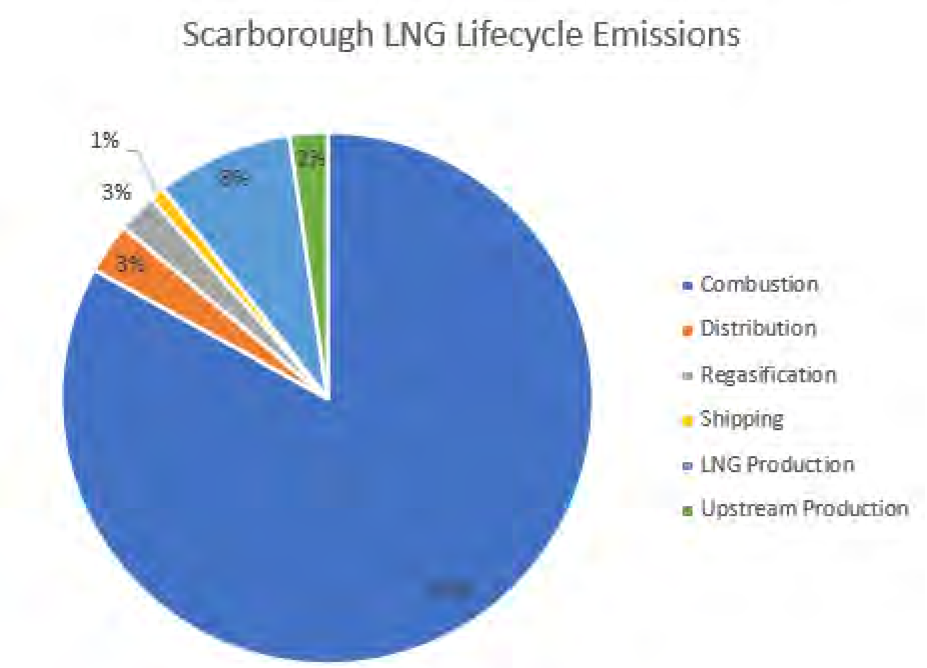


Figure 7-8: Indicative Scarborough Gas Lifecycle Emissions

The IPCC summarised the lifecycle emissions intensity of electricity from various emissions sources (IPCC, 2011) (Figure 7-9). This showed that the median emissions intensity of gas fuelled electricity was approximately 450 $kgCO_2e$/MWh and that Scarborough emissions intensity fits within the interquartile range for global gas fired electricity of 400-550 $kgCO_2e$/MWh. IPCC also show that oil

[10] ERM, 2019. Comparative Life Cycle Assessment: Browse and Scarborough

[11] Note – construction, installation and decommissioning emissions are attributed to each stage of the value chain in this analysis.

and coal power electricity generates approximately 850 $kgCO_2e/MWh$ and 1000 $kgCO_2e/MWh$ respectively, whilst renewables and nuclear are 0-50 $kgCO_2e/MWh$.

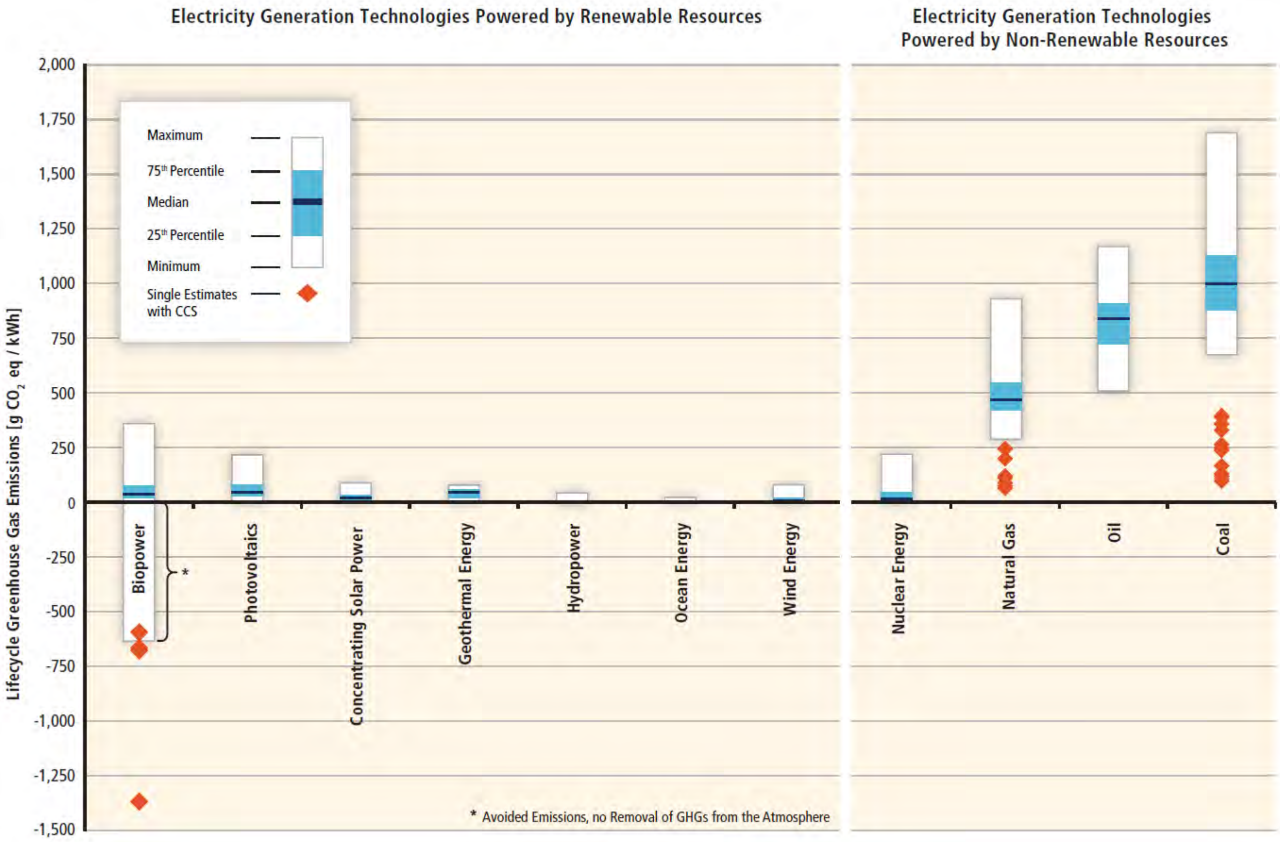


Figure 7-9: Comparison of the Lifecycle Emissions Intensity from Various Electricity Generation Technologies (IPCC 2011)

7.1.3.4 Net emissions impact

Numerous independent energy and climate bodies agree that natural gas has a significant role to play in reducing net global GHG emissions and supporting a progressive transition to renewable energy sources. As a recent example, the IEA, concluded that coal-to-gas switching helped avoid 100 $MtCO_2$-e in 2019 (IEA, 2020), following the avoidance of 95 $MtCO_2$-e in 2018. This observed empirical evidence lends significant credence to the expectation that natural gas, including from sources such as Scarborough, will continue to lead to lower net atmospheric concentrations of GHGs than would otherwise be the case.

Relevant energy mixes

When considering comparative lifecycle impacts, several assumptions need to be made, including where downstream emissions occur and what the appropriate comparator energy mix is.

<u>Customer Markets</u>

In the context of Scarborough, customer markets are key to understanding where downstream emissions occur. Since Scarborough does not have its offtake fully contracted for the life of the project, a reasonable assumption is that Scarborough LNG will form part of the regional, commoditised LNG market.

Scarborough is geographically positioned to provide LNG to Asian markets, so it's unlikely that material amounts of Scarborough LNG will be consumed in Europe, which is the other major importer. Within Asia, the International Energy Agency (IEA) forecasts suggest that most future gas demand in Asia is in China, India, Japan and Korea, and 'Other developing Asia' (IEA, 2019). These regions have therefore been selected as likely customer markets. This does not preclude sales of Scarborough gas to other customers.

Energy Scenarios

To consider the net impact on a country's electricity grid or energy system, assumptions need to be made about how that will evolve over time. The IEA presents three scenarios in their latest World Energy Outlook (WEO), which reflect different levels of ambition with global policies to mitigate climate change.

These are the Current Policy Scenario (CPS), which assumes existing policies continue. This results in greater levels of fossil fuel use and emissions than the other scenarios. The Stated Policy Scenario (STEPS) presents a case where countries implement their public policies and targets, even if there is not yet a clear path for them to do so.

Both the CPS and STEPS start with an understanding of today's energy system and look forward to how it may evolve forward in time. The third WEO scenario, the Sustainable Development Scenario (SDS), is calibrated off a requirement to meet three sustainability goals: meeting the Paris Agreement's climate change goals[12], eradicating energy poverty by 2030 and reducing the health impacts of poor air quality. The SDS is essentially 'reverse engineered' to meet this predetermined sustainable future.

Gas' role in the energy system

When comparing gas consumption to other sources of electricity generation it also is important to consider the role that gas plays in the electricity mix. Gas is transportable, dispatchable and available at scale today, and competes with other fuel sources with similar characteristics. It is however more expensive than some other sources of electricity, such as renewables, that are often quoted as the cheapest source of electricity in many of the world's energy markets (for example CSIRO, 2018[13]). Renewables are growing rapidly and experience policy support from governments wishing to decarbonise and modernise their electricity system. Where installed, renewable electricity often dispatches at zero marginal cost. Natural gas is primarily expected to compete with other dispatchable energy sources in the portion of the grid not satisfied by renewables.

There are however limits to the growth of renewables. CSIRO (2017[14]) surveyed literature from global regulatory agencies and collated data showing that many of the potential markets for Scarborough gas (India (IND), Japan (JPN), OECD Pacific ex Australia (PAO) and South East Asia (SEA)) cannot build sufficient renewables to meet their projected 2050 electricity demand. Where growth of renewables is constrained, gas is expected to be a particularly important component of efforts to decarbonise energy supply. The growth of renewables may also be constrained by the need to ensure grid stability, but the response to this constraint can be supported by the use of gas partnering to address their intermittency and enable deeper penetration of renewables into grid mixes.

The role of gas will increasingly be to supplement domestically produced renewables. In doing so, it will compete with other transportable, dispatchable fossil fuels such as oil and coal, which along with competing sources of natural gas are therefore the appropriate comparators when considering alternative energy sources to Scarborough gas.

Other solutions such as intercontinental high voltage direct current transmission and transportable hydrogen may also play a role in the decarbonising global energy mix, however current forecasts

[12] Specifically it has been "constructed on the basis of limiting the temperature rise to below 1.8°C with a 66% probability" (IEA, 2019)

[13] Graham, P.W., Hayward, J, Foster, J., Story, O.1 and Havas, L. 2018, GenCost 2018. CSIRO, Australia.

[14] Hayward, J.A. and Graham, P.W. 2017, Electricity generation technology cost projections: 2017- 2050, CSIRO, Australia.

suggest that these contributions will remain negligible in comparison to other sources, even under the more dynamic SDS.

Emissions intensities of relevant fuel sources

Based on IPCC data (IPCC, 2011[15]), the average emissions intensity when producing power for gas is 450 $kgCO_2e/MWh$, coal is 1000 $kgCO_2e/MWh$ and oil is 850 $kgCO_2e/MWh$. Therefore, gas represents the lower emissions option to fill predicted energy demand beyond renewables. Renewables and nuclear had a range of lifecycle emissions intensities ranging from near zero up to 50 $kgCO_2e/MWh$.

Scope 3 Emissions Under International Frameworks

The emissions arising from the consumption of Scarborough gas along with other feed sources in those markets are to be managed under domestic and international emissions control frameworks.

All likely customers for Scarborough gas are in countries that have ratified the Paris Agreement. Under the Paris Agreement and global GHG accounting conventions, each country is responsible for accounting for, reporting and reducing emissions that physically occur in its jurisdiction.

This means that the Paris Agreement is the framework which manages Scope 3 emissions associated with customer consumption of Scarborough gas. As per Section 3.4.1, the Paris Agreement requires parties to publish NDCs, reflecting their commitment towards agreed global goals. The likely major users of Scarborough gas have made the following commitments as part of their current NDCs, which are designed to be successively tightened over time through future periodic NDC updates.

China[16]:

- To achieve the peaking of carbon dioxide emissions around 2030 and making best efforts to peak early;
- To lower carbon dioxide emissions per unit of GDP by 60% to 65% from the 2005 level by 2030;
- To increase the share of non-fossil fuels in primary energy consumption to around 20% by 2030; and
- To increase the forest stock volume by around 4.5 billion cubic meters on the 2005 level by 2030.

Japan[17]:

- a GHG reduction of 26.0% by fiscal year (FY) 2030 compared to FY 2013 (25.4% reduction compared to FY 2005) (approximately 1.042 billion tonnes of CO_2 equivalent as 2030 emissions)

India[18]:

- To reduce the emissions intensity of its GDP by 33 to 35 percent by 2030 from 2005 level.

[15] IPCC, 2011: Summary for Policymakers. In: IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[16] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/China%20First/China's%20First%20NDC%20Submission.pdf

[17] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Japan%20First/20150717_Japan%27s%20INDC.pdf

[18] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/India%20First/INDIA%20INDC%20TO%20UNFCCC.pdf

- To achieve about 40 percent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 with the help of transfer of technology and low cost international finance including from Green Climate Fund (GCF).
- To create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030

South Korea[19]:

- Reduce emissions by 37% below business as usual levels by 2030.

Australian customers will also consume Scarborough gas as domestic or pipeline gas. Under the Paris Agreement, Australia has a target of reducing emissions by 26-28 per cent below 2005 levels by 2030. Australia stated in its Nationally Determined Contribution (NDC) that it would apply its target as an emissions budget covering the period 2021-2030. The cumulative emission budget for this period is 4800 MT to reach the 26% reduction target (DoEE, 2018).

Australia's emissions projections 2019 (DOEE, 2019) provides a summary of how Australia is tracking to achieve its NDC of 26 to 28 per cent below 2005 levels by 2030. Projected emissions to 2030 from the LNG sector (direct combustion and fugitive) are included in the methodology used to underpin these projections. The methodology is based on an export capacity of 82 MPTA of LNG in 2020 and include the addition of a second LNG train at Pluto in the mid-2020s.

In accordance with the Paris Agreement, these countries are required to update their NDCs, to "reflect its highest possible ambition", by 2025. These measures constitute examples of how third party emissions associated with the combustion of Scarborough gas will be managed and mitigated in customer nations.

LNG use is expected to reduce global emissions

If Scarborough was considered to have an impact on the fuel mix of its customer markets, then it would be appropriate to compare the lifecycle emissions intensity of Scarborough's products with the most relevant alternatives.

As discussed above, renewable energy sources are low-cost and receive favourable policy support, but face intermittency and physical space constraints. Scarborough's lifecycle emissions can be compared to other fuels that can be imported to customer markets to supplement renewables – that is the fossil fuel share of these grids.

Under the IEA's Stated Energy Policy Scenario (STEPS) the intensity of the fossil fuel share of the energy mix drops slightly, from 925 $kgCO_2e/MWh$ in 2018 to 894 $kgCO_2e/MWh$[20] in 2040; remaining well above the lifecycle emissions intensity of electricity produced from Scarborough LNG (480 $kgCO_2e/MWh$). Even in the SDS, the emissions intensity of the fossil sourced electricity in customer markets only reduces to 732 $kgCO_2e/MWh$ by 2040 – still well above the emissions intensity of electricity generated with Scarborough gas.

The role that increased gas consumption can play in delivering a lower emissions energy system is evident in the changes in fuel mix that are required to achieve the SDS. When focusing on customer markets for Scarborough LNG (assumed to be China, India, Japan and SE Asia as defined by the IEA) total primary energy use remains essentially flat at about 5,300 million tonnes of oil equivalent (Mtoe) per year, whilst coal and oil demand decrease by 45%. Gas and zero carbon energy (mostly nuclear, solar and wind) fill the gap left by decreased coal and oil demand, with gas use increasing

[19] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Republic%20of%20Korea%20First/INDC%20Submission%20by%20the%20Republic%20of%20Korea%20on%20June%2030.pdf

[20] This calculations take the electricity mix from the IEA 2019 WEO and applies the lifecycle emissions intensities published by the IPCC in 2011. The WEO emissions values have not been used since they are for final use only, rather than full lifecycle (transport, distribution etc). This is not however expected to materially impact the conclusions.

by more than 350 Mtoe (70% of 2018 levels) and zero carbon energy increasing by 1500 Mtoe (180% of 2018 levels). (Figure 7-10)

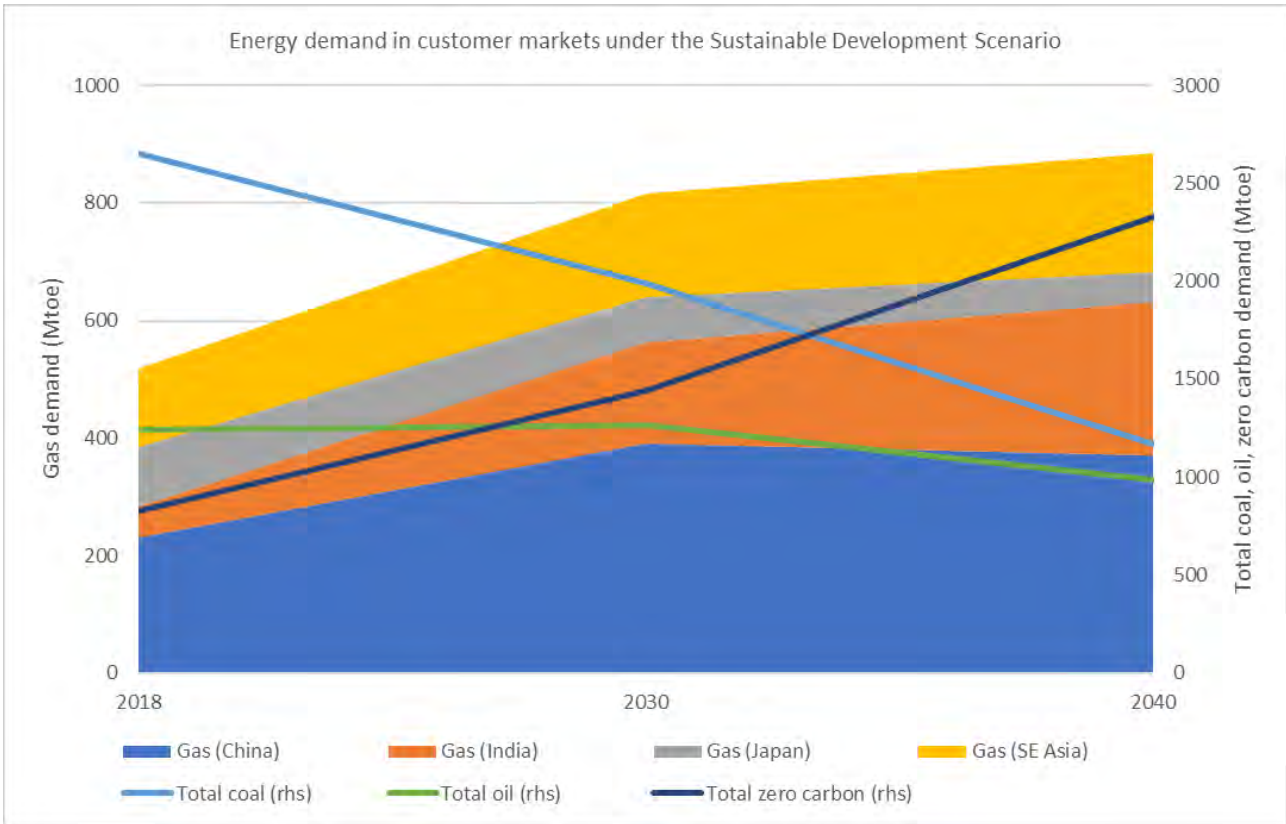


Figure 7-10: Forecast fossil fuel demand in the IEA's SDS in relevant markets, showing that natural gas demand grows (IEA 2019)

However, as the IEA has also shown in Figure 7-11 below, there is insufficient forecast gas supply to meet this demand. In the absence of projects such as Scarborough to meet this demand, the alternatives are other gas sources, coal and oil. In aggregate, these alternatives are likely to lead to higher emissions outcomes than delivered by Scarborough gas.

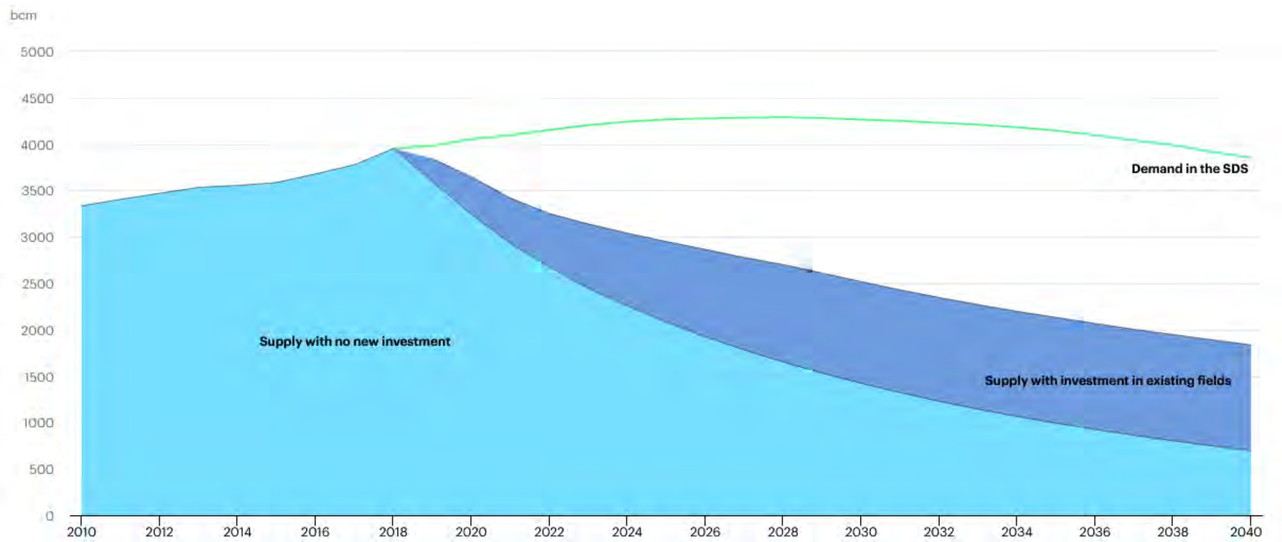


Figure 7-11: Forecast overall gas demand in the IEA's SDS showing portion provided by existing investment and the gap to be filled by new projects such as Scarborough. IEA 2020

Under the IEA's STEPS scenario gas use is expected to increase by 90% in the relevant Asian markets[21]. In the IEA's SDS, which requires more ambitious action to reduce emissions, gas use grows by 70% in these markets.

As Figure 7-11 shows, existing fields will not be sufficient to meet gas demand in the SDS, even assuming investment to maintain supply from these fields continues. The shortfall of up to 2,000 billion cubic meters (bcm) per year will require development of a range of new gas fields and gives confidence that there will be sufficient market demand to support a project of Scarborough's scale. While Scarborough will not affect the demand for gas in the global energy system, Scarborough gas is expected to displace more emissions intensive fossil fuels such as oil and coal and subsequently support an overall reduction in net global atmospheric GHG concentration.

Gas' role in the WA domestic gas market

The primary product from Scarborough will be LNG, but under the Western Australia's domestic gas reservation policy, Scarborough will be required to market 15% of its gas for domestic use in Western Australia. This policy has resulted in WA's electricity generation being more dependent on gas than other states.

The emissions intensity of gas relative to the aggregate of WA electricity generators can be determined using data published by the Clean Energy Regulator (CER, 2019[22]). This includes all 'designated generation facilities' that report under NGER.

Table 7-22: Western Australian Electricity Emissions Intensity

Primary fuel	Total Generation (million MWh)	Scope 1 and 2 emissions ($MtCO_2e$)	Emissions intensity (tCO_2e/MWh)
Natural gas	13.1	7.4	0.57
Black coal	9.7	8.9	0.9
Oil	0.06	0.04	0.7
Solar, wind, landfill gas and hydro	2	0.01	0.007
Total	**25**	**16.3**	**(Average) 0.65**

Table 7-22 shows that gas-generated electricity in WA is approximately 15% less emissions intensive than the average electricity generated in the 2018 financial year. If the availability of Scarborough domestic gas results in an increase in the proportion of electricity generated using gas, the average emissions intensity of WA power generation will be reduced.

7.1.3.5 Existing Environmental Approvals

Emissions from the combustion of fuel and flaring as part of onshore processing have been estimated based on apportioning GHG emissions associated with the processing of Scarborough feed gas. For Pluto, emissions were described in the Pluto LNG Development Public Environment Review (Pluto PER) Section 5.1.1.6. The Pluto LNG Facility was approved under Ministerial Statement 757 and Commonwealth Approval Decision EPBC 2006/2968. The Pluto Public Environment Review (PER) is available for review on the WA EPA website:

[21] Gas use in primary energy increases from 519 to 987 million tonnes of oil equivalent (Mtoe) under the STEPS, in China, India, Japan and SE Asia (IEA, 2019). It reaches 884 Mtoe in the SDS in 2030, or 1087 Mtoe for the CPS.

[22] Greenhouse and energy information for designated generation facilities 2017-18, accessed 28 February 2019.

http://www.epa.wa.gov.au/sites/default/files/PER_documentation/1632-PER-PLUTO%20LNG%20PER.pdf

The total GHG emissions assessed in the PER were 4.1 $MtCO_2e$/yr. The Pluto LNG Facility currently emits approximately 2 $MtCO_2e$/yr. The proportion of gas from the Scarborough reservoirs and Pluto, Xena or other reservoirs processed at the Pluto LNG Facility will vary over time, but the total production and emissions will remain within limits set by the relevant approvals. This is illustrated in Figure 7-12. Similarly, any volumes of Scarborough gas processed at the Karratha Gas Plant will be subject to the limits set by the relevant approvals for the Karratha Gas Plant. Figure 7-12 below illustrates the current and projected emissions at Pluto LNG relative to current Pluto approvals.

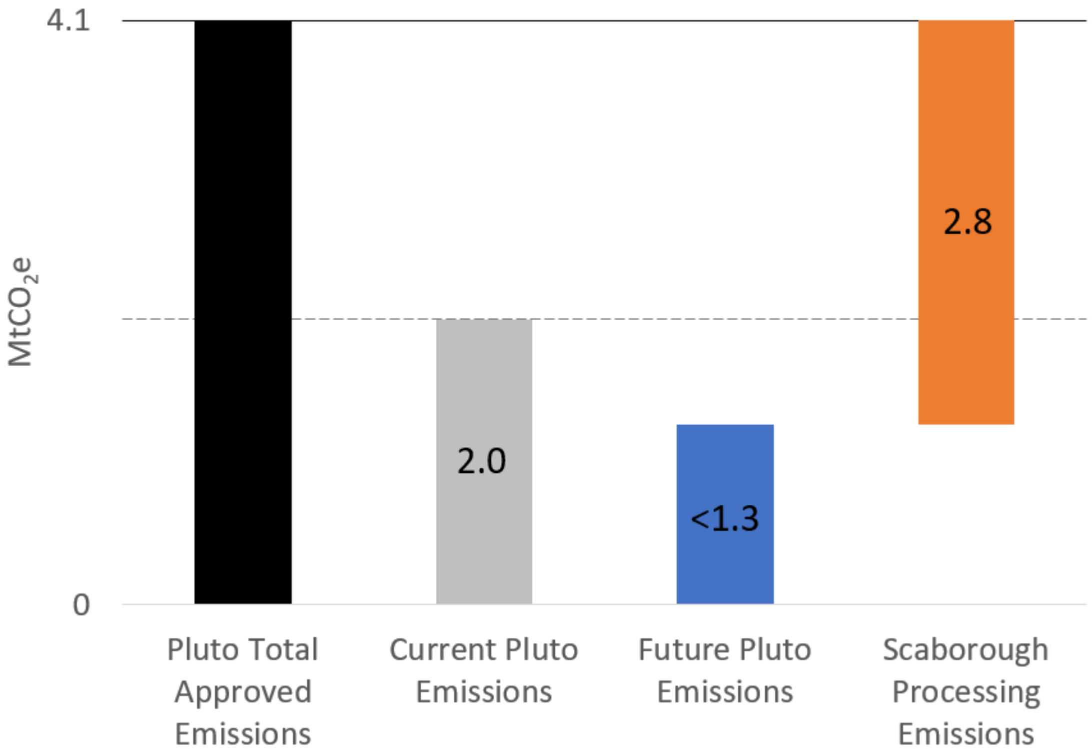


Figure 7-12: Approved Pluto LNG Facility Emissions including Scarborough gas

7.1.3.6 Greenhouse Gas Management and Mitigation

This section outlines Woodside's approach to the following:

- reducing direct emissions from Scarborough to ALARP and acceptable levels;
- in relation to indirect emissions, commitments to various management and mitigation measure given the:
  - uncertainty about the lifecycle outcome articulated above;
  - residual uncertainty about future climate change trajectories.

By focusing on the challenge of providing clean, affordable and reliable energy, Woodside can contribute to achieving the goals of the Paris Agreement. Furthermore, Woodside has a portfolio of actions which can mitigate GHG emissions. These relate to a range of activities across the value chain, including direct GHG emissions from Scarborough and scope 3 emissions and are described below in a modified Institute of Environmental Management and Assessment greenhouse emission reduction hierarchy. Recognising the role of industry and governments globally to mitigate global GHG emissions, a summary of Woodside's climate change related external advocacy is also described.

In summary, the expected role of Scarborough gas in reducing net global atmospheric concentrations further demonstrates the acceptability of Scarborough. While Woodside is not in a position to control Scarborough Scope 3 emissions, it is committed to implementing a range of initiatives to influence the transition to a low carbon economy. These measures (outlined later in this section) reflect Woodside's level of operational control over these emissions.

Management and mitigation measures relating to direct GHG emissions from Scarborough as well as indirect emissions from onshore processing

Avoid

Complete avoidance of GHG emissions for Scarborough is not considered feasible. As described in section 7.1.3.1, GHG emissions will result from all phases of the project and from transport, distribution and consumption of Scarborough gas.

Reduce

- **Implementation of design optimisation to reduce direct GHG emissions:**
  - Scarborough will incorporate energy efficiencies to reduce direct GHG emissions to ALARP in design, which currently include (as described in section 4.5.4.1) allowance for a battery energy storage system; selection of minimally manned concept to reduce living quarters and helicopter emissions and drive process simplification; waste heat recovery rather than gas fired heating; pre cooling of incoming gas using a gas-gas exchanger rather than refrigeration; internally flow coated export trunkline to reduce compression requirement; and selection of efficient aeroderivative turbines. The FPU will be designed to have no continuous operational flaring, consistent with Woodside's implementation of the World Bank Zero Routine Flaring Initiative for oil projects.
  - Further direct GHG emission optimisation will continue during the design phase.
- **Implementation of Woodside's energy management requirements for Scarborough, requiring a facility specific:**
  - Energy management plan which will be developed prior to operational phase;
  - Fuel and flare analysis, baselining and forecasting throughout operational life;
  - Annual setting of energy efficiency improvement and flare reduction targets throughout operational life;
  - Ongoing optimisation of energy efficiency through periodic opportunity identification workshops/studies, evaluation and implementation.
- **Indirect emissions from onshore processing of Scarborough gas are regulated** by relevant legislation and approval requirements for the onshore LNG plants. These include:
  - For the Pluto LNG facility, Ministerial Statement 757 which under Condition 12 requires a Greenhouse Gas Abatement Program[23] to ensure that: the plant is designed and operated in a manner which achieves reductions in GHG emissions as far as practicable; provides ongoing GHG emission reductions over time; ensures that through the use of best practice, total GHG emissions per unit of

[23] https://files.woodside/docs/default-source/our-business---documents-and-files/pluto---documents-and-files/pluto-lng-environmental-compliance-documents/pluto_lng_project_-_greenhouse_gas_abatement_program.pdf?sfvrsn=40d81cf5_6

product are minimised; and the management of GHG emissions in accordance with relevant national frameworks.

- For the Karratha Gas Plant, the existing Ministerial Statement 536 Condition 4 requires a Greenhouse Gas Emissions Management Plan. Additionally, as part of the North West Shelf Project Extension approvals process (under assessment) a new draft Greenhouse Gas Management Plan[24] is expected to include key provisions such as: adoption of practicable and efficient technologies to reduce GHG emissions; annual fuel and flare targets; routine emissions monitoring and reporting; prevention of total GHG emissions exceeding 7.7 Mtpa (including emissions associated with processing Scarborough gas and other KGP feedstocks), and implementation of the facility specific energy management plan.
- **Adoption of the Methane Guiding Principles[25],** including minimising any methane emissions in Woodside operations and the value chain. Operationally, this results in the implementation of a leak detection and repair program and implementing suitable methane emissions reduction projects over the project lifecycle.

<u>Offset</u>

- **Offsetting reservoir CO_2 emissions** – The indirect GHG emissions associated with reservoir CO_2 at the Pluto LNG Facility (which will include processing of Scarborough gas) is offset, as required under Ministerial Statement 757.
- **Carbon offsets business** – Woodside maintains a business to produce and acquire carbon offsets. For example, we have recently entered a partnership with Greening Australia for large-scale native tree planting projects to generate quality carbon offsets. The first phase involves planting up to 5,000 hectares primarily in Western Australia. This builds upon the offsets of Pluto reservoir emissions through a partnership with CO_2 Australia which has offset more than 500,000 tonnes of CO_2 since 2008.

Management and mitigation measures relating to third party GHG emissions from customer use and transport

As articulated above, Scarborough gas is expected to contribute to lower net atmospheric concentrations of GHGs than would otherwise be the case if Scarborough were not developed. However, climate change, and the policy response to it, has evolved rapidly and is expected to continue to do so. Therefore, Woodside proposes to adopt a range of management and mitigation measures to addressing the uncertainty. These measures (as outlined below) are considered appropriate given that Woodside does not have operational control over third party GHG emissions.

<u>Reduce</u>

- ***Promotion of the Methane Guiding Principles*** in order to maximise the positive contribution that natural gas makes to the reduction of global atmospheric GHG concentrations**.** This includes working with the value chain to reduce methane emissions in third party systems (such as regasification and distribution) and encouraging them to join Woodside and others in becoming a formal signatory to the Principles.

<u>Substitute</u>

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24 https://www.epa.wa.gov.au/sites/default/files/PER_documentation2/NWS%20Project%20Extension%20-%20Appendix%20B%20-%20Greenhouse%20Gas%20Management%20Plan.pdf

25 https://methaneguidingprinciples.org/

- **A program to actively promote and market the role of LNG in displacing higher carbon intensity fuels** – as described in the Section 7.1.3.6 above, LNG has the potential to displace higher carbon intensity fuels in the energy mix in target markets and Woodside is actively pursuing these opportunities. LNG is predicted to provide a growing amount of energy into the global mix in a decarbonising economy, as described in Section 7.1.3.4. Woodside monitors and reports on the global energy outlook and gas demand in target markets to informs business strategy.
- **A program to continue to develop and deploy new technologies to substitute for higher carbon intensive fuels** – Woodside is actively pursuing the development of new markets and applications for natural gas products. These currently include:
  - LNG fuel research and implementation, displacing more carbon intensive fuels such as for ships and power generation in remote locations. For example, Woodside has constructed an LNG truck-loading facility in the Pilbara, which has potential to provide LNG to remote mine sites in place of diesel-fired power generation.
  - Hydrogen – Woodside is exploring longer term opportunities to produce and export hydrogen on a commercial scale, including hydrogen from regasification, and has invested in the Hydrogen Energy Network consortium that plans to build and operate 100 hydrogen refuelling stations in South Korea, amid growing interest in the fuel in key markets.

Advocate

- **A program to continue advocacy for stable policy frameworks that reduce carbon emissions** – Engaging and advising legislators and regulators to support frameworks that can progress an orderly transition to a lower-carbon future. Current examples of this advocacy include:
  - Support for the Paris Agreement - which establishes global targets, a framework for global emissions management and a mechanism for increasing ambition over time through successive NDCs.
  - Support for market mechanisms such as carbon pricing, together with targets based on science and measures to reduce the economic and social costs of transition so that frameworks endure.
  - Advocate for the development of effective domestic and international offset markets **–** which can reduce the cost of emission reductions or allow greater ambition for the same cost[26]
- **Maintain membership of relevant international climate related business advocacy groups** in order to contribute to the further evolution of global regulatory frameworks**.** Whilst these organisations will themselves change and develop over time, current Woodside memberships include:
  - Global Carbon Capture and Storage institute, which aims to accelerate the development, demonstration and deployment of the technology
  - International Emissions Trading Association, which advocates for GHG emission trading as a means to decrease the costs of reducing emissions

[26] https://www.ieta.org/resources/International_WG/Article6/CLPC_A6%20report_no%20crops.pdf

  - IPIECA, the global oil and gas industry association for advancing environmental and social performance,
  - Methane Guiding Principles, which includes a principle to advocate for sound policy and regulations on methane emissions

Monitor and report

- **A program to continue to monitor and report on the global energy outlook** including the demand for lower carbon intensive energy such as LNG. Currently this involves the following:
  - Monitoring developments in the global energy outlook and emerging regulatory change in order to adapt business plans and strategies for changing expectations, and to manage risk.
  - For example, when making investment decisions, Woodside considers sensitivities across a range of variables, including commodity prices, carbon prices, length of asset life, exchange rates and interest rates.
  - In addition to internal reporting, current examples of how the company reports on its resilience to changing scenarios include the Annual Report, the Sustainable Development Report and the sustainability data hub (https://www.woodside.com.au/sustainability/sustainability-data-hub).

Whilst these may change over time, continued monitoring and adaptive management are expected to remain a central part of Woodside's approach to climate change and other matters of external business context.

7.1.3.7 Greenhouse Gas Emission and Energy Efficiency Reporting

National Greenhouse and Energy Reporting Act 2007 (NGER Act)

The National Greenhouse and Energy Reporting System (NGERS) requires Woodside to report on GHG emissions and energy use from activities which are under its operational control. Woodside will report GHG emissions and energy use from the offshore facilities in accordance with its requirements under the NGER Act and will be subject to the safeguard mechanism.

Voluntary Reporting

Woodside also voluntarily publishes additional information about the emissions at facilities that it operates or has an equity share of. This includes annual reporting through the Woodside Annual and Sustainability Reports as well as participation in the CDP (formerly known as the Carbon Disclosure Project) and Dow Jones Sustainability Index. These reports include data on direct emissions, strategic approaches to climate change, climate change advocacy, risk management and strategy.

Woodside has also included a set of disclosures aligned with the recommendations of the Task Force for Climate Related Financial Disclosure (TCFD) in the 2019 Annual Report to be published in February, 2020.

7.1.3.8 Impact or Risk

Due to the high level of complexity and numerous variables associated with climate and ecological processes and the relatively small contribution to global GHG emissions from Scarborough, it is not considered feasible to correlate the potential impact of Scarborough GHG emissions on receptors, including MNES (be that impact negative or positive in the case of replacing higher carbon fuels).

Cumulative increases in net global atmospheric GHG concentrations are considered to contribute to climate change.

As a result of climate change, further impacts may occur, which include the following potential ecological impacts:

- Change in habitat
- Change in fauna behaviour
- Injury/mortality to fauna
- Change in ecosystem dynamics

And potential impacts to social values:

- Changes to the functions, interests or activities of other users.

Receptors Potentially Impacted by Climate Change

Australian receptors impacted by climate change have been evaluated in the following sections. However, in consideration of the GHG emissions from Scarborough it is important to evaluate these impacts in the context of the global reduction in net GHG emissions expected from the use of Scarborough gas as a cleaner energy source than other transportable, dispatchable fuel options as discussed in Section 7.1.3.3.

Ecological impacts: Plankton, Epifauna and Infauna, Coral, Seagrass, Macroalgae, Saltmarsh, Mangroves, Shoreline Habitats, Seabirds and Migratory Shorebirds, Fish, Marine Mammals, Marine Reptiles

Biodiversity will be affected by climate change in a variety of ways and there will be much spatial variation in ecological change (CSIRO, 2015). A report by Australia's Biodiversity and Climate Change Advisory Group (Steffen et al., 2009) in 2009 gives a summary of potential impacts to marine and terrestrial species, habitats and ecosystems across Australia. The impacts to taxa are outlined in Table 7-23 and the impacts to ecosystems in Table 7-24.

Extensive modelling and monitoring studies over the last twenty years provide considerable evidence that global climate change is already affecting and will continue to affect species (Hoegh-Guldberg et al., 2018). In addition, climate-change related impacts to flora and fauna are likely to be highly species-dependent and spatially variable. However, fauna distribution patterns are likely to shift in response to a changing climatic regime. Species distributions are likely to shift towards the poles and upwards in elevation and shifts in phenology (earlier spring and later autumn life history events) are the most frequently observed and cited ecological responses to climate change (Dunlop et al., 2012).

Climate change may not only change species distribution patterns but also life-history traits such as migration patterns, reproductive seasonality and sex-ratios (see Table 7-23). For example, Dunlop (2009) highlights that in Australia, migratory birds have undergone changes in the first arrival date (3.5 days/decade), and last date of departure (5.1 days/decade) (Beaumont et al., 2006). Pairing of sleepy lizards has been observed to start earlier and last longer when the last months of winter are warmer (Bull and Burzacott, 2002). Climate change may account for earlier arrival of bird species in the Australian Alps, but the change appears not to be a simple consequence of incremental annual warming resulting from earlier snow-melt (Green, 2006; Norment and Green, 2004).

Table 7-23 Overview of impacts of climate change to the future vulnerability of particular taxa (modified after Steffen et al 2009)

Taxa	Potential vulnerability
Mammals	Narrow-ranged endemics susceptible to rapid climate change in situ (Williams et al., 2003); changes in competition between grazing macropods in tropical savannas mediated by changes in fire regimes and water availability (Ritchie and Bolitho, 2008); herbivores affected by decreasing nutritional quality of foliage as a result of CO_2 fertilisation.
Birds	Changes in phenology of migration and egg-laying; increased competition of resident species; breeding of waterbirds susceptible to reduction; top predators vulnerable to changes in food supply; rising sea levels affecting birds that nest on sandy and muddy shores, saltmarshes, intertidal zones,

Taxa	Potential vulnerability
	coastal wetlands and low-lying islands; saltwater intrusion into freshwater wetlands affecting breeding habitat.
Reptiles	Warming temperatures may alter sex ratios of species with environmental sex determination to cope with warming in situ.
Amphibians	Frogs may be the most at-risk terrestrial taxa. Amphibians may experience altered interactions between; pathogens, predators and fires.
Fish	Freshwater species vulnerable to reduction in water flows and water quality; limited capacity for freshwater species to migrate to new waterways; all species susceptible to flow-on effects of warming on the phytoplankton base of food webs.
Invertebrates	Expected to be more responsive than vertebrates due to short generation times, high reproduction rates and sensitivity to climatic variables.
Plants	Climate change may impact various functional dynamics of plants due to changes in; increasing CO_2, fires, plant phenology and specific environmental characteristics.

The results of climate change such as altering temperature, rainfall patterns and fire regimes, are likely to lead to changes in vegetation structure across all terrestrial ecosystems within Australia (Table 7-24; Dunlop et al., 2012). Increases in fire regimes will impact Australian ecosystems by altering composition structure, habitat heterogeneity and ecosystem processes. Changes in climate variability, as well as averages, could also be important drivers of altered species interactions, both native and invasive species (Dunlop et al., 2012). Climate change could result in significant ecosystem shifts, as well as alterations to species ranges and abundances within those ecosystems (Hoegh-Guldberg et al., 2018).

Table 7-24 Projected impacts of CO_2 rise and climate change on Australian ecosystems (modified after Steffen et al 2009)

Key component of environmental change	Projected impacts on ecosystems
Coral reefs	
CO_2 increases leading to increased ocean acidity	Reduction in ability of calcifying organisms, such as corals, to build and maintain skeletons.
Sea surface temperature increases, leading to coral bleaching	If frequency of bleaching events exceeds recovery time, reefs will be maintained in an early successional state or be replaced by communities dominated by macroalgae.
Oceanic systems (including planktonic systems, fisheries, sea mounts and offshore islands)	
Ocean warming	Many marine organisms are highly sensitive to small changes in average temperature (1–2 degrees), leading to effects on growth rates, survival, dispersal, reproduction and susceptibility to disease.
Changed circulation patterns, including increase in temperature stratification and decrease in mixing depth, and strengthening of East Australian Current	Distribution and productivity of marine ecosystems is heavily influenced by the timing and location of ocean currents; currents transfer the reproductive phase of many organisms. Climate change may suppress upwelling in some areas and increase it in others, leading to shifts in location and extent of productivity zones.
Changes in ocean chemistry	Increasing CO_2 in the atmosphere is leading to increased ocean acidity and a concomitant decrease in the availability of carbonate ions.
Estuaries and coastal fringe (including benthic, mangrove, saltmarsh, rocky shore, and seagrass communities)	
Sea level rise	Landward movement of some species as inundation provides suitable habitat, changes to upstream freshwater habitats will have flow-on effects to species.
Increase in water temperature	Impacts on phytoplankton production will affect secondary production in benthic communities.
Savannas and grasslands	

Key component of environmental change	Projected impacts on ecosystems
Elevated CO_2	Shifts in competitive relationships between woody and grass species due to differential responses.
Increased rainfall in north and northwest region	Increased plant growth will lead to higher fuel loads, in turn leading to fires that are more intense, frequent and occur over large areas.
Tropical rainforests	
Warming and changes in rainfall patterns	Increased probability of fires penetrating into rainforest vegetation resulting in shift from fire-sensitive vegetation to communities dominated by fire-tolerant species.
Change in length of dry season	Altered patterns of flowering, fruiting and leaf flush will affect resources for animals.
Rising atmospheric CO_2	Differential response of different growth forms to enhanced CO_2 may alter structure of vegetation.
Temperate forests	
Potential increases in frequency and intensity of fires	Changes in structure and species composition of communities with obligate seeders may be disadvantaged compared with vegetative resprouters.
Warming and changes in rainfall patterns	Potential increases in productivity in areas where rainfall is not limiting; reduced forest cover associated with soil drying projected for some Australian forests.
Inland waterways and wetlands	
Reductions in precipitation, increased frequency and intensity of drought	Reduced river flows and changes in seasonality of flows.
Changes in water quality, including changes in nutrient flows, sediment, oxygen and CO_2 concentration	May affect eutrophication levels, incidence of blue-green algal outbreaks.
Sea level rise	Saltwater intrusion into low-lying floodplains, freshwater swamps and groundwater; replacement of existing riparian vegetation by mangroves.
Arid and semi-arid regions	
Increasing CO_2 coupled with drying in some regions	Interaction between CO_2 and water supply critical, as 90% of the variance in primary production can be accounted for by annual precipitation.
Shifts in seasonality or intensity of rainfall events	Any enhanced runoff redistribution will intensify vegetation patterning and erosion cell mosaic structure in degraded areas. Changes in rainfall variability and amount will also impacts on fire frequency. Dryland salinity could be affected by changes in the timing and intensity of rainfall.
Warming and drying, leading to increased frequency and intensity of fires	Reduction in patches of fire-sensitive mulga in spinifex grasslands potentially leading to landscape-wide dominance of spinifex.
Alpine/montane areas	
Reduction in snow cover depth and duration	Potential loss of species dependent on adequate snow cover for hibernation and protection from predators; increased establishment of plant species at higher elevations as snowpack is reduced.

The IPCC Special Report describes impacts of warming above pre-industrial levels to key receptor groups including terrestrial ecosystems, mangroves, warm-water corals, unique and threatened systems, and arctic regions (Hoegh-Guldberg et. al. 2018). These receptor groups show varying sensitivity to warming conditions, with a range of responses shown at 1oC warming; from corals suffering moderate impacts, to mangroves not showing any impacts that are detectable and attributable to climate change (Hoegh-Guldberg et al., 2018). Once warming reaches 1.5oC, all receptor groups show impacts attributable to climate change with severity ranging from moderate impacts that are detectable and attributable to climate change (mangroves), to impacts that are severe and widespread (warm-water corals) (Hoegh-Guldberg et al., 2018). At the point where global temperature rise due to climate change reaches 2°C, increasing numbers of receptor groups suffer impacts which are high to very high, and likely to be irreversible (terrestrial ecosystems, warm-water corals, unique and threatened systems, and arctic regions) (Hoegh-Guldberg et al., 2018). Some key impacts are discussed further in sections to follow.

Terrestrial Ecosystems

All terrestrial ecosystems are likely to be impacted by a changing climate (Table 7-24; Steffen et al 2009; Hughes 2010; Dunlop et al. 2012; Hoegh-Guldberg et. al. 2018). The predicted impact of climate change on these ecosystems is highly variable, both between ecosystems and within individual ecosystems (Dunlop et al., 2012). Below is a summary of impacts to key terrestrial ecosystems (other ecosystems are summarised in Table 7-24).

Tropical Rainforests

Projections of future climate changes in the wet tropics of Australia under different scenarios are outlined by Mcinnes (2015). It is likely that temperatures in the wet tropics will become hotter and potentially fires and cyclones will be more intense. Consequently, there is an increased probability of fires penetrating into rainforest vegetation resulting in a shift from fire-sensitive vegetation to communities dominated by fire-tolerant species; and changing rainforest disturbance regime as cyclones become more intense) (Hughes, 2011; Steffen et al., 2009). Changes in the timing of seasons (e.g. extended summer) could cause change in the seasonal response of plants, and alterations to species ranges and abundances (Hoegh-Guldberg et al., 2018).

Alpine/ Montane Areas

Alpine systems are generally considered to be among the most vulnerable to future climate change (Hughes 2003). The extent of true alpine habitat in Australia is very small (0.15% of the Australian land surface) with limited high-altitude refuge (Hughes, 2003).

Australian alpine regions are home to a variety of alpine vertebrates who rely on snow cover for their survival. There is evidence of a reduction in populations of dusky antechinus, broad-toothed rats and the mountain pygmy possum. The first two species are active under the snow throughout winter and are therefore subject to increased predation by foxes when snow is reduced (Hughes, 2003). The pygmy possum depends upon snow cover for stable, low temperatures during hibernation (Hughes, 2003).

Marine Ecosystems

Sea surface temperatures have increased across the globe over recent decades which poses a significant threat to marine ecosystems including changes to species abundance, community structure and increased frequency and intensity of thermally induced coral bleaching events (CSIRO, 2017).

Between 1920 and 2000, sea level is estimated to have risen on average by 1.2 mm per year due to climate change (Church et al., 2006). In addition to changes in sea level, oceanic warming has also served to alter ocean currents around Australia. In response to both ocean warming and stratospheric ozone depletion the East Australian Current has increased in strength by about twenty percent since 1978 (Cai and Cowan, 2006).

Sea-surface temperatures are projected to continue to increase, with estimates of warming in the Southern Tasman Sea of between 0.6 to 0.9°C and between 0.3 to 0.6°C elsewhere along the Australian coast by 2030 (Church et al., 2006). Sea levels will increase by 18 to 59 cm by 2100 in response to both thermal expansion and melting of ice-sheets (Solomon et al., 2007). This will lead to some coastal inundation affecting mangroves, salt marshes and coastal freshwater wetlands. Furthermore, as CO_2 is gradually absorbed by oceans and fresh water, the water becomes more acidic, which increases the solubility of calcium carbonate, the principal component of the skeletal material in aquatic organisms (Steffen et al., 2009). Below is a summary of potential climate change impacts to two key ecosystems - mangroves and coral reefs.

Mangroves

Mangrove ecosystems in Australia will face higher temperatures, increased evaporation rates and warmer oceans (McInnes, 2015) as well as an associated sea-level rise (Hoegh-Guldberg et al., 2018). Modelling indicates an increased likelihood of future severe and extended droughts across parts of Northern Australia (Dai, 2013). Consequently, mangrove ecosystems may increase their southern range as a result of warmer temperatures. However, higher temperatures and evaporation rates, and extended droughts could lead to die-offs in northern Australia and a change in mangrove distribution and abundance (Duke et al., 2017). Mangrove systems should cope with rising sea-level by accumulating more peat or mud which will give them the opportunity to adjust to a rising sea level (Field, 1995).

Coral Reefs

Climate change has emerged as a threat to coral reefs, with temperatures of just 1°C above the long-term summer maximum for an area over 4–6 weeks being enough to cause mass coral bleaching and mortality (Baker et al., 2008; Hoegh-Guldberg, 1999; Hughes et al., 2017; Spalding and Brown, 2015). Coral mortality or die off following coral bleaching events can stretch across thousands of square kilometres of ocean (Gilmour et al., 2016; Hoegh-Guldberg, 1999; Hughes et al., 2017). The impacts associated with a warming ocean, coupled with increasing acidification, are expected to undermine the ability of tropical coral reefs to provide habitat for fish and invertebrates, which together provide a range of ecosystem services (e.g., food, livelihoods, coastal protection); (Hoegh-Guldberg et al., 2018).

<u>Social impacts: KEFs, AMPs, Protected Places, Commonwealth Managed Fisheries, State Management Fisheries, Tourism and Recreation, Coastal Settlements</u>

Changes to climate can result in impact to social receptors that have values which include the ecological receptors (discussed above). This includes KEFs and AMPs.

Climate change also impacts on the functions, interests or activities of other users which rely on ecological value, including commercial and recreational fisheries and tourism.

Summary

Scarborough gas processing and consumption results in GHG emissions, but these emissions are expected to displace emissions from other sources. GHG emissions from Scarborough are expected to result in a reduction of net global atmospheric GHG concentrations by displacing higher carbon intensive energy sources as described in Section 7.1.3.6. Even in low carbon scenarios such as the IEA SDS which has a 66% likelihood of limiting global temperature rise to 1.8°, gas use continues to grow in likely customer markets.

The following section evaluates climate change as a potential impact of global GHG emissions.

Table 7-25: Receptor/impact matrix after evaluation of context

Impacts	Receptor: Climate	Plankton	Epifauna and Infauna	Coral	Seagrass	Macroalgae	Saltmarsh	Mangroves	Shoreline Habitats	Seabirds and Migratory Shorebirds	Fish	Marine Mammals	Marine Reptiles	KEFs	AMPs	Protected Places	Commonwealth Managed Fisheries	State Management Fisheries	Tourism and Recreation	Coastal Settlements
Climate change	✓																			
Change in habitat			X	X	X	X	X	X	X					X	X					
Change in fauna behaviour											X	X	X		X					
Injury/mortality to fauna		X	X	X	X	X	X	X	X	X	X	X	X		X					
Change in ecosystem dynamics		X	X	X	X	X	X	X	X	X	X	X	X		X					
Changes to the functions, interests or activities of other users																X	X	X	X	X

Detailed Impact Evaluation

Climate Change

A recent Intergovernmental Panel on Climate Change (IPCC) Report (Hoegh-Guldberg et al., 2018) summarises the potential impact of human-induced climate change (at 1.5 and 2°C) on a range of climatic variables (e.g. temperature, precipitation, drought, extreme events) and the likely consequence to different ecosystems and ecosystem services, at a range of spatial scales.

Modelling indicates that temperatures will increase across Australia, rainfall patterns will change significantly and extreme events such as droughts, floods and wildfires will become more common. These changes are likely to impact on individual species, ecosystems and ecosystem services such as food and water availability. Within decades, environments across Australia may be substantially different (CSIRO, 2015).

In the global context, the use of Scarborough gas is expected to result in an overall reduction in net global GHG emissions by displacing emissions associated with higher carbon intensity energy sources which are required to compliment the development of renewable energy, as described in Section 7.1.3.4. It is therefore not feasible to link GHG emissions from Scarborough to a measurable increase in global temperature or other climate change impacts.

It is not possible to link GHG emissions from Scarborough with climate change or any particular climate related impacts given:

- That it is the net global GHG concentrations that cause climate change and climate related impacts;
- The estimated scope 1 and scope 3 emissions associated with Scarborough are negligible in the context of existing and future predicted global GHG concentrations;
- The inability to precisely predict the amount of total future global GHG emissions;
- The inability to predict future national and international initiatives on climate change and the impact they will have on total future global GHG emissions, including Scarborough emissions

7.1.3.9 Demonstration of Acceptability

Overall, in the context of Australia's international commitments, and legislation and policy, it is considered that given the proposed mitigation of emissions, safeguard mechanism obligations, and the importance of gas as a clean and reliable source of energy in the current and future energy mix, GHG emissions from the proposed Scarborough development are acceptable. When considered with receptor sensitivity, the Impact Significance Level of routine GHG emissions from Scarborough has been evaluated as **Negligible (F)** for all receptors. The impacts overall have been determined to be **acceptable** based on an evaluation against the criteria:

To meet the principles of ESD

Giving consideration to economic development that safeguards the welfare of future generations, Scarborough is considered to align with the core objectives of ESD by:

- Providing a clean and reliable energy source. Gas is expected to play a key role in the future energy mix (e.g. as a partner to renewables). In addition, gas has the potential to contribute to an incremental reduction in global GHG emissions by displacing more carbon intensive power generation (e.g. coal).
- Contributing to the IEAs Sustainable Development Scenario (SDS) which shows that increased gas use in Scarborough's likely customer markets is consistent with three objectives of:

  - Mitigating climate change in line with the Paris Agreement targets
  - Providing universal energy access by 2030 and
  - Reducing the severe health impacts of air pollution.
- Through a range of management and mitigation measures as described in Section 7.1.3.6, addressing the following:
  - Uncertainty about the lifecycle outcome;
  - Residual uncertainty about future climate change trajectories.

Internal Context

- Woodside Climate Change Policy (https://www.woodside.com.au/sustainability/climate-change) and Woodside Management System requirements requirements. As described in Section 7.1.3.6, will be implemented for Scarborough via:
  - Design optimisation to reduce direct GHG emissions to ALARP (see also Energy Efficiencies in Section 4.5.4.1);
  - The FPU will be designed to have no continuous operational flaring;
  - Energy management plan which will be developed prior to operational phase;
  - Fuel and flare analysis, baselining and forecasting throughout operational life;
  - Annual setting of energy efficiency improvement and flare reduction targets throughout operational life;
  - Ongoing optimisation of energy efficiency through periodic opportunity identification workshops/studies, evaluation and implementation.
- In addition, as described in Section 7.1.3.6, Woodside will continue to:
  - actively monitor and market the role of LNG in displacing higher carbon intensity fuels.
  - Advocate for stable policy frameworks that reduce carbon emissions.
  - Monitor and report on the global energy outlook including the demand for lower carbon intensive energy such as LNG.
- Woodside has also established a business to produce and acquire carbon offsets as described in Section 7.1.3.6.

External Context

- GHG emissions from petroleum developments was identified by one stakeholder during the formal consultation process (Appendix K). It is considered that the assessment of impacts of GHG emissions has been undertaken and that proposed mitigation and management of GHG emissions address this issue.
- More broadly than Scarborough, the global consensus on climate change led to the implementation of the Paris Agreement which establishes a target to limit climate change to well below 2°C. The Paris Agreement establishes a framework where countries make NDCs to manage and reduce their own emissions.

Other Requirements

- The targets set by the Paris Agreement are detailed in Section 3.4.1.

- Australia's NDC is to reduce emissions by 26-28% below 2005 levels by 2030. The federal government's plan to meet the NDC already considers the emissions from processing Scarborough gas through an onshore LNG plant.
- Australia's primary policy to manage Scarborough GHG emissions is the Safeguard Mechanism. This requires any Scope 1 emissions above a facility specific baseline to be offset.
- GHG emissions from onshore processing are covered under other appropriate legislation and approvals, for example the Pluto Ministerial Statement 757 and Greenhouse Gas Abatement Program and the proposed North West Shelf Project Extension (under assessment).
- The Western Australian Government released a GHG Emissions Policy for Major Projects on 28 August 2019. The Policy included an aspirational target of net zero greenhouse gas emissions by 2050. The Minister for Environment will consider how the Policy relates to major proposals assessed under Part IV of the EP Act (Government of Western Australia, 2019) including the Pluto LNG Facility and North West Shelf Karratha Gas Plant.

Environmental Performance Outcomes

To manage impacts to affected receptors to at or below the defined acceptable levels the following EPO have been applied:

EPO 3.1: Optimise efficiencies in air emissions and reduce direct GHG emissions to ALARP and Acceptable Levels.

EPO 3.2: Actively support the global transition to a lower carbon future by net displacement of higher carbon intensity energy sources.

7.1.3.10 Summary of the Impact Assessment

Table 7-26 provides a summary of the risk assessment and acceptability for impacts from GHG emissions on receptors.

Table 7-26: Summary of impacts, management controls, impact significance ratings and EPOs for GHG Emissions

Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity level	Magnitude	Impact significance level	Acceptability
Climate	Climate change	**EPO 3.1:** Optimise efficiencies in air emissions and reduce direct GHG emissions to ALARP and Acceptable Levels. **EPO 3.2:** Actively support the global transition to a lower carbon future by net displacement of higher carbon intensity energy sources. *(EPO 3.2 and CM38 have been developed in the context of Woodside not having operational control over third party GHG emissions)*	**CM4:** Facilities will be designed and operated to optimise energy efficiency, including: • Design optimisation to reduce direct GHG emissions to ALARP • The FPU will be designed to have no continuous operational flaring • Development of energy management plans prior to operations • Fuel and flare analysis, baselining and forecasting throughout the life of operations • Annual setting of energy efficiency improvement and flare reduction targets • Ongoing optimisation of energy efficiency through periodic opportunity identification workshops/studies, evaluation and implementation. **CM5:** Reporting of Scarborough scope 1 GHG emissions as per regulatory requirements. **CM38:** Develop and implement a Program to support **EPO 3.2** relating to third party GHG emissions which will include the following: • Working with the natural gas value chain to reduce methane emissions in third party systems (e.g.	Low sensitivity (at location)	Slight	Negligible (F)	Acceptable

Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity level	Magnitude	Impact significance level	Acceptability
			regasification and distribution), such as through the adoption of the Methane Guiding Principles. • Promoting the role of LNG in displacing higher carbon intensity fuels • Supporting the development of new technologies to reduce higher carbon intensive energy sources • Advocacy for stable policy frameworks that reduce carbon emissions. • Monitoring the global energy outlook including the demand for lower carbon intensive energy such as LNG and displacing higher carbon intensive fuels. • Mechanisms to ensure adaptive management of these measures for the duration of the project in accordance with the Environment Regulations, including regular reviews in conjunction with relevant operations Environment Plan revision cycles.				

7.1.4 Routine Acoustic Emissions

Routine acoustic emissions refer to noise generated during an activity.

Activities conducted during Scarborough may produce noise and associated vibrations in the air, underwater and beneath the earth's surface.

Given the multiple metrics commonly used to express sound levels and assess potential impacts to marine fauna, it is important to ensure any comparisons between specific sound level values are made using the same measures. For example, peak Sound Pressure Level (SPL) compared with peak SPL, or root mean square (RMS) SPL with RMS SPL, rather than peak SPL compared to Sound Exposure Level (SEL). Also, care must be taken when comparing decibel sound levels in air with sound levels underwater. The information below describes how underwater sound is measured and referenced.

The decibel (dB) scale is a logarithmic scale that expresses the ratio of two values of a physical quantity. It is used to measure the amplitude or 'loudness' of a sound. As the dB scale is a ratio, it is denoted relative to some reference level, which must be included with dB values if they are to be meaningful. The reference pressure level in underwater acoustics is 1 micropascal (µPa). Whereas the reference pressure level used in air is 20 µPa, which was selected to match human hearing sensitivity.

Underwater sound is typically measured in terms of instantaneous pressure (sound pressure level – SPL), in dB re 1µPa (Richardson et al., 2005). SPL for an impulsive sound is typically expressed in terms of peak or peak-to-peak SPL. SPL can also be expressed as an RMS measure, which is an average pressure over a duration of time. The RMS SPL measure is commonly associated with continuous sounds; however, it is also used to characterise pulse sounds where the time duration is related to pulse duration or a percentage of energy of the pulse signal.

RMS SPL has historically been used to assess potential impacts to marine life, although SEL and peak SPL are increasingly used. SEL accounts for the duration of a sound exposure and enables comparison between sound from different sound signals (and therefore sound sources) with different characteristics.

SEL is a metric used to describe the amount of acoustic energy that may be received by a receptor (such as a marine animal) from an event. SEL is the dB level of the time-integrated, squared sound pressure normalised to a one second period, and is expressed as dB re 1 µPa^2.s.

Metric terminology used in this section are based on the metrics in the ISO 18405 Underwater Acoustics – Terminology (ISO 2017) (Table 7-27). However, previously used metrics are also provided where they are used in literature published prior to 2017.

Table 7-27: Metric terminology for underwater sound

Metric	Previously used	ISO 18405:2017	
		Main text	Tables/equations
Sound pressure level	SPL_{rms}, SPL_{RMS}	SPL	SPL (L_p)
Peak pressure	SPL_{pk}	PK	PK (L_{pk})
Sound exposure level	SEL_{cum}	SEL_{24h}	SEL_{24h} ($L_{E,24h}$)

Underwater noise is distinguished as two different sound categories: (1) impulsive; and (2) continuous (non-pulsed). Note that impulsive sounds (such as pile driving) are typically characterised using different measures or metrics compared to continuous sound (such as the FPU/vessel and ambient sound). Therefore, it is not meaningful to directly compare sound level values in dB between the two types of sound or with given threshold values, without first considering appropriate conversion between the metrics being used to characterise sound level.

Continuous Noise

Continuous noise is a category of sound that is described by a continual non-pulsed sound. Continuous sound can be tonal, broadband, or both. Some of these non-pulse sounds can be transient signals of short duration but without the essential properties of pulses (e.g. rapid rise-time) (Southall et al., 2007).

Due to the continuous non-pulsed properties of continuous noise, the risk and severity of potential impact to marine fauna is lower than that of impulsive noise. Activities which may produce continuous noise sound include vessels, drilling, FPU operation and Remotely Operated Underwater Vehicles (ROVs).

Impulsive Noise

Impulsive noise is a category of sound that is described by a series of pulsed sound events, defined as brief, broadband, atonal and transient. Impulsive noise is most common in industrial construction or exploration, including seismic acquisition, vertical seismic profiling (VSP), pile driving, blasting (single pulse), multibeam echo sounder and sonar.

These sounds are all characterised by a relatively rapid rise from ambient pressure to a maximal pressure value followed by a decay period that may include a period of diminishing, oscillating maximal and minimal pressures. The rapid rise-time characteristic of these sounds ensures that they are also broadband in nature, with the higher-frequency components being related to the rapidity of the risetime (Southall et al. 2007). Pulses, either as isolated events or repeated in some succession, generally have an increased capacity to induce physical injury as compared with sounds that lack these features.

7.1.4.1 Sources of the Aspect

Activities and facilities associated with Scarborough will generate routine acoustic emissions during drilling, installation & commissioning and operations. Source level is a measure of sound at a nominal distance of 1 m from the source. It is denoted in dB re 1 μPa@ 1 m and will differ depending upon the activities being undertaken. Furthermore, whether impulsive or continuous noise emission are discharged will also depend upon the activity. A summary of source level and type of noise emission is provided in Table 7-28. Acoustic emissions will be produced during:

- vertical seismic profiling
- pre-lay surveys
- drilling operations (including MODU operations)
- installation of FPU – piling
- FPU operations
- hydrocarbon extraction
- vessel operations (including trunkline installation vessels)
- helicopter operations
- removal of subsea infrastructure, including the trunkline.

Vertical Seismic Profiling

VSP may be required to confirm well location during the drilling phase of Scarborough. The duration of VSP is short, up to 24 hours for the well, and utilises relatively small airguns that generate low sound energy levels and are a pulsed noise source. VSP operations are typically of short duration, normally taking no more than a day to complete.

The VSP source (typically 750 cubic inches (cui) and comprising of three 250 cui airguns) is expected to generate a noise level around 216 dB re 1 µPa (SPL) @ 1 m, with most noise concentrated at low (<100 Hz) frequencies. Empirical measurements of an equivalent small sized airgun array (440 cui) undertaken by Curtin University of Marine Science and Technology (CMST, 2013) demonstrated that the source would attenuate to 160 dB re 1 µPa^2.s (SEL) within 500 m, equating to a total of 56 dB attenuation over 500 m. VSP activities associated with Scarborough are expected to reach 160 dB re 1 µPa (SPL) at about 590 m. Matthews (2012) indicates that airguns with a 250 cui source that is discharged about five times at 20 second intervals, sound levels of approximately 238 dB re 1 µPa (PK) are generated at 1 m (Matthews, 2012), with frequencies less than 200 Hz. Sound levels are expected to attenuate rapidly to about 180 dB re 1 µPa (PK) within 100 m (Matthews, 2012).

Pre-lay Survey

The pre-lay survey utilises a side scan sonar towed behind a project supply vessel, or a multi-beam echo sounder (MBES). Most modern MBES systems work by transmitting a broad acoustic pulse from a hull or pole mounted transducer. Transponders will be placed on the seabed to assist in correct flowline placement, acoustic metrology and long baseline (LBL)/ultra-short baseline (USBL). Pre-lay survey may be used during the construction phase of the Project.

Typical frequency and source levels (Jimenez-Arranz et al., 2017) are:

- MBES – 210–245 dB re 1 µPa @ 1 m (PK); 221 dB re 1 µPa @ 1 m (SPL) at 12 to 700 kHz
- USBL – 184–206 dB re 1 µPa @ 1 m (PK) at 18 to 36 kHz.

Side scan survey and MBES emit high frequency impulsive noise between 12 and 700 kHz. High frequency sound attenuates rapidly in water and the area of exposure will be within the immediate vicinity of the activity.

Drilling Operations

During drilling operations, the MODU will produce low-intensity continuous sound. Sound produced from an active MODU is predominantly below 2 kHz, with peak frequencies below 500 hertz (Hz). Broadband source sound levels ranging between 157 and 162 dB re 1 µPa (SPL) have been recorded for semisubmersible drilling rigs (Hannay et al., 2004; McCauley, 1998, 2002). The MODU will emit routine acoustic emissions during the drilling and operational phase of Scarborough.

An acoustic monitoring program commissioned by Santos was conducted during an exploratory drilling program in 2003, which indicated that the drilling operation was not audible between 8 and 28 km from the MODU (or beyond) (McCauley, 2004).

Noise associated with a moored MODU will be restricted to drilling activities, such as drill pipe operations and on-board machinery. A range of broadband values (59 to 185 dB re 1 µPa at 1 m (SPL)) have been quoted for various MODUs (Oceans of Noise, 2004), where noise is likely to be between 100 to 190 dB re 1 µPa at 1 m (SPL) during drilling, and between 85 to 135 dB re 1 µPa at 1 m (SPL) when not actively drilling. McCauley (1998) recorded received noise levels of about 117 dB re 1 µPa at 1 m (SPL) at 125 m from a moored MODU while actively drilling (with activity support vessel on anchor).

FPU Operations

Production platforms have machinery mounted on decks raised above the sea, hence, most noise is transmitted to the marine environment from air (i.e. power generation and operational flaring). Continuous machinery noise on-board the FPU may be radiated into the underwater environment via the mooring lines and risers, which may act as transducers. Monitoring programs have indicated that underwater noise from platforms is typically very low or not detectable (Jiménez-Arranz et al., 2017; McCauley, 2002).

Gales (1982) assessed noise from 18 oil and gas platforms and found the strongest noise levels were relatively low frequency (<100 Hz, and mostly between 4 and 38 Hz), with sound levels of 110 to 130 dB re 1 µPa (unspecified unit) @100 feet (30 m) (Gales, 1982). Noise from the platforms was found to be lower than levels recorded from support vessels, with a cumulative increase in overall underwater noise of 20 to 30 dB from the noise produced by a support vessel operating near an operations platform (Gales, 1982).

Acoustic emissions within 1 m from the FPU during operations are expected to be 180 dB re 1µPa SPL, reducing to 120 dB re 1µPa SPL within 4.55 km (Marshall Day Acoustics, 2019).

Hydrocarbon Extraction

Noise will also be generated during hydrocarbon extraction as a result of the operation of the wellheads and subsea infrastructure.

The continuous noise produced by an operational wellhead was measured by McCauley (2002). At 113 dB re 1 m Pa, broadband noise level was very low and only marginally above rough sea condition ambient noise. For a number of nearby wellheads, the sources would have to be in very close proximity (<50 m apart) before their signals summed to increase the total noise field (with two adjacent sources only increasing the total noise field by 3 dB). Hence, for multiple wellheads in an area, the broadband noise level in the vicinity of the wellheads would be expected to be of the order of 113 dB re 1 m Pa and are expected to drop to background levels within <200 m from the wellhead.

Based on the measurements of wellhead noise discussed in McCauley (2002), which included flow noise in flowlines, noise produced along a flowline or the export pipeline may be expected to be similar to that described for wellheads, with the radiated noise field falling to ambient levels within a hundred metres of the flowline. Woodside has undertaken acoustic measurements on noise generated by the operation of choke valves associated with the Angel facility (JASCO, 2015). These measurements indicated choke valve noise is continuous, and the frequency and intensity of noise emitted is dependent on the rate of production from the well. Noise intensity at low production rates (16% and 30% choke positions) were approximately 154–155 dB re 1 m Pa, with higher production rates (85% and 74% choke positions) resulting in lower noise levels (141–144 dB re 1 m Pa). Noise from choke valve operation was broadband in nature, with the majority of noise energy concentrated above 1 kHz.

Installation of FPU

FPU station keeping will be maintained by moorings. The preferred installation technique for FPU moorings is through suction piling of moorings given the associated costs, safety and environmental impacts are likely to be much less. Should suction piling be undertaken, the resulting noise will be associated with the pump and is expected to be similar to continuous operational noise of other machinery described above for FPU operation. There are potentially technical constraints for this option based on the geotechnical conditions at the FPU location which may require driven piling.

Approximately 20 piles would be required in the Offshore Project Area, with each taking one day (24 hours) to install in water depths of approximately 900 m. Pile driving would generate low frequency impulsive sound. The noise emanating from a pile during pile-driving is a function of its material type, its size, the force applied to it and the characteristics of the substrate into which it is being driven. The frequency bandwidth for most of the energy in pile driving sounds is typically below 1000 Hz. Given the substrate characteristics in the Offshore Project Area, 5 m diameter steel piles may be required.

Predicted sound levels within 1 m of the piling location during pile driving is 235 dB re 1μPa SPL. reducing to 160 dB re 1μPa SPL within 38.25 km (Marshall Day Acoustics, 2019).

Vessel and MODU Operations

Vessels generate underwater sound from their propellers and thrusters. Vessels, including the MODU, used in deeper water or the pipelay vessel during trunkline installation, may use Dynamic Positioning (DP) where propellers and thrusters are used to hold position, rather than anchoring.

Excluding DP, marine vessels produce low frequency sound (i.e. below 1 kHz) from the operation of machinery, hydrodynamic flow sound around the hull and from propeller cavitation, which is typically the dominant source of sound (Ross, 1987, 1993). Tugboats, crew boats, supply ships and many research vessels in the 50–100 m size class typically have broadband source levels in the 165–180 dB re 1 μPa SPL range (Gotz et al., 2009). In comparison, underwater sound levels generated by large ships can produce levels exceeding 190 dB re 1 μPa (Gotz et al., 2009) and vessels up to 20 m size class typically 151 to 156 dB re 1μPa (Richardson et al., 1995).

DP MODU underwater noise measurements were taken for the MAERSK Discoverer drill rig used on the North West Shelf (Woodside, 2011). They showed the system emitted tonal signals between 200 Hz and 1.2 kHz, which is within the auditory bandwidth for cetaceans. The measured source level was between 176 and 185 dB re 1 μPa SPL @ 1 m. A noise assessment for the Deepwater Millennium (McPherson et al., 2013) DP drillship, drilling off the Northwest Cape, estimated the broadband source level for drilling operations at 196 dB re 1 μPa SPL @ 1 m, with all six thrusters working at 100%. This is a worst-case scenario as standard operation uses thrusters at 60% capacity or less, depending on weather conditions.

Measured source levels of the pipelay vessel Deep Orient under DP (length 135 m, breadth – 27 m, draft 6.85 m) showed a source level of 168 SPL @1 m (dB re 1 μPa). The source level of a support vessel with DP of 186 dB re 1 μPa (SPL) @1 m was derived from measured levels of the Setouchi Surveyor (Hannay et al., 2004; McCauley, 2005).

Noise modelling has shown that, assuming a source level of 186 dB re 1μPa SPL @ 1 m (Hannay et al. 2004), sound levels will be reduced to 120 dB re 1μPa SPL within 4.903 km (Marshall Day Acoustics, 2019). Given the size of the vessel (length 135 m, breadth 27 m and draft 6.85 m (Marshall Day Acoustics (2019)), acoustic emissions do not originate form a single point source (as is assumed in the modelling) and therefore, the modelled near field sound levels are exaggerated and considered highly conservative. Although SEL_{24h} is modelled for the pipelay and support vessel, in reality marine fauna will not be within close proximity of the vessels for a 24-hour duration, given that the relevant marine fauna are mobile, and that the vessels will be continually moving. As such, SEL_{24h} is not applied in the impact assessment of this activity.

ROV Operations

An ROV is a tethered underwater vehicle equipped with at least a video camera and lights. Additional equipment may include sonars, magnetometers, a still camera, a manipulator or cutting arm, water samplers, and instruments that measure water clarity, water temperature, water density, sound velocity, light penetration and temperature. ROVs may be used during Scarborough for assessing the FPU or trunkline.

ROVs may be fitted with measurement devices such as sonar, that emit a pulse of sound (often called a 'ping') and then listens for reflections (echo) of that pulse. ROVs may be used during construction, operation and decommissioning phases of the Project.

Typical frequency and sound source levels for ROV mounted sonar is (Jimenez-Arranz et al., 2017):

- frequency range between 3k Hz–200 kHz
- source level 150–235 dB re 1 uPa SPL @ 1 m.

Helicopter Operations

Helicopter noise is emitted to the atmosphere during routine helicopter flights. Helicopter trips will occur regularly during construction and less frequently during operation of Scarborough. Sound emitted from helicopter operations is typically below 500 Hz (Richardson et al., 1985). The peak-received level diminishes with increasing helicopter altitude, but the duration of audibility often increases with increasing altitude. Richardson et al. (1995) reports that helicopter sound is audible in air for four minutes before it passed over underwater hydrophones, but detectable underwater for only 38 seconds at 3 m depth and 11 seconds at 18 m depth. Noise levels reported for a Bell 212 helicopter during fly-over was reported at 162 dB re 1 µPa and for Sikorsky-61 is 108 dB re 1 µPa at 305 m (Simmonds et al., 2004).

Removal of Subsea Infrastructure

Removal of subsea infrastructure including the trunkline will be evaluated at end of field life. Options of leave in-situ, removal or part removal of the infrastructure will be part of a future comparative assessment, which will assess the costs and benefits of the options. If subsea infrastructure is removed, acoustic emissions may be caused by methods such as mechanical cutting.

Table 7-28: Sources of aspect and the operating frequency and noise levels

Source of aspect	Operating frequency (kHz)	Source Level (@1 m)		Sound category^	Reference
		SPL (L_p)	*PK (L_{pk})*		
VSP	<0.1	216	238	I	CMST, 2013 Matthews, 2012
ROV	3–200	150–235	-	C	Jimenez-Arranz et al., 2017
Pre-lay survey: • MBES • USBL	 12–700 18–36	 221 -	 210–245 184–206	 I I	 Jimenez-Arranz et al., 2017
Drilling operations	<2	<190	-	C	Hannay et al., 2004; McCauley, 1998, 2002; Oceans of Noise, 2004
FPU operations		180		C	Erbe et al., (2013)
FPU installation – Pile driving*		235	-	I	Marshall Day Acoustics (2019)
Vessel operations: • Support vessel • Pipelay vessel	 0.2–1 0.2–1	 186 168	 -	 C C	 Hanney et al., 2004 McCauley, 2005 Marshall Day Acoustics, 2019
Helicopter operations	0.5	162	-	C	Simmonds et al., 2004
^ Sound category: I = impulsive; C = continuous * Suction piling techniques are expected to generate similar, continuous noise emissions to FPU operations					

7.1.4.2 Impact or Risk

Routine acoustic emissions produced by offshore activities has the potential to result in the following impact(s):

- a change in ambient noise.

As a result of a change in ambient noise, further impacts may occur, which include:

- a change in fauna behaviour
- injury/ mortality to fauna
- changes to the functions, interest or activities of other users.

To inform the assessment of potential impacts to marine fauna from underwater noise associated with Scarborough, Marshall Day Acoustics were contracted to undertake underwater noise modelling to inform the Scarborough Project OPP. The full report is presented as a technical appendix (Appendix E) (Marshall Day Acoustics, 2019). Modelling was undertaken using the dBSea software to predict underwater noise levels using dBSea model solvers: dBSea Parabolic Equation (PE), dBSeaRay and dBSeaModes. Model parameters included noise level spectra, source locations and depths, bathymetry, sound speed profile and seabed properties.

Three key noise generating activities associated with Scarborough were modelled:

- FPU installation (pile driving)
- vessel operation of pipelay vessel with DP thrusters
- FPU and subsea infrastructure operation.

<u>Modelling Methodology</u>

1. FPU Installation – Impact piling

For driven piling of 5 m diameter steel piles, a source level of 225 dB re 1 μPa^2.s for a single pulse with a frequency between 31.5 Hz – 20 kHz was applied. The source level was based on maximum levels reported by the South Australia Pile Driving Guidelines (DPTI, 2012). The source depth is based on 0 m pile penetration on the basis that this would represent a worst-case scenario in terms of noise propagation. Model solvers dBSeaPE and dBSeaRay were used to model sound levels from FPU operations.

2. FPU Operations – FPU with offload tanker and support vessel with DP

Noise source levels for FPU operations include 180 SPL @1 m (dB re 1 μPa) for a stationary moored, typical FPU topside equipment operating, as derived from Erbe et al., 2014 (50th percentile data used). For the support vessel under DP, source levels were predicted using data derived from measured levels of the Setouchi Surveyor (Hannay et al., 2004) of 186 SPL @1 m (dB re 1 μPa). A frequency range of 31.5 Hz to 2.5 kHz was used. The modelling source depth was 5 m below the surface and the source location was in 980 m water depth in the Offshore Project Area. Model solvers dBSeaPE and dBSeaRay were used to model sound levels from FPU operations.

3. Vessel Operations

Broadband source levels within the frequency range of 31.5 Hz to 10 kHz were used to predict sound levels for vessel operations. For the pipelay vessel, a source level of 168 SPL @1 m (dB re 1 μPa) was used, based on measured levels Deep Orient: length 135 m, breadth – 27 m, draft 6.85 m, source data based on DP in calm seas. As described above for FPU installation, the source level for support vessel with DP of 186 SPL @1 m (dB re 1 μPa) was derived from measured levels of the Setouchi Surveyor (Hannay et al., 2004; McCauley, 2005). The model source location was at 5 m source depth, in a water depth of 20 m. The source location is on the State and Commonwealth boundary 3 nm offshore from Dampier. Evaluation of pipelay vessel operation noise has been conducted using dBSeaModes normal mode solver, verified to be appropriate for use in shallow water environments with homogenous bathymetry and sediment composition.

<u>Change in Ambient Noise</u>

Ambient noise levels are influenced by natural variables including wave action, wind, rain, seismic events, marine fauna communication (including both vocalisations and other behaviours such as whale breaching), and anthropogenic sources including shipping, military practices (i.e. sonar), recreational boat use and industrial development.

Underwater ambient noise levels have been recorded at 90 dB re 1 μPa (SPL) under very calm, low wind conditions, to 120 dB re 1 μPa (SPL) under windy conditions (McCauley, 2005). Large fluctuations in ambient noise levels in the Project Area are expected due to changes in weather systems and seasons, biological events such as whale migrations, and presence of shipping and other industrial activities.

Changes in ambient noise have the potential to impact marine fauna as discussed below.

Change in Fauna Behaviour

Elevated underwater noise can result in changes to marine fauna behaviour by masking or interfering with other biologically important sounds, including vocal communication, echolocation, signals and sounds produced by predators or prey, and through disturbance leading to behavioural changes or displacement from important areas (Richardson et al., 1995).

The sensitivity of fauna behaviour to elevated noise levels vary both inter- and intra-specifically, with individual responses often being influenced by the present behaviour, such as reproductive behaviours, foraging or migration.

Thresholds, where appropriate, for behavioural response of different species to noise are discussed in the sections that follow.

Injury/Mortality to Fauna

In some cases, injury or morality to marine fauna can occur due to elevated noise levels by causing direct physical effects on hearing or other organs, including (Richardson et al., 1995):

- potential for mortality/mortal injury resulting from exposure to noise (considered negligible given the noise sources associated with the Petroleum Activities Program, with the exception of plankton)
- Permanent Threshold Shift (PTS) – permanent reduction in the ability to perceive sound after being exposed to noise
- Temporary Threshold Shift (TTS) – temporary reduction in the ability to perceive sound after being exposed to noise, with hearing returning to normal.

Exposure to sufficiently intense sound may lead to an increased hearing threshold. If this shift is reversed and the hearing threshold returns to normal, the effect is called a temporary threshold shift (TTS). Southall et al., 2007 defined TTS as a threshold shift of 6 dB above the normal hearing threshold. If the threshold shift does not return to normal, permanent threshold shift (PTS) has occurred. Threshold shifts can be caused by acoustic trauma from a very intense sound of short duration, as well as from exposure to lower level sounds over longer time periods (Houser et al., 2017).

Changes to the Functions, Interest or Activities of Other Users

Where the functions, interests or activities of other marine users involve marine fauna, any effect to fauna presence or abundance will indirectly impact on the functions, interests or activities of other users. The potential impact may occur for the duration of the noise emission; however, following cessation of the activity, long term changes in fauna abundance or distribution are not expected. Given the location, short-term nature of the more significant noise generating activities, and that the impacts to fish populations will be negligible, changes to the functions, interests or activities of other users, such as commercial fisheries, from acoustic emissions are not notable and have not been evaluated further.

A change in noise can potentially impact on the functions, interests or activities of other marine users that are dependent on underwater communications (e.g. Defence).

Receptors Potentially Impacted

Routine acoustic emissions have the potential to disrupt ecological processes that are sensitive to under water noise. As described for changes in behaviour above, vulnerability of individuals to injury or mortality varies between species. Receptors for which impacts have been determined to be negligible have been discussed below.

Plankton (Zooplankton)

Few studies have reported negative impacts of impulsive noise on zooplankton (including meroplankton or temporary members of the plankton such as fish eggs and larvae, and invertebrate and coral larvae), and none from more than 10 m away from an airgun. This suggests the range of chronic effects on fish eggs and larvae due to seismic discharges is likely to be restricted to <10 m (Table 7-29). Popper et al., (2014) presented a threshold of >210 dB re 1 μPa^2.s (SEL) or 207 dB re 1 μPa (PK) for mortality and potential mortal injury, which is lower (and therefore more conservative) than the observed effects provided in Table 7-29.

Table 7-29: Summary of impulsive noise impacts on fish eggs and larvae

Species	Source	Source level (dB re 1 μPa @ 1 m)	Distance from source (m)	Exposure level (dB re 1 μPa)	Observed effect	Reference
Cod (larvae 5 days)	Single airgun	250	1	250	Delamination of the retina	Matishov (1992)
Cod (larvae 2–10 days)	Single airgun	222	1	222	No injuries detected	Dalen and Knutsen (1986)
			10	202	No injuries detected	
Fish eggs (Anchovy)	Single airgun	230 (estimated)	1	230	7.8% of eggs injured relative to control	Kostyvchenko (1973)
Fish eggs (Red Mullet)			10	210	No injuries detected	
			1	230	No injuries detected	
			10	210	No injuries detected	
Dungeness Crab (larvae)	Seven airgun array	244 (estimated)	1	233.5	No significant difference in survival rate relative to controls	Pearson et al., (1994)

Applying sound exposure guidelines for eggs and larvae (SEL_{24h} >210 dB re 1 μPa^2.s) (Popper et al., 2014) indicates that mortality or potential permanent injury may occur within 2.39 km of the largest acoustic source (Marshall Day Acoustics, 2019). A study by McCauley (1994) calculated the impact in a seismic survey area assuming plankton mortality of 100% within 10 m of an airgun. It argued that the total mortality due to seismic testing would be <1% of plankton in the surveyed area. A more recent study undertaken by McCauley et al. (2017) showed potential for noise impulses discharged from a single 150 cui airgun resulted in zooplankton mortality and reduction in abundance out to more extended ranges (1.2 km), at levels up to 178 dB re 1 μPa PK-PK Pressure.

Furthermore, Richardson et al. (2017) modelled the effect proposed by McCauley et al. (2017) in the context of ocean ecosystem dynamic and zooplankton population dynamic. The report concluded that even if the full effect reported by McCauley et al., (2017) did exist, plankton abundance would not be adversely affected, due to extensive movement of water masses carrying plankton through survey areas, and the rapid reproductive cycle and high reproductive potential characteristics of planktonic organisms.

The literature and acoustic modelling results suggest that a reduction in plankton may occur within 2.39 km or the acoustic source, representing a small proportion of the plankton stock in the NWMR. Rapid recovery and repopulation are expected and the overall impact to plankton abundance is likely to be negligible, and not evaluated further.

Epifauna and Infauna

Although sparsely distributed, epifauna and infauna in the Project Area consists of invertebrates including small burrowing worms and crustaceans. These invertebrate species are permanently in contact with the bottom substrate and accordingly it is important to also consider the propagation of vibration through the ground, particularly for an acoustic emission from piling activities. For benthic epifauna and infauna, this type of vibration is likely of similar or greater importance than water-borne vibration or even the compressional component of a sound (Roberts and Elliott, 2017). However, the published scientific information on vibration sensitivity in marine invertebrates is extremely scarce (Roberts et al., 2015; Roberts et al., 2016; Popper and Hawkins, 2018). Only a small number of studies have indicated reception of vibration and behavioural responses in bivalve molluscs (Mosher, 1972; Ellers, 1995; Kastelein et al., 2008), which, although they may occur in the Project Area, were not dominant. To date, there is no convincing evidence for any significant effects induced by non-impulsive noise in benthic invertebrates.

Few marine invertebrates have sensory organs that can perceive sound pressure, but many have organs or elaborate arrays of tactile 'hairs', called mechanoreceptors, that are sensitive to hydro-acoustic disturbances (McCauley, 1994). Close to an impulsive noise source, the mechano-sensory system of many benthic crustaceans will perceive the 'sound' of compressed air pulses. However, for most species such stimulation would only occur within the near-field or closer, perhaps within distances of several metres from the source (McCauley, 1994).

Decapod crustaceans have a variety of external and internal sensory receptors that are potentially responsive to sound and vibration. However, the exoskeleton and body plan of aquatic decapods are more capable of responding to particle displacement components of an impinging sound field than pressure changes. The limited acoustic sensitivity of decapods is also related to their lack of any gas-filled spaces such as those associated with pressure detection in fishes. However, many decapods have extensive arrays of hair-like receptors both on and inside their exoskeleton that most probably respond to water- or substrate-borne displacements. They also have many proprioceptive organs that may perceive vibrations (Christian et al., 2004).

Studies have indicated that offshore marine seismic survey activity has no effect on catch rates of crustaceans in the surrounding area (Andriguetto-Filho et al., 2005; Parry and Gason, 2006). In addition, Wardle et al. (2001) observed little effect on invertebrate (crustaceans, echinoderms and molluscs) populations inhabiting a reef that was exposed to airgun noise. Furthermore, Christian et al. (2004) conducted a behavioural investigation during which caged snow crabs were positioned 50 m below a seven-gun array. Observations on the crabs' responses to seismic survey pulses were recorded by remote underwater camera. No obvious startle behaviours were observed.

More recently, field experiments were undertaken in water depths of 10–12 m, to understand the impacts of seismic surveys, an anthropogenic impulsive sounds source (Day et al., 2016). Researchers suggested the findings were broadly applicable to scallop and spiny lobster fisheries throughout the world, and bivalve and crustaceans in general. The exposure levels measured in the study were compared to levels of a hypothetical source modelled and are considered equivalent to a commercial ~3100 in^3 seismic source. Key findings from these experiments showed:

- seismic exposure did not result in any lobster mortality, but some temporary and permanent sub- lethal effects (for example reflexes – tail extension and righting, and damage to the sensory hairs of the statocyst) were observed
- lobsters collected from a site subject to high levels of anthropogenic aquatic noise were shown to already have some sub-lethal damage (significant damage to the statocyst hairs) prior to the study; however, the damage resulting from the study was less than that of other lobsters

- seismic exposure did not cause immediate mass mortality of scallops; however, it did increase the risk of mortality, and result in significant changes in behaviour (reduction in classic behaviours and air gun signals eliciting a novel velar flinch behaviour) and reflexes (faster recessing times and indications of slowed righting times) during and following seismic exposure.

Although previous studies observed little effect of impulsive noise on invertebrate behaviour and population (as inferred from commercial catch rates), Day et al (2016) found evidence of behavioural responses and sub-lethal effects from repeated exposure to impulsive noise. Therefore, it is possible that a small number of individuals may present similar effects. However, given the relative sparsity of marine invertebrates in the Project Area, and the short-term nature of the impulsive noise, impacts are likely to be negligible and have not been evaluated further.

<u>Defence</u>

There is a Naval Communications Station located just north of Exmouth that utilises very low frequency (19.8 kHz) transmissions to communicate with vessels and submarines. This type of function is not expected to be a consistent requirement in the area. The Defence communication frequency doesn't overlap with that predicted for noise emissions from ongoing activities (e.g. MODU, FPU), but may for some temporary (e.g. pre-lay survey, ROV operations) activities. Given the temporary nature of these Project activities, and the inconsistent nature of communication emissions, impacts are likely to be negligible and have not been evaluated further.

Marine receptors that may be impacted by routine acoustic emissions are outlined in Table 7-30.

Table 7-30: Receptor/impact matrix after evaluation of context

	Receptor						
Impacts	*Ambient Noise*	*Plankton*	*Epifauna and Infauna*	*Fish*	*Marine Mammals*	*Marine Reptiles*	*Defence*
Change in ambient noise	✓						X
Change in fauna behaviour			X	✓	✓	✓	
Injury/mortality to fauna		X	X	✓	✓	✓	

Detailed Impact Evaluation

<u>*Ambient Noise*</u>

Ambient noise levels in the Project Area may be elevated during all phases of the project. Underwater noise surveys in the region detected marine fauna vocalisations and anthropogenic sources including vessel noise; seismic survey signals; mooring noise artefacts (McCauley, 2011). Although ambient noise levels in the Project Area have not been recorded, they are expected to be towards the upper limit of published ambient noise levels given the presence of shipping fairways and high vessel traffic in the Trunkline Project Area and adjacent to the Offshore Project Area.

As shown in Table 7-28, activities emitting the greatest source levels are associated with temporary activities including geotechnical surveys and installation of facilities. Longer term activities, such as operation of the FPU, have much lower source levels and smaller EMBA. For impact piling activities, Woodside will implement the soft start procedure at the commencement of piling activities and shut down zones during the activity, to limit the noise emissions.

Predicted Impact Summary

Given the extent of the EMBA, and the temporary nature of the largest source levels, adverse impacts to a substantial area of habitat are not expected.

In order to minimise impacts from acoustic emissions, Woodside will implement internal requirements, specifically the VSP Procedure.

Impacts from routine acoustic emissions on ambient noise will have no lasting effect. Receptor sensitivity of ambient noise is low (low value, open water), and therefore Impact Significance Level of routine acoustic emissions on ambient noise is **Negligible (F).**

Change in Fauna Behaviour and Injury/Mortality to Fauna

Fish

Sound is perceived by fish through the ears and the lateral line which are sensitive to vibration. Some species of teleost or bony fish (e.g. herring) have a structure linking the gas-filled swim bladder and ear. These species usually have increased hearing sensitivity. These species are considered to be more sensitive to anthropogenic underwater noise sources than species such as cod (*Gadus sp.*) which do not possess a structure linking the swim bladder and inner ear. Fish species that either do not have a swim bladder (e.g. elasmobranchs and scombroid fish (mackerel and tunas)) or have a much-reduced swim bladder (e.g. flat fish), tend to have a relatively low auditory sensitivity. Considering these differences in fish physiology, Popper et al. (2014) developed sound exposure guidelines for fish for impulsive noise. These are presented in Table 7-31. Data on exposure or received levels to provide similar thresholds in response to continuous noise are lacking (Popper et al., 2014), as described below.

Table 7-31: Threshold for impulsive exposure to fish (Popper et al., 2014)

Type of Fish	Mortality and potential mortal injury	Impairment	
		Recoverable Injury (PTS)	*Temporary Threshold Shift (TTS)*
Type 1 – No swim bladder (particle motion detector)	>219 dB re 1 µPa^{2}s (SEL) Or >207 dB re 1 µPa (PK)	>216 dB re 1 µPa^{2}s (SEL) Or >213 dB re 1 µPa (PK)	>186 dB re 1 µPa^{2}s (SEL)
Type 2 – Swim bladder is not involved in hearing (particle motion detector)	>210 dB re 1 µPa^{2}s (SEL) Or >207 dB re 1 µPa (PK)	>207 dB re 1 µPa^{2}s (SEL) Or >203 dB re 1 µPa (PK)	>186 dB re 1 µPa^{2}s (SEL)
Type 3 – Swim bladder involved in hearing (primary pressure detection)	>207 dB re 1 µPa^{2}s (SEL) Or >207 dB re 1 µPa (PK)	>207 dB re 1 µPa^{2}s (SEL) Or >203 dB re 1 µPa (PK)	>186 dB re 1 µPa^{2}s (SEL)

Underwater continuous noise has been shown to result in recoverable injury or TTS in sound pressure sensitive species, including the goldfish (*Carassius auratus*), at 170 dB re 1 µPa (SPL) over 48 hours (Smith et al., 2006), and the catfish (*Pimelodus pictus*) at 158 dB re 1 µPa (SPL) over 12 hours (Amoser and Ladich, 2003). However, the data for several species of fish lacking sound pressure specialisations showed no TTS in response to long term noise exposure, including tilapia (*Oreochromis niloticus*) (Smith et al., 2004), bluegill sunfish (*Lepomis macrochirus*) (Scholik and Yan, 2002) and rainbow trout (*Oncorhynchus mykiss*) (Wysocki et al., 2007). Rainbow trout exposed to continuous noise levels of up to up to 150 dB re 1 µPa (SPL) for nine months in an aquaculture facility showed no hearing loss nor any negative effects on fish health (Wysocki et al., 2007).

Guideline noise levels criteria from Popper et al. (2014) provide impact threshold for shipping and other continuous noise sources to Type 3 fish (swim bladder involved in hearing) at 170 dB re 1 µPa (SPL) over 48 hours for recoverable injury, and 158 dB re 1 µPa (SPL) over 12 hours for TTS. In absence of more conclusive studies, these impact thresholds have been applied for conservatism.

Underwater impulsive sound such as pile driving may have negative impacts on fish species ranging from behavioural disturbance to physical injury/mortality. The hearing system of most fishes is sensitive to sound pressures between 50 Hz and 500 Hz (Ladich and Fay, 2013), which overlaps the predominant frequency ranges of pile driving activities.

The following fish types have been identified for this evaluation of impacts and risks from acoustic emissions:

- site-attached species associated with the Ancient Coastline at 125 m Depth Contour KEF
- demersal fish species, including commercial fish species such as tropical snappers and emperors (families Lutjanidae and Lethrinidae)
- pelagic fish species, including commercial fish species such as mackerel
- whale sharks.

A relatively small portion of the Ancient Coastline at 125 m Depth Contour KEF overlaps the Trunkline Project Area. An ROV survey of the Trunkline Project Area within the Montebello Marine Park assessed benthic habitats within the Ancient Coastline KEF. The results of this survey indicated that benthic habitat was typically bare sand with various bedforms. No moderate or high relief features or areas of consolidated hard substrate were present. Benthic organisms (sponges and soft corals) typically occurred as single or very low density aggregations (Advisian, 2019). The environmental values of the KEF refer to potential areas of hard substrate or rocky escarpments that may provide enhanced biodiversity or biologically important habitat in areas otherwise dominated by soft sediments. However, these features were not observed within the portion of the KEF surveyed. Hence, no significant site-attached fish assemblages are expected to occur within the portion of the Ancient Coastline KEF that overlaps the Montebello Marine Park.

The Trunkline Project Area also overlaps a small portion of the Continental Slope Demersal Fish Communities KEF. Demersal fish species, such as snapper, emperor and cod, though not as strong swimmers as pelagic fish species, cannot be regarded as ‘site-attached’ as they can move away from a noise source. Individuals would have to remain within ranges of several kilometres of the noise source for a full 24-hour period to be exposed to sound levels that could cause TTS. Pelagic fishes are most likely to exhibit behavioural responses (avoidance) by moving away from a static noise source. Hence, no significant impacts are expected to occur to demersal fish assemblages within the portion of the Continental Slope Demersal Fish Communities KEF overlapped by the Trunkline Project Area.

Most pelagic fishes likely to be present in the region would belong to the Suborder Scombroidei, which includes all of the large, pelagic, fast-swimming fish species: Family Sphyraenidae (barracudas); Family Gempylidae (snake mackerels); Family Trichiuridae (cutlassfishes); Family Scombridae (mackerels and tunas); Family Xiphiidae (swordfishes); and Family Istiophoridae (billfishes). Scombridae species are hearing generalists (narrower frequency range with higher auditory thresholds), in that most species in these families possess a swim bladder but lack the mechanical connection to the inner ear and the otoliths.

As a group, they seem able to detect mid-range frequencies (~300–1000 Hz). Large, pelagic, fast-swimming fish species such as mackerel, billfishes and tunas are highly unlikely to experience TTS effects as they can swim away from an impulsive or continuous noise source. Individuals would have to remain within ranges of several kilometres of the noise source for a full 24-hour period to be exposed to sound levels that could cause TTS. Pelagic fishes are most likely to exhibit behavioural responses (avoidance) by moving away from a static noise source.

Most pelagic and open water fish species (including whale sharks) are expected to swim away when impulsive noise reaches levels at which it might cause physiological effects. BPM (2008) recorded no exposure mortality from the Woodside Maxima 3D MSS Phase I and Phase II survey of fish species such as mackerel (*Decapterus macarellus*), barracuda (*Sphyraena barracuda*), large billfish (sailfish or marlin), schooling bait fish and a number of species of rays and sharks.

Behavioural responses are expected to be short-lived, with duration of effect less than or equal to the duration of exposure. For some fish, strong ‘startle’ responses have been observed at sound levels of 200 to 205 dB re 1 µPa, indicating that sounds at or above this level may cause fish to move away from the sound source. Other studies (McCauley et al., 2003) have found that active avoidance may occur in some fish species at sound levels of ~161–168 dB re 1 µPa SPL (~186–193 PK). While fish may initially be startled and move away from the sound source, once the source moves on fish would be expected to move back into the area.

There is a paucity of data about responses of sharks, including whale sharks, and rays to underwater noise. It is expected that the potential effects to whale sharks associated with acoustic noise will be the same as for other pelagic fish species, resulting in minor and temporary behavioural change such as avoidance. This aligns with Popper et al. (2014) guidelines, which detail that there is the potential for a high risk of behavioural impacts in fish species near (tens of metres) an impulsive noise source such as pile driving, with the level of risk declining to low at thousands of metres from the source.

Given whale sharks do not have swim bladders, they are categorised as fish that are less sensitive to noise (Type 1 fish without swim ladder) and therefore, unlikely to be impacted by impulsive noise unless at close distances to the source location (Popper et al., 2014). Underwater sound emissions are not listed as a threat in the IUCN Red List listing (Pierce and Norman, 2016) or the Conservation advice *Rhincodon typus* (Whale Shark) (TSSC, 2015d).

Predicted Impact Summary

Applying impact thresholds detailed in Table 7-31 for Type 1 fish (no swim bladder), mortality or lethal injury could occur up to 0.75 km (R_{max}) from the piling location during piling. For Type 2 fish (swim is not involved in hearing) and Type 3 fish (swim bladder involved in hearing), mortality or lethal injury could occur at 2.39 km and 3.5 km (R_{max}) from the piling location during piling, respectively. For all fish types, TTS could occur if exposed to SEL_{24h} at ranges up to 34.06 km from source.

During FPU operation, recoverable injury and TTS to Type 3 fish (swim bladder involved in hearing) may occur within 0.36 km and 0.78 km (R_{max}) from the FPU respectively. TTS due to continuous acoustic emissions from the pipelay and support vessel in the Trunkline Project Area is not considered credible.

Although there is some evidence of impacts to fish a result of acoustic emissions, the potential for mortality, lethal or recoverable injury is restricted to within close distances of the piling location (<3.5 km). Although TTS could occur at greater distances (up to 34.06 km for piling in the Offshore Project Area), given the temporary nature of this activity, impacts may occur to a small proportion of the resident or transient fish populations, and are temporary in nature. Whale sharks are not expected to occur in the Offshore Project Area (Section 5.4.4), with the closest areas of significant habitat (foraging BIAs) located >165 km from the piling location. Consequently, impacts to whale sharks are not expected.

Noise emissions will be limited through the implementation of soft start procedure during piling activities, and implementation of the Woodside VSP Procedure.

Overall, the impacts to fish, including listed species such as the whale shark, from routine acoustic emissions is assessed as having no lasting effect. Receptor sensitivity of fish is high (high value species), and therefore Impact Significance Level of routine acoustic emissions on fish, including listed species, is **Negligible (F).**

Marine Mammals

The potential impacts of anthropogenic noise on marine mammals have been the subject of considerable research; reviews are provided by Richardson et al. (1995), Nowacek et al., (2007), Southall et al., (2007), Weilgart (2007) and Wright et al., (2007).

Southall et al., (2007), Finneran and Jenkins (2012) and Wood et al., (2012) reviewed available literature to determine exposure criterion for injury, referred to as the onset of non-recoverable permanent hearing loss (PTS) and temporary hearing threshold shift (TTS), in cetaceans.

In marine mammals, the onset level and growth of TTS is frequency specific, and depends on the temporal pattern, duty cycle, and the hearing test frequency of the fatiguing stimuli. Exposure to intense impulse noise might be more hazardous to hearing than non-impulsive noise. Sounds generated by seismic airguns, pile-driving and mid-frequency sonars have been tested directly and proven to cause noise-induced threshold shifts in marine mammals at high received levels. Finneran (2015) reviewed the current state of knowledge on TTS and PTS. TTS typically decreases in marine mammals relative to the logarithm of the increasing recovery time, although there is considerable individual difference in TTS-related parameters between species that have been tested.

PTS is considered injurious in marine mammals, but there are no published data on the sound levels that cause PTS in marine mammals. Onset levels of PTS are typically extrapolated from TTS onset levels and assumed growth functions (Southall et al., 2007). Only a few studies have investigated TTS in marine mammals in response to exposure to impulsive sounds. Lucke et al. (2009) tested the effect of a single airgun on a male harbour porpoise. They documented onset of TTS at received (unweighted) SEL of 164 dB re 1 $\mu Pa^2 s$. This equates to a high frequency cetacean weighted SEL_{24h} of 140 dB re 1 $\mu Pa^2 \cdot s$ (NOAA 2016). Kastelein et al. (1997) tested the auditory tolerance of a harbour porpoise to playbacks of broadband pile driving sounds. After one hour of exposure an unweighted SEL 146 dB re 1 $\mu Pa^2 \cdot s$ and a SEL_{24h} of 180 dB re 1 μPa^2.s. They calculated an onset of TTS for this type of sound at a SEL_{24h} of approximately 175 dB re 1 μPa^2.s. Kastelein et al. (2017) exposed a harbour porpoise to 10 and 20 consecutive airgun impulses at received SEL_{24h} of 188–191 dB re 1 $\mu Pa^2 \cdot s$ with a mean shot interval of around 17 seconds.

Finneran et al. (2015) tested the exposed three bottlenose dolphins to ten impulses produced by a seismic air gun. The highest exposures were conducted at peak sound pressure levels of 210 dB re 1 μPa (PK) and 212 dB re 1 μPa (PK-PK), and cumulative (unweighted) SEL_{24h} of 195 dB re 1 μPa^2.s.

The NMFS (2018) criteria incorporate the best available science to estimate PTS and TTS onset in marine mammals from sound energy (SEL_{24h}) and sound pressure levels (PK) (Table 7-33).

Beyond the area in which injury may occur, the impact on marine mammal behaviour is the most important measure of a potential impact of underwater noise.

Behavioural reactions to acoustic exposure are generally more variable, context-dependent, and less predictable than the effects of noise exposure on hearing or physiology. This is because behavioural responses to anthropogenic sound depend upon operational and environmental variables, and on the physiological, sensory and psychological characteristics of exposed animals. It is important to note that the animal variables may differ (greatly in some cases) among individuals of a species, and even within individuals, depending on various factors (e.g. sex, age, previous history of exposure, season, animal activity). However, within certain similar conditions, there appears to be some relationship between the sound exposure level and the magnitude of behavioural response.

Southall et al. (2007) graded the severity of context-specific behavioural responses to noise exposure, as follows (refer to Table 7-32 for a detailed description):

- relatively minor and/or brief: score 0–3
- a higher potential to affect feeding, reproduction or survival: score 4–6
- considered likely to affect these life functions: score 7–9.

Table 7-32: Behavioural disturbance scale (Southall et al., 2007)

Response Score	Corresponding Behaviours in Free-ranging Subjects
0	No observable response.
1	Brief orientation response (investigation/visual orientation).
2	Moderate or multiple orientation behaviours. Brief or minor cessation/modification of vocal behaviour. Brief or minor change in respiration rates.
3	Prolonged orientation behaviour. Individual alert behaviour. Minor changes in locomotion speed, direction, and/or dive profile but no avoidance of sound source. Moderate change in respiration rate. Minor cessation or modification of vocal behaviour (duration <duration of source operation).
4	Moderate changes in locomotion speed, direction, and/or dive profile but no avoidance of sound source. Brief, minor shift in group distribution. Moderate cessation or modification of vocal behaviour (duration more or less equal to the duration of source operation).
5	Extensive or prolonged changes in locomotion speed, direction, and/or dive profile but no avoidance of sound source. Moderate shift in group distribution. Change in inter-animal distance and/or group size (aggregation or separation). Prolonged cessation or modification of vocal behaviour (duration >duration of source operation).
6	Minor or moderate individual and/or group avoidance of sound source. Brief or minor separation of females and dependent offspring. Aggressive behaviour related to sound exposure (e.g. tail/flipper slapping, fluke display, jaw clapping/gnashing teeth, abrupt directed movement, bubble clouds). Extended cessation or modification of vocal behaviour. Visible startle response. Brief cessation of reproductive behaviour.
7	Extensive or prolonged aggressive behaviour. Moderate separation of females and dependent offspring. Clear anti-predator response. Severe and/or sustained avoidance of sound source. Moderate cessation of reproductive behaviour.
8	Obvious aversion and/or progressive sensitisation. Prolonged or significant separation of females and dependent offspring with disruption of acoustic reunion mechanisms. Long-term avoidance of area (>source operation). Prolonged cessation of reproductive behaviour.
9	Outright panic, flight, stampede, attack of conspecifics, or stranding events. Avoidance behaviour related to predator detection.

The more severe the response on the scale, the lower the amount of time that the animals will tolerate it before there could be significant negative effects on life functions. This would constitute a disturbance under the relevant regulations.

Available data on marine mammal behavioural responses to pulsed sounds are highly variable and context-specific. Recent studies on the behavioural response to humpback whales to seismic airguns has demonstrated behavioural response to seismic airguns above received sound exposure levels of 140 dB re 1 µPa^2.s (SEL) (Dunlop et al., 2017). This study used the behavioural response of humpback whales to noise from two different moving air gun arrays (20 and 140 cubic inch air gun array) to determine whether a dose–response relationship existed. To do this, a measure of avoidance of the source was developed, and the magnitude (rather than probability) of this response was tested against dose. The proximity to the source, and the vessel itself, was included within the one-analysis model. Humpback whales were more likely to avoid the air gun arrays (but not the controls) within 3 km of the source at sound exposure levels over 140 dB re 1 µPa^2.s (SEL), meaning that both the proximity and the received level were important factors and the relationship between dose (received level) and therefore the 140 dB re 1 µPa^2.s (SEL) cannot be adopted as a stand-alone threshold if the source proximity is greater than 3 km. This study tested towing an airgun source directly into the incoming path of a southern humpback migration which included mother and calf humpback whales, therefore the context and applicability of these results may not be directly applicable to the behavioural response to all cetaceans in every context and has not been adopted for the assessment of potential behavioural impacts from VSP due to that fact that the source is stationary. It should be noted that Dunlop et. al. 2017 makes reference that their results are surprisingly consistent with previous studies with humpback whales in different behavioural contexts. For example, feeding humpback whales responded at ranges up to 3 km from the source, at levels of 150–169 dB re 1 µPa (SPL) (Malme et al., 1985), and resting female humpback whales with calves displayed avoidance reactions at 140 dB re 1 µPa (SPL), though other cohorts reacted at higher levels (157–164 dB re 1 µPa (SPL)) (McCauley et al., 2003).

NMFS (2013) sets the behavioural response threshold for marine mammals at 160 dB re 1 µPa (SPL) for impulsive noise and 120 dB re 1 µPa (SPL) for continuous noise. The value for impulsive sound sits in the upper-mid range for disturbance impacts identified in Southall et al. (2007) and consequently this criterion has been used (in lieu of more suitable up to date criteria) for assessing onset of potentially strong behavioural reaction in this assessment, although it should be borne in mind that this value is possibly over-pessimistic. The value for continuous sound sits roughly mid-way between the range of values identified in Southall et al. (2007) but is lower than the value at which most mammals responded at a response score of 6 (i.e. once the received SPL is greater than 140 dB re 1 µPa). Considering the paucity and high level of variation of data relating to onset of behavioural impacts due to continuous sound, it is recommended that any ranges predicted using this number are viewed as probabilistic and possibly over-precautionary.

The criteria for use in assessing the likelihood of injury as a result of Scarborough are summarised in Table 7-33.

Table 7-33: Noise exposure criteria for onset of TTS and PTS (NMFS 2018) and behavioural response (NMFS 2013)

Hearing group	PTS onset thresholds (received level)		TTS onset thresholds (received level)		Behavioural response
	Impulsive	*Non-impulsive*	*Impulsive*	*Non-impulsive*	
Low-frequency cetaceans	Lpk, flat: 219 dB LE, LF, 24h: 183 dB	LE, LF, 24h: 199 dB	Lpk, flat: 213 dB LE, LF, 24h: 168 dB	LE, LF, 24h: 179 dB	Lp 160 dB
Mid-frequency cetaceans	Lpk, flat: 230 dB LE, MF, 24h: 185 dB	LE, MF, 24h: 198 dB	Lpk, flat: 224 dB LE, MF, 24h: 170 dB	LE, MF, 24h: 178 dB	Lp 160 dB
High-frequency cetaceans	Lpk, flat: 202 dB LE, HF, 24h: 155 dB	LE, HF, 24h: 173 dB	Lpk, flat: 196 dB LE, HF, 24h: 140 dB	LE, HF, 24h: 153 dB	Lp 160 dB

Predicted Impact Summary

Cumulative Sound Exposure Levels (SEL_{24h}) from driven piling in the Offshore Project Area are estimated to exceed threshold criteria for PTS and TTS for low frequency cetaceans at maximum depth distances of 34 km and 99 km (R_{max}), respectively (Figure 7-13, Figure 7-14). For high frequency cetaceans, such as dolphins, the equivalent distances where PTS and TTS could occur is 42.91 km and 17.49 km (R_{max}), respectively (Figure 7-13, Figure 7-14). The SEL_{24h} assumes that a whale is exposed to the SEL_{24hr} over a 24hr period, which is considered unlikely as the whale would be expected to be transient through the area and move away from the sound source.

Sound levels (PK) would exceed threshold criteria for PTS and TTS for low frequency cetaceans at maximum distances of 0.59 km and 0.75 km (R_{max}), respectively. For high frequency cetaceans, PTS and TTS thresholds would be exceed at 0.88 km and 1.5 km (R_{max}), respectively. Behavioural response thresholds for marine mammals would be reached at a maximum distance of 38 km from the piling location during pile driving.

Continuous acoustic emissions (SEL_{24h}) associated with FPU operation may cause PTS and TTS to low frequency cetaceans within 0.73 km and 1.4 km (R_{max}) if exposed over a 24hr duration. For high frequency cetaceans PTS and TTS thresholds may be exceed within <0.01 km and 0.34 km (R_{max}) respectively. Based on SPL behavioural response thresholds, behavioural disturbance of marine mammals from FPU operations may occur up to 4.6 km from source (Figure 7-15).

In the Trunkline Project Area, underwater noise generated by vessel operations could result in behavioral response of marine mammals up to 4.903 km from the vessel (Figure 7-16). It is not considered credible for TTS or PTS to occur due to vessel noise.

Impact, or driven piling is not the preferred method for FPU installation, however this method may need to be carried as a contingency in the unlikely event that geotechnical conditions preclude the preferred approach for suction piling. In the event impact piling takes place, this would be the most intense noise source, noting that this would be short-term, that is less than 24 hours for each pile (up to 20 piles).

The FPU location is within the distribution BIA, and within 36 km of a migration BIA, for pygmy blue whales. Furthermore, recent findings (Gavrilov and McCauley, 2018), suggest that migrating individuals may also traverse the Offshore Project Area. Pygmy blue whales migrate past Exmouth and the Montebello Islands from April and August during their northern migration and October to December during their southbound migration. If piling activities were to occur during these months, pygmy blue whales may be exposed to noise levels that could cause physical impact (PTS) from a single pile strike within 590 m and from cumulative exposure over 24 hours up to a max distance of 34 km, and TTS from a single strike within 750 m and from cumulative exposure over 24 hours at max distance of 99 km. Behavioural disturbance may occur at distances up to 38 km from the source, and would therefore intercept with the distribution and migration BIA. While this activity is unlikely to result in significant impacts to marine mammals given the short-term nature of the emissions, the Conservation Management Plan for the Blue Whale 2015-2025 (statutory recovery plan under the EPBC Act 1999 for blue whales) includes an action - *'Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area'*. Given that there is a potential for impacts from acoustic emissions within the pygmy blue whale distribution BIA, and potentially extending to the migration BIA, impact piling activities are proposed to be restricted during the peak migration periods for the northern migration of the pygmy blue whale (May and June) and southern migration (November and December).

During FPU operations, potential impacts are restricted to within 4.6 km (behavioural disturbance), with no overlap on the migration BIA. Such behavioural responses are expected to be restricted to localized avoidance. Operation of the FPU is unlikely to displace a significant number of pygmy blue whales or disrupt migration of individuals migrating outside the BIA boundaries.

The migration BIA for humpback whales is >150 km from the FPU and therefore, impacts to migrating humpback whales rom piling noise or FPU operation are not expected.

Migrating humpback and pygmy blue whales are more likely to occur in the Trunkline Project Area. Behavioural responses may occur within 5 km of the pipelay vessel during installation activities. Such behavioural responses will be restricted to within 5 km of the vessel, which will be continually moving at a slow speed. Given the width of the migration BIAs of both pygmy blue and humpback whales, the operation of the pipelay vessel is unlikely to present a barrier to migration. Any disturbance is likely to be temporary (based on the duration of the construction activities) and localised (within kilometres of the vessel) and on this basis likely to be at the individual level.

There is limited information about sperm whale distribution in Australian waters; however, they are usually found in deep offshore waters, with more dense populations close to continental shelves and canyons (DotE, 2019). While there is the potential for sperm whales to be present in the area, there are no known BIAs for sperm whales in the NWMR and any impacts are likely to be limited to individuals.

Dugongs are not expected to be resident in the Project Area given the lack of significant seagrass habitat (Section 5.4.4). Transient individuals may traverse the Trunkline Project Area as they migrate between foraging habitats. Any individuals that are encountered may display behavioural responses to acoustic emissions form the pipelay vessel. However, since dugong encounters are expected to be infrequent, the number of individuals that may be affected is not expected to represent a significant proportion of the regional population.

The greatest noise source is driven piling in the Offshore Project Area. This activity is temporary and therefore any impacts to marine mammals will only occur to a small proportion of the regional populations, mitigating population level effects. Acoustic emissions from activities in the Trunkline Project Area are also temporary. Although FPU operation will result in long-term acoustic emissions, the EMBA is restricted to within close proximity of the FPU which has not been identified as important for resting, foraging or breeding.

In order to minimise impacts to ambient noise, Woodside will implement internal requirements, specifically the VSP Procedure. Woodside VSP Procedure sets out the manner in which VSP operations are to be carried out. This procedure contains measures that are consistent with industry standards, and includes requirements for:

- Pre-start visual observations
- Soft start procedures
- Operating procedures
- Low visibility operating procedures

For impact piling activities, Woodside will implement the soft start procedure at the commencement of piling activities and shut down zones during the activity. In addition, Woodside commits to not undertaking impact piling activities during the peak migration periods for the northern migration of the pygmy blue whale (May and June) and southern migration (November and December).

All relevant activities associated with routine acoustic emissions will be conducted in line with the *EPBC Act Policy Statement 2.1 – Interaction between Offshore Seismic Exploration and Whales.*

Underwater noise exposure to marine mammals within the Offshore Project Area will occur during the construction/installation phase of the project and will be continuous for the duration of the operations phase of the project, for a limited area in the vicinity of the FPU. As shown in Figure 7-9, there is no overlap between the migration BIAs for pygmy blue and humpback whales and the Offshore Project Area. Part of the Trunkline Project Area overlaps the migration BIAs for both species, and noise exposure from vessel operations during pipeline installation may overlap migration periods within these BIAs (Table 5-3). However, pipeline installation activities will have a limited duration (weeks to months) and the areas of overlap between the Trunkline Project Area and the BIAs represent a very small proportion of the overall migratory corridors. Consequently, given the limited spatial and temporal overlap with the migration of pygmy blue and humpback whales any impacts from noise exposure will be limited to low level behavioural responses to transient individuals only, and there will be no impacts at a population level.

Impacts from routine acoustic emissions on marine mammals will have no lasting effect. Receptor sensitivity of marine mammals is high (high value species), and therefore the Impact Significance Level of routine acoustic emissions on marine mammals is **Slight (E).**

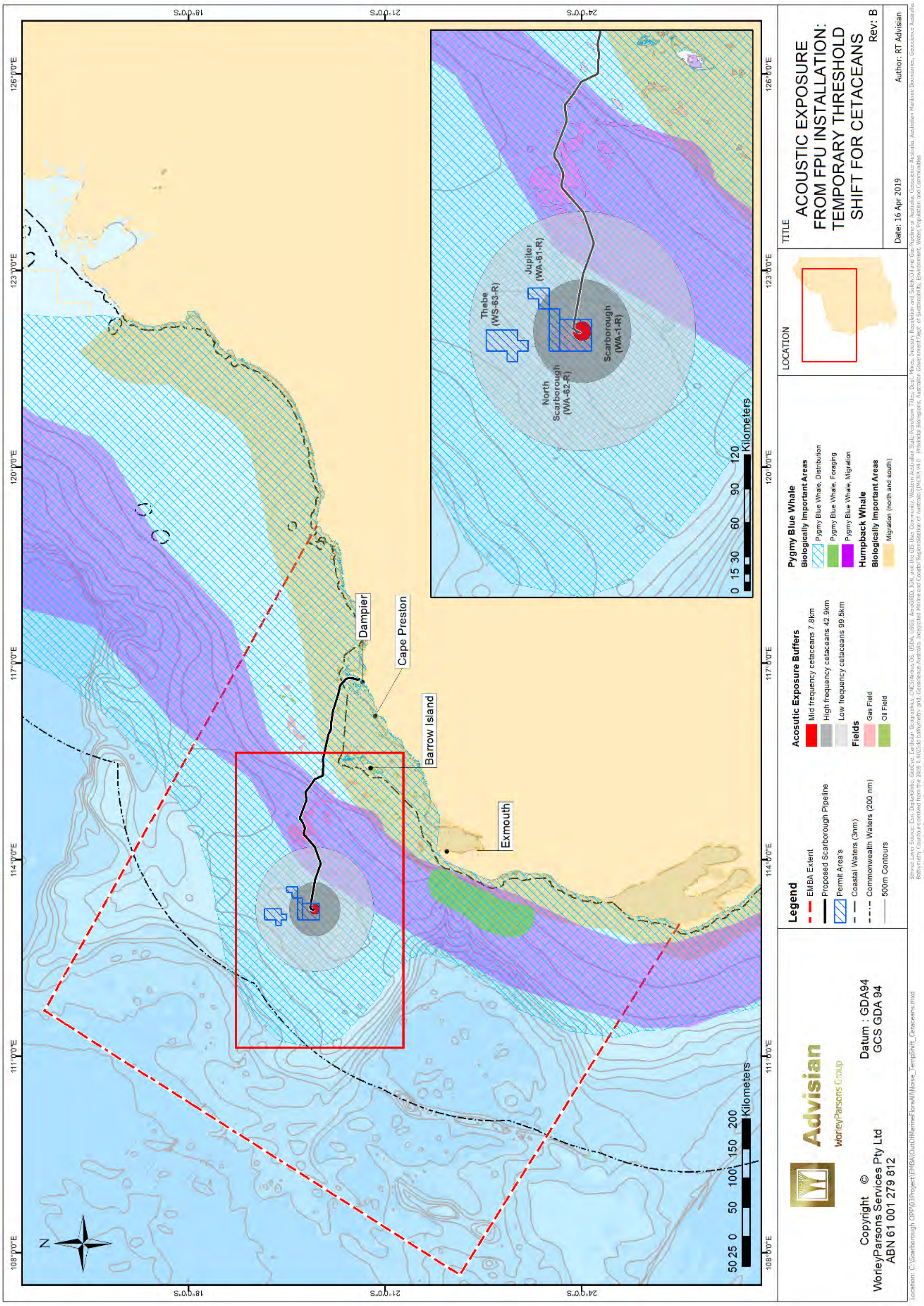


Figure 7-13: Predicted exposure area from impulsive noise from FPU installation activities that may cause a temporary threshold shift in cetaceans

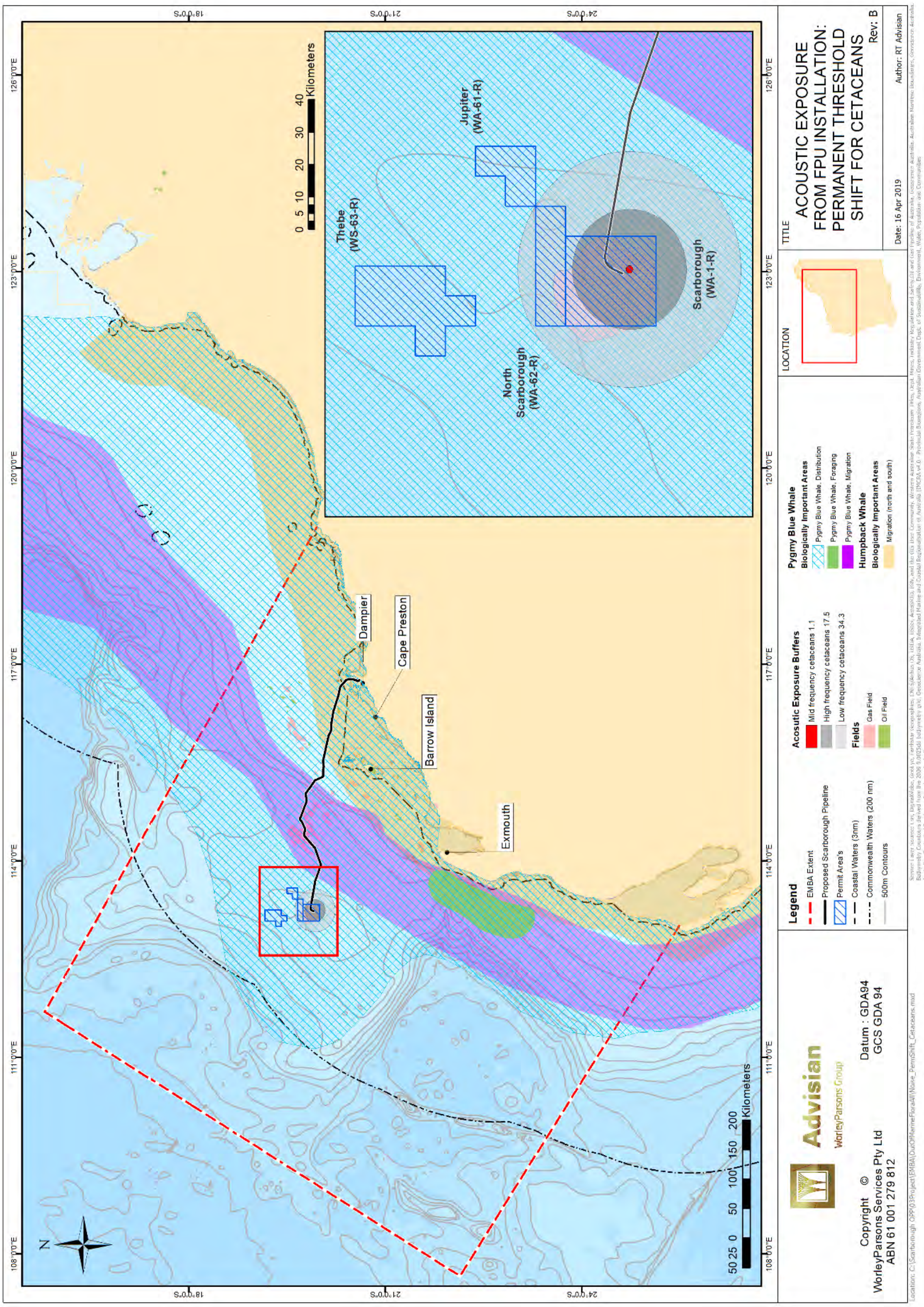


Figure 7-14: Predicted exposure area from impulsive noise from FPU installation activities that may cause a permanent threshold shift in cetaceans

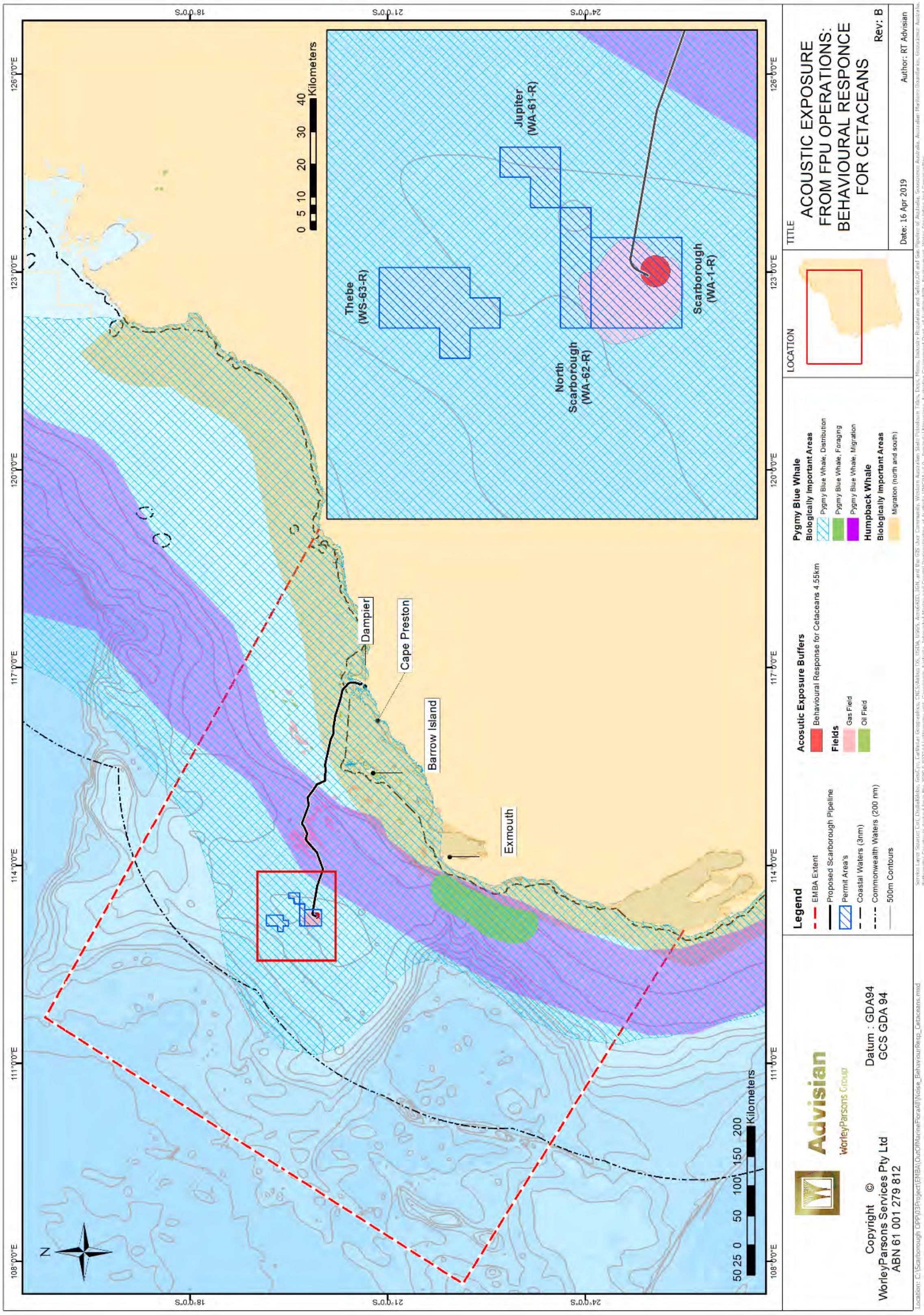


Figure 7-15: Predicted exposure area from continuous noise from FPU operations that may cause a behavioural response in cetaceans

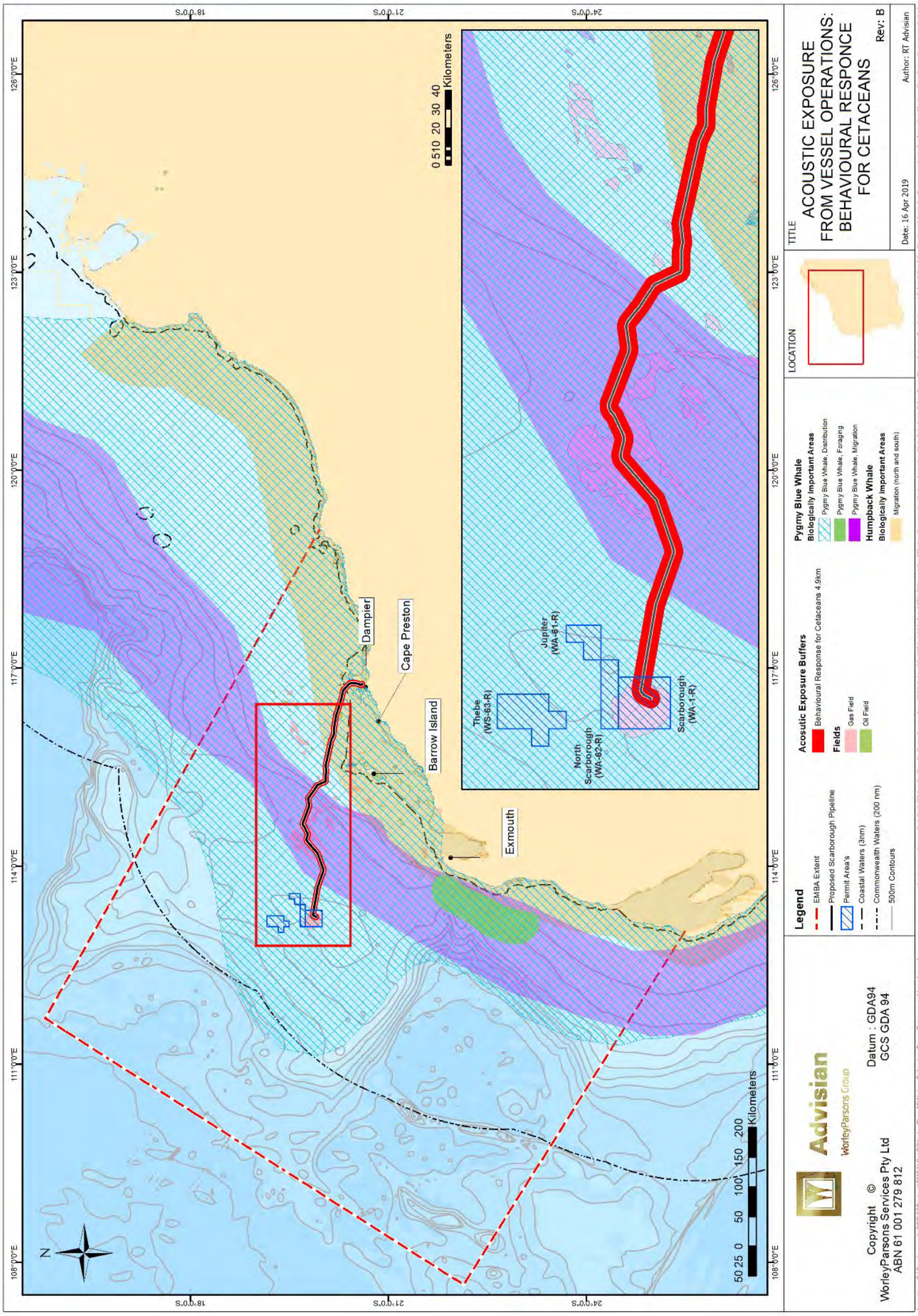


Figure 7-16: Predicted exposure area from continuous noise from vessel operations that may cause a behavioural response in cetaceans

Marine Reptiles

There is a paucity of data regarding responses of marine turtles to underwater noise. Electro-physical studies have indicated that the best hearing range for marine turtles is in the 100 to 700 Hz range (Popper et al., 2014). Because of their rigid external anatomy, it is possible that sea turtles are highly protected from impulsive sound (Popper et al., 2014).

Popper et al., (2014) provided injury thresholds for turtles (>207 dB PK) however no thresholds were provided for behavioural disturbance. McCauley (2000) noted that sea turtles exhibit increased swimming activity in response to impulsive noise exposure at 166 dB re 1 uPa (SPL). McCauley et al., (2003), Popper et al., (2014) and O'Hara and Wilcox (1990), however, reference behavioural exposure thresholds for impulsive noise sources on caged green and loggerhead turtles and turtle injury thresholds specific to pile driving (Table 7-34).

For continuous noise sources, such as vessel operations, marine turtles have been shown to avoid low-frequency sounds (Lenhardt, 1994). Further, playback study of diamondback terrapins (*Malaclemys terrapin terrapin*) using boat noise, some animals were observed to increase or decrease swimming speed while others did not alter their behaviour at all (Lester et al., 2013).

Table 7-34: Impulsive noise exposure for marine turtles

Species	Received Level			Effect	Source
	SPL (L_p)	*PK (L_{pk})*	*SEL (L_E)*		
Sea turtles	-	>207	210	Injury	Popper et al., 2014
Loggerhead turtle	175-176	-	-	Avoidance response	O'Hara and Wilcox, 1990
One green and one loggerhead turtle	166	-	-	Noticeable increase in swimming behaviour, presumed avoidance response	McCauley et al., 2003
One green and one loggerhead turtle	175	-	-	Behaviour becomes increasingly erratic, presumed alarm response	McCauley et al., 2003

Turtles may be exposed to helicopter noise when on the sea surface (e.g. when basking or breathing). Hearing in marine turtles is adapted for the perception of sound underwater (Popper et al., 2014), where they spend most of their time. As such, turtles are not expected to perceive noise levels from helicopters that may result in PTS or TTS; impacts may consist of 'startle' responses such as diving, which are exhibited when turtles are exposed to other disturbances such as the passage of vessels. Typical startle responses occur at relatively short ranges (tens of metres) (Hazel et al., 2007) and as such, startle responses during typical helicopter flight profiles are considered to be remote. In the event of a behavioural response to the presence of a helicopter, turtles are expected to exhibit diving behaviour, which is of no lasting effect.

Predicted Impact Summary

Acoustic emissions form pile driving may exceed marine turtle impact thresholds for mortality/lethal injury and behavioural response at 2.395 km and 24.6 km (R_{max}), respectively. For the continuous noise emissions associated with the FPU operation and pipelay vessels, the distance at which the behavioural response threshold is exceeded is lower, at 0.48 km and 0.46 km (R_{max}) respectively.

Marine turtles are expected to occur in the Offshore Project Area infrequently. Significant or critical habitat is not known to occur for any turtle species in the Offshore Project Area, with the closest BIA located >150 km away. Although the Trunkline Project Area overlaps areas identified as potential critical breeding habitat for loggerhead, hawksbill, flatback and green turtles, the area of impact from acoustic sources in these habitats are restricted to within 0.46 km of the pipelay vessel (Figure 7-17), preventing displacement of a significant proportion of the breeding population. Furthermore, trunkline installation activities will be temporary and the vessel continually moving, further reducing the potential for impact at the individual and population level.

Impacts of acoustic signals on sea snakes have not be researched in great depth. Guinea and Whiting (2005) reported that very few short-nosed sea snakes moved as far as 50 m from the reef flat and are therefore unlikely to be encountered in high numbers in the Project Area.

The greatest noise source is driven piling in the Offshore Project Area, where marine reptiles are not expected to occur in large numbers. This piling activity is temporary, further reducing the number of individuals that could be present within the area where noise levels exceed impact thresholds. Although individuals are more likely to occur in the Trunkline Project Area, particular in areas that overlap BIAs and (draft) critical habitat, routine acoustic emissions from activities in the Trunkline Project Area are also temporary and restricted to behavioural responses in close proximity to the vessel.

In order to minimise impacts to ambient noise, Woodside will implement internal requirements, specifically the VSP Procedure. Woodside VSP Procedure sets out the manner in which VSP operations are to be carried out. This procedure contains measures that are consistent with industry standards, and includes requirements for:

- Pre-start visual observations
- Soft start procedures
- Operating procedures
- Low visibility operating procedures

For impact piling activities, Woodside will implement the soft start procedure at the commencement of piling activities and shut down zones during the activity.

These procedures reduce the potential for impacts to marine fauna from acoustic emissions by ensuring that there is no prolonged exposure of acoustic emissions activities to marine fauna once they are detected.

Impacts to sea snakes from routine acoustic emissions are to be managed in accordance with approved Conservation Advice for the Short-nosed Sea snake (DSEWPaC, 2011). The Conservation advice outlines the monitoring of known populations to identify key threats and ensure there are no anthropogenic disturbance in areas where the species occurs, excluding necessary actions to manage the conservation of the species.

As shown in Figure 7-4 and described in Table 5-4, part of the Trunkline Project Area overlaps BIAs and habitat critical (internesting buffer) for several species or marine turtle, and noise exposure from vessel operations during pipeline installation may overlap breeding seasons within these BIAs and habitat critical. However, pipeline installation activities will have a limited duration (weeks to months). There is no overlap between the Trunkline Project Area and important internesting habitat and the areas of overlap between Trunkline Project Area and the BIAs are located in offshore waters at a considerable distance from the nesting beaches Consequently, given the limited spatial and temporal overlap with marine turtle nesting and internesting activities any impacts from noise exposure will be limited to low level behavioural responses to transient individuals only, and there will be no impacts at a population level.

Impacts from routine acoustic emissions on marine reptiles will have no lasting effect. Receptor sensitivity of marine reptiles is high (high value species), and therefore the Impact Significance Level of routine acoustic emissions on marine reptiles is **Slight (E).**

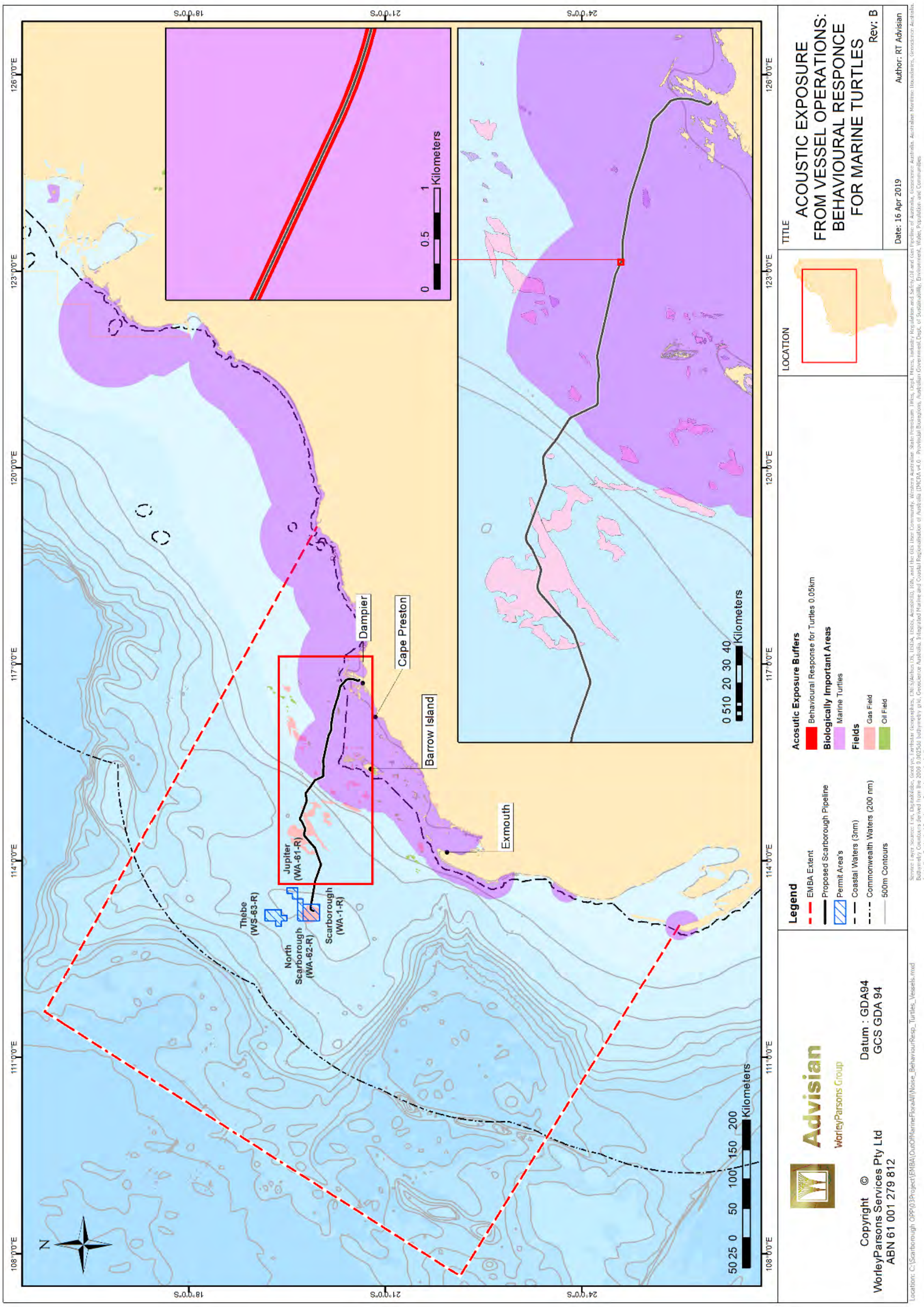


Figure 7-17: Predicted exposure area from continuous noise from vessel operations that may cause a behavioural response in turtles

7.1.4.3 Demonstration of Acceptability

Impact acceptability has been demonstrated for all impacts based on evaluation against the criteria described in Section 6.4.4. The outcomes of this determination are summarised below.

Principles of ESD

The Scarborough development is consistent with the relevant principles of ESD:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making

The Scarborough development will result in no significant impacts to receptors identified as potentially affected. Significant impact definitions:

- Ambient Noise:
  - To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.
- Fish:
  - To not have a substantial adverse effect on a population of fish or the spatial distribution of the population.
- Marine Mammals:
  - To not have a substantial adverse effect on a population of marine mammals or the spatial distribution of the population.
  - To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.
  - To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.
- Marine Reptiles:
  - To not have a substantial adverse effect on a population of marine reptiles or the spatial distribution of the population
  - To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat, such that an adverse impact on marine ecosystem functioning or integrity results
  - To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

Internal Context

The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards.

With respect to acoustic emissions, Woodside will implement its internal requirement:

- VSP Procedure.

External Context

During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on affected receptors from routine acoustic emissions.

Other requirements

The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES, specifically:

- All relevant activities associated with routine acoustic emissions will be conducted in line with the EPBC Act Policy Statement 2.1 – Interaction between Offshore Seismic Exploration and Whales.
- Act consistently with conservation advice for sea snakes.
- Act consistently with the relevant action in the Conservation Management Plan for the Blue Whale 2015-2025 (statutory recovery plan under the EPBC Act 1999 for blue whales), which includes an action that '*Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area'*.

Acceptable Levels of Impact

Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013)).

Activities associated with the Scarborough development that cause routine acoustic emissions are not inconsistent with recovery plans or wildlife conservation plans/advice that are in force for a potentially affected species, including the:

- Conservation Advice for the Short-nosed Sea snake (DSEWPaC, 2011)
- Conservation Management Plan for the Blue Whale 2015-2025 (Commonwealth of Australia, 2015a)

Statement of Acceptability

Based on an assessment against the defined acceptable levels, the impacts on affected receptors from Routine Acoustic Emissions is considered acceptable, given that:

- the activity is aligned with the relevant principles of ESD.
    - o Acoustic emissions associated with Scarborough are, in general, restricted to within close proximity of the source, with the exception of pile driving which is a relatively short-term activity (~20 days).
    - o Long term acoustic emissions (i.e. FPU operation) are not expected to disrupt population dynamics or function of marine fauna.
    - o Activities within the Trunkline Project Area are temporary and acoustic emissions restricted to within close proximity of the pipelay vessel, which will

  - be continually moving, avoiding reduction in the area of occupancy of important marine fauna populations.
  - The potential for mortality and lethal injury to marine fauna to occur is restricted within close proximity of the piling locations in the Offshore Project Area which lacks significant habitat for marine fauna.
  - Recoverable injury and behavioural responses may occur at greater distances from the piling locations, however, are note expected to result in displacement of a large proportion of the regional population.
- the proposed controls are consistent with Woodside's internal policies, procedures and standards
- feedback from stakeholders has been taken into consideration
- legislative requirements/industry standards have been adopted
- the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices:
  - Impacts to sea snakes from routine acoustic emissions are to be managed in accordance with approved Conservation Advice for the Short-nosed Sea snake (DSEWPaC, 2011). The Conservation advice outlines the monitoring of known populations to identify key threats and ensure there are no anthropogenic disturbance in areas where the species occurs, excluding necessary actions to manage the conservation of the species.
  - Impacts to pygmy blue whales will be managed in accordance with the Conservation Management Plan for the Blue Whale 2015, specifically the action to manage anthropogenic noise in biologically important areas such that any blue whale continues to utilise the area without injury and is not displaced from a foraging area. This being achieved by limiting impact piling to outside of peak migration periods.
- the predicted level of impact is at or below the defined acceptable levels for all receptors.

Environmental Performance Outcomes

To manage impacts to affected receptors to at or below the defined acceptable levels the following EPO have been applied:

EPO 4.1: Undertake the Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.

EPO 4.2: Undertake the Scarborough development in a manner that prevents a substantial adverse effect on a population of fish, marine mammals, marine reptiles, or the spatial distribution of a population.

EPO 4.3: Undertake the Scarborough development in a manner that will not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

EPO 4.4: Impact piling activities will not occur during the months of May and June, and November and December to avoid peak migration periods of the pygmy blue whale.

7.1.4.4 Summary of the Impact Assessment

Table 7-35 provides a summary of the risk assessment and acceptability for impacts from routine acoustic emissions on receptors.

Table 7-35: Summary of impacts, management controls, impact significance ratings and EPOs for Routine Acoustic Emissions.

<table>
<tr><th>Receptor</th><th>Impact</th><th>Environmental Performance Outcome</th><th>Adopted Control(s)</th><th>Receptor sensitivity level</th><th>Magnitude</th><th>Impact significance level</th><th>Acceptability</th></tr>
<tr><td>Ambient Noise</td><td>Change in ambient noise</td><td rowspan="4">EPO 4.1: Undertake the Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.
EPO 4.2: Undertake the Scarborough development in a manner that prevents a substantial adverse effect on a population of fish, marine mammals, marine reptiles, or the spatial distribution of a population.
EPO 4.3: Undertake the Scarborough development in a manner that will not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.
EPO 4.4: Impact piling activities will not occur during the months of May and June, and November and December to avoid peak migration periods of the pygmy blue whale.</td><td rowspan="4">CM6: Woodside VSP Procedure implemented while VSP operations are undertaken to prevent prolonged exposure to marine fauna.
CM7: For impact piling activities, Woodside will implement the soft start procedure at the commencement of piling activities and shut down zones during the activity.
CM8: EPBC Regulations 2000 Part 8 Division 8.1 Interacting with cetaceans.
CM37: Impact piling activities required for FPU installation will not occur during the peak migration periods for the northern migration of the pygmy blue whale (May and June) and southern migration (November and December).</td><td>Low value (open water)</td><td>No lasting effect</td><td>Negligible (F)</td><td>Acceptable</td></tr>
<tr><td>Fish</td><td>Change in fauna behaviour
Injury/mortality to marine fauna</td><td>High value species (MNES species known to be present.)</td><td>No lasting effect</td><td>Slight (E)</td><td>Acceptable</td></tr>
<tr><td>Marine Reptiles</td><td>Change in fauna behaviour
Injury/mortality to marine fauna</td><td>High value species (i.e. flatback turtle)</td><td>No lasting effect</td><td>Slight (E)</td><td>Acceptable</td></tr>
<tr><td>Marine Mammals</td><td>Change in fauna behaviour
Injury/mortality to fauna</td><td>High value species (i.e. pygmy blue whale)</td><td>No lasting effect</td><td>Slight (E)</td><td>Acceptable</td></tr>
</table>

7.1.5 Physical Presence – Displacement of Other Users

Displacement of other marine users can include temporary or long-term disruption to activities of commercial fishers, shipping, tourism and recreation or other industry.

7.1.5.1 Sources of the Aspect

Activities and facilities associated with Scarborough will displace other marine users during:

- surveys
- vessel operations
- MODU operations
- helicopter operations
- trunkline installation
- installation of the FPU and subsea infrastructure.
- removal of subsea infrastructure including trunkline

Vessel, FPU and MODU Operations

The movement of survey, installation and support vessels within the Project Area, and the physical presence of the vessels, MODU and FPU, have the potential to displace other marine users. Types of vessels may include moored or semi-moored MODU or dynamically positioned MODU or drill ship, subsea installation vessels (ISV), pipelay vessels, survey vessels, dredging vessels and support vessels. The type and number of vessels in the Project Area at any one time, and the duration of presence, will differ depending on the project phase. Vessel presence is expected to be greatest for short-term project phases (e.g. trunkline installation) in the Trunkline Project Area or drilling activities in the Offshore Project Area. Fewer vessels will typically be required during the long-term operational project phase.

MODUs and FPUs will only be present in the Offshore Project Area 375 km from shore in approximately 900 m water depth, whereas the pipelay vessel will traverse the length of the Trunkline Project Area. Support vessels will operate in both the Offshore Project Area and Trunkline Project Area. The FPU will have a 500 m safety exclusion zone surrounding their location within the Offshore Project Area for the duration of the operational project phase.

Trunkline Installation

The base case design is a 32-inch dry gas trunkline from the Scarborough FPU to shore, with a total route length of approximately 430 km. The trunkline installation and ongoing physical presence could displace other marine users. The physical presence of the trunkline will remain for the duration of field life.

It is anticipated that trunkline stabilisation is required in water depths shallower than 40 m, which corresponds to a location about 50 km offshore from the Pluto LNG Facility. The seabed is proposed to be trenched and the trunkline buried in this water depth. The material dredged during trenching will be used to backfill the trench, covering the trunkline.

The risk of marine users interacting with the trunkline is limited to potential snagging of fishing gear with the trunkline on the seafloor. Where the trunkline is backfilled, a reduced snagging risk will occur as the pipeline will be buried below the seabed.

Installation of the FPU and Subsea Infrastructure

Subsea infrastructure including wellheads, flowlines, manifolds will be located within the Offshore Project Area. The physical presence of this infrastructure will remain for the duration of field life. Wellheads and manifolds take up a small area on the seabed, however, may rise several metres above the seabed. The risk of marine users interacting with the subsea infrastructure is negligible within the Offshore Project Area due to the water depths (approximately 900 m).

Helicopter Operations

Helicopters will be used to transport personnel on/offshore during drilling and during periods of FPU manning in the Offshore Project Area and during trunkline installation in the Trunkline Project Area. The risk of marine users interacting with helicopter operations is restricted to temporary displacement due to increased air traffic in the area.

7.1.5.2 Impact or Risk

Displacement of other marine users due to physical presence of vessels, helicopters and trunkline and subsea infrastructure may result in the following impact:

- changes to the functions, interests or activities of other users.

Changes to the Functions, Interests or Activities of Other Users

Physical presence of vessels, trunkline, MODU and FPU and the use of helicopters are likely to result in localised changes to the functions, interests or activities of other users. The duration of change will depend upon the activity or duration for which the vessel and/or MODU is required. In the case of the FPU, trunkline and subsea infrastructure presence, the change will be permanent for the duration of the field life.

Receptors Potentially Impacted

Tourism and Recreation

Tourism and recreation activities in the region include recreational fishing, diving and snorkelling, yachting and wildlife watching. Most of these activities occur within shallow waters close to shore or within fauna aggregation areas. Tourism and recreation within the Offshore Project Area are expected to be limited by the distance offshore and water depths. Although recreational fishing may occur at greater distances from shore, these activities are usually associated with areas of elevated biodiversity, such as offshore shoals or reefs. Since the Offshore Project Area does not contain such habitat, it is not considered an area frequented by recreational fishers.

Tourism and recreation activities may be more common in the Trunkline Project Area, particularly in proximity to the Montebello Islands. Pipeline installation activities will have a limited duration (weeks to months) and during this period access of recreational users to the pipeline corridor may be restricted. However, as described in Section 7.1.6 the presence of the pipeline and any associated infrastructure will result in a net environmental benefit for demersal fish assemblages, and potentially also for recreational fishers targeting these assemblages. Given the location, and the short-term nature of activities in this area, impacts to tourism and recreational activities are unlikely, and have not been evaluated further.

Defence

Defence activities in the vicinity of the Offshore and Trunkline Project Areas may include Naval vessel traffic and Air Force training exercises. Neither of these types of activities are expected to be a consistent presence in the area. The MODU and FPU (i.e. above-sea infrastructure) are also on the outer extent of the training area (Figure 5-58) associated with the Learmonth Air Force Base. As such, any potential interaction is expected to be minimal and not significantly different from interaction with other facilities within the northwest region, and therefore impacts have not been evaluated further. Any potential impact to Naval vessel operations are considered as similar to the 'Shipping' impact evaluation presented below.

Table 7-36 outlines the potential impacts to receptors associated with displacing other marine users.

Table 7-36: Receptor/impact matrix after evaluation of context

	Receptor					
Impacts	***Commonwealth Managed Fisheries***	***State Managed Fisheries***	***Tourism and Recreation***	***Shipping***	***Industry***	***Defence***
Changes to the functions, interests or activities of other users	✓	✓	X	✓	✓	X

Detailed Impact Evaluation

<u>*Commonwealth and State Managed Fisheries*</u>

Five Commonwealth managed fisheries (one of which is inactive) and seven State managed fisheries overlap the Project Area. Potential impacts to commercial fishers depend on the use of the area by fishers, in addition to the temporal and spatial extent of the presence of vessels and facilities/infrastructure.

Potential impacts to commercial fisheries include damage to fishing and loss of commercial catch due to displacement from fishing grounds. Damage to trawl nets could occur if they catch or snag on subsea infrastructure. The Northwest Slope Trawl Fishery (Commonwealth) and the Pilbara Trawl Fishery (State) overlap the Trunkline Project Area. No trawl fisheries overlap the Offshore Project Area. Subsea infrastructure presenting the greatest snag hazard, such as wellheads and manifold, are located in the Offshore Project Area only where trawl fishing does not occur. The trunkline will be buried at depths <40 m, which correlates to about 50 km offshore, this area corresponds to the higher area of fish trawling activity. Burying the trunkline negates the snagging risk within the Trunkline Project Area.

Predicted Impact Summary

During installation of the FPU and other subsea infrastructure, and during surveys and drilling, the presence of vessels (and MODU) in the Offshore Project Area will present a surface hazard to fishing vessels. During drilling a 500 m safety exclusion zone will be required around the MODU and, once operational, the FPU will also have a 500 m radius safety exclusion zone. This will result in short-term exclusion during drilling and installation, and longer-term exclusion during the operational phase. Given the distance offshore, the Offshore Project Area is not an area of high commercial fishing activity. Furthermore, the 500 m safety exclusion zone around the MODU and/or FPU comprises a relatively small area when compared to the extent of the individual fishery boundaries that overlap. As such, displacement of commercial fisheries due to activities in the Offshore Project Area are not expected to impact commercial fishing activities or the economic viability of the fisheries.

Fishing activity is expected to be higher in the shallower waters of the Trunkline Project Area. Here, fishers will be temporarily displaced from parts of the Trunkline Project Area during activities associated with the trunkline such as installation or surveys. Additionally, fishers may be temporarily displaced from the Borrow Grounds Project Area during dredging. As with the FPU, a requested

500 m safety exclusion zone will be present around the pipelay vessel. During trunkline installation, the pipelay vessel has low manoeuvrability, meaning that fishing vessels will be required to avoid the vessel. However, the trunkline installation activity will take place over a short period comparative to Scarborough and therefore any displacement will be temporary. Furthermore, the pipelay vessel is continually moving and only operating within a small spatial footprint at any one time. Therefore, fishing vessels will not be excluded from the entire Trunkline Project Area for the total duration of trunkline installation, further reducing the timeframe within which displacement could occur. Once installation activities have occurred, the trunkline remains in situ and is buried at water depths <40 m, negating snagging risk from trawling vessels. Considering the temporary and localised displacement potential for commercial fisheries due to installation activities in the Trunkline Project Area and Borrow Grounds Project Area, and that the trunkline is buried below the seabed in waters depths <40 m, impacts to the fishing activities is not expected.

Vessel operations undertaken as a part of this activity will adhere to MARPOL and the various Marine Orders (as appropriate to vessel class) enacted under the *Navigation Act 2012*. This Act regulates navigation and shipping including Safety of Life at Sea (SOLAS). Notifications will be made to representatives of State and Commonwealth fisheries, informing them of planned activities.

The presence of commercial fisheries in the Offshore Project Area is low. The trunkline installation phase of Scarborough, when vessel use will be highest, is a comparatively short phase. Therefore, any displacement of fishing activities will be temporary. Once installation activities have ceased, the trunkline remains in situ and is buried at water depths <40 m, negating snagging risk from trawling vessels in these waters. Impacts from physical presence of the Scarborough development on Commonwealth and State managed fisheries will be slight. Receptor sensitivity is high (high value marine user), and therefore Impact Significance Level is **Minor (D).**

Shipping

Commercial shipping in the Project Area is high, particularly in areas where the Trunkline Project Area traverses shipping fairways and as it approaches the state water boundary where the ports of Dampier and Port Hedland are in located. In comparison to the Trunkline Project Area, shipping activity in the Offshore Project Area is relatively low. As such, activities associated with the Offshore Project Area (e.g. drilling, FPU installation and operation, subsea infrastructure installation) are less likely to impact commercial shipping compared to activities associated with the Trunkline Project Area.

During trunkline installation, the pipelay vessel will have limited manoeuvrability, meaning that commercial shipping vessels will be required to alter course to avoid the vessel and its 500 m safety exclusion zone. This may result in minor delays or increased fuel use due to a less direct route. However, the presence of the pipelay vessel will be temporary throughout the trunkline installation activities only. Furthermore, the pipelay vessel will be continuously moving, albeit at a slow speed, so that it will not be present in a single location (e.g. a shipping fairway) for more than a few weeks at most. Once the trunkline is installed, the presence and operation of the trunkline will not impact on commercial shipping activities.

Predicted Impact Summary

AMSA have provided comment on the placement of the moorings and cross referenced them with Traffic data. Shows trunkline crosses charted shipping fairways where vessel traffic is heavy. Woodside to provide Marine Safety Information as per AMSA's request.

Vessel operations undertaken as a part of this activity will adhere to MARPOL and the various Marine Orders (as appropriate to vessel class) enacted under the *Navigation Act 2012*. This Act regulates navigation and shipping including Safety of Life at Sea (SOLAS). Notifications will be made to the Australian Hydrographic Service (AHS), informing them of planned activities.

Impact to commercial shipping is limited to the temporary presence of vessels throughout the trunkline installation activities. The trunkline installation will present short-term disruption to commercial shipping who may need to avoid the installation vessels. The installation phase of Scarborough, when vessel use will be highest, is comparatively short. Therefore, displacement will be temporary and limited to minor course alteration.

Impacts from physical presence of the Scarborough development on shipping will be slight. Receptor sensitivity is medium (medium value marine user), and therefore Impact Significance Level is **Slight (E).**

Industry

The NWS is an area of active oil and gas exploration and production. The closest facility to the Offshore Project Area is the Woodside Pluto facility (160 km to the west). The closest facilities to the Trunkline Project Area are the Woodside Pluto facility (4 km) and the Jadestone Stag facility (8 km). The Trunkline Project Area passes through several exploration and production permits with a variety of titleholders. In addition, the Trunkline Project Area also crosses existing trunklines including the Reindeer and Wheatstone trunklines.

Displacement of, or interference with, other oil and gas activities are not expected within the Offshore Project Area (given the lack of other activities), however activities associated with the trunkline, such as trunkline installation, may result in short-term interference. However, as previously described, the pipelay vessel will be continuously moving so that it will not be present in a single location for more than a few weeks at most. Once installed, the presence and operation of the trunkline will not result in significant interference with other petroleum activities.

Predicted Impact Summary

Vessel operations undertaken as a part of this activity will adhere to MARPOL and the various Marine Orders (as appropriate to vessel class) enacted under the *Navigation Act 2012*. This Act regulates navigation and shipping including Safety of Life at Sea (SOLAS). Notifications will be made to the Australian Hydrographic Service (AHS), informing them of planned activities.

Activities associated with the trunkline, such as trunkline installation, may result in localised, short-term interference to industry vessels required minor course alteration. Once the trunkline is installed this interference will be greatly reduced as the interference with other oil and gas activities are not expected within the Offshore Project Area given its distance from other facilities.

Impacts from physical presence of the Scarborough development on industry will be slight. Receptor sensitivity is medium (medium value marine user), and therefore Impact Significance Level is **Slight (E).**

7.1.5.3 Demonstration of Acceptability

Impact acceptability has been demonstrated for all impacts based on evaluation against the criteria described in Section 6.4.4. The outcomes of this determination are summarised below.

Principles of ESD

The Scarborough development is consistent with the relevant principles of ESD:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making

The Scarborough development will result in no significant impacts to receptors identified as potentially affected. Significant impact definitions:

- Commonwealth and State managed fisheries:
  - To not have a substantial adverse effect on the sustainability of commercial fishing.
  - To not interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted.
- Shipping:
  - To not interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted.
- Industry:
  - To not interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted.

Internal Context

The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards.

External Context

During stakeholder consultation with relevant persons, specific concerns were raised regarding the potential impacts of the Scarborough development on affected receptors from displacement of other users:

- AMSA have provided comment on the placement of the moorings and cross referenced them with Traffic data. Shows trunkline crosses charted shipping fairways where vessel traffic is heavy. Woodside to provide Marine Safety Information as per AMSA's request.

Other requirements

The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES, specifically:

- Vessel operations undertaken as a part of this activity will adhere to the *Navigation Act 2012*, MARPOL and the various Marine Orders (as appropriate to vessel class) enacted under this Act. This Act regulates navigation and shipping including Safety of Life at Sea (SOLAS), which includes specific requirements for navigational lighting. Although the Act does not apply to the operation of petroleum facilities, it may apply to some support vessels. Woodside will notify AHS and representative of Commercial and State fisheries of all activities.

Acceptable Levels of Impact

Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013)).

Statement of Acceptability

Based on an assessment against the defined acceptable levels, the impacts on affected receptors from Physical Presence: Displacement of Other Users is considered acceptable, given that:

- the activity is aligned with the relevant principles of ESD.
    - The presence of other marine users in the Offshore Project Area is low; the area does not represent important fishing grounds or areas of high vessel traffic (such as shipping fairways), is remote from other oil and gas activities, and is too far offshore for notable tourism and recreational uses.
    - Activities occurring in the Offshore Project Area, including the long-term operation of the FPU, are not expected to change or impact the interests or functions of other users.
    - The installation phase of Scarborough, when vessel use will be highest is a comparatively short phase of Scarborough. Once the installation phase of Scarborough is completed (trunkline installation, FPU and subsea infrastructure), vessel presence will be significantly reduced in the Project Area.
    - The area covered by the Trunkline Project Area includes areas of increased activity such as shipping fairways, known fishing grounds and petroleum export pipelines.
    - Trunkline installation will be limited to approximately one year of activity, following which its presence and operation is unlikely to present a hazard to other users.
- the proposed controls are consistent with Woodside's internal policies, procedures and standards
- feedback from stakeholders has been taken into consideration
- legislative requirements/industry standards have been adopted
- the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices
- the predicted level of impact is at or below the defined acceptable levels for all receptors.

Environmental Performance Outcomes

To manage impacts to affected receptors to at or below the defined acceptable levels the following EPO have been applied:

EPO 5.1: Undertake the Scarborough development in a manner that prevents a substantial adverse effect on the sustainability of commercial fishing.

EPO 5.2: Undertake the Scarborough development in a manner that does not interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted.

7.1.5.4 Summary of the Impact Assessment

Table 7-37 provides a summary of the risk assessment and acceptability for impacts from displacement of other marine users to receptors.

Table 7-37: Summary of impacts, management controls, impact significance ratings and EPOs for displacement of other marine users

Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity level	Magnitude	Impact significance level	Acceptability
Commonwealth Managed Fisheries	Changes to the function interests or activities of others	**EPO 5.1:** Undertake the Scarborough development in a manner that prevents a substantial adverse effect on the sustainability of commercial fishing. **EPO 5.2:** Undertake the Scarborough development in a manner that does not interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted.	**CM9:** Vessels to adhere to the navigation safety requirements including the Navigation Act 2012 and any subsequent Marine Orders. **CM10:** Notify Australian Hydrographic Service (AHS) of activities and movements prior to activity commencing. **CM11:** Notify representatives of State and Commonwealth fisheries of activities.	High value marine user	Slight	Minor (D)	Acceptable
State Managed Fisheries				High value marine user	Slight	Minor (D)	Acceptable
Shipping				Medium value marine user	Slight	Slight (E)	Acceptable
Industry				Medium value marine user	Slight	Slight (E)	Acceptable

7.1.6 Physical Presence – Seabed Disturbance

Seabed disturbance includes changes to the existing physical (e.g. substrate) and biological (e.g. habitat) values of the environment.

7.1.6.1 Sources of the Aspect

Throughout the development of Scarborough, disturbance to the seabed will occur during:

- pre-lay surveys
- drilling operations
- installation of the FPU and subsea infrastructure
- trunkline installation and stabilisation
- removal of subsea infrastructure including trunkline
- MODU operations
- vessel operations
- ROV operations.

Pre-lay Surveys

Geotechnical surveys may be required to collect data to inform installation activities, in order to confirm the seabed sediments. Seabed disturbance can result from placing survey equipment on the seafloor, or when collecting seabed samples.

Geotechnical surveys typically involve in-situ testing and piston/push sampling. Following sampling, all equipment is withdrawn from the seabed. A small hole (<1 m^2) will remain, which will eventually collapse and infill with the movement of surface sediments in ocean current.

An Ultra Short Base Line (USBL) system will be used during geotechnical surveys to accurately monitor survey equipment deployed from the survey vessel. USBL is an underwater positioning system that uses a vessel-mounted transceiver to detect the range and bearing to a sampling target.

To ensure the USBL system is functioning correctly, the system will be calibrated using a USBL beacon. This involves deploying a USBL beacon complete with acoustic release, float and weight to the seabed for a period of one to two hours. Once the calibration is complete, the beacon is released from the seabed and ascends to the surface where it is recovered to the survey vessel. The weight will remain on the seabed. Seabed disturbance will be localised to the area of the weight (about 0.1 m^2).

Drilling and MODU Operations

The proposed production wells will be drilled using a moored or semi-moored MODU or dynamically positioned drill ship.

Seabed disturbance will result from the anchor holding testing and MODU anchor mooring system, including placement of anchors and chain/wire on the seabed, potential dragging during tensioning, and recovery of anchors. Mooring may require a 12-point pre-laid mooring system at each well location, depending on the time of year. Although the exact anchoring configurations are currently unknown, a semi-submersible MODU with an 8 to 12-point anchoring system could disturb up to 0.013 km^2 per well (13,000 m^2), allowing for anchor footprint and disturbance from anchor chains (NERA, 2018). For the 30 proposed wells, this gives a total footprint of 0.39 km^2.

Dynamic positioning of the MODU uses satellite navigation and radio transponders in conjunction with thrusters to maintain the position of the MODU at the required location. Information about the position of the MODU is provided via seabed transponders, which are replaced on the seabed and emit signals that are detected by receivers on the MODU and used to calculate position. The transponders are typically deployed in an array on the seabed, using clump weights comprising concrete, for the duration of the drilling at each well. They are recovered at the end, generally by ROV. Clump weights are recovered if practicable to do so or may be left in-situ on the seafloor. Clump weights generally consist of a clumped group of four 20 kg weights covering an area less than 1 m². A total seabed disturbance area of 20 m² per well is anticipated, giving a total 0.0006 km² (600 m²) for the proposed 30 wells.

Installation of the FPU and Infield Subsurface Infrastructure

The FPU will be moored in place by 20 permanent piles. The piles will be installed either by suction piling (preferred) or driven piling. Where suction piling is used, suction piles will typically be 6 m to 8 m in diameter, and about 30 m in length, with each weighing about 180 tonnes. Based on these dimensions, 20 piles will result in a seabed disturbance area of 0.001 km² (1000 m²).

The infield subsea infrastructure required for Scarborough along with the disturbance area is expected to disturb an area of approximately 0.234 km² (this includes a 50% contingency as the figure is subject to refinement during the design process).

Table 7-38: Extent of seabed disturbance for the FPU and infield subsurface disturbance

Infrastructure	Area (km²)
Scarborough Field	
FPU and infield infrastructure (flowlines, umbilicals, ILT's, risers and anchors, flowlines)	0.038
Jupiter and Thebe fields (flowlines and interfield lines)	0.027
Jupiter and Thebe Field	
Flowlines and interfield lines	0.090
Total Disturbance	0.156
Total Disturbance with 50% contingency	0.234

Flowline and umbilical installation may require jetting or trenching techniques for burial. Jetting uses high pressure water and air or water to create a trench by fluidising the seabed, which is then dispersed into the water column. In areas of harder soil materials, the jetting equipment will be substituted by a mechanical cutter.

Trenching techniques involve a mechanical cutter, which is used to cut a trench about 1 m wide and 0.5 m deep below the seabed. The umbilical then falls within the trench which is backfilled over time by sediment deposition.

The installation of subsea infrastructure required for the project will generate turbidity when placed on the seafloor. Once placed, seabed sediments will be disturbed and enter the water column, increasing local turbidity for a short period.

Trunkline installation and stabilisation

The base case design is a 32-inch dry gas trunkline between the Scarborough FPU and the Pluto LNG Facility, with a total route length of about 430 km. The pre-lay dredging works associated with the trunkline development involves dredging of an approximately 2.5–3.5 m deep trench along the trunkline route from the State waters boundary to approximately KP 50 within the indicative trunkline corridor (of 30 m width). Trenched material will be disposed at existing spoil grounds (i.e. Spoil

Ground 5A[27]) within the region, while backfill will be sourced from one of the pre-identified borrow ground locations.

It is anticipated that trunkline stabilisation and hence trenching and backfill activities is required in water depths shallower than 40 m, which corresponds to a location about 50 km offshore. Trenching and backfill activities would therefore result in seabed disturbance in Commonwealth waters from approximately KP 32 to KP 50 (including within existing spoil ground 5A) and at the proposed Borrow Ground (Figure 7-18). A seabed disturbance footprint of up to approximately 17 km^2 may occur at the Borrow Ground through dredging and up to 5 km^2 at Spoil Ground 5A through the placement of sediment (noting it is a previously disturbed spoil ground). These disturbance footprints are considered conservative as they are based on the entire designated borrow ground and spoil ground being disturbed.

Further, to avoid accidental incursion of seabed disturbance into the Dampier Marine Park which is adjacent to the proposed borrow ground, a 250m buffer zone will be applied. Sea Dumping Permits under the *Environment Protection (Sea Dumping) Act 1981* will be in place where required to support the activity. Sea dumping activities will be undertaken in accordance with the Sea Dumping Act and any permit as required.

For a section of the trunkline route in the vicinity of KP209 (Figure 7-18), seabed material (2,500–15,000 m^3) may be mobilised and/or displaced to allow safe pipelay operations to be conducted in approximately 580 m water depth, at the top of the slope. This relocation/intervention of seabed material will be completed using a potential combination of ROV or other subsea equipment based methods, such as mass flow excavation, heavy duty grab, jetting or a grader. Any displaced material will not be recovered to the surface and will be placed in vicinity of the pipeline route (within a radius of approximately 250 m), and/or relocated along the pipeline corridor down gradient. Potential seabed disturbance associated with this activity is therefore expected to cover an approximately 500 m corridor in this area.

Seabed disturbance from installing and stabilising the trunkline is estimated at 12.9 km^2 based on an indicative trunkline corridor of 30 m width encompassing the trunkline for the entire 430 km. This is considered a conservative disturbance estimate, as while there will be a few locations along the trunkline route where seabed disturbance extends wider than 30 m (e.g. slope crossing), the average width of seabed disturbance across the entire trunkline route is expected to be less than 30 m. This disturbance area for the indicative trunkline corridor includes rock placement for pipeline crossings.

[27] Spoil Ground 5A is located within the Trunkline Project Area and lies adjacent to the proposed Scarborough trunkline route between approximately KP 32 and KP 50, with a width of approximetly 300 m (Figure 5-14).

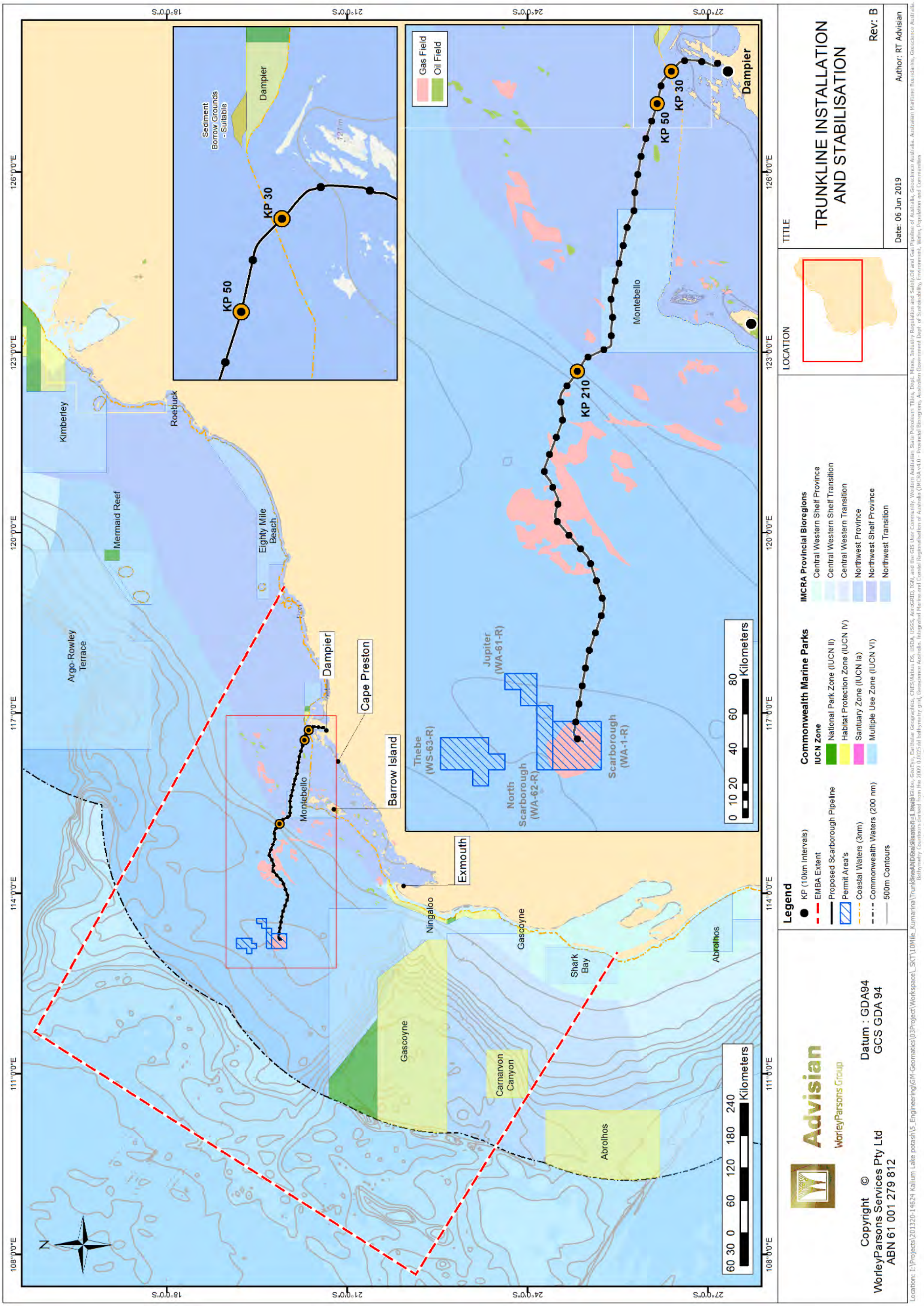


Figure 7-18: Proposed borrow ground and trunkline stabilisation areas

Sediment dispersion modelling

Sediment dispersion modelling was undertaken to assess the potential impacts to water quality and benthic communities and habitats from dredging, spoil disposal and backfill activities occurring in Commonwealth waters as part of the overall program (which includes State and Commonwealth waters activities) (Appendix J).

Three-dimensional numerical modelling was used to simulate the distribution of sediments suspended by dredging operations during the full duration of the dredging program. The modelling relied upon specification of sediment discharges over time for each of the expected sources of sediment suspension and predicted the evolution of the combined sediment plumes via current transport, dispersion, sinking and sedimentation. The model also allowed for the subsequent resuspension of settling sediments due to the erosive effects of currents and waves.

Modelling of the potential sediment dispersion from the dredging, spoil disposal and backfill activities required temporal and spatial representation of the hydrodynamic (e.g. currents) and waves conditions within the project area. A hydrodynamic and wave model framework for the Mermaid Sound area had previously been constructed, calibrated and validated for a past marine modelling study of dredge spoil stability and navigation for WEL (RPS, 2016); this existing model framework was adopted and further refined for this activity. The configuration of the current and wave models is in line with best practice for sediment dispersion modelling in Western Australia as outlined by WAMSI Dredging Science Node guidance (Sun et al., 2016).

There are inherent limitations to the accuracy of any numerical model study (RPS, 2019e; Appendix J). These limitations have been minimised during this modelling scope by incorporating actual data where available, aligning with best practice guidance, and utilising extensive past project experience from both a modelling and dredging perspective.

Model Scenarios

To provide for uncertainty in the dredge schedule, two modelling scenarios have been run, with work either commencing in the summer season or the winter season (Table 7-39).

Analysis of wind data in the region from 1993–2017 has shown that the period of 2016–2017 is likely to be representative of typical conditions. The dredge modelling was simulated using hydrodynamic and wave data taken from this period, with nominal start dates for model simulation purposes being chosen as 1 July 2016 (winter) and 1 January 2017 (summer). It should be noted that these scenarios for the purpose of modelling are mutually exclusive in terms of time and methodology.

The modelling outputs represent the overall program including the combination of both State and Commonwealth activities and hence provides a conservative representation of Commonwealth outputs. Note, the results observed on any given day may vary markedly and therefore percentile distributions are used, which summarise the outcomes over the entire scenario and do not represent an instantaneous plume footprint at any point in time (Appendix J). The analysis is based on the 95th percentile depth averaged results.

Table 7-39: Summary of modelling scenarios for the overall program (both Commonwealth and State activities) including sequencing of individual components under each scenario

Activity	Area	Scenario 1 (Dredging and backfill material from Borrow Ground A with a winter start date)	Scenario 2 (Dredging and backfill material from Borrow Ground A with a summer start date)
Trailing suction hopper dredge - dredging and spoil disposal operations	State and Commonwealth	Modelled activities completed between 1 July 2016 and 21 August 2016	Modelled activities completed between 1 January 2017 and 21 February 2017

Activity	Area	Scenario 1 (Dredging and backfill material from Borrow Ground A with a winter start date)	Scenario 2 (Dredging and backfill material from Borrow Ground A with a summer start date)
Backhoe dredge - dredging and spoil disposal operations	State only	Modelled activities completed between 21 August 2016 and 10 September 2016	Modelled activities completed between 21 February 2017 and 13 March 2017
Simulations run-on period[28]	State and Commonwealth	Modelled to occur between 10 September 2016 and 1 December 2016	Modelled to occur between 13 March 2017 and 1 June 2017
TSHD backfill activities	State and Commonwealth	Modelled activities completed between 1 December 2016 and 9 February 2017	Modelled activities completed between 1 June 2017 and 10 August 2017
Rock backfill using a side dump vessel	State only	Modelled activities completed between 9 February 2017 and 2 March 2017	Modelled activities completed between 10 August 2017 and 31 August 2017
Further simulation run on period[29]	State and Commonwealth	Modelled to occur between 2 March 2017 and 30 April 2017	Modelled to occur between 31 August 2017 and 31 October 2017

Modelled quantities and sediment properties

While actual volumes of material required from the offshore borrow ground is not yet confirmed, about 1.6 Mm^3 of sandy sediments with a low proportion of fines has been modelled. The critical geotechnical information required as input to the modelling is PSD data for the sediments to be dredged. This data has been specified (WEL, 2018b) for each pipeline section. The resultant PSDs have been redistributed to match the material size classes used in the model. For the offshore borrow ground, it has been assumed that the measured PSDs between KP30 and KP50 were applicable. The PSD data for these sections is characterised mainly as coarse sand, with 15% of the total mass existing as fines. Note this approach is considered conservative as PSD data sampled from the offshore borrow ground can be characterised mainly as coarse sand with a low fines fraction (on average 3% fines).

Conservatively, modelling did not include the 250 m buffer zone between the borrow ground and Dampier AMP.

Thresholds

Modelling of activities considered thresholds that describe potential environmental impacts to the benthic communities of Mermaid Sound and also considered the conservation values of the adjacent Dampier AMP.

Model outputs were interrogated by a series of water quality thresholds to predict the extent of impacts in a series of zones as recommended by Technical Guidance Environmental Impact Assessment of Marine Dredging Proposals (EPA 2016). Thresholds have been developed based on the definitions of management zones suggested within the guidance document. Thresholds were selected for benthic habitats on the basis of past and present mapping of the communities surrounding the Borrow Ground and Mermaid Sound and technical justification from the work of the Western Australian Marine Science Institute's Dredging Node (WAMSI: https://www.wamsi.org.au/dredging-science-node). Thresholds for three management zones – a Zone of Influence (ZoI), a Zone of Moderate Impact (ZoMI) and a Zone of High Impact (ZoHI) – were

[28] The period modelled to account for suspended sediments that may remain in the water column following the completion of dredging activities

[29] The period modelled to account for suspended sediments that may remain in the water column following the completion of backfill activities

defined. The definition of the zones applied to the modelling to assess impacts to the benthic values of the Dampier Marine Park are presented in Table 7-40.

Table 7-40: Impact Zone Definitions

Impact Zone[30]	Definition of Zone
Zone of High Impact	Is the area where impacts on benthic communities or habitats are predicted to be irreversible. The term irreversible means 'lacking a capacity to return or recover to a state resembling that prior to being impacted within a timeframe of five years or less'. Areas within and immediately adjacent to proposed dredge and disposal sites are typically within zones of high impact.
Zone of Moderate Impact	The area within which predicted impacts on benthic organisms are recoverable within a period of five years following completion of the dredging activities. This zone abuts, and lies immediately outside of, the zone of high impact. Proponents should clearly explain what would be protected and what would be impacted within this zone, and present an appraisal of the potential implications for ecological integrity of the impacts over the timeframe from impact to recovery (e.g. through loss of productivity, food resources, shelter). Where recovery from the impact predicted in this zone is likely to result in an 'alternate state' compared with that present prior to development, then this outcome should be clearly stated in environmental assessment documents, along with justification as to why the predicted impacts should be included within this zone (rather than the Zone of High Impact) and an appraisal of the potential consequences for ecological integrity and biological diversity.
Zone of Influence	The area within which changes in water quality associated with dredge plumes are predicted and anticipated during the dredging operations, but where these changes would not result in a detectible impact on benthic biota. These areas can be large, but at any point in time the dredge plumes are likely to be restricted to a relatively small portion of the Zone of Influence. The outer boundary of the Zone of Influence bounds the composite of all of the predicted maximum extents of dredge plumes and represents the point beyond which dredge-generated plumes should not be discernible from background conditions at any stage during the dredging campaign.

In recognition that different species may display very different degrees of tolerance and susceptibility to the same level of sediment-related pressure, it is appropriate to generate different predictions for identified management zones for different groups of benthic organisms or community/habitat types.

The criteria associated with each management zone varied across three ecological zones, which were broadly defined based on past studies of these areas. The ecological zones are named as follows, with reference to the trunkline chainages, and with the spatial extents set for this study as shown in Figure 7-19:

- **Offshore**: the trunkline area beyond KP25, and generally all areas north of a boundary line containing Rosemary Island, Legendre Island and Delambre Island.
- **Zone B**: the trunkline area between KP8 and KP25, adjacent coral and macroalgae habitats within Mermaid Sound, and generally all coral, macroalgae and mixed community habitats between Dolphin Island and Bezout Island, and at Madeleine Shoals to the north of Legendre Island.
- **Zone A**: the trunkline area between the shoreline and KP8, adjacent macroalgae and mangrove habitats within Mermaid Sound, and generally all mangrove, marsh and seagrass habitats between Nickol Bay and Point Samson.

To define the outer boundary of the ZoI, consideration has been given to the concentration of suspended sediments that may alter water quality but below which no change would be detectable. The variation in natural turbidity is considered for each ecological zone and seasonally (summer (November to March) and Winter (April to October)). The consideration of baseline water quality across the three ecological zones also reflects that it would be easier to visually detect change in environments with lower suspended sediment concentrations (Offshore zone) than those with higher

[30] As per Technical Guidance Environmental Impact Assessment of Marine Dredging Proposals (EPA 2016)

suspended sediment concentrations (Zone A) and similarly seasonally (ie summer naturally higher turbidity than winter). The ZoI threshold will be exceeded at any point within the model domain where dredging, spoil disposal and backfill is forecast to increase the depth-averaged concentration of SSC (specifically the contribution attributable to dredging activities) to a level greater than the seasonal 80th percentile of baseline SSC over a 24-hour average period for that specific ecological zone (Appendix J).

The impact thresholds applicable to the offshore ecological zone considered that benthic communities in Commonwealth waters and the Dampier Marine Park adjacent to the proposed Borrow Ground are predominantly bare substrate with sparse coverage of biota made up largely of sponges and filter feeders. This assumption of benthic community type was confirmed in recent surveys of the Dampier Marine Park and Borrow Ground (Advisian 2019c; Appendix B), and previously for Spoil Ground 5A (Woodside, 2009). As such, impact thresholds for filter feeder-sponge habitat were developed by MScience (2019) based on studies undertaken as part of the WAMSI Dredging Node (Pineda et al. 2017; Appendix J). Thresholds based on coral, seagrass or macroalgae were not considered for the offshore zone as they are not known to form significant communities in the area. The adopted thresholds for the ZoMI and ZoHI were based on effect concentrations (LC_{10} for ZoMI and LC_{50} for ZoHI derived for *Carteriospongia foliascens*) over a 28-day exposure period as suggested within Pineda et al. 2017. The thresholds were based on laboratory experiments using sponge species of different morphologies (encrusting, cup and fan) and nutritional modes (phototrophic and heterotrophic), and therefore considered representative of the variety of sponge biology. Of these species, one (*Carteriospongia foliascens*) was determined to be sensitive to suspended sediment concentrations; and another (*Cliona orientalis*) as sensitive but with potential for recovery (Abdul Wahab et al. 2018).

Where suspended sediments generated from activities in Commonwealth waters enter State waters applicable thresholds for BCH present in State waters are used. Ecological Zones A and B use the possible mortality thresholds of Jones et al. (2019). These thresholds are only developed for corals. The (Jones et al. 2019) thresholds are based directly on results of water quality and coral health monitoring around the Gorgon Project at Barrow Island where coral communities exist in relatively clear, almost oceanic conditions. These are conservatively representing Zone B.

Corals in Zone A will be more tolerant to elevated suspended sediments and low light levels than those of Zone B due to adaptation and a different community composition of more tolerant species. This is also reflected in the higher baseline SSCs recorded in Zone A. This is reflected in the higher thresholds used, which are adjusted based on the baseline water quality data.

Sponges and filter feeders in Zones A and B occur among corals. This mixed community is best evaluated using coral thresholds which present the most conservative thresholds.

Seagrass thresholds applied to Zone A and Zone B are drawn from Table ES1 of the Abstract in Statton et al. (2017). As all seagrasses found in the area which may be impacted by trunkline dredging, spoil disposal and backfill activities are ephemeral and impacts will be of a short duration, recovery within five years is highly likely. Thus, only a ZoMI threshold is proposed. That threshold is drawn from recommendations in the paper for *Halodule uninervis* (Statton et al. 2017). Given this threshold is lower than that proposed for the coral communities, the coral threshold is applied across this ecological zone as a conservative threshold for all benthic communities.

Thresholds for SSC and Daily Light Interval (DLI) have been applied to the modelling for the ZoMI and ZoHI. A sedimentation threshold has not been applied to the modelling, as studies about sedimentation effects on corals and sponges continue to be equivocal on the effects of sedimentation alone (Duckworth et al., 2017; Pineda et al., 2017a). In practice, sedimentation impacts will be driven by high SSC levels (which will also drive low light). Where thresholds have been evaluated for multiple stressors, SSC and DLI levels have been an order of magnitude below the SSC levels required to sustain a sedimentation rate close to that reported as having effects on benthos (Duckworth et al., 2017; Pineda et al., 2017a). Thus, SSC and DLI thresholds used in the modelling would be breached well before SSC reached levels capable of sustaining required sedimentation rates that are predicted to impact benthic communities.

Due to a lack of suitable instrumentation the inherent issues of measuring ecologically relevant sediment deposition levels over appropriate scales (mg $cm^{-2}d^{-1}$) to contextualise past laboraotory and field based studies of sediment deposition on benthic communities is limited. (Whinney et al 2017). This lack of suitable instrumentation to measure sediment deposition over appropriate scales means there are no data sets that can be reliably used to calibrate/validate sediment deposition modules in numerical models (Jones et al 2019). In the absence of this data it is recommended that SSC measurements are used as a means of defining spatial effects for sediment deposition based on Jones et al. (2019).

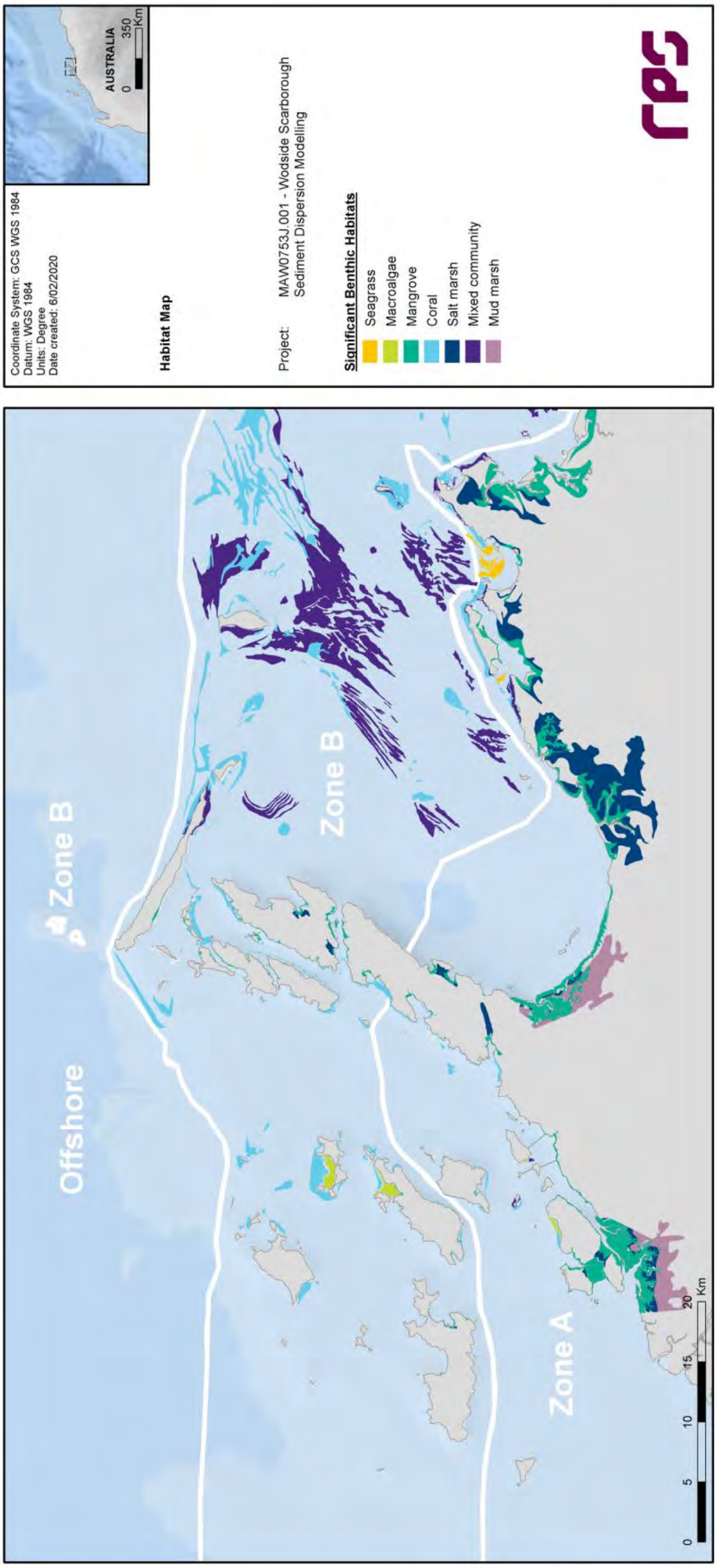


Figure 7-19: Delineation of the proposed ecological zones (Zone A, Zone B and Offshore)

Model outcomes – management zones

Anlaysis of the modelling results was undertaken to determine the extents of the defined management zones; ZoI, ZoMI and ZoHI[31], based on the application of the defined thresholds over the entire program of dredging, disposal and backfill operations for each season. It should be noted that the indicated management zone extent represents a cumulative measure of exceedances of the relevant thresholds over a ten-month period representing the overall programme for both State and Commonwealth activities. As such they do not represent an instantaneous sediment plume footprint at any point in time (i.e. this is not a depiction of the visual plume produced on a single day of the activity, which would be significantly less). The indicated areas of threshold exceedances are largely a reflection of the areas of sediment confluence due to the proximity to the key activity area, where there is a sustained input of suspended sediments over periods of several months, and the influence of local metocean conditions acting to inhibit rates of settling and increase rates of resuspension.

In summary, dredging, spoil disposal and backfill activities undertaken in Commonwealth waters are predicted to cause detectable changes in water quality from elevated suspended sediment concentrations (SSC) (as represented by the ZoI), however these increases in suspended sediment are predicted to remain below the intensity-duration thresholds that may cause an impact to benthic biota (as represented by the ZoMI). This is based on the conservative application of coral thresholds in ecological zone B (including Madeleine Shoals[32]) and sponge thresholds in the offshore zone (i.e. Dampier Marine Park), as the most sensitive receptors in each zone (Appendix J).

This conclusion is supported by Figure 7-20 and Figure 7-21, which shows that the ZoMI associated with dredging, spoil disposal and backfill activities along the trunkline route is restricted to State waters predominantly in the vicinity of KP10 irrespective of what season the activity is undertaken, and that these impacts are attributable to activities undertaken in State waters. The only exception is a small isolated pocket on the southern side of Hauy Island, where the ZoMI attributable to dredging at the offshore borrow ground suggests reversible impacts to a small area of coral (0.2 ha; refer to Figure 7-22) when borrow ground dredging is undertaken during winter. This may be attributable to the combined effects of model bathymetry and hydrodynamics, representing sediments that are transported into the shallowest-possible grid cells and then “trapped” upon reversal of the tide. While there is a potential for dredged sediments to be found in the indicated areas, the high concentration at the water-land boundaries may be overstated, particularly in consideration of the durations required to trigger the ZoMI thresholds.

Figure 7-23 and Figure 7-24 illustrate the predicted extents of the ZoI associated with dredging, spoil disposal and backfill activities commencing in winter and summer respectively[33].

Detectable changes in water quality (as represented by the ZoI) from trunkline dredging, spoil disposal and bacfill activities within Commonwealth waters is predicted to remain within the vicinity of the activity, with some incursion into State waters. When activities are undertaken in winter conditions, sediment plumes at low concentrations are forecasted to drift generally towards the south-west, while the predicted net drift direction for sediment plumes from trunkline dredging activities commencing during summer conditions is towards the north-east. This drift is driven by the prevailing southwesterly winds over the summer season (Appendix J). In the offshore ecological zone, a notably larger ZoI is forecast along the trunkline in the vicinity of spoil ground 2B in State waters and Spoil Ground 5A in Commonwealth waters when the activity is undertaken during winter conditions (Scenario 1; Figure 7-23) than for summer conditions (Scenario 2; Figure 7-24). This is

[31] Note ZoHI figures have not been included as they are limited to State water activities (See Appendix J).

[32] Note the assessment of Madeleine Shoals using Zone B thresholds was post applied following the completion of modelling, as it was originally located in the Offshore ecological zone. However, it was identified that it may contain benthic communities and habitats such as corals, and hence was reassessed using the more conservative Zone B thresholds.

[33] Note given the sequencing of activities the borrow dredging and backfill activites therefore commence in the opposing seasons.

largely a consequence of the lower thresholds applicable during the winter period, and consequently the lower levels of dredge-excess SSC required to cause exceedances.

Similarly, a larger ZoI is predicted at the offshore borrow ground for Scenario 2 (where backfill operations will occur during winter; Figure 7-24) than for Scenario 1 (summer operation; Figure 7-23) and this is largely considered attributable to the lower winter thresholds. For offshore borrow ground dredging activities the majority of the sediment suspended by dredging is forecasted to be dispersed in the offshore area between the borrow ground and Legendre Island in both seasons, including incursion into the Habitat Protection zone (IV) of the Dampier Marine Park. Figure 7-24 illustrates that detectable changes in water quality, as represented by the ZoI, are predicted to extend into the Habitat Protection Zone (IV) of the Dampier Marine Park, however is not forecasted to intersect with the National Park Zone (II). Strong tidal flows between Hauy Island and Delambre Island will aid movement of suspended sediment towards the shallow waters of Nickol Bay (State waters), away from the National Park Zone (II) of the Dampier Marine Park which lies east of the borrow ground in Commonwealth waters (Appendix J). For Scenario 2, the ZoI is also shown to extend south intersecting the mixed community habitat found at Madeleine Shoals and the nearshore habitats of Legendre Island. However the increase in SSC from dredging in these areas are not predicted to exceed the intensity-duration thresholds that may cause an impact to benthic biota (as represented by the ZoMI) with the exception of a small isolated pocket on the southern side of Hauy Island (see above).

Modelling also shows that SSC levels are predicted to be an order of magnitude below the SSC levels required to sustain a sedimentation rate close to that reported as having effects on benthos (Duckworth et al., 2017; Pineda et al., 2017a), thus no impacts from sedimentation are predicted, with the possible exception of a small isolated pocket on the southern side of Hauy Island where the ZoMI threshold has been exceeded.

Figure 7-20: Predicted Zone of Moderate Impact for the overall program commencing in winter conditions (1st July 2016 to 30th April 2017). Note no ZoMI In Commonwealth waters.

Figure 7-21: Predicted Zone of Moderate Impact for the overall program commencing in summer conditions (1st January 2017 to 31st October 2017).

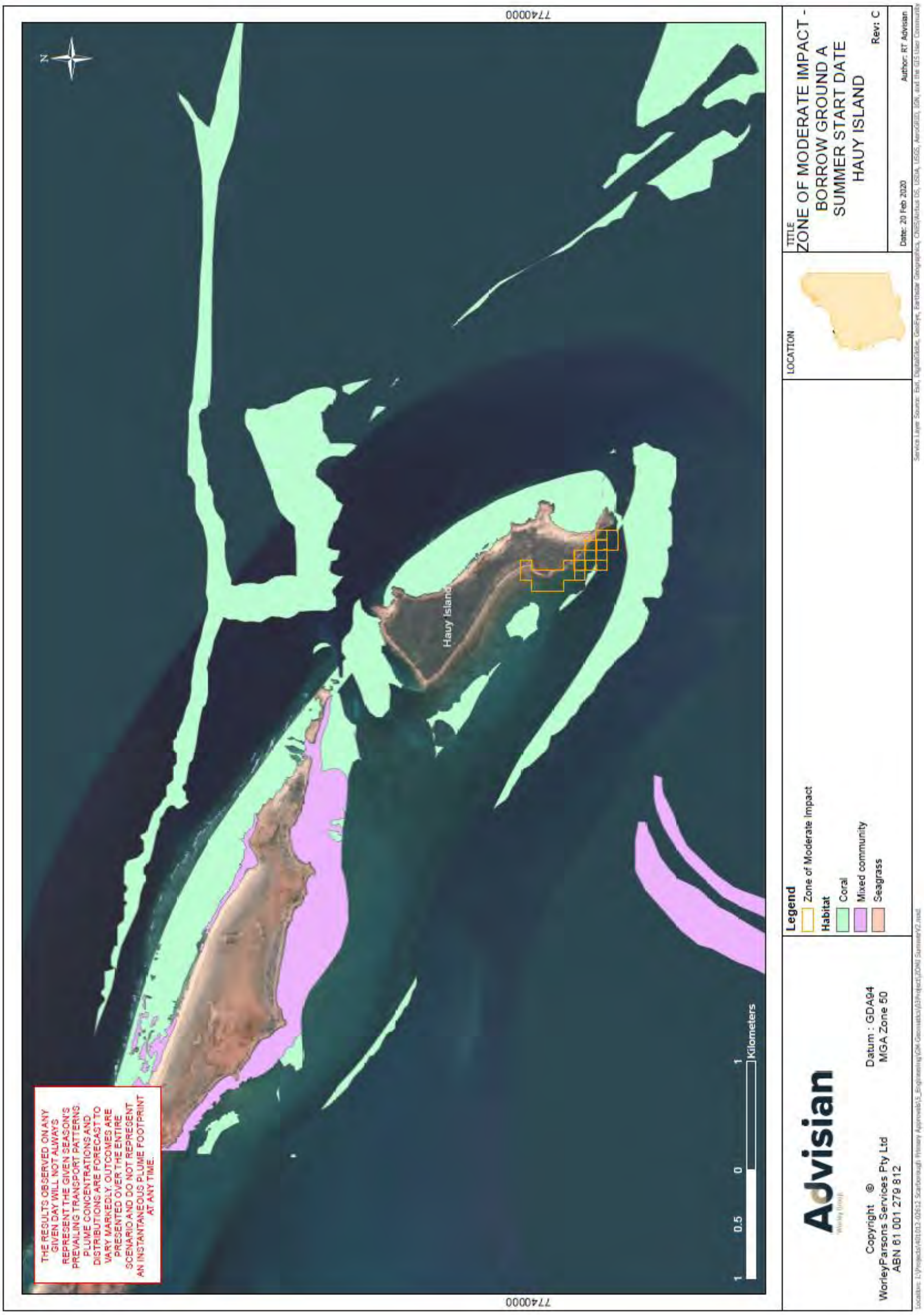


Figure 7-22: Area of coral habitat predicted to intersect with Zone of Moderate Impact from borrow ground dredging activities for the overall program commencing in summer conditions, with borrow ground activities being undertaken in winter.

Figure 7-23: Predicted Zone of Influence for the overall program commencing in winter conditions (1 July 2016 to 10 April 2017)

Figure 7-24: Predicted Zone of Influence for the overall program commencing in summer conditions (1 January 2017 to 31 October 2017)

Removal of Subsea Infrastructure

Removal of subsea infrastructure including trunkline will be evaluated at end of field life. Options of leave in-situ, removal or part removal of the infrastructure will be part of a future comparative assessment, which will assess the costs and benefits of the options.

If all subsea infrastructure is removed at the end of field life, the total seabed disturbance will equate to the same or similar to that of the infield subsea infrastructure and trunkline installation and be within the same area previous seabed disturbance took place.

Vessel and ROV Operations.

The use of an ROV during activities as described may result in temporary seabed disturbance and suspension of sediment as a result of working close to, or occasionally on, the seabed. ROV use close to or on the seabed is limited to that required for effective and safe subsea activities. The footprint of a typical ROV is about 2.5 m × 1.7 m (4.25 m^2).

While vessel anchoring in deeper waters is unlikely, there may be occasions where support vessels anchor in shallower waters, while working on the trunkline route, for example to conserve fuel. Should this be required, the level of seabed disturbance is dependent on the anchoring, however, use of a single anchor could result in a total disturbance area of up to 1300 m^2.

7.1.6.2 Impact or Risk

Routine physical presence resulting in a disturbance to the seabed from the sources described above will result in the following impacts:

- change in habitat
- change in water quality.

Which may have the following further impacts:

- injury/mortality to fauna.

<u>*Change in Habitat*</u>

Pre-lay and post-lay seabed intervention activities (e.g. dredging, spoil disposal, backfill, span rectification etc.) associated with the installation of subsea infrastructure and the trunkline on the seabed are likely to result in localised sedimentation and permanent modification of seabed habitat in the vicinity of the infrastructure and at the borrow ground and spoil ground location. A total area of approximately 14 km^2 of habitat modification is anticipated from permanent placement of infrastructure on the seabed, while up to approximately17 km^2 may be modified by dredging at the borrow ground (i.e. removal of sediment) and up to 5 km^2 spoil disposal and Spoil Ground 5A (i.e. placement of sediment within a previously disturbed spoil ground) in Commonwealth waters. These areas are conservative as they are based on the entire 30 m trunkline corridor, designated borrow ground and spoil ground being disturbed.

The trunkline stabilisation and burial may result in coarser seabed sediments within the trunkline corridor. Where the trunkline remains exposed, the predominantly soft benthos would be replaced with the hard-outer coating of the pipeline.

The mooring of the MODU, vessel anchoring, ROV use and geotechnical surveys will result in localised, small scale seabed disturbance, sedimentation and habitat modification.

<u>*Change in Water Quality*</u>

Trunkline dredging and spoil disposal, seabed material relocation, sourcing of material from the borrow ground and associated trunkline backfill, and of seabed infrastructure have the potential to cause temporary increases in suspended sediments and turbidity levels in marine waters and associated increase in net sedimentation.

Injury and/or Mortality to Marine Fauna

As a result of a change in water quality and change in habitat, further impacts to receptors may occur, which include injury or mortality to marine fauna resulting from an increase in turbidity, change in habitat from sediment placement or removal or physical contact with equipment or infrastructure being installed.

Temporary increases in suspended sediments and turbidity levels, associated sediment deposition and sediment placement can potentially result in the following impacts:

- adversely affect marine biota by reducing light penetration through the water column, thereby temporarily reducing productivity and growth rates
- cause clogging and damage to the feeding and breathing apparatus of filter feeding organisms (Parr et al., 1998)
- cause burial and smothering of benthic organisms
- cause localised and temporary reduction in oxygen levels due to the release of potentially organic rich sediments into the water column
- increase organic matter and nutrient availability to marine organisms subsequently resulting in eutrophic waters with knock-on effects for the productivity of marine ecosystems
- cause toxicological effects to marine organisms associated with the potential re-suspension of previously contaminated sediments.

Receptors Potentially Impacted

The receptors most at risk in this location are:

- plankton
- epifauna and infauna and other benthic receptors
- coral
- fish
- marine reptiles
- AMPs
- KEFs.

Plankton

Plankton are widely dispersed throughout the water column. Injury/mortality to planktonic species may occur due to a change in water quality due to physical alterations to turbidity. Impacts to zooplankton from turbidity are associated with variations in predator prey dynamics which favours planktonic feeders over visual feeders (Gophen, 2015). In contrast impacts to phytoplankton occur due to decreases in available light, therefore reducing productivity (Dokulil, 1994).

Due to the temporary and localised nature of changes in water quality, impacts to plankton are not predicted, and have not been evaluated further.

Fish

The presence of subsea infrastructure has the potential to act as artificial habitat or hard substrate for the settlement of marine organisms that would not otherwise be successful in colonising the area. Over time, the colonisation of subsea infrastructure can lead to the development of a community, which subsequently provides predator or prey refuges, foraging resources for pelagic fish species, and artificial reefs potentially supporting fish aggregations (Gallaway et al., 1981) (Bond et al., 2018).

Disturbance of the seabed during installation of subsea infrastructure may make prey for predatory demersal fish (e.g. epifauna and infauna) temporarily more available, which may result in a short-term attraction of demersal fish to the area due to the increased prey availability.

As described in Section 5.3.10, the majority of the seabed within the Offshore Project Area and along the trunkline route is predominantly flat and featureless and comprised of unconsolidated mud, clay or sandy sediments. These low complexity habitats support relatively low diversity and low abundance fish assemblages compared to more complex habitats (e.g. hard substrates and reefs). The installation of subsea infrastructure and the trunkline across these flat and featureless areas may create a more rugose seabed and provide substrate for attachment of organisms such as sponges and gorgonians. The resulting habitat will be relatively complex compared to the pre-existing habitat and will serve as artificial reefs. Recent survey work on the North West Shelf has highlighted the increased fish species richness and abundance associated with subsea pipelines (Bond et al., 2018; McLean et al., 2020), and these studies noted that the fish assemblages associated with pipelines tended to have a relatively high portion of large, commercially important fish species that preferred complex habitats.

The McLean et al. (2020) study utilised ROV video to assess fish species richness and abundance, and marine growth type, extent and complexity along sections of a subsea gas pipeline (56–82 m water depth) that traverses the Montebello AMP. A total of 7493 fish from 81 species and 33 families were recorded, and of these 81 species, 27 are considered fishery-target species in the Pilbara Demersal Scalefish fishery (PDSF), with select commercial fishing activities permitted with authorisation within the Montebello AMP. The pipeline offers a corridor of hard bottom habitat within a marine park that facilitates epibiotic growth and the presence of reef-associated species in a region characterised by sandy sediments. Results indicated the potential importance of subsea infrastructure as a habitat for fish, and in consequence, potentially also as structures with value to commercial fisheries (McLean et al., 2020).

The predicted increase in the fish assemblage diversity and abundance is not expected to have any negative environmental consequences. The presence of subsea infrastructure within the Offshore Project Area and the Trunkline Project Area will result in a net environmental benefit for demersal fish assemblages, and potentially also for commercial and recreational fisheries targeting these assemblages.

Increased suspended sediments concentrations associated with dredging, spoil disposal and backfill operations, as well as the installation of infrastructure may affect fishes ability to forage, hunt and avoid predators (Harvey et al., 2017). Elevated concentrations of suspended sediments may also cause physiological impacts such as gill impairment. An analysis of available literature suggests that impacts range from minimal (10 mg/l SSC) to extreme (1000 mg/l SSC) (Harvey et al., 2017).

For dredging, spoil disposal and backfill dredging activities undertaken in Commonwealth waters, modelling indicates that excess SSC is predicted to remain less than 10 mg/L, based on 95th percentile results (Figure 5-2 and Figure 5-6 of Appendix J). Further, the trenching and backfill operations are expected to rapidly progress along the trunkline route ensuring increased suspended sediment levels are spatially and temporally confined. Similarly, spoil disposal activities within Commonwealth waters are expected to result in short term elevations during disposal, as they progress along Spoil Ground 5A, parallel to the trunkline route. While elevated SSC at the borrow ground during dredging will be intermittent given the nature of the activity (i.e. dredging then backfill).

Therefore, impacts to fish assemblages are not expected as a result of increased SSC from dredging, spoil disposal and backfill operation, as well as the installation of infrastructure.

Negative impact to fish assemblages from seabed disturbance or commercial and recreational fisheries targeting these assemblages is not anticipated, and as such this has not been evaluated further.

Table 7-41: Receptor/impact matrix after evaluation of context

	Receptor								
Impacts	**Water Quality**	**Epifauna and Infauna**	**Coral**	**Plankton**	**Fish**	**Marine Reptiles**	**Commonwealth and State Managed Fisheries**	**KEFs**	**AMPs**
Change in water quality	✓							✓	✓
Change in habitat		✓	✓		X	✓		✓	✓
Injury or mortality to fauna		✓	X	X	X			✓	
Changes to the functions, interests or activities of other users							X		

Detailed Impact Evaluation

Water Quality

Water quality change occurs when seabed sediments enter the water column (turbidity). After a period, the suspended sediments settle and the turbidity in the water column returns to pre-disturbance levels.

The installation of the subsea infrastructure will result in temporary and localised displacement of surface sediments in the Project Area. The displacement of naturally occurring sediments from installation activities is likely to result in low levels of highly localised (within tens of metres of the disturbance area) increases in turbidity levels at the seabed that will quickly disperse in the oceanic marine environment due to prevailing hydrodynamic conditions. As such, any reduction in water quality will be temporary and will be limited to the waters close to the seabed immediately surrounding the disturbance area. This will result in low levels of sediment deposition which is likely to be naturally reworked into surface sediment layers through bioturbation. Further, infrastructure will be positioned on the seabed within the design footprint, to ensure that the overall area of seabed disturbance is limited.

Sediment mobilisation from displacement / relocation of sediments along the trunkline at approximately KP 209 are expected to remain in the vicinity of the activity. This is estimated to be over a distance of a few hundred metres, however may extend further based on geotechnical properties and tendency of sediments to relocate typically downgradient, similar to natural relocation of sediments in this area. The sediment will be relocated/placed in vicinity of trunkline route and water quality changes associated with the activity will likely result in localised increases in turbidity levels that will disperse under oceanic hydrodynamic conditions, and result in low levels of sediment deposition further afield.

Dredging, spoil disposal and backfill activities in Commonwealth waters would result in seabed disturbance between the State waters boundary (approximately KP 32) to KP 50 in Commonwealth waters and at the proposed Borrow Ground. Trenched material will be disposed at existing spoil grounds (i.e. Spoil Ground 5A) within the region, while backfill will be sourced from one of the pre-identified borrow ground locations, of which the offshore borrow ground in Commonwealth waters is assessed here.

Water quality changes as a results of dredging, spoil disposal and backfill activities in Commonwealth waters has been examined through modelling. Detectable changes in water quality (as represented by the ZoI) from trunkline dredging and spoil disposal activities within Commonwealth waters is predicted to remain within the vicinity of the activity, with some incursion into State waters. When the activity is undertaken during winter conditions, the ZoI along the trunkline is predicted to be notably larger, which is largely a consequence of the lower thresholds applicable during the winter period, and consequently the lower levels of dredge-excess SSC required to cause exceedances. For trunkline dredging and spoil disposal activities commencing in winter conditions, sediment plumes at low concentrations are forecasted to drift generally towards the south-west, while the predicted net drift direction for sediment plumes from trunkline dredging activities commencing during summer conditions is towards the north-east. This drift is driven by the prevailing southwesterly winds over the summer season (Appendix J). The trenching and backfill operations are expected to rapidly progress along the trunkline route ensuring increased suspended sediment levels are spatially and temporally confined. Similarily, spoil disposal activities within Commonwealth waters are expected to result in short term elevations during disposal, although are expected to progress along Spoil Ground 5A, parallel to the trunkline route. This means the potential for elevated turbidity at any site, is expected to be of short duration (i.e. likely less than five days).

For offshore borrow ground dredging the majority of the sediment suspended by dredging is forecasted to be dispersed in the offshore area between the borrow ground and Legendre Island in both seasons, including incursion into the Habitat Protection zone (IV) of the Dampier Marine Park. Detectable changes in water quality, as represented by the ZoI, are predicted to extend into the Habitat Protection Zone (IV) of the Dampier Marine Park, however is not forecasted to intersect with the National Park Zone (II). Strong tidal flows between Hauy Island and Delambre Island will aid movement of suspended sediment towards the shallow waters of Nickol Bay (State waters), away from the National Park Zone (II) of the Dampier Marine Park which lies east of the borrow ground in Commonwealth waters (Appendix J).

Detectable changes in water quality for borrow ground activities undertaken during winter are notably larger than summer operation and this is largely considered attributable to the lower winter thresholds. When activities are undertaken during winter, detectable changes in water quality are shown to extend south intersecting the mixed community habitat found at Madeleine Shoals and the nearshore habitats of Legendre Island. However the increase in SSC from dredging in these areas are not predicted to exceed the intensity-duration thresholds that may cause an impact to benthic biota (as represented by the ZoMI) with the exception of a small isolated pocket on the southern side of Hauy Island (refer to coral section). Peaks in suspended sediment associated with borrow ground dredging is expected to be of short duration given the intermiitent nature of the activity, whereby the vessel will dredge and load the sediment, then transits to the trunkline and place the material.

Backfill operations involve the placement of coarser materials for trunkline stabilisation. As such the fines component is expected to be less than the dredging of the seabed. Given the lower fines component, suspended sediments are expected to settle more rapidly limiting the temporal and spatial scale of any elevated turbidity. Additionally, the backfill operations are expected to progress rapidly along the trunkline route and hence limit the period of elevated suspended sediment in any one location along the trunkline. Similar to trunkline dredging activities, modelling indicates that detectable changes in water quality as a result of backfill activities in Commonwealth waters is also predicted spatially remain in the vicinity of the activity location. Where rock dumping is required for pipeline stabilisation purposes elevated turbidity is expected during placement of the rock on the seabed, however this is expected to be temporally and spatially confined such that any water quality impacts are not expected to cause an impact to any sensitive receptors.

Predicted Impact Summary

Sediment mobilisation from displacement / relocation of sediments along the trunkline corridor as a result of installation of subsea infrastructure and seabed intervention activities is expected to remain in the vicinity of the activity and will be within an area of predominantly bare sand habitat. The change in water quality will be localised around the placement of infrastructure on the seabed and temporary in nature.

Modelling has shown that the elevations in turbidity as a result of dredging, spoil disposal and backfill operations in Commonwealth waters, including those adjacent to the Dampier Marine Park, will remain below the intensity-duration thresholds predicted to cause an impact to benthic communities, with the exception being a small pocket of coral on the southern side of Hauy Island, where reversible impacts are predicted. It is considered that, although there is a predicted detectable change in water quality that extends into the Habitat Protection Zone (IV) of the Dampier Marine Park, the nature of the change is temporary and is not inconsistent with the objectives of the zoning of the marine park. Modelling has indicated that detectable water quality changes (as represented by the ZoI) are not predicted within the National Park Zone (II) of the Dampier Marine Park. This is discussed in more detail in the Table 7-42.

Impacts from seabed disturbance on water quality will be slight. Receptor sensitivity of water quality is low (low value, open water), and therefore the Impact Significance Level of seabed disturbance on water quality is **Negligible (F).**

Epifauna and Infauna

Epifauna and infauna may be impacted from the permanent placement of infrastructure (identified in Table 7-38) and the trunkline, placement of temporary infrastructure (anchors, ROV, geotechnical equipment) on the seabed, where directly disturbed during dredging along the trunkline route between KP32 and KP50 and within the borrow ground, and as a result of sediment placement during disposal at Spoil Ground 5A (a previously disturbed area).

Seabed intervention activities have the potential to also indirectly affect filter feeder-sponge habitat through reduced light availability for photosynthesis of the sponges' symbionts, reduced filtering and feeding due to elevated SSCs, and increased sediment deposition that could result in tissue smothering (Abdul Wahab et al. 2019).

Disturbance to the seabed can alter the physical seabed habitat conditions, resulting in epifauna and infauna community changes (Newell et al., 1998). Trunkline and subsea infrastructure installation are permanent for the duration of field life and will result in the displacement and/or permanent loss of some epifauna and infauna over the infrastructure and trunkline footprint. However, the presence of oil and gas infrastructure may artificially increase habitat complexity in areas of featureless seabed, resulting in higher species richness and abundance of epifauna associated with infrastructure, compared to adjacent natural habitats (Mclean et al., 2020; McLean et al., 2018; McLean et al., 2017; Bond et al., 2018).

Offshore Project Area

The seafloor in the Offshore Project Area is characterised by sparse marine life dominated by motile organisms (ERM, 2013) including shrimp, sea cucumbers, demersal fish and small, burrowing worms and crustaceans (Section 5.3.10). Benthic communities in the Offshore Project Area are representative of the Exmouth Plateau and of deepwater soft sediment habitats reported in the region (e.g. BHP Billiton, 2004; Woodside, 2005; Woodside, 2006; Brewer et al., 2007; RPS, 2011; Woodside, 2013; Apache, 2013).

Trunkline Project Area

The infauna recorded along the trunkline route is sparse but highly diverse. The abundance of the fauna is inversely associated with depth, with distinct differences in the fauna on the shelf and slope.

SKM (2006) also identified polychaetes as dominant, which comprised 79% of the fauna by abundance and 75% of the fauna by species richness. Although infauna of the Trunkline Project Area is expected to be more abundant when compared to the Offshore Project Area, species present are expected to be well represented in the wider NWMR.

Geotechnical and geophysical information collected in the Trunkline Project Area (Table 5-2) along the shelf to the coastal water boundary shows that sediments predominantly comprise of sands and silty sands (Fugro, 2019). As part of the Pluto LNG Foundation Project, surveys were completed to determine the presence and extent of any sessile benthic assemblages adjacent to the proposed trunkline route in Spoil Ground 5A. The survey was completed between the State waters boundary and adjacent to KP 50.3 to determine the suitability of the area for an offshore spoil disposal ground (Woodside, 2009). Twenty-Nine sites were surveyed with a drop camera and the seabed was classified as silty sand with low species abundance and diversity with sparse sponges and soft corals (Figure 5-14). The seabed substrate observed on the drop camera footage is consistent with the geophysical and geotechnical data collected along the trunkline route. The drop camera study is also in close proximity to the proposed trunkline route (less than 1km). Given that the seabed substrate is consistent between the drop camera study and the geophysical and geotechnical data, benthic communities and habitats along the proposed trunkline route are expected to be similar to those observed in the drop camera study. This sparse benthos is considered representative of the area and is similar to that observed in other regional studies where seabed sediments consist of silty to coarse sands, typical of the North West Shelf (Keesing 2019, Advisian 2019b).

Modelling (Appendix J) of trenching and backfill operations between KP 32 and KP 50 shows that the duration and frequency terms of the thresholds are expected to be maintained at a level where no impacts are predicted from increased levels of suspended sediments. Given that:

- epifaunal communities are classed as sparse and of low diversity in the vicinity of the proposed trunkline between KP 32 and KP 50,
- that this sparse benthos is considered representative of the area and is similar to that observed in other regional studies where seabed sediments consist of silty to coarse sands, typical of the North West Shelf (Keesing 2019, Advisian 2019b), and
- that the water quality is expected to remain at a level that would not impact the observed epifauna,

there is a high level of confidence that epifaunal communities will not be modified, destroyed, fragmented, isolated and important or substantial areas of habitat will not be disturbed from the physical placement of the trunkline or from trenching and backfill activities between KP 32 and KP50.

The drop camera surveys completed in Spoil Ground 5A prior to its use for the Pluto foundation project showed that benthic communities and habitats were sparse. Sediments disposed at the spoil ground from the Pluto trunkline route are expected to be broadly similar to those noted in the original drop camera survey, given the proximity of sourced materials (<1km). Further given that the spoil ground is expected to contain sediments that are similar to those observed prior to its original use and that the area has been previously disturbed during the Pluto foundation project, epifauna is expected to be sparse within Spoil Ground 5A. Therefore epifaunal communities will not be modified, destroyed, fragmented, isolated and important or substantial areas of habitat will not be disturbed from the use of Spoil Ground 5A.

Between KP 50 and the Montebello Islands Marine Park the seabed is generally featureless carbonate sands with some silt and shell gravel. These areas are not expected to support substantial habitat given that the substrate is similar to that observed between the State Waters boundary and KP 50 (Figure 5-14) and in the South Eastern section of the Montebello Islands Marine Park where only sparse benthic filter feeder communities were observed.

Some isolated areas of calcarenite outcropping are identified from the geophysical data (Table 5-2). The calcarenite outcrops are generally overlain by a thin veneer of coarse sands with isolated outcropping of the underlying harder calcarenite layer (Table 5-2). The calcarenite outcrops observed from the geophysical data collected along the trunkline route are spatially limited in comparison with larger more linearly consistent areas of exposed harder substrate such as the Ancient Coastline KEF (Section 5.5.2). Calcarenites are spread widely over the North West Shelf (Wilson, 2013) and are observed at multiple points in the geophysical data between KP 50 and the Montebello Islands Marine Park. Areas where the calcarenite is identified as being less than 0.5m below the surface and thus has the potential to outcrop at the seabed generally run perpendicular to the trunkline route (Table 5-2) limiting the areas where the trunkline intersects areas of potential harder substrate. Between KP 50 and the Montebello Islands Marine park the trunkline would only intersect an approximate area of 0.01km^2 of seabed where the underlying calcarenite layer is less than 0.5m below the surface as identified from the geophysical data (Table 5-2).

The harder areas of calcarenite have the potential to support more abundant and diverse benthic communities, however the patchiness of the exposure of the underlying hard substrate is expected to limit the potential to support significant epifaunal habitats. One of the largest areas of outcropping identified in this section of the trunkline project area covers an area of 0.03 km^2 with the trunkline only intersecting 0.00016 km^2 (or 0.005%) of the area of outcropping. Between KP 50 and KP 109 small clusters of depressions are also observed in the geophysics data which appear to expose the underlying calcarenite (Table 5-2). These areas of depressions run perpendicular to the trunkline route (Table 5-2). The intersection of the trunkline route with these clusters of depressions only represents an area of approximately 0.0004 km^2. The clusters of depressions are spatially confined with a cluster typically covering an area of approximately 0.016km^2. The actual area of exposed calcarenite is expected to be much less given that these clustered depressions intermittently expose the underlying harder substrate. Thus the trunkline would only intersect a small portion of the harder substrates identified from the geophysical data. Calcarenite outcropping is also common across the North West Shelf (Wilson 2013, Keesing 2019). A minor temporary increase in suspended sediments at the seabed associated with the trunkline installation would not reach the intensity and duration terms of the impact thresholds for epifaunal communities due to the rapid progress of the trunkline installation and thus no impacts are predicted beyond the direct footprint.

Given that the trunkline will only intersect a very small proportion of harder substrate which is well represented regionally (Wilson 2013, Keesing 2019) the trunkline will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat that may support more abundant epifaunal communities. Given the sporadic nature of the outcropping through the thin veneer of sediments in these areas the trunkline also has the potential to increase the areas of harder substrate which may lead to an increase in the abundance and diversity of epifaunal communities in this section of the trunkline route.

Between KP 50 and KP 109 small clusters of depressions are also observed in the geophysics data which appear to expose the underlying calcarenite (Table 5-2). These areas of depressions run perpendicular to the trunkline route (Table 5-2). The intersection of the trunkline route with these clusters of depressions only represents an area of approximately 0.0004 km^2. The clusters of depressions are spatially confined with a cluster typically covering an area of approximately 0.016km^2. Given that the trunkline route intersects a very small area of these clustered depressions that intermittently expose the underlying harder substrate the trunkline will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat.

The trunkline route intersects the Montebello Islands Marine Park between KP 109 and KP 191.7. The CSIRO study (Keesing 2019) summarised in section 5.6.1.3 showed that the topography in the vicinity of the Scarborough trunkline in the South Eastern section of the Marine Park was predominantly flat bottom with some occasional bioturbated areas, and the substrate was typically fine sands, although site 81 was predominantly rock (Figure 5-43). These sites within the vicinity of the Scarborough trunkline had low numbers of sponges, whips and gorgonians (Figure 5-44) and as a result, complex benthic filter feeder communities were largely absent. Analysis of the high definition ROV video data (Advisian, 2019b) found that the area in which the trunkline intersects the North West section of the Montebello AMP is characterised by bare sandy sediments, interspersed with predominantly sparse benthic communities and epifauna (Table 5-10, Figure 5-41). The maximum observed density of sponges did however increase in survey areas 2 and 3. Further description of the epifaunal communities in the Montebello Islands Marine Park is provided in Section 5.6.1.3.

The North Western section of the Montebello Islands Marine Park appears more similar to the adjacent PFTF Area 1 than the South Eastern section of the marine park. Surveys of the PFTF Area 1 showed the seabed was similar to the marine park with predominantly flat bottom with fine sand substrate. Similar biota types (sponges, gorgonians, whips and other soft corals, hydroids, crinoids and sea pens) were present in the two areas with sponges and whips being abundant in PFTF Area 1, making up more than 50% of biota scored in images from 6 sites.

The trunkline intersects an area of sparse epifauna in the South Eastern section of the marine park and intersects areas of more abundant and diverse epifauna in the North Western section of the marine park, however these areas are typical of the benthos found both within the marine park (Advisian 2019) and regionally as observed in the PFTF Area 1 (Keesing 2019). Given that epifaunal communities were well represented either side of the proposed trunkline route (Advisian 2019) and regionally (Keesing 2019) and that the footprint of the trunkline is extremely small in comparison with the spatial extent of these communities in the North Western section of the Montebello Islands Marine Park, the presence of the trunkline will not destroy, fragment, isolate these communities. Nor will it disturb a substantial area of habitat given the small footprint of the trunkline. The habitat is also well represented spatially and the diversity and abundance of the habitat within the footprint is consistent with that observed adjacent to the direct footprint and in the adjacent PFTF Area 1. A minor temporary increase in suspended sediments at the seabed associated with the trunkline installation would not reach the intensity and duration terms of the impact thresholds due to the rapid progress of the trunkline installation and thus no impacts are predicted beyond the direct footprint.

ROV surveys and geophysical surveys of the continental shelf show that the area is generally devoid of hard substrate with the exception of two areas. The main area of exposed hard substrate occurs in about 1000 m depth where the continental slope meets the abyssal plain. The bottom of the rocky cliffs is situated in about 1050 m water depths with an almost vertical wall extending 20 m up to about 1030 m at the surveyed location. The rock appears to be sedimentary with clear bands or layers occurring in the rock profile. No epifauna was observed on the exposed rock (SKM, 2006).

The second area of harder substrate comprises a series of rock pinnacles located at about 300 m water depth. Results from the geotechnical studies indicated that there was potential for rock pinnacles to be spread over a 4 x 1 km area of seabed along the 300 m contour (Figure 5-16).

Additional survey work was completed in 2018 to collect higher resolution imagery of the pinnacles. This confirmed that the pinnacles were confined to a small area (around 100 m long x 75 m wide) approximately 350 m from the pipeline route alignment and that they are not widespread across the continental shelf (Figure 5-17). The pinnacles provide structure for a diversity of fauna including fish and invertebrates. Many tens of fish were observed gathered around these pinnacles, most probably belonging to either the Glaucosomidae or Pricanthidae families. Crinoids, hydroids and ophiuroids were also common. Other species visible on the mounds include anemones, soft corals, small crustacean like shrimp and some larger brachyurans, possibly *Cyrtomaia suhmii.* Imagery was sent to Professor Murray Roberts (University of Edinburgh) for expert assessment. It was confirmed that the yellow corals which were originally identified as *Lophelia* were "at first glance *Dendrophyllia cornigera* (well known in the Mediterranean Sea), but perhaps more likely a Leptosammia species (same family: Dendrophylliidae)". It was also confirmed that there was no evidence of *Lophelia* sp. in the imagery that was reviewed (M. Roberts, pers. comm).

Given that any seabed material displacement is likely to result in localised turbidity for short periods of time and that the rock pinnacles observed are approximately 350 m from the trunkline alignment, water quality impacts associated with the seabed material displacement are not expected to pose a risk to the surrounding epifauna and infauna communities on the continental shelf including the isolated filter feeders and soft corals observed at the pinnacles. Further, placement of seabed material from the trunkline route in the vicinity of KP 209 will not impact the pinnacles given they are over 3 km from this activity. The trunkline route alignment will avoid the pinnacles and controls are in place to manage the trunkline positioning, so there will not be any direct impacts to the pinnacles.

Where the trunkline would be located within the deeper waters beyond the slope, epifauna and infauna communities would be similar to those described for the Offshore Project Area. The low energy, soft bottom seafloor around Scarborough supports sparse marine fauna as reported for the Exmouth Plateau. Sediments are calcareous, fine-grained and low in nutrients. Benthic communities are dominated by motile organisms, including shrimp, sea cucumbers, demersal fish and small, burrowing worms and crustaceans.

Borrow Ground Project Area

Surveys have been completed at the Borrow Ground Project Area (Advisian, 2019c) to determine the suitability of the proposed area as a source of trunkline stabilisation material. Towed video and drop camera surveys of both the potential borrow ground and the DMP directly adjacent to the borrow ground, confirm that the seabed and its benthic composition are relatively uniform in structure and composition. Both locations are dominated by bare substrate with large areas of seabed that are apparently largely devoid of any epibenthic species. Where epibenthos is present, the percentage cover of species is comparatively low (in the order of 5%), with no transects recording greater than 10% coverage in the species present. Common species present were alcyonaceans (mainly solitary soft corals), pennatulaceans (sea pens), crinoids (feather stars), asteroids (sea stars) and hydroids. No benthic primary producer habitat in the form of hard corals, macroalgae or seagrass was recorded or observed along any of the survey transects. The benthic habitat observed is consistent with a broad scale characterisation of the Pilbara seabed undertaken by UWA and CSIRO (Pitcher et al 2016) and anecdotal results from a recent survey by CSIRO (Keesing, J.K. (Ed.) 2019).

Based on the coarse sediment (with minimal fines) and the area being largely devoid of any epibenthic species, no important or substantial area of epifaunal or infaunal habitat is expected to be modified, destroyed, fragmented, isolated or disturbed as a result of works in the Borrow Ground Project Area. Beyond this direct disturbance area, modelling has shown that the elevations in turbidity as a result of dredging operations adjacent to the Dampier Marine Park, will remain below the intensity-duration thresholds predicted to cause an impact to benthic communities, with the exception being a small pocket of coral on the southern side of Hauy Island, where reversible impacts are predicted. It is considered that, although there is a predicted detectable change in water quality that extends into the Habitat Protection Zone (IV) of the Dampier Marine Park, the nature of the change is temporary and is not inconsistent with the objectives of the zoning of the marine park. Modelling has indicated that detectable water quality changes (as represented by the ZoI) are not predicted within the National Park Zone (II) of the Dampier Marine Park.

Value of epifauna as a food source for turtles

Shallower waters (<40 m) support important habitats, including biologically important areas where aggregations of individuals of a protected species (for example turtles) breed and forage (Director of National Parks, 2018). The species present may feed on plants and animals on the seafloor in the shallower waters, which may include epifauna that is present. As described in Section 5.4.6.4, flatback, green and hawksbill turtles have an omnivorous diet; with flatbacks feeding mainly on algae and a variety of invertebrates (molluscs, soft corals, sea cucumbers and jellyfish), hawksbills primarily targeting sponges but also consuming seagrass and invertebrates (shrimp, squid, anemones, sea cucumbers and soft corals), and green turtles eating seagrass, macroalgae and jellyfish.

For all three species of marine turtle, there is no overlap between the Trunkline and Borrow Ground project areas and foraging BIAs. The foraging BIAs for flatback, green and hawksbill turtles in the region are located in shallow, inshore waters along the Pilbara coast and around islands, primarily Barrow Island, the Montebello Islands, and Dixon Island in the Dampier Archipelago. Therefore, important foraging habitats remain available outside these project areas and available for utilisation. Minimum water depths in the Trunkline and Borrow Grounds project areas are approximately 35 m, and therefore any areas of overlap with epifauna and infauna are unlikely to represent important areas for foraging for flatback, green or hawksbill turtles. As described in Section 5.4.6.4, hawksbill turtles feed primarily on sponges, but they do so in relatively shallow waters, with juveniles largely foraging in water depths of 0 – 20 m, and adults in deeper depths of < 45 m. Although some limited loss of marine turtle foraging habitat may occur as a result of the installation of the trunkline on the seabed, as described in Section 5.3.10, such foraging habitat is widely represented in the region and any loss is expected to be negligible. Further to this, surveys of the trunkline route have not indicated the presence of any unique or limiting benthic foraging habitat for marine turtles within the trunkline corridor. Based on the key food sources of marine turtle species, and the relative abundance of epifauna and infauna found in the Trunkline and Borrow Grounds project areas, these areas are unlikely to support foraging aggregations of marine turtles (Pendoley Environmental, 2020).

For the Borrow Ground, the direct disturbance area is adjacent to the Dampier Marine Park, for which foraging for marine turtles is an identified value. However, there are no designated foraging BIAs for marine turtles that overlap the Dampier Marine Park. Recent benthic habitat surveys of an area of the Dampier AMP habitat protection zone adjacent to the Borrow Grounds Project Area (Advisian, 2019c) showed the seabed and benthic composition of the area surveyed was relatively uniform in structure and composition. The survey area was dominated by bare sandy substrate with large areas of seabed that are apparently largely devoid of any epibenthic species. Given the coarse nature of the sediments at the borrow ground, it is expected that the duration and frequency terms of any intensity-duration-frequency threshold of turbidity elevation would be maintained below that currently predicted as required to generate material levels of stress to ecological communities in areas of higher filter feeder abundance in the eastern end of the marine park. Sediment dispersion modelling for the dredging of the Borrow Ground showed no exceedance of the ZoMI or ZoHI in the offshore ecological zone. A ZoI was defined which does extend into the boundary of the habitat protection zone of the Dampier Marine Park. However, it is noted that the ZoI is defined as an area within which changes in water quality associated with dredge plumes are predicted but where these changes would not result in a detectible impact on benthic biota including epifauna and infauna which may have foraging value of the adjacent habitat protection zone.

As such impacts to epifauna and infauna are not likely to result in displacement of marine turtles from foraging areas in shallower waters of the Trunkline and Borrow Ground Project Areas.

Value of epifauna and infauna as habitat for fish

The Continental Slope Demersal Fish Communities are recognised as a KEF because of their biodiversity values, including high levels of endemism (DotE, 2018b). The Trunkline Project Area intersects a small portion of the KEF, across one of its thinnest points throughout its distribution (Figure 5-37). Most of the KEFs area lies further south, extending about 240 km from the Trunkline Project Area to just past the tip of the Exmouth Peninsula, splitting from a single corridor into three. Physical habitat modification is listed as a potential concern for this KEF (DotE, 2018b). While epifauna and infauna, in particular infauna, are important to demersal fish communities, the potential impact to the fish assemblages within the KEF from habitat disturbance is restricted to the overlap of the trunkline and impacts to benthic biota including epifauna and infauna will be highly localised, and not result on an adverse impact to the functioning or integrity of the KEF.

Also, it is also known that the proposed trunkline will offer a corridor of hard bottom habitat that facilitates epibiotic growth and the presence of reef-associated species in a region characterised by sandy sediments. Studies support the potential importance of subsea infrastructure as a habitat for fish, and in consequence, potentially also as structures with value to commercial fisheries (McLean et al., 2020). The predicted increase in biodiversity as a result of the subsea infrastructure is not expected to have any negative environmental consequences. The increased biodiversity is also likely to offer benefits to other foraging species, including marine turtles.

Predicted Impact Summary

Seabed disturbance and potential impacts to epifauna and infauna will occur a result of the placement of infrastructure, and the mobilisation and/or displacement of sediments along the trunkline. Habitat within the Project Area may be reduced or altered, leading to a localised change in epifauna and infauna local communities. However, this will be limited to the offshore seabed infrastructure, the Trunkline Project Area, and location identified as the Borrow Ground, representing a small proportion of the total area, that is well represented in the region (refer Section 5.3.10).

Modelling (Appendix J) of trenching and backfill operations in shallower waters (between KP 32 and KP 50) shows that the duration and frequency terms of the thresholds are expected to be maintained at a level where no impacts are predicted from increased levels of suspended sediments. Given that epifaunal communities are classed as sparse and of low diversity in the vicinity of the proposed trunkline between KP 32 and KP 50 and water quality is expected to remain at a level that would not impact the observed epifauna, there is a high level of confidence that epifaunal communities will not be modified, destroyed, fragmented, isolated and important or substantial areas of habitat will not be disturbed from the physical placement of the trunkline or from trenching and backfill activities between KP 32 and KP 50.

Sediment mobilisation and/or displacement along the trunkline at approximately KP 209 are expected to result in temporary elevations in turbidity. Due to the methods being used (e.g. Mass Flow Excavator, heavy duty grab etc.), any increase in turbidity will only occur in bottom waters. Both the increased turbidity, and the associated sediment deposition, is expected to be restricted to the vicinity of the activity. Based on ROV transects undertaken in the area (Advisian, 2019a; Appendix A), the seabed within the KP 209 area is expected to be predominantly bare sand habitat with a sparse coverage of benthic organisms, such as epifauna, sponges or soft corals. As for the trunkline trenching and stabilisation, water quality impacts associated with the seabed material displacement are not expected to pose a risk to the surrounding epifauna and infauna communities.

Epifauna and infauna sensitivity has been classified as generally low given the deep waters of the Offshore Project Area and the majority of the Trunkline Project Area. However, in water depths < 40 m for the Trunkline Project Area, and the Borrow Ground Area, epifauna and infauna in these locations, while sparse may be a food source or habitat for turtles and fish which could make their value in these areas higher. While direct impacts of seabed disturbance on these receptors is discussed further in the sections to follow, as discussed above there is a potential for indirect effects a result of the loss of epifauna and infauna, however this is not likely to result on an adverse impact to the functioning or integrity of the KEF, or result in displacement of marine turtles from foraging areas in shallower waters of the Trunkline and Borrow Ground Project Areas.

No threatened or migratory species, or ecological communities (as defined under the EPBC Act), were identified in the benthic communities during studies completed in the Offshore Project Area (ERM, 2013a) or the trunkline project area (Advisian, 2019a, Advisian, 2019b).

Impacts from seabed disturbance on epifauna and infauna will be minor. Receptor sensitivity of epifauna and infauna is low (low value, homogenous).The Impact Significance Level of seabed disturbance on epifauna and infauna has been identified as **Slight (E).**

<u>*Coral*</u>

Dredging, spoil disposal and backfill activities have the potential to impact coral as a result of elevated concentrations of suspended sediment (turbidity), changes in light quality and quantity, and sedimentation (Jones et al. 2016). Elevated turbidity within the water column reduces light penetration and therefore the availability of light for photosynthesis (Erftemeijer et al. 2012). While, elevated sedimentation rates may also suppress coral growth and survival when energy expenditure is redirected to actively clear settled sediments from coral tissue (Erftemeijer et al. 2012; Jones et al. 2016).

Coral communities of the Dampier Archipelago predominantly occur as narrow linear features fringing the shorelines of islands and the Burrup Peninsula, typically between 2 m and 10 m mean lower low water (Blakeway and Radford, 2005; Jones, 2004). Within Commonwealth waters, geophysical surveys coupled with environmental data found that the trunkline route consists of carbonate sands with some finer components, which supports sparse filter feeder communities. Similarly, preliminary findings from the benthic habitat survey completed in the Borrow Ground Project Area and adjacent areas of the Dampier AMP found that benthic habitat within the Borrow Grounds Project Area and the adjacent area of the Dampier Marine Park Habitat Protection Zone (IV) consisted of sand with little to no biota throughout the area. As such no direct disturbance to coral communities from installation and seabed intervention activities is expected.

Modelling has been completed that considers impacts to benthic communities and habitats in Commonwealth and State waters, including coral habitats of the Dampier Archeipelgo and inshore of the proposed Borrow Ground (Appendix J). Modelling has shown that dredging, spoil disposal and backfill activities undertaken in Commonwealth waters are predicted to cause detectable changes in water quality from elevated suspended sediment concentrations (as represented by the ZoI). However, increases in suspended sediment levels are predicted to remain below the intensity-duration thresholds at which impacts to benthic biota may occur. This includes the coral assemblages of the Dampier Archipelago and on the seaward slopes of outer islands such as Legendre Island and around Madeleine Shoals.

The only exception is a small isolated pocket on the southern side of Hauy Island, which is predicted to exceed the ZoMI thresholds for Zone B (i.e. coral thresholds). This elevation in suspended sediments is expected to be temporary and spatially confined such that any water quality impacts are predicted to cause reversible impacts to a small proportion of coral (0.2 ha of 9512 ha of significant coral communities mapped in the Dampier Archipelago), but not expected to cause irreversible impact to any sensitive receptors. Further, as previously stated, this ZoMI pocket may be attributable to the combined effects of model bathymetry and hydrodynamics.

Modelling also shows that SSC levels are predicted to be an order of magnitude below the SSC levels required to sustain a sedimentation rate close to that reported as having effects on benthos (Duckworth et al., 2017). Thus no impacts from sedimentation are predicted, with the possible exception of the small isolated pocket on the southern side of Hauy Island where the ZoMI threshold based on suspended sediment and daily light interval thresholds has been exceeded for a number of the duration terms.

Predicted Impact Summary

Based on the modelling results (Appendix J), potential impact to coral communities from seabed disturbance within the Trunkline Project Area, including trunkline dredging, spoil disposal and backfill activities in Commonwealth waters are not anticipated, and as such this has not been evaluated further. In contrast, borrow ground dredging is predicted to temporarily impact (reversible loss) a small area of coral on the south side of Hauy Island, representing about 0.2 ha of the mapped significant coral communities in the Dampier Archipelago (9512 ha).

It should be noted however, any modelled impacts are not expected to eventuate due to the implementation of a tiered monitoring and management framework informed by water quality. This framework will be implemented to ensure dredging activities and associated water quality are managed to a level where impacts are not predicted to occur to benthic communities and habitats, including coral communities within State waters.

The framework is premised on adaptive management, which will use telemetered water quality monitoring data (i.e. turbidity data) to inform changes to the dredging operations where designated trigger levels are exceeded at a monitoring site/s as a result of the dredging activities. For context, the tiered approach is based on three levels of triggers as follows:

- The Level 1 trigger is designed as an early warning indicator where a dredge plume may be present, but at which no impact to benthic communities is predicted. This trigger serves as an early warning that turbidity levels are starting to rise.

- The Level 2 trigger is designed to provide an early warning that a duration term of the ZoMI (where impacts are predicted but are expected to be reversible within five years) is approaching its limit. It provides a two-day warning before the ZoMI threshold is breached to allow the project to proactively manage turbidity-generating activities while dredging (e.g. reduce overflow, move location of the dredge etc.) to prevent the potential of a Level 3 trigger exceedance. This proactive management is expected to prevent any impacts to benthic communities and habitat during dredging, spoil disposal and backfill operations.
- The Level 3 trigger is based on a water quality level at which reversible impacts may occur based on the ZoMI threshold. In the event of a level 3 trigger attributable to dredging, spoil disposal and backfill activities, management action/s (e.g. no overflow, cease dredging) will be implemented to reduce turbidity, and impacts verified through coral monitoring at the affected site.

Monitoring sites will be selected as appropriate to provide assurance EPO 6.2 and EPO 6.4 are met through the implementation of the tiered monitoring and management framework, which aims to avoid the potential minor impacts to a small proportion of coral (0.2ha) described above by proactively managing borrow ground dredging operations.

Given the small proportion of potentially impacted coral (represented by the ZoMI), which is considered reversible within five years, and the controls implemented, the magnitude has been assessed as slight. Receptor sensitivity of coral is high and therefore Impact Significance Level of seabed disturbance on coral has been identified as **Minor (D).**

It should be noted that proposed management of potential impacts to significant benthic communities and habitats from activities originating in State waters will be addressed under relevant State legislation.

Marine Turtles

Marine turtles may be impacted from the permanent placement of infrastructure (identified in Table 7-38) and the trunkline, or placement of temporary infrastructure (anchors, ROV, geotechnical equipment) on the seabed.

Disturbance to the seabed can alter the physical seabed habitat conditions, resulting in changes to epifaunal communities. Trunkline and subsea infrastructure installation are permanent for the duration of field life and will result in the displacement of some individuals and/or permanent loss of some foraging and internesting habitat for marine turtles over the infrastructure and trunkline footprint.

Disturbance of the seabed is not anticipated to significantly affect mobile marine fauna such as marine turtles, which are generally present within the water column and are not solely reliant on benthic habitats. Impacts from seabed disturbance on epifaunal communities may result in some changes to, and/or loss of, foraging habitat for marine turtles, or displacement of individual turtles from areas utilised as foraging habitat.

Both the Trunkline and Borrow Grounds project areas are overlapped by nesting and internesting ‘Habitat Critical for the Survival of a Species’ (habitat critical) for flatback, green and hawksbill turtles, as defined in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017). The defined habitat critical for each species is based on either a 60 km radius (for flatback turtles) or a 20 km radius (for green and hawksbill turtles) from key nesting locations and represents habitat within which individuals may rest on the seabed between nesting events. The presence of marine turtles in the Trunkline and Borrow Grounds project areas are expected to peak during breeding periods.

The Recovery Plan identifies habitat modification from infrastructure/coastal development as a threat to the stocks of flatback, green, and hawksbill turtles in the North West Shelf and Pilbara region.

The area of seabed to be disturbed within the Trunkline Project Area represents a very small portion of the habitat available for foraging or internesting flatback, green and hawksbill turtles. As described in Table 5-4 and shown in Figures 5-32, 5-33 and 5-34, there is no overlap between the foraging BIAs for flatback, green and hawksbill turtles around the Dampier Archipelago and the Trunkline or Borrow Grounds project areas, as the foraging habitat is limited to inshore, shallow waters close to key nesting beaches.

Based on the defined 30 m width of the Trunkline Project Area, the areas of overlap with the habitat critical for each species of marine turtle are as follows:

- Flatback turtle:
    - habitat critical – overlap area 3.19 km; 0.02%
- Green turtle:
    - habitat critical – overlap area 1.58 km; 0.03%
- Hawksbill turtle:
    - habitat critical – overlap area 1.58 km; 0.02%

Similarly, the area of seabed to be disturbed within the Borrow Grounds Project Area also represents a very small portion of the habitat available for internesting flatback, green and hawksbill turtles. Based on an area of 16.64 km^2 for the Borrow Grounds Project Area, the overlap (as a percentage of the overall habitat critical area around the Dampier Archipelago) with the habitat critical for each species of marine turtle are as follows:

- Flatback turtle:
    - habitat critical – 0.10%
- Green turtle:
    - habitat critical – 0.35%
- Hawksbill turtle:
    - habitat critical – 0.17%

Predicted Impact Summary

As described in Section 5.4.6.4, internesting behaviours exhibited by flatback turtles extend further offshore compared to other marine turtle species in the NWMR, However, tracking data indicates that flatback turtles in the NWMR travel and forage in relatively shallow coastal waters less than 70 m deep (Chevron Australia Pty Ltd, 2015). The 60 km internesting buffer for flatback turtles in the Recovery Plan is based primarily on the movements of tagged internesting flatback turtles along the North West Shelf reported by Whittock et al. (2014), which found that flatback turtles may demonstrate internesting displacement distances up to 62 km from nesting beaches. However, these movements were confined to longshore movements in nearshore coastal waters or travel between island rookeries and the adjacent mainland (Whittock et al., 2014). There is no evidence to date to indicate flatback turtles swim out into deep offshore waters during the internesting period.

A more recent paper by the same authors (Whittock et al., 2016) has more precisely defined flatback turtle internesting habitat along the North West Shelf. The Whittock et al. (2016) study developed a habitat suitability map to identify areas where internesting flatback turtles may be present along the North West Shelf, based on data compiled for a suite of environmental variables and satellite tracks of 47 internesting flatback turtles from five different mainland and island rookeries tracked over 1289 days. Whittock et al. (2016) defined suitable internesting habitat as water 0–16 m deep and within 5–10 km of the coastline, while unsuitable internesting flatback habitat was defined as waters >25 m deep and >27 km from the coastline. The primary environmental variables that influenced flatback internesting movement were bathymetry, distance from coastline, and sea surface temperature.

Suitable areas of internesting habitat were located close to many known flatback turtle rookeries across the region (Whittock et al., 2016).

Suitable internesting habitat for green turtles is also likely to be limited to relatively shallow waters within close proximity of the coastline. While information on internesting movements of green turtles in Western Australia is limited, tracking data has shown that during nesting periods, female green turtles typically inter-nest in shallow, nearshore waters between 0 and 10 m deep (Pendoley, 2005) and remain <5 km nesting beaches on Barrow Island, Varanus Island, and Rosemary Island (Pendoley, 2005) and within 10 km of nesting beaches on the Lacepede Islands (Waayers et al., 2011). These conclusions for green turtles internesting are also supported by other international scientific studies that suggest internesting grounds are located close to nesting beaches, in 10–18 m of water (Stoneburner, 1982; Mortimer & Portier, 1989; Maylan, 1995; Tucker et al., 1995; Starbird & Hills, 1992). Hays et al. (2000) deployed time-depth recorders on green turtles that had nested on Ascension Island in the South Atlantic, to examine their diving behaviour during the subsequent internesting interval. All the turtles performed dives where they remained at a fixed depth for a long period, surfaced briefly and then dived to the same depth again. It is generally believed these dive profiles are caused by the turtles resting on the seabed. The maximum depth that turtles routinely reached on these resting dives was between 18 and 20 m, with resting dives deeper than 20 m being extremely rare (Hays et al., 2000).

Information on hawksbill turtles nesting on Varanus and Rosemary Islands suggests females remain within several (less than ten) kilometres of their nesting beaches on Varanus Island and within 1 km of nesting beaches on Rosemary Island (Pendoley, 2005).

Based on this understanding, it is considered unlikely that internesting turtles will occur in the Trunkline Project Area around the Montebello Islands where water depths range from 46 m to 214 m. At the shallowest point, which is in waters adjacent to the Dampier Archipelago, water depths in the Trunkline Project Area are approximately 30 m. Water depths of the Borrow Grounds Project Area range between approximately 30 to 40 m. Internesting green and hawksbill turtles are unlikely to utilise habitat at these water depths. Flatback turtles nesting on beaches of the Dampier Archipelago may inter-nest in the shallower waters of the Trunkline Project Area and Borrow Grounds Project Area, however, large numbers are not expected.

For all three species of marine turtle the overlap between the Trunkline and Borrow Grounds project areas and the habitat critical are extremely small, with the vast majority of suitable internesting and foraging habitat remaining available outside these project areas and available for utilisation. Minimum water depths in the Trunkline and Borrow Grounds project areas are approximately 30 m, and therefore any areas of overlap with the defined habitat critical are unlikely to represent important internesting habitat for flatback, green or hawksbill turtles. Although some loss of marine turtle foraging habitat may occur as a result of the installation of the trunkline on the seabed, such foraging habitat is widely represented in the region and any loss is expected to be negligible. Surveys of the trunkline route have not indicated the presence of any unique or limiting benthic foraging habitat for marine turtles within the trunkline corridor. Based on the key food sources of marine turtle species, and the relative abundance of epifauna and infauna found in the trunkline and borrow grounds areas, the Trunkline and Borrow Grounds project areas are unlikely to support foraging aggregations of marine turtles (Pendoley, 2020a).

Therefore, seabed disturbance within the Trunkline and Borrow Grounds project areas is not expected to adversely impact on biologically important behaviours or biologically important habitat, including habitat critical to the survival of marine turtles. The Trunkline and Borrow Grounds project areas are not likely to represent important internesting habitat for flatback, green and hawksbill turtles, and any displacement of individuals from areas utilised as foraging habitat will not result in any significant impacts at a population level.

Impacts from seabed disturbance on marine turtles will be slight. Receptor sensitivity of marine turtles is high, and the Impact Significance Level of seabed disturbance on marine turtles is **Minor (D)**.

AMPs

The Trunkline Project Area traverses the northern border of the Montebello Marine Park. Approximately 80 km of pipeline will extend into the park, equating to approximately 2.4 km^2 overlap (allowing for a 30 m disturbance area on the trunkline). This conservative disturbance area represents 0.07% of the Montebello Marine Park, including the area intersecting the Ancient Coastline KEF.

Relevant habitat critical and BIAs that intersect the Trunkline Project Area in the Montebello AMP include an internesting buffer habitat critical and internesting BIA for flatback turtles, migration corridor for humpback whales and foraging area for whale sharks. The conservative disturbance area of approximately 2.4 km^2 represents just 0.01% of the habitat critical for flatback turtles around the Montebello Islands, and the relatively deep offshore waters where the trunkline corridor overlaps the northern extent of the Montebello Marine Park do not represent important internesting habitat for flatback turtles. The disturbance area within the Montebello Marine Park represents an extremely small percentage (<0.001%) of the humpback whale migration BIA and whale shark foraging BIA.

Analysis of the high definition ROV video data (Advisian, 2019b) found that the area in which the trunkline intersects the Montebello AMP is characterised by bare sandy sediments, interspersed with predominantly sparse benthic communities and epifauna. Benthic organisms (including sponges and soft corals) generally occur as single or low density aggregations of individuals with isolated denser areas of sponges in areas identified from the bathymetry as having a more complex seabed structure.

The pipeline alignment was selected to ensure the intersections with harder more complex areas of seabed are minimised with the pipeline generally running perpendicular to these areas. This minimises any direct loss of sponges which are generally associated with these areas of more complex bathymetry in the Montebello Marine Park. The majority of the trunkline route within the Montebello AMP will also run adjacent to the existing Pluto trunkline ensuring there is minimal disturbance to new areas of the AMP. The trunkline route has also been selected to minimise the seabed disturbance, with alternative options requiring additional seabed intervention (**Section 4.5.4.6**).

The intersection of the trunkline with isolated areas of denser sponges is not expected to fragment the community given that any loss of sponges will be localised to the trunkline footprint. Given that epifaunal communities were well represented either side of the proposed trunkline route (Advisian 2019) and regionally (Keesing 2019) and that the footprint of the trunkline is extremely small in comparison with the spatial extent of these communities in the North Western section of the Montebello Islands Marine Park, the presence of the trunkline will not destroy, fragment, isolate these communities. Nor will it disturb a substantial area of habitat given the small footprint of the trunkline. The habitat is also well represented spatially and the diversity and abundance of the habitat within the footprint is consistent with that observed adjacent to the direct footprint and in the adjacent PFTF Area 1.

Anchor disturbance in respect to known areas of higher sensitivity along the trunkline route has been considered, including the isolated areas of higher sponge density within the Montebello Marine Park. The water depths across the trunkline's intersection with the Montebello Marine Park (waters of approximately 60 – 130 m depth) are expected to preclude the use of anchors for mooring by support vessels. This limitation is not intended to constrain the right of a vessel to anchor anywhere within the Project Area including the AMP (in the event feasible) '*due to circumstances of force majeure or distress or for the purpose of rendering assistance to persons, ships, or aircraft in danger or distress*' as legislated under the United Nations Convention on the Law of the Sea (UNCLOS) and accordingly permitted under the 'North Marine Parks Network Management Plan'. In summary, seabed disturbance impacts within the AMP from the use of mooring anchors by support vessels are not expected (as anchoring within the AMP is not a planned activity).

Seabed intervention activities have the potential to also indirectly affect filter feeder-sponge habitat through reduced light availability for photosynthesis of the sponges' symbionts, reduced filtering and feeding due to elevated SSCs, and increased sediment deposition that could result in tissue smothering (Abdul Wahab et al. 2019). A minor temporary increase in suspended sediments at the seabed associated with the trunkline installation within the Montebello Marine Park would not reach the intensity and duration terms of the impact thresholds due to the rapid progress of the trunkline installation and thus no impacts are predicted beyond the direct footprint.

Trunkline installation activities are not expected to negatively impact the areas of bare sandy substrate of the Montebello Marine Park. Recent research has also confirmed that habitats containing the greatest biodiversity in these offshore environments are the habitats formed by colonising invertebrates on oil and gas subsea infrastructure including pipelines. These habitats and the species present on these structures in the NWS of Western Australia have been subject to detailed assessment by McLean et al. (2020), McLean et al. (2018), Bond et al. (2018) and McLean et al. (2017). These habitats not only have structural complexity but also create habitat for a large diversity of fish species that commonly occur elsewhere in the NWS but do not occur over soft unconsolidated sediments.

The Borrow Grounds Project Area is located adjacent to the Dampier Marine Park, with a 250 m buffer between. The Dampier Marine Park covers about 1252 km² and includes waters from less than 15 m to 70 m depth. Conservation values identified within the reserve (Director of National Parks, 2018) include:

- foraging areas adjacent to important breeding areas for migratory seabirds
- foraging areas adjacent to important nesting sites for marine turtles
- part of the migratory pathway of the protected humpback whale
- high level protection for offshore shelf habitats adjacent to the Dampier Archipelago, and for the shallow shelf with depths ranging from 15 m to 70 m
- examples of the communities and seafloor habitats of the NWS province bioregion as well as the Pilbara (nearshore) and Pilbara (offshore) meso-scale bioregions
- part of a hotspot for sponge biodiversity (area between Dampier and Port Hedland).

Recent benthic habitat surveys of an area of the Dampier AMP habitat protection zone adjacent to the Borrow Grounds Project Area (Advisian, 2019c) showed the seabed and benthic composition of the area surveyed was relatively uniform in structure and composition. The survey area was dominated by bare sandy substrate with large areas of seabed that are apparently largely devoid of any epibenthic species. Given the coarse nature of the sediments at the borrow ground, it is expected that the duration and frequency terms of any intensity-duration-frequency threshold of turbidity elevation would be maintained below that currently predicted as required to generate material levels of stress to ecological communities in areas of higher filter feeder abundance in the eastern end of the marine park. Sediment dispersion modelling for the dredging of the Borrow Grounds showed no exceedance of the ZoMI or ZoHI in any zones of the Dampier AMP. A ZoI was defined (Figure 7-23) which does extend into the boundary of the Dampier AMP habitat protection zone (but not into the National Park or Multiple use zones). However, it is noted that the ZoI is defined as an area within which changes in water quality associated with dredge plumes are predicted but where these changes would not result in a detectable impact on benthic biota i.e values of the adjacent habitat protection zone.

Seabed intervention activities have the potential to also indirectly affect filter feeder-sponge habitat through reduced light availability for photosynthesis of the sponges' symbionts, reduced filtering and feeding due to elevated SSCs, and increased sediment deposition that could result in tissue smothering (Abdul Wahab et al. 2019).

Indirect impacts to filter feeder communities due to elevations in suspended sediment and associated sediment deposition as a result of subsea installation and seabed intervention activities have been assessed. Sediment transport modelling predicted detectable changes in water quality from elevated SSC as a result of dredging, spoil disposal and backfill activities undertaken in Commonwealth waters, including the Habitat Protection Zone (IV) of the Dampier Marine Park, however these increases in suspended sediment are predicted to remain below the intensity-duration thresholds that may cause an impact to fliter feeder-sponge habitat (Pineda et al. 2017).

Further, modelling also shows that levels of suspended sediment are predicted to be an order of magnitude below the SSC levels required to sustain a sedimentation rate close to that reported as having effects on benthos (Pineda et al., 2017a). This is further supported by WAMSI dredging science node studies, which concluded that a 30 day sediment smothering period did not cause mortality, visible signs of host stress, lipid depletion or overall changes in sponge respiration rates, and it did not affect the photosymbiont activity or microbiome composition of the studied species (Abdul Wahab et al. 2019). Given the modelling results and the temporary nature of the installation and seabed intervention activities, indirect impacts to filter feeder communities from elevated suspended sediment and associated sediment deposition are therefore not anticipated.

Predicted Impact Summary

Given the small footprint of the trunkline, and subsequent percentage disturbance to the Montebello AMP (0.07%) the project activities are not expected to modify, destroy, fragment, isolate or disturb important or substantial areas of habitat important to turtles, whale sharks or whales in the Montebello AMP.

For activities undertaken within the Borrow Ground, the nature of the change within the Dampier AMP is temporary as activities are short term and intermittent. Sediment dispersion modelling for the dredging of the Borrow Grounds showed no exceedance of the ZoMI or ZoHI in any zones of the Dampier AMP. Modelling has indicated that detectable water quality changes (as represented by the ZoI) are not predicted within the National Park Zone (II) of the Dampier Marine Park. Impacts of the activities are as such not inconsistent with the objectives of the zoning of the marine park.

Given the temporary and localised nature of any water quality impacts to the Montebello and Dampier AMPs, and the low abundance of filter feeders adjacent to the proposed borrow ground in the Dampier AMP, activities are not expected to modify, destroy, fragment, isolate or disturb an important or substantial area of habitat.

Infrastructure will be positioned on the seabed within the design footprint, to ensure that the overall area of seabed disturbance is limited.

Impacts from seabed disturbance on AMPs will be slight. Receptor sensitivity of AMPs is high (high value habitat).The Impact Significance Level of seabed disturbance on AMPs has been identified as **Minor (D)**

KEFs

Three KEFs overlap the Offshore Project Area and Trunkline Project Area: the Exmouth Plateau, Ancient Coastline at 125 m Depth Contour and Continental Slope Demersal Fish Communities. Seabed disturbance will occur within these KEFs and may lead to change in habitat and a highly localised change to water quality, which will be short-term, associated with the temporal extent of installation activities (months).

The Trunkline Project Area and Offshore Project Area lie within the Exmouth Plateau KEF. The KEF occupies an area of 49,310 km² within water depths of 800 – 4000 m (Exon & Willcox, 1980, cited in Falkner et al., 2009; Heap & Harris, 2008). The Trunkline Project Area enters the KEF about 240 km offshore, extending about 60 km into the KEF before reaching the Offshore Project Area. The Trunkline Project Area and Offshore Project Area occupy a relatively small portion of the entire KEF (approximately 0.005%). Installation of seabed infrastructure is not likely to modify, destroy, fragment, isolate or disturb important or substantial areas of habitat within the Exmouth Plateau KEF. Given the small area of the KEF overlapped by the Trunkline Project Area and Offshore Project Area, no impact to the values of this KEF is anticipated.

A relatively small portion of the Ancient Coastline at 125 m Depth Contour KEF overlaps the Trunkline Project Area. This intersect is located about 360 km offshore north-north-west of the Montebello Islands. While physical habitat modification is not listed as a potential concern for this KEF, any seabed disturbance will be a very small portion within the KEF. Impact will not occur to the hard substrates of the KEF, as the trunkline route will avoid hard substrates and associated increase in species richness.

An ROV survey of the trunkline route undertaken in 2019 (Advisian, 2019b) targeted areas of interest including the ancient coastline KEF. Bathymetry data was analysed to select sites that could be expected to support benthic communities, including areas of potential harder substrate. The survey found that the area in which the trunkline intersects the Montebello AMP is characterised by bare sandy sediments, interspersed with predominantly sparse benthic communities and epifauna.

The Continental Slope Demersal Fish Communities are recognised as a KEF because of their biodiversity values, including high levels of endemism (DotE, 2018b). The Trunkline Project Area intersects a small portion of the KEF, across one of its thinnest points throughout its distribution. Most of the KEFs area lies further south, extending about 240 km from the Trunkline Project Area to just past the tip of the Exmouth Peninsula, splitting from a single corridor into three. Physical habitat modification is listed as a potential concern for this KEF (DotE, 2018b). However, any potential impact to the KEF from habitat disturbance is restricted to the overlap of the trunkline and impacts will be highly localised.

Predicted Impact Summary

Small areas of seabeds in three KEFs will be disturbed a result of activities associated with Scarborough. Impacts however will not be significant as the disturbance will be over a relatively small proportion of each of the KEFs and avoid important or substantial areas of habitat. This includes hard substrates of the Ancient Coastline at 125 m Depth Contour KEF.

Impact to the Continental Slope Demersal Fish Communities KEF may occur, and physical habitat modification is listed as a potential concern for the KEF, however impacts will be highly localised and are not expected to impact the functioning or integrity of the KEF as a whole. Furthermore, as discussed in previous sections, installation of the trunkline is not likely to modify, destroy, fragment, isolate or disturb important or substantial areas of habitat within this KEF, but rather add to hard substrate and foraging habitat for demersal fish along the trunkline corridor. It is known that the proposed trunkline will offer a corridor of hard bottom habitat that facilitates epibiotic growth and the presence of reef-associated species in a region characterised by sandy sediments. The predicted increase in biodiversity as a result of the subsea infrastructure is not expected to have any negative environmental consequences. Studies support the potential importance of subsea infrastructure as a habitat for fish, and in consequence, potentially also as structures with value to commercial fisheries (McLean et al., 2020).

No impacts to the Exmouth Plateau KEF are predicted, nor the hard substrates of the Ancient Coastline at 125 m Depth Contour KEF.

Impacts from seabed disturbance to the Continental Slope Demersal Fish Communities KEF will be slight. Receptor sensitivity of KEFs is high (high value), and therefore Impact Significance Level of seabed disturbance on KEFs is **Minor (D)**.

7.1.6.3 Demonstration of Acceptability

Table 7-42 provides demonstration of acceptability for all receptors predicted to be potentially impacted from seabed disturbance.

Table 7-42: Demonstration of Acceptability for Physical Presence: Seabed Disturbance

<table>
<tr><th colspan="4">Demonstration of Acceptability</th></tr>
<tr><th>Receptor</th><th>Acceptability Criteria and Assessment</th><th>Acceptable Levels of Impact</th><th>Statement of Acceptability</th></tr>
<tr><td>Water quality</td><td>Principles of ESD
The Scarborough development is consistent with the relevant principles of ESD:
Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
The Scarborough development will result in no significant impacts to water quality. Significant impact definitions:
to not result in a substantial change to water quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health.
Internal Context
The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards.

External Context
During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on water quality.

Other requirements
The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management</td><td>Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).
Activities associated with Scarborough during trunkline installation and in the borrow ground are not inconsistent with the objectives for relevant zoning of the Montebello and Dampier Marine Park. This includes multiple use zones for both the Montebello and Dampier Marine Park, as well as the habitat protection zone and national park zone for the Dampier Marine Park.</td><td>Based on an assessment against the defined acceptable levels, the impact to water quality from Seabed Disturbance is considered acceptable, given that:
the activity is aligned with the relevant principles of ESD.
Sediment mobilisation from displacement / relocation of sediments along the trunkline corridor as a result of installation of subsea infrastructure and seabed intervention activities is expected to remain in the vicinity of the activity and will be within an area of predominantly bare sand habitat.
The change in water quality will be localised around the placement of infrastructure on the seabed and temporary in nature.
The impact assessment demonstrates that impacts to water quality will not result in irreversible environmental damage.
Modelling has shown that the elevations in turbidity as a result of dredging, spoil disposal and backfill operations in Commonwealth waters, including those adjacent to the Dampier Marine Park will be restricted to the habitat protection zone and remain below the intensity-duration thresholds predicted to cause an impact to benthic communities, with the exception being a small pocket of coral on the southern side of Hauy Island, where reversible impacts are predicted.
the proposed controls are consistent with Woodside’s internal policies, procedures and standards
feedback from stakeholders has been taken into consideration</td></tr>
</table>

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***

	and conservation advices, and significant impact guidelines for MNES, specifically:
	• Sea Dumping Permits under the Environment Protection (Sea Dumping) Act 1981 will be in place where required. Sea dumping activities will be undertaken in accordance with the act and under permit as required.
	
	As activities will take place within or adjacent to AMPs, there are also principles, objectives and values to be considered. These are detailed below and specific values assessed against relevant receptors in sections to follow.
	Montebello Marine Park
	The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species. While water quality is not specifically listed as a value of the park, natural values of the marine park include:
	• diverse fish communities, and biologically important Areas for foraging habitat for whale sharks
	• biologically important areas for migratory pathways for humpback whales
	• biologically important areas for breeding habitat for seabirds
	• biologically important areas for internesting, foraging, mating and nesting habitat for marine turtles
	In addition, mining, fishing and tourism and recreation are listed as an important activity for social and economic values of the Marine Park
	Dampier Marine Park
	The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species. The objective of the Habitat Protection Zone (IV) is to provide for the conservation of ecosystems, habitats and native species in
			• legislative requirements/industry standards have been adopted
			• the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices
			  • Activities associated with the trunkline installation will result in temporary and localised changes in the water quality, and not result in significant impacts to the ecosystem, habitats and native species of the Montebello Marine Parks.
			  • Activities undertaken within the borrow ground will result in temporary and localised changes in the water quality, and not harm or cause destruction of the seafloor habitats of the Dampier Marine Park. Modelling has shown that the elevations in turbidity remain below the intensity-duration thresholds predicted to cause an impact to benthic communities in the Marine Park habitat protection zone-with the exception being a small pocket of coral on the southern side of Hauy Island, where reversible impacts are predicted. It is considered that, although there is a predicted detectable change in water quality that ZoI extends into the Habitat Protection Zone (IV) of the Dampier Marine Park, the nature of the change is temporary and is not inconsistent with the objectives of the zoning of the marine park. Modelling has indicated that detectable water quality changes (as represented by the ZoI) are not predicted within the National Park Zone (II) of the Dampier Marine Park.
			• the predicted level of impact is at or below the defined acceptable levels.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	as natural a state as possible, while allowing activities that do not harm or cause destruction to seafloor habitats. The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible. While water quality is not specifically listed as a value of the park, natural values of the marine park include: • diverse fish communities • biologically important areas for migratory pathways for humpback whales • biologically important areas for breeding habitat for seabirds • biologically important areas for internesting for marine turtles In addition, the Dampier Marine Park is also noted as a hotspot for sponge diversity and includes several submerged coral reefs and shoals including Delambre Reef and Tessa Shoals. In addition, port activities, fishing and recreation are listed as an important activity for social and economic values of the Marine Park		**Environmental Performance Outcomes** To manage impacts to water quality to at or below the defined acceptable levels the following EPO have been applied: **EPO 6.1:** Undertake Scarborough development in a manner that prevents a substantial change to water quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health. **EPO 6.2:** Undertake activities within the borrow ground to not harm or cause destruction to the sea floor habitats (including significant areas of sponge habitat) of the Dampier Marine Park habitat protection zone. **EPO 6.3:** Changes to water quality in the Montebello Marine Park as a result of the trunkline installation will be not be inconsistent with the objective of the multiple use zone.
Epifauna and infauna and (note includes macroalgae)	**Principles of ESD** The Scarborough development is consistent with the relevant principles of ESD: • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. • The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations • The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making	Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).* Activities associated with Scarborough during pipeline	Based on an assessment against the defined acceptable levels, the impact to epifauna and infauna from Seabed Disturbance is considered acceptable, given that: • the activity is aligned with the relevant principles of ESD. ◦ Sediment mobilisation and/or displacement along the trunkline corridor is expected to be restricted to the vicinity of the activity and will be within an area of predominantly bare sand habitat.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	The Scarborough development will result in no significant impacts to epifauna and infauna. Significant impact definitions: • to not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **Internal Context** The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards. **External Context** During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on epifauna and infauna. **Other requirements** The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES, specifically: • Sea Dumping Permits under the Environment Protection (Sea Dumping) Act 1981 will be in place where required. Sea dumping activities will be undertaken in accordance with the act and under any permit as required. As activities will take place adjacent to AMPs, there are also principles, objectives and values to be considered. **Montebello Marine Park** The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of	installation and in the borrow ground are not inconsistent with the objectives for relevant zoning of the Montebello and Dampier Marine Park. Seabed disturbance caused by the activities associated with Scarborough are not inconsistent with the objectives of the zoning of the Dampier Marine Park, in that the zone of impact does not extend into the Marine Park boundary causing impacts to benthic habitat (specifically sponges). Seabed disturbance caused by the activities associated with Scarborough are not inconsistent with the objectives of the zoning of the Montebello Marine Park in that although some loss of benthic habitat, this will not impact the ability for marine turtles to utilise the area for foraging.	• water quality impacts associated with the seabed material displacement are not expected to pose a risk to the surrounding epifauna and infauna communities. Dredging, spoil disposal and backfill activities undertaken in Commonwealth waters are predicted to cause detectable changes in water quality from elevated suspended sediment concentrations, however these increases in suspended sediment are predicted to remain below the intensity-duration thresholds that may cause an impact to filter feeder-sponger communities. • Based on the geophysical, geotechnical data and studies of the more complex seabed features, the trunkline project area is considered largely devoid of epibenthic species. Any intersections of the isolated calcarenite outcropping identified from the geophysical data along the trunkline route are likely to represent a very small area, given the 32 inch diameter of the pipeline. Given the small area of disturbance from the trunkline, the isolated nature of the calcarenite outcrops along the trunkline route and the wide distribution of these outcrops across the North West Shelf (Wilson 2013), no modification, destruction, fragmentation, isolation or disturbance to an important or substantial area of habitat for filter feeder communities is expected along the trunkline route are predicted.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	ecosystems, habitats and native species. Natural values of the marine park include: • diverse fish communities, and biologically important Areas for foraging habitat for whale sharks • biologically important areas for foraging habitat for marine turtles **Dampier Marine Park** The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species. The objective of the Habitat Protection Zone (IV) is to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while allowing activities that do not harm or cause destruction to seafloor habitats. The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible. The Dampier Marine Park is noted as a hotspot for sponge diversity.		• Shallower waters (<40 m) support important habitats of protected species, including foraging of turtles on plants and animals on the seafloor. Trunkline Corridor and Borrow Grounds Project Areas are shown to be unlikely to support foraging aggregations, due to key food sources and relative abundance of epifauna and infauna within these areas (Pendoley Environmental, 2020), and impacts to epifauna and infauna are not likely to result in displacement of marine turtles from foraging areas in shallower waters of the Trunkline and Borrow Ground Project Areas. • While epifauna and infauna, in particular infauna, are important to demersal fish communities, particularly within the Continental Slope Demersal Fish Communities KEF, the potential impact to the fish assemblages within the KEF from habitat disturbance is restricted to the overlap of the trunkline and impacts to benthic biota including epifauna and infauna will be highly localised, and not result on an adverse impact to the functioning or integrity of the KEF. • Based on the coarse sediment (with minimal fines) and the area being largely devoid of any epibenthic species, no important or substantial area of epifaunal or infaunal habitat, or protected species which depend upon them, is expected to be modified, destroyed, fragmented, isolated or disturbed as a result of works in the Trunkline Corridor and Borrow Ground Project Areas.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
			• Generally sparse epifauna and infauna communities have been identified in the Project Area, no threatened or migratory species or ecological communities were identified. Those epifauna and infauna communities observed are likely to be well represented elsewhere in the region with impacts restricted to a localised proportion of benthic fauna communities. • the proposed controls are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices • Although some loss of marine turtle foraging habitat may occur within the Montebello Marine Park as a result of the installation of the trunkline on the seabed, such foraging habitat is widely represented in the region and any loss is expected to be negligible. Surveys of the trunkline route have not indicated the presence of any unique or limiting benthic foraging habitat for marine turtles within the trunkline corridor.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
			• Activities undertaken within the borrow ground will result in temporary and localised changes in the water quality, and not harm or cause destruction of the seafloor habitats of the Dampier Marine Park. Modelling has shown that the elevations in turbidity are restricted to the habitat protection zone and remain below the intensity-duration thresholds predicted to cause an impact to benthic communities in the Marine Park. Sponge habitat within the Dampier Marine Park, are not exposed to elevated turbidity above impact thresholds. • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Outcomes** To manage impacts to epifauna and infauna to at or below the defined acceptable levels the following EPO have been applied: **EPO 6.2:** Undertake activities within the borrow ground to not harm or cause destruction to the sea floor habitats (including significant areas of sponge habitat) of the Dampier Marine Park habitat protection zone. **EPO 6.4:** Undertake Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 6.5**:Seabed Disturbance from trunkline installation within the Montebello Marine Park will be limited to less than 0.07% of the total park area.
Coral	**Principles of ESD** The Scarborough development is consistent with the relevant principles of ESD: • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.	Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted	Based on an assessment against the defined acceptable levels, the impact to coral from Seabed Disturbance is considered acceptable, given that: • the activity is aligned with the relevant principles of ESD.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	• The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations • The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making The Scarborough development will result in no significant impacts to coral. Significant impact definitions: • to not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **Internal Context** The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards. **External Context** During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on coral. **Other requirements** The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES, specifically: • Sea Dumping Permits under the Environment Protection (Sea Dumping) Act 1981 will be in place where required. Sea dumping activities will be undertaken in accordance with the act and under permit as required.	significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013))*.	• Based on the modelling results (Appendix J), potential impact to coral communities from seabed disturbance and in particular trunkline dredging and spoil disposal activities in Commonwealth waters are not anticipated. • Borrow ground dredging is predicted to temporarily impact (reversible loss) a small area of coral on the south side of Hauy Island, representing about 0.2 ha of the mapped significant coral communities in the Dampier Archipelago (9512 ha). Given the small proportion of potentially impacted coral (represented by the ZoMI), which is considered reversible within five years, the magnitude of any impacts will be slight. • the proposed controls are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted, including: • Development of a management framework for dredging and backfill activities based on water quality to manage activities to achieve EPO 6.2 and EPO 6.4 (**CM34**). • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Outcomes** To manage impacts to coral to at or below the defined acceptable levels the following EPO have been applied: **EPO 6.4:** Undertake Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
Marine turtles	**To meet the principles of ESD** The Scarborough development is consistent with the relevant principles of ESD: • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. • The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations • The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making The Scarborough development will result in no significant impacts to marine reptiles. Significant impact definitions: • to not have a substantial adverse effect on a population of marine reptiles or the spatial distribution of the population • to not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results • to not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species. **Internal Context** The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards. **External Context** During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential	Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).* Activities associated with Scarborough during pipeline installation and in the borrow ground are not inconsistent with the objectives for relevant zoning of the Montebello and Dampier Marine Park. Seabed disturbance caused by the activities associated with Scarborough are not inconsistent with the objectives of the zoning of the Dampier Marine Park, in that the zone of impact does not extend into the Marine Park boundary causing impacts to benthic habitat (specifically sponges). Seabed disturbance caused by the activities associated with Scarborough are not inconsistent with the objectives of the zoning of the Montebello Marine Park in that although	Based on an assessment against the defined acceptable levels, the impact to marine turtles from Seabed Disturbance is considered acceptable, given that: • the activity is aligned with the relevant principles of ESD. • The area of seabed to be disturbed within the Trunkline Project Area represents a very small portion of the habitat available for foraging or internesting flatback, green and hawksbill turtles. • It is considered unlikely that internesting turtles will occur in the Trunkline Project Area around the Montebello Islands or within the Borrow Grounds Project Area. • There is no overlap between the foraging BIAs for flatback, green and hawksbill turtles around the Dampier Archipelago and the Trunkline or Borrow Grounds project areas, as the foraging habitat is limited to inshore, shallow waters close to key nesting beaches. Although some loss of marine turtle foraging habitat may occur as a result of the installation of the trunkline on the seabed, such foraging habitat is widely represented in the region and any loss is expected to be negligible. Surveys of the trunkline route have not indicated the presence of any unique or limiting benthic foraging habitat for marine turtles within the trunkline corridor. • Based on the key food sources of marine turtle species, and the relative abundance of epifauna and infauna found in the Trunkline and Borrow Grounds project areas, these areas are unlikely to support foraging aggregations of marine turtles. **Environmental Performance Outcomes**

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	impacts of the Scarborough development on marine reptiles. **Other requirements** The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES. Impacts to turtles are to be managed in accordance with the Recovery plan for marine turtles in Australia (DoEE, 2017), including to *manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival.* The recovery plan also identifies conservation actions, however none that relate specifically to seabed disturbance. In addition, there is in place approved Conservation Advice for the Short-nosed Seasnake (DSEWPaC, 2011). This advice includes to: • Monitor known populations to identify key threats. Ensure there is no anthropogenic disturbance in areas where the species occurs, excluding necessary actions to manage the conservation of the species. The Conservation advice adds that habitat occurs primarily on the reef flats in shallow waters of outer reef edges to depths of 10 m. As such this advice is not considered relevant for this activity. As activities will take place within or adjacent to AMPs, there are also principles, objectives and values to be considered. These are detailed below, and specific values assessed against relevant receptors in sections to follow. **Montebello Marine Park** The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of	some loss of benthic habitat, this will not impact the ability for marine turtles to utilise the area for foraging. Activities associated with Scarborough that cause seabed disturbance are not inconsistent with a recovery plan or wildlife conservation plan/advice that is in force for a species of marine turtles, including the: • Recovery plan for marine turtles in Australia (DoEE, 2017)	To manage impacts to marine turtles to at or below the defined acceptable levels the following EPO has been applied: **EPO 6.6**: Trunkline installation and borrow ground activities will be undertaken in a manner that aims to avoid the displacement of marine turtles from important foraging habitat or from habitat critical during nesting and internesting periods.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	ecosystems, habitats and native species. Natural values of the marine park include: • biologically important areas for internesting, foraging, mating and nesting habitat for marine turtles **Dampier Marine Park** The objective of the Habitat Protection Zone (IV) is to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while allowing activities that do not harm or cause destruction to seafloor habitats. The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible. [Add multi use zone] Natural values of the marine park include: • biologically important areas for internesting for marine turtles		

AMPs	**Principles of ESD**
	The Scarborough development is consistent with the relevant principles of ESD:
	• Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
	• The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
	• The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
	The Scarborough development will result in no significant impacts to AMPs. Significant impact definitions:
	• to not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that
		Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).*
		
		Activities associated with Scarborough during trunkline installation and in the borrow grounds are not inconsistent with the objectives for relevant
			Based on an assessment against the defined acceptable levels, the impact to AMPs from Seabed Disturbance is considered acceptable, given that:
			• the activity is aligned with the relevant principles of ESD.
			  • (See discussion points for all previous receptors)
			  • The Trunkline Project Area traverses the northern border of the Montebello Marine Park. Approximately 80 km of pipeline will extend into the park, equating to approximately 2.4 km^2 overlap (allowing for a 30 m disturbance area on the trunkline). This conservative disturbance area would result in 0.07% of the Montebello Marine Park,
			  • The intersection of the trunkline with isolated areas of denser sponges is not expected to fragment the community given that any loss of sponges will be localised to the trunkline footprint.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	an adverse impact on marine ecosystem functioning or integrity results. **Internal Context** There are no specific Woodside internal requirements with respect to seabed disturbance, or potential impacts to seabed disturbance to AMPs. **External Context** Consultation with the DNP was undertaken during the preparation of the OPP. During this consultation additional information was provided in addition to the OPP in order that they could consider the acceptable levels of impact that were determined for the Scarborough development. The information provided by Woodside was sufficient for the DNP to consider the activity, the predicted impacts and support the acceptable levels of impact, and subsequent EPOs proposed by Woodside in the OPP. **Other requirements** The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES, specifically: • With respect to seabed disturbance, activities associated with Scarborough will not be conducted in a manner inconsistent with the Objectives of the respective zones of the AMPs, the Principles of the IUCN Area Categories of the Values of the AMPs. **Montebello Marine Park** The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species. Natural values of the marine park include:	zoning of the Montebello and Dampier Marine Parks. This includes multiple use zones for both the Montebello and Dampier Marine Park, as well as the habitat protection zone and national park zone for the Dampier Marine Park.	• A minor temporary increase in suspended sediments at the seabed associated with the trunkline installation would not reach the intensity and duration terms of the impact thresholds due to the rapid progress of the trunkline installation and thus no impacts are predicted beyond the direct footprint. • The pipeline alignment was selected to ensure the intersections with harder more complex areas of seabed are minimised with the pipeline generally running perpendicular to these areas. This minimises any direct loss of sponges which are generally associated with these areas of more complex bathymetry in the Montebello AMP. The majority of the trunkline within the Montebello AMP will also run adjacent to the existing Pluto trunkline ensuring there is minimal disturbance to new areas of the AMP. The trunkline route has also been selected to minimise the seabed disturbance, with alternative options requiring additional seabed intervention • To avoid accidental encroachment of seabed disturbance from borrow ground activities on the Dampier AMP, a 250m buffer zone will be implemented between the borrow ground and the AMP

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	• diverse fish communities, and biologically important Areas for foraging habitat for whale sharks • biologically important areas for migratory pathways for humpback whales • biologically important areas for breeding habitat for seabirds • biologically important areas for internesting, foraging, mating and nesting habitat for marine turtles In addition, mining, fishing and tourism and recreation are listed as an important activity for social and economic values of the Marine Park **Dampier Marine Park** The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species. The objective of the Habitat Protection Zone (IV) is to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while allowing activities that do not harm or cause destruction to seafloor habitats. The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible. While water quality is not specifically listed as a value of the park, natural values of the marine park include: • diverse fish communities • biologically important areas for migratory pathways for humpback whales • biologically important areas for breeding habitat for seabirds • biologically important areas for internesting for marine turtles In addition, the Dampier Marine Park is also noted as a hotspot for sponge diversity and includes several		• Activities undertaken within the borrow ground will result in temporary and localised changes in the water quality, and not harm or cause destruction of the seafloor habitats of the Dampier Marine Park. Modelling has shown that the elevations in turbidity are restricted to the habitat protection zone and remain below the intensity-duration thresholds predicted to cause an impact to benthic communities in the Marine Park , with the exception being a small pocket of coral on the southern side of Hauy Island, where reversible impacts are predicted. Sponge habitat within the Dampier Marine Park, are not exposed to elevated turbidity above impact thresholds • the proposed controls are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices • (See discussion points for all previous receptors) • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Outcomes** To manage impacts to AMPs to at or below the defined acceptable levels the following EPO have been applied: **EPO 6.2:** Undertake activities within the borrow ground to not harm or cause destruction to the sea floor habitats (including significant areas of sponge habitat) of the Dampier Marine Park habitat protection zone.

<table>
<tr><th colspan="4">Demonstration of Acceptability</th></tr>
<tr><th>Receptor</th><th>Acceptability Criteria and Assessment</th><th>Acceptable Levels of Impact</th><th>Statement of Acceptability</th></tr>
<tr><td></td><td>submerged coral reefs and shoals including Delambre Reef and Tessa Shoals.
In addition, port activities, fishing and recreation are listed as an important activity for social and economic values of the Marine Park</td><td></td><td>EPO 6.5: Seabed Disturbance from trunkline installation within the Montebello Marine Park will be limited to 0.07% of the total park area.
EPO 6.7: Undertake Scarborough Trunkline Installation within the Montebello AMP in a manner that will be not be inconsistent with the objective of the multiple use zone.</td></tr>
<tr><td>KEFs</td><td>Principles of ESD
The Scarborough development is consistent with the relevant principles of ESD:
Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
The Scarborough development will result in no significant impacts to KEFs. Significant impact definitions:
to not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results.
Internal Context
There are no specific Woodside internal requirements with respect to seabed disturbance, or potential impacts to seabed disturbance to KEFs.

External Context
During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on KEFs.</td><td>Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts to KEFs (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).</td><td>Based on an assessment against the defined acceptable levels, the impact to KEFs from Seabed Disturbance is considered acceptable, given that:
the activity is aligned with the relevant principles of ESD.
Physical habitat modification is not listed as a potential concern for the Exmouth Plateau KEF, and no impact to the values of this KEF are anticipated.
Impacts within the Ancient Coastline at 125 m Depth Contour KEF will not occur to hard substrate.
ROV survey data from the Ancient Coastline KEF within theMontebello AMP shows that the area that the trunkline intersects is characterised by bare sandy sediment.
Impact to the Continental Slope Demersal Fish Communities KEF may occur, and physical habitat modification is listed as a potential concern for the KEF, however impacts will be highly localised and are not expected to impact the KEF as a whole. Installation of the trunkline will add hard substrate and foraging habitat for demersal fish within the KEF.</td></tr>
</table>

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	Other requirements The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES, specifically:		• While epifauna and infauna, in particular infauna, is important to demersal fish communities, the potential impact to the fish assemblages within the Continental Slope Demersal Fish Communities KEF from habitat disturbance is restricted to the overlap of the trunkline and impacts to benthic biota including epifauna and infauna will be highly localised, and not result on an adverse impact to the functioning or integrity of the KEF. • The proposed trunkline will offer a corridor of hard bottom habitat that facilitates epibiotic growth and the presence of reef-associated species in a region characterised by sandy sediments. The predicted increase in biodiversity as a result of the subsea infrastructure is not expected to have any negative environmental consequences. Studies support the potential importance of subsea infrastructure as a habitat for fish, and in consequence, potentially also as structures with value to commercial fisheries. • the proposed controls are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Outcomes**

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
			To manage impacts the KEF to at or below the defined acceptable levels the following EPO have been applied: **EPO 6.8:** Undertake Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of the Continental Slope Demersal Fish Communities KEF results.

7.1.6.4 Summary of the Impact Assessment

Table 7-43 provides a summary of the risk assessment and acceptability for impacts from routine seabed disturbance on receptors.

Table 7-43: Summary of impacts, management controls, impact significance ratings and EPOs for routine seabed disturbance

Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity level	Magnitude	Impact significance level	Acceptability
Water quality	Change in water quality	**EPO 6.1:** Undertake Scarborough development in a manner that prevents a substantial change to water quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health. **EPO 6.2:** Undertake activities within the borrow ground to not harm or cause destruction to the sea floor habitats (including significant areas of sponge habitat) of the Dampier Marine Park habitat protection zone. **EPO 6.3:** Changes to water quality in the Montebello Marine Park as a result of the trunkline installation will be not be inconsistent with the objective of the multiple use zone. **EPO 6.4:** Undertake Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 6.5**:Seabed Disturbance from trunkline installation within the Montebello Marine Park will be limited to less than 0.07%of the total park area. **EPO 6.6**: Trunkline installation and borrow ground activities will be undertaken in a manner that aims to avoid the displacement of marine	**CM12:** Infrastructure will be positioned on the seabed within design footprint to reduce seabed disturbance. **CM33:** A 250m buffer zone will be implemented between the offshore borrow ground and the Dampier AMP **CM34:** Development of a management framework for dredging and backfill activities based on water quality to manage activities to achieve EPO 6.2 and EPO 6.4	Low value	Slight	Negligible (F)	Acceptable
Epifauna and infauna	Change in habitat			Low value	Minor	Slight (E)	Acceptable
Coral	Change in habitat			High value	Slight	Minor (D)	Acceptable
Marine turtles	Change in habitat Injury or mortality			High value	Slight	Minor (D)	Acceptable
AMPs	Change in habitat Change in water quality			High value	Slight	Minor (D)	Acceptable
KEFs	Change in habitat Change in water quality Injury or mortality			High value	Slight	Minor (D)	Acceptable

Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity level	Magnitude	Impact significance level	Acceptability
		turtles from important foraging habitat or from habitat critical during nesting and internesting periods. **EPO 6.7:** Undertake Scarborough Trunkline Installation within the Montebello AMP in a manner that will be not be inconsistent with the objective of the multiple use zone. **EPO 6.8:** Undertake Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity of the Continental Slope Demersal Fish Communities KEF results.					

7.1.7 Routine and Non-Routine Discharges: Sewage and Greywater

7.1.7.1 Sources of the Aspect

Vessels and facilities used in the oil and gas industry vary in size but often include accommodation facilities for crew and passengers. The use of these facilities will result in routine discharges of domestic wastes such as sewage and greywater. Activities and facilities associated with Scarborough will discharge sewage and greywater to the marine environment during:

- vessel operations
- MODU operations
- FPU operations.

Vessel, FPU and MODU Operations

The use of ablution, laundry and galley facilities by crew will result in the generation of sewage and greywater, which are treated and discharged to the marine environment. Depending on waste production rates and the specifications of sewage systems available, the total volume of this waste stream discharged typically ranges between 0.04 and 0.45 m^3 per day per person (EMSA, 2016).

Waste generation is dependent on the number of persons on board. A review of current petroleum activities shows that facilities such as FSPOs and platforms may discharge around 60 m^3 of wastewater (consisting of sewage and greywater) per day; while vessels and MODUs typically generate around 5–15 m^3 of waste water per day (NERA, 2017). Support vessels for anchoring, towage, installation, commissioning, dredging and so on are expected to have between 20 and 60 persons on board (POB) each vessel. The largest construction vessel (used for trunkline installation) may have <700 POB. Vessel and POB numbers will peak during construction and commissioning; whereas during operations, the maximum manning for the FPU is <100 POB; with one support vessel.

Using a rate of 0.375 m^3/person/day as a guide (NERA, 2017), the maximum discharge volumes from the largest sources have been calculated for each phase. For installation and commissioning. the stationary facility with the largest discharge volume (FPU with a peak commissioning workforce of ~600) would discharge 225 m^3/day. The largest vessel with <700 POB would discharge 262 m^3/day. During operations, the FPU would discharge ~37.5 m^3/day at peak manning; and the support vessel ~9.4 m^3/day.

Facilities and MODUs generally discharge this waste stream over a longer term (extending from months to years), with the discharge point remaining relatively stationary; while vessels will typically discharge waste over a shorter period, and discharge while in transit.

7.1.7.2 Impact or Risk

Discharges of sewage and greywater from the sources described above has the potential to result in the following impacts:

- change in water quality
- injury/mortality to marine fauna
- change in aesthetic value
- changes to the functions, interest or activities of other marine users.

Change in Water Quality

Sewage and greywater contain nutrients (e.g. ammonia, nitrite, nitrate and orthophosphate), which when discharged can lead to nutrient loading and eutrophication. Eutrophication occurs when the addition of nutrients, such as nitrates and phosphates, causes adverse changes to the ecosystem, such as increased growth of primary producers such as phytoplankton and benthic algae which can deplete oxygen in the water column and result in changes in biological.

Chemicals within sewage and greywater discharges may include organics (e.g. volatile and semi-volatile organic compounds, oil and grease, phenols, endocrine disrupting compounds) and inorganics (e.g. hydrogen sulphide, metals and metalloids, surfactants, phthalates, residual chlorine). There is also the potential for biological pathogens, such as bacteria, viruses, protozoa and parasites.

While organics may degrade through bacterial action, oxidation and evaporation, there is the potential for some chemicals to persist (e.g. metals and chlorinated organics). These are likely to be most concentrated in the vicinity of the discharge.

Sewage and greywater may also include some particulate matter which can cause an increase in the turbidity of the receiving waters close to the point of discharge. Discharges will disperse and dilute rapidly, with concentrations of wastes significantly dropping with distance from the discharge point. Several studies have quantified the high levels of dilution, including Loehr et al. (2006). A study by the US EPA (2002) found that discharge plumes behind cruise ships moving at between 9.1 and 17.4 knots are diluted by a factor of between 200,000:1 and 640,000:1. The discharges and level of effluent dilution in the studies did not present significant localised toxicity impacts to marine biota from any changes in water quality.

Injury/Mortality to Marine Fauna

A change in water quality from the discharge of sewage and greywater could result in injury or mortality to marine fauna. This could be the result of oxygen depletion in the waters due to nutrient enrichment, or due to toxins and chemicals present in the discharged wastes.

Open marine waters are typically influenced by regional wind and large-scale current patterns resulting in the rapid mixing of surface and near surface waters where sewage discharges may occur. This means nutrients from the discharge of sewage will not accumulate or lead to eutrophication due to the highly dispersive environment. Therefore, the receptors with the greatest potential to be impacted are those in the immediate vicinity of the discharge (NERA, 2017). Given that sewage discharges from vessels and facilities are at or near the surface, and remain buoyant, the receptors with the potential to be impacted are also those within or on surface waters; i.e. plankton, fish and other marine fauna.

Change in Aesthetic Value

The composition of sewage and greywater may include physical particulate matter such as solids composed of floating, settle able, colloidal and dissolved matter. These substances can affect aspects of aesthetics such as ambient water colour, the presence of surface slicks/sheens and odour. The stationary facilities with the greatest discharge volumes (MODU and FPU) will be located >375 km from the closest shore. While the pipelay, dredging and support vessels will be closer to shore and in shallower waters during trunkline installation and dredging, these activities are of shorter duration, and most of these vessels are smaller and will generate less waste. Also, as vessels are moving during the discharge of sewage and greywater, this promotes mixing and dilution of the waste.

Given the distance of the project offshore, the proximity of water quality changes to the discharge source, the rapid consumption of matter by planktonic species and bacteria, and the spatial nature of tourism and recreation activities and coastal settlements (i.e. on or near the shoreline); impacts to receptors associated with changes in aesthetic values are not expected to occur and as such are not evaluated further.

Changes to the Functions, Interest or Activities of Other Marine Users

Significant discharges of sewage and greywater could result in water quality deterioration, including introduction of toxins and pathogens that could affect the activities of other marine users including commercial and recreational fishers. The largest expected discharge volumes from stationary facilities are ~375 km from shore, in a well-mixed marine environment. Although trunkline installation and dredging will occur in shallower waters closer to shore, these activities are of shorter duration, and discharges would be from moving vessels, promoting mixing and dilution. Therefore, this impact is not expected to occur and is not evaluated further.

Receptors Potentially Impacted

Routine discharges of sewage and greywater have the potential to impact on receptors which may be vulnerable to the toxicity. The receptors which have the potential to be impacted include:

- water quality
- plankton
- fish
- marine mammals
- marine reptiles
- KEFs.

Plankton

Plankton communities have a naturally patchy distribution in both space and time, and are known to have naturally high mortality rates, primarily through predation (ITOPF, 2011). However, in favourable conditions (e.g. supply of nutrients), plankton populations can rapidly increase. Once the favourable conditions cease, plankton populations will collapse and/or return to previous conditions. Plankton populations have evolved to respond to these environmental perturbations by copious production within short generation times (ITOPF, 2011). However, any potential change in phytoplankton or zooplankton abundance and composition is expected to be localised, typically returning to background conditions within tens to a few hundred metres of the discharge location (e.g. Abdellatif, 1993; Axelrad et al., 1981; Parnell, 2003).

The NWMR is typically characterised by low planktonic productivity. If a nutrient source was introduced, there is the potential for plankton productivity to increase, however due to the nature of the open ocean marine environment, eutrophication is not expected to occur due to rapid mixing.

Fish, Marine Mammals and Marine Reptiles

Other ecological receptors that may be present in surface waters that have the potential to be impacted by discharges of sewage and greywater include pelagic fish species, cetaceans and marine reptiles. These organisms could be exposed to toxins and other chemicals present in the waste stream which could potentially result in injury or mortality.

Studies indicate that direct impacts are only expected from prolonged exposure in waters with poor mixing (McKinley and Johnston, 2010). In addition, pelagic species are expected to be able to actively avoid discharge plumes and therefore evade impacts associated with toxic exposure. Less mobile organisms such as larval stage fish however may be subject to elevated levels of mortality due to inability to avoid discharge plume.

Bioaccumulation can occur as a result of toxins and chemicals passing through the food chain. As plankton impacts are expected to be restricted to the mixing zone, effects of bioaccumulation on receptors along the food chain, namely, fish, reptiles, birds and cetaceans are therefore not expected beyond the immediate vicinity of the discharge in deep open waters.

Fish species within the Project Area are transient, with no identified areas of significance within the Project Area, other than a section of the trunkline which does overlap the foraging BIA for whale sharks. While it is possible that some fish may be exposed to toxins and other chemicals in the sewage and grey water waste stream, this is only likely to occur close to the discharge point.

Some cetacean species may also be present within the Offshore Project Area and Trunkline Project Area that may be subject to ingestion of planktonic species which have been exposed to toxins from sewage and greywater discharges. A BIA for migration of Blue whale and Pygmy Blue whale populations as well as a BIA for known distribution of Humpback whales exist within the Offshore Project Area. Within the Trunkline Project Area, a BIA for Humpback migration is present.

The Offshore Project Area and pipeline corridor intersect with Commonwealth waters that are utilised by the following EPBC Act listed turtle species: the loggerhead turtle, the green turtle, the leatherback turtle, the hawksbill turtle and the flatback turtle. The Offshore Project Area, where most discharges will be located, is located in deep offshore waters, is devoid of primary producers and emergent features, and the area does not represent important habitat (e.g. for foraging or breeding) for marine turtle. However, given the large distribution of most species of marine turtles, particularly the leatherback turtle, transient individuals may occur infrequently. The Trunkline Project Area overlaps known breeding habitat for green, hawksbill and flatback turtles, and loggerhead turtles are known to forage in the area.

Impacts to surface dwelling species including fish, cetaceans and reptiles via toxicity is not expected and due to the highly localised nature of impacts to planktonic species (prey), any impacts from sewage and greywater to ecological pelagic receptors are considered unlikely and this impact has not been evaluated further.

KEFs

Given the impacts are restricted to surface waters in the immediate vicinity of the discharge, benthic species have not been considered. On this basis, the KEFs within the Project Area have not been identified at risk as the values associated with these KEFs related to the attributes of the demersal habitats and features.

Table 7-44 outlines the potential impacts to receptors associated with the routine and non-routine discharge of sewage and grey water.

Table 7-44: Receptor/impact matrix after evaluation of context

	Receptor					
Impacts	**Water Quality**	**Plankton**	**Fish**	**Marine Mammals**	**Marine Reptiles**	**KEF**
Change in water quality	✓					X
Injury/mortality to marine fauna		X	X	X	X	X

Detailed Impact Evaluation

Water Quality

The mixing zone boundary of routine and non-routine discharges of sewage and greywater has been studied within the industry and for municipal sewage treatment plants. Monitoring of sewage discharges has demonstrated that a 10 m³ sewage discharge over 24 hours from a stationary source in shallow water, reduced to about 1% of its original concentration within 50 m of the discharge location (Woodside, 2008). In addition to this, monitoring at distances 50, 100 and 200 m downstream of the platform and at five different water depths confirmed that discharges were rapidly diluted or nutrients rapidly metabolised and no elevations in water quality monitoring parameters (e.g. total nitrogen, total phosphorous and selected metals) were recorded above background levels at any station.

The European Chemicals Bureau Chemical Hazard Assessment and Risk Management procedure (CIN, 2004) applies a worst-case default dilution factor of 1000 at a distance of 500 m for an offshore point source discharge. This same factor is also applied by the Australian National Industrial Chemicals Notification and Assessment Scheme (NICNAS, 2014).

For fixed discharge sources, the maximum discharge is expected to be ~225 m³/day, at peak workforce during FPU commissioning (expected to take about three months). NERA (2017) uses discharge volumes <150 m³/day; and states that it is expected to remain within the nominal mixing zone boundary of 500 m around fixed facilities. The defined mixing zone is suitably conservative when compared to metropolitan sewage treatment plants (STP) that routinely discharge much larger quantities of residential, industrial and commercial wastewater into the marine environment. For example, the Water Corporation discharges 100 million m³/year of treated wastewater from three STPs in Perth (NERA (2017)).

Predicted Impact Summary

Generally, the impact is expected to be limited to within 500 m from discharge during FPU and MODU operations. For vessels, typically waste discharge is over a shorter term and discharged while in transit, therefore the potential for this impact is lower due to a more spread-out discharge over a spatial scale.

Vessel operations undertaken as a part of this activity will adhere to the *Navigation Act 2012*, MARPOL and the various Marine Orders (as appropriate to vessel class) enacted under this Act. This Act implements into Australian law Australia's obligations under the International Convention for the Prevention of Pollution from Ships (MARPOL Convention).

Impacts from routine and non-routine discharges of sewage and greywater on water quality will be slight. Receptor sensitivity is low (low value, open water), and therefore Impact Significance Level is **Negligible (F).**

7.1.7.3 Demonstration of Acceptability

Impact acceptability has been demonstrated for all impacts based on evaluation against the criteria described in Section 6.4.4. The outcomes of this determination are summarised below.

Principles of ESD

The Scarborough development is consistent with the relevant principles of ESD:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations

- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making

The Scarborough development will result in no significant impacts to receptors identified as potentially affected. Significant impact definitions:

- Water quality
    - To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.

Internal Context

The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards.

External Context

During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on affected receptors from routine and non-routine discharges of sewage and greywater.

Other requirements

The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES, specifically:

- Vessel operations undertaken as a part of this activity will adhere to the *Navigation Act 2012*, MARPOL and the various Marine Orders (as appropriate to vessel class) enacted under this Act. This Act implements into Australian law Australia's obligations under the International Convention for the Prevention of Pollution from Ships (MARPOL Convention).

Acceptable Levels of Impact

Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013)).

Statement of Acceptability

Based on an assessment against the defined acceptable levels, the impacts on affected receptors from Routine and Non-Routine Discharge: Sewage and Greywater is considered acceptable, given that:

- the activity is aligned with the relevant principles of ESD.
    - The contribution of sewage and greywater discharge from Scarborough will be comparable with existing vessels and facilities on the North West Shelf, and not result in a notable change to the water quality of the wider area.
    - Impacts to surface dwelling species including fish, cetaceans and marine reptiles via toxicity is not expected, and does not pose any lasting effect. Due to the highly localised nature of impacts to planktonic species (prey), impacts from sewage and greywater to ecological pelagic receptors are not expected.
- the proposed controls are consistent with Woodside's internal policies, procedures and standards
- feedback from stakeholders has been taken into consideration

- legislative requirements/industry standards have been adopted
- the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices
- the predicted level of impact is at or below the defined acceptable levels for all receptors.

Environmental Performance Outcomes

To manage impacts to affected receptors to at or below the defined acceptable levels the following EPO have been applied:

EPO 7.1: Undertake Scarborough development activities in a manner that does not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.

7.1.7.4 Summary of the Impact Assessment

Table 7-45 provides a summary of the risk assessment and acceptability for impacts from sewage and greywater to receptors.

Table 7-45: Summary of key management controls, impact significance ratings, acceptability and EPOs for sewage and greywater

Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity level	Magnitude	Impact significance level	Acceptability
Water quality	Change in water quality	**EPO 7.1:** Undertake Scarborough development activities in a manner that does not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	**CM13:** Compliance with relevant MARPOL, Commonwealth requirements and subsequent Marine Order requirements for sewage management.	Low value (open water)	Slight	Negligible (F)	Acceptable

7.1.8 Routine and Non-Routine Discharges: Food Waste

Food waste will be generated on board the vessels and offshore facilities used during Scarborough. These will be discharged under controlled conditions to the marine environment.

7.1.8.1 Sources of the Aspect

Activities and facilities associated with Scarborough that will generate and discharge food waste to the marine environment include:

- FPU operations
- MODU operations
- vessel operations.

FPU, MODU and Vessel Operations

FPU, MODU and vessel operations used for Scarborough include accommodation facilities for crew and passengers. The crew and passengers will generate waste including food waste which will be discharged under controlled conditions to the marine environment. The average volume of food waste discharged overboard will vary depending on the number of personnel on board at any time, and the types of meals prepared. This is estimated to be in the order of 1–2 kg per person per day.

Food waste will be discharged throughout all phases of Scarborough. The FPU and MODU will discharge food waste from a stationary point over the term of their operations (months to years). Support vessels and pipelay vessels will typically discharge over short-term operations (weeks to months), possibly while in transit.

Food waste will disperse and break up rapidly in the marine environment, with some of the waste being consumed by surface dwelling organisms upon discharge. Food waste will be restricted to the immediate vicinity of the discharge location and is expected to be undetectable further than 500 m from the discharge source.

7.1.8.2 Impact or Risk

The discharges of food waste from the identified sources has the potential to result in:

- change in water quality
- change in fauna behaviour.

Change in Water Quality

The presence of food waste within the water column can increase nutrient loads, resulting in potential reduction to biological oxygen demand (BOD). However, studies into the effects of nutrient enrichment indicate that the influence of nutrients in open marine areas such as the locations for Scarborough, is much less significant than that experienced in enclosed areas (McIntyre and Johnson, 1975). Black et al. (1994) state that biological oxygen demand BOD of treated effluent is not expected to lead to oxygen depletion in the receiving waters and food waste discharges are expected to result in the same outcome. Impacts to water quality relating to nutrient enrichment are thus not evaluated further.

Change in Fauna Behaviour

Discharge of food waste into the marine environment has the potential to attract some opportunistic marine fauna including fish and seabirds to the area in response to the increased food availability or, indirectly because of attraction of prey species. However, given the small quantities of food waste to be disposed, any attraction is likely to be minor, temporary and localised.

Receptors Potentially Impacted

Food wastes are discharged overboard and given they are typically buoyant they will initially remain at the surface or in the upper zone of the water column. The discharge will introduce an additional food source that has the potential to attract fish and birds that are present in the area. This change to behaviour will be for a short period and localised to the area immediately surrounding the point of discharge. It is not likely to affect the overall population or have a wider implication on the species potentially impacted.

Seabirds and Migratory Shorebirds

The Project Area may be occasionally visited by migratory and oceanic birds but does not contain any emergent land that could be utilised as roosting or nesting habitat and contains no known critical habitats (including feeding) for any species. As most of the area is offshore and away from islands or other emergent features, any presence of seabirds or shorebirds is considered likely to be of a transient nature only. For activities closer to shore, these are short-term and not at a fixed location. Based on this the impacts from food discharge to birds has not been evaluated further.

Fish

Fish species within the Project area are expected to be transient, with no identified areas of significance within the Project Area, other than a section of the trunkline which does overlap the foraging BIA for whale sharks.

The temporary attraction of transient fish will be for a short period and localised around the point of discharge. There will be no lasting effect on high value species as a result of food waste discharge from Scarborough. Food waste is not identified as a threat in any EPBC listed threatened species recovery plans or conservation advice, including the Conservation advice for whale sharks (TSSC, 2015d). On this basis the impacts of the discharge of food waste on fish has not been evaluated further.

KEFs

Given the impacts are restricted to surface waters in the immediate vicinity of the discharge, benthic species have not been considered. On this basis, the KEFs within the Project Area have not been identified at risk as the values associated with these KEFs related to the attributes of the demersal habitats and features.

The receptors within the environment that may be affected by the discharge of food waste, that are potentially at risk from the identified impacts are outlined in Table 7-46.

Table 7-46: Receptor/impact matrix after evaluation of context

	Receptor			
Impacts	Water Quality	Seabirds and Migratory Shorebirds	Fish	KEFs
Change in water quality	✓			X
Change in fauna behaviour		X	X	

Detailed Impact Evaluation

Water Quality

Discharges of food waste has the potential to change the local water quality for a short period through the addition of a temporary nutrient source. This nutrient loading would rapidly return to background conditions following dispersion through surface currents and wave action.

The extent of this potential impact for Scarborough is restricted to the immediate vicinity of the discharge location, this being the Offshore Project Area, and along the trunkline route during construction activities.

Predicted Impact Summary

The water quality within the Project Area is typical of an unpolluted tropical offshore environment. Given the small volumes, and the offshore location for Scarborough, the change to water quality as a result of the discharge of food waste will not be substantial.

Vessel operations undertaken as a part of this activity will adhere to the Navigation Act 2012, MARPOL and the various Marine Orders (as appropriate to vessel class) enacted under this Act. This Act implements into Australian law Australia's obligations under the International Convention for the Prevention of Pollution from Ships (MARPOL Convention) and navigation and shipping including Safety of Life at Sea (SOLAS), which includes specific requirements for navigational lighting. Although the Act does not apply to the operation of petroleum facilities, it may apply to some activities of operations support vessels.

Vessels will also implement waste management procedures which provide for safe handling and transportation, segregation, storage and appropriate classification of all waste generated, reducing the volume of waste discharged.

Impacts from routine and non-routine discharges of sewage and greywater on water quality will have no lasting effect. Receptor sensitivity is low (low value, open water), and therefore Impact Significance Level is **Negligible (F).**

7.1.8.3 Demonstration of Acceptability

Impact acceptability has been demonstrated for all impacts based on evaluation against the criteria described in Section 6.4.4. The outcomes of this determination are summarised below.

Principles of ESD

The Scarborough development is consistent with the relevant principles of ESD:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making

The Scarborough development will result in no significant impacts to receptors identified as potentially affected. Significant impact definitions:

- Water quality
    - To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.

Internal Context

The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards.

External Context

During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on affected receptors from routine and non-routine discharges of food waste.

Other requirements

The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES, specifically:

- Vessel operations undertaken as a part of this activity will adhere to the *Navigation Act 2012*, MARPOL and the various Marine Orders (as appropriate to vessel class) enacted under this Act. This Act implements into Australian law Australia's obligations under the International Convention for the Prevention of Pollution from Ships (MARPOL Convention).

Acceptable Levels of Impact

Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013)).

Statement of Acceptability

- the activity is aligned with the relevant principles of ESD.
  - Volumes of food waste are small, and discharges occur in open offshore waters.
  - There will be rapid dilution and consumption of food waste within the water column.
  - The change in behaviour of marine fauna including birds and fish will be for a short period and localised to the area immediately surrounding the point of discharge.
- the proposed controls are consistent with Woodside's internal policies, procedures and standards
- feedback from stakeholders has been taken into consideration
- legislative requirements/industry standards have been adopted
- the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices
- the predicted level of impact is at or below the defined acceptable levels for all receptors.

Environmental Performance Outcomes

To manage impacts to affected receptors to at or below the defined acceptable levels the following EPO have been applied:

EPO 8.1: Undertake Scarborough development activities in a manner that does not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.

7.1.8.4 Summary of the Impact Assessment

Table 7-47 provides a summary of the risk assessment and acceptability for impacts from discharges of food waste on receptors.

Table 7-47: Summary of impacts, management controls, impact significance ratings and EPOs for discharges – food waste

Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity level	Magnitude	Impact significance level	Acceptability
Water quality	Change in water quality	**EPO 8.1:** Undertake Scarborough development activities in a manner that does not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	**CM14:** Compliance with relevant MARPOL, Commonwealth requirements and subsequent Marine Order requirements for waste discharges. **CM15:** Implementation of waste management procedures which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.	Low value (open water)	No lasting effect	Negligible (F)	Acceptable

7.1.9 Routine and Non-Routine Discharges: Chemicals and Deck Drainage

7.1.9.1 Sources of the Aspect

Activities and facilities associated with Scarborough will routinely and non-routinely discharge chemicals and deck drainage. Discharges will be made during:

- FPU operations
- MODU operations
- vessel operations.

Vessel, FPU and MODU Operations

Chemicals are used during vessel, MODU, FPU and ROV activities for a variety of purposes within the Offshore Project Area and Trunkline Project Area. The FPU and vessels will be used during all phases of Scarborough, with the FPU only in the Offshore Project Area, and vessels also in the Trunkline Project Area. The MODU will only be used during drilling phases in the Offshore Project Area. Chemicals and hydrocarbons that will be used and discharged, or may be contained in the following types of discharges:

- deck drainage and bilge water
- non-process chemicals (maintenance and cleaning chemicals)
- fire suppressions systems (possibly including water, foam, CO^2 and extinguishers).

Usually a facility will have an open and closed drainage system. The open system collects deck drainage (firewater, stormwater, and washdown water), drip trays, and sample returns. Non-contaminated streams (such as rainwater from the roof of the living quarters) are sent directly to the open drains for discharge. Potentially contaminated streams will go to a bilge/slops tank for initial treatment first (such as an oil-water separator).

For high water flows beyond the capacity of the slops tank (e.g. firewater deluge or storm), the first flush is recovered to the slops tank, and the overflow goes directly to the open drain catchment (with this overflow considered to be uncontaminated drainage water).

The closed drain system collects hazardous wastes from the processing system and liquids from equipment and piping during maintenance and routes the hazardous waste to the closed drain collection tank/s. This collected water is disposed via the produced water system.

Facilities and MODUs generally discharge this waste stream over the life of the facility, with the discharge point remaining relatively stationary; while vessels will typically discharge waste over a shorter period, and discharge while in transit.

Deck Drainage and Treated Bilge

Deck drainage and treated bilge are generally similar in composition, although they are discharged via different pathways. Deck drainage can originate from rainfall, ocean spray or wash-down operations and is routinely discharged to the marine environment. Deck drainage typically contains particulate matter and residual chemicals such as cleaning chemicals, oil and grease in small volumes.

Bilge tanks receive wash water and waste liquids from all major process and machinery equipment and diesel/chemical storage areas on the FPU, MODU and project vessels. FPU, MODU and vessel decks are designed for deck drainage, however during washing or in the event of chemical or hydrocarbon leaks or spills to the deck, they may be plugged and diverted to bilge tanks.

The bilge system is designed to safely collect, contain and dispose of oily water from hazardous areas so that discharge of hydrocarbons to the marine environment is avoided. These fluids may contain contaminants such as oil, detergents, solvents, chemicals and solid waste, typically at low levels. Bilge water is then treated onboard using an oily water separator (OWS) to reduce any oily residue to below 15 ppm or where there are no visible signs of oil. The discharge of treated bilge is non-continuous and infrequent.

7.1.9.2 Impact or Risk

A discharge of deck drainage and treated bilge from the vessels, MODU or FPU to the marine environment has the potential to result in the following impacts to receptors:

- change in water quality
- change in sediment quality
- injury or mortality to marine fauna.

Change in Water Quality

As described above, deck drainage and treated bilge may contain a range of chemicals, oil, grease and solid material. These types of discharges are not dissimilar to other vessel and facility-based discharges occurring in the NWMR during petroleum and non-petroleum-based activities.

Shell (2010) undertook modelling for treated bilge discharges from a Floating LNG (FLNG) facility on the open marine environment, which predicted that concentrations of hydrocarbons and other chemicals rapidly dilute in the water column and fall below the predicted no effect concentration (PNEC) within a short time period and distance from the discharge source.

During maintenance, breaking containment of vessels, opening lines, high-pressure cleaning, and topping up and changing fluids may be performed, and can result in discharge of cleaning fluids, and similar contaminants, and low concentrations of sodium hypochlorite and corrosion inhibitor. These non-process chemicals are expected to be low in concentration and dilute rapidly within the water column.

There are several types of fire-fighting foams available, such as such as Aqueous Film Forming Foam (AFFF); Alcohol-Resistant AFFF; Protein Foams; Alcohol Resistant Protein Foams; Film-forming Fluoroprotein Foams (FFFP); Class A Foams; Medium and High Expansion Foams and Wetting Agents. They usually come in a concentrate that is diluted with water and agitated to form a foam solution.

Given the typically low levels of potential contaminants, relatively small and infrequent volumes of bilge and deck drainage water discharged, rapid mixing, changes in water quality due to discharge of bilge and deck drainage water from the FPU, MODU and vessels will be short-term and highly localised to the discharge point.

Change in Sediment Quality

Impacts associated with routine and non-routine chemical and deck drainage discharges will be limited to the area surrounding the discharge source of the vessel, MODU or FPU. The stationary facilities and many of the support vessels will be concentrated around the well locations, which is ~930 m deep. Due to the dispersive nature of chemical discharges within the highly mixed offshore marine environment, toxins associated with surface discharges are not expected to reach marine sediments at concentrations that will result in notable changes to sediment quality. Therefore, impacts to sediment quality resulting from discharges of deck drainage and treated bilge is as such not discussed further; nor are any benthic receptors.

Injury/Mortality to Marine Fauna

As a result of a change in water quality, further impacts to receptors may occur, which include injury or mortality to marine fauna resulting from exposure to toxins in the chemicals and deck drainage discharge. Given that surface discharges are rapidly dispersed, the marine fauna at risk is limited to surface dwelling species.

For marine organisms including plankton, birds, fish and marine reptiles, OSPAR (2014) suggests that that the PNEC of dispersed oil is 70.5 ppb, which, given MARPOL requirements, is not expected, even within close proximity to the discharge point (Shell, 2010). Following discharge, concentration is expected to rapidly dilute further in the open ocean environment.

Biocides that may be present in discharges following maintenance of systems may pose a potential toxicity impact to marine fauna, in particular plankton and early life stages of fish (Walsh, 1978). However, the concentration at discharge and volumes would be very low, and rapidly disperse.

Firefighting foams such as AR-AFFF and FFFP contain organic and fluorinated surfactants, which can deplete dissolved oxygen in water (Schaefer 2013; ANSUL 2007; IFSEC Global 2014). However, in their diluted form (as applied in the event of a fire or test), these foams are generally considered to have a relatively low toxicity to aquatic species (Schaefer 2013; IFSEC Global 2014), and further dilution of the foam mixtures in dispersive aquatic environments may then occur before there is any substantial demand for dissolved oxygen (ANSUL 2007). The AR-AFFF and FFFP type foams are biodegradable and do not bioaccumulate (Mercury Firesafety 2013; Dafo Fomtec AB 2013).The use of AFFF foams is not banned in WA, however, the Commonwealth Government's National Industrial Chemicals Notification and Assessment Scheme (NICNAS) recommends that Australian industries should actively seek alternatives to – and phase out – PFAS and PFAS-related substances of concern, including AFFF. Alternative chemicals should be less toxic and not persist in the environment.

As discharges will be sporadic (i.e. no continuous flow), there is no potential for fluids to accumulate in the water column.

Although fish, marine mammals and marine reptiles may be present within receiving waters, it is unlikely that large numbers of individuals will occur within close proximity of the release point and therefore be exposed to PNEC. The expected volumes of discharges would not be significant enough to cause any notable impact to transient marine fauna, in the well-mixed marine environment.

Receptors Potentially Impacted

Routine and non-routine discharges of chemicals and deck drainage have the potential to impact on receptors which may be vulnerable to the toxicity. The receptors which have the potential to be impacted include:

- water quality
- plankton
- fish
- marine mammals
- marine reptiles.

Plankton, Fish and Marine Mammals and Reptiles

Plankton, including fish and coral larval, may be exposed to discharges exceeding 70.5 ppb within close proximity of the discharge point. However, given the small volumes released and rapid dilution within the mixing zone, the proportion of the plankton population exposed to PNEC is expected to be negligible when considering total plankton biomass in the Scarborough Project Area and wider environment.

Toxicological effects from firefighting foams is typically only associated with prolonged or frequent exposures, such as on land and in watercourses near firefighting training areas (McDonald et al., 1996; Moody and Field, 2000). Ongoing testing by the United States Fish and Wildlife Service (FWS) found that wetting agents and fluorine-free foams have a higher acute toxicity than AFFF agents but are still considered ‘lightly to practically non-toxic’ on the FWS scale (USDAFS, 2000).

Foam agents that do not contain fluorinated surfactants usually contain higher concentrations of hydrocarbon surfactants and solvents, in order to compensate for the lack of film formation; which are generally more toxic in aquatic systems (IFSEC Global, 2008). The AFFF agents were the least toxic of the foam concentrates tested (an order of magnitude lower in toxicity than the fluorine-free foams) and are considered practically non-toxic to relatively harmless, according to the FWS scale (USDAFS, 2000).

Early life stages of fish (embryos, larvae) and other plankton would be the most susceptible organisms to toxic exposure from chemicals and hydrocarbons present in the deck discharges, as they have limited mobility and are therefore likely to be exposed to the plume at the discharge points, if present. However, these types of organisms are expected to rapidly recover once the activity ceases, as they are known to have high levels of natural mortality and a rapid replacement rate (UNEP, 1985).

As discharges of chemicals and deck drainage are expected to be infrequent, of low volumes (~5 m^3 for fire system testing) and rapidly disperse, it is not expected that any impacts will occur to transient, EPBC-listed species. It is also expected that effects on planktonic communities, if any, would be very localised and of a short-term nature (i.e. negligible).

Due to the negligible proportion of plankton impacted, indirect impacts to higher trophic levels (e.g. through predation) are unlikely. On this basis the impact to these species from Scarborough is negligible, and not evaluated further.

KEFs

Given the impacts are restricted to surface waters in the immediate vicinity of the discharge, benthic species have not been considered. On this basis, the KEFs within the Project Area have not been identified at risk as the values associated with these KEFs related to the attributes of the demersal habitats and features.

Table 7-48 outlines the potential impacts to receptors associated with routine and non-routine discharges of deck drainage and treated bilge.

Table 7-48: Receptor/impact matrix after evaluation of context

	Receptor					
Impacts	***Water Quality***	***Plankton***	***Fish***	***Marine Mammals***	***Marine Reptiles***	***KEFs***
Change in water quality	✓					X
Injury/mortality to fauna		X	X	X	X	

Detailed Impact Evaluation

Water Quality

Deck drainage and treated bilge may contain a range of chemicals, oil, grease and solid material. This particulate matter can cause an increase in the turbidity of the receiving waters close to the point of discharge. The additions of these substances into the marine environment will result in a change ambient water quality, however, as outlined above these discharges are expected to rapidly dilute in the water column (Shell, 2010). Discharges will disperse and dilute rapidly, with concentrations significantly dropping with distance from the discharge point.

Non-process chemicals (such as biocides, corrosion inhibitor and cleaning fluids) will be of low concentrations and volumes and are expected to disperse rapidly.

Fire-fighting foams which contain organic and fluorinated surfactants can deplete dissolved oxygen in water. In the event that firefighting foam is required (in the event of an emergency or for infrequent testing), the foam systems mix the concentrates (~3%) with water (~97%) prior to application. There is then further dilution and dispersion following discharge to the open-water environment around the facility. Its expected ~5 m^3 could be discharged to the surface during infrequent testing, which would rapidly disperse.

The stationary facilities are located >375 km from the closest shore. While the pipelay, dredging and support vessels will be closer to shore and in shallower waters during trunkline installation and dredging, these activities are of shorter duration, and most of these vessels are smaller and will generate less deck drainage and bilge. Also, vessels are typically moving during the discharge of treated bilge, which promotes mixing and dilution.

Predicted Impact Summary

Given the typically low levels of potential contaminants, relatively small and infrequent volumes of chemicals and deck drainage water discharged, and rapid mixing, biodiversity, ecological integrity, social amenities and human health will not be impacted.

Vessel operations undertaken as a part of this activity will adhere to the *Navigation Act 2012*, MARPOL and the various Marine Orders (as appropriate to vessel class) enacted under this Act. This Act implements into Australian law Australia's obligations under the International Convention for the Prevention of Pollution from Ships (MARPOL Convention).

Vessels will also implement waste management procedures which provide for safe handling, transportation, segregation, storage and appropriate classification of all waste generated, reducing the volume of waste discharged.

Impacts from routine and non-routine discharges of chemicals and deck drainage on water quality will have no lasting effect. Receptor sensitivity is low (low value, open water), and therefore Impact Significance Level is **Negligible (F).**

7.1.9.3 Demonstration of Acceptability

Impact acceptability has been demonstrated for all impacts based on evaluation against the criteria described in Section 6.4.4. The outcomes of this determination are summarised below.

Principles of ESD

The Scarborough development is consistent with the relevant principles of ESD:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.

- The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making

The Scarborough development will result in no significant impacts to receptors identified as potentially affected. Significant impact definitions:

- Water quality
  - o To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.

Internal Context

The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards.

With respect to routine and non-routine discharges of chemicals and deck drainage, Woodside will implement its internal requirement:

- Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints.

External Context

During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on affected receptors from routine and non-routine discharges of chemicals and deck drainage.

Other requirements

The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES, specifically:

- Vessel operations undertaken as a part of this activity will adhere to the *Navigation Act 2012*, MARPOL and the various Marine Orders (as appropriate to vessel class) enacted under this Act. This Act implements into Australian law Australia's obligations under the International Convention for the Prevention of Pollution from Ships (MARPOL Convention).

Acceptable Levels of Impact

Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013)).

Statement of Acceptability

Based on an assessment against the defined acceptable levels, the impacts on affected receptors from Routine and Non-Routine Discharge: Chemicals and Deck Drainage is considered acceptable, given that:

- the activity is aligned with the relevant principles of ESD.
  - o Discharges are non-continuous and infrequent, and due to the small volumes of discharge, high level of dispersion and rapid reduction in toxicity to below PNEC within close proximity to the discharge source, pose no lasting effect

to receptors. Discharge plumes are not expected to accumulate in the water column or intersect with the benthic environment.

  - The contribution of chemicals and deck drainage discharge from Scarborough will be comparable with existing vessels and facilities on the North West Shelf, and not result in a notable change to the water quality of the wider area.
  - Impacts to surface dwelling species including fish, cetaceans and marine reptiles via toxicity is not expected, and does not pose any lasting effect. Due to the highly localised nature of impacts to planktonic species (prey), any impacts from chemicals and deck drainage bilge discharge to ecological pelagic receptors are considered unlikely.
- the proposed controls are consistent with Woodside's internal policies, procedures and standards
- feedback from stakeholders has been taken into consideration
- legislative requirements/industry standards have been adopted
- the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices
- the predicted level of impact is at or below the defined acceptable levels for all receptors.

Environmental Performance Outcomes

To manage impacts to affected receptors to at or below the defined acceptable levels the following EPO have been applied:

EPO 9.1: Undertake Scarborough development activities in a manner that does not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.

7.1.9.4 Summary of the Impact Assessment

Table 7-49 provides a summary of the risk assessment and acceptability for impacts from deck drainage and treated bilge to receptors.

Table 7-49: Summary of impacts, management controls, impact significance ratings and EPOs for deck drainage and treated bilge

Receptor	Impact	Environmental Performance Outcome	Adopted control(s)	Receptor sensitivity level	Magnitude	Impact significance level	Acceptability
Water quality	Change in water quality	**EPO 9.1:** Undertake Scarborough development activities in a manner that does not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.	**CM14:** Compliance with relevant MARPOL, Commonwealth requirements and subsequent Marine Order requirements for waste discharges. **CM15:** Implementation of waste management procedures which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.	Low value (open water)	No lasting effect	Negligible (F)	Acceptable

7.1.10 Routine and Non-Routine Discharges: Brine and Cooling Water

7.1.10.1 Sources of the Aspect

Activities and facilities associated with the development of Scarborough will routinely and non-routinely discharge brine and cooling water to the marine environment at the sea surface. Brine and cooling water will be discharged during:

- vessel operations
- MODU operations
- FPU operations.

Vessel, FPU and MODU Operations

<u>Brine</u>

Reverse osmosis (RO), distillation or desalination plants on board vessels, the MODU and FPU use seawater to produce potable and demineralised water; resulting in reject brine (i.e. hypersaline water) that is discharged to the marine environment. The potable water produced is stored in tanks on board.

During the distillation process, relatively small volumes of reject brine is produced and discharged. Reject brine discharge is typically 20 to 50 percent higher in salinity than the intake seawater (depending on the desalination process used) and may contain low concentrations of scale inhibitors and biocides, which are used to avoid fouling of pipework (Woodside, 2014).

Reject brine water will be discharged throughout all phases of Scarborough. Quantities, source and location will vary depending on the phase of the development. Models developed by the US EPA (Frick et al., 2001) for temporary brine discharges from vessels assuming no ocean current (i.e. 0 m/s) found that brine discharges from the surface dilute 40–fold at 4 m from the source. This modelling can be used as an indicator for predicting horizontal attenuation and diffusion of reject brine; and suggests that the salinity concentration drops below environmental impact thresholds within 4 m of the discharge point.

<u>Seawater for Cooling</u>

The machinery systems fitted on board vessels, MODUs and FPUs are designed to work with maximum efficiency and run for long hours. Significant energy loss from machinery can be in the form of heat energy. This loss of heat energy must be reduced or carried away by a cooling medium, to avoid malfunctioning or breakdown of the machinery. When compared with cooling water use and discharge from the FPU, cooling water discharge from vessels and MODUs is a much smaller rate and temporary whereas FPU cooling water discharge will be constant throughout the operational field life. Sime both are in a similar location, the impact of FPU cooling water is considered conservatively representative of that from MODUs.

In the current design, a central cooling medium system will be fitted on the FPU for this purpose. This is used in a closed circuit to cool down the engine room machinery. The heat which the closed circuit cooling medium removes from equipment is then transferred to seawater via heat exchangers. The closed circuit cooling medium is composed of demineralised water, dosed with biocide, corrosion inhibitor and possibly oxygen scavenger on an as-needed basis, but is not discharged except during system maintenance.

The seawater system which removes heat from the closed loop cooling medium is “once through”. Seawater is drawn from the ocean, dosed with hypochlorite (chlorine) and pumped though a heat exchanger with the cooling medium before being returned to the ocean via a dump caisson. The majority of chlorine injected into the system will react and be neutralised in the system. Residual chlorine will be discharged overboard at an expected concentration of less than 1000 ppb.

Seawater used for cooling purposes from the FPU will be routinely discharged overboard from either the surface or at a point below sea level (depending on final design) at a temperature expected to be less than 70°C and rates less than 200,000 m³/d. Discharge volumes from vessels and the MODU will be significantly smaller, in the order of ~50 m³/d, depending on vessel size.

It should be noted that the actual discharge rates, temperatures and concentrations discussed in this section may vary, however these values have been selected as conservative indications for the purpose of modelling the potential impacts. Cooling water discharges from other offshore facilities are provided below for comparison:

- Browse FPSO - 720,000 m^3/day, approximately 50°C (Woodside 2019)
- Shell's Prelude FLNG facility - 1,200,000 m^3/day, between 39°C and 42°C (Shell 2009)
- ConocoPhillips' Barossa FPSO - 360,000 m^3/day, approximately 45°C (ConocoPhillips 2018)Cooling Water Modelling

Modelling of the cooling water discharge from the FPU was undertaken to predict the plume size, location, concentrations of residual chlorine present, and the distance where the plume temperatures approach ambient conditions (RPS, 2019a; Appendix E). Both near-field and far-field modelling was undertaken for cooling water discharges; these are used to describe different processes and scales of effect. The near-field zone ends where the discharged plume reaches the same density as the ambient water. The far-field modelling expands on the outcomes of the near-field mixing by allowing the time-varying nature of currents to be included, and the potential for recirculation of the plume back to the discharge location to be assessed.

The near-field mixing and dispersion of the water discharge was simulated using the Updated Merge (UM3) flow model. The UM3 model is a three-dimensional Lagrangian steady-state plume trajectory model designed for simulating single and multiple-port submerged discharges in a range of configurations, available within the Visual Plumes (VPLUMES) modelling package provided by the United States Environmental Protection Agency (Frick et al., 2003).

The far-field mixing and dispersion of the discharges was predicted using the three-dimensional discharge and plume behaviour model, MUDMAP (RPS, 2019a). The far-field calculation (passive dispersion stage) employs a particle-based, random walk procedure. Any chemicals/constituents within the discharge stream are represented by a sample of Lagrangian particles. These particles are moved in three dimensions over each subsequent time step according to the prevailing local current data as well as horizontal and vertical mixing coefficients.

Modelling included scenarios that considered dilution contours for summer, winter, and transitional and annualised conditions. Since engineering of the cooling water system is ongoing, the following conservative discharge scenarios were selected for modelling to cover the expected range of parameters:

- Cooling water discharge rate and temperature of 165,600 m^3/d (45°C), 64,800 m^3/d (57°C) and 82,800 m^3/d (60°C)
- Discharge depths of 0 m, 10 m, and 30 m (to allow for the final design of the FPU)
- Current strengths of weak, medium and strong
- Residual chlorine source concentration of 1,000 ppb.
- Near-field modelling was undertaken for all the above scenarios; a sub-set of far-field modelling scenarios were selected based on the outcomes of the near-field modelling results. Stochastic assessment was employed to provide probabilistic interpretation across a wide range of conditions.

- Environmental, Health and Safety Guidelines (EHS guidelines) by International Finance Corporation (IFC) recommend temperature criteria for the effluent into seawater of a 3°C maximum temperature excess above ambient at the edge of the mixing zone (IFC, 2007).
- The residual chlorine guideline value for protecting aquatic ecosystems in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000) is 3 ppb. This figure was adopted as a marine low reliability trigger value, to be used only as an indicative interim working level. A literature review conducted by CSIRO for Woodside which considered the basis for the ANZECC value in addition to more recent studies, used a species sensitivity distribution curve to determine an acute 99% species protection level of 5 ppb (CSIRO 2008b), which is the threshold applied in modelling.

In order for the source chlorine and temperature values to drop below their associated threshold values, modelling was used to estimate the distance required to reach:

- a minimum of 200-fold dilution (based on chlorine thresholds);
- a minimum of 1.7-fold dilution (based on temperature differential for the 165,600 m^3/day discharge scenario);
- a minimum of 2.3-fold dilution (based on temperature differential for the 82,800 m^3/day discharge scenario);
- a minimum of 2.2-fold dilution (based on temperature differential for the 64,800 m^3/day discharge scenario).

Modelling of the cooling water discharge predicted the following (RPS, 2019a; APPENDIX F):

- For most combinations of season and discharge depth, the primary factor influencing dilution of the plume is the strength of the ambient current. Weak currents allow the plume to plunge further and reach the trapping depth closer to the discharge point, which slows the rate of dilution. Increased current strengths increase the horizontal distance travelled by the plume.
- The discharge plume pooled under weak currents, which caused lower dilutions (higher concentrations) further from the discharge location.
- Episodes of recirculation – where the plume moved back under the discharge at some later time due to the oscillatory nature of the tide – were also observed, compounding the pooling effect and further lowering the dilution values.
- The worst-case maximum horizontal distance, and the total area of coverage until dilution was achieved for chlorine was for the 165,600 m^3 scenario at a depth of 30 m; of 2.5 km (99^{th} percentile); and a total area of coverage of 5.5 km^2.
- The maximum depth of the plume (from any scenario) from the discharge location was 38 m.
- The worst-case maximum horizontal distance until the $\triangle$3°C temperature differential is met was 120 m (discharge of 165,600 m^3 at a depth of 30 m scenario).

Far-field modelling results for chlorine are summarised in Table 7-50 and for temperature in Table 7-51. Note that the percentile figures do not represent the location of a plume at any point in time; they are a statistical and spatial summary of the percentage of time that particular dilution values occur across all replicate simulations and time steps. For example, if the 95^{th} percentile minimum dilution at a particular location in the model is predicted as a value of 100, this means that for 95% of the time the dilution level will be higher than 100, and for only 5% of the time the dilution level will be lower than 100.

Table 7-50: Far-field modelling estimates of distance required to reach dilution requirement for chlorine (RPS, 2019a)

Discharge Rate: 165,600 m³/day; Temperature: 45°C; Depth: 0 m		
Percentile	**95th**	**99th**
Maximum horizontal distance till dilution is achieved (km)[1]	0.64	1.79
Total area of coverage till dilution is achieved (km^2)[1]	0.528	4.409
Maximum depth from discharge (m)	8	
Discharge Rate: 165,600 m³/day; Temperature: 45°C; Depth 30 m		
Percentile	**95th**	**99th**
Maximum horizontal distance till dilution is achieved (km)[1]	0.77	2.47
Total area of coverage till dilution is achieved (km^2)[1]	0.70	5.48
Maximum depth from discharge (m)	38	
Discharge Rate: 64,800 m³/day; Temperature: 57°C; Depth: 0 m		
Percentile	**95th**	**99th**
Maximum horizontal distance (m) till dilution is achieved (km)[1]	0.18	0.62
Total area of coverage till dilution is achieved (km^2)[1]	0.05	0.37
Maximum depth from discharge (m)	6	
Discharge Rate: 64,800 m³/day; Temperature: 57°C; Depth: 30 m		
Percentile	**95th**	**99th**
Maximum horizontal distance till dilution is achieved (km)[1]	0.21	0.63
Total area of coverage till dilution is achieved (km^2)[1]	0.07	0.55
Maximum depth from discharge (m)	38	

[1] *Value shown is from the worst-case season*

Table 7-51: Far-field modelling estimates of distance required to reach dilution requirement for temperature (RPS, 2019a)

Discharge Rate: 165,600 m^3/day; Temperature: 45°C; Depth: 0 m		
Percentile	**95th**	**99th**
Maximum horizontal distance till dilution is achieved (km)[1]	<0.04	0.09
Discharge Rate: 165,600 m^3/day; Temperature: 45°C; Depth 30 m		
Percentile	**95th**	**99th**
Maximum horizontal distance till dilution is achieved (km)[1]	<0.04	0.12
Discharge Rate: 64,800 m^3/day; Temperature: 57°C; Depth: 0 m		
Percentile	**95th**	**99th**
Maximum horizontal distance (m) till dilution is achieved (km)[1]	<0.04	<0.04
Discharge Rate: 64,800 m^3/day; Temperature: 57°C; Depth: 30 m		
Percentile	**95th**	**99th**
Maximum horizontal distance till dilution is achieved (km)[1]	<0.04	0.09

[1] Value shown is from the worst-case season

7.1.10.2 Impact or Risk

Routine and non-routine discharges of brine and cooling water from the sources described above will result in the following impacts:

- change in water quality
- change in sediment quality
- injury/mortality to marine fauna.

Change in Water Quality

The key physicochemical stressors that are associated with reject brine and cooling water discharge that may change the water quality include salinity, pH, temperature and chemical toxicity.

Scale inhibitors and biocides are commonly used within the systems described above to prevent fouling. Scale inhibitors are typically low molecular weight phosphorous compounds that are water-soluble.The biocides typically used in the industry are highly reactive and degrade rapidly in the marine environment (Black et al., 1994). As such, any potential impacts to water quality are expected to be limited to the source of the discharge where concentrations are highest.

Change in Sediment Quality

Increased salinity and other toxins from chemical additives in brine and cooling water discharges could potentially accumulate in benthic sediments, causing changes to sediment quality. However, given that the discharge point is at or near the surface, based on the nature of the discharge modelling of the discharge predicted that the cooling water discharge plumes will be within surface layers (maximum depth of 38 m) and will not interact with the seabed (approximately 900m water depth). Therefore, impacts to seabed sediments or benthic habitats resulting from brine and cooling water discharges from the FPU are not predicted.

Injury/Mortality to Marine Fauna

Changes in salinity as a product of routine discharges of cooling and brine water, can affect the ecophysiology of marine organisms. Most marine species can tolerate short-term fluctuations in salinity in the order of 20% to 30% (Walker and McComb, 1990) as well as temperature changes.

Exposure to toxins in the reject brine or cooling water can also cause injury or mortality to marine fauna. Given surface discharges are rapidly dispersed, the marine fauna at risk is limited to surface dwelling species.

Receptors Potentially Impacted

Routine and non-routine discharges of brine and cooling water have the potential to impact on receptors which may be vulnerable to the changes in salinity or temperature, or toxicity of chemical additives. The receptors which have the potential to be impacted include:

- water quality
- plankton
- fish
- marine mammals
- marine reptiles.
- Commercial fisheries

Marine Reptiles

At the Scarborough Offshore project area, marine reptiles may transit but are unlikely to be present in significant numbers close to the source of routine discharges (cooling water etc). Significant habitat for marine reptiles is typically located in shallower waters close to nesting beaches which are not predicted to be exposed to cooling water discharges.

Table 7-52 outlines the potential impacts to receptors associated with routine and non-routine discharges of brine and cooling water.

Table 7-52: Receptor/impact matrix after evaluation of context

	Receptor							
Impacts	Water Quality	Plankton	Epifauna and Infauna	Fish	Marine Mammals	Marine Reptiles	Key Ecological Features	Commercial Fisheries
Change in water quality	✓						✓	
Injury/mortality to fauna		✓	✓	✓	✓	X		
Changes to functions, interests or activities of other users								✓

Detailed Impact Evaluation

Water Quality

A change in water quality will occur following routine and non-routine cooling water and brine discharges due to the addition of biocides (i.e. chlorine) and scale inhibitors into the water column resulting in increased toxicity levels, increased salinity levels and increased water temperature within the vicinity of the discharge points.

Water quality within the Project Area, where the discharge would occur, is typical of the offshore marine environment. Surface waters experience high-levels of energy, with wave action and surface currents resulting in rapid dissipation of discharges.

Reject brine water is typically 20–50% higher in salinity to the surrounding water and based on models developed by the US EPA (Frick et al., 2001), discharges of brine water will sink through the water column where it will be rapidly mixed with receiving waters and dispersed by ocean currents, decreasing in salinity rapidly as distance from source increases.

The volume of brine discharged from vessel and FPU operations for Scarborough is orders of magnitude lower than that discharged for large commercial desalination plants. For example, the Water Corporation's Burrup Peninsula Desalinated Water and Seawater Supplies Project has conditional approval to discharge 208 ML/day (208,000 m^3) into King Bay; and the Southern Seawater Desalination Plant (SSDP) located south of Perth is licenced to discharge 170 GL/year.

Water quality monitoring at the SSDP found that salinity was within 1 ppt of background concentration at the boundary of the LEPA (Water Corporation, 2017). Monitoring at the Large desalination facilities in the Canary Islands and Spain found rapid dilution of salinity, temperature, pH and chemicals to near-ambient levels was generally recorded in the near-field region (i.e. 10 m to 20 m) around the outfalls. Models developed by the US EPA suggested that the salinity concentration drops below environmental impact thresholds within 4 m of the discharge point (Frick et al., 2001).

Within the immediate area of influence of the discharge, water temperatures will be elevated impacting water quality. However as predicted in the modelling results, the threshold level (i.e. 3°C above ambient temperature) is achieved within 120 m (for the worst-case discharge scenario).

This prediction is supported by modelling undertaken by Woodside for its Torosa South-1 drilling program in the Scott Reef complex of continuous wastewater discharges (including cooling water) (Woodside, 2014). This study predicted that discharge water temperature decreases quickly as it mixes with the receiving waters, with the discharge water temperature being <1 °C above ambient within 100 m (horizontally) of the discharge point, and 10 m vertically (Woodside, 2014).

Generally, reject brine and cooling water containing chemical additives are inherently safe at the low dosages used. The chemicals used will be selected with the lowest practicable environmental impacts and risks subject to technical constraints. They are usually consumed in the inhibition process, so there is little or no residual chemical concentration remaining upon discharge.

The location of the discharge is a well-mixed offshore location. Water quality is typical of the region, and impacts will be limited to within the predicted plume, which does not intersect any sensitive features.

Predicted Impact Summary

Modelling of the long-term routine cooling water discharge from the FPU predicted that the worst-case maximum horizontal extent until dilution factors were achieved was 2.5 km for chlorine (5 ppb, 99% species protection level), and 120 m for temperature (<3 °C).

While concentrations that may be considered lethal are likely to be concentrated closer to the source, it can be conservatively predicted that an impact could occur to the extent of the mixing zone. As such, it is expected that 99% of marine species will be safe from acute impacts from chlorine in cooling water discharge at 2.5 km from the FPU under any discharge scenario currently being considered and under any metocean conditions modelled.

Impacts from routine and non-routine discharges of brine and cooling water will have no lasting effect on water quality. Receptor sensitivity of water quality is low (low value, open water), and therefore the Impact Significance Level of routine and non-routine discharges of brine and cooling water on water quality has been evaluation as **Negligible (F)**.

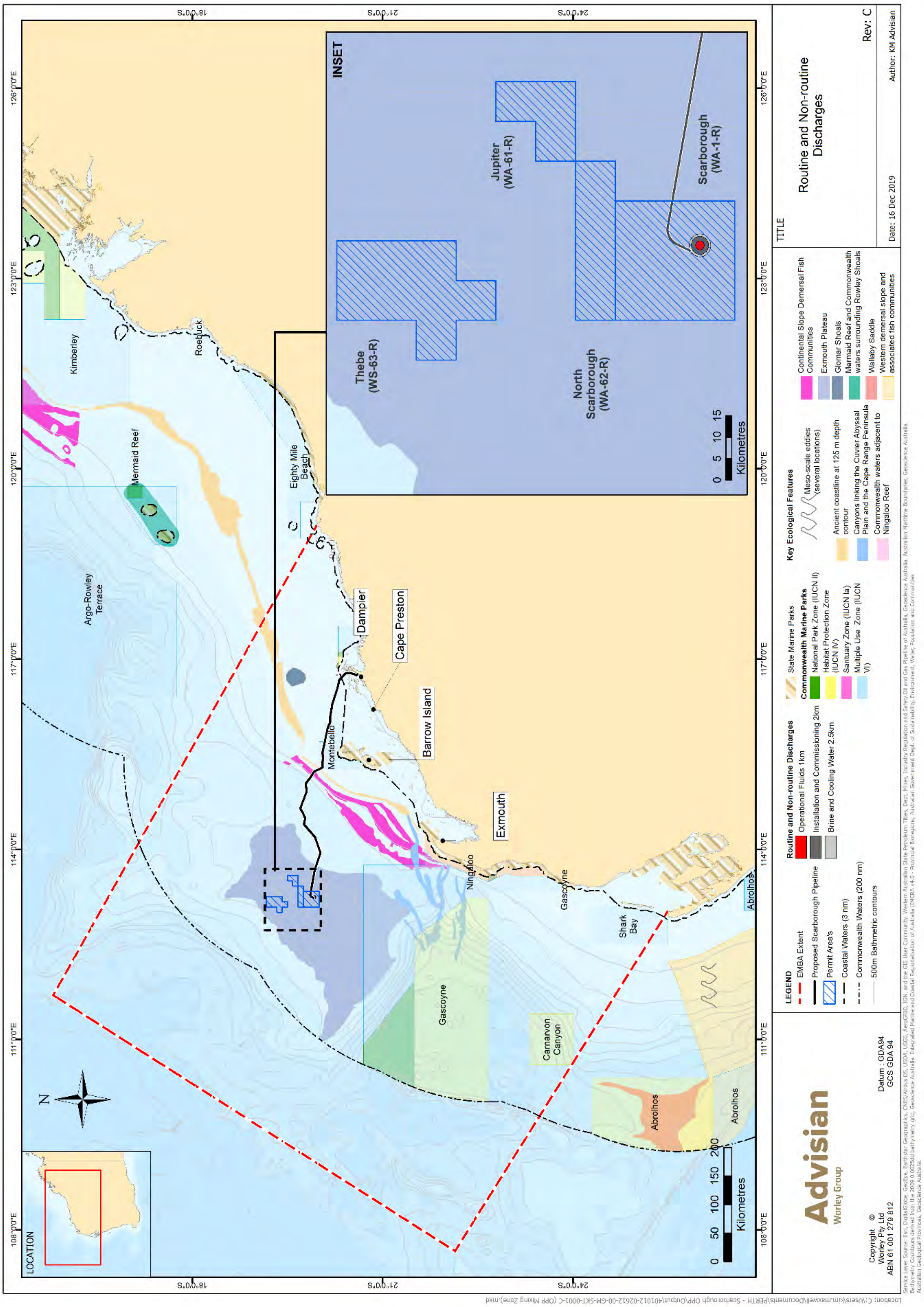


Figure 7-25: Predicted mixing zone for brine and cooling water discharge (light grey shading) associated with the FPU operations

Plankton

As a result of a change in water quality, further impacts to receptors may occur, which include injury or mortality to marine fauna resulting from increases in salinity and changes in temperature, or exposure to toxins or chemicals in the reject brine or cooling water. Given surface discharges are rapidly dispersed, the marine fauna at risk is limited to surface-dwelling species.

Larval plankton stages are known to be more susceptible to impacts of increased salinity than that of most marine life (Neuparth, Costa & Costa, 2002). Early life stages of fish (embryos, larvae) and other plankton would also be most susceptible to toxic exposure from chemicals in the brine discharges, as they have limited mobility and are therefore likely to be exposed to the plume at the outfall, if present. However, these types of organisms are expected to rapidly recover once the activity ceases, as they are known to have high levels of natural mortality and a rapid replacement rate (UNEP, 1985). Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints.

Discharged brine sinks through the water column where its rapidly mixed with receiving waters and dispersed by ocean currents. In addition, brine discharges from vessels, particularly along the pipeline corridor, are expected to occur while in transit, therefore aiding in dispersion and reducing overall impacts to plankton populations. As such, any potential impacts are expected to be limited to the source of the discharge where concentrations are highest. Modelling described above suggests that the salinity falls below impact threshold levels (40-fold dilution) within 4 m of the discharge point. This is confirmed by studies that indicate effects from increased salinity on planktonic communities in areas of high mixing and dispersion are generally limited to the point of discharge only (Azis et.al., 2003).

Predicted Impact Summary

Modelling of the long-term routine cooling water discharge from the FPU predicted that the worst-case maximum horizontal extent for increase water temperatures was 120 m, and 2.5 km until the chlorine dilution factor was achieved, for surface discharge scenarios. The worst-case extent for the 0 m discharge depth scenarios was estimated at 1.79 km; as the plume is positively buoyant, once it surfaces, dispersion is reduced. Therefore, for surface discharges, the potential to interact with plankton in the water column is reduced. Even for the 30 m discharge depths, the plume is only predicted to plunge to a maximum depth of 38 m, so the exposure to the 930 m deep water column at the FPU site is limited to only the surface extent.

As discussed in Section 5.5.1, primary productivity appears to be enhanced along the northern and southern boundaries of the Exmouth Plateau, and along the adjacent shelf edge to the east of the plateau (Brewer et al., 2007). As described by Falkner et al. (2009), the centre of the plateau is characterised by moderate seafloor temperatures and low primary productivity. Therefore, while the discharge is to occur within the Exmouth Plateau KEF, this is at a significant distance (>150 km) from the periphery of the plateau that has been identified as having increased productivity (Brewer et al., 2007; Falkner et al., 2009).

Consequently, it is not anticipated that this discharge will result in impacts to the ecological integrity of the KEF. Any reductions of existing populations are expected to rapidly recover once the activity ceases, given the high levels of natural mortality and a rapid replacement rate (Houde and Zastrow, 1993; ITOPF, 2011; Tang et al., 2014). As such, exposure of planktonic communities is not considered to result in significant impacts on a population level nor would exposure affect ecological diversity or productivity within the Project Area. Impacts are therefore considered to result in undetectable or limited local degradation of the environment, rapidly returning to original state by natural action.

Impacts from routine and non-routine discharges of brine and cooling water will have no lasting effect on plankton. Receptor sensitivity of plankton is low (low value, homogenous), and therefore the

Impact Significance Level of routine and non-routine discharges of brine and cooling water on plankton has been evaluation as **Negligible (F)**.

Fish and Commercial / Recreational Fisheries

As a result of a change in water quality, further impacts to receptors may occur, which include injury or mortality to marine fauna resulting from increases in salinity and changes in temperature, or exposure to toxins or chemicals in the reject brine or cooling water. Given surface discharges are rapidly dispersed, the marine fauna at risk is limited to surface-dwelling species. Therefore, toxicity impacts to pelagic communities deeper in the water column, or to benthic habitats and communities, are not predicted to occur.

The effect of chlorine on marine organisms is well known, given its use as a biocide. A study by Taylor (2006) investigating the effects of chlorination from biofouling agents used in seawater cooling units on coastal and estuarine environments suggested very limited impact of oxidant use and the associated chlorination by-products on receiving waters, both in terms of plume toxicity and any more widespread ecotoxicological influence. This would be even more the case in the deep, open ocean environment of the Exmouth Plateau. The toxicity of residual chlorine to fish mainly depends on residual chlorine concentration and exposure time, and is also affected by temperature, salinity, pH and organic matter content of the receiving waters (Fisher et al. 1999).

Sublethal effects can include growth reduction in some juvenile life stages, alteration of the permeability of membranes and modification of blood composition. Lethal concentrations required for juvenile Arabian toothcarp (96hr LC50 ranging from 59 – 215 ppb chlorine) (Saeed et al., 2019) may be present within 200m of the discharge point (to reach 50 ppb at 99th percentile, worst case discharge scenario), which suggests that injury or mortality to fish may occur if a species has prolonged exposure in this area. However pelagic fish are transient marine fauna that are unlikely to remain within the relatively narrow plume, which will move around depending on the metocean conditions. In addition, Abarnou and Miossec (1992) suggest that mobile organisms such as fish and marine mammals and reptiles may detect and avoid areas with low levels of chlorine.

Chlorine does not persist for extended periods in water but is very reactive and its by-products persist longer. It is rapidly converted to hypochlorous acid (HOCl) and hydrochloric acid (HCl) in receiving waters (ANZECC, 2000). Elevated water temperatures have the potential to induce minor physical stress in marine fauna and may result in potential mortality for prolonged exposure. Wolanski (1994) demonstrated that elevated seawater temperatures have the potential to alter the physiological processes of exposed biota. These alterations may cause a variety of effects, ranging from behavioural responses (including attraction and avoidance behaviour), minor stress and potential mortality for prolonged exposure (Walkuska and Wilczek, 2010).

Due to the relatively inert properties and low concentrations of scale inhibitors and biocides within the brine and cooling water discharge, the high level of dilution and mixing within the receiving offshore environment as well as the ability of pelagic species to avoid discharge plumes, impacts to pelagic fish would be limited to species that experienced prolonged exposure close to the source of the discharge. While it is difficult to estimate the number that may be affected, it is expected that this would be limited to individuals and a negligible proportion of the population or a species.

The modelling of FPU cooling water discharge predicted the maximum horizontal distance from the source until the chlorine dilution factor was achieved is 2.5 km and a maximum plume depth was 38 m, therefore presenting a shallow field for individuals to transit through (RPS, 2019a).

Discharge plume temperature drops rapidly in the marine environment. For most discharge scenarios, the temperature differential (<3°) is achieved within the near-field zone; and the worst-case for far-field is within 345 m. The plume is positively-buoyant, therefore demersal and pelagic species are unlikely to be exposed to worse than near-ambient temperatures.

The existing environment in the Offshore Project Area, where discharges will predominantly occur, is a well-mixed marine environment. As described in Section 5.4.4.4, the deep water and predominantly featureless, flat soft sediment seabed is of low complexity and low productivity (see Section 5) in the Offshore Project Area and reduces the species diversity and richness of pelagic and demersal fish assemblages. Although sporadic upwelling events and increased primary productivity along the along the northern and southern boundaries of the Exmouth Plateau KEF may temporarily increase fish diversity, overall, fish fauna is not expected to be abundant in the Offshore Project Area, which is located >150 km from the periphery of the plateau. Continental slope fish communities off the west coast of Australia (including the Exmouth Plateau) have a low overall density, which appears to be linked to the low biological productivity of the overlying waters (Williams et al., 2001).

Four conservation-significant fish species (or habitat) may occur in the Offshore Project Area: Longfin mako, Shortfin mako, Great white shark and Giant manta ray. No threatened or migratory rays or sawfish are likely to occur in the Offshore Project Area, due to the absence of key habitat for these species.

While there are overlapping commercial fisheries, the only Commonwealth Fishery expected to be active within the vicinity of the Project is the NWSTF. However, given the fishing method (i.e. trawl) and operations in deep water areas (>200 m) of this fishery, no significant exposure to a surface discharge of cooling water is likely.

Predicted Impact Summary

While there is the potential for levels of biocide or temperature increases that could injure or kill fish in the event of prolonged exposure, the transient nature of fish does not suggest that this would occur. Impacts will be limited to any individual species that remain within the plume for a prolonged period, and it is not likely that there would be any notable impact to a population of fish.

While this impact will occur for the duration of the activities which cause the discharges (e.g. FPU operations), the stressors of the discharge (temperature and chlorine) do not result in accumulation and as such frequent short-term exposure will not amount to long-term injury or mortality.

The plume will conservatively (based on the maximum diameter and horizontal extent) cover an exposure area within the top 30 m of water of 5.8 km^2 of the 49,310 km2 (0.01%) of the Exmouth KEF. While the discharge is to occur within the Exmouth Plateau KEF, this is at a significant distance (>50 km) from the location that has been identified as having increased productivity according the Brewer et al., 2007. Subsequently it is not anticipated that this discharge will result in impacts to the ecological integrity of the KEF. In the Trunkline Project Area and Borrow Ground Project Area where vessels may discharge smaller volumes of brine this is even less likely to result in any injury and mortality to fish, and so this has not been evaluated further.

The location of the discharge is not within an important habitat for a migratory fish species and as such there are no predicted impacts to this habitat. Additionally, the discharge will not result in any exposure to Australian Marine Parks. Nor is the location significant for fishing, with recreational fishing unlikely due to the distance offshore, and the commercial fisheries limited to trawl operations that target waters below the surface.

Impacts from routine and non-routine discharges or brine and cooling water will have no lasting effect on fish and the commercial and recreational fisheries that may target fish assemblages. When considered with receptor sensitivity, Impact Significance Level of routine and non-routine discharges of brine and cooling water have been evaluated as **Slight (E).**

Marine Mammals

As a result of a change in water quality, further impacts to receptors may occur, which include injury or mortality to marine fauna resulting from increases in salinity and changes in temperature, or exposure to toxins or chemicals in the reject brine or cooling water. Given surface discharges are rapidly dispersed, the marine fauna at risk is limited to surface-dwelling species.

The effect of chlorine on marine organisms is well known, given its use as a biocide. Impacts are typically limited to juvenile life stages. Abarno and Miossec (1992) suggest that mobile organisms such as fish and marine mammals and reptiles may detect and avoid areas with low levels of chlorine. The reactive compounds of chlorine do not persist long in the marine environment.

Elevated water temperatures have the potential to induce minor physical stress in marine fauna and may result in potential mortality for prolonged exposure.

Due to the relatively inert properties and low concentrations of scale inhibitors and biocides within the brine and cooling water discharge, the high level of dilution and mixing within the receiving offshore environment as well as the relatively resistant nature of pelagic species to increased temperatures and their expected avoidance of discharge plumes, impacts to pelagic species associated with injury or death would be limited to species that experienced prolonged exposure close to the source of the discharge. While it is difficult to estimate the number that may be injured, it is expected that this would be limited to individuals and a negligible proportion of the population or a species.

The modelling of FPU cooling water discharge predicted the maximum horizontal distance from the source until the chlorine dilution factor was achieved is 2.5 km and a maximum plume depth was 38 m, therefore presenting a shallow field for individuals to transit through (RPS, 2019a).

Discharge plume temperature drops rapidly in the marine environment. For most discharge scenarios, the temperature differential (<3°) is achieved within the near-field zone; and the worst-case for far-field is within 120 m. The plume is positively-buoyant, therefore demersal and pelagic species are unlikely to be exposed to worse than near-ambient temperatures.

A total of nine conservation significant marine mammals (or habitat) may occur in the Offshore Project Area (Table 5-7). Although some dolphin species may have distributions that extend into offshore waters, their presence is not considered likely given their preference for coastal or continental shelf waters. The exception is the False killer whale, which is more likely to occur in the Offshore Project Area. Only one BIA, for the Pygmy blue whale, overlaps the Offshore Project Area. However, this BIA is designated for distribution only, rather than more sensitive behaviours such as foraging and migration.

Predicted Impact Summary

While there is the potential for levels of biocide or temperature increases that could injure or kill marine mammals in the event of prolonged exposure, the transient nature of large marine fauna does not suggest that this would occur. Impacts will be limited to any individual species that remain within the plume for a prolonged period, and it is not likely that there would be any notable impact to a population of marine mammals.

While this impact will occur for the duration of the activities which cause the discharges (e.g. FPU operations), the stressors of the discharge (temperature and chlorine) do not result in accumulation and as such frequent short-term exposure will not amount to long-term injury or mortality.

The Offshore Project Area is located within a distribution BIA for pygmy blue whale. The Conservation Management Plan for the Blue Whale (reference) does not list a change in temperature or salinity as a threat, although it does lists acute and chronic chemical discharge. Given the small volumes and low levels of toxicity, and the avoidance behaviour expected in marine mammals, biocides and chlorine in cooling water and brine discharges associated with Scarborough development are not expected to result in a threat to pygmy blue whale. It is expected that individual pygmy blue whales found within the Offshore Project Area will be transient, and not performing behaviours (such as foraging and resting) which require them to stay in any location for an extended period of time. Individuals encountering the cooling water plume will be able to move away, limiting impacts and avoiding injury / mortality occurring.

Listed threatened species which may occur in the Offshore Project Area include sei whale (V), blue whale (E), fin whale (V) and humpback whale (V), however critical behaviours are not expected to occur in any of these species in the vicinity of the Scarborough development. Individuals encountering the cooling water plume will be able to move away, limiting impacts and avoiding injury / mortality occurring.

Impacts from routine and non-routine discharges or brine and cooling water will have no lasting effect on marine mammals. Receptor sensitivity of marine mammals is high (high value fauna), and therefore the Impact Significance Level of routine and non-routine discharges of brine and cooling water on plankton has been evaluation as **Slight (E).**

KEFs

A change in water quality will occur following routine and non-routine cooling water and brine discharges due to the addition of biocides (i.e. chlorine) and scale inhibitors into the water column resulting in increased toxicity levels, increased salinity levels and increased water temperature within the vicinity of the discharge points. These changes could result in impacts to KEFs.

The Offshore Project Area, where discharges will occur, is within the Exmouth Plateau KEF. The Exmouth Plateau is defined as a KEF as it is a unique seafloor feature with ecological properties of regional significance, which apply to both the benthic and pelagic habitats within the feature (Section 5.5.1).

Predicted Impact Summary

Based on impact evaluations for water quality above, the discharge of cooling water is expected to result in a relatively small area of impact in the Offshore Project Location. The change to water quality resulting from discharges will be temporary and habitat or ecosystem function or integrity will not be impacted.

Chemicals dosed into all systems will be selected with the lowest practicable environmental impacts and risks subject to technical constraints, in order to lower potential toxicity of discharges. Woodside will also develop a management framework for all discharges.

Impacts from routine and non-routine discharges of brine and cooling water will have no lasting effect on KEFs. Receptor sensitivity is high (high value), and therefore Impact Significance Level of routine and non-routine discharges of brine and cooling water on KEFs is **Slight (E).**

7.1.10.3 Demonstration of Acceptability

Table 7-53 provides demonstration of acceptability for all receptors predicted to be potentially impacted from routine and non-routine discharges of brine water and cooling water

Table 7-53: Demonstration of Acceptability for Routine Discharges: Brine and Cooling Water

<table>
<tr><th colspan="4">Demonstration of Acceptability</th></tr>
<tr><th>Receptor</th><th>Acceptability Criteria and Assessment</th><th>Acceptable Levels of Impact</th><th>Statement of Acceptability</th></tr>
<tr>
<td>Water quality</td>
<td>Principles of ESD
The Scarborough development is consistent with the relevant principles of ESD:
Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
The Scarborough development will result in no significant impacts to water quality. Significant impact definitions:
to not result in a substantial change to water quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health.
Internal Context
The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards, including:
Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints.
External Context</td>
<td>Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).</td>
<td>Based on an assessment against the defined acceptable levels, the impact to water quality from Routine and Non-Routine Discharges: Cooling water and brine is considered acceptable, given that:
the activity is aligned with the relevant principles of ESD.
While this impact will occur for the duration of the activities which cause the discharges (e.g. FPU operations), the high energy marine environment means that discharges will be quickly dissipated and will not accumulate or result in long-term changes to water quality.
The impact assessment demonstrates that impacts to water quality will not result in irreversible environmental damage.
The discharge will not result in any exposure to Australian Marine Parks.
the proposed controls are consistent with Woodside's internal policies, procedures and standards
feedback from stakeholders has been taken into consideration
legislative requirements/industry standards have been adopted
the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices
the predicted level of impact is at or below the defined acceptable levels.
Environmental Performance Outcomes
To manage impacts to water quality to at or below the defined acceptable levels the following EPO have been applied:</td>
</tr>
</table>

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on water quality. **Other requirements** The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES.		**EPO 10.1:** Undertake Scarborough FPU and Support Operations in a manner that prevents a substantial change to water quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health.

Plankton	**Principles of ESD**
	The Scarborough development is consistent with the relevant principles of ESD:
	• Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
	• The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
	• The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
	
	The Scarborough development will result in no significant impacts to plankton. Significant impact definitions:
	• To not result in a substantial adverse effect on a population of plankton including its life cycle and spatial distribution
	Internal Context
		Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).*	Based on an assessment against the defined acceptable levels, the impact to plankton from Routine and Non-Routine Discharges: Cooling water and brine is considered acceptable, given that:
			• the activity is aligned with the relevant principles of ESD.
			  • While this impact will occur for the duration of the activities which cause the discharges (e.g. FPU operations), the high energy marine environment means that discharges will be quickly dissipated and will not accumulate or result in widespread impacts to plankton
			  • The impact assessment demonstrates that impacts to water quality will not result in irreversible environmental damage.
			  • While the discharge is to occur within the Exmouth Plateau KEF, this is at a significant distance (>150 km) from the location that has been identified as having increased productivity according the Brewer et al., 2007. Subsequently it is not anticipated that this discharge will result in impacts to the ecological integrity of the KEF.
			  • The discharge will not result in any exposure to Australian Marine Parks.
			• the proposed controls are consistent with Woodside's internal policies, procedures and standards
			• feedback from stakeholders has been taken into consideration

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards, including: • Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **External Context** During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on plankton. **Other requirements** The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES.		• legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Outcomes** To manage impacts to plankton to at or below the defined acceptable levels the following EPO have been applied: **EPO 10.2:** Undertake Scarborough FPU and Support Operations in a manner that prevents a substantial adverse effect on a population of plankton including its life cycle and spatial distribution. **EPO 10.3**:Undertake Scarborough FPU and Support Operations in a manner that prevents significant impacts on the values of the Exmouth Plateau KEF.
Fish and Commercial / Recreational Fisheries	**Principles of ESD** The Scarborough development is consistent with the relevant principles of ESD: • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. • The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations • The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making	Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant*	Based on an assessment against the defined acceptable levels, the impact to fish from Routine Discharges: Cooling water and brine is considered acceptable, given that: • the activity is aligned with the relevant principles of ESD. • While this impact will occur for the duration of the activities which cause the discharges (e.g. FPU operations), the stressors of the discharge (temperature and chlorine) do not result in accumulation and as such frequent short-term exposure will not amount to long-term injury or mortality.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	The Scarborough development will result in no significant impacts to fish. Significant impact definitions: • to not have a substantial adverse effect on a population of fish, of the spatial distribution of the population • to not substantially modify, destroy or isolate an area of important habitat for a migratory species • to not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species. **Internal Context** The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards, including: • Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **External Context** During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on fish. **Other requirements** The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES. Specifically, for impacts to fish this includes: • Impacts to specific species of fish and sharks that may be present are to be managed in accordance with the	*impact guidelines 1.1 (DotE, 2013)).* Activities associated with Scarborough are not inconsistent with relevant recovery plans including those for identified for listed species. Activities associated with Scarborough prevent significant impacts on the values of the Exmouth Plateau KEF.	• The impact evaluation determined that for the discharge of cooling water / brine, the impact will be at the individual level and not on the population of a fish species. This is because the impacts would only occur close to the source and require that the fish remained within the plume and not move through it. • The location of the discharge is not within an important habitat for a migratory fish species and as such there is no predicted impacts to any important habitats. • The discharge will not result in any exposure to Australian Marine Parks. • The plume will conservatively (based on the maximum diameter and horizontal extent and 99% species protection at 99th percentile) cover an exposure area within the top 30 m of water of 5.48 km2 of the 49,310 km2 (approximately 0.01%) of the Exmouth KEF. While the discharge is to occur within the Exmouth Plateau KEF, this is at a significant distance (>50 km) from the location that has been identified as having increased productivity according the Brewer et al., 2007. Subsequently it is not anticipated that this discharge will result in impacts to the ecological integrity of the KEF. • Given low predicted impact to fish, and low levels of commercial and recreational fishing at the Offshore Project Location, there is no predicted impact to fisheries targeting the offshore fisheries. • the proposed controls are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***

	specific conservation advices. These advices identify habitat degradation / modification and vessel disturbance as the key threats. While generally no explicit management actions are identified, for some species there are specific requirements.
	• Sawfish and river sharks:
	  • Identify risks to important sawfish and river shark habitat and measures needed to reduce those risks.
	  • Implement measures to reduce adverse impacts of habitat degradation and/or modification. (Freshwater sawfish only)
	• Whale shark:
	  - Minimise offshore developments and transit time of large vessels in areas close to marine features likely to correlate with Whale Shark aggregations and along the northward migration route that follows the northern Western Australian coastline along the 200 m isobath.
			• the predicted level of impact is at or below the defined acceptable levels.
			
			Environmental Performance Outcomes
			To manage impacts to fish or commercial/recreational fisheries to at or below the defined acceptable levels the following EPOs have been applied:
			EPO 10.4: Undertake Scarborough FPU and Support Operations in a manner that prevents a substantial adverse effect on a population of fish, or the spatial distribution of the population.
			EPO 10.5: Undertake Scarborough FPU and Support Operations in a manner that prevents a substantial modification, destruction or isolation an area of important habitat for a migratory species
			EPO 10.6: Undertake Scarborough FPU and Support Operations in a manner that prevents serious disruption of the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.
			EPO 10.3:Undertake Scarborough FPU and Support Operations in a manner that prevents significant impacts on the values of the Exmouth Plateau KEF.
			EPO 10.9: Undertake Scarborough FPU and Support Operations in a manner that aims to avoid any change in spawning biomass of a commercially important species and does not lead to changes in recruitment that may be discernible from normal natural variation.

Marine mammals	**Principles of ESD** The Scarborough development is consistent with the relevant principles of ESD: • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.	Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant	Based on an assessment against the defined acceptable levels, the impact to fish from Routine Discharges: Cooling water and brine is considered acceptable, given that: • the activity is aligned with the relevant principles of ESD.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	• The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations • The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making The Scarborough development will result in no significant impacts to marine mammals. Significant impact definitions: • to not have a substantial adverse effect on an endangered marine mammal species that results in a reduction to the area of occupancy of an important population • to not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in a Commonwealth marine area results • to not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species. **Internal Context** The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards, including: • Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **External Context** During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential	impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).* Activities associated with Scarborough are not inconsistent with relevant recovery plans including those for identified for listed species.	• the transient nature of large marine fauna suggests that impacts will be limited to any individual species that remain within the plume for a prolonged period, and it is not likely that there would be any notable impact to a population of marine mammals. • the stressors of the discharge (temperature and chlorine) do not result in accumulation and as such frequent short-term exposure will not amount to long-term injury or mortality. • Listed threatened species which may occur in the Offshore Project Area include sei whale (V), blue whale (E), fin whale (V) and humpback whale (V), however critical behaviours are not expected to occur in any of these species in the vicinity of the Scarborough development. Individuals encountering the cooling water plume will be able to move away, limiting impacts and avoiding injury / mortality occurring. • the proposed controls are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices. This includes the assessment and management of development activities. • The Offshore Project Area is located within a distribution BIA for pygmy blue whale. The Conservation Management Plan for the Blue Whale (reference) does not list a change in temperature or salinity as a threat, although it does lists acute and chronic chemical discharge. Given the small volumes and low levels of toxicity, and the avoidance behaviour expected in marine mammals, biocides and chlorine in cooling water and brine discharges

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	impacts of the Scarborough development on marine mammals. **Other requirements** The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES, specifically: • Impacts to specific species of marine mammals that may be present are to be managed in accordance with the specific conservation advices. These advices identify noise interference and vessel disturbance as the key threats, and do not specifically related to this aspect. Generally, however, activities will be conducted in line with the management measures and conservation advice relevant to each species, as provided below. Sei whale: • Assess and manage acoustic disturbance. • Assess and manage physical disturbance and development activities. Blue whale: • Assess and address anthropogenic noise. • Minimise vessel collision. Fin whale: • Once the spatial and temporal distribution (including biologically important areas) of Fin Whales is further defined, assess the impacts of increasing anthropogenic noise (including seismic surveys, port expansion, and coastal development).		associated with Scarborough development are not expected to result in a threat to pygmy blue whale. It is expected that individual pygmy blue whales found within the Offshore Project Area will be transient, and not performing behaviours (such as foraging and resting) which require them to stay in any location for an extended period of time. Individuals encountering the cooling water plume will be able to move away, limiting impacts and avoiding injury / mortality occurring. • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Outcomes** To manage impacts to fish to at or below the defined acceptable levels the following EPOs have been applied: **EPO 10.7:** Undertake Scarborough FPU and Support Operations in a manner that prevents a substantial adverse effect on a population of marine mammals or the spatial distribution of the population. **EPO 10.5**: Undertake Scarborough FPU and Support Operations in a manner that prevents a substantial modification, destruction or isolation an area of important habitat for a migratory species **EPO 10.6**: Undertake Scarborough FPU and Support Operations in a manner that prevents serious disruption of the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	• Develop a national vessel strike strategy that investigates the risk of vessel strikes on Fin Whales and identifies potential mitigation measures • Ensure all vessel strike incidents are reported in the National Vessel Strike Database. Humpback whale: • For actions involving acoustic impacts (example pile driving, explosives) on Humpback Whale calving, resting, feeding areas, or confined migratory pathways, undertake site-specific acoustic modelling (including cumulative noise impacts). • Ensure the risk of vessel strike on Humpback Whales is considered when assessing actions that increase vessel traffic in areas where Humpback Whales occur and, if required appropriate mitigation measures are implemented to reduce the risk of vessel strike.		

KEF	**Principles of ESD**
	The Scarborough development is consistent with the relevant principles of ESD:
	• Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
	• The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
	• The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
	
	The Scarborough development will result in no significant impacts to KEFs. Significant impact definitions:
		Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).*	Based on an assessment against the defined acceptable levels, the impact to KEFs from Routine and Non-Routine Discharges: Operational Cooling Water and Brine is considered acceptable, given that:
			• the activity is aligned with the relevant principles of ESD.
			  • Based on impact evaluations for water and sediment quality above, the discharge of cooling water is expected to result in a relatively small area of impact around the FPU or MODU.
			  • The only KEF which may be impacted is the Exmouth Plateau. Given the small amount of representative habitat within the KEF that will be impacted from discharges, no impacts to marine ecosystem functioning or integrity of the KEF are expected.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	• To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results. **Internal Context** The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards, including: • Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **External Context** During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on KEFs. **Other requirements** The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES: • Marine Bioregional Plan for the NorthWest Marine Region (DSEWPC, 2012)		• The impact assessment demonstrates that impacts to sediment quality will not result in irreversible environmental damage nor fragment any habitats. • The discharge will not result in any exposure to Australian Marine Parks. • the proposed controls are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Outcomes** To manage impacts to epifauna and infauna to at or below the defined acceptable levels the following EPO have been applied: **EPO 10.3**:Undertake Scarborough FPU and Support Operations in a manner that prevents significant impacts on the values of the Exmouth Plateau KEF. **EPO 10.8:** Undertake Scarborough FPU and Support Operations in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature.

7.1.10.4 Summary of the Impact Assessment

Table 7-54 provides a summary of the risk assessment and acceptability for impacts from discharges of brine water and cooling water on receptors.

Table 7-54: Summary of impacts, key management controls, impact significance ratings, acceptability and EPOs for brine and cooling water

Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity	Magnitude	Impact significance level	Acceptability
Water quality	Change in water quality	**EPO 10.1:** Undertake Scarborough FPU and Support Operations in a manner that prevents a substantial change to water quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health. **EPO 10.2:** Undertake Scarborough FPU and Support Operations in a manner that prevents a substantial adverse effect on a population of plankton including its life cycle and spatial distribution. **EPO 10.3**:Undertake Scarborough FPU and Support Operations in a manner that prevents significant impacts on the values of the Exmouth Plateau KEF. **EPO 10.4:** Undertake Scarborough FPU and Support Operations in a manner that prevents a substantial adverse effect on a population of fish, or the spatial distribution of the population. **EPO 10.5**: Undertake Scarborough FPU and Support Operations in a manner that prevents a substantial modification, destruction or isolation an area of important habitat for a migratory species **EPO 10.6**: Undertake Scarborough FPU and Support Operations in a manner that prevents serious disruption of the lifecycle (breeding,	**CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints.	Low value (open water)	No lasting effect	Negligible (F)	Acceptable
Plankton	Injury/ mortality to fauna			Low value (open water)	No lasting effect	Negligible (F)	Acceptable
Fish	Injury/ mortality to fauna			High value (protected species)	No lasting effect	Slight (E)	Acceptable
Marine mammals	Injury/ mortality to fauna			High value (protected species)	No lasting effect	Slight (E)	Acceptable
KEFs	Change in water quality			High value	No lasting effect	Slight (E)	Acceptable
Commercial Fisheries	Injury/ mortality to fauna			High value marine users	No lasting effect	Slight (E)	Acceptable

Receptor	Impact	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity	Magnitude	Impact significance level	Acceptability
		feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species. **EPO 10.7:** Undertake Scarborough FPU and Support Operations in a manner that prevents a substantial adverse effect on a population of marine mammals or the spatial distribution of the population. **EPO 10.8:** Undertake Scarborough FPU and Support Operations in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results. **EPO 10.9:** Undertake Scarborough FPU and Support Operations in a manner that avoids any change in spawning biomass of a commercially important species and does not lead to changes in recruitment that may be discernible from normal natural variation.					

7.1.11 Routine and Non-Routine Discharges: Operational Fluids

7.1.11.1 Sources of the Aspect

Activities and facilities associated with Scarborough will routinely and non-routinely discharge operational fluids. Discharges will be made during:

- hydrocarbon extraction
- hydrocarbon processing.

Hydrocarbon Extraction

During operations, the flow rate of hydrocarbons through flowlines will be controlled at the wellhead. The wellheads and manifolds will be connected to umbilicals to support the operation. Subsea control fluids will be supplied through these umbilicals and used for the functioning of the choke valves by providing lubrication, corrosion protection, bacterial protection and stability with other chemicals. These fluids, including MEG, will be discharged throughout the operations phase to the marine environment at or near the seabed at volumes of about 2 L per actuation which may occur up to several times a day. It should be noted that these discharges are not continuous.

Hydrocarbon Processing

Following extraction, hydrocarbons will flow through the riser to the FPU for processing.

The liquids in the vapour phase will then be condensed to meet the requirements of the trunkline specification, during which condensed water will be produced and discharged to the marine environment at a rate of up to approximately 285 bbl/day (45.3 m^3). Discharge will either be overboard from the surface, or from a point below the surface depending on the final design of the FPU.

Wells are not expected to produce formation water until they start to ‘water out’ towards the end of well life. Once they start to water out, up to approximately 200 bbl/day (31.7 m^3) of formation water may be produced. At this stage of the well life, the combined volume of condensed water and formation water (referred thereafter as produced water (PW)) is expected to be approximately 485 bbl/day (or 77 m^3). Such volume will only be generated for a limited duration, at which point the well will be shut-in. PW will be only be discharged during the operations phase of Scarborough.

The condensed water and produced formation water streams are treated onboard the FPU to remove, residual salt, MEG, mercury, scale, and fines. The PW that is discharged may contain residual amounts of MEG and corrosion inhibitor hydrocarbons (mainly dissolved), salts (soluble and precipitated) from the reservoir, fines and mercury. The discharge will dilute rapidly within the water column. Insoluble salts that may form on discharge and precipitate out will be of an inert nature and disperse rapidly in the water. Potential impacts from these chemicals are therefore expected to be lower than that predicted for residual hydrocarbons. On this basis residual hydrocarbons are the focus of the assessment of impacts from the discharge of operational fluids.

It should be noted that the actual discharge rates and concentrations discussed in this section may vary, however these values have been selected as conservative indications for the purpose of modelling the potential impacts.

Produced Water Modelling

PW discharges were modelled to quantify the likely extent of the discharge plume, and in particular the dilution of residual hydrocarbons in the water column (RPS, 2019b; APPENDIX G). Modelling included scenarios that considered near and far field modelling of dilution for summer, winter and transitional conditions, based on the following parameters:

- PW flow rate of 95 m^3/day (as a conservative level)
- Discharge depths of 0 m, 10 m, and 30 m (to allow for the final design of the FPU).
- Current strengths of weak, medium and strong
- Variety of plume temperatures and densities
- TPH source concentration of 29 mg/L[34].
- Impact threshold for TPH of 0.07 mg/L (set by the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000), and derived from Tsvetnenko (1998) using the USEPA methods (Stephan et al. 1985, USEPA 1994d)).

The modelling investigated specifically whether the dilution of the PW discharge would be sufficient to meet the ANZECC & ARMCANZ guideline value of 0.07 mg/L, thereby achieving dilution by a factor of 1:414.3.

Near-field modelling of the PW discharge predicted the following:

- The surface discharge increases the extent of the turbulent mixing zone, and the discharge travels the greatest lateral distance.
- Following the initial mixing, the plume is near neutrally-buoyant, and travels laterally in the water column.
- For most combinations of season and discharge depth, the primary factor influencing dilution of the plume is the strength of the ambient current. Weak currents allow the plume to plunge further and reach the trapping depth closer to the discharge point, which slows the rate of dilution. Increased current strengths increase the horizontal distance travelled by the plume.
- The required dilution factor of 414.3 for TPH was not achieved for any of the scenarios by the end of the near-field mixing zone.
- Diameter of plume at the edge of the near-field mixing zone is in the order of a few meters, with the maximum diameter at the edge of the near-field mixing zone predicted to be approximately 4 m.
- Depth of the plume is generally between 0.1 m and 4.4 m, with the maximum plume depth predicted to be approximately 30 m.

Near-field and far-field modelling are used to describe different processes and scales of effect, and therefore the far-field modelling results will not necessarily correspond to the outcomes at the end of the near-field mixing zone for any given discharge scenario. The 0 m and 30 m scenarios were selected for far-field modelling, as the two depth extremes.

- Far-field modelling predicts the worst-case maximum exposure area is 0.7 km^2, and the maximum horizontal distance is 0.81 km.

Table 7-55: Summary of PW modelling

Discharge depth	Near-field	Far-field
0 m	• Depth of plume ranges between 0.1–4.4 m below the sea surface	• Maximum depth of the plume is 5 m below the surface.

[34] This concentration has been chosen to represent the maximum TPH concentration potentially present in the discharge stream given uncertainties around actual TPH concentration in future discharges. In implementing the activities, Woodside will however meet levels which are ALARP.

Discharge depth	Near-field	Far-field
	• Maximum horizontal distance is 866 m • Diameter of plume at edge of near-field mixing zone ranges between 0.4–3.7 m • Average dilution factors are 1:1519 – 1:140	• Maximum horizontal distance is 543 m. • The maximum area of exposure is 0.48 km^2.
10 m	• Depth of plume is 9–11 m below the surface • Maximum horizontal distance is 123 m • Diameter of plume at end of near-field zone is 0.5–1.8 m • Average dilution factors 1:88–1:140	• N/A
30 m	• Depth of plume is 29–31 m below the surface • Maximum horizontal distance is 123 m • Diameter of plume at end of near-field zone is 0.6–1.7 m • Average dilution factors are 1:43–1:181	• Maximum depth of the plume is 33 m below the surface. • Maximum horizontal distance is 810 m. • The maximum area of exposure is 0.7 km^2.

[1] *Value shown is from the worst-case season*

7.1.11.2 Impact or Risk

Routine and non-routine discharges of operational fluids from the above activities to the marine environment has the potential to result in the following impacts to receptors:

- change in water quality
- change in sediment quality
- injury/mortality to fauna
- change in habitat
- changes to the functions, interests or activities of other users.

Change in Water Quality

A change in water quality may occur subsea around the well head during hydrocarbon extraction or at the surface during hydrocarbon processing. The key physio-chemical stressors associated with operational fluid discharges is toxicity.

Change in Sediment Quality

A change in sediment quality may occur subsea around the well head during hydrocarbon extraction. The key physio-chemical stressors associated with operational fluid discharges is toxicity.

Injury/Mortality to Fauna

As a result of a change in water quality, further impacts to receptors may occur, which include injury or mortality to marine fauna resulting from exposure to toxins or chemicals associated with the discharge of operational fluids.

Following a discharge of subsea control fluids, the marine fauna most at risk are expected to dwell at or near the seabed within both the water column and sediment. Due to the relatively small volumes of discharges per actuation (~2 L), control fluids are expected to disperse and dilute rapidly. As discharges will occur individually (no continuous flow) and based on the low toxic nature of the chemicals, it is likely that any impacts to marine fauna will be negligible.

As outlined above, PW contains some toxic components, which have the potential to result in injury or mortality of marine fauna. PW will be discharged at or relatively near the surface (0 – 30 m), therefore marine fauna most likely to be impacted by the plume are expected to dwell in surface waters. As previously discussed, modelling for PW indicates that the ANZECC & ARMCANZ guideline value of 0.07 mg/L for TPH will be reached at a maximum horizontal distance of 0.81 km from the discharge source, the plume being of a relatively narrow diameter and potentially extending to a maximum of 33 m below the surface. Impacts to fauna as a result of toxicity from hydrocarbons within the water column are therefore restricted within this range of the discharge source.

Change in habitat

As a result of a change in sediment quality and/or water quality, further impacts to receptors may occur, which include a change in habitat resulting from smothering and alteration of the seabed, or exposure to toxins or chemicals in the operational fluids discharges.

Change to the Functions, Interests or Activities of Other Users

As a result of impacts to fish species from routine and non-routine discharges of operational fluids, fisheries which operate in the area have the potential to be impacted via a reduction in fish stocks.

Receptors Potentially Impacted

Routine and non-routine discharges of operational fluids have the potential to impact on receptors which may be vulnerable to toxicity. The receptors which have the potential to be impacted include:

- water quality
- sediment quality
- plankton
- epifauna and infauna
- fish
- marine mammals
- marine reptiles
- Key Ecological Features
- Commonwealth and State managed fisheries.

Fish, Marine Mammals, Marine Reptiles

The routine and non-routine discharge of operational fluids, specifically produced water, will result in a narrow plume (1 - 4 m) with the potential for levels of TPH above the ANZECC & ARMCANZ guideline value of 0.07 mg/L extending to a maximum of around 0.81 km from the source of the discharge.

This exposure area however is conservative based on the assumptions made on maximum volume of oil in water on discharge and given the discharge rates and environmental conditions modelled. It should also be noted that ongoing discharges of PW are not anticipated, as wells are expected to only produce formation water between the time they start to water out toward the end of the well life and the well is shut in.

Pelagic fish, reptiles and marine mammals traversing waters within a 0.81 km radius around the discharge point may be exposed to TPH at concentrations above the ANZECC & ARMCANZ guideline value. Injury or death to fauna is only expected as a result of prolonged exposure to operational fluid discharges. Given the limited size of the plume, and that these species will be moving through the area and are unlikely to remain still on location for extended period of times, significant impacts are not anticipated.

Several pelagic species including Blue whale and Pygmy whales, Humpback whales, marine turtle species, fish species and bird species have distribution which extends to the Offshore Project Area and may be present during activities. However, no BIAs lie within the Offshore Project Area. Due to the mobile nature of pelagic species, if exposed to operational fluid discharges, they would be subjected to a change in water quality for a very short time only as they transit through the discharge plume. As transient species, they are not expected to experience any chronic or acute toxicity effects. For this reason, and due to the lack of species BIAs within the Offshore Project Area, prolonged exposure is unlikely.

Due to the high level of mixing and resulting dilution within the receiving offshore environment, the relatively small predicted EMBA, and the low concentrations TPHs and or chemicals within the PW discharge, the impacts to mammals, reptiles and fish from operational discharges is negligible and pose no lasting effect. Planktonic species (prey) may be impacted (as discussed below) however not at a significant scale to cause impact to higher order species.

On this basis the impacts to fish, cetaceans, marine reptiles from routine and non-routine discharges of operational fluids during activities have not been evaluated further.

Commonwealth and State Managed Fisheries

Where the functions, interests or activities of other marine users involve marine fauna, any effect to fauna presence or abundance will indirectly impact on the functions, interests or activities of other users. Given that the impacts to fish have been evaluated to be unlikely, the subsequent impact to fisheries is also unlikely and not evaluated further.

Table 7-56 summarises the potential impacts to receptors associated with routine and non-routine discharges of operational fluids.

Table 7-56: Receptor/impact matrix after evaluation of context

Impacts	Receptor: Water Quality	Sediment Quality	Plankton	Epifauna and Infauna	Fish	Marine Mammals	Marine Reptiles	Key Ecological Features	Commonwealth managed Fisheries	State Managed Fisheries
Change in water quality	✓							✓		
Change in sediment quality		✓								
Injury/mortality to fauna			✓	✓	X	X	X			
Change in habitat								✓		
Changes to the functions, interests or activities of other users									X	X

Detailed Impact Evaluation

Water Quality

A change in water quality will occur following routine and non-routine discharges of operational fluids due to toxic additives and residual hydrocarbon in the discharge streams resulting in increased toxicity levels in the vicinity of the discharge point.

The subsea control fluid being used for Scarborough is not yet known. Due to the instantaneous nature and relatively small volumes of control fluid discharges throughout the operations phase of the project and the dynamic offshore marine environment, it is expected that fluids within the water column will disperse and dilute rapidly.

Toxic additives which may be present within the PW discharge stream include MEG, scale inhibitors, biocides, corrosion inhibitors and a range of other production chemicals. MEG is an organic compound which may be present in trace volumes within the PW discharge stream. In addition, scale inhibitors are typically low molecular weight phosphorous compounds that are water-soluble, and only have acute toxicity to marine organisms about two orders of magnitude higher than typically used in the water phase (Black et al., 1994). The biocides typically used in the industry are highly reactive and degrade rapidly (Black et al., 1994).

Residual hydrocarbons will be present within the discharge stream due to lack of ability to remove all hydrocarbons during processing. TPH within the PW discharge stream are expected to be low but have conservatively been estimated at up to 29 mg/L for the purpose of impact evaluation.

An ANZECC & ARMCANZ guideline value of 0.07 mg/L has been set for TPHs. Assuming a source concentration of 29 mg/L, the discharge would have to be diluted by a factor of 1:414.3 to return to this level.

Predicted Impact Summary

Modelling of PW discharged from the FPU predicts that PNEC will be reached within a maximum horizontal distance of 0.81 km for all conditions (RPS, 2019b; APPENDIX G). The plume will be limited to a diameter of a 1-4 m and extend to a depth of up to 30 m below the surface. Far-field modelling predicts that the maximum area of exposure is 0.7 km^2, for the worst case modelled. As such, any potential impacts to water quality are expected to be limited to within relatively close proximity of the source of the discharge where concentrations are highest.

Given discharges of operational fluids are expected to result in a relatively small area of impact around the FPU (Figure 7-26), the change to water quality resulting from routine discharges of operational fluids will be temporary and habitat or ecosystem function or integrity will not be impacted.

According to the Marine Bioregional Plan for the North-west Marine Region, the region is widely used by a range of industries including widescale and longstanding petroleum activities.

Chemicals dosed into all systems will be selected with the lowest practicable environmental impacts and risks subject to technical constraints, in order to lower potential toxicity of discharges. Woodside will also develop a management framework for produced water discharges.

Impacts from routine and non-routine discharges of operational fluids will have a slight effect on water quality. Receptor sensitivity is low (low value, open water), and therefore Impact Significance Level of routine and non-routine discharges of operational fluids on water quality is **Negligible (F).**

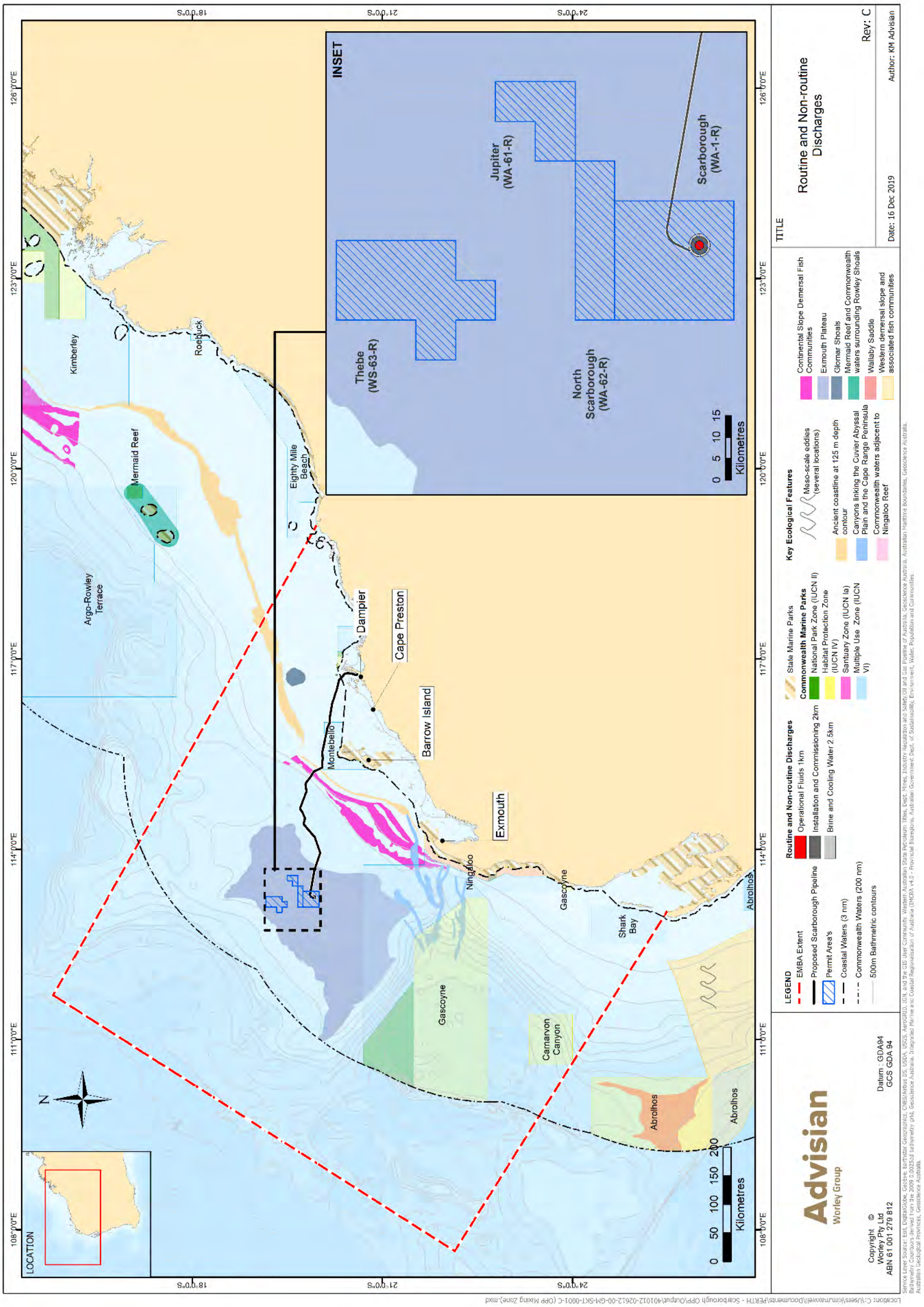


Figure 7-26: Predicted mixing zone for operational fluids (red shading) associated with the FPU operations

Sediment Quality

Modelling suggests that discharges of PW and associated toxins will not reach the seabed due to the water depth of which the FPU operates (approximately 930 m), and the dispersive nature of PW discharges in a high energy offshore marine environment such as the permit area. The maximum depth of the TPH plume is predicted to be approximately 33 m (RPS, 2019b; Appendix G).

Any solids present in the condensed water and produced formation water streams are separated out by distillation in the MEG unit and will either be discharged or collected and transported to shore for disposal (pending an ALARP analysis during Front End Engineering and Design (FEED). In addition, any residual insoluble MEG salts formed on discharge, will precipitate out of solution and are likely to be dispersed by the ocean currents. Given these salts will be inert they have not been considered further in terms of impacts to sediment quality.

A change in sediment quality has the potential to also occur due to a subsea release of control fluids during hydrocarbon extraction. Any persistent component of the control fluid may accumulate on or within the sediment profile, thus changing the chemical composition.

Predicted Impact Summary

Subsea control fluids are discharged from the christmas trees close to the seabed. Subsea control fluids generally have inherently low toxicity, and at such intermittent, small volumes (~2 L), these fluids would disperse rapidly, and are not expected to accumulate and result in changes to the sediment quality.

There are no Management Plans, Recovery Plans or Conservation Advice related specifically to water quality. In addition, the activity is not proposed to take place in any AMPs, and as such there are no specific principles, objectives and values to be considered.

Chemicals dosed into all systems will be selected with the lowest practicable environmental impacts and risks subject to technical constraints, in order to lower potential toxicity of discharges. Woodside will also develop a management framework for produced water discharges.

Impacts from routine and non-routine discharges of operational fluids will have no lasting effect on sediment quality. Receptor sensitivity is low (low value, open water), and therefore Impact Significance Level of routine and non-routine discharges of operational fluids on sediment quality is **Negligible (F).**

Plankton

A change in water quality as a result of PW discharges has the potential to result in the injury or death of planktonic species within the water column through toxicity effects. As plankton are generally surface-dwelling organisms, subsea discharges during hydrocarbon extraction will not result in a detectable level of impact to plankton. Early life stages of fish (embryos, larvae) and other plankton would be the most susceptible organisms to exposure from hydrocarbons and chemicals in the PW discharges, as they have limited mobility and are therefore likely to be exposed to the plume at the outfall, if present. However, these types of organisms are expected to rapidly recover once the activity ceases, as they are known to have high levels of natural mortality and a rapid replacement rate (UNEP, 1985).

Phytoplankton are typically not sensitive to the impacts of hydrocarbons, though they do bioaccumulate it rapidly (Hook et al., 2016). If phytoplankton are exposed to hydrocarbons, it may affect their ability to photosynthesize and therefore resulting in impacts to the next trophic level in the food chain (Hook et al., 2016). Hydrocarbons can also inhibit growth in phytoplankton, depending on the concentration range. For example, photosynthesis is stimulated by low concentrations of oil in the water column (10-30 ppb) but become progressively inhibited above 50 ppb. Conversely, photosynthesis can be stimulated below 100 ppb for exposure to weathered oil (Volkman et al., 2004). The threshold of 70 ppb (0.07 mg/L) used as the impact threshold for this assessment for

TPH is therefore considered appropriate given the variability in the levels at which phytoplankton is impacted.

Zooplankton (microscopic animals such as rotifers, copepods and krill that feed on phytoplankton) are vulnerable to hydrocarbons (Hook et al., 2016). Water column organisms that come into contact with hydrocarbons risk exposure through ingestion, inhalation and dermal contact (NRDA, 2012), which can cause immediate mortality or decline in egg production and hatching rates along with a decline in swimming speeds (Hook et al., 2016).

Plankton is generally abundant in the upper layers of the water column and is the basis of the marine food web, so the presence of hydrocarbons in any one location is unlikely to have long-lasting impacts on plankton populations at a regional level. Reproduction by survivors or migration from unaffected areas is likely to rapidly replenish losses (Volkman et al., 2004). Oil spill field observations show minimal or transient effects on plankton (Volkman et al., 2004), therefore PW discharges are expected to have a lesser effect due to lower associated TPH concentrations. Once background water quality is re-established, plankton may take weeks to months to recover (ITOPF, 2011a).

Predicted Impact Summary

Modelling predicts the threshold for TPH will be reached within approximately 0.81 km horizontally and 33 m vertically from the discharge point; and far-field modelling predicts the maximum area of exposure above the threshold is 0.7 km^2 (RPS, 2019b; Appendix G). Impacts associated with hydrocarbon exposure are therefore expected to be limited to within this range from the discharge source.

Once discharged, PW is expected to rapidly mix within receiving waters and dispersed by ocean currents. As such, any potential impacts associated with the low volumes of biocides, corrosion inhibitors and other chemical additives within the PW discharge stream are expected to be limited to the source of the discharge where concentrations are highest.

As discussed in Section 5.5.1, primary productivity appears to be enhanced along the northern and southern boundaries of the Exmouth Plateau, and along the adjacent shelf edge to the east of the plateau (Brewer et al., 2007). As described by Falkner et al. (2009), the centre of the plateau is characterised by moderate seafloor temperatures and low primary productivity. Therefore, while the discharge is to occur within the Exmouth Plateau KEF, this is at a significant distance (>150 km) from the periphery of the plateau that has been identified as having increased productivity (Brewer et al., 2007; Falkner et al., 2009).

Consequently, it is not anticipated that this discharge will result in impacts to the ecological integrity of the KEF. Any reductions of existing populations are expected to rapidly recover once the activity ceases, given the high levels of natural mortality and a rapid replacement rate (Houde and Zastrow, 1993; ITOPF, 2011; Tang et al., 2014).

Chemicals dosed into all systems will be selected with the lowest practicable environmental impacts and risks subject to technical constraints, in order to lower potential toxicity of discharges. Woodside will also develop a management framework for produced water discharges.

Impacts from routine and non-routine discharges of operational fluids will have no lasting effect on plankton. Receptor sensitivity is low (low value, open water), and therefore Impact Significance Level of routine and non-routine discharges of operational fluids on plankton is **Negligible (F).**

Epifauna and Infauna

As a result of a change in sediment or water quality, further impacts to benthic habitat receptors may occur, which include injury or mortality to benthic epifauna and infauna resulting from the increased (water) or accumulation (sediment) of potential contaminants and toxins.

Any potential impacts associated with operational fluids discharges will be limited to the area surrounding the discharge source of the MODU or FPU. The stationary facilities will be concentrated around the well locations, which is approximately 900 m deep and >375 km from shore.

Predicted Impact Summary

Modelling suggests that PW plumes will not reach the seabed due to the water depth of which the FPU or MODU operate (>900 m), as the maximum plume depth is predicted to be 33 m (RPS, 2019b).

Due to the dispersive nature of chemical discharges within the highly mixed offshore marine environment, toxins associated with these surface discharges are not expected to reach benthic waters or marine sediments.

Chemicals dosed into all systems will be selected with the lowest practicable environmental impacts and risks subject to technical constraints, in order to lower potential toxicity of discharges. Woodside will also develop a management framework for produced water discharges.

Impacts from routine and non-routine discharges of operational fluids will have no lasting effect on epifauna and infauna. Receptor sensitivity is low (low value, homogenous), and therefore Impact Significance Level of routine and non-routine discharges of operational fluids on epifauna and infauna is **Negligible (F).**

Key Ecological Features

The Offshore Project Area occurs within the Exmouth Plateau KEF. The Exmouth Plateau is defined as a KEF as it is a unique seafloor feature with ecological properties of regional significance, which apply to both the benthic and pelagic habitats within the feature. Therefore, as a result of a change in sediment quality and/or water quality, potential impacts to this KEF may occur.

There is no solids component in the operational fluids discharge, and therefore no smothering or alteration of the seabed is expected to occur.

Predicted Impact Summary

Based on impact evaluations for water and sediment quality above, the discharge of operational fluids is expected to result in a relatively small area of impact around the FPU or MODU. The change to water quality resulting from discharges of operational fluids will be temporary and habitat or ecosystem function or integrity will not be impacted. Subsea fluids are expected to disperse rapidly and not expected to accumulate and result in changes to the sediment quality. As such, no subsequent impacts to benthic or pelagic habitats are expected to occur.

The only KEF which may be impacted is the Exmouth Plateau. Given the small amount of representative habitat within the KEF that will be impact from operational fluid discharges, no impacts to marine ecosystem functioning or integrity of the KEF are expected.

Physical habitat modification is recognised as a pressure ‘of less concern’ in the Marine Bioregional Plan for the NorthWest Marine Region (DSEWPC, 2012). In addition, the activity is not proposed to take place in any AMPS, and as such there are no specific principles, objectives and values to be considered.

Chemicals dosed into all systems will be selected with the lowest practicable environmental impacts and risks subject to technical constraints, in order to lower potential toxicity of discharges. Woodside will also develop a management framework for produced water discharges.

Impacts from routine and non-routine discharges of operational fluids will have no lasting effect on KEFs. Receptor sensitivity is high (high value), and therefore Impact Significance Level of routine and non-routine discharges of operational fluids on KEFs is **Slight (E).**

7.1.11.3 Demonstration of Acceptability

Table 7-57 provides demonstration of acceptability for all receptors predicted to be potentially impacted from routine and non-routine discharges of operational fluids.

Table 7-57: Demonstration of Acceptability for Routine and Non-Routine Discharges: Operational Fluids

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***

Water quality	**Principles of ESD**
	The Scarborough development is consistent with the relevant principles of ESD:
	• Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
	• The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
	• The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
	
	The Scarborough development will result in no significant impacts to water quality. Significant impact definitions:
	• to not result in a substantial change to water quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health.
	
	Internal Context
	The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards, including:
	• Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints.
	• Woodside will develop a management framework for PW discharges
		Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).*	Based on an assessment against the defined acceptable levels, the impact to water quality from Routine and Non-Routine Discharges: Operational Fluids is considered acceptable, given that:
			• the activity is aligned with the relevant principles of ESD.
			  ◦ Modelling of PW discharged from the FPU predicts that PNEC will be reached within a maximum horizontal distance of 0.81 km for all conditions (RPS, 2019b; APPENDIX G).
			  ◦ As such, any potential impacts to water quality are expected to be limited to within relatively close proximity of the source of the discharge where concentrations are highest
			  ◦ The impact assessment demonstrates that impacts to water quality will not result in irreversible environmental damage.
			  ◦ The discharge will not result in any exposure to Australian Marine Parks.
			• the proposed controls are consistent with Woodside's internal policies, procedures and standards
			• feedback from stakeholders has been taken into consideration
			• legislative requirements/industry standards have been adopted
			• the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	External Context During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on water quality. **Other requirements** The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES.		• the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Outcomes** To manage impacts to water quality to at or below the defined acceptable levels the following EPO have been applied: **EPO 11.1:** Undertake Scarborough FPU Operations in a manner that prevents a substantial change to water quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health.

Sediment quality	**Principles of ESD**
	The Scarborough development is consistent with the relevant principles of ESD:
	• Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
	• The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
	• The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
	
	The Scarborough development will result in no significant impacts to sediment quality. Significant impact definitions:
	• to not result in a substantial change to sediment quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health.
		Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).*	Based on an assessment against the defined acceptable levels, the impact to sediment quality from Routine and Non-Routine Discharges: Operational Fluids is considered acceptable, given that:
			• the activity is aligned with the relevant principles of ESD.
			  ◦ Modelling suggests that discharges of PW and associated toxins will not reach the seabed
			  ◦ Subsea control fluids generally have inherently low toxicity, and at such intermittent, small volumes (~2 L), these fluids would disperse rapidly, and are not expected to accumulate and result in changes to the sediment quality.
			  ◦ The impact assessment demonstrates that impacts to sediment quality will not result in irreversible environmental damage. Sediments are unlikely to be contacted due to discharges being located at or near the surface.
			  ◦ The discharge will not result in any exposure to Australian Marine Parks.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	Internal Context The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards, including: • Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints. • Woodside will develop a management framework for PW discharges **External Context** During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on sediment quality. **Other requirements** The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES.		• the proposed controls are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Outcomes** To manage impacts to sediment quality to at or below the defined acceptable levels the following EPO have been applied: **EPO 11.2:** Undertake Scarborough FPU Operations in a manner that prevents a substantial change to sediment quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health.
Plankton	**Principles of ESD** The Scarborough development is consistent with the relevant principles of ESD: • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. • The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations	Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a	Based on an assessment against the defined acceptable levels, the impact to plankton from Routine and Non-Routine Discharges: Operational Fluids is considered acceptable, given that: • the activity is aligned with the relevant principles of ESD.

<table>
<tr><th colspan="4">Demonstration of Acceptability</th></tr>
<tr><th>Receptor</th><th>Acceptability Criteria and Assessment</th><th>Acceptable Levels of Impact</th><th>Statement of Acceptability</th></tr>
<tr><td></td><td>The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
The Scarborough development will result in no significant impacts to plankton. Significant impact definitions:
To not result in a substantial adverse effect on a population of plankton including its life cycle and spatial distribution
Internal Context
The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards, including:
Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints.
Woodside will develop a management framework for PW discharges
External Context
During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on plankton.
Other requirements
The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES.</td><td>Commonwealth marine area as defined in the Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).</td><td>Modelling predicts the threshold for TPH will be reached within approximately 0.81 km horizontally and 33 m vertically from the discharge point; and far-field modelling predicts the maximum area of exposure above the threshold is 0.7 km^2 (RPS, 2019b; Appendix G).
Once discharged, PW is expected to rapidly mix within receiving waters and dispersed by ocean currents.
The impact assessment demonstrates that impacts to water quality will not result in irreversible environmental damage.
While the discharge is to occur within the Exmouth Plateau KEF, this is at a significant distance (>50 km) from the location that has been identified as having increased productivity according to Brewer et al., 2007. Consequently, it is not anticipated that this discharge will result in impacts to the ecological integrity of the KEF.
The discharge will not result in any exposure to Australian Marine Parks.
the proposed controls are consistent with Woodside’s internal policies, procedures and standards
feedback from stakeholders has been taken into consideration
legislative requirements/industry standards have been adopted
the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices
the predicted level of impact is at or below the defined acceptable levels.</td></tr>
</table>

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
			Environmental Performance Outcomes To manage impacts to plankton to at or below the defined acceptable levels the following EPO have been applied: **EPO 11.3:** Undertake Scarborough FPU Operations in a manner that prevents a substantial adverse effect on a population of plankton including its life cycle and spatial distribution. **EPO 11.4**: Undertake Scarborough FPU Operations in a manner that prevents a significant impact on the values of the Exmouth Plateau KEF.

Epifauna and infauna	**Principles of ESD**
	The Scarborough development is consistent with the relevant principles of ESD:
	• Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
	• The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
	• The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
	
	The Scarborough development will result in no significant impacts to epifauna and infauna. Significant impact definitions:
	• To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.
		Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).*	Based on an assessment against the defined acceptable levels, the impact to epifauna and infauna from Routine and Non-Routine Discharges: Operational Fluid is considered acceptable, given that:
			• the activity is aligned with the relevant principles of ESD.
			  • Modelling suggests that PW plumes will not reach the seabed due to the water depth of which the FPU or MODU operate (>900 m), as the maximum plume depth is predicted to be 33 m (RPS, 2019b).
			  • Due to the dispersive nature of chemical discharges within the highly mixed offshore marine environment, toxins associated with these surface discharges are not expected to reach benthic waters or marine sediments.
			  • The impact assessment demonstrates that impacts to sediment quality will not result in irreversible environmental damage.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	Internal Context The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards, including: • Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints. • Woodside will develop a management framework for PW discharges **External Context** During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on epifauna and infauna. **Other requirements** The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES.		• The discharge will not result in any exposure to Australian Marine Parks. • the proposed controls are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Outcomes** To manage impacts to epifauna and infauna to at or below the defined acceptable levels the following EPO have been applied: **EPO 11.5:** Undertake Scarborough FPU Operations in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.
KEF	**Principles of ESD** The Scarborough development is consistent with the relevant principles of ESD: • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.	Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts	Based on an assessment against the defined acceptable levels, the impact to KEFs from Routine and Non-Routine Discharges: Operational Fluid is considered acceptable, given that: • the activity is aligned with the relevant principles of ESD.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	• The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations • The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making The Scarborough development will result in no significant impacts to KEFs. Significant impact definitions: • To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results. **Internal Context** The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards, including: • Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints. • Woodside will develop a management framework for PW discharges **External Context** During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on KEFs. **Other requirements**	(as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013))*.	• Based on impact evaluations for water and sediment quality above, the discharge of operational fluids is expected to result in a relatively small area of impact around the FPU or MODU. • The only KEF which may be impacted is the Exmouth Plateau. Given the small amount of representative habitat within the KEF that will be impacted from operational fluid discharges, no impacts to marine ecosystem functioning or integrity of the KEF are expected. • The impact assessment demonstrates that impacts to sediment quality will not result in irreversible environmental damage. • The discharge will not result in any exposure to Australian Marine Parks. • the proposed controls are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Outcomes**

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES: • Marine Bioregional Plan for the NorthWest Marine Region (DSEWPC, 2012)		To manage impacts to epifauna and infauna to at or below the defined acceptable levels the following EPO have been applied: **EPO 11.4**: Undertake Scarborough FPU Operations in a manner that prevents a significant impact on the values of the Exmouth Plateau KEF. **EPO 11.6:** Undertake Scarborough FPU Operations in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results.

7.1.11.4 Summary of the Impact Assessment

Table 7-58 provides a summary of the impact assessment and acceptability for impacts from operational fluid discharges to ecological and social receptors.

Table 7-58: Summary of impacts, management controls, impact significance ratings and EPOs for operational discharges

Receptor	Impact	Environmental Performance Outcome	Adopted control(s)	Receptor sensitivity	Magnitude	Impact significance level	Acceptability
Water quality	Change in water quality	**EPO 11.1:** Undertake Scarborough FPU Operations in a manner that will not result in a substantial change in water quality (including temperature) which may adversely impact on biodiversity, ecological integrity, social amenity or human health. **EPO 11.2:** Undertake Scarborough FPU Operations in a manner that prevents a substantial change to sediment quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health. **EPO 11.3:** Undertake Scarborough FPU Operations in a manner that prevents a substantial adverse effect on a population of plankton including its life cycle and spatial distribution.	**CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **CM18:** Development of a management framework for produced water discharges.	Low value (open water)	Slight	Negligible (F)	Acceptable
Sediment quality	Change in sediment quality			Low value (open water)	No lasting effect	Negligible (F)	Acceptable
Plankton	Injury/ mortality to fauna			Low value (open water)	No lasting effect	Negligible (F)	Acceptable
Epifauna and Infauna	Injury/ mortality to fauna			Low value (open water)	No lasting effect	Negligible (F)	Acceptable

Receptor	Impact	Environmental Performance Outcome	Adopted control(s)	Receptor sensitivity	Magnitude	Impact significance level	Acceptability
KEFs	Change in habitat	**EPO 11.4**: Undertake Scarborough FPU Operations in a manner that prevents a significant impact on the values of the Exmouth Plateau KEF. **EPO 11.5:** Undertake Scarborough FPU Operations in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 11.6:** Undertake Scarborough FPU Operations in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results.		High value	No lasting effect	Slight (E)	Acceptable

7.1.12 Routine and Non-Routine Discharges: Subsea Installation and Commissioning

Routine and non-routine discharges from subsea installation and commissioning activities include discharges of commissioning and hydrotest fluids into the marine environment.

7.1.12.1 Sources of the Aspect

Installation and commissioning of infrastructure for Scarborough will result in the discharge of commissioning and hydrotest fluids. Routine and non-routine discharges of commissioning and hydrotest fluids will occur during:

- installation of the FPU
- installation of subsea infrastructure
- commissioning
- pre-commissioning

Installation of FPU

During installation, the FPU will be hooked up to the SURF and trunkline infrastructure. Connection of the FPU to subsea infrastructure will result in the release of a small volume of commissioning fluids. Commissioning fluids will comprise of chemically treated and filtered seawater. Chemicals may consist of biocide, corrosion inhibitor and oxygen scavenger, scale inhibitor, MEG and fluorescein dye. Discharges associated with connection of the FPU to subsea infrastructure will occur during the installation of FPU. These discharges will only be during the installation of the FPU at the proposed offshore location.

Installation of Subsea Infrastructure

Subsea infrastructure (umbilicals, risers, flowlines, manifolds, well jumpers, MEG lines, export riser base) is required to transport gas from wells to the FPU. During installation the connection of subsea infrastructure will result in discharges of hydrotest fluid in small quantities. Hydrotest fluids may consist of biocide, corrosion inhibitor and oxygen scavenger, scale inhibitor, MEG and fluorescein dye.

Buckling is a risk that exists during installation of flowlines. If a buckle occurs, it could result in the rupture of the flowline and seawater entering the flowline. In the event preservation of the internals of a flowline is compromised, the line may require dewatering post commissioning activities. Contingency dewatering activities during construction (e.g. wet buckle) are possible but are considered non-routine. The requirement for contingency dewatering is determined by the technical design specifications and performance criteria of the line. Should these be compromised (i.e. failed welding joint) various repair strategies will be assessed and a decision made should the contingency be required. The volume of chemically-treated seawater that would be discharged in the event of a wet buckle depends on the location, extent and repair method. Worst case scenario would be complete dewatering of the compromised flowline.

Commissioning

Commissioning activities include testing the integrity of the subsea infrastructure by leak testing with hydrotest fluids. A pressure pump will be used to assess the pressure-volume relationship. Failure of testing equipment or integrity of the tested infrastructure may lead to a loss of hydrotest fluids. Where possible, the FPU components will be assembled and pre-commissioned at the onshore fabrication/pre-assembly sites. However, should it be required to be conducted in the Project Area there will be small localised discharges around each of the test locations as that infrastructure is tested and the flowlines are depressurised during pre-commissioning. There may also be small localised discharges at a connection points if they are not made correctly, however this will quickly be detected during pumping due to failure to reach test pressure. Pressure test mediums will match the contents of the system being tested.

Pre-commissioning

Once installation and hook up of subsea infrastructure are complete, the subsea infrastructure, including the SURF and the trunkline will be subject to pre-commissioning, required to test the integrity of the subsea infrastructure. This will be conducted using hydrotest fluids, whereby the infrastructure pressures will be monitored to detect leaks. Fluids will then be left in place to provide corrosion protection prior to dewatering, at which time they will be discharged at the offshore location.

Proposed volumes of pre-commissioning fluids for the trunkline is 190,000 m³ of chemically treated seawater with a 20% contingency, resulting in a maximum likely volume as 223,000 m³.For the various SURF scope discharges, the likely highest individual discharge volume is 5,300 m³ with a 10% contingency, for flowline hydrotest dewatering, resulting in a maximum likely volume as 5,800 m³. The location and timing of the discharge is unknown; however, it is assumed it will be discharged from a single point on the seabed in the vicinity of the proposed location of the FPU at any time of the year. For this assessment, the discharge rate is estimated at around 1500 m³/hr for the trunkline and 85 m³/hr for the offshore flowlines. The discharges will be relatively short in duration. Residual biocide may be present in the hydrotest water at the time it is discharged at concentrations in the order of 500–1500 ppm.

Modelling results for discharges of 220, 000 m³ of flooding fluid associated from dewatering activities of Wheatstone's trunkline and flowlines estimated any exceedance of the 48-hour median threshold is within 3.5 km of the point of discharge (Chevron, 2015). RPS conducted hydrotest discharge modelling, summarised below (RPS, 2019c; APPENDIX H).

7.1.12.2 Impact or Risk

Discharges during FPU and subsea installation and commissioning has the potential to result in the following impacts:

- change in water quality
- change in sediment quality
- injury/mortality to fauna
- changes to the functions, interests or activities of other users.

<u>Change in Water and Sediment Quality</u>

Modelling undertaken by Chevron determined the plume generated by the discharge of dewatering fluid. A total volume of 220,000 m³ of treated seawater was modelled for discharge over a six to eight-day period, with an average discharge flowrate of 0.448 m³ per second (1612.8 m³/hr). Based on a median lethal concentration (LC_{50}) of 0.06 ppm (over 48 hours), it was predicted that the plume would dilute to below the threshold at 3.5 km from the discharge location (Chevron, 2015).

<u>Hydrotest Discharge Modelling</u>

Modelling was undertaken for Scarborough (RPS, 2019c; APPENDIX H) for discharges of hydrotest water from the FPU location. The modelling looked at scenarios where the discharge was made from the seabed, and from a location 10 m below the sea surface, for two flow rates (795 m^3/hr and 220 m^3/hr).

When discharged at the seabed, the plume remains close to the seabed, while for surface discharges the plume plunges to a depth of around 20 m before becoming neutrally buoyant and travelling laterally. The nearfield modelling shows that at the extent of the nearfield mixing zone in all cases, the biocide constituent of the hydrotest discharge is not expected to reach the required levels of dilution, and predicted a maximum horizontal distance of 0.152 km before reaching the trapping depth (APPENDIX H).

Near-field and far-field modelling are used to describe different processes and scales of effect, and therefore the far-field modelling results will not necessarily correspond to the outcomes at the end of the near-field mixing zone for any given discharge scenario. Two scenarios were selected for far-field modelling, as the two depth extremes. Far-field modelling predicted (Table 7-59):

- the maximum horizontal extent before dilution is achieved is 1.56 km; and the maximum area of exposure is 3.7 km^2 (both for the higher flow rate, 930 m depth scenario).

Table 7-59 Far-field modelling summary of Hydrotest Discharge modelling

Discharge Rate: 795 m^3/hr; Depth: 930 m			
Percentile	**95th**	**99th**	**100th**
Maximum horizontal distance till dilution is achieved (km)[1]	1.20	1.39	1.56
Total area of coverage till dilution is achieved (km^2)[1]	2.30	2.90	3.70
Maximum depth from discharge (m)	930		
Discharge Rate: 220 m^3/hr; Depth: 10 m			
Percentile	**95th**	**99th**	**100th**
Maximum horizontal distance till dilution is achieved (km)[1]	0.02	0.12	1.15
Total area of coverage till dilution is achieved (km^2)[1]	0.002	0.03	0.49
Maximum depth from discharge (m)	12		

[1] Value shown is from the worst-case season

The distance at which the dilution is met is less than predicted for the Chevron Wheatstone project (3 - 4 km), however the flow rate modelled was approximately double that of Scarborough (Chevron, 2015). This will be a factor of the current speed and direction at the time of the discharge. While the maximum diameter is not known (beyond the nearfield mixing zone), the diameter of the plume at the edge of this zone is up to around 25 m. The diameter will be affected by the current speed, with increases in current speed serving to restrict the diameter of the plume.

Other small volume chemical discharges, such as hydrotest chemicals from FPU hook-up and hydrotest activities, will disperse immediately on discharge to the environment. The potential impact from these small volume chemical discharges to marine environment is expected to be limited to localised and temporary change in water quality from the discharge point.

Injury/Mortality to Marine Fauna

A change in water/sediment quality may result in further impacts, such as injury/mortality to marine fauna. Marine fauna, including epifauna/infauna, plankton, and fish within close proximity to the discharge point, will be exposed to the discharged waters which may include biocides and other additives. Following discharge, concentration is expected to rapidly dilute further in the open ocean environment.

Changes to the Functions, Interests or Activities of Other Users

Fishing activities are typically focussed in coastal waters, and minimal fishing effort is known to be undertaken in the Offshore Project Area where discharges will occur. Given the distance of the discharge point and subsequent plume from shore (375 km), impacts from the discharge of commissioning fluids such as changes to the functions, interest or activities of Commonwealth and State managed fisheries are unlikely. Therefore, the potential impact from changes to Commonwealth and State managed fisheries is not assessed further.

Receptors Potentially Impacted

Routine and non-routine discharges of FPU and subsea installation and commissioning fluids have the potential to impact on receptors which may be vulnerable to toxicity. The receptors which have the potential to be impacted include:

- water quality
- sediment quality
- plankton
- epifauna and infauna
- fish (and fisheries)
- KEFs.

Fish and Commercial / Recreational fisheries

WET test data estimated that the discharge of flooding fluid containing biocide has the potential to cause acute toxicity to fish at concentrations above 6.3–100.0 mg/L over 96 hours which is greater than the modelled threshold of 0.06 ppm over 48 hours (Chevron, 2015).

Potential impacts to pelagic fish species from dewatering are expected to be localised to the immediate vicinity of the discharge location. Any residual chemicals in the discharge plume will be at very low concentrations, well below levels that could result in any acute toxicity effects to fish. Any pelagic fish in the vicinity of the discharge plume are highly unlikely to be able to detect the very low residual concentrations of any treatment chemicals in the filtered seawater Impacts to pelagic fish from small discharge volumes associated with leak testing is expected to be highly localised and negligible.

No known breeding, feeding or aggregation areas are located within the discharge plume. Critical habitat for the survival of whale sharks in waters adjacent to Ningaloo Reef, >200 km from the Offshore Project Area, is identified in the Whale shark (*Rhincodon typus*) recovery plan 2005–2010 (DEH, 2005). An additional BIA for the whale shark is located 165 km from the Offshore Project Area. While habitat degradation/modification is listed as a key threat in this habitat, the distance from the discharge point prevents any direct impacts to aggregating individuals. Fish are not expected to be abundant and diversity is expected to be limited due to depth and the lack of hard substrate/habitat complexity. Individual fish may pass through the area, however, are unlikely to come into contact with the discharge plume for significant periods of time. Exposure times of sufficient duration that may lead to toxic effects are not expected. The low likelihood of pelagic species being exposed to the discharge; and the ability of fish to move away from the discharge plume, the potential for toxic impacts to occur from dewatering discharge are considered to be localised, short-term and negligible at the population or bioregional scale.

The existing environment in the Offshore Project Area, where discharges will predominantly occur, is a well-mixed marine environment. As described in Section 5.4.4.4, the deep water and predominantly featureless, flat soft sediment seabed is of low complexity and low productivity (see Section 5) in the Offshore Project Area and reduces the species diversity and richness of pelagic and demersal fish assemblages. Although sporadic upwelling events and increased primary productivity along the along the northern and southern boundaries of the Exmouth Plateau KEF may temporarily increase fish diversity, overall, fish fauna is not expected to be abundant in the Offshore Project Area, which is located >50 km from the periphery of the plateau. Continental slope fish communities off the west coast of Australia (including the Exmouth Plateau) have a low overall density, which appears to be linked to the low biological productivity of the overlying waters (Williams et al., 2001).

While there are overlapping commercial fisheries, the only Commonwealth Fishery expected to be active within the vicinity of the Project is the NWSTF. However, given the localised and short-term nature, no significant exposure to the discharge is likely.

The discharge during installation and commissioning will be restricted to a small area around the discharge point and will disperse rapidly in the environment. The extent of fish exposed at levels where impacts could occur will be small and exposure to fisheries negligible given the offshore location and the localised, temporary and negligible impacts. As such impacts have not been evaluated further.

Table 7-60 outlines the potential impacts to receptors associated with discharges of inhibited seawater.

Table 7-60: Receptor/impact matrix after evaluation of context

	Receptor					
Impacts	***Marine Sediment***	***Water Quality***	***Plankton***	***Epifauna and Infauna***	***Fish***	***KEFs***
Change in water quality		✓				✓
Change in sediment quality	✓					✓
Injury/mortality to fauna			✓	✓	X	

Detailed Impact Evaluation

Sediment and Water Quality

The release of commissioning and hydrotest fluids may alter water quality; and sediment quality, if it reaches the seabed.

Chemicals in the commissioning and hydrotest fluids may consist of biocide, corrosion inhibitor and oxygen scavenger, scale inhibitor, MEG and fluorescein dye. MEG is an organic compound which may be present in trace volumes within the discharge stream. In addition, scale inhibitors are typically low molecular weight phosphorous compounds that are water-soluble (Black et al., 1994).

Biocide is considered to be the primary chemical in dewatering fluids to have the highest toxicity to marine receptors (Chevron, 2015). The biocides will however degrade rapidly and will not accumulate in the seabed sediments or remain within the water column. Chemicals dosed into all systems will be selected with the lowest practicable environmental impacts and risks subject to technical constraints, in order to lower potential toxicity of discharges.

Predicted Impact Summary

The discharge location is not determined, and may be at 10 m water depth, or at the seafloor (930 m). The 10 m release only reaches a maximum depth of 12 m and does not the reach the seabed. However for the seafloor release, the dewatering plume is expected to travel in close proximity to the seabed (RPS, 2019c; APPENDIX H), therefore dewatering may result in change in sediment quality.

Modelling has determined that hydrotest water will potentially extend to 1.56 km (Table 7-59) (or a maximum area of potential exposure of 3.7 km^2) from the discharge point, as a narrow neutrally buoyant plume.

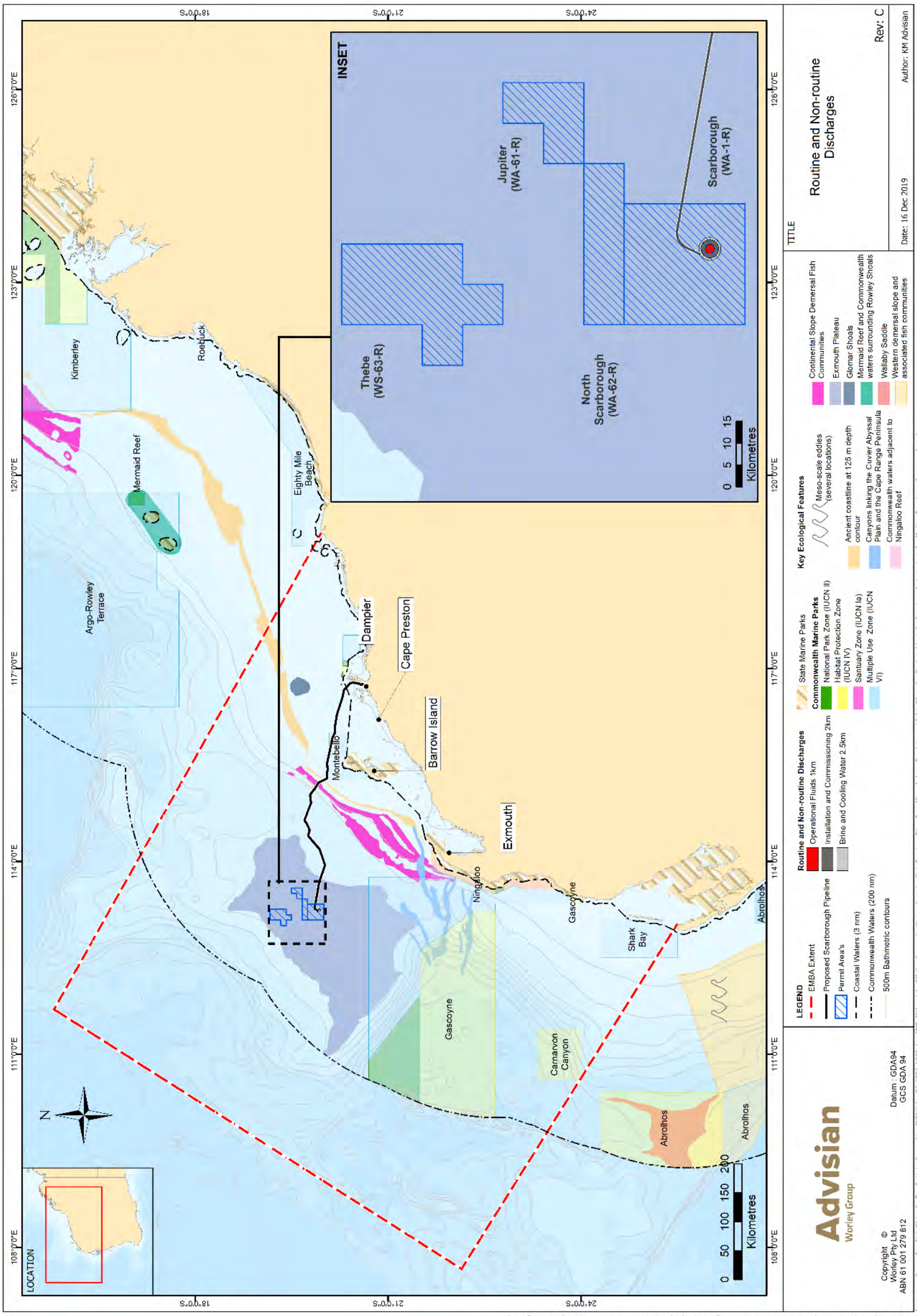


Figure 7-27: Predicted mixing zone for hydrotest discharges (dark grey shading) associated with the FPU operations

Given low volumes of subsea installation and commissioning discharges associated with Scarborough, and the nature of the chemicals in the discharge to biodegrade rapidly and not accumulate in the environment, biodiversity, ecological integrity, social amenities and human health will not be impacted.

Impacts from routine and non-routine discharges of subsea installation and commissioning fluids will have a slight effect on water quality and sediment quality. Receptor sensitivity is low (low value, open water), and therefore Impact Significant Level of routine and non-routine discharges of subsea installation and commissioning fluids on water quality and sediment quality is **Negligible (F).**

Plankton

A change in water quality as a result of FPU and subsea installation and commissioning fluid discharges has the potential to result in the injury or death of planktonic species within the water column through toxicity effects. As plankton are generally surface-dwelling organisms, subsea discharges will not result in a detectable level of impact to plankton. Early life stages of fish (embryos, larvae) and other plankton would be the most susceptible organisms to exposure from chemicals in the subsea installation and commissioning fluid discharges, as they have limited mobility and are therefore likely to be exposed to the plume at the outfall, if present. However, these types of organisms are expected to rapidly recover once the activity ceases, as they are known to have high levels of natural mortality and a rapid replacement rate (UNEP, 1985).

Whole of Effluent Toxicity (WET) test data estimated that the discharge of flooding fluid containing biocide chemical Hydrosure 0-3670R (a type of biocide typically used in hydrotesting) has the potential to cause acute toxicity to marine organisms at concentrations above 0.06 ppm over 48 hours (Chevron, 2015). WET testing included the consideration of impacts to fish and pelagic invertebrate species. Chemicals dosed into all systems will be selected with the lowest practicable environmental impacts and risks subject to technical constraints, in order to lower potential toxicity of discharges.

Predicted Impact Summary

Modelling has determined that hydrotest water will potentially extend to 1.56 km (Table 7-59) from the discharge point, as a narrow neutrally buoyant plume. Impacts associated with chemical toxicity are therefore expected to be limited to within this range from the discharge source.

Once discharged, subsea installation and commissioning fluids are expected to rapidly mix with the receiving waters and be dispersed by ocean currents. As such, any potential impacts associated with the low volumes of biocides, corrosion inhibitors and other chemical additives within the subsea installation and commissioning fluids discharge stream are expected to be limited to the source of the discharge where concentrations are highest.

As discussed in Section 5.5.1, primary productivity appears to be enhanced along the northern and southern boundaries of the Exmouth Plateau, and along the adjacent shelf edge to the east of the plateau (Brewer et al., 2007). As described by Falkner et al. (2009), the centre of the plateau is characterised by moderate seafloor temperatures and low primary productivity. Therefore, while the discharge is to occur within the Exmouth Plateau KEF, this is at a significant distance (>150 km) from the periphery of the plateau that has been identified as having increased productivity (Brewer et al., 2007; Falkner et al., 2009).

Consequently, it is not anticipated that this discharge will result in impacts to the ecological integrity of the KEF. Any reductions of existing populations are expected to rapidly recover once the activity ceases, given the high levels of natural mortality and a rapid replacement rate (Houde and Zastrow, 1993; ITOPF, 2011; Tang et al., 2014).

Discharges during installation and commissioning will be restricted to a small area around the discharge point and will disperse rapidly in the environment. Impacts from routine and non-routine discharges of subsea installation and commissioning fluids will have no lasting effect on plankton. Receptor sensitivity is low (low value, open water), and therefore Impact Significance Level of routine and non-routine discharges of operational subsea installation and commissioning fluids on plankton is **Negligible (F).**

Epifauna and Infauna

As a result of a change in sediment or water quality, further impacts to benthic habitat receptors may occur, which include injury or mortality to benthic epifauna and infauna resulting from the increased (water) or accumulation (sediment) of potential contaminants and toxins. Epifauna and infauna sensitivity to dewatering discharges is expected to be similar to pelagic invertebrate species such as plankton.

No sensitive benthic habitats have been identified within the discharge plume given the water depth of the area (>100 m) receives insufficient light to sustain ecologically sensitive primary producers. Epifauna and infauna abundance within the discharge plume was characterised by sparse marine life dominated by motile organisms (ERM 2013a).

Predicted Impact Summary

Modelling indicates the plume is initially a thin horizontal jet due to its large initial momentum, and then the plume begins a gradual rise/fall due to slight positive/negative buoyancy ending at a trapping depth or the seabed after it reaches neutral buoyancy (APPENDIX H). This suggests the plume may contact the seabed if it is more negatively buoyant, or where discharged from the seabed. Rapid dilution of the plume from deepwater flow and internal tides of the Exmouth Plateau may lower biocide concentration of the plume before seabed contact (when discharged at surface).

For discharges of hydrotest water at the seabed, the ecological consequences may include temporary and localised impact to epifauna and infauna populations with a temporary decline in abundance in the immediate area of the discharge, however, populations would recover rapidly by recolonisation by surrounding populations (Neff, 2005). The ecological integrity of epifauna and infauna communities will be maintained in the wider region. Impacts will be confined to a localised area not effecting the ecosystem function (DHI, 2014; APASA, 2012).

Chemicals dosed into all systems will be selected with the lowest practicable environmental impacts and risks subject to technical constraints, in order to lower potential toxicity of discharges.

Discharges during installation and commissioning will be restricted to a relatively small area around the discharge point and will disperse rapidly in the environment. The extent of seabed exposed at levels where impacts could occur will be small, and potential impacts are expected to be localised, temporary and negligible. Impacts from routine and non-routine discharges of subsea installation and commissioning fluids will have no lasting effect on epifauna and infauna. Receptor sensitivity is low (low value, homogenous), and therefore Impact Significant Level of routine and non-routine discharges of subsea installation and commissioning fluids on epifauna and infauna is **Negligible (F).**

KEFs

The Offshore Project Area occurs within the Exmouth Plateau KEF. The Exmouth Plateau is defined as a KEF as it is a unique seafloor feature with ecological properties of regional significance, which apply to both the benthic and pelagic habitats within the feature. Therefore, as a result of a change in sediment quality and/or water quality, potential impacts to this KEF may occur.

Values of the Exmouth Plateau with the potential to be affected by dewatering is limited to impacts to benthic environments containing low habitat heterogeneity within the plume. There is no solids component in the discharge, and therefore no smothering or alteration of the seabed is expected to occur.

The seafloor composition within the dewatering plume is expected to primarily be mud and clay material. Survey of the plume area identified the seafloor to contain sparse marine life dominated by motile taxa typical of deep-water soft substrates (ERM, 2013a; DEWHA, 2008a).

Predicted Impact Summary

The hydrotest discharge depth is not yet determined, but if it is discharged from the surface (10 m), it will not contact the benthic environment. If it is discharged from the seafloor location (930 m), modelling predicts the maximum horizontal distance before dilution is achieved is 1.56 km, or a maximum area of exposure of 3.7 km^2 (RPS, 2019c; APPENDIX H). This footprint represents only 0.00007 of the Exmouth Plateau KEF (49310 km^2).

Impacts to the Exmouth Plateau would be limited to localised and temporary impacts to benthic fauna from dewatering. Physical habitat modification is recognised as a pressure ‘of less concern’ in the Marine Bioregional Plan for the NorthWest Marine Region (DSEWPC, 2012). In addition, the activity is not proposed to take place in any AMPS, and as such there are no specific principles, objectives and values to be considered.

Chemicals dosed into all systems will be selected with the lowest practicable environmental impacts and risks subject to technical constraints, in order to lower potential toxicity of discharges.

Impacts from routine and non-routine discharges of subsea installation and commissioning fluids will have no lasting effect on KEFs. Receptor sensitivity is high (high value), and therefore Impact Significance Level of routine and non-routine discharges of subsea installation and commissioning fluids on KEFs is **Slight (E).**

7.1.12.3 Demonstration of Acceptability

Table 7-61 provides demonstration of acceptability for all receptors predicted to be potentially impacted from routine and non-routine discharges of subsea installation and commissioning fluids.

Table 7-61: Demonstration of Acceptability for Routine and Non-Routine Discharges: Subsea Installation and Commissioning

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***

Water quality	**Principles of ESD**
	The Scarborough development is consistent with the relevant principles of ESD:
	• Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
	• The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
	• The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
	
	The Scarborough development will result in no significant impacts to water quality. Significant impact definitions:
	• to not result in a substantial change to water quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health.
	
	Internal Context
	The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards, including:
	• Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints.
	
	External Context
	During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on water quality.
		Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).*	Based on an assessment against the defined acceptable levels, the impact to water quality from Routine and Non-Routine Discharges: Subsea Installation and Commissioning is considered acceptable, given that:
			• the activity is aligned with the relevant principles of ESD.
			    • The maximum horizontal distance before dilution is achieved is predicted as 1.56 km, or a maximum area of exposure of 3.7 km^2.
			    • The impact assessment demonstrates that impacts to water quality will not result in irreversible environmental damage.
			    • The discharge will not result in any exposure to Australian Marine Parks.
			• the proposed controls are consistent with Woodside's internal policies, procedures and standards
			• feedback from stakeholders has been taken into consideration
			• legislative requirements/industry standards have been adopted
			• the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices
			• the predicted level of impact is at or below the defined acceptable levels.
			
			Environmental Performance Outcomes

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	Other requirements The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES.		To manage impacts to water quality to at or below the defined acceptable levels the following EPO have been applied: **EPO 12.1:** Undertake Scarborough Installation and Commissioning in a manner that prevents a substantial change to water quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health.

Sediment quality	**Principles of ESD**
	The Scarborough development is consistent with the relevant principles of ESD:
	• Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
	• The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
	• The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
	
	The Scarborough development will result in no significant impacts to sediment quality. Significant impact definitions:
	• to not result in a substantial change to sediment quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health.
	
	Internal Context
	The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards, including:
		Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).*	Based on an assessment against the defined acceptable levels, the impact to sediment quality from Routine and Non-Routine Discharges: Subsea Installation and Commissioning is considered acceptable, given that:
			• the activity is aligned with the relevant principles of ESD.
			  ◦ The maximum horizontal distance before dilution is achieved is predicted as 1.56 km, or a maximum area of exposure of 3.7 km^2.
			  ◦ The impact assessment demonstrates that impacts to sediment quality will not result in irreversible environmental damage.
			  ◦ The discharge will not result in any exposure to Australian Marine Parks.
			• the proposed controls are consistent with Woodside's internal policies, procedures and standards
			• feedback from stakeholders has been taken into consideration
			• legislative requirements/industry standards have been adopted

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	• Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **External Context** During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on sediment quality. **Other requirements** The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES.		• the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Outcomes** To manage impacts to sediment quality to at or below the defined acceptable levels the following EPO have been applied: **EPO 12.2:** Undertake Scarborough Installation and Commissioning in a manner that prevents a substantial change to sediment quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health.

Plankton	**Principles of ESD**
	The Scarborough development is consistent with the relevant principles of ESD:
	• Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
	• The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
	• The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
		Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant*	Based on an assessment against the defined acceptable levels, the impact to plankton from Routine and Non-Routine Discharges: Subsea Installation and Commissioning is considered acceptable, given that:
			• the activity is aligned with the relevant principles of ESD.
			    • The maximum horizontal distance before dilution is achieved is predicted as 1.56 km, or a maximum area of exposure of 3.7 km^2.
			    • Once discharged, subsea installation and commissioning fluids are expected to rapidly mix with the receiving waters and be dispersed by ocean currents.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	The Scarborough development will result in no significant impacts to plankton. Significant impact definitions: • To not result in a substantial adverse effect on a population of plankton including its life cycle and spatial distribution **Internal Context** The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards, including: • Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **External Context** During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on plankton. **Other requirements** The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES.	*impact guidelines 1.1 (DotE, 2013)).*	• The impact assessment demonstrates that impacts to water quality will not result in irreversible environmental damage. • While the discharge is to occur within the Exmouth Plateau KEF, this is at a significant distance (>150 km) from the location that has been identified as having increased productivity according to Brewer et al., 2007. Consequently, it is not anticipated that this discharge will result in impacts to the ecological integrity of the KEF. • The discharge will not result in any exposure to Australian Marine Parks. • the proposed controls are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Outcomes** To manage impacts to plankton to at or below the defined acceptable levels the following EPO have been applied: **EPO 12.3:** Undertake Scarborough Installation and Commissioning in a manner that prevents a substantial

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
			adverse effect on a population of plankton including its life cycle and spatial distribution.

Epifauna and infauna	**Principles of ESD**
	The Scarborough development is consistent with the relevant principles of ESD:
	• Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
	• The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
	• The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
	
	The Scarborough development will result in no significant impacts to epifauna and infauna. Significant impact definitions:
	• To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.
	Internal Context
	The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards, including:
	• Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints.
	
	External Context
	During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on epifauna and infauna.
		Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).*	Based on an assessment against the defined acceptable levels, the impact to epifauna and infauna from Routine and Non-Routine Discharges: Subsea Installation and Commissioning is considered acceptable, given that:
			• the activity is aligned with the relevant principles of ESD.
			  • No sensitive benthic habitats have been identified within the discharge plume given the water depth of the area (>100 m) receives insufficient light to sustain ecologically sensitive primary producers.
			  • Modelling indicates the plume is initially a thin horizontal jet due to its large initial momentum, and then the plume begins a gradual rise/fall due to slight positive/negative buoyancy ending at a trapping depth or the seabed after it reaches neutral buoyancy
			  • For discharges of hydrotest water at the seabed, the ecological consequences may include temporary and localised impact to epifauna and infauna populations with a temporary decline in abundance in the immediate area of the discharge, however, populations would recover rapidly by recolonisation by surrounding populations (Neff, 2005).
			  • The impact assessment demonstrates that impacts to sediment quality will not result in irreversible environmental damage.
			  • The discharge will not result in any exposure to Australian Marine Parks.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	Other requirements The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES.		• the proposed controls are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Outcomes** To manage impacts to epifauna and infauna to at or below the defined acceptable levels the following EPO have been applied: **EPO 12.4:** Undertake Scarborough Installation and Commissioning in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.
KEF	**Principles of ESD** The Scarborough development is consistent with the relevant principles of ESD: • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. • The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of	Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact	Based on an assessment against the defined acceptable levels, the impact to KEFs from Routine and Non-Routine Discharges: Subsea Installation and Commissioning is considered acceptable, given that: • the activity is aligned with the relevant principles of ESD.

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
	the environment is maintained or enhanced for the benefit of future generations • The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making The Scarborough development will result in no significant impacts to KEFs. Significant impact definitions: • To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results. **Internal Context** The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards, including: • Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **External Context** During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on KEFs. **Other requirements** The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES: • Marine Bioregional Plan for the NorthWest Marine Region (DSEWPC, 2012)	on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1 (DotE, 2013)).*	• The only KEF which may be impacted is the Exmouth Plateau. Values of the Exmouth Plateau with the potential to be affected by dewatering is limited to impacts to benthic environments containing low habitat heterogeneity within the plume. • The seafloor composition within the dewatering plume is expected to primarily be mud and clay material. Survey of the plume area identified the seafloor to contain sparse marine life dominated by motile taxa typical of deep-water soft substrates (ERM, 2013a; DEWHA, 2008a). • The hydrotest discharge depth is not yet determined, but if it is discharged from the surface (10 m), it will not contact the benthic environment. If it is discharged from the seafloor location (930 m), modelling predicts the maximum horizontal distance before dilution is achieved is 1.56 km, or a maximum area of exposure of 3.7 km2 (RPS, 2019c; APPENDIX H). This footprint represents only 0.00007 of the Exmouth Plateau KEF (49310 km²). • Physical habitat modification is recognised as a pressure 'of less concern' in the Marine Bioregional Plan for the NorthWest Marine Region (DSEWPC, 2012). In • The impact assessment demonstrates that impacts to sediment quality will not result in irreversible environmental damage. • The discharge will not result in any exposure to Australian Marine Parks. • the proposed controls are consistent with Woodside's internal policies, procedures and standards

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
			• feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Outcomes** To manage impacts to KEFs to at or below the defined acceptable levels the following EPO have been applied: **EPO 12.5:** Undertake Scarborough Installation and Commissioning in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results.

7.1.12.4 Summary of the Impact Assessment

Table 7-62 provides a summary of the risk assessment and acceptability for impacts from routine and non-routine subsea installation and commissioning discharges on receptors.

Table 7-62: Summary of impacts, key management controls, acceptability, impact significance ratings and EPOs for routine and non-routine discharges: subsea installation and commissioning.

<table>
<tr><th>Receptor</th><th>Impact</th><th>Environmental Performance Outcome</th><th>Adopted control(s)</th><th>Receptor sensitivity level</th><th>Magnitude</th><th>Impact significance level</th><th>Acceptability</th></tr>
<tr><td>Water quality</td><td>Change in water quality</td><td rowspan="5">EPO 12.1: Undertake Scarborough Installation and Commissioning in a manner that prevents a substantial change to water quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health.
EPO 12.2: Undertake Scarborough Installation and Commissioning in a manner that prevents a substantial change to sediment quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health.
EPO 12.3: Undertake Scarborough Installation and Commissioning in a manner that prevents a substantial adverse effect on a population of plankton including its life cycle and spatial distribution.
EPO 12.4: Undertake Scarborough Installation and Commissioning in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.
EPO 12.5: Undertake Scarborough Installation and Commissioning in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results.</td><td rowspan="5">CM16: Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints.</td><td>Low value (open water)</td><td>Slight</td><td>Negligible (F)</td><td>Acceptable</td></tr>
<tr><td>Sediment quality</td><td>Change in sediment quality</td><td>Low value (open water)</td><td>Slight</td><td>Negligible (F)</td><td>Acceptable</td></tr>
<tr><td>Plankton</td><td>Injury/ mortality to fauna</td><td>Low value (open water)</td><td>No lasting effect</td><td>Negligible (F)</td><td>Acceptable</td></tr>
<tr><td>Epifauna and Infauna</td><td>Injury/ mortality to fauna</td><td>Low value (open water)</td><td>No lasting effect</td><td>Negligible (F)</td><td>Acceptable</td></tr>
<tr><td>KEFs</td><td>Change in water quality
Change in sediment quality</td><td>High value habitat</td><td>No lasting effect</td><td>Slight (E)</td><td>Acceptable</td></tr>
</table>

7.1.13 Routine and Non-Routine Discharge: Drilling

7.1.13.1 Sources of the Aspect

Activities associated with Scarborough, that will generate drilling discharges include:

- drilling operations
- well abandonment.
- well intervention

Routine discharges will include:

- drilling fluids
- drill cuttings
- subsea control fluids
- cement
- completions fluids (including well clean-up fluids, suspension fluids).

Occasional bulk discharges of drilling fluids from the mud pits may also occur during the cleaning of equipment.

Drilling Operations

Around 20 wells with an additional 10 contingency wells are planned to be drilled during the proposed development of Scarborough, which will result in the same number of discharge locations. Each well is expected to take two to three months to drill.

Drilling activities generate drill cuttings, require cementing of the casing, and require the use of a range of fluids. Throughout the drilling program several different fluids are to be run through the closed circulation system including, but not limited to, drilling fluids (water-based muds and non-water-based muds), sea water, and kill-weight brine. During the displacement of one fluid to another, both fluids will mix. This mixture may be discharged to the environment, depending on its content.

Depending on the drilling phase and hole section, drill cuttings and fluids are discharged both subsurface and from surface waters. Non-routine bulk discharges of drilling fluids may also take place, these will be discharged to surface waters.

Each type of discharge is described further below.

<u>Drilling Fluids</u>

Drilling fluids (also termed drilling muds) serve a range of functions including aiding in cuttings transport to surface, maintaining bore stability and hydrostatic pressure, reducing friction and cleaning and cooling of the drill bit.

Water based muds (WBM) will be used during drilling activities and consists mainly of seawater with the addition of chemical and mineral additives to aid in its function. Drilling additives typically used may include:

- chlorides (e.g. sodium, potassium)
- bentonite (clay)
- cellulose polymers

- guar gum
- barite
- calcium carbonate.

These additives are either completely inert in the marine environment, naturally occurring benign materials, or readily biodegradable organic polymers with a very fast rate of biodegradation in the marine environment. Drilling fluids are either mixed on the MODU or received pre-mixed, then stored and maintained in a series of mud pits aboard the MODU.

WBM will be discharged to the marine environment at the location of the well being drilled under the following scenarios:

- at the seabed when drilling the top hole (riser less) sections
- below sea surface as fluid remaining on drill cuttings, after passing through solids control equipment (SCE) (bottom hole sections, drilled with riser in place)
- from the mud pits from a pipe below the sea surface, if the WBM cannot be re-circulated/ re-used through the drilling fluid system (due to deterioration/contamination), re-used on the well or on another well; or stored.

If WBM cannot be re-used due to bacterial deterioration or does not meet required drilling fluid properties, it is discharged to the marine environment, using seawater flushing.

Non-water-based muds (NWBM) refers to drill fluids that have a hydrocarbon rather than water base fluid. NWBM may be used, should the offset history, geohazards assessment and borehole stability studies indicate that NWBM is required to manage well stability to safe levels.

Like a WBM system, a range of standard solid and liquid additives may be added to alter specific mud properties for each section of the well, dependent on the conditions encountered while drilling. Discharge scenarios are much the same as that described for WBM, however NWBM will not be used for top hole section drilling (riserless); therefore, no direct seabed discharge of NWBM will occur. NWBM that cannot be re-used are recovered from the mud pits and transported to shore for recycling or disposal.

The mud pits and associated equipment are cleaned out at the completion of drilling operations. Should NWBM be used, mud pit residue and wash water will be treated onboard through Solid Control Equipment (SCE) and may be discharged to sea where the residue contains <1% oil volume. Where the mud pit residue exceeds 1% by volume, the residue will be retained and disposed onshore.

Drill Cuttings

Drilling generates drill cuttings due to the breakup of solid material from within the borehole. Cuttings are expected to range from very fine to very coarse (<1 cm diameter) after separation from the drilling fluid. Depending on the drilling phase and hole section, drill cuttings and fluids are discharged both subsurface and from surface waters.

Cuttings from drilling the top-hole section are discharged to the seabed at the well site. During top hole section drilling, based on a typical well profile, approximately 270 m^3 of drill cuttings will be produced per well.

Once the top-hole section is complete, installation of the riser and BOP provides a conduit back to the MODU, forming a closed circulating system. Solids control equipment (SCE) then removes cuttings from drilling fluids before being recycled and circulated back to the MODU.

The SCE uses shale shakers to remove coarse cuttings from the drilling mud. After processing by the shale shakers, the recovered mud from the cuttings may be directed to centrifuges, which are used to remove fine solids (~ 4.5 to 6 µm). The cuttings with retained fluids are discharged below the water line in accordance with Woodside standards, and the mud is recirculated into the drill fluid system.

During bottom hole section drilling (for a typical well profile) approximately 110 m^3 of drill cuttings will be produced per well (actual volumes will depend on the final depth of the well).

If a NWBM system is required to drill a well section, the cuttings from the NWBM drilling fluid system will pass through a cuttings dryer to reduce the average residual oil on cuttings (OOC) to <6.9% for the well, which is aligned with World Bank Guidelines (World Bank 2015) and Woodside standards.

Cement

Once each of the top-hole sections are drilled, casing is inserted into the wellbore and secured in place by pumping cement into the annular space back to approximately 300 m above the casing shoe, which may involve a discharge of excess cement at the seabed (~80 m^3/well).

Wherever possible, the cement line flush volumes are included in the planned cement jobs. When a job is completed, the cement unit is cleaned, and the residual cement discharged overboard. The discharge volumes of residual cement products are approximately 1 m^3.

At the commencement of the drilling campaign there may be a requirement to run a cement unit test to test the functionality of the cement unit and the cement bulk delivery system prior to performing an actual cement job. This test would result in a small volume of approximately 10 m3 of cement slurry being discharged at surface to sea. The slurry is usually a mix of cement and water however may sometimes contain stabilisers or chemical additives. Also, in the rare event that the cement products become contaminated, the entire volume (~180 m^3 per well) may need to be discharged to sea.

Subsea Control Fluids

Pressure-control equipment (including Blow Out Preventers (BOP)) use hydraulics for operation. Subsea control fluids are water-based hydraulic control fluids used in control systems on the subsea trees, and BOPs.

Subsea control fluids will be discharged during:

- installation of the subsea trees (~10 L per well)
- function testing of the subsea tree (~30 L per test)
- function testing of the BOP control system includes pressure testing approximately every 21 days and a function test approximately every seven days, excluding the week a pressure test is conducted. The maximum volume of control fluid that will be released to the marine environment per well is 1320–2250 L of water-based fluid containing about ~3% active ingredient (40–68 L of control fluid additive).

Completion Fluids

Completion fluids are usually brines (i.e. a mixture of seawater or formation water) with additives that can include:

- chlorides (often sodium, potassium or calcium)
- bromides
- hydrate inhibitor (MEG)
- biocide
- oxygen scavenger.

They are designed to have the proper density and flow characteristics to be compatible with the reservoir formation. Completion fluids are used to run well completions, and during wellbore clean-up and flowback during drilling.

Wellbore and casing clean-up are required at various stages of the drilling operations to ensure the contents of the well are free of contaminants before the next stage of drilling. A chemical wellbore cleanout fluid train may be used to remove residual fluids (including NWBM, if used) from the wellbore. The wellbore cleanout fluid is usually brine (similar to completion fluid) that can include several chemicals, such as biocide and surfactant. During the clean-up process, fluids are circulated back to the MODU, and, if required, analysed before they are discharged overboard. Discharge volume would be ~400 m^3 (based on the designs of the proposed production wells).

Kill-weight brine may also be used during well suspension or well abandonment, which is a brine (e.g. sodium chloride) of adequate density to control formation pressure.

Well Intervention

At some point in the life of all oil and gas wells, parts will require maintenance, repair or replacement. Well intervention activities generally occur within the wellbore and may include the following activities, as well as any other drilling activities described in Section 4.4.3:

- well logging activities (slickline, wireline, coil tubing)
- well testing and flowback
- well workovers.

Relevant discharge types generated from these activities may include the following:

- subsea control fluid (control of subsea tree)
- completions fluids
- well annular fluids.

These discharges are not expected to be different from those described above under the associated headings.

Well annular fluids may also be discharged during well intervention.

Well Annular Fluids

Well annular fluids refer to the fluids that remain in the wellbore, or annular spaces between the casing. It may consist of weighted drilling fluid and cement-contaminated mud, seawater, barite, cement polymer, and may include small amounts of hydrocarbon.

If a well is underperforming, or surveillance indicates debris is contained within the well, the contents of the wellbore may be flowed to a MODU. This displaces the well fluids (i.e. suspension/completion fluids). These are discharged overboard, as potential gas content makes it too dangerous to personnel to filter or treat them.

Well Abandonment

The following well abandonment activities can result in discharges to the marine environment:

- install and pressure test BOP
- cutting/perforation of casing or production tubing
- install permanent reservoir and surface barrier (cementing).

Relevant discharge types generated from these activities may include the following:

- subsea control fluids
- well annular fluids (see below)
- cement.

Well Annular Fluids

WBM used during riserless drilling fluids will be released to the marine environment when the well head is removed during abandonment. Upon wellhead removal, small volumes (~ 1 m^3) of fluid exchange between the annular spaces and the ocean may occur. The exchange will not be instantaneous as the annular spaces are small and the fluids are typically heavier than seawater. The non-instantaneous nature of the release of the well annular fluids is expected to result in rapid dilution within meters of the release location.

7.1.13.2 Impact or Risk

Routine and non-routine discharges of drilling-related fluids may result in the following impacts:

- change in water quality
- change in sediment quality
- change in habitat
- injury/mortality to marine fauna.

Some fluids are discharged at the sea surface (or just below); and some are discharged at the seabed. Due to water depth in the Offshore Project Area (approximately 900 m), this will determine the exposure pathway, and hence potential impacts and receptors.

Surface discharges include all those circulated to the MODU then discharged overboard, which include:

- drill cuttings, and drill fluids as fluid remaining on drill cuttings (bottom hole sections); consists of WBM and NWBM if used; or from clean out of mud pits.
- cement, from cleaning of cement systems
- completion fluid.

Subsea discharges from the subsea tree, wellhead or to the seabed during drilling, well intervention and abandonment that are likely to interface with the benthic environment include:

- drill fluids for top-hole drilling (riserless) – WBM only
- drill cuttings for top-hole drilling (riserless)
- cement
- subsea control fluids
- well annular fluids.

Change in Water Quality

The key physicochemical stressors that are associated with drilling discharges include turbidity and resulting sedimentation and chemical toxicity.

Discharges such as completion fluids and well annular fluids are typically inert and low-toxicity. These fluids are mostly brine, with a small proportion of chemical additives such as surfactants, biocide, corrosion inhibitor, oxygen scavenger, MEG, guar gum and so on. Well annular fluid may have some residual hydrocarbon from the reservoir, but in small amounts.

The main potential impact to water quality from drilling-related discharges is due to the following discharge types, which are described further below:

- drill cuttings and drill fluid
- cement
- completion fluids
- subsea control fluid
- well annular fluids.

Drill Cuttings and Fluid

A change in water quality because of drill cutting and fluid discharges may occur via a change in turbidity at the seabed or within the water column, increased chemical content in the water column and through oxygen depletion. Table 7-63 shows the expected volumes, mud types and discharge locations for an example well.

Table 7-63: Details of the drill cuttings and drilling fluids discharged for an example well[35]

Well Section	Interval Length (m)	Cuttings Volume (m^3)	Mud Type	Liquid Mud Volume (m^3)	Mud Solids Volume (m^3)	Discharge Duration (d)	Discharge Location
42" Conductor	60	53.6	WBM	266	8	0.3	Seabed
26" Surface Casing	627	214.8	WBM	1543	169	1.7	Seabed
13 5/8 " Production Casing	289	44.8	NWBM/ WBM	632	0	0.8	Surface (-1 m MSL)
9 5/8" Production Liner	645	49.0	NWBM/ WBM	123	0	1.8	Surface (-1 m MSL)
9 5/8" Open Hole	300	14.8	NWBM/ WBM	37	25/64 (if WBM)	1.8	Surface (-1 m MSL)
Totals		**377.1**	**-**	**2601.1**	**202.6**	**6.4**	**-**

When cuttings are discharged from the surface, the larger particles, representing about 90% of the mass of the solids, form a plume that settles quickly to the bottom (or until the plume entrains enough seawater to reach neutral buoyancy) (Hinwood et al, 1994). About 10% of the mass of the solids form another plume in the upper water column that drifts with prevailing currents away from the platform and is diluted rapidly in the receiving waters (Neff, 2005; 2010). There is a large body of knowledge indicating a discharge of cuttings with adhered fluids dilutes rapidly. These studies have found that that within 100 m of the discharge point, a drilling cuttings and fluid plume released at the surface will have diluted by a factor of at least 10,000, while Neff (2005) states that in well-mixed oceans waters (as is likely to be the case within the drilling area), drilling mud is diluted by more than 100-fold within 10 m of the discharge.

[35] The volumes quoted in this table are estimates only for the purpose of undertaking as assessment of the environmental impacts. Detailed design will be undertaken further and the assessment updated in relevant activity EPs.

Drill cuttings and fluid from the bottom-hole sections will be smaller in volume and will be discharged from the surface, resulting in a wider area of deposition, but a much smaller cuttings pile depth (IOGP, 2016). Research has shown that volumes of bottom hole cuttings sharply decrease with distance from the discharge point; however, the distribution of these cuttings is generally very patchy (Nedwed, 2006; Balcom, 2012).

Dispersion of the cuttings plume is influenced by two factors: fluid type (i.e. particle size) and ocean current speed. The case studies described in Neff (2005) used WBMs and surface current speeds of 0.15–0.3 m/s. As currents in the Offshore Project Area are ~0.25 m/s at the surface (Section 5.3.2), and WBMs are expected to cause the largest turbidity risk for the drilling program, the dispersion extents in Neff (2005) are considered representative.

Using the widely-accepted dilution factor of 10,000 (Neff, 2005), cuttings (and adhered fluids) are expected to reach 100 mg/L within 100 m of the MODU. Using a conservative ocean current speed of 0.1 m/s (which is below average current speeds in the Offshore Project Area), these discharges are expected to disperse to 100 mg/L within ~16 minutes.

Cement

Cement operations during drilling and well abandonment involve routine and non-routine discharges that can result in increased toxicity and turbidity in the water column. Modelling of cement discharges for another offshore project (BP Azerbaijan, 2013) was used because it provides an appropriate, but conservative, comparison of the potential extent of exposure from this activity.

In this study, two hours after the start of discharge, plume concentrations were determined to be between 5 and 50 ppm with the horizontal and vertical extents of the plume ~150 m and 10 m, respectively (BP Azerbaijan, 2013). Five hours after ceasing the discharge, modelling indicates that the plume will have dispersed to concentrations <5 ppm.

Completion Fluids

Completion fluids are generally brine with additives that can have toxicity such as biocides, oxygen scavengers, and MEG.

The volume of one wellbore and subsequent discharge volume would be ~400 m^3 (based on the designs of the proposed production wells). The change to water quality is expected to be localised; drilling discharges have previously been identified to dissipate no more than 100 m from the drilling site (Kinhill, 1998; IRCE, 2003). As this is an intermittent batch discharge any change in water quality will be short-term, due to rapid dilution from ocean currents.

Subsea Control Fluids

Subsea control fluids are water-based hydraulic fluids containing ~3% active ingredients. Modelling undertaken for another offshore drilling project indicates that a release of subsea control fluids during function testing is expected to reach a dilution of 3000 times within a maximum displacement plume of 98 m (BP Azerbaijan, 2013). Based on this information, it is expected concentrations of subsea control fluid would be ~10 ppm within 100 m of the BOP. Using a conservative ocean current speed of 0.1 m/s. fluids would be expected to travel 100 m (and thus reach concentrations of 10 ppm) in ~16 minutes.

Well Annular Fluids

The small volumes and non-instantaneous nature of the release of the well annular fluids is expected to result in rapid dilution to a no-effect concentration within meters of the release location.

Change in Sediment Quality

Toxins from chemical additives could potentially accumulate in benthic sediments, causing changes to sediment quality; and smothering and alteration of the seabed can impact physical characteristics of the seabed. Characteristics of sediment quality that may change include sediment structure, particle distribution, particle flow and chemical composition.

Impacts associated with routine and non-routine drilling discharges will be limited to the area surrounding the discharge source at the well locations and MODU, which are in approximately 900 m water and >375 km from shore.

Due to the dispersive nature of chemical discharges within the highly mixed offshore marine environment, toxins associated with surface discharges are not expected to reach marine sediments at concentrations that will result in notable changes to sediment quality.

Drill Cuttings and Fluids

The discharge of drill cuttings and unrecoverable fluids at the seabed during riserless top hole drilling results in a localised area of sediment deposition (known as a cuttings pile) near the well site. The dimensions of the cuttings pile depend on several factors, including volume and composition of cuttings, and oceanographic conditions at the discharge location. This seabed discharge has the greatest impact to sediment quality, as the solids tend to clump and settle rapidly around the discharge point (Neff, 2010). Accumulation of drill cuttings on the seafloor causes changes in physical properties and chemical composition of sediments and can include changes in sediment grain size and minerology, increase in concentrations of metals (e.g. barium), and forms of petroleum hydrocarbons (from the NWBM).

Several field studies are summarised in IAOGP (2016) for WBM discharged at the seafloor; and in all cases found that cuttings could be detected visually, or as elevated barium concentrations in benthic sediments within 10 – 150 m of the discharge, with a greater spread down-current. Maximum height of the cuttings pile was usually <50 cm. When cuttings were discharged from the MODU (i.e. at the surface), the increased depth allows small particles to disperse over greater distances, leaving thinner layers of cuttings near the well site – for example, WBM cuttings discharged from a single well in >300 m water may disperse so widely they may not be detectable in sediments at any distance from the MODU (IAOGP, 2016). However, when discharged to deeper water, NWBM cuttings may be deposited over a much larger area, to a horizontal distance of 500–1000 m from the discharge site (with concentrations decreasing with increasing distance) (IAOGP, 2016).

Therefore, a conservative exposure radius of 1000 m is assumed based on available research (IAOGP, 2016). This indicates there is the potential for smothering impacts and potential toxicity within an area of ~3.14 km^2 per well. For the proposed 20 wells plus 10 contingency wells, this gives a conservative total exposure area of approximately 90 km^2.

Other studies support these conclusions. Increases in turbidity at the seabed from drill cutting discharges during riserless drilling (i.e. direct discharge to the seabed) are expected to be highly localised and limited to within close proximity of the source (Neff, 2005).

Some components of NWBM are potentially bioaccumulative; though it is thought that the ability of organisms to oxidise and expel aromatics means that while hydrocarbons may be bioavailable, they are not expected to bioconcentrate (Melton et al. 2000). The physical and chemical persistence of drill cuttings on the seafloor depends on the energy of bottom waters and drilling substance reactivity and biodegradability. Most minerals in cuttings are stable and insoluble in water, and most of the organic chemicals in WBM and NWBM are biodegradable (IAOGP, 2016).

Cement

For cement discharges, the potential for toxicity is associated with the chemical additives that are added to cement mixtures; therefore, toxicity associated with the discharge of cement is limited to the subsurface release of cement (not discharge of dry cement).

Terrens et al. (1998) suggest that once the cement has hardened, the chemical constituents are locked into the hardened cement. Consequently, the extent of this hazard is limited to the waters directly adjacent to the displaced subsea cement (expected to be 10–50 m from the well) or pelagic waters within 150 m of the well (BP Azerbaijan, 2013).

Overspill of cement will permanently alter physical sediment properties, immediately adjacent to the well (within <50 m). The potential disturbance area is 0.007 km² per well; giving a total potential disturbance footprint of~0.21 km² for the proposed wells.

<u>*Change in Habitat*</u>

As a result of a change in sediment quality and/or water quality, further impacts to receptors may occur, which include a change in habitat resulting from smothering and alteration of the seabed, or exposure to toxins or chemicals in the drilling discharges.

Drill Cuttings and Fluids

Drill cuttings and cement discharges can physically smother seabed habitat and alter seabed substrate; and can also expose benthic habitats to chemical toxicity. Some components of WBM or NWBM are potentially bioaccumulative; though it's thought that the ability of organisms to oxidise and expel aromatics means that while hydrocarbons may be bioavailable, they are not expected to bioconcentrate (Melton et al., 2000).

An increase in NWBM in benthic sediments may lead to depletion of oxygen in surface layers, and potentially an increase in ammonia and sulphide leading to eutrophication. This can cause a change in or decrease in diversity of the benthic community (IAGOGP, 2016). Discharges of WBM and NWBM cuttings can affect mobile and sessile fauna mainly by burial, changes in bottom topography, or smothering by elevated water turbidity from suspended fine clay/barite particles.

The extent of the impact on the seafloor habitat depends on the type of cuttings and depth of water, but based on studies described above, a conservative impact radius of 1000 m is assumed. This indicates there is the potential for impacts to habitat over an area of ~3.14 km² per well.

Neff (2010) found that recolonisation of synthetic-based, mud-cuttings piles in cold-water marine environments began within one to two years of ceasing discharges, once the hydrocarbon component of the cutting piles biodegraded. Additional studies indicate that benthic infauna and epifauna recover relatively quickly, with substantial recovery in deepwater benthic communities within three to ten years (Jones, Gates and Lausen, 2012). Although these studies were associated with cold, deepwater environments, the recovery processes are expected to be similar. Although effectiveness and recovery time may differ, the species present in soft sediment are well adapted to changes in substrate, especially burrowing species (Kjeilen-Eilertsen, 2004); therefore, recovery is expected to be quicker.

Exposure duration is conservatively estimated at approximately 10 years. Consequently, a conservative recovery duration of ten years is used for evaluating the potential impacts and risks associated with this activity.

Cement

Most cement discharges that will occur during these activities will be at the seabed during cementing of the casing. The potential impacts of smothering from a surface release are expected to be significantly less, due to small volumes, intermittent nature of these discharges, and high potential for dispersal by ocean currents.

Once cement overspill from cementing activities hardens, the area directly adjacent to the well (10–50 m) will be altered, resulting in the destruction of seabed habitat within this area (Terrens et.al., 1998). This impact on soft sediment communities is not expected to affect the diversity or ecosystem function in this area and thus is only considered a localised impact.

Injury/Mortality to Marine Fauna

As a result of a change in water quality, further impacts to receptors may occur, which include injury or mortality to marine fauna resulting from an increase in turbidity or salinity, or exposure to toxins or chemicals in the drilling discharges.

Drill Cuttings and Fluids

The toxicity of widely used synthetic-based fluids (NWBM) is generally considered low, with WBMs inherently less toxic. Neff (2005) states that in well-mixed ocean waters (as is likely to be the case within the drilling area), drilling mud is diluted by more than 100-fold within 10 m of the discharge point, indicating that, following dilution, concentrations would be well below acute impact levels. This is further demonstrated by Melton *et al.* (2000), who used modelling to demonstrate that WBM and NWBM cuttings and solids within the water column fall below the United States Environment Protection Agency (USEPA) minimum 96-hour LC50 for drilling fluids within the first few metres of a surface discharge point.

Various other studies support the understanding that only organisms very close to the discharge point will be exposed to chemical concentrations above toxicity thresholds (Boehm et al., 2001; Kinhill, 1998; IRCE, 2003; SKM, 1996; Melton, 2000).

Although fish, marine mammals and marine reptiles may be present within receiving waters, it is unlikely that large numbers of individuals will occur within close proximity of the release point and therefore be exposed to PNEC. The expected volumes of discharges would not be significant enough to cause any notable impact to marine fauna, in the well-mixed marine environment.

Receptors Potentially Impacted

Routine and non-routine discharges of drilling fluids have the potential to impact on receptors which may be vulnerable to turbidity, toxicity and smothering. The receptors which have the potential to be impacted include:

- water quality
- sediment quality
- epifauna and infauna
- plankton
- fish
- marine mammals
- marine reptiles
- KEFs.

The presence of drill cuttings and fluids in the marine environment has the potential to disrupt ecological receptors that may be vulnerable to a physical and/or chemical change in water quality and sediment quality. The receptors at risk of impacts associated with the discharge of drilling-related fluids are those either in the water column for surface discharges, or in the benthic habitat where cuttings or other discharges are deposited directly on the seabed during riserless drilling or removal of the well cap.

Fish, Marine Reptiles and Marine Mammals

Any surface and subsurface drilling-related discharge types could impact species in the water column. The discharge types with the greatest potential to impact plankton are drill cuttings and fluids, cement, and completion fluid.

Jenkins and McKinnon (2006) reported that levels of suspended sediments >500 mg/L are likely to produce a measurable impact upon larvae of most fish species, and that levels of 100 mg/L will affect the larvae of some species if exposed for periods greater than 96 hours. This study also indicate that levels of 100 mg/L are likely to affect the larvae of several marine invertebrate species, and that fish eggs and larvae are more vulnerable to suspended sediments than older life stages.

Using the dilution assumptions described above (Neff, 2005; Melton et al. 2000), drilling cuttings and fluid discharge drops below the USEPA acute toxicity threshold of 10,000 ppm within 10 m of the discharge point; which is expected within 2 minutes, using conservative current speeds.

Therefore, fish larvae are not expected to be impacted. Any impact to fish larvae would be limited due to the small exposure footprint, high natural mortality of larvae, and dispersive characteristics of the open water in the Offshore Project Area.

Components of the WBM system generally have a low toxicity and are considered by OSPAR to pose little or no risk to the environment (PLONOR). If NWBM are used, returns will be treated to reduce OOC to <6.9%, which is aligned with World Bank guidelines and Woodside standards. The combination of low toxicity and rapid dilution of treated NWBMs discharged in association with drill cuttings are of little risk of direct toxicity to water-column biota (Neff et al., 2000).

The existing environment in the Offshore Project Area, where discharges will predominantly occur, is a well-mixed marine environment. As described in Section 5.4.4.4, the deep water and predominantly featureless, flat soft sediment seabed is of low complexity and low productivity in the Offshore Project Area and reduces the species diversity and richness of pelagic and demersal fish assemblages. Although sporadic upwelling events and increased primary productivity along the along the northern and southern boundaries of the Exmouth Plateau KEF may temporarily increase fish diversity, overall, fish fauna is not expected to be abundant in the Offshore Project Area, which is located >50 km from the periphery of the plateau. Continental slope fish communities off the west coast of Australia (including the Exmouth Plateau) have a low overall density, which appears to be linked to the low biological productivity of the overlying waters (Williams et al., 2001).

Four conservation-significant fish species (or habitat) may occur in the Offshore Project Area: Longfin mako, Shortfin mako, Great white shark and Giant manta ray. No threatened or migratory rays or sawfish are likely to occur in the Offshore Project Area, due to the absence of key habitat for these species.

While there are overlapping commercial fisheries, the only Commonwealth Fishery expected to be active within the vicinity of the Project is the NWSTF. However, given discharges are localised and temporary, no significant exposure to targeted commercial species is likely.

The presence of marine reptiles will be limited due to the distance from any significant breeding or foraging habitat.

As described in **Section 5.4.5.2**, the eastern edge of the Exmouth Plateau KEF overlaps a very small portion of the migration BIA for the pygmy blue whale, and nearly all of the KEF is overlapped by the distribution BIA for this species. Hence, it is possible that pygmy blue whales may occur across the Exmouth Plateau during the peak of the southbound migration in November to December, and the peak of the northbound migration in May to June. The Exmouth Plateau KEF does not overlap any other whale BIAs, marine turtle habitat critical to the survival of a species, or the foraging BIA for the whale shark. It is also believed that the deep waters above the gully/saddle on the inner edge of the plateau (the Montebello Saddle) are thought to be important for sperm whales that may feed in the region (based on 19th century whaling records; Townsend 1935). However, the location for discharge is not within the more significant areas, and presence is of marine mammals is likely to be limited to transient species at certain times of the year.

Therefore, only transient marine fauna, which includes fish, marine reptiles and marine mammals, would have the potential to be exposed to these discharges. Concentrations of drilling fluid would fall below acute toxicity thresholds (10,000 ppm) for species even more sensitive to changes in water quality, any impact to values and sensitivities would be negligible. Even with the conservative impact area set for this discharge, exposures to transient individuals would be limited and are expected only for short durations. The location of the discharge is within a KEF, however not near any of the features that are possibly significant for fish and marine mammals. Consequently, any potential impact is expected to be limited to transient individuals, with recoverable concentrations resulting in localised, short-term impacts on species.

On this basis the impacts to fish, from discharging drill cuttings and fluids during activities associated with Scarborough has not been evaluated further.

Table 7-64 outlines the potential impacts to receptors associated with routine and non-routine drilling discharges.

Table 7-64: Receptor/impact matrix after evaluation of context

	Receptor							
Impacts	**Water Quality**	**Sediment Quality**	**Plankton**	**Epifauna and Infauna**	**Fish**	**Marine Mammals**	**Marine Reptiles**	**KEFs**
Change in water quality	✓							
Change in sediment quality		✓						
Change in habitat								✓
Injury/mortality to fauna			✓	✓	X	X	X	

Detailed Impact Evaluation

<u>*Water Quality*</u>

The potential impact to water quality from drilling-related discharges is due to drill cuttings and fluids, cement, completion fluids, well annular fluids and subsea control fluid.

Drill Cuttings and Fluids

The routine and non-routine discharge of cuttings and adhered fluids from the surface will occur intermittently during drilling. Neff (2005) states that although the total volumes of muds and cuttings discharged to the ocean during the drilling of a well are large, the impacts in the water column environment are minimal, because discharges of small amounts of materials are intermittent.

When cuttings are discharged to the ocean, the larger particles, which represent ~90% of the mass of the mud solids, form a plume that settles quickly to the bottom (or until the plume entrains enough sea water to reach neutral buoyancy). Hinwood et al. (1994) indicate that larger particles of cuttings and adhered muds (90–95%) fall to the seabed close to the release point.

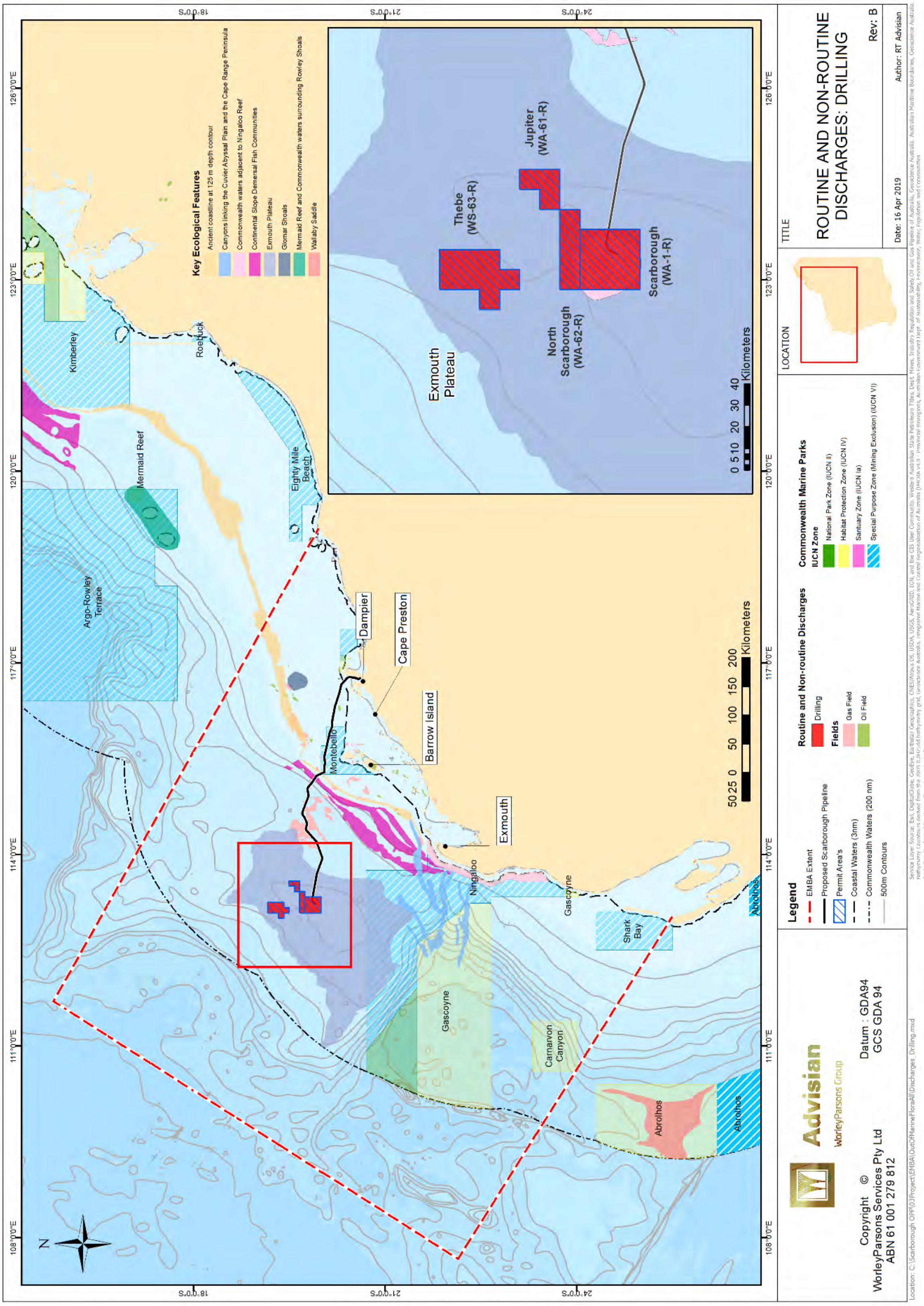
Other studies including Hinwood et. al (1994) and Neff (2005), which note that within 100 m of the discharge point, a drilling cuttings and fluid plume released at the surface will have diluted by a factor of at least 10,000; and that in well-mixed ocean waters (as is likely to be the case within the Project Area), drilling mud is diluted by more than 100-fold within 10 m of the discharge point.

Using the widely-accepted dilution factor of 10,000 (Neff, 2005), cuttings (and adhered fluids) are expected to reach 100 mg/L within 100 m of the MODU. Using a conservative ocean current speed of 0.1 m/s (which is well below average current speeds in the Offshore Project Area), these discharges are expected to disperse to 100 mg/L within ~16 minutes.

The area potentially impacted by turbidity was conservatively set at 1000 m from the MODU. That is, it is expected that 1000 m away from the MODU, turbidity concentrations are below impact thresholds (Figure 7-28).

Regarding toxicity, using the dilution assumptions described above (Neff, 2005; Melton et al., 2000), drilling cuttings and fluid discharge drops below the USEPA acute toxicity threshold of 10,000 ppm within 10 m of the discharge point; which is expected within two minutes, using conservative current speeds.

If NWBM are used, the cuttings tend to clump together in particles that rapidly settle to the seabed, suggesting that synthetic-based mud-coated cuttings tend to be less likely to increase water column turbidity (American Chemistry Council, 2006).



Note: MODU operations would not occur within all these areas simultaneously.

Figure 7-28: Predicted exposure area from drill cuttings and fluid discharges associated with MODU operations

Cement

Previous modelling (BP Azerbaijan, 2013) has shown low concentrations (<50 ppm) of cement particles within localised (~150 m horizontal and 10 m vertical) areas within two hours of discharge; and these concentrations reduce to <5 ppm approximately five hours after discharge ceases.

Because cement is expected to harden within a few hours, and because exposure to in-water concentrations are expected to be limited due to the rapid dispersion and dilution through the water column, the potential for acute or chronic effects on other receptors due to water quality is not discussed further.

Completion Fluids

The change to water quality due to discharges of completion fluid is expected to be localised; drilling discharges have previously been identified to dissipate no more than 100 m from the drilling site (Kinhill, 1998; IRCE, 2003).

Subsea Control Fluid

It is expected concentrations of subsea control fluid would be ~10 ppm within 100 m of the well heads (BP Azerbaijan, 2013). Using a conservative ocean current speed of 0.1 m/s, fluids would be expected to travel 100 m (and thus reach concentrations of 10 ppm) in ~16 minutes.

Given the small volumes associated with this discharge and limited exposure times due to rapid dilution, any potential impact to this aspect is expected to be localised and short-term.

Well Annular Fluids

The small volumes and non-instantaneous nature of the release of the well annular fluids is expected to result in rapid dilution to a no-effect concentration within meters of the release location.

Predicted Impact Summary

Studies have shown that subsea control fluid, completion fluid and well annular fluid have a predicted extent of <100 m (Kinhill, 1998; IRCE, 2003; BP Azerbaijan, 2013) which is less than that conservatively used to asses impact for drill cuttings and fluids (500 m). Therefore, these discharge types are not assessed separately for those receptors impacted by changes to water quality.

The extent of the area that is impacted by the discharge of drilling fluids and cuttings is conservatively estimated to be restricted to 1000 m for turbidity, and within 10 m for toxicity. Controls will be applied to manage this in accordance with Woodside internal requirements including:

- Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints, in order to lower potential toxicity of discharges.
- WBM will be used during drilling activities as the first preference. Where WBM cannot meet required technical specifications, NWBM may be used following technical justification.
- Bulk overboard discharge of NWBM is prohibited.
- Drill cuttings returned to the MODU will be processed to reduce oil on cuttings to < 6.9% by weight on wet cuttings (measured as a well average only including sections drilled with NWBM) prior to discharge, which is aligned with World Bank guidelines and Woodside standards.
- Drill cuttings returned to the MODU will be discharged below the waterline.

While the location of the discharge is within the Exmouth Plateau KEF, the localised and temporary nature of the discharge will not result in impacts to the values of the KEF, including the areas identified significant for fish and marine mammals.

Impacts from routine and non-routine discharges during drilling on water quality will be slight. Receptor sensitivity is low (low value, open water), and therefore Impact Significance Level is **Negligible (F).**

Sediment Quality

Subsea discharges that may affect sediment quality are drill cuttings and fluids, cement and subsea control fluids.

Drill Cuttings and Fluids

A change in sediment quality is an alteration in the condition of the sediment from its previous state which may occur due to discharges of both drilling cuttings and fluid. WBM has the potential to change sediment texture, in turn inhibiting the settlement of planktonic polychaete and mollusc larvae (Swan et al., 1994). The dilution of solid elements of the WBM into substrate largely depends on the energy level of the local environment and the 'mixing' that takes place but is expected to occur rapidly following release (especially with WBM).

WBM will be used during drilling activities as the first preference. Where WBM cannot meet required technical specifications, NWBM may be used following technical justification. Base fluids for NWBM (if required) are designed to be biodegradable in offshore marine sediments. Biodegradation can result in a low oxygen (anoxic) environment; however, this is dependent on the bioavailability of the base fluid. NWBM are designed to be low in toxicity and are not readily bioavailable.

Studies around the world also indicate biological effects from seabed communities associated with the deposition of NWBM cuttings are limited to ~500 m from a well site (Davis et.al., 1989; Daniels, 1998; Limia, 1996; Oliver and Fisher, 1999; Terrens et.al, 1998). Other studies found that in deeper water, NWBM may disperse horizontally from 500 -1000 m, therefore a conservative impact radius of 1000 m is assumed (Garcia et al. 2011; IAOGP, 2016). This indicates there is the potential for burial, smothering impacts and potential toxicity over an area of ~3.14 km² per well. For the proposed 20 plus 10 contingency wells, this gives a conservative total footprint of 94.2 km^2.

A study on the impacts of drilling in Bass Strait by Terrens et al. (1998) observed biological effects within 100 m of the drilling site shortly after drilling; recovery of seabed communities across the area were reported within four months. This study found that after 11 months NWBM was not detectable in sediments, indicating that recovery of the seabed is through a combination of dispersion and biodegradation. Neff (2010) found that recolonisation of synthetic-based, mud-cuttings piles in cold-water marine environments began within one to two years of ceasing discharges, once the hydrocarbon component of the cutting piles biodegraded. These studies were associated with cold, deepwater environments, but the recovery processes are expected to be similar.

In addition to degradation of drilling fluids, physical dispersion of drilling cuttings and fluids can be expected, given the influence of subsea currents in the area. Exposure duration is conservatively estimated at ~10 years. Consequently, a conservative recovery duration of ten years is used for evaluating the potential impacts and risks associated with this activity.

Cement

Overspill of cement will impact sediment quality immediately adjacent to the well once it hardens, permanently altering physical sediment properties. The potential disturbance area from discharge of cement is 0.007 km² per well; giving a total potential disturbance footprint of ~0.21 km² for the proposed wells.

Cement discharges may result in a localised alteration of seabed substrate within a habitat that is considered homogenous and not overly sensitive.

Subsea Control Fluids

Subsea control fluids have only ~3% active ingredients and are of relatively small volumes. Control fluids are expected to disperse rapidly throughout the water column adjacent to the seabed. Modelling for another offshore project indicates that subsea control fluid would dilute to below impact thresholds within 100 m from the BOP, and within 16 minutes (BP Azerbaijan, 2013). There is potential for some toxins in the control fluid to accumulate in the sediment, but due to small volumes and rapid dispersal, it is considered negligible.

Predicted Impact Summary

The marine sediment within the Project Area bare sandy/silt and calcareous ooze and is reflective of the broader sediment found on the Exmouth Plateau and the deep-water environment of the NWMR. Given the relatively small volumes and area of impact, the offshore location and the low sensitivity of marine sediment in the Project Area, biodiversity, ecological integrity, social amenities and human health will not be impacted. Sediments at the Offshore Project Location within the Exmouth Plateau KEF will be impacted, however this is very localised and a very small within are within the large expanse of the KEF which occupies an area of 49,310 km² (Exon & Willcox, 1980, cited in Falkner et al., 2009; Heap & Harris, 2008), and away from significant habitats identified within this KEF.

Impacts from routine and non-routine discharges during drilling on sediment quality will be slight. Receptor sensitivity is low (low value, open water), and therefore Impact Significance Level is **Negligible (F).**

Plankton

Any surface and subsurface drilling-related discharge types could impact plankton, as they are widely dispersed throughout the water column. The discharge types with the greatest potential to impact plankton are drill cuttings and fluids and cement.

Drill Cuttings and Fluid

Injury/mortality to planktonic species may occur due to a change in water quality following discharges of drill cuttings and fluids. Impacts to these organisms can be as a product of both physical and/or chemical alterations of water quality, predominantly in the water column. Impacts to zooplankton from turbidity are associated with variations in predator prey dynamics which favours planktonic feeders over visual feeders (Gophen, 2015), while impacts to phytoplankton occur due to decreases in available light, therefore reducing productivity (Dokulil, 1994). Surveys completed by ERM (2013) during the wet and dry season within the Exmouth Plateau in the vicinity of the Offshore Project Area found that there is very low planktonic productivity in the region.

Jenkins and McKinnon (2006) reported that levels of suspended sediments greater than 500 mg/L are likely to produce a measurable impact upon larvae of most fish species, and that levels of 100 mg/L will affect the larvae of some species if exposed for periods greater than 96 hours. Jenkins and McKinnon (2006) also indicated that levels of 100 mg/L may affect the larvae of several marine invertebrate species, and that fish eggs and larvae are more vulnerable to suspended sediments than older life stages. Note, any impact to fish larvae is expected to be limited due to high natural mortality rates (McGurk, 1986), intermittent exposure, and the dispersive characteristics of the open water in the vicinity of the wells.

As dilution estimates (e.g. Hinwood et al., 1994; Neff, 2005) suggest suspended sediment concentrations caused by the discharge of drill cuttings will be well below the levels required to cause an effect on fish or invertebrate larvae (i.e. predicted levels are well below a 96-hour exposure at 100 mg/L, or instantaneous 500 mg/L exposure), minimal impact to larvae, or other marine fauna (pelagic fish, cetaceans, seabirds), is expected from the discharge of drill cuttings. Neff (2010) explains that the lack of toxicity and low bioaccumulation potential of the drilling muds means that the effects of the discharges are highly localised and are not expected to spread through the food web (of which planktonic species are the basis).

The toxicity of widely used NWBMs to zooplankton is considered low, with acute toxicity >10,000 ppm (Vik, Dempsey and Nesgård, 1996). As WBMs are inherently less toxic, the impact threshold for NADF was used for this evaluation. In well-mixed ocean waters (as is likely to be the case within the Project Area), drilling mud is diluted by more than 100-fold within 10 m of the discharge point, indicating that, following dilution, concentrations would be well below acute impact levels Neff (2005).

This is supported by Melton et al. (2000), who used modelling to demonstrate that WBM and NADF cuttings and solids within the water column fall below the United States Environment Protection Agency (USEPA) minimum 96-hour LC50 for drilling fluids within the first few metres of a surface discharge point (using a current speed of 0.17 m/s, which is slower than currents in the region).

Knowing that drilling fluids dilute 100-fold within 10 m of the discharge, and assuming the concentration of drilling fluids upon release is 100% (or 1,000,000 ppm), it is expected that concentrations of drilling fluid would fall below acute toxicity thresholds (10,000 ppm) within 10 m from the MODU. Using a conservative ocean current speed of 0.1 m/s, these discharges are expected to disperse to below acute toxicity thresholds within two minutes.

Therefore, only organisms very close to the discharge point would be exposed to chemical concentrations above the acute toxicity threshold, and only for a very short period. Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints, lowering the potential consequence of discharge.

Predicted Impact Summary

As discussed in Section 5.5.1, primary productivity appears to be enhanced along the northern and southern boundaries of the Exmouth Plateau, and along the adjacent shelf edge to the east of the plateau (Brewer et al., 2007). As described by Falkner et al. (2009), the centre of the plateau is characterised by moderate seafloor temperatures and low primary productivity. Therefore, while the discharge is to occur within the Exmouth Plateau KEF, this is at a significant distance (>150 km) from the periphery of the plateau that has been identified as having increased productivity (Brewer et al., 2007; Falkner et al., 2009).

Consequently, it is not anticipated that this discharge will result in impacts to the ecological integrity of the KEF. Any reductions of existing populations are expected to rapidly recover once the activity ceases, given the high levels of natural mortality and a rapid replacement rate (Houde and Zastrow, 1993; ITOPF, 2011; Tang et al., 2014).

The open nature of the Scarborough Project Area and associated environmental conditions (i.e. windy, strong currents, etc.), the content of and dispersive nature of drilling muds within the marine environment (Hindwood, 1994; Neff, 2005) and the high population replenishment of these organisms, it is expected that impacts to plankton species will be limited to within 500 m of the discharge point and return to previous conditions within a relatively short period of time.

Impacts from routine and non-routine discharges during drilling will have no lasting effect on plankton. Receptor sensitivity is low (low value, open water), and therefore Impact Significance Level of routine and non-routine discharges during drilling on plankton is **Negligible (F).**

Epifauna and Infauna

Subsea discharges that may affect epifauna and infauna are drill cuttings and fluids and cement.

Drill Cuttings and Fluids

The main environmental disturbance from discharging drilling cuttings and fluids is associated with the smothering and burial of sessile benthic and epibenthic fauna (Hinwood et al. 1994). Sessile benthic organisms located below the cuttings pile are likely to be smothered, while demersal species may be temporarily displaced from the area within which cuttings discharges accumulate. Ecological impacts are predicted when sediment deposition is equal to or greater than 6.5 mm (in thickness) (IOGP, 2016); confined to within a few hundred metres of the well location. Low levels of sediment deposition away from the immediate area of the well site may occur and would represent a thin layer of settled drill cuttings which will likely be naturally reworked into surface sediment layers through bioturbation (USEPA, 2000) and will not be of a significant impact.

Many studies have shown that the effects on seabed fauna and flora from the discharge of drilling cuttings with water based muds are subtle, although the presence of drill-fluids in the seabed close to the drilling location (<500 m) can usually be detected chemically (e.g. Cranmer, 1988; Neff et al., 1989; Hyland et al., 1994; Daan & Mulder, 1996; Currie & Isaacs, 2005; OSPAR, 2009; Bakke et al., 2013).

Ecological impacts are not expected for mobile benthic fauna such as crabs and shrimps or pelagic and demersal fish given their mobility (IOGP, 2016). Balcom et al. (2012) concluded that impacts associated with the discharge of cuttings and base fluids (including (NWBMs) are minimal, with impacts highly localised to the area of the discharge. Changes to benthic communities are normally not severe. These impacts are highly localised with short-term recovery that may include changes in community composition with the replacement of infauna species that are hypoxia-tolerant (IOGP, 2016). Recovery of affected benthic infauna, epifauna and demersal communities is expected to occur quickly, given the short duration of sediment deposition and the widely represented benthic and demersal community composition.

Jones et al. (2006, 2012) compared pre- and post-drilling ROV surveys and documented physical smothering effects from WBM cuttings within 100 m of the well. Outside the area of smothering, fine sediment was visible on the seafloor up to at least 250 m from the well. After three years, there was significant removal of cuttings particularly in the areas with relatively low initial deposition (Jones et al., 2012). The area impacted by complete cuttings cover had reduced from 90 m to 40 m from the drilling location, and faunal density within 100 m of the well had increased considerably and was no longer significantly different from conditions further away.

Studies around the world also indicate biological effects from seabed communities associated with the deposition of NWBM cuttings are limited to ~500 m from a well site (Davis et.al., 1989; Daniels, 1998; Limia, 1996; Oliver and Fisher, 1999; Terrens et.al, 1998). Other studies found that in deeper water, NWBM may disperse horizontally from 500 -1000 m, therefore a conservative impact radius of 1000 m is assumed (Garcia et al. 2011; IAOGP, 2016). This indicates there is the potential for smothering impacts and potential toxicity over an area of ~3.14 km² per well.

Additional studies indicate that benthic infauna and epifauna recover relatively quickly, with substantial recovery in deepwater benthic communities within three to ten years (Jones, Gates and Lausen, 2012). These studies were associated with cold, deepwater environments, but the recovery processes are expected to be similar. Although effectiveness and recovery time may differ, the species present in soft sediment are well adapted to changes in substrate, especially burrowing species (Ref. 107); therefore, recovery is expected to be quicker. Within the Offshore Project Area and surrounding Exmouth Plateau environment, epifauna and infauna species dominate fauna abundance and are sparse and uniform in presence. Fauna include motile organisms such as shrimps, small burrowing worms, sea cucumbers, sea stars and crustaceans. There are no EPBC listed threatened benthic communities or species in the Offshore Project Area or within the footprint of the discharge location (ERM, 2013a).

The IAOGP paper (2016) found that the abundance and diversity of sessile and slow-moving megafauna could be reduced within the 50-100 m of cuttings discharge to the seafloor; and mobile megafauna were usually unaffected. Effects were the greatest at water depths >600 m. However, this study also found that in most cases, there is substantial recovery in benthic communities within one to a few years.

In general, research suggests that any smothering impacts within the Project Area will be limited to 1000 m from the well site, and full recovery is expected. Given the dispersive and inert nature of WBMs, the localised settling of NWBMs, the sparse and uniform nature of epifauna and infauna species in the Offshore Project Area and the lack of EPBC listed species, the impacts to epifauna and infauna species are expected to be limited.

Cement

Once cement overspill from cementing activities hardens, the area directly adjacent to the well (10–50 m) will be altered, resulting in the destruction of seabed habitat within this area; affecting any resident infauna and epifauna (Terrens et.al, 1998). The potential disturbance area is 0.007 km² per well. For the 20 proposed wells plus 10 contingency wells (estimate only) for Scarborough Project, results in a potential disturbance footprint of ~0.21 km².

The potential impacts of smothering from a surface release are expected to be significantly less, due to small volumes, intermittent nature of these discharges, and high potential for dispersal by ocean currents. This impact on soft sediment communities is not expected to affect the diversity or ecosystem function in this area.

Predicted Impact Summary

Impacts to benthic species are predicted to be locally restricted, temporary during drilling activities, and localised to within a conservative radius of 1000 m of each proposed well (giving a potential disturbance footprint of ~3.14 km² per well; and a total 94.2 km^2 for the proposed 20 wells plus 10 contingency wells).

Impacts from routine and non-routine discharges during drilling will have no lasting effect on epifauna and infauna. Receptor sensitivity is low (low value, homogenous), and therefore Impact Significance Level of routine and non-routine discharges during drilling on epifauna and infauna is **Negligible (F).**

KEFs

Discharges that may affect KEFs are drill cuttings and fluids and cement.

Although the Project Area lies within three KEFs, only one intersects with the Offshore Project Area where drilling activities will be undertaken, which is the Exmouth Plateau. Values associated with this KEF relate to attributes of demersal habitats and features, and it is likely to be an important area of biodiversity, as it provides an extended area offshore for communities adapted to depths of around 1000 m.

Drill Cuttings and Fluids

Drill cuttings and cement discharges can physically smother seabed habitat and alter seabed substrate; and can also expose benthic habitats to chemical toxicity. As described above, impacts associated with discharges of drilling fluid and cuttings will be limited to the area surrounding the discharge source. During riserless drilling, direct deposition of drilling fluids and cuttings on the seabed will impact a relatively small area of the KEF when compared to its overall size (49,310 km²).

A conservative impact radius of 1000 m is assumed indicating there is the potential for burial, smothering impacts and potential toxicity over an area of ~3.14 km² per well.

This gives a total footprint of 94.2 km² for approximately 20 proposed wells plus 10 as contingency. This represents a very small fraction of the Exmouth Plateau KEF (49310 km²).

During surface discharges, due to the dispersive nature of chemical discharges within the highly mixed offshore marine environment, fluids and cuttings are expected to disperse rapidly within the water column and settle on the seabed in low volumes and chemical concentrations.

Cement

The proposed wells are located within a single KEF (Exmouth Plateau) and have the potential to be exposed to smothering and alteration of the seabed. Benthic habitat is expected to comprise soft sediment infauna communities that are widespread and homogenous in the region and is considered a unique seafloor feature with ecological properties of regional significance, which apply to both the benthic and pelagic habitats within the feature (DSEWPC, 2012).

Terrens et.al (1998) indicated that cement from upper-hole sections displaced to the seabed may affect the seabed around the well to a radius of ~10 m to 50 m from the well, resulting in the potential for disturbance of 0.007 km² per well. For the proposed wells for Scarborough Project, results in a potential disturbance footprint of 0.21 km²; which represents a very small fraction of the whole KEF.

Cement discharges may result in a localised alteration of seabed substrate within a habitat that is considered homogenous and not overly sensitive.

Summary

Predicted Impact Summary

The only KEF which may be impacted is the Exmouth Plateau. Given the small amount of representative habitat within the KEF that will be impact from drilling discharges (0.0013% of the KEF), no impacts to marine ecosystem functioning or integrity of the KEF are expected.

Physical habitat modification is recognised as a pressure 'of less concern' in the Marine Bioregional Plan for the NorthWest Marine Region (DSEWPC, 2012). In addition, the activity is not proposed to take place in any AMPS, and as such there are no specific principles, objectives and values to be considered.

Impacts from routine and non-routine discharges during drilling will have a slight effect on KEFs. Receptor sensitivity is high (high value), and therefore Impact Significance Level of routine and non-routine discharges during drilling on KEFs is **Minor (D).**

7.1.13.3 Demonstration of Acceptability

Impact acceptability has been demonstrated for all impacts based on evaluation against the criteria described in Section 6.4.4. The outcomes of this determination are summarised below.

Principles of ESD

The Scarborough development is consistent with the relevant principles of ESD:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making

The Scarborough development will result in no significant impacts to receptors identified as potentially affected. Significant impact definitions:

- Water quality

- To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.

- Sediment quality:
  - To not substantially change sediment quality, which may adversely impact biodiversity, ecological integrity, social amenity or human.
- Plankton:
  - To not have a substantial adverse effect on a population of plankton including its life cycle and spatial distribution.
- Epifauna and infauna:
  - To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.
- KEFs:
  - To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results.

Internal Context

The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards.

With respect to routine and non-routine discharges during drilling, Woodside will implement its internal requirement:

- Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints.

External Context

During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on affected receptors from routine and non-routine discharges during drilling.

Other requirements

The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES.

Acceptable Levels of Impact

Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013)).

Statement of Acceptability

Based on an assessment against the defined acceptable levels, the impacts on affected receptors from Routine and Non-Routine Discharge: Drilling is considered acceptable, given that:

- the activity is aligned with the relevant principles of ESD.

  - These discharges will result in localised and temporary changes in water quality, such as increased toxicity and turbidity, which can potentially impact marine fauna.
  - The predominantly dispersive and non-toxic nature of drilling-related discharges, the location of the Offshore Project Area in deep (~930 m), highly mixed and relatively sparse open water, and lack of sensitive receptors mean that the discharges are localised.
  - These discharges will result in localised changes in sediment quality, including increased toxicity and smothering and alteration of the seabed, which can potentially impact sediment quality, epifauna and infauna and the Exmouth Plateau KEF.
  - Multiple studies of drill cuttings and fluid discharges found that depending on mud type, water depth and current, water quality would fall below acute toxicity thresholds within 10 m of the discharge point; within about two minutes. Sediment quality was found to potentially be impacted by smothering and toxicity over a horizontal distance of <1000 m from the discharge. Therefore, a conservative radius of 1000 m has been set, and a conservative recovery duration of ten years has been used for evaluating the potential impacts and risks associated with this activity. This conservative disturbance footprint of ~3.14 km^2 per well gives a total of 94.2 km^2 for the proposed 20 wells plus 10 contingency wells.
  - Cement overspill will permanently alter the seabed immediately adjacent (<50 m) to the wells, giving a total estimated disturbance footprint of 0.007 km^2 per well (or 0.21 km^2 for the proposed 20 wells plus 10 contingency wells). As benthic habitat is expected to comprise soft sediment infauna communities that are widespread and homogenous in the region, cement discharges are not expected to affect the diversity or ecosystem function in this region.
  - Therefore, the total disturbance footprint of the worst-case drilling-related discharges type (drill cuttings and fluids) is 94.02 km^2; for the proposed wells. This represents a small fraction of the Exmouth Plateau KEF, which is the only KEF intersected by the Offshore Project Area.
- the proposed controls are consistent with Woodside’s internal policies, procedures and standards
- feedback from stakeholders has been taken into consideration
- legislative requirements/industry standards have been adopted
- the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices
- the predicted level of impact is at or below the defined acceptable levels for all receptors.

Environmental Performance Outcomes

To manage impacts to affected receptors to at or below the defined acceptable levels the following EPO have been applied:

EPO 13.1: Undertake Scarborough Drilling activities in a manner that does not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.

EPO 13.2: Undertake Scarborough Drilling activities in a manner that prevents substantial change in sediment quality, which may adversely impact biodiversity, ecological integrity, social amenity or human.

EPO 13.3: Undertake Scarborough Drilling activities in a manner that prevents a substantial adverse effect on a population of plankton including its life cycle and spatial distribution.

EPO 13.4: Undertake Scarborough Drilling activities in a manner that does not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.

EPO 13.5: Undertake Scarborough Drilling activities in a manner that prevents significant impacts on the values of the Exmouth Plateau KEF.

EPO 13.6: Undertake Scarborough Drilling activities in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results.

7.1.13.4 Summary of the Impact Assessment

Table 7-65 provides a summary of the risk assessment and acceptability for impacts from drilling discharges on receptors.

Table 7-65: Summary of impacts, key management controls, impact significance ratings, acceptability and EPOs for drilling discharges

Receptor	Impact	Environmental Performance Outcome	Adopted control(s)	Receptor sensitivity level	Magnitude	Impact Significance level	Acceptability
Sediment Quality	Change in sediment quality	**EPO 13.1:** Undertake Scarborough Drilling activities in a manner that does not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. **EPO 13.2:** Undertake Scarborough Drilling activities in a manner that prevents substantial change in sediment quality, which may adversely impact biodiversity, ecological integrity, social amenity or human. **EPO 13.3:** Undertake Scarborough Drilling activities in a manner that prevents a substantial adverse effect on a population of	**CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **CM19:** WBM will be used during drilling activities as the first preference. Where WBM cannot meet required technical specifications, NWBM may be used following technical justification. **CM20:** Bulk overboard discharge of NWBM is prohibited.	Low value (open water)	Slight	Negligible (F)	Acceptable
Water Quality	Change in water quality			Low value (open water)	Slight	Negligible (F)	Acceptable
Plankton	Injury/ mortality to fauna			Low value (open water)	No lasting effect	Negligible (F)	Acceptable
Epifauna and Infauna	Injury/ mortality to fauna			Low value (open water)	No lasting effect	Negligible (F)	Acceptable

Receptor	Impact	Environmental Performance Outcome	Adopted control(s)	Receptor sensitivity level	Magnitude	Impact Significance level	Acceptability
KEFs	Change in habitat	plankton including its life cycle and spatial distribution. **EPO 13.4:** Undertake Scarborough Drilling activities in a manner that does not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 13.5:** Undertake Scarborough Drilling activities in a manner that prevents significant impacts on the values of the Exmouth Plateau KEF. **EPO 13.6:** Undertake Scarborough Drilling activities in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results.	**CM21:** Drill cuttings returned to the MODU will be processed to reduce oil on cuttings to < 6.9% by weight on wet cuttings (measured as a well average only including sections drilled with NWBM) prior to discharge. **CM22:** Drill cuttings returned to the MODU will be discharged below the waterline.	High value habitat	Slight	Minor (D)	Acceptable

7.2 Unplanned Aspects

7.2.1 Unplanned Discharge: Chemicals

7.2.1.1 Sources of the Aspect

Activities and facilities associated with Scarborough may result in the unplanned discharge of chemicals to the marine environment during:

- drilling operations
- FPU operations.
- vessel operations
- MODU operations
- ROV operations
- helicopter operations

Vessel, MODU, FPU and ROV Operations

Chemicals are used during vessel, MODU, FPU and ROV activities for a variety of purposes within the Offshore Project Area and Trunkline Project Area. FPU, vessels and ROVs may be used during all phases of Scarborough in both the Offshore Project Area and Trunkline Project Area, whereas MODUs will only be used during drilling phases in the Offshore Project Area. Chemicals that will be used and may inadvertently be released may include:

- non-process chemicals (maintenance and cleaning chemicals)
- non-process hydrocarbons - i.e. hydraulic fluids used in machinery (including cranes, winches, ROVs), small volumes of fuel
- drilling fluids/muds/cement
- operational process chemicals.

<u>Non-Process Chemicals</u>

Non-process chemicals, such as wash chemicals, cleaning chemicals, maintenance and solvents are generally held onboard in low quantities (typically <50 L containers) and are located within chemical cabinets or bunded storage areas on the vessels and MODU. Spills of these chemicals may result from human error or damage to a chemical container during handling. Spills are generally captured by the drain system and routed to a holding tank for treatment or disposal onshore. In the event that a spill is not contained on deck or within a bunded area, there would be a release to the marine environment of up to 50 L.

<u>Non-Process Hydrocarbons</u>

Non-process hydrocarbons (hydraulic fluids) are used in hydraulic-powered machinery such as winches, cranes and ROVs, and are hydrocarbon-based with added chemical component additives. Unplanned discharges are predominantly due to failure of hydraulic hoses or minor leaks from process components, or spills during periodic refuelling of hydraulic hoses. Spills or leaks from hydraulic hoses are usually very small volumes (~1 L) and are typically contained within a bunded or drained area under the equipment mounted on deck. These small on-deck spills would be very unlikely to make it into the marine environment. A burst hydraulic hose on an extended crane could potentially result in hydraulic fluid being sprayed in a fine jet out over the water. However, this would only result in a small volume (~25 L) being released, due to the small capacity of hydraulic hoses.

ROVs are typically used during subsea works for surveying during drilling or production activities and during installation of the trunkline. ROVs may also be used for ongoing subsea inspection and maintenance activities of the wells and trunkline. ROV hydraulic lines are exposed to the marine environment and have the potential to be pinched through Operator error or may become caught resulting in minor hydraulic leaks (typically <20 L, based on capacity of hydraulic hoses).

Hydraulic fluids are medium oils of light to moderate viscosity and have a relatively rapid spreading rate and will dissipate quickly, particularly in high sea states. Lubricating oils may also be held onboard, typically stored with the non-process chemicals and held in low quantities. These hydrocarbons are more viscous, and so in the event of an unplanned discharge the spreading rate of a slick of these oils would be slightly slower.

Small volumes of MDO or aviation fuel could be released to the deck and/or the marine environment during bunkering, due to a partial or total failure of bulk transfer hoses. The credible volumes of such releases would be in the order of <200 L for MDO; and <100 L for aviation fuel (during helicopter refuelling).

Operational Process Chemicals

Operational process chemicals (such as MEG) stored on the FPU are generally kept in larger quantities compared to vessels or MODUs, subject to the requirement of the ongoing production from the wells. Typically, process chemicals are stored in dedicated tanks such as ISO tanks, which may be permanently plumbed in. Tank volumes for chemical storage can be up to 40 m³. In the event of damage or corrosion of the tank, the worst-case credible chemical spill scenario could result in the entire tank volume being discharged and entering the marine environment.

Bulk transfer of process chemicals may occur via hoses directly from a supply vessel to the dedicated chemical storage on the FPU. Unplanned discharge may occur through Operator error or failure to follow procedures during bulk transfer. Typical spill volumes during transfer via hoses is less than 0.2 m³, based on the volume of the transfer hose and the immediate shutoff of the pumps by personnel involved in the bulk transfer process. However, the worst-case credible spill scenario during transfer could result in up to 8 m³ of discharge of chemical to the deck and/or into the marine environment, based on partial or total failure of a bulk transfer hose or fittings, combined with a failure in procedure to shutoff fuel pumps, for a period of up to five minutes. This unlikely scenario represents a complete failure of the bulk transfer hose combined with a failure to follow procedures (which require transfer activities to be monitored), coupled with a failure to immediately shut off pumps.

The behaviour of process chemicals when released in the marine environment is dependent on their physical and chemical properties, that is their tendency to evaporate, float, dissolve in the water column, or sink to the seabed. The potential risk to receptors arises from the resulting ecotoxicity, bioaccumulation, and biodegradation of chemicals.

Drilling Operations

Drilling Fluids/Muds

Unplanned discharge of drilling muds or fluids may occur during events such as:

- bulk transfer of mud or base oil from the supply vessel to the MODU
- failure of the slip joint packer
- loss of chemical container during transfer from the supply vessel to the MODU.

A support vessel will undertake bulk transfer of mud or base oil to the MODU, if and when required. Failure of a transfer hose or fittings during a transfer or backload, as a result of an integrity or fatigue issue, could result in a spill of mud or base oil to either the bunded deck or into the marine environment.

The most likely spill volume of mud is likely to be less than 0.2 m³ based on the volume of the transfer hose and the immediate shutoff of the pumps by personnel involved in the bulk transfer process. However, the worst-case credible spill scenario could result in up to 8 m³ of mud being discharged. This scenario represents a complete failure of the bulk transfer hose combined with a failure to follow procedures requiring transfer activities to be monitored, coupled with a failure to immediately shut off pumps (e.g. mud pumped through a failed transfer hose for a period of about five minutes).

The slip joint packer enables compensation for the dynamic movement of the MODU (heave) in relation to the static location of the BOP. A partial or total failure of the slip joint packer could result in a loss of mud to the marine environment. The likely causes of this failure include a loss of pressure in the pneumatic (primary) system combined with loss of pressure in the back up (hydraulic) system.

Catastrophic sequential failure of both slip joint packers (pneumatic and hydraulic) would trigger the alarm and result in a loss of the volume of fluid above the slip joint (conservatively 1.5 m³) plus the volume of fluid lost in the one minute (maximum) taken to shut down the pumps. At a flow rate of 1000 gallons per minute this volume would equate to an additional 3.8 m³. In total, it is expected that this catastrophic failure would result in a loss of 5.3 m³.

Failure of either of the slip joint packers at a rate not large enough to trigger the alarms could result in an undetected loss of 20 bbl (3 m³) maximum assuming a loss rate of 10 bbl/hr and that MODU personnel would likely walk past the moon pool at least every two hours.

Loss of a drilling chemical container or drum during transfer from the supply vessel to the MODU may occur due to crane operator error or machinery failure. The maximum container that could be lost is an intermediate Bulk Container (IBC) which can hold 1 m³ of chemicals. In the event that an IBC or drum is lost to the marine environment and cannot be recovered the contents will discharge, either immediately or over a period depending on the damage to the drum or container.

<u>Cement</u>

Bulk cement is transferred as powder from the supply vessel to the MODU prior to being mixed into a slurry in the cement unit. Additives are required to form a cement slurry; these are transferred to the MODU in drums from the supply vessel to the MODU. Unplanned discharge to the marine environment may occur due to crane operator error or machinery failure resulting in loss of a drum of cement additive, which cannot be recovered. Cement additives are typically stored in drums <100 litres.

7.2.1.2 Impact or Risk

Risk events resulting from unplanned chemical discharges have the potential to result in the following impacts:

- change in water quality
- change in sediment quality
- injury or mortality to marine fauna.

<u>Change in Water Quality</u>

Unplanned discharges of non-process chemicals and hydrocarbons may decrease the water quality in the immediate vicinity of the release and occur at all locations over Scarborough and throughout the life of the project. Only small volumes (<0.2 m³) are anticipated, resulting in very short-term impacts to water quality, and limited to the immediate release location.

The worst-case scenario of an unplanned release of operational process chemicals during FPU operation is 8 m³ during bulk transfer, or 40 m³ for the loss of an entire ISO tank. The worst-case drilling fluid or cement unplanned discharge is 8 m³ which could occur during bulk transfer from the supply vessel to the MODU during drilling. These discharges would be to the sea surface and would rapidly dilute through mixing by surface currents and wave action.

Change in Sediment Quality

Impacts associated with unplanned chemical releases will be limited to the area surrounding the discharge source of the vessel, MODU, FPU or ROV. Non-process chemicals or hydrocarbons may inadvertently be discharged by vessels or ROVS in shallower waters, closer to shorelines, however volumes would be <0.2 m³.

Larger volumes of process chemicals could potentially be released from the FPU or MODU, however, while entrainment of some of the discharge may occur during the mixing by currents and wave action, flocculation and settlement of particles through approximately 900 m water depth is not expected to occur. Chemicals toxins associated with surface discharges are not expected to reach marine sediments at concentrations that will result in notable changes to sediment quality. Therefore, impacts to sediment quality resulting from unplanned discharges of chemicals are not evaluated further.

Injury or Mortality to Marine Fauna

As a result of a change in water quality, further impacts to receptors may occur, which include injury or mortality to marine fauna resulting from exposure to toxins in the released chemicals. Given that surface discharges are rapidly dispersed, and subsea discharges (from ROVs) would be of very small volumes, the marine fauna at risk is limited to surface dwelling species.

Receptors at Risk

Risk events resulting from unplanned discharge of chemicals has the potential to impact the following receptors:

- water quality
- plankton
- fish
- marine mammals
- marine reptiles.

Given the impacts are restricted to surface waters in the immediate vicinity of the discharge, benthic species have not been considered. On this basis, the KEFs within the Project Area have not been identified at risk as the values associated with these KEFs related to the attributes of the demersal habitats and features.

Plankton, Fish and Marine Mammals and Reptiles

Potential impacts to plankton from an accidental chemical discharge and the associated impact to water quality may include acute toxicity resulting in mortality of planktonic organisms. Given the rapid turnover of plankton communities (UNEP, 1985) and nature and scale of the credible releases, these impacts will be short-lived. Similarly, impacts to fish are expected to be of no lasting effect, as fish species are mobile and not restricted to the area affected by an unplanned chemical discharge. As such the impact to plankton and fish have not been evaluated further.

Other ecological receptors that may be present in surface waters that have the potential to be impacted by unplanned discharges of chemicals include transient marine mammals and marine reptiles. These organisms could be exposed to toxins and other chemicals present in the discharge which could potentially result in injury or mortality such as temporary irritation of sensitive membranes such as the eyes, mouth, and digestive system.

Physical coating of marine fauna by and sub-lethal or lethal effects from toxic chemicals, is considered unlikely given the expected low volumes of discharge, short exposure times and the rapid dilution and dispersion of the chemical discharge once entering the marine environment. Impacts to marine fauna will be limited to temporary irritation of sensitive membranes. The largest discharge volume potential (40 m^3) is from the FPU location, which is in a highly mixed, open water environment approximately 900 m deep.

Although distribution of some marine fauna species extends to the deeper, offshore waters of the Offshore Project Area, no known aggregation areas occur and therefore the likelihood of individuals being exposed to unplanned chemical releases at concentrations high enough to impact are considered negligible and not evaluated further.

Table 7-66 outlines the potential impacts to receptors associated with unplanned chemical releases.

Table 7-66: Receptor/impact matrix

	Receptor				
Impacts	***Water Quality***	***Plankton***	***Fish***	***Marine Mammal***	***Marine Reptiles***
Change in water quality	✓				
Injury/mortality to fauna		X	X	X	X

Detailed Risk Evaluation

Water Quality

The open water location and relatively small volumes of chemicals released will result in rapid dilution close to the source of discharge and is expected to have no lasting effects.

Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints. Woodside will implement waste management procedures to ensure the safe handling and transportation, segregation, storage and appropriate classification of wastes, to reduce the likelihood of an unplanned discharge.

Given the occasional nature of unplanned chemical discharge, the small volumes, and the offshore location for Scarborough, the change to water quality resulting from unplanned discharge of chemicals will not be substantial, and likelihood of the risk event occurring is **Highly Unlikely**.

Risk events from unplanned chemical discharges can lead to impacts on receptors, which will be slight. Receptor sensitivity is low, leading to a **Negligible (F**) risk consequence, and likelihood of the risk event occurring is **Highly Unlikely**. The risk of unplanned chemical discharge from Scarborough have therefore been evaluated as **Low**.

Demonstration of Acceptability

Risk acceptability has been demonstrated for all risks based on evaluation against the criteria described in Section 6.4.4. The outcomes of this determination are summarised below.

Principles of ESD

The Scarborough development is consistent with the relevant principles of ESD:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making

The Scarborough development will result in no significant impacts to receptors identified as potentially affected. Significant impact definitions:

- Water quality
  - To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.

Internal Context

The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards.

With respect to impacts related to an unplanned release of chemicals, Woodside will implement its internal requirement:

- Chemicals must be selected with the lowest practicable environmental impacts and risks subject to technical constraints.

External Context

During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on affected receptors from unplanned discharge of chemicals.

Other requirements

The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES.

Acceptable Levels of Impact

Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013)).

Statement of Acceptability

Based on an assessment against the defined acceptable levels, the impacts on affected receptors from Unplanned Discharge of chemicals is considered acceptable, given that:

- the activity is aligned with the relevant principles of ESD.

    - No lasting effect on any receptors are expected; and overall, the impacts of an unplanned chemical release are localised and temporary.
    - Due to small volumes (<0.2 m³), impacts will be very localised to the discharge point, and not result in a substantial adverse effect on a population of the species.
    - Physical coating of marine fauna by and sub-lethal or lethal effects from toxic chemicals is considered unlikely, given the expected low volumes of discharge, short exposure times and the rapid dilution and dispersion of the chemical discharge once entering the marine environment.
    - Reduction in water quality will be localised and short-term.
- the proposed controls are consistent with Woodside's internal policies, procedures and standards
- feedback from stakeholders has been taken into consideration
- legislative requirements/industry standards have been adopted
- the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices
- the predicted level of impact is at or below the defined acceptable levels for all receptors.

Environmental Performance Outcomes

To manage impacts to affected receptors to at or below the defined acceptable levels the following EPO have been applied:

EPO 14.1: Undertake Scarborough development in a manner that will prevent an unplanned release of chemicals to the marine environment resulting in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.

7.2.1.3 *Summary of the Risk Assessment*

Table 7-67 provides a summary of the risk assessment and acceptability for impacts from unplanned chemical releases on receptors.

Table 7-67: Summary of risk assessment for unplanned chemical releases

Receptor	Risk	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity	Risk Consequence	Likelihood	Risk rating	Acceptability
Water quality	Change in water quality	**EPO 14.1**: Undertake Scarborough development in a manner that will prevent an unplanned release of chemicals to the marine environment resulting in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health	**CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **CM15:** Implementation of waste management procedures which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.	Low value (open water)	Negligible (F)	Highly Unlikely	Low	Acceptable

7.2.2 Unplanned Discharge: Solid Waste

Non-hazardous solid wastes including paper, plastics and packaging, and hazardous solid wastes such as batteries, aerosols, contaminated materials and process wastes may be unintentionally released into the marine environment. Release of these waste streams may occur because of overfull and/or uncovered bins, incorrectly disposed items or spills during transfers of waste.

7.2.2.1 Sources of the Aspect

Activities and facilities associated with Scarborough may result in the accidental release of hazardous and non-hazardous waste into the marine environment. Unplanned discharges may occur during:

- vessel operations
- MODU operations
- FPU operations.

Vessel, MODU and FPU Operations

On board vessels, MODUs and FPUs, solid materials will be used, and waste created. These wastes are handled and stored onboard and are transported to shore to be disposed of at licensed onshore facilities. Waste material may be lost to the marine environment because of:

- human error
- incorrect or inappropriate waste storage
- mechanical failure or breakdown of equipment used to store wastes
- inadequate hazardous waste management.

Material and waste onboard vessels, MODUs or FPUs may be hazardous or non-hazardous. Hazardous wastes are defined as an object or substance that displays toxic, explosive, poisonous or flammable characteristics, which can no longer fulfil its intended use and requires disposal. Hazardous waste that may be accidentally lost to the marine environment includes:

- batteries, aerosol cans, empty paint cans, printer cartridges, fluorescent tubes
- hydrocarbon-contaminated materials (e.g. pipe dope, oily rags, oil filters)
- contaminated personal protective equipment (PPE)
- hazardous process waste.

Non-hazardous wastes are those which are not classified as hazardous (as per the characteristics described above) but which, if released into the marine environment, may pose a threat to receptors through smothering, entanglement or ingestion. Non-hazardous materials and wastes will be disposed of onshore, however they could be accidentally dropped or lost overboard due to overfull bins or crane operator error. Non-hazardous materials and wastes include:

- paper and cardboard
- wooden pallets
- scrap steel, metal, aluminium, cans, etc
- glass
- plastics.

Unplanned release of hazardous and non-hazardous solid wastes could occur during general servicing and routine operations throughout all phases of Scarborough. Due to the potential for a wide range of hazardous and non-hazardous waste materials and substances, predicting exposure area is difficult. Solid waste dispersion varies and is dependent on the buoyancy of the material. For example, metal waste is likely to sink to the seafloor near the release site, whereas plastic items may float and disperse to greater distances away from the source. In general, incidents of accidental releases of waste are expected to be remote, and quantities small.

7.2.2.2 Impact or Risk

Risk events resulting from an accidental release of waste from vessels or facilities to the marine environment has the potential to result in the following impacts:

- change in water quality
- injury/mortality to fauna
- change in aesthetic values.

Change in Water Quality

Hazardous solid wastes such as paint cans, oily rags, etc., can cause localised contamination of the water through a release of toxins and chemicals.

Injury/Mortality to Fauna

The unplanned discharge of solid wastes can result in the mortality to fauna either through contamination or physical injury depending on the nature of the waste.

Change in Aesthetic Values

The accidental release of waste has the potential to result in unfavourable aesthetic conditions through the visual presence of waste within coastal or shoreline environments. The Project Area lies within Commonwealth waters between 5.5 km to 375 km from the coast. Any accidental release of waste has a low likelihood of reaching coastal and shoreline environments where tourism, recreation, settlements and indigenous sites are located. Aesthetic impacts to social receptors are therefore not expected and are not evaluated further.

Receptors at Risk

Risk events resulting from an unplanned discharge of hazardous/non-hazardous solid waste chemicals has the potential to impact the following receptors through contamination and physical injury:

- water quality
- fish
- seabirds and migratory shorebirds
- marine mammals
- marine reptiles.

The receptors within the environment that may be affected by the unplanned discharge of solid wastes are outlined in Table 7-68.

Table 7-68: Receptor/impact matrix

Impacts	Receptor				
	Water Quality	Fish	Seabirds and Migratory Shorebirds	Marine Mammals	Marine Reptiles
Change in water quality	✓				
Injury/mortality to fauna		✓	✓	✓	✓

Detailed Risk Evaluation

<u>Water Quality</u>

Unplanned hazardous waste discharges, such as contaminated materials, may leach into the marine environment causing localised increases in toxicity. The level of impact to water quality will depend on the nature of the discharge, however the volumes of the hazardous components are generally low (such as residual paint in cans or oily rags). Modelling of small volumes of hydrocarbons such as this (e.g. Shell, 2010) indicate rapid dilution in the offshore marine environment, with impacts limited to the immediate vicinity of the contamination.

Given likely small volumes, and occasional nature of the event, these would result in temporary and highly localised changes to the water quality.

The water quality within the Project Area is typical of an unpolluted tropical offshore environment.

Given the small volumes, occasional nature of the events and the offshore location, biodiversity, ecological integrity, social amenities and human health will not be impacted.

Vessel operations undertaken as part of the activity will adhere to various Marine Orders, as appropriate to vessel class, including Marine Order 95 – Garbage. Woodside will ensure that waste management procedures are implemented which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated. These controls will reduce the likelihood of an unplanned discharge occurring and ensure compliance with EPOs.

Risk events from unplanned discharge of solid waste can lead to impacts on receptors, which will be slight. Receptor sensitivity is low for water quality, leading to a **Negligible (F)** risk consequence. The likelihood of an event occurring is **Remote**, and the risk of an unplanned discharge of solid waste has therefore been evaluated as **Low**.

<u>*Seabirds and Migratory Shorebirds, Fish, Marine Reptiles and Marine Mammals*</u>

Marine fauna, including fish, seabirds and shorebirds, marine mammals and marine reptiles may be impacted through ingestion or entanglement of waste or through exposure to toxic chemicals.

Ingestion or entanglement of marine fauna has the potential for physical harm which may limit feeding/foraging behaviours and thus can result in mortalities. Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris was listed as a key threatening process under the EPBC Act in August 2003 (DoEE, 2018). The Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE, 2018) identifies EPBC Act-listed species for which there are scientifically documented adverse impacts resulting from marine debris. C&R Consulting (2009) reported that between 1974 and 2008, a total of 77 individuals of a variety of different species had been subject to impacts associated with entanglement in, or ingestion of, plastic debris within Australian waters. Of the reported species, humpback whales, marine turtles, Australian pelicans and a range of cormorant species dominate records. For these records, the sources of waste are unknown. Marine turtles and seabirds in particular may be at risk from plastics which may cause entanglement or be mistaken for food (e.g. DoEE, 2018; DoEE, 2017) and ingested causing damage to internal tissues and potentially preventing feeding activities. In the worst instance this could have a lethal affect to an individual. Marine debris has been identified as threat in the Recovery Plan for Marine Turtles in Australia (2017–2027).

Receptor presence in the Project Area is greatest within the Trunkline Project Area, however some species' distribution is known to extend to the Offshore Project Area approximately 375 km offshore. Seabirds and marine turtles, which are fauna susceptible to impacts from non-hazardous solid wastes, are found in greater densities and numbers in proximity to islands and shorelines where breeding, nesting and foraging habitat occurs. Therefore, it is considered unlikely that they will occupy the Offshore Project Area and if they do, it is likely to be in a temporary and transient nature. Fish, which are susceptible to impacts from minor volumes of hazardous contamination, are unlikely to be found in large numbers on the sea surface of the Offshore Project Area or the Trunkline Project Area. Activities in the Trunkline Project Area where solid wastes could be unintentionally released into the marine environmental will be limited to trunkline installation and survey activities, both of which are short-term, reducing the likelihood of an interaction between solid waste and marine fauna occurring.

Impacts to species including fish, birds, marine mammals and marine reptiles from the unplanned discharge of solid waste is unlikely given low occurrence of unplanned discharges and the location of the activities at significant distance from sensitive habitats. Significant impacts are unlikely to occur at an individual level and will not occur at a population level, nor result in the decrease of the quality of the habitat such that the extent of these species is likely to decline.

While, the threat abatement plan for impacts of marine debris on vertebrate marine life does not list explicit management actions for non-related industries (DEWHA, 2009), management controls outlined in Table 7-69 will reduce the risk of unplanned discharge of solid waste. These include:

- Project vessels compliant with Marine Order 95 (pollution prevention – Garbage).
- Implementation of waste management procedures which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.

For construction and IMR activities occurring within the Montebello Marine Park, and adjacent to the Dampier Marine Park, the short-term and transient nature of vessel movement will not be inconsistent with the objective of the Multiple Use Zone (VI) to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species, or for the Habitat Protection Zone (IV) to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while allowing activities that do not harm or cause destruction to seafloor habitats. The values identified for both these AMPs includes biologically important areas for foraging habitat for whale sharks, breeding and foraging habitat for seabirds, internesting, foraging, mating and nesting habitat for marine turtles, and migratory pathways for humpback whales. These values will not be impacted given the significant distance from sensitive locations.

Risk events from unplanned discharge of solid waste can lead to impacts on receptors, which will be slight. Receptor sensitivity is high for seabirds and migratory shorebirds, fish, marine reptiles and marine mammals, leading to a **Minor (D)** risk consequence for fauna. The likelihood of an event occurring is **Remote**, and the risk of an unplanned discharge of solid waste has therefore been evaluated as **Low** for all receptors.

7.2.2.3 Demonstration of Acceptability

Impact acceptability has been demonstrated for all impacts based on evaluation against the criteria described in Section 6.4.4. The outcomes of this determination are summarised below.

Principles of ESD

The Scarborough development is consistent with the relevant principles of ESD:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making

The Scarborough development will result in no significant impacts to receptors identified as potentially affected. Significant impact definitions:

- Water quality
    - To not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.
- Seabirds and Migratory Shorebirds:
    - To not have a substantial adverse effect on a population of seabirds or shorebirds, or the spatial distribution of the population.
    - To not substantially modify, destroy or isolate an area of important habitat for a migratory species.
    - To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.
- Fish
    - To not have a substantial adverse effect on a population of fish, or the spatial distribution of the population.
- Marine Mammals:
    - To not have a substantial adverse effect on a population of marine mammals or the spatial distribution of the population.
    - To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.
    - To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.
- Marine Reptiles:
    - To not have a substantial adverse effect on a population of marine reptiles or the spatial distribution of the population
    - To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat, such that an adverse impact on marine ecosystem functioning or integrity results

- To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

Internal Context

The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards.

External Context

During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on affected receptors from displacement of other users:

Other requirements

The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES; specifically:

- Vessel operations undertaken as a part of this activity will adhere to various Marine Orders, as appropriate to vessel class, including Marine Order 95 – Garbage.
- Requirements of the Threat Abatement Plan for the impacts of marine debris on vertebrates (DoEE, 2018) and the Recovery Plan for Marine Turtles in Australia (DoEE, 2017) have been met.

Acceptable Levels of Impact

Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013)).

Statement of Acceptability

Based on an assessment against the defined acceptable levels, the impacts on affected receptors from Unplanned Discharge of chemicals is considered acceptable, given that:

- the activity is aligned with the relevant principles of ESD.
  - The location of the activity is at significant distance from sensitive habitats.
  - Unplanned discharges will be occasional and of small volumes.
  - Management controls will be in place to minimise the incidence of unplanned discharges.
- the proposed controls are consistent with Woodside's internal policies, procedures and standards
- feedback from stakeholders has been taken into consideration
- legislative requirements/industry standards have been adopted
- the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices:
  - Threat Abatement Plan for impacts of marine debris on vertebrate life
- the predicted level of impact is at or below the defined acceptable levels for all receptors.

Environmental Performance Outcomes

To manage impacts to affected receptors to at or below the defined acceptable levels the following EPO have been applied:

EPO 15.1: Undertake Scarborough development in a manner that will prevent an unplanned release of solid waste to the marine environment resulting in a significant impact

EPO 15.2: Undertake Scarborough development in a manner that will prevent a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.

EPO 15.3: Undertake Scarborough development in a manner that will prevent a substantial adverse effect on a population of seabirds or shorebirds, or the spatial distribution of the population.

EPO 15.4: Undertake Scarborough development in a manner that will prevent a substantial adverse effect on a population of fish or the spatial distribution of the population.

EPO 15.5: Undertake Scarborough development in a manner that will prevent a substantial adverse effect on a population of marine mammals or the spatial distribution of the population.

EPO 15.6: Undertake Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.

EPO 15.7: Undertake Scarborough development in a manner that will prevent a substantial adverse effect on a population of marine reptiles or the spatial distribution of the population.

EPO 15.8: Undertake Scarborough development in a manner that will not substantially modify, destroy or isolate an area of important habitat for a migratory species.

EPO 15.9: Undertake Scarborough development in a manner that will not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

7.2.2.4 Summary of the Risk Assessment

Table 7-69 provides a summary of the risk assessment and acceptability for risks from unplanned discharge of solid waste to receptors.

Table 7-69: Summary of risk assessment for the unplanned discharge of solid waste

Receptor	Risk	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity	Risk Consequence	Likelihood	Risk rating	Acceptability
Water Quality	Change in water quality	**EPO 15.1:** Undertake Scarborough development in a manner that will prevent an unplanned release of solid waste to the marine environment resulting in a significant impact **EPO 15.2:** Undertake Scarborough development in a manner that will prevent a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health. **EPO 15.3:** Undertake Scarborough development in a manner that will prevent a substantial adverse effect on a population of seabirds or shorebirds, or the spatial distribution of the population. **EPO 15.4:** Undertake Scarborough development in a manner that will prevent a substantial adverse effect on a population of fish, or the spatial distribution of the population. **EPO 15.5:** Undertake Scarborough development in a manner that will prevent a substantial adverse effect on a population of marine mammals or the spatial distribution of the population. **EPO 15.6:** Undertake Scarborough development in a manner that will not modify,	**CM23:** Project vessels compliant with Marine Order 95 (pollution prevention – Garbage). **CM15:** Implementation of waste management procedures which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.	Low value (open water)	Negligible (F)	Remote	Low	Acceptable
Migratory Shorebirds and Seabirds	Injury/mortality to fauna			High value species	Minor (D)	Remote	Low	Acceptable
Fish				High value species	Minor (D)	Remote	Low	Acceptable
Marine Mammals				High value species	Minor (D)	Remote	Low	Acceptable
Marine Reptiles				High value species	Minor (D)	Remote	Low	Acceptable

Receptor	Risk	Environmental Performance Outcome	Adopted Control(s)	Receptor sensitivity	Risk Consequence	Likelihood	Risk rating	Acceptability
		destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 15.7:** Undertake Scarborough development in a manner that will prevent a substantial adverse effect on a population of marine reptiles or the spatial distribution of the population. **EPO 15.8:** Undertake Scarborough development in a manner that will not substantially modify, destroy or isolate an area of important habitat for a migratory species. **EPO 15.9:** Undertake Scarborough development in a manner that will not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.						

7.2.3 Physical Presence (Unplanned): Seabed Disturbance

Unplanned seabed disturbance includes physical changes to the existing seabed substrate and any features that may be present such as benthic habitats.

7.2.3.1 Sources of the Aspect

Throughout the proposed offshore Scarborough Project, unplanned disturbance to the seabed may occur during:

- MODU operations
- vessel operations
- FPU operations
- Trunkline installation.

During these activities, the primary cause for unplanned seabed disturbance is through dropped objects from the FPU, MODU or vessels. Additional unplanned disturbance to the seabed may occur from anchor drag during MODU operations, or from placement of infrastructure, specifically the trunkline, outside of the proposed footprint.

Dropped Objects

While not intended, objects such as tools and equipment may be dropped from the MODU, FPU, support, survey and installation vessels. Operator error, bad weather events or failure of equipment may lead to the object loss. Potential dropped objects from during each of the key activities, along with the associated footprint, are identified in Table 7-70.

Table 7-70: Potential dropped objects from vessels, FPU or MODU during Scarborough activities

Activity	Dropped object	Maximum footprint (m²)
Geotechnical surveys	Survey/sampling equipment Small tools	15
Drilling operations	Casing Small tools/equipment Container/IBC	15
Installation of the FPU and subsea infrastructure	Subsea infrastructure lost during installation activities, such as: • manifold • anchor • umbilical termination assembly • riser • flowline end termination. Small tools/equipment	280
Trunkline installation and stabilisation	Small tools/equipment	10

Activity	Dropped object	Maximum footprint (m²)
Removal of subsea infrastructure	Subsea infrastructure lost during removal activities, such as: • manifold • anchor • umbilical termination assembly • riser • flowline end termination. Small tools/equipment	280
MODU operations	Small tools/equipment Container/IBC	10
Vessel operations	Small tools/equipment Container/IBC	10
FPU operations	Small tools/equipment Container/IBC	10

Anchor Drag

During drilling, the MODU will be secured on station by mooring lines, as designed by the mooring analysis, which are held in place by anchors deployed to the seabed. High energy weather events such as cyclones, occurring while the MODU is on station, can lead to excessive loads on the mooring lines, resulting in failure (either anchor(s) dragging or mooring lines parting). A failure of mooring integrity may lead to the mooring lines and anchors attached to the MODU being trailed across the seabed. If mooring failure is sufficient, the MODU may move off station, increasing the likelihood of anchor drag across the seafloor.

Industry statistics from the North Sea show that a single mooring line failure for MODUs is the most common failure mechanism (33 × 10-4 per line per year), followed by a double mooring line failure (11 × 10-4 per line per year) (Petroleumstilsynet, 2014). Note that single and double mooring line failures do not typically result in the loss of station keeping. If partial or complete mooring failures are sufficient to result in a loss of station keeping, industry experience indicates that MODUs may drift considerable distances from their initial position (Offshore: Risk & Technology Consulting Inc., 2002). Partial mooring failures leading to a loss of station keeping resulted in smaller MODU displacements, due to the remaining anchors dragging along the seabed when compared to complete mooring failures; complete mooring failures resulted in a freely drifting MODU (Offshore: Risk & Technology Consulting Inc., 2002).

Seabed disturbance area size from anchor drag will depend on the extent of the drag.

Positioning of trunkline outside proposed footprint

The identified route for the trunkline, has been determined based on consideration of seabed features including sensitive environmental areas and existing infrastructure. During installation, the vessels will manage positioning.

7.2.3.2 Impact or Risk

Risk events resulting from unplanned disturbance to the seabed have the potential to result in the following impacts:

- change in habitat
- change in water quality.

Which may have the following further impacts:

- injury and/or mortality to fauna.

Change in Habitat

Dropped objects and anchor drag on the seabed are likely to result in localised sedimentation and modification of seabed habitat, which will be permanent if the object cannot be recovered or anchor drag has impacted hard bottom substrate.

Change in Water Quality

Change in water quality, through sediment disturbance and turbidity, is temporary and limited to when the dropped object touches down on the seabed or when the anchor is being dragged. After a period, the suspended sediments settle and the turbidity in the water column returns to pre-disturbance levels. Given the scenarios that would lead to unplanned seabed disturbance are unlikely to be of scale to cause resuspension of sediments, and the location of the activity, this impact has not been evaluated further.

Injury and/or Mortality to Marine Fauna

As a result of a change in water quality and change in habitat, further impacts to receptors may occur, which include injury or mortality to marine fauna resulting from an increase in turbidity, or physical contact with equipment or infrastructure being installed.

Given that a change to water quality is unlikely, the only receptors that would potentially be at risk of unplanned seabed disturbance are bottom dwelling species including epifauna and infauna. Risks to other marine fauna have not been evaluated further.

Receptors at Risk

Receptors at risk of events resulting from unplanned seabed disturbance are outlined in Table 7-71.

Table 7-71: Receptor/impact matrix

	Receptor				
Impacts	Water Quality	Epifauna and Infauna	Plankton	Fish	KEFs
Change in water quality	X				
Change in habitat		✓		X	✓
Injury or mortality		✓	X	X	✓

Detailed Risk Evaluation

Epifauna and Infauna

Benthic communities, including epifauna and infauna may be impacted by the dropped objects (identified in Table 7-70), the drag of anchors on the seabed or the incorrect positioning of infrastructure specifically the trunkline. Disturbance to the seabed can alter the physical seabed habitat conditions, resulting in community changes. If not recovered, dropped objects may result in the permanent loss of a small area under the object.

The seafloor in the Offshore Project Area is characterised by sparse marine life dominated by motile organisms (ERM, 2013). Such motile organisms include shrimp, sea cucumbers, demersal fish and small, burrowing worms and crustaceans. Benthic communities in the Offshore Project Area are representative of the Exmouth Plateau and of deepwater soft sediment habitats reported in the region (e.g. BHP Billiton, 2004; Woodside, 2005; Woodside, 2006; Brewer et al., 2007; RPS, 2011; Woodside, 2013; Apache, 2013). No threatened or migratory species, or ecological communities (as defined under the EPBC Act), were identified in the benthic communities during studies completed in the Offshore Project Area (ERM, 2013a) or trunkline route (Advisian, 2019a, Advisian 2019b).

Dropped objects within the Offshore Project Area have a maximum footprint of 280 m². Habitat within the Offshore Project Area may be reduced to the extent of the dropped object's footprint. If anchor drag occurs, habitat impact will span the extent of the drag area. Both risks lead to a localised change in communities; however, substantial adverse effect is not anticipated, given the sparse marine life that are well represented elsewhere in the region.

The infauna recorded along the trunkline route is sparse. While most of the sampled seabed comprised soft sediments, geotechnical data indicated the presence of a rock pinnacle field in about 300 m depth. It is unclear what the rock pinnacles are constructed from. However, the structures provide habitat for a diverse suite of epifaunal species that are not usually found on the soft sediments. The proposed trunkline route avoids such features, and if it was positioned incorrectly, there is a risk of impact to these communities. This however is not anticipated due to controls in place to manage the trunkline positioning.

Given generally sparse benthic communities in the Project Area, no threatened or migratory species, or ecological communities were identified and those epifauna and infauna communities observed are likely to be well represented elsewhere in the region, impacts are expected to be restricted to a localised proportion of epifauna and infauna communities.

Dampier Marine Park is a hotspot for sponge diversity, however there are no identified values for epifauna and infauna related to the Montebello Marine Park.

Risk events from unplanned seabed disturbance can lead to impacts on receptors, which will be slight. Receptor sensitivity for epifauna and infauna is low, leading to a **Negligible (F**) risk consequence. As the likelihood of the risk event occurring is **Highly Unlikely**, the risk of unplanned seabed disturbance from Scarborough have been evaluated as **Low**.

KEFs

Three KEFs overlap the Offshore Project Area and Trunkline Project Area; the Exmouth Plateau, Ancient Coastline at 125 m Depth and Continental Slope Demersal Fish Community. Non-routine seabed disturbance from dropped objects or anchor drag will occur within these KEFs and may lead to change in habitat.

The Trunkline Project Area and Offshore Project Area lie within the Exmouth Plateau KEF. The KEF occupies an area of 49,310 km² within water depths of 800–4000 m (Exon & Willcox, 1980, cited in Falkner et al., 2009; Heap & Harris, 2008). The Trunkline Project Area enters the KEF about 240 km offshore within water depths of ~1100 m, extending about 60 km into the KEF before reaching the Offshore Project Area. The Trunkline Project Area and Offshore Project Area occupy a relatively small portion of the entire KEF, and any unplanned seabed disturbance will be an even smaller portion within it. Physical habitat modification is not listed as a potential concern for this KEF.

A relatively small portion of the Ancient Coastline at 125 m Depth KEF overlaps the Trunkline Project Area. This intersect is located about 360 km offshore, north-north-west of the Montebello Islands. Any dropped object will be an even smaller portion within the KEF. Impact will not occur to the hard substrates of the KEF. Physical habitat modification is not listed as a potential concern for this KEF.

The Continental Slope Demersal Fish Community is recognised as a KEF because of its biodiversity values, including high levels of endemism (DotE, 2018b). The Trunkline Project Area intersects a small portion of the KEF, across one of its thinnest points throughout its distribution. Most of the KEF area lies further south, extending about 240 km from the Trunkline Project Area to just past the tip of the Exmouth Peninsula, splitting from a single corridor into three. Physical habitat modification is listed as a potential concern for this KEF (DotE, 2018b). However, any potential impact to the KEF from habitat disturbance is restricted to the footprint of the dropped object and will be highly localised.

The non-routine seabed disturbance within the KEFs is highly localised and relatively small compared to the size of the KEFs. There will be no substantial adverse effect on the KEF or the communities within it.

KEFs form an essential part of the Marine Park network. There are no KEFs in the Dampier Marine Park. The Montebello Marine Park contains one KEF: ancient coastline at 125 m depth contour.

Risk events from unplanned seabed disturbance can lead to impacts on receptors, which will be slight. Receptor sensitivity for KEF is high, leading to a **Minor (D)** risk consequence. As the likelihood of the risk event occurring is **Highly Unlikely**, the risk of unplanned seabed disturbance from Scarborough have been evaluated as **Moderate** for KEFs.

7.2.3.3 Demonstration of Acceptability

Risk acceptability has been demonstrated for all impacts based on evaluation against the criteria described in Section 6.4.4. The outcomes of this determination are summarised below.

Principles of ESD

The Scarborough development is consistent with the relevant principles of ESD:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making

The Scarborough development will result in no significant impacts to receptors identified as potentially affected. Significant impact definitions:

- Epifauna and infauna
  - To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact occurs to marine ecosystem functioning or integrity results.
- KEFs:
  - To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact occurs to marine ecosystem functioning or integrity in an area defined as a KEF results.

Internal Context

The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards.

External Context

During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on affected receptors from displacement of other users:

Other requirements

The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES.

Acceptable Levels of Impact

Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013)).

Statement of Acceptability

Based on an assessment against the defined acceptable levels, the impacts on affected receptors from Unplanned Seabed Disturbance is considered acceptable, given that:

- the activity is aligned with the relevant principles of ESD.
    - Unplanned seabed disturbance from Scarborough will result in localised impacts or disturbance to benthic communities but is not expected to affect the population or local ecosystem function.
    - No threatened or migratory species, or ecological communities were identified, and those epifauna and infauna communities observed are likely to be well represented elsewhere in the region.
    - Unplanned seabed disturbance within the KEFs would be highly localised and relatively small compared to the size of the KEF.
- the proposed controls are consistent with Woodside's internal policies, procedures and standards
- feedback from stakeholders has been taken into consideration
- legislative requirements/industry standards have been adopted
- the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices.
- the predicted level of impact is at or below the defined acceptable levels for all receptors.

Environmental Performance Outcomes

To manage impacts to affected receptors to at or below the defined acceptable levels the following EPO have been applied:

EPO 16.1: Undertake the Scarborough development in a manner which prevents unplanned seabed disturbance.

EPO 16.2 Undertake the Scarborough development in a manner which does not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.

EPO 16.3: Undertake the Scarborough development in a manner which does not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results.

7.2.3.4 Summary of the Risk Assessment

Table 7-72 provides a summary of the risk assessment and acceptability for risks from unplanned seabed disturbance on receptors.

Table 7-72: Summary of risks assessment for unplanned seabed disturbance

<table>
<tr><th>Receptor</th><th>Risk</th><th>Environmental Performance Outcome</th><th>Adopted Control(s)</th><th>Receptor sensitivity</th><th>Risk Consequence</th><th>Likelihood</th><th>Risk rating</th><th>Acceptability</th></tr>
<tr><td>Epifauna and infauna</td><td>Change in habitat
Injury/ mortality to fauna</td><td rowspan="2">EPO 16.1: Undertake the Scarborough development in a manner which prevents unplanned seabed disturbance.
EPO 16.2: Undertake the Scarborough development in a manner which does not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.
EPO 16.3: Undertake the Scarborough development in a manner which does not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in an area defined as a Key Ecological Feature results.</td><td rowspan="2">CM12: Infrastructure will be positioned on the seabed within design footprint to reduce seabed disturbance</td><td>Low value</td><td>Negligible (F)</td><td>Highly Unlikely</td><td>Low</td><td>Acceptable</td></tr>
<tr><td>KEFs</td><td>Change in habitat</td><td>High Value</td><td>Minor (D)</td><td>Highly Unlikely</td><td>Moderate</td><td>Acceptable</td></tr>
</table>

7.2.4 Physical Presence (Unplanned): IMS

Non-indigenous Marine Species (NIMS) are species which are translocated into a recipient environment where they are not historically found. Invasive marine species (IMS) are NIMS that are translocated into a marine environment where they have the potential to establish and disrupt the natural balance of marine ecosystems.

Not all NIMS that are translocated to a receiving location will survive through to establishment and only a subset of these species that become established will impact on social/cultural, human health, economic and/or environmental values are considered IMS (DoF, 2016).

Example IMS could include a variety of different plants and animals such as: fish, seastars, crabs, molluscs, worms, sponges, microscopic dinoflagellates, shellfish, algae, bacteria and viruses.

7.2.4.1 Sources of the Aspect

Activities that have the potential to result in the unplanned establishment of IMS in the Project Area are:

- installation of FPU
- installation of subsea infrastructure
- trunkline installation
- MODU operations
- vessel operations.

Installation of FPU, Trunkline, Subsea Infrastructure, and MODU and Vessel Operations

There is a potential for NIMS to be translocated into the marine environment of the Project Area during installation, commissioning and support operations. Vessels will be used throughout all stages of Scarborough. Vessels used may be mobilised from within or outside Australian waters. Vessels has been identified as the single most important vector for the translocation of NIMS (DAFF 2010). All vessels are inherently subject to some level of marine fouling. Organisms attach to the vessel hull, particularly in areas where organisms can find a good surface (e.g. seams, strainers and unpainted surfaces) or where turbulence is lowest (e.g. niches, sea chests, etc.). Previously, ballast water discharges from commercial vessels were thought to be the most significant mechanism for the translocation of NIMS, however recent research suggests that more NIMS translocations are attributable to vessel biofouling more than any other mechanism (Hewitt et al., 1999, 2004; Mineur et al., 2007).

NIMS could establish in the Project Area, and potentially become IMS, under several scenarios:

- NIMS could be present as biofouling on vessels/MODUs or infrastructure and be translocated to the Project Area and transferred directly to the seafloor or subsea structures where they establish.
- NIMS could be present in ballast and translocated to the Project Area where they are transferred directly to the seafloor or subsea structures where they establish.

If NIMS are translocated to the Project Area via the mechanisms above, they could be subsequently transferred between project vessels/MODUs/infrastructure and by extension to Commonwealth marine environments beyond the Project Area (including ports)[36].

[36] While introduction of NIMS to ports has potential to lead to establishment of IMS in State waters, impacts to receptors in State waters are considered out of scope of this OPP.

Ballast Water

Ballast water is carried in ships' ballast tanks to improve stability, balance and trim. It is taken up or discharged when cargo is unloaded or loaded, or when a ship needs extra stability in bad weather. When a ship takes on ballast water, plants and animals that live in the ocean are also picked up. Ballast water exchange involves the substitution of water in ship's ballast tanks using either a sequential, flow-through, dilution or other exchange method, potentially releasing ballast water at a location foreign to where it was taken on. Ballasting and de-ballasting a vessel is essential in achieving maximum vessel performance through a range of functions such as vessel propulsion, stress reduction on ship hull, stability and manoeuvrability, among others.

Release of unmanaged ballast water could transfer a range of NIMS into a recipient environment, depending on the location that ballast water was taken onboard. The major vector pathways for the introduction of marine pest species into Australia are ballast water carried in vessels and biofouling on vessels (or internal parts of the vessel that are exposed to sea water) (DAWR, 2018). A study done by Gollasch et al. (2002) on 1508 samples identified a total of 990 different species within the ballasts of ships. The species varied in taxa from fungi, bacteria, algae and protozoans to small fish and invertebrates at varying life stages.

Ballast water has been recognised as a major pathway for introducing NIMS into new environments, giving rise to adoption of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (Ballast Water Convention). The Ballast Water Convention aims to prevent the spread of IMS from one region to another, by establishing standards and procedures for the ballast water management, including phasing out the use of ballast water exchange. In Australian waters, vessels are required to demonstrate compliance to Australian Ballast Water Management Requirements (DAWR 2017, version 7) which outlines approved methods of ballast water management in line with the Ballast Water Convention, including:

- use of a Ballast Water Management System
- ballast water exchange conducted in an acceptable area
- use of low risk ballast water (such as fresh potable water, high seas water or fresh water from an on-board freshwater production facility)
- retention of high-risk ballast water on board the vessel
- discharge to an approved ballast water reception facility.

Vessels may be required to undertake ballast water exchange within the Project Area. Should this be the case, ballast water exchange will only occur via the acceptable methods detailed in the Australian Ballast Water Management Requirements (DAWR 2017, version 7) and in accordance with the *Biosecurity Act 2015*.

Biofouling

The term biofouling refers to the accumulation and growth of aquatic organisms on submerged and/or wetted surfaces of marine vessels, facilities, infrastructure and equipment, including both external and internal surfaces.

Biofouling poses a risk to biosecurity if organisms are translocated from a donor location and become established in a recipient location. For this is occur, Lewis et al. (2010) suggest that biofouling organisms must be successful in the following process:

- colonise a vessel (or other infrastructure) in donor location
- survive translocation from the donor to the recipient location
- adults, offspring and/or fragments transfer from the vessel to the surrounding recipient environment
- colonise available substrata or habitat in the recipient location
- undergo ongoing reproduction in the recipient location to establish a viable population.

Biofouling usually begins as a biofilm (e.g. bacteria, diatoms and cyanobacteria) gradually developing to support a range of taxa, including; algae, sessile animals (e.g. barnacles), mobile benthic and epibenthic organisms (e.g. worms, starfish and crabs) along with commensals, parasites and pathogens.

Biofouling may occur on the FPU, trunkline and SURF over time. Vessels are required to antifoul regularly and should adhere to the National Biofouling Management Guidelines (petroleum production and exploration; and commercial vessels) (Commonwealth of Australia, 2009).

Establishment of IMS

Although there is a potential for NIMS to establish themselves in a foreign environment via ballast water and biofouling, not all NIMS that enter Australian waters and are released into the marine environment are successful in establishing a population and progressing to an IMS. For successful establishment to occur, a NIMS must first enter the ballast during water uptake and/or establish on a vector (e.g. hull), survive translocation from donor to recipient region, and then successfully be transferred, colonise and spread in the recipient environment to establish a new viable population. Biotic and abiotic factors can influence the survival probability of translocated NIMS and establish IMS.

Table 7-73: Biotic and Abiotic factors influencing the establishment of IMS

Biotic	Abiotic
Presence of natural predators	Water depth
Level physical disturbance	Environmental conditions (i.e. salinity, nutrient concentration, water temperature, light availability, etc.)
Dispersion rate	Transport conditions (i.e. vessel ballast water age, vessel speeds, etc.)
Reproductive rate	
Diet type	
Level of environmental adaptability	
Level of competitive strength	
Level of similarity of source and receiving environment	
Level of injury received throughout voyage or removal	
Sedimentation rates (fouling organisms)	

To manage the risk of IMS, Woodside has a comprehensive IMS Management Plan that has been developed in consultation with the relevant authorities.

7.2.4.2 Impact or Risk

Risk events resulting from the successful establishment of IMS in the Project Area has the potential to result in:

- changes in ecosystem dynamics
- changes to the functions, interests or activities of other users.

<u>Change in Ecosystem Dynamics</u>

Once an IMS is established, they have the potential to impact on native marine species diversity and abundance in a variety of ways. Table 7-74 describes the ways IMS can result in changes to ecosystem dynamics.

Table 7-74: Description of impacts from IMS causing changes to ecosystem dynamics

Factors driving changes to ecosystem dynamics from IMS	Description of impact
Competition for natural resources	IMS may decrease available resources for local species and, assuming they are unable to attain the resource elsewhere, result in a reduction in survival probability. Displacement of native species is more likely to occur should IMS occupy a similar niche or utilise similar resources.
Reduced natural resources	Due to lack of evolutionary equilibrium, an IMS may drastically reduce resources in an area due to lack of natural predators, abundant food source or other resource.
Predation	As organisms within the recipient environment have not co-evolved with the IMS, if the IMS is predatory native prey species are more vulnerable to predation due to a lack of adaptive response strategies. Reduction in species abundance as a product of increased predation may also impact on population dynamics and distribution of native species with cascading impacts throughout the ecosystem. Predation of native species may improve survivability of other native species as a product of decreased pre-existing ecosystem stresses such as interspecific competition or predator-prey interactions. This may have further flow on effects to existing environment and may not necessarily be a positive impact.
Change nutrient cycling processes	Establishment of IMS can result in local changes in nutrient cycles as a product of variations in nutrient uptake. Alteration of available nutrients can impact the species who use them, with cascading impacts throughout the wider ecosystem.
Change in habitat	Establishment of IMS may change habitat composition leading to creation of new habitats, or fragmentation of existing habitats. A new habitat type may allow other native species to increase distribution or range, influencing population process of existing species. In species with limited dispersal, habitat fragmentation can result in isolation of subpopulations with secondary impacts to population genetics, population dynamics, species distribution, ecosystem processes, resource consumption and nutrient cycling processes.
Spread of disease	IMS may be a virus or pathogen itself, or may be vector to viruses, bacteria or pathogens. The introduction of disease through IMS could have devastating affects to native species which lack inherent resistance to introduced diseases. A decrease in native species abundance can have knock on affects at the ecosystem level through processes related to predator-prey interactions or competition for resources.

Despite the potential high consequence of the establishment of an IMS within a high value environment as a result of introduction, unlike coastal or sheltered nearshore waters, the deep offshore open waters of the Project Area are not conducive to the settlement and establishment of IMS (Geiling, 2014), due to the lack of light or suitable habitat to sustain growth or survival. The majority of activities associated with Scarborough will be undertaken in an open ocean, offshore location away from shorelines, with the majority of activities occurring in waters >900 m deep around the FPU, well locations and subsea infrastructure. Furthermore, during FPU operations vessels will be used only intermittently due to the FPU's minimally manned status.

Activities which may occur in more shallower waters (within Commonwealth waters) along the export pipeline (up to 30 m water depth) will occur infrequently.

Current studies suggest that there are 429 introduced and cryptogenic species within Australian marine waters (DAFF, 2010). However, the IMS reported are typically restricted to nearshore environments within State waters, rather than offshore Commonwealth waters of the Project Area.

Surveying throughout Western Australian marine habitats indicated that there is a strong presence of marine NIMS (DAFF, 2010). Port Hedland, Shark Bay and other major ports and tourist destinations have been a focus for surveying of IMS. The Dampier Archipelago is subject to high amount of vessel traffic due to industrial activity and the presence of a large port structure. In addition, a paper by Huisman et al. (2008) gave an informative overview of introduced marine biota in Western Australian waters, including the Dampier region. The paper summarised findings from several intensive marine biodiversity surveys conducted within the Dampier region by the Western Australian Museum (1998–2002). Overall >4500 marine animal and plant species collected by the survey were identified to species level by expert taxonomists worldwide and a total of five species of introduced (NIMS) barnacles were identified. There was a predominant presence of Barnacles found throughout the surveys, most likely translocated by vectors moving through the area (DAFF, 2010).

Changes to the Functions, Interests or Activities of Other Users

The establishment of IMS has the potential to cause changes to the functions, interests or activities of other users through indirect impact such as changes to fisheries target species resulting in economic and social implications, or due to compromised reputation to the oil and gas industry.

Receptors Potentially at Risk

Risk events resulting from unplanned introduction of IMS has the potential to impact the following receptors:

- epifauna and infauna
- Commonwealth Managed Fisheries
- State Managed Fisheries
- shipping
- industry
- defence.

Commonwealth and State Managed Fisheries

The establishment of IMS may causes changes to the target prey abundance, distribution or behaviour, and in turn result in impacts to the activities of commercial Fisheries.

The Northwest Slope Trawl Fishery is likely to be the only Commonwealth fishery that may have active fishing areas intersecting with the Scarborough Project area. The Northwest Slope Trawl Fishery operates in deep water from the coast of the Prince Regent National Park to Exmouth between the 200 m depth contour to the outer limit of the Australian Fishing Zone (AFZ).

Given the low likelihood of IMS colonisation in this location i.e. due to distance from shore, activities associated with the Scarborough Project are unlikely to result in establishment of IMS, to negatively affect commercial fishing activities or greatly interfere with marine users in the region. On this basis the risk of introduction of IMS to fisheries has not been evaluated further.

The receptors at risk from IMS are listed in Table 7-75.

Table 7-75: Receptor/impact matrix

Impacts	Receptor: Epifauna and Infauna	Coral	Seagrass	Macroalgae	Cth Managed Fisheries	State Managed Fisheries	Shipping	Industry	Defence
Change in ecosystem dynamics	✓	✓	✓	✓					
Changes to the functions, interests or activities of other users					X	X	✓	✓	✓

Detailed Risk Evaluation

<u>Epifauna and Infauna, Coral, Seagrass and Macroalgae</u>

Benthic communities including epifauna and infauna are susceptible to impacts from IMS due to the risk of changes to the ecosystem dynamics such as competition for resources and predation (Table 7-75).

Benthic productivity on the outer continental shelf and slope is low, and is a function of water depth, low nutrient availability, and the absence of hard substrates. Studies completed within the region indicate that benthic composition in deep-water habitats is generally lower in abundance than shallow water habitats of the region (DEWHA, 2008a; Brewer et al., 2007). The seafloor in the Offshore Project Area is characterised by sparse marine life dominated by motile organisms (ERM, 2013). Such motile organisms included shrimp, sea cucumbers, demersal fish and small, burrowing worms and crustaceans. This soft bottom habitat is also supporting patchy distributions of mobile epibenthos, such as sea cucumbers, ophiuroids, echinoderms, polychaetes and sea-pens (DEWHA, 2008). The dominant types of epifauna were arthropods and echinoderms (especially shrimp and sea cucumbers, respectively), while the dominant infauna groups were crustaceans and polychaetes (ERM, 2013). Benthic communities in the Offshore Project Area are representative of the Exmouth Plateau and of deep-water soft sediment habitats reported in the region.

Along the Trunkline Project Area in Commonwealth waters, the benthic habitat is also sparse; however, there may be potential for greater diversity and abundance in shallower water environment. Benthic species along the trunkline may include polychaetes, bryozoans, molluscs (bivalves and gastropods), cnidarians, echinoderms and porifera (Section 5.3.10). The benthic habitat is representative of the Exmouth plateau and broader NWMR (Brewer et al., 2007).

Marine primary producers such as coral, seagrass and macroalgae are absent from the Offshore Project Area. Hard coral, or zooxanthellate corals, are typically found in shallow waters and are unlikely to be found in the Scarborough area. Soft coral, or azooxanthellate coral, are known to be found at most depths, however, require hard substrate for attachment which is not found within the Scarborough area. It is possible that hard and soft corals exist along the Trunkline Project Area.

The potential for IMS to establish and impact benthic habitats in the Scarborough Project area decreases with water depth. The water depths, distance from shore and the open ocean environment of the Offshore Project Area and much of the Trunkline Project Area provides unfavourable environmental conditions for survival of IMS during translocation and establishment at the recipient location. As the Trunkline Project Area traverses the continental shelf towards the boundary with State waters, conditions become more favourable for IMS establishment. However, vessels, MODU and FPU transiting to the Scarborough Project area form international ports will travel in deep waters.

In terms of ballast water exchange, all vessels will undertake ballast water exchanges in accordance with the Australian Ballast Water Management Requirements (version 7; DAWR, 2017). There is therefore a low likelihood of IMS being translocated to, and establishing in, the Project Area.

Woodside's IMS risk assessment process will be applied to project vessels which enter the Project Area, and all activities undertaken will be compliant with the Woodside Invasive Marine Species Management Plan, ensuring that the EPOs can be met Given the controls in place for IMS management, and the low likelihood of IMS translocation to, and colonisation of, this location, activities associated with Scarborough will not result in establishment of IMS, nor subsequently modify or disturb an important or substantial area of benthic habitat such that an adverse impact on marine ecosystem functioning results.

Risk events from unplanned introduction of IMS can lead to impacts on receptors, which will be slight. Receptor sensitivity for epifauna and infauna and macroalgae is low leading to a **Negligible (F**) risk consequence, and receptor sensitivity for coral and seagrass is high leading to a **Minor (D)** risk consequence. The likelihood of the risk event occurring is **Remote**, therefore the risk has been assessed for all receptors as Low.

Industry, Shipping, Defence

The establishment of IMS has a potential to disturb the functions and activities of other marine users, including the oil and gas industry, shipping or Defence by increasing the risk of further translocation of IMS within and beyond the region.

The NWMR supports a number of industries including petroleum exploration and production. There are seven sedimentary petroleum basins in the NWMR. The closest productive fields to the Scarborough Project area would be Woodside's Pluto platform and subsea infrastructure (5 km), Jadestone's Stag platform (8 km) and Santos's Reindeer platform (19 km).

Given the controls in place for IMS management, and the low likelihood of IMS translocation to, and colonisation of, this location, activities associated with Scarborough will not result in establishment of IMS, and as such not adversely affect other marine user activities in the region. EPBC Listed threatened species recovery plans or conservation advice do not list IMS as a key threat to species recovery. Ballast water exchanges will be managed in accordance with the Australian Ballast Water Management Requirements (version 7; DAWR, 2017). Woodside's IMS risk assessment process will be applied to project vessels and MODU's which enter the Project Area. Based on the outcomes of each IMS risk assessment, management measures commensurate with the risk (such as the treatment of internal systems, IMS Inspections or cleaning) will be implemented to minimise the likelihood of IMS establishing.

Risk events from unplanned introduction of IMS can lead to impacts on receptors, which will be slight. Receptor sensitivity for industry, shipping and defence is medium, leading to a **Slight (E)** risk consequence. The likelihood of the risk event occurring is **Remote**, therefore the risk has been assessed for all receptors as Low.

7.2.4.3 Demonstration of Acceptability

Risk acceptability has been demonstrated for all impacts based on evaluation against the criteria described in Section 6.4.4. The outcomes of this determination are summarised below.

Principles of ESD

The Scarborough development is consistent with the relevant principles of ESD:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.

- The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making

The Scarborough development will result in no significant impacts to receptors identified as potentially affected. Significant impact definitions:

- Epifauna and infauna
  - To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact occurs to marine ecosystem functioning or integrity results.
- Coral
  - To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact occurs to marine ecosystem functioning or integrity results.
- Seagrass
  - To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact occurs to marine ecosystem functioning or integrity results.
- Macroalgae
  - To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact occurs to marine ecosystem functioning or integrity results.
- Industry
  - To not have a substantial adverse effect on water quality such that an adverse impact on industry use occurs.
  - To not interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted
- Shipping
  - To not interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted
- Defence
  - To not interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted

Internal Context

The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards.

All activities will be undertaken in accordance with Woodside's IMS risk assessment process.

External Context

During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on affected receptors from displacement of other users:

Other requirements

The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES; specifically:

- All vessels will undertake ballast water exchanges in accordance with the Australian Ballast Water Management Requirements (version 7; DAWR, 2017)

Acceptable Levels of Impact

Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013)).

Statement of Acceptability

Based on an assessment against the defined acceptable levels, the impacts on affected receptors from Unplanned IMS is considered acceptable, given that:

- the activity is aligned with the relevant principles of ESD.
  - The distance offshore and water depths of the majority of the Project Area are prohibitive to survival and establishment of IMS.
  - In areas of the Project Area that are more favourable for IMS establishment (i.e. shallower waters of the Trunkline Project Area), controls in line with international legislation are in place to prevent translocation and establishment of IMS.
- the proposed controls are consistent with Woodside's internal policies, procedures and standards
- feedback from stakeholders has been taken into consideration
- legislative requirements/industry standards have been adopted
  - All vessels will undertake ballast water exchanges in accordance with the Australian Ballast Water Management Requirements (version 7; DAWR, 2017)
- the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices.
- the predicted level of impact is at or below the defined acceptable levels for all receptors.

Environmental Performance Outcomes

To manage impacts to affected receptors to at or below the defined acceptable levels the following EPO have been applied:

EPO 17.1: Undertake the Scarborough development in a manner which prevents a known or potential pest species (IMS) becoming established.

EPO 17.2 Undertake the Scarborough development in a manner which does not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.

EPO 17.3: Undertake the Scarborough development in a manner which prevents a substantial adverse effect on water quality such that an adverse impact on industry use occurs.

EPO 17.4: Undertake the Scarborough development in a manner which does not interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted.

7.2.4.4 Summary of the Risk Assessment

Table 7-76 provides a summary of the risk assessment and acceptability for impacts from IMS on receptors.

Table 7-76: Summary of risks, key management controls, acceptability, EPOs and residual risk rating for IMS

Receptor	Risk	Environmental Performance Outcome	Adopted control(s)	Receptor sensitivity	Risk Consequence	Likelihood	Risk rating	Acceptability
Epifauna and infauna	Change in ecosystem dynamics	**EPO 17.1:** Undertake the Scarborough development in a manner which prevents a known or potential pest species (IMS) becoming established. **EPO 17.2** Undertake the Scarborough development in a manner which does not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 17.3:** Undertake the Scarborough development in a manner which prevents a substantial adverse effect on water quality such that an adverse impact on industry use occurs. **EPO 17.4:** Undertake the Scarborough development in a manner which does not interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted.	**CM24:** Compliance with the Woodside Invasive Marine Species Management Plan. **CM25:** Requirements of the Australian Ballast Water Management to be met.	Low value habitat (homogenous)	Negligible (F)	Remote	Low	Acceptable
Coral				High value	Minor (D)	Remote	Low	Acceptable
Seagrass				High value	Minor (D)	Remote	Low	Acceptable
Macroalgae				Low value	Negligible (F)	Remote	Low	Acceptable
Industry, Shipping, Defence	Changes to the functions, interests or activities of other users			Medium value	Slight (E)	Remote	Low	Acceptable

7.2.5 Physical Presence (Unplanned): Collision with Marine Fauna

Physical presence of vessels may result in unplanned collision with marine fauna including marine mammals, marine reptiles and fish.

7.2.5.1 Sources of the Aspect

Physical presence of vessels and unplanned collision with marine fauna has the potential to occur during:

- vessel operations.

Vessel Operations

Activities associated with Scarborough will require vessels for supply and transport. Types of vessels may include, but not be limited to, MODUs or drill ships, subsea installation vessels (ISV), pipelay vessels and support vessels. Vessels will be used across all phases of the project throughout the Scarborough including the Offshore Project Area and the Trunkline Project Area.

The type and number of vessels in the Project Area at any one time, and the duration of presence, will differ depending on the project phase. Vessel presence is expected to be greatest for short-term project phases (e.g. trunkline installation), with long term operational project phase requiring fewer vessels.

7.2.5.2 Impact or Risk

Risk events resulting from an unplanned collision between vessels and marine fauna has the potential to result in:

- injury to/mortality of fauna.

<u>Injury to/Mortality of Fauna</u>

Vessels operating in the Scarborough Project area may present a potential hazard to marine mammals, marine reptiles and fish. Vessel movements can result in collisions between the vessel (hull and propellers) and marine fauna, potentially resulting in superficial injury, serious injury that may affect life functions (e.g. movement and reproduction), or mortality. Although the risk of vessel strike to marine fauna is inherent to all vessel types, records of vessel collision with marine megafauna report a higher number of collisions with whale-watching boats, naval ships and container ships (DoEE, 2016). Further, the likelihood of vessel/marine fauna collision being lethal is influenced by vessel speed; the greater the speed at impact, the greater the risk of mortality (Jensen and Silber, 2004; Laist et al., 2001). Vanderlaan and Taggart (2007) found that the chance of lethally injuring a large whale due to a vessel strike increases from about 20% at 8.6 knots to 80% at 15 knots.

Receptors Potentially Impacted

Risk events resulting from an unplanned collision between vessels and marine fauna has the potential to impact the following receptors:

- fish
- marine mammals
- marine reptiles.

Fish (including Whale Sharks)

Fish species most vulnerable to collision with vessels include large sharks which frequent the upper portions of the water column. This is particularly relevant to the whale sharks which have been shown to spend approximately 25% of their time less than 2 m from the surface and greater than 40% in the upper 15 m of the water column (Wilson et al., 2006; Gleiss et al., 2013). Conservation advice for the whale shark (TSSC, 2015) identifies boat strike form large vessels as a potential threat.

Due to the whale shark's broad distribution in Australian waters, individuals are likely to occur in the Offshore Project Area, though aggregation is not expected. The Trunkline Project Area traverses the BIA based on known foraging activity centred on the 200 m isobath from July to November, following peak aggregation at Ningaloo reef. It is likely that individual whale sharks would be encountered at greater frequency by project phases associated with the Trunkline Project Area (e.g. surveys, pipeline installation), should they occur in this timeframe.

Although there may be an increase in encounter rate in a section of the Trunkline Project Area within a restricted timeframe, the amount of overlap between the BIA and the Trunkline Project Area represents less than half of the overall Trunkline Project Area (including State waters), and a negligible proportion of the overall BIA. The trunkline installation is a relatively short-term activity, and the presence of vessels in this area will be transient and temporary. Thus, reducing the likelihood of a vessel collision occurring, which is further substantiated by the slow speed of vessels conducting activities.

Other species of shark, ray of fish is generally less vulnerable to vessel strike due to preferred habitat use. However, smaller fish are at risk of mortality through being caught in thrusters during station keeping operations (DP). However, noise emissions generated by DP operation will generally deter fish from the vicinity of the operating thrusters where lethal injury could occur.

The impact to fish from vessel strikes for Scarborough has been determined as negligible, and as such not evaluated further.

Table 7-77 outlines the potential impacts to receptors associated with unplanned vessel collisions.

Table 7-77: Receptor/risk matrix

	Receptor		
Impacts	***Fish***	***Marine Mammals***	***Marine Reptiles***
Injury/mortality to fauna	X	✓	✓

Detailed Risk Evaluation

Marine Mammals

As described above, vessel speed influences the probability of a vessel collision with a cetacean occurring and also the chance that the collision will result in lethal injury (Vanderlaan and Taggart, 2007). Additionally, behaviour of individuals may also influence likelihood of collision occurring. Although large cetaceans are expected to show localised avoidance in response to vessel noise, studies have reported limited behavioural response to approaching ships (McKenna et al., 2015) individuals engaging in behaviours such as feeding, mating or nursing may be less aware of their surroundings and more susceptible to collision (Laist et al., 2001).

Fourteen species of whales, including four threatened species, may occur in the Offshore Project Area and Trunkline Project Area, although key foraging, breeding or other aggregations have not been identified. In general, large cetaceans tend to have wide-ranging oceanic distributions meaning that while occurrence in the Project Area is possible, the absence of aggregating behaviours reduces the likelihood that encounters will involve large numbers of individuals. The exception is during migration periods where numbers may be increased.

Two threatened and migratory species, the humpback whale and pygmy blue whale, have known migratory routes, which have been designated BIAs, that are intersected by the Trunkline Project Area. The Commonwealth Conservation Advice for the Humpback whales and the Conservation Management Plan for the Pygmy Blue Whale identify vessel disturbance and strike as a threat to the EPBC listed species (DoE, 2015a; DoE, 2015b). Overlap of BIAs with the Offshore Project Area are restricted to the distribution BIA for Pygmy Blue Whales. Migration (both northbound and southbound) of both species is confined to peak timeframes (Section 5.4.5.2). Migration timing for Humpback whales on the Western Australian coast is May-November with a northern migration past Dampier in June/July and southern migration occurring primarily in Oct/Nov. Pygmy Blue Whales migrate south from October/December and northern migration occurs from April/August, with peak abundance on the NWS in June and July. It is likely that a greater number of individuals would be encountered during project phases associated with trunkline activities (e.g. surveys, pipeline installation), should they occur in the migration periods. However, due to the slow speed of vessels conducting these activities, the likelihood of a collision occurring is low, and the risk of a collision result in lethal injury reduced further.

Smaller cetaceans, such as dolphins, comprise a lower proportion of vessel collision records (DoEE, 2016), though it is difficult to determine if this is due to a lower collision rate or lower detection rate of incidents. Dolphins often engage in bow riding which may make them more vulnerable to entanglement with propellers or thrusters compared to larger cetaceans.

Fourteen species of dolphin may occur in the Project Area, and eleven of these may occur in the Offshore Project Area. However, most dolphins, except the killer whale, show preference for coastal habitats over deep offshore waters. This reduces the likelihood of dolphin species being encountered in the Offshore Project Area and interacting with vessels associated with activities such as drilling or FPU installation and operation. However, as the Trunkline Project Area enters shallower, more coastal habitats, the frequency of occurrence may increase. As with larger cetaceans above, the likelihood of encountering individuals during project phases associated with Trunkline Project Area activities (e.g. surveys, pipeline installation) is expected to be higher than during activities in the Offshore Project Area. Nevertheless, in the absence of known aggregation or critical habitat along the Trunkline Project Area large numbers of individuals are not expected to be encountered. Furthermore, dolphin species are known to bow ride and have high agility around vessels, thus the risk of vessel strike is considered low.

Studies in Queensland showed that dugongs spend around 47% of their time within 1.5 m of the sea surface, with claves spending 13% of their time travelling or resting on their mother's back (Hodgson, 2004). It has been postulated (Hodgson 2004) that vessel speed is the primary factor influencing collision risk between vessels and dugongs since evidence suggests that dugongs fail to flee or evade the approach of fast approaching vessels until an impact is unavoidable (Groom et al., 2004).

The correlation of dugong distribution and seagrass habitat suggests that dugongs will occur in the Offshore Project Area very rarely. As the Trunkline Project Area enters shallower waters, encounter rate is expected to increase. However, large expanses of seagrass habitat are absent (Advisian, 2019a) and therefore any dugongs encountered are likely to be restricted to few individuals migrating between foraging habitats. Overall, dugong encounters are not expected in the Project Area. This expectation is supported by the absence of BIAs for this species within 250 km of the Trunkline Project Area.

While the amount of time dugongs spend at the sea surface can increase vulnerability to vessel strike, this behaviour also increases detection of individuals enabling vessels to take evasive action.

Furthermore, vessels operating in the vicinity of the Trunkline Project Area will be moving slowly, allowing individuals to take evasive action. This will reduce the likelihood of a collision with a vessel occurring and that such a collision will result in fatal injury.

Marine Reptiles

The Recovery Plan for Marine Turtles in Australia recognises vessel strikes as a key threat to EPBC listed turtle species. Marine turtles on the sea surface or in shallow coastal waters have been observed to avoid approaching vessels by typically moving away from the vessel's track (Hazel et al., 2007). Hazel et al. (2007) suggests this observed avoidance behaviour is based primarily on visual cues (although these authors acknowledge vessel noise is within range of turtle hearing), and the success of this behaviour in avoiding a vessel strike largely depends on the speed of the approaching vessel (rather than vessel type) and the prevailing water clarity. In a collision, the turtle's carapace provides a level of protection from serious injury, although the type and severity of the injuries would depend on the force of the collision and structure of the vessel, and whether the animal is struck by the hull or propellers. Turtles may be particularly vulnerable to vessel strike while surfacing to rest or breathe. However, it has been reported that turtles spend a comparatively limited amount of time (3–6%) at the surface, with dives lasting between 15 and 60 minutes in general (Milton and Lutz, 2003).

Considering the offshore location, marine turtles are expected to be an infrequent visitor to the Offshore Project Area. As water depth decreases along the Trunkline Project Area the occurrence of marine turtles is expected to increase. The Trunkline Project Area intersects internesting BIAs for flatback, hawksbill, loggerhead and green turtles. These BIAs are based on distances that female turtles have been recorded as travelling from nesting beaches. Studies have shown that Flatback turtles predominantly remain within 10 km of the nesting beach, however they can also travel distances up to approximately 62 km during the internesting period (Whittock, Pendoley and Hamann, 2014). These internesting buffers have been defined as 60 km for flatback turtles and 20 km for hawksbill, loggerhead and green turtles within the Recovery Plan (DoEE, 2017). Within Commonwealth waters, it is acknowledged that an increased number of individuals may be encountered by vessels undertaking activities associated with the trunkline (e.g. pipelay, surveys) within the vicinity of offshore islands/archipelagos during breeding season (October to March). It is expected that individuals will respond to vessel presence by avoiding the immediate vicinity of the vessels, and combined with low vessel speed, will reduce the likelihood of a vessel-turtle collision.

Few sea snake species occur in deeper oceanic environments with inshore coral reef habitat being preferred. As such, the occurrence of sea snakes in the Offshore Project Area or the Trunkline Project Area in Commonwealth waters is considered rare, making any interactions with project vessels highly unlikely.

Marine Fauna Summary

While there is a risk of collision with marine fauna with vessels associated with Scarborough, the implementation of controls measures will reduce the potential impact to low and will not result in substantial adverse effects on population or spatial distribution, modify, destroy, fragment, isolate or disturb important habitat, or disrupt the lifecycle of an ecologically significant portion of the population of a migratory species. Controls will include adhering to the requirements of the EPBC Regulations 2000 Part 8 Division 8.1 Interacting with cetaceans. These regulations include the following measures:

- activity support vessels will not travel greater than 6 knots within 300 m of a cetacean or turtle (caution zone) and not approach closer than 100 m from a whale;
- activity support vessels will not approach closer than 50 m for a dolphin or turtle and/or 100 m for a whale (with the exception of animals bow riding);

- if the cetacean or turtle shows signs of being disturbed, activity support vessels will immediately withdraw from the caution zone at a constant speed of less than 6 knots; and
- vessels will not travel greater than 8 knots within 250 m of a whale shark and not allow the vessel to approach closer than 30 m of a whale shark.

Implementing this control during vessel activities will help to reduce the risks of a collision with marine fauna which could result in an impact of injury or mortality.

Whilst vessel strike is identified as a threat in the Recovery Plan for Marine Turtles (DoEE, 2017), no explicit relevant management actions are recommended. There is reference to the National Strategy for Mitigating Vessel Strike of Marine Mega-fauna (DoEE, 2016) within the Recovery Plan; this strategy was released (and remains) in draft form. Based on available data (from NSW and Queensland) within the Strategy, the 'potential areas of concern' for turtles are typically associated with nearshore areas around port facilities; i.e. it is therefore considered that ‘potential areas of concern’ would not occur within the trunkline route through Commonwealth waters.

Within the Recovery Plan there is reference to undertaking dredging and trawling activities in internesting habitat outside peak nesting seasons. For the section of trunkline (i.e. KP 32 to KP 50) that may require trenching and backfilling, consideration will be given to fauna mitigation methods such as the seasonal timing of installation activities to limit disturbance to turtles within the development of Environment Plans.

The conservation management plan for the blue whale (Commonwealth of Australia, 2015a) recommends minimising vessel collision through speed reduction, and aligns with the control measures implemented by Woodside. Activities associated with Scarborough will be managed in accordance with all relevant management actions and recommendations.

For construction and IMR activities occurring within the Montebello Marine Park, and adjacent to the Dampier Marine Park, the short-term and transient nature of vessel movement will not be inconsistent with the objective of the Multiple Use Zone (VI) to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species, or for the Habitat Protection Zone (IV) to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while allowing activities that do not harm or cause destruction to seafloor habitats. The values identified for both these AMPs includes biologically important areas for internesting, foraging, mating and nesting habitat for marine turtles, and migratory pathways for humpback whales. These values will not be impacted given the significant distance from sensitive locations.

Risk events from an unplanned collision between vessel and marine fauna can lead to impacts on receptors, which will have no lasting effect. Receptor sensitivity is high, leading to a **Slight (E)** risk consequence, and likelihood of the event occurring is **Highly Unlikely**. The risk of unplanned collision between vessel and marine fauna from activities associated with Scarborough has therefore been evaluated as **Low**.

7.2.5.3 Demonstration of Acceptability

Risk acceptability has been demonstrated for all impacts based on evaluation against the criteria described in Section 6.4.4. The outcomes of this determination are summarised below.

Principles of ESD

The Scarborough development is consistent with the relevant principles of ESD:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations

- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making

The Scarborough development will result in no significant impacts to receptors identified as potentially affected. Significant impact definitions:

- Marine Mammals:
  - To not have a substantial adverse effect on a population of marine mammals or the spatial distribution of the population.
  - To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.
  - To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.
- Marine Reptiles
  - To not have a substantial adverse effect on a population of marine reptiles or the spatial distribution of the population.
  - To not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.
  - To not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

Internal Context

The Scarborough development is consistent with Woodside internal requirements, including policies, procedures and standards.

External Context

During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of the Scarborough development on affected receptors from displacement of other users:

Other requirements

The proposed controls and impact and risk levels are consistent with national and international standards, laws, and policies including applicable plans for management and conservation advices, and significant impact guidelines for MNES; specifically:

- Activities will be adhered to the requirements of the EPBC Regulations 2000 Part 8 Division 8.1 Interacting with cetaceans
- Requirements of the Conservation Management Plan for Blue Whales (Commonwealth of Australia, 2015a) have been met.
- Consideration of seasonal timing for trenching and backfill activities to be consistent with the guidance for dredging and trawling within the Recovery Plan for Marine Turtles (DoEE, 2017).

Acceptable Levels of Impact

Activities associated with Scarborough are not inconsistent with the principles of ESD, and the assessment of impacts and risks of the activities has not predicted significant impacts (as defined in the Significant impact criteria for an impact on the environment in a Commonwealth marine area as defined in the *Matters of National Environmental Significance – Significant impact guidelines 1.1* (DotE, 2013)).

Statement of Acceptability

Based on an assessment against the defined acceptable levels, the impacts on affected receptors from collision with marine fauna is considered acceptable, given that:

- the activity is aligned with the relevant principles of ESD.
  - Vessel movements associated with Scarborough will not significantly increase the current level of activity in the wider area.
  - Wide migratory distribution of species potentially at risk and their low-density presence within the Scarborough area means that interactions are unlikely.
  - Controls are in place to manage vessel movements.
- the proposed controls are consistent with Woodside's internal policies, procedures and standards
- feedback from stakeholders has been taken into consideration
- legislative requirements/industry standards have been adopted
  - All vessels will undertake ballast water exchanges in accordance with the Australian Ballast Water Management Requirements (version 7; DAWR, 2017)
- the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices.
- the predicted level of impact is at or below the defined acceptable levels for all receptors.

Environmental Performance Outcomes

To manage impacts to affected receptors to at or below the defined acceptable levels the following EPO have been applied:

EPO 18.1: Undertake the Scarborough development in a manner which prevents a vessel strike with protected marine fauna during project activities.

EPO 18.2 Undertake the Scarborough development in a manner which does not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.

EPO 18.3: Undertake the Scarborough development in a manner which prevents a substantial adverse effect on a population of marine mammals or the spatial distribution of the population.

EPO 18.4: Undertake the Scarborough development in a manner which prevents a substantial adverse effect on a population of marine reptiles or the spatial distribution of the population.

EPO 18.5: Undertake the Scarborough development in a manner which does not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

7.2.5.4 Summary of the Risk Assessment

Table 7-78 provides a summary of the risk assessment and acceptability for impacts from vessel collision with marine fauna on receptors.

Table 7-78: Summary of risks, key management controls, acceptability, EPOs and residual risk rating for physical presence (unplanned): collision with marine fauna

Receptor	Risk	Environmental Performance Outcome	Adopted control(s)	Receptor sensitivity	Risk Consequence	Likelihood	Risk rating	Acceptability
Marine Mammals Marine Reptiles	Injury to/ mortality of fauna	**EPO 18.1:** Undertake the Scarborough development in a manner which prevents a vessel strike with protected marine fauna during project activities. **EPO 18.2** Undertake the Scarborough development in a manner which does not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results. **EPO 18.3:** Undertake the Scarborough development in a manner which prevents a substantial adverse effect on a population of marine mammals or the spatial distribution of the population. **EPO 18.4:** Undertake the Scarborough development in a manner which prevents a substantial adverse effect on a population of marine reptiles or the spatial distribution of the population. **EPO 18.5:** Undertake the Scarborough development in a manner which does not seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**CM8:** EPBC Regulations 2000 Part 8 Division 8.1 Interacting with cetaceans **CM32**: Marine fauna interaction mitigation measures to be considered and implemented as appropriate during the EP process	High value species	Slight (E)	Highly Unlikely	Low	Acceptable

7.2.6 Unplanned Hydrocarbon Release

Unplanned hydrocarbon releases include both gas and liquid hydrocarbons that could unintentionally be released into the marine environment.

7.2.6.1 Sources of Aspect

Activities and facilities associated with Scarborough which may result in the unplanned discharge of gas hydrocarbons to the marine environment are:

- drilling operations
- commissioning
- FPU operations
- hydrocarbon extraction
- hydrocarbon processing
- gas export
- decommissioning.

A key difference between Scarborough and many other offshore developments is that the reservoirs contain no or only trace liquid hydrocarbons, which means there is no credible risk of hydrocarbon spill due to well blowout and only from fuel or non-process LOC.

Activities and facilities associated during the installation, commissioning, operations and decommissioning phases of Scarborough which may result in the unplanned discharge of liquid hydrocarbons to the marine environment are:

- vessel operations
- MODU operations
- helicopter operations.

Drilling Operations

During drilling operations, a loss of well control (LOWC) could result in an uncontrolled subsea release of hydrocarbons resulting from an over-pressurised reservoir. The major causes of a LOWC are identified as:

- well intervention
- dropped objects
- intersection with shallow gas
- human error.

Hydrocarbons of the Scarborough, Jupiter and Thebe reservoirs contain no measurable liquid condensate fraction so in a loss of containment there is expected to be no or negligible liquid component.

High pressure and low temperatures experienced at the depths in the development area are likely to cause released gas to combine with water to form hydrates. The hydrates will rise through the water column and upon reaching shallower water depths are likely to decompose into methane and water.

FPU Operations, Hydrocarbon Extraction and Hydrocarbon Processing, Hydrocarbons Export

During operations, hydrocarbons extracted from the reservoir will flow from the wellhead via the christmas trees and manifolds through the flowlines to the FPU. On the FPU, the gas is separated from the MEG and dehydrated further prior to export.

Extreme environmental conditions or other causes which result in an exceedance of the design criteria and a catastrophic failure of the facility and/or individual equipment (e.g. cranes, flare tower) could result in unplanned release of gas hydrocarbons. Topsides, this could be from process and non-process hydrocarbon inventories. Subsea, there is potential for a loss on containment from pipelines, flowlines or risers.

Causes of structural failure could include:

- internal corrosion
- external corrosion
- equipment failure
- extreme weather
- seismic events/seabed instability
- dropped objects
- fire/explosion event.

It is also possible that failure of down-well barriers or physical damage to a completed well could also result in a loss of control of a production well.

In addition to a loss of well control, a subsea loss of containment includes the potential loss of hydrocarbons from production flowlines and the trunkline. Given the nature of the hydrocarbons, in the event of a subsea loss of containment there is unlikely to be any liquid hydrocarbons released.

Vessel and MODU Operations

Vessels will be used during all phases of Scarborough in both the Offshore Project Area and Trunkline Project Area. Types of vessels may include MODUs or drill ships, subsea installation vessels (SIV), deepwater pipelay vessels and support vessels. All project vessels (including MODUs and drill ships) will use marine diesel oil (MDO) or marine gas oil (MGO) as fuel.

The sources of unplanned MDO or MGO releases that could occur during vessel and MODU operations are:

- bunkering failure
- rupture of vessel fuel tank.

Bunkering

Bunkering of marine diesel between support vessel/s and the MODU or SIV may occur in the Offshore Project Area or Trunkline Project Area. Loss of containment of marine diesel during bunkering operations could occur due to:

- Partial or total failure of a bulk transfer hose or fittings during bunkering, due to operational stress or other integrity issues could spill marine diesel to the deck and/or into the marine environment. This would be in the order of less than 200 L, based on the likely volume of a bulk transfer hose (assuming a failure of the dry break coupling and complete loss of hose volume).

- Partial or total failure of a bulk transfer hose or fittings during bunkering, combined with a failure in procedure to shutoff fuel pumps, for a period of up to five minutes, resulting in about 8 m³ MDO loss to the deck and/or into the marine environment.

Fuel Tank Rupture

During Scarborough, an unplanned release of MDO could occur if the fuel tank of any vessel is ruptured. This could eventuate from a collision between project vessels (e.g. support vessel with a MODU or pipelay vessel) or between a project vessel and a third-party vessel such as commercial fishing or shipping vessels. For a vessel collision to result in the worst-case scenario of a hydrocarbon spill potentially impacting an environmental receptor, several factors must align:

- Vessel interaction must result in a collision.
- The collision must have enough force to penetrate the vessel hull.
- The collision must be in the exact location of the fuel tank.
- The fuel tank must be full, or at least have a volume higher than the point of penetration.

The spill scenarios for the vessels are described in the sections below.

Deepwater Pipelay Vessel and Refuelling Vessel

The deep water pipelay vessels and the refuelling vessels that will be required to support these vessels may have a maximum single tank inventory of 2000 m³ of MDO. A rupture of the largest single tank of the refuelling vessel is considered as the worst-case credible release for this scenario.

Based on the International Maritime Organisation's decision to implement a 0.50% sulphur cap on marine fuel from 2020, the assumption is being made that there will be no heavy fuel oils (HFO), which have sulphur levels much higher than this cap, in use or stored onboard any of the contracted vessels.

Nearshore Pipelay Barge

The nearshore pipelay barges being considered for the Project have a maximum fuel inventory of less than 400 m³.

Note that a loss of vessel fuel tank integrity is also possible at locations closer to shore, therefore a potential scenario of 2000 m³ MDO also exists (Table 7-79).

MODU/FPU Bulk Fuel Tank

The worst-case credible non-process release from the FPU or MODU is a failure or rupture of the main diesel storage tank. MODUs typically have a total MDO capacity of about 966–1400 m³ that is distributed through a multiple isolated tank. MODU fuel tanks are located in the MODU pontoons, typically located on the inner sides of pontoons and can be over 10 m below the waterline.

A volume of 250 m³ of MDO is considered an appropriate worst case for a single fuel tank, based on existing facilities.

Note that a loss of vessel fuel tank integrity is also possible at the FPU location, therefore a potential scenario of 2000 m³ MDO also exists at this location (Table 7-79).

Summary of Credible Hydrocarbon Spill Scenarios

A summary of the credible hydrocarbon spill scenarios that could occur during Scarborough are provided in Table 7-79.

Note that minor spills to water have been assessed in Section 7.1.

Table 7-79: Credible hydrocarbon spill scenarios

Scenario	Hydrocarbon type	Maximum credible volume	Location
Loss of well control (LOWC)	Dry gas	No or negligible liquid hydrocarbon	FPU/MODU location
Facility failure	Dry gas	No or negligible liquid hydrocarbon	FPU location
Pipeline rupture	Dry gas	No or negligible liquid hydrocarbon	FPU location Trunkline route
Loss of containment during bunkering	MDO	8 m³	FPU location Trunkline route
Topsides loss of containment from FPU/MODU	MDO	250 m³	FPU/MODU location
Vessel fuel tank rupture	MDO/MGO	2000 m³ (pipelay vessel)	Trunkline route FPU location

Hydrocarbon Characteristics

MDO is characterised by a large mixture of low- and semi- to low-volatile compounds (95%) and persistent hydrocarbons (5%). Additionally, MDO typically contains <3% aromatic hydrocarbons that could potentially dissolve in the water column.

MGO is typically a lighter fuel that contains about 60% aromatics, therefore, to be conservative, MDO has been used in in this risk assessment.

Table 7-80 summarises hydrocarbon characteristics of MDO.

Table 7-80: Characteristics of liquid hydrocarbons

Physical Properties	MDO
Density (kg/m³)	829
American Petroleum Institute (API)	37.2
Dynamic viscosity (centipoises; cP)	4 (at 25 °C)
Pour Point (°C)	-7
Gas to condensate ratio (bbl/MMscf)	N/A
Oil Property Category	II
Oil Persistence Classification	Non-persistent

7.2.6.2 Impact or Risk

Risk events resulting from an unplanned hydrocarbon release have the potential to result in the following impacts:

- change in water quality
- change in sediment quality
- change in habitat.

As a result of these changes, further impacts may occur, which include:

- change in fauna behaviour
- injury or mortality to fauna
- change in aesthetic value
- change to the function, interests and activities of other users.

Quantitative Hydrocarbon Spill Modelling

In assessing the potential impacts of an unplanned hydrocarbon release, representative worst-case scenarios (in terms of volume and location) were assessed. For Scarborough, the worst-case scenario was identified to be an instantaneous surface release of 2000 m³ of MDO, representing loss of vessel fuel tank integrity. As the worst-case scenario, the following assessment of impacts will also address the potential impacts of other credible lesser releases.

To inform the impact assessment, quantitative hydrocarbon spill modelling was undertaken for the worst-case hydrocarbon release scenarios (RPS, 2019d; APPENDIX I). It is not practicable for spill modelling to be undertaken at every potential spill location within the Offshore Project Area. Release locations were selected by considering locations that would:

- have the greatest potential environmental consequence to the receiving environment (closest to sensitive receptors)
- be considered at greater risk of a spill event.

Accordingly, a spill of MDO was modelled at three representative locations; two along the trunkline at sensitive locations, and one at the FPU (Table 7-81).

Table 7-81: Spill release locations for 2000 m³ MDO spill

Location	Coordinates	Water Depth
Outside Mermaid Sound	19° 59' 46.476" S 115° 22' 5.582"E	80 m
Within the Montebello Australian Marine Park	19° 53' 54.715" S 113° 14' 19.561"E	74 m
FPU	19° 53'54.715" S 113° 14' 19.561"E	930 m

Quantitative hydrocarbon spill modelling was undertaken by RPS, on behalf of Woodside, using a three-dimensional hydrocarbon spill trajectory and weathering model, SIMAP (Spill Impact Mapping and Analysis Program), which is designed to simulate the transport, spreading and weathering of specific hydrocarbon types under the influence of changing meteorological and oceanographic forces (RPS, 2019d; APPENDIX I).

<u>Hydrocarbon Exposure Thresholds</u>

The outputs of the quantitative hydrocarbon spill modelling are used to assess the extent of hydrocarbon exposure (which informs the EMBA and area described in Section 5) and the subsequent environmental risk by showing areas where specified impact thresholds for receptors are exceeded.

Woodside identifies exposure thresholds for floating (i.e. surface), entrained, dissolved and shoreline hydrocarbons (Table 7-82). These thresholds are used to support the assessment of the receptors present in the exposure area. Surface and accumulated shoreline hydrocarbon concentrations are expressed as grams per square metre (g/m²), with entrained and dissolved hydrocarbon concentrations expressed as parts per billion (ppb).

Table 7-82: Summary of ecological and socio-cultural impact thresholds used to support impact assessment of a hydrocarbon spill

Parameter	Exposure Thresholds	Justification
Surface hydrocarbon	1 g/m²	This threshold is used to define an area within which social-cultural impacts to the visual amenity of the marine environment may occur. The surface threshold of ≥1 g/m² is based on the relationship between film thickness and appearance (Bonn Agreement oil appearance code, 2015), and represents a 'rainbow sheen' appearance. This threshold is considered below levels which would cause ecological impacts, and instead represents potential for visual amenity impacts.
	10 g/m²	This threshold is used to define an area within which ecological impacts to the marine environment may occur from surface hydrocarbons. It represents the minimum oil thickness (0.01 mm) at which ecological impacts (e.g. to birds and marine mammals) are expected to occur. Thresholds for registering biological impacts resulting from contact of surface slicks have been estimated by different researchers at about 10–25 g/m² (French et al., 1999; Koops et al., 2004; National Oceanic and Atmospheric Administration, 1996). Potential impacts of surface slick concentrations in this range for floating hydrocarbons may include harm to seabirds through ingestion from preening of contaminated feathers, or the loss of the thermal protection of their feathers. The 10 g/m² threshold is the reported level of oiling to instigate impacts to seabirds and is also applied to other wildlife, though it is recognised that 'unfurred' animals, where hydrocarbon adherence is less, may be less vulnerable. 'Oiling' at this threshold is taken to be of a magnitude that can cause a response from the most vulnerable wildlife such as seabirds. Due to weathering processes, surface hydrocarbons will have a lower toxicity due to change in their composition over time. Potential impacts to shoreline sensitive receptors may be markedly reduced in instances where there is extended duration until contact. A surface threshold of 10 g/m² represents a 'dull metallic colour' (Bonn Agreement, 2015).
Dissolved aromatic hydrocarbon[1] (ppb)	500 ppb	This threshold is used to define an area within which ecological impacts to the marine environment may occur from dissolved hydrocarbons. Therefore, it may also be associated with socio-cultural impacts. The threshold concentration value for dissolved hydrocarbons has been established with reference to results from Woodside-commissioned ecotoxicity tests on Marine Diesel Oil (Ecotox Services Australia [ESA 2013]. The ecotoxicity tests were undertaken on a broad range of taxa of ecological relevance for which accepted standard test protocols are well established. These ecotoxicology tests are focused on the early life stages of test organisms, when organisms are typically at their most sensitive. The eight ecotoxicology tests were conducted on seven mainly tropical-subtropical species representatives from six major taxonomic groups. The seven species were tested for chronic (function of life) effects of immobilisation, early life stage development/growth and acute toxicity (i.e. mortality). The laboratory-based ecotoxicity tests used a range of water accommodated fraction (WAF) concentrations to expose the different test organisms. For each ecotoxicity test, samples of the WAF were analysed to determine the TPH concentration of the solution. The ecotoxicity testing focusses on the total petroleum hydrocarbons (TPH) concentration of the WAF of the hydrocarbon and includes the carbon chains C6 to C36. TPH concentration is representative of the sum of the hydrocarbons in each test solution for C6–C36. Typically, C4 to C10 compounds are volatile (BP < 180 °C), C11 to C15 compounds are semi-volatile (BP 180–265 °C), C16 to C20 compounds have low volatility (265–380 °C) and C21 compounds and above are residual (BP > 380 °C).

Parameter	Exposure Thresholds	Justification
		Table 7-83 presents the results of the 'no-observed-effect concentrations' (NOEC) for the marine diesel WAFs. The reported NOECs for organisms tested ranged from 520 ppb to 3500 ppb. For seven of the nine tests, no statistically significant effect on the test organisms was observed even at the highest WAF concentration used in the testing (denoted with the symbol # in Table 7-83). Based on these ecotoxicology tests, a conservative threshold of 500 ppb has been adopted. This 500 ppb threshold is below the lowest NOEC for the most sensitive organism tested. These thresholds are calculated based on exposure of organisms to dissolved aromatic hydrocarbons for periods of 1 to 96 hours and are, therefore, conservative when used for instantaneous contact. **Table 7-83: summary of total petroleum hydrocarbon NOEC for key life-histories of different biota based on toxicity tests for WAF of marine diesel. After: ESA 2013.**

Biota and Life Stage	Exposure Duration	NOEC TPH (ppb)
Sea urchin fertilisation	1 hours	3500 #
Sea urchin larval development	72 hours	3500 #
Milky oyster larval development	48 hours	3500 #
Micro-algal growth test	72 hours	520
Macro-algal (kelp) germination test	72 hours	2530 #
Rock oyster larval spat	48 hours	3500 #
Amphipod juvenile survival	96 hours	520
Copepod juvenile survival	48 hours	2530 #
Larval fish imbalance test	96 hours	2530 #

Lowest-observable-effect concentration (LOEC) was not reached during test.

Parameter	Exposure Thresholds	Justification
Entrained hydrocarbon[1] (ppb)	500 ppb	This threshold is used to define an area within which ecological impacts to the marine environment may occur from entrained hydrocarbons. Therefore, it may also be associated with socio-cultural impacts. Entrained hydrocarbons present a number of possible mechanisms for toxic exposure to marine organisms. The entrained hydrocarbon droplets may contain soluble compounds, hence have the potential for generating elevated concentrations of dissolved aromatic hydrocarbons (e.g. if mixed by breaking waves against a shoreline). Physical and chemical effects of the entrained hydrocarbon droplets have also been demonstrated through direct contact with organisms; for example, through physical coating of gills and body surfaces, and accidental ingestion (National Research Council, 2005). The threshold concentration of entrained hydrocarbons that could result in a biological impact cannot be determined directly using available ecotoxicity data for Water Accommodated Fractions (WAF) of hydrocarbons. It is also noted that entrained hydrocarbons are less biologically available to organisms through absorption into their tissues than dissolved aromatic hydrocarbons. Therefore adoption of a threshold based on toxicity data will be a conservative approach. The selected threshold of 500 ppb is below the NOEC for the seven sensitive organisms tested in relation to dissolved hydrocarbons. The modelling of entrained hydrocarbons specifically represents the total volume of diesel predicted to be entrained under metocean conditions. As discussed above, the

Parameter	Exposure Thresholds	Justification
		dissolved threshold is based on the exposure of organisms for periods of 1 to 96 hours and therefore is highly conservative when used for instantaneous contact.
Shoreline	100 g/m²	Owens and Sergy (1994) define accumulated hydrocarbon <100 g/m² to have an appearance of a stain on shorelines. French-McKay (2009) defines accumulated hydrocarbons ≥100 g/m² to be the threshold that could impact the survival and reproductive capacity of benthic epifaunal invertebrates living in intertidal habitat; therefore, ≥100 g/m² has been adopted as the threshold for shoreline accumulation.

[1] *these refer to instantaneous concentrations*

<u>Summary of Predicted Hydrocarbon Exposure</u>

Stochastic Spill Modelling

Stochastic modelling was carried out for this study, whereby SIMAP was applied to repeatedly simulate the defined credible spill scenarios using different randomly-selected conditions. These modelling simulations provide insight into the probable behaviour of a potential spill under the meteorological conditions expected to occur within the EMBA. They predict the most probable path and transport rates for unplanned releases using historical wind and ocean current data. The model runs many single trajectories (e.g. 100 scenarios per release location per season), varying the start time (and hence prevailing wind and current conditions). This approach ensures that the predicted transport and weathering of a hydrocarbon slick is subjected to a range of oceanic conditions. All scenarios were modelled for a duration of 42 days.

Key results from the stochastic modelling undertaken for the unplanned discharge of 2000 m^3 of MDO at the three release locations are summarised in Table 7-84 (RPS, 2019d; Appendix I).

Table 7-84: Summary of worst-case extent of stochastic spill modelling to be used in risk assessment

Scenario	Model Parameter	Summary

Outside Mermaid Sound	Floating – 1 g/m^2 threshold for socio-cultural impacts	• Exposures above the threshold are predicted to occur within ~83 km of the source.
		• Exposures above the threshold are predicted to have a probability of intersecting the following key sensitive receptors:
		  ◦ 4% probability to WA Coastline
		  ◦ 3% probability to Dampier Marine Park
		  ◦ 4% probability to Dampier Archipelago (including Legendre)
		• <1% probability to Montebello Marine Park

	Floating – 10 g/m^2 threshold for ecological impacts	• Exposures above the threshold are predicted to occur within ~30 km of the source.
		• Exposures above the threshold are predicted to have a probability of intersecting the following key sensitive receptors:
		  ◦ 3% probability to WA Coastline
		  ◦ 2% probability to Dampier Marine Park
		  ◦ 2% probability to Dampier Archipelago (including Legendre Island
		  ◦ <1% probability to Montebello Marine Park

	Entrained	• Exposures above the threshold are predicted to occur within ~163 km of the source. • Exposures above the threshold are predicted to have a probability of intersecting the following key sensitive receptors, at the associated maximum concentration in the worst-case simulation:

Scenario	Model Parameter	Summary
		• 44% probability to Dampier Marine Park; 10,407 ppb • 23% to Dampier Archipelago (including Legendre Island and Rosemary Island); 10,911 ppb • 23% probability to WA Coastline; 6,832 ppb • <1% probability to Montebello Marine Park. • Entrainment of MDO is only expected to occur under moderate wind conditions, within the upper water column.
	Dissolved	• Exposures above the threshold are predicted to occur within ~35 km of the source. • Exposures above the threshold are predicted to have a probability of intersecting the following key sensitive receptors, at the associated maximum concentration in the worst-case simulation: • 2% probability to Dampier Marine Park; 635 ppb • <1% probability to the Dampier Archipelago; 366 ppb.
	Shoreline	• The maximum local accumulated concentration ashore for the worst-case simulation was predicted to be 156 g/m² (at WA Coastline). • Exposures above the threshold are predicted to have a probability of intersecting the following key sensitive receptors, at the associated maximum accumulated volume in the worst-case simulation: • 1% probability to Dampier Archipelago; 3 m^3 • 1% to WA Coastline; 3 m^3 • Other shoreline receptors were <1%.
Within the Montebello Marine Park	Floating – 1 g/m^2 threshold for socio-cultural impacts	• Exposures above the threshold are predicted to occur within ~82 km of the source. • Exposures above the threshold are predicted to have a probability of intersecting the following key sensitive receptors: • 100% probability to Montebello Marine Park (as release location is inside Park) • <1% probability of exposures above the threshold are predicted to any other receptor (including Montebello Islands, Barrow Island and other AMPs).
	Floating – 10 g/m^2 threshold for ecological impacts	• Exposures above the threshold are predicted to occur within ~40 km of the source. • Exposures above the threshold are predicted to have a probability of intersecting the following key sensitive receptors: • 100% probability to Montebello Marine Park (as release location is inside Park) • <1% probability of exposures above the threshold are predicted to any other receptor (including Montebello Islands, Barrow Island and other AMPs).
	Entrained	• Exposures above the threshold are predicted to occur within ~310 km of the source, with the greatest extent towards the south-west. • Exposures above the threshold are predicted to have a probability of intersecting the following key sensitive receptors, at the associated maximum concentration in the worst-case simulation: • <70% probability to Montebello Marine Park; 156,954 ppb • <4% probability to Montebello Islands Marine Park, Barrow Island; 4,577 ppb • 7% to the Muiron Islands Marine Management Area; 2,392 ppb • <4% probability to Ningaloo Coast North World Heritage Area; 2,438 • Entrainment of MDO is only expected to occur under moderate wind conditions, within the upper water column.

Scenario	Model Parameter	Summary

	Dissolved	• Exposures above the threshold are predicted to occur within ~85 km of the source, with the greatest extent towards the south-west.
		• Exposures above the threshold are predicted to have a probability of intersecting the following key sensitive receptors, at the associated maximum concentration in the worst-case simulation:
		  • 9% probability to Montebello Marine Park; 1,990 ppb.
		  • <1% probability for all other sensitive receptors. The worst-case maximum concentration for these receptors was only 200 ppb, which is below the exposure threshold.

	Shoreline	• There is <1% probability of any shoreline contact above the threshold. • The maximum local accumulated concentration ashore for the worst-case simulation was only 11 g/m² at Barrow Island and WA Coastline – which is not above the threshold of 100 g/m². • Barrow Island and WA Coastline were only predicted to accumulate a maximum of 1 m³ for the worst-case simulation. • No other shoreline contact was predicted above the threshold.
FPU	Floating – 1 g/m² threshold for socio-cultural impacts	• Exposures above the threshold are predicted to occur within ~115 km of the source, with the greatest extent predicted towards the south. • Exposures above the threshold are predicted to have a probability of intersecting the following key sensitive receptors: • 1% probability to Gascoyne Marine Park. • <1% for all other sensitive receptors.

	Floating – 10 g/m² threshold for ecological impacts	• Exposures above the threshold are predicted to occur within ~113 km of the source, with the greatest extent predicted towards the south.
		• Exposures above the threshold are predicted to have a probability of intersecting the following key sensitive receptors:
		  • 1% probability to Gascoyne Marine Park.
		  • <1% for all other sensitive receptors.

	Entrained	• Exposures above the threshold are predicted to occur within ~476 km of the source, with the greatest extent towards the south-west.
		• Exposures above the threshold are predicted to have a probability of intersecting the following key sensitive receptors, at the associated maximum concentration in the worst-case simulation:
		  • 8% probability to Gascoyne Marine Park; 7,236 ppb
		  • <1% probability for all other sensitive receptors. The worst-case maximum concentration for these receptors was only 196 ppb, which is below the exposure threshold.
		• Entrainment of MDO is only expected to occur under moderate wind conditions, within the upper water column.

	Dissolved	• Exposures above the threshold are predicted to occur within ~74 km of the source, with the greatest extent towards the south-west. • No sensitive receptors are predicted to receive dissolved aromatic hydrocarbons at the 500 ppb threshold.
	Shoreline	• There is no shoreline contact above the exposure threshold predicted.

Deterministic Spill Modelling

Deterministic modelling (or single spill trajectory analysis) is used to predict the fate (transport and weathering behaviour) of spilled oil over time under predefined hydrodynamic and meteorological conditions. It was used to demonstrate the potential maximum extent of the area exposed to entrained hydrocarbons. The deterministic runs shown in Figure 7-29, Figure 7-30 and Figure 7-31 were for the three modelled release locations (of 2,000 m^3 MDO) and represent runs which showed the greatest extent of exposure to the south-west (with proximity to various sensitive environments) and to the shorelines.

While the stochastic figures may show a large extent of an area that could potentially be exposed at some point to hydrocarbons (in the event of a worst case spill) the worst-case deterministic runs indicate that the potential area exposed to entrained hydrocarbons is much smaller, at maximum over a 30 km^2 area and for only a small period of time.

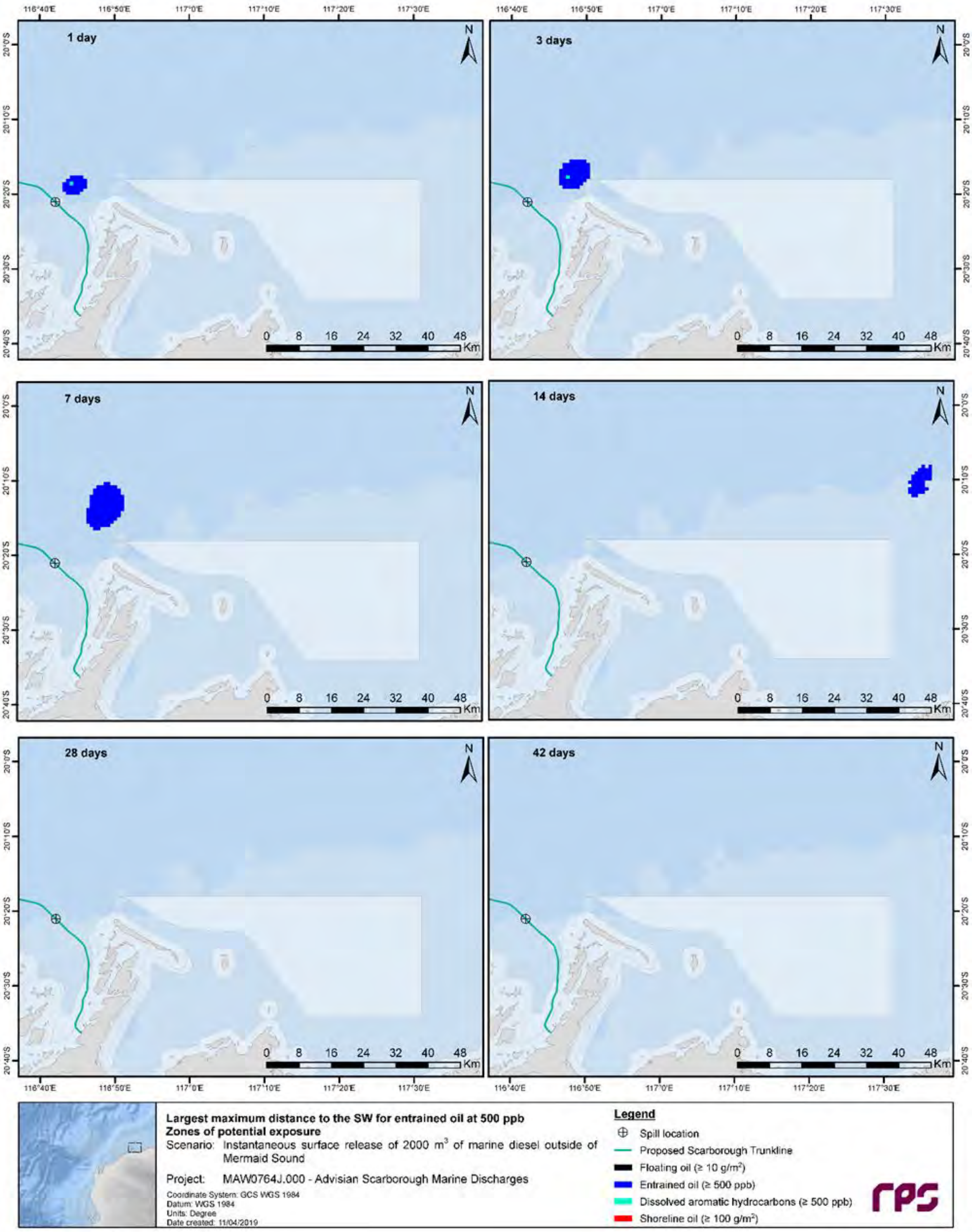


Figure 7-29: Time series from a single deterministic model run for an instantaneous release of 2000 m^3 of MDO from outside Mermaid Sound

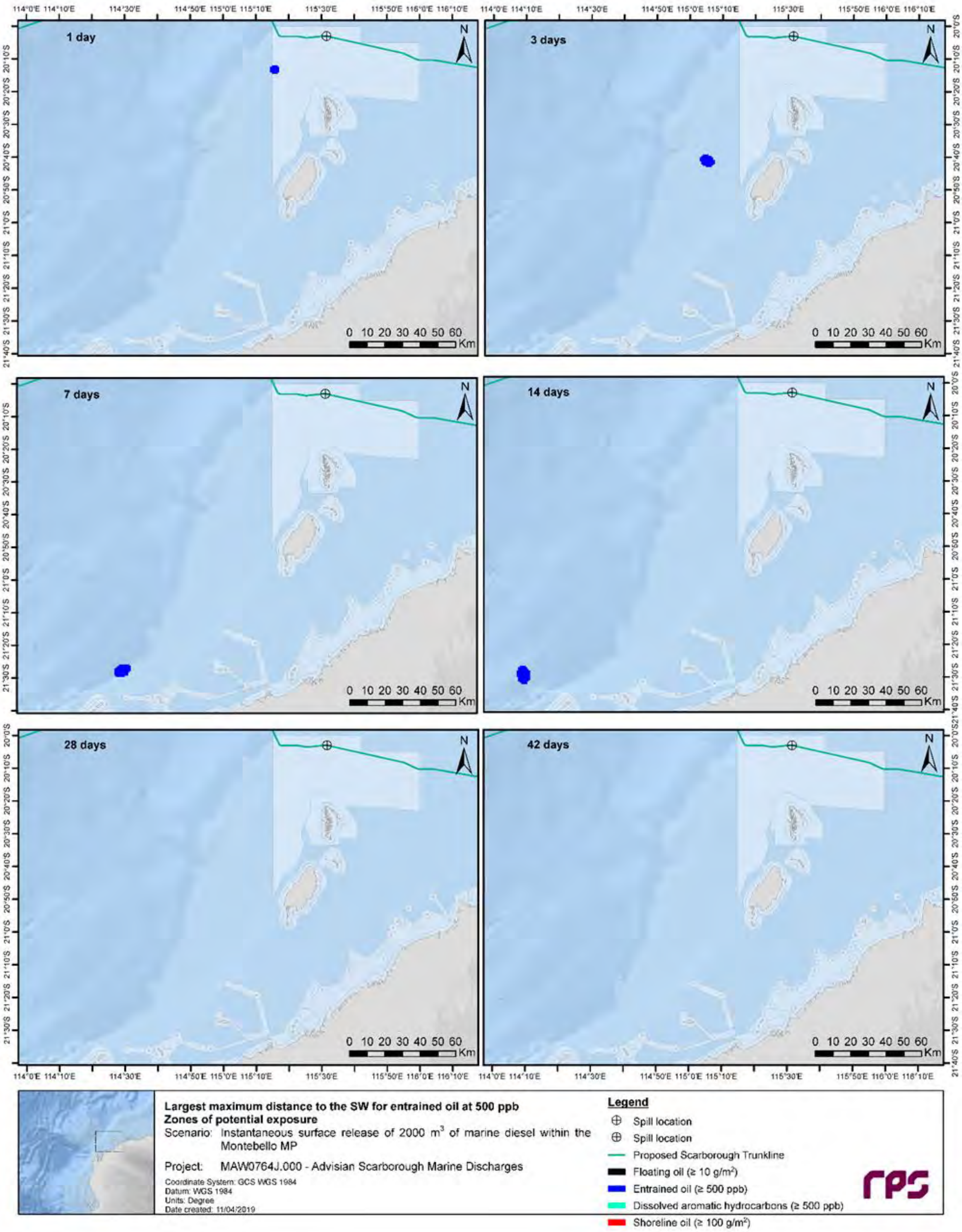


Figure 7-30: Time series from a single deterministic model run for an instantaneous release of 2000 m3 of MDO from within the Montebello Australian Marine Park

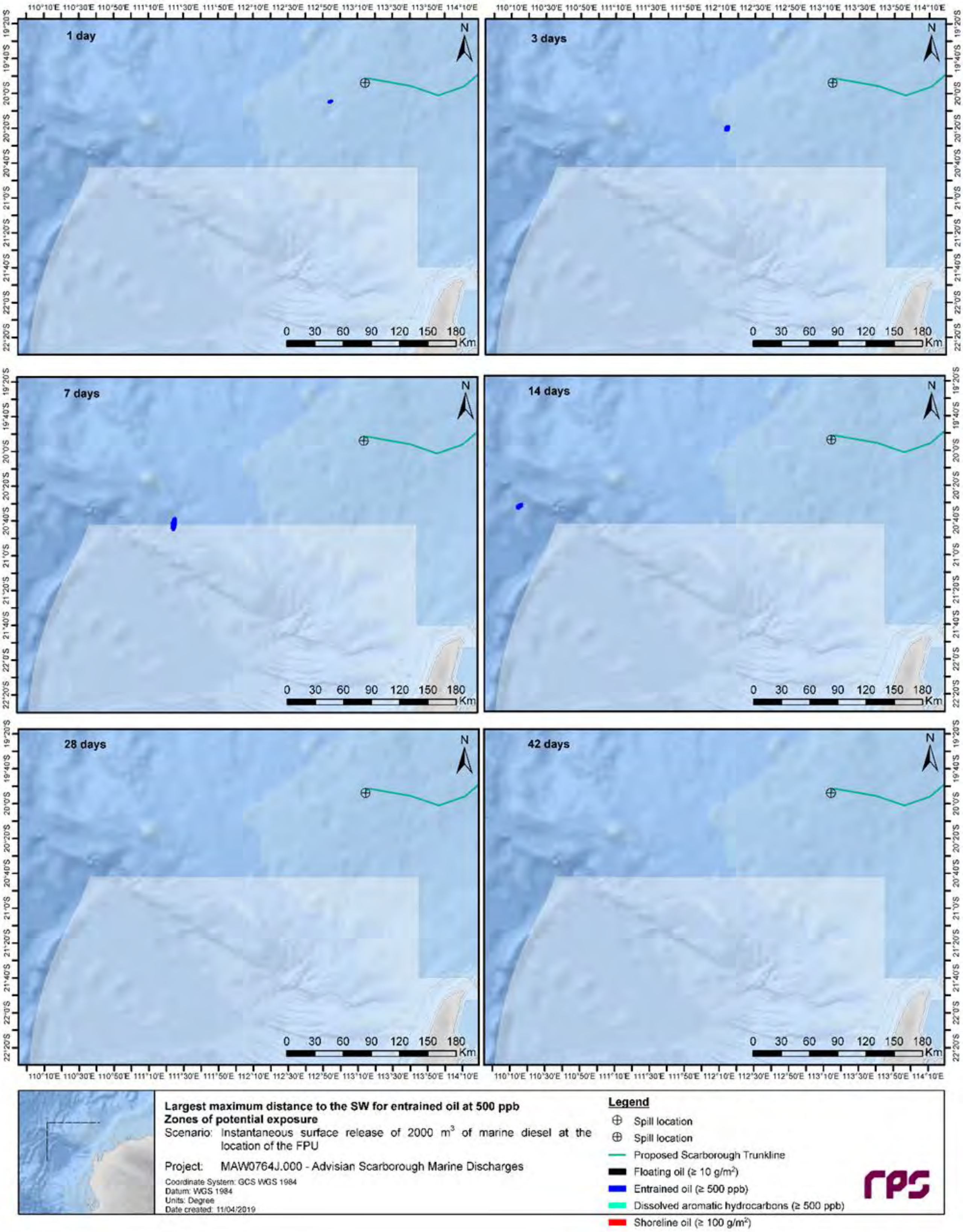


Figure 7-31: Time series from a single deterministic model run for an instantaneous release of 2000 m3 of MDO from the location of the FPU

Changes in Water Quality

In the event of a hydrocarbon release, water quality would be affected due to hydrocarbon exposure.

Dry Gas

In the event of a release of gas hydrocarbons from a loss of well control, the difference in density will mean gas bubbles will rise to the sea surface where it is released into the atmosphere.

Water depths encountered in Project Area (about 900 m), and associated high pressure and low temperature conditions, would result in any released gas to combine with water to form hydrates (Figure 7-32), a solid ice-like substance. Following formation, these hydrates would rise through the water column and, upon reaching shallower water depths (depths above the hydrate formation line as shown in (Figure 7-32)), decompose into methane and water. As methane is highly soluble in water, it would dissolve quickly into the water column after hydrate decomposition. The dissolved methane would biodegrade whereas the gaseous methane will continue to rise to the sea surface and be transported away by surface winds. Water produced by the dissociation of hydrates will disperse within the water column.

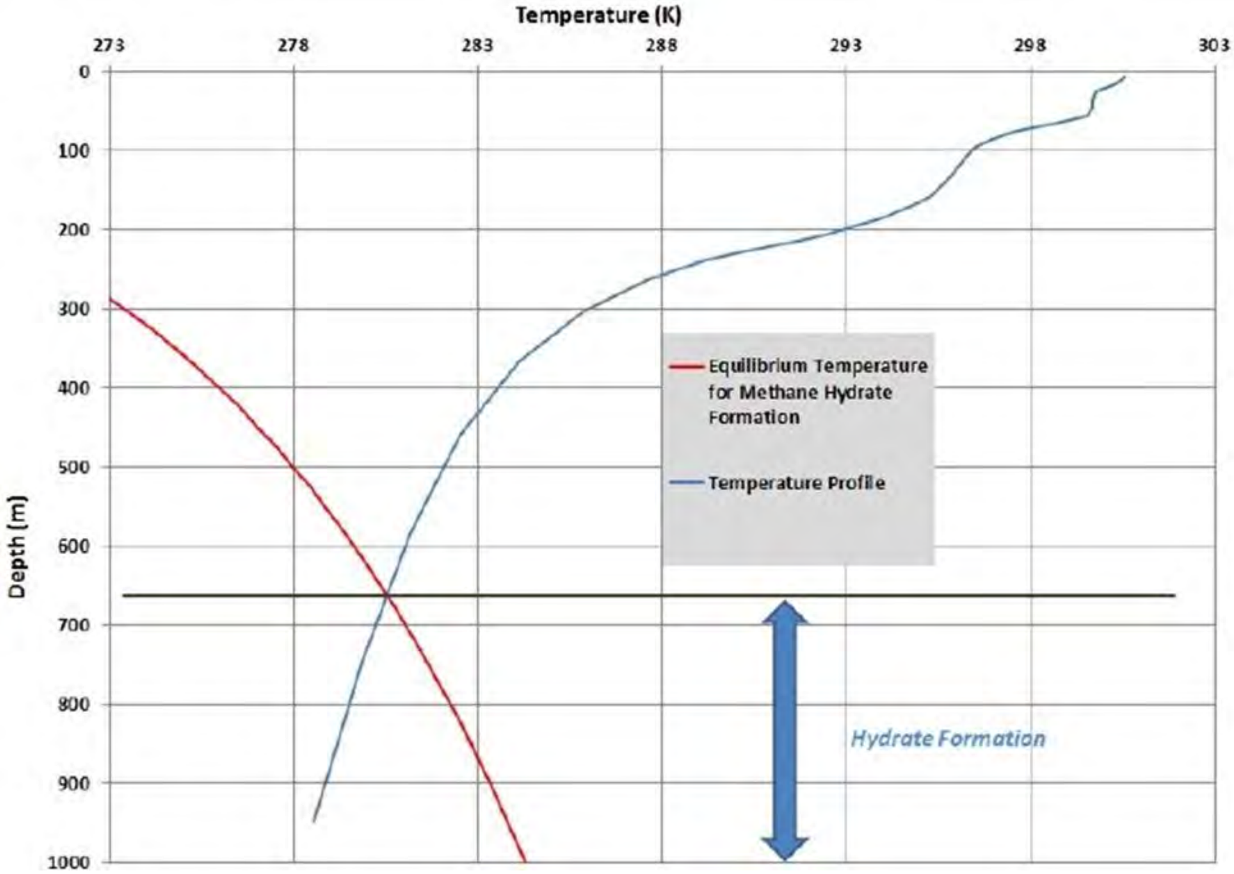


Figure 7-32: Hydrate formation for methane release during a well blow out scenario (Bishmnoi and Natarajan, 1996, cited in ERM, 2013)

Following the 2012 gas leak from the Elgin platform in the North Sea, monitoring of water and sediment (Webster et al., 2012a, b) and fish health (Webster et al., 2012b, c) found no evidence of hydrocarbon contamination above background levels. Although this was in colder sea temperatures than is present at the project area, in general, as the temperature increases, the solubility of a gas decreases, meaning more gas will escape from solution. Therefore, potential impacts arising from a liquid hydrocarbon release are expected to exceed (in terms of impact pathway and spatial extent) that of a gas release.

Due to the pressure difference between the gas and surrounding water, contamination of the water column or sediment a result of a loss of well control and significant gas release is expected to be minimal and not evaluated further.

MDO

MDO is a non-persistent fuel oil and contains a small proportion of heavy components (or low-volatile components) that tend to physically entrain into the upper water column in the presence of moderate winds (i.e. >12 knots) and breaking waves but may re-float to the surface if these conditions abate. In the event of a substantial spill, the heavier components can remain entrained or remain on the sea surface for an extended period.

When spilt into the warm tropical and subtropical marine environment expected, MDO spreads rapidly and forms a very thin slick, with most of the volatile components typically evaporating in less than a day. Approximately 41% by mass of this oil is predicted to evaporate over the first couple of days depending on the prevailing wind conditions, with further evaporation slowing over time. The heavier (low volatility) components of the oil tend to entrain into the upper water column due to wind-generated waves, but can subsequently resurface depending on conditions (RPS, 2019d).

RPS conducted weathering simulations to illustrate the potential behaviour of MDO when exposed at the water's surface. Variable wind conditions were used (4-19 knots), as this is the worst-case scenario as the wind conditions generate entrainment of the hydrocarbon in the water column. Approximately 24 hours after the spill, around 45% of the oil mass is forecast to have entrained and a further 36% is forecast to have evaporated, leaving only a small proportion of the oil floating on the water surface (<1%).The residual compounds will tend to remain entrained beneath the surface under conditions that generate wind waves (approximately >6 m/s).

Variable wind does result in a higher percentage of biological and photochemical degradation, with an approximate rate of 1.8% per day. Whereas the constant wind scenario shows ~50% of the oil evaporates within 36 hours with negligible entrainment, but with a rate of only ~0.2% degradation per day.

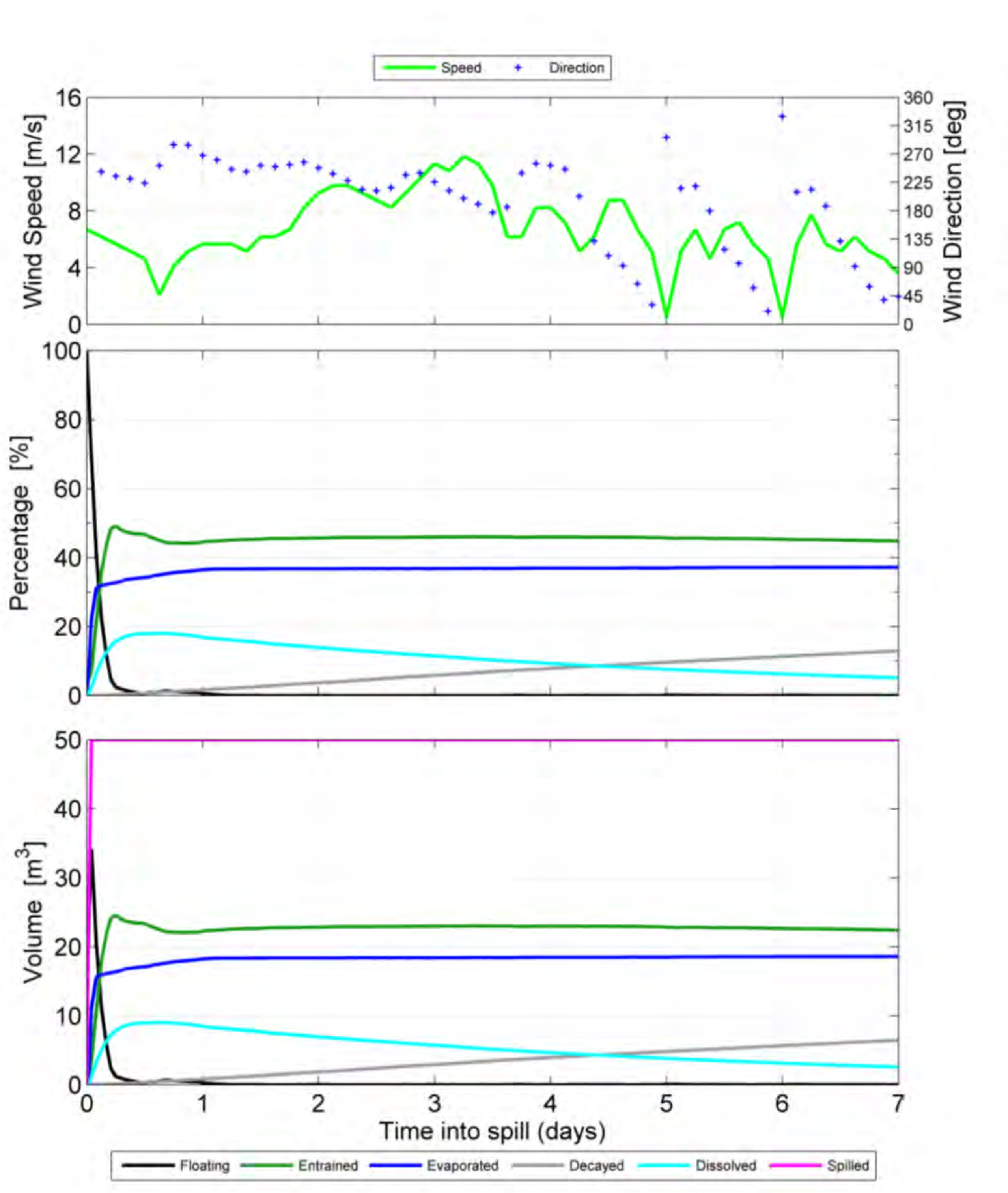


Figure 7-33: Mass balance plot representing, as a proportion (middle panel) and volume (bottom panel), the weathering of 50 m³ MDO; subject to variable wind at 27 °C water temperature and 25 °C air temperature (RPS, 2019d)

Changes in Sediment Quality

In the event of a liquid hydrocarbon release, entrained hydrocarbons may be present at concentrations above biological impact thresholds (500 ppb). Such hydrocarbon contact may lead to reduced marine sediment quality by several processes, such as adherence to sediment and deposition shores or seabed habitat.

Typically, an MDO release would entrain into the top ~10 m of the water column. The water depth of the shallowest release point is 74 m, but entrained oil may contact benthic habitats in shallow water, or in intertidal zones.

The hydrocarbon properties of the dry gas and lack of any entrainment fraction means that adherence to sediments is not expected and is not evaluated further.

Change in Habitat

Because of a change in sediment quality and/or water quality, further impacts to receptors may occur, which include a change in habitat resulting from:

- exposure of benthic habitats to in-water concentrations of hydrocarbons
- exposure of intertidal and shoreline habitats to surface hydrocarbons
- exposure of shoreline habitats to shoreline exposure.

Habitats can refer to benthic habitats (including seagrass and macroalgae, KEFs and coral reefs), or shoreline habitats (including mangroves, saltmarsh and so on).

Different habitats types have a different sensitivity to hydrocarbon exposure, and different recovery rates, which is considered in the evaluation of impacts to the receptors.

Injury/Mortality to Marine Fauna

Because of a change in water quality, further impacts to receptors may occur, which include injury or mortality to marine fauna. There are three exposure pathways:

- in-water exposure to entrained or dissolved hydrocarbons for marine fauna present in the water column
- surface hydrocarbons exposure for those species that breathe, feed or are otherwise present on the sea surface
- shoreline exposure for species that forage, breed, nest or are otherwise are present on shorelines (for example marine turtles and shorebirds).

Several threatened, migratory and/or listed marine species have the potential to be present within the area predicted to be contacted by surface, in-water and shoreline hydrocarbons above the impact thresholds. Different species have a different sensitivity to hydrocarbon exposure which is considered in the evaluation of impacts to the receptors.

Surface exposures present the greatest risk to air-breathing marine fauna and seabirds, either through contact or inhalation of the VOCs, which can result in irritation to skin and eyes or damage respiratory systems (Etkins, 1997; Kirwan and Short, 2003); or fouling of marine avifauna feathers (O'Hara and Morandin, 2010). As such, the particular values and sensitivities with the potential to be affected by surface hydrocarbon exposures are:

- migratory marine mammals (specifically Humpback Whale and Pygmy Blue Whale)
- resident dolphin populations
- marine turtle foraging and internesting
- marine avifauna foraging.

Entrained hydrocarbons represent the dispersed insoluble oil droplets phase and pose a hazard to marine life that become entrained (i.e. juvenile fish, larvae, and plankton) with the hydrocarbon plume, via direct ingestion or the consumption of contaminated prey. Given the mobility of marine fauna (e.g. marine mammals, marine turtles) that may be present in the area at the time of the spill, no chronic impacts or risks are expected because these fauna are unlikely to undergo prolonged exposure.

Although the potential for acute exposure is widespread, the interaction of mobile marine fauna with surface hydrocarbons is expected to be limited because weathering will limit the duration of exposure. Therefore, exposures are expected to result in acute impacts to a small number of individuals but are unlikely to impact the viability of local populations.

Change in Fauna Behaviour

As a result of a change in water quality, further impacts to receptors may occur, which include a change in fauna behaviour to avoid hydrocarbon contact. This could include foraging, breeding, nesting, migrating and so on. Different species have a different sensitivity to hydrocarbon exposure which is considered in the evaluation of impacts to the receptors.

Change in Aesthetic Value

As a result of a change in water quality, further impact may occur. A visible sheen on the water surface may be observed, and residue may persist in nearshore areas. Shoreline accumulation over visible thresholds may also impact aesthetics.

This has the potential to reduce the visual amenity of the area for tourism and discourage recreational activities.

Change to the Functions, Interests or Activities of Other Users

As a result of a change in water quality or aesthetic value, further impacts may occur. The presence of a surface hydrocarbon slick can directly impact the activities of other marine users due to exclusion from the area.

Indirect impacts may also occur where a hydrocarbon release effects the presence, abundance or health of commercially targeted species for fisheries or aquaculture activities.

If a visible sheen or residue is observed, there is potential to reduce the visual amenity of the area for tourism and discourage recreational activities.

Receptors Potentially Impacted

Risk events resulting from unplanned hydrocarbon releases have the potential to impact several receptors including:

- water quality
- sediment quality
- habitats – coral, seagrasses, macroalgae, saltmarshes, mangroves and shoreline habitats
- marine fauna – plankton, fish, marine mammals, marine reptiles and seabirds and migratory shorebirds
- values of KEFs and protected areas such as AMPs
- functions, interests and activities of other marine users – commercial fisheries, tourism, shipping and other industries.

Table 7-85 outlines the potential impacts to receptors associated with hydrocarbon releases.

Table 7-85: Receptor/impact matrix

	Receptors																						
Impacts	*Water Quality*	*Sediment Quality*	*Plankton*	*Coral*	*Seagrass and*	*Macroalgae*	*Saltmarsh*	*Mangroves*	*Shoreline Habitats*	*Seabirds and Migratory Shorebirds*	*Fish*	*Marine Mammals*	*Marine Reptiles*	*KEFs*	*AMPs*	Protected Place	*Commonwealth Managed Fisheries*	*State Managed Fisheries*	*Tourism and Recreation*	*Shipping*	*Industry*	*Defence*	*Settlements*
Change in water quality	✓																						
Change in sediment quality		✓																					
Change in habitat				✓	✓	✓	✓	✓	✓					✓	✓	✓							
Change in fauna behaviour										✓	✓	✓	✓		✓	✓	✓	✓	✓				
Injury/mortality to fauna			✓							✓	✓	✓	✓		✓	✓	✓	✓	✓				
Changes to functions, interests or activities of other users															✓	✓	✓	✓	✓	✓	✓	✓	✓
Change in aesthetic value															✓	✓			✓				✓

Detailed Risk Evaluation

Water Quality

An unplanned release of hydrocarbons, specifically MDO, would result in a change in water quality, affecting the ambient water quality within the EMBA.

The highly-mixed, open water location and characteristics of hydrocarbons released will result in rapid evaporation and dispersion. However, MDO contains a small proportion of heavy components (or low-volatile components) that tend to physically entrain into the upper water column in the presence of moderate winds (i.e. >12 knots) and breaking waves but may refloat to the surface if these conditions abate. If a substantial spill occurred, the heavier components could remain entrained or remain on the sea surface for an extended period and travel significant distances from the source, albeit at low levels.

The hydrocarbon characteristics of MDO mean that in variable wind conditions, it is expected that approximately 24 hours after the spill, around 45% of the oil mass is forecast to have entrained and a further 36% is forecast to have evaporated, leaving only a small proportion of the oil floating on the water surface (<1%) (RPS, 2019d).

Entrained hydrocarbons that result from a potential spill at the FPU location or along the pipeline route could travel according to modelling up to 476 km from the location, which is the worst-case scenario based on distance from the source. While the stochastic figures may show a large extent of an area that could potentially be exposed at some point to hydrocarbons (in the event of a worst-case spill) the worst-case deterministic runs indicate that the potential area exposed to entrained hydrocarbons is much smaller, at maximum over a 30 km^2 area and for only a small period of time given the nature of MDO to evaporate and spread quickly.

Given the control measures in place to prevent unplanned hydrocarbon releases, the offshore location of Scarborough and hydrocarbon characteristics, the change to water quality resulting from unplanned hydrocarbon releases may occur at significant distance from the source, however, will be temporary. Exposure to significant habitats will be at low levels such that no significant habitats or ecosystem function or integrity will be impacted (as discussed in the receptor sections to follow).

Based on the assessment, the magnitude of a potential impact to water quality associated with a release of hydrocarbons is slight. Receptor sensitivity of water quality is low (low value, open ocean), and therefore the consequence of a release of hydrocarbons on water quality is **Negligible (F).**

Sediment Quality

Due to the depth of water at the FPU site, based on predictions in the modelling, sediment quality in the Offshore Project Area is unlikely to be impacted by surface releases of hydrocarbons. A spill originating in the shallower waters of the Trunkline Project Area could potentially result in entrained hydrocarbons contacting marine sediment, although this is not likely given MDO is typically entrained in the top ~10 m of the water column, subject to wave and wind action.

Shoreline contact is not predicted for spills from areas offshore, however there is potential that should a spill occur closer to State waters, there could be the potential for exposure to shallow waters and shorelines around islands and the mainland. Modelling predicts that there is only 1% probability of shorelines being contacted over the exposure threshold, for any release location, at WA Coastline and Dampier Archipelago (RPS, 2019d), with small predicted volumes ashore (approximately 3 m^3).

Where exposure to sediments occurs, toxins may accumulate within marine sediment, however given that these will be at low levels over relatively small areas this will not result in changes to the sediment quality such that there is adverse effects on biodiversity, ecological integrity, social amenity or human health.

Based on the assessment, the magnitude of a potential impact to sediment quality associated with a release of hydrocarbons is slight. Receptor sensitivity of sediment quality is low (low value, homogenous), and therefore the consequence of a release of hydrocarbons on sediment quality is **Negligible (F).**

Plankton

Injury/mortality to planktonic species may occur due to a change in water quality following an unplanned hydrocarbon release. Any surface and subsurface hydrocarbon release could impact plankton, as they are widely dispersed throughout the water column.

Primary production by plankton (supported by sporadic upwelling events in the offshore waters of the NWS) is an important component of the primary marine food web. Planktonic communities are generally mixed, including phytoplankton (cyanobacteria and other microalgae) and secondary consuming zooplankton, such as crustaceans (e.g. copepods), and the eggs and larvae of fish and invertebrates (meroplankton).

Exposure to hydrocarbons in the water column (entrained or dissolved) can change species composition, with declines or increases in one or more species or taxonomic groups (Batten et al., 1998). Phytoplankton may also experience decreased rates of photosynthesis (Tomajka, 1985). For zooplankton, such as fish, coral and invertebrate eggs and larvae, direct effects of contamination may include toxicity, suffocation, changes in behaviour, or environmental changes that make them more susceptible to predation.

Impacts on plankton communities are likely to occur in areas where entrained or dissolved aromatic hydrocarbon threshold concentrations are exceeded, but communities are expected to recover relatively quickly (within weeks or months). This is due to high population turnover, with copious production within short generation times that also buffers the potential for long-term (i.e. years) population declines (International Tanker Owners Pollution Federation, 2011a).

When first released, MDO has a higher toxicity due to the presence of the volatile components. Plankton making contact close to the spill source at the time of the spill may be impacted, however given the short-term nature of the scenario, it is unlikely that large populations of plankton will be affected at the sea surface above thresholds as this is only predicted for the first few days after the spill. All three release locations predict low probabilities and low concentration to intersect with sensitive receptors.

Given hydrocarbon characteristics, expected rapid weathering and then degradation of the entrained component to below impact thresholds, and relatively quick recovery times of plankton, unplanned releases from Scarborough are not expected to have a substantial adverse effect on plankton life cycle and spatial distribution.

Based on the assessment, the magnitude of a potential impact to plankton associated with a release of hydrocarbons is slight. Receptor sensitivity of plankton is low (low value, open water), and therefore the consequence of a release of hydrocarbons on plankton is **Negligible (F).**

Fish

Injury/mortality to fish species may occur due to a change in water quality following an unplanned hydrocarbon release. Any surface and subsurface hydrocarbon release could impact fish, as they are widely dispersed throughout the water column.

Impacts to sharks and rays may occur through direct contact with hydrocarbons and contaminate the tissues and internal organs, either through direct contact or via the food chain (consumption of prey). As gill breathing organisms, sharks and rays may be vulnerable to toxic effects of dissolved hydrocarbons (entering the body via the gills) and entrained hydrocarbons (coating of the gills inhibiting gas exchange).

The effects of exposure to oil on the metabolism of fish appear to vary according to the organs involved, exposure concentrations and route of exposure (waterborne or food intake). Oil reduces the aerobic capacity of fish exposed to aromatics in the water, and to a lesser extent affects fish consuming contaminated food (Cohen et al., 2005). The liver, a major detoxification organ, appears to be where anaerobic activity is most impacted, probably increasing anaerobic activity to help eliminate ingested oil from the fish (Cohen et al., 2005).

Fish are perhaps most susceptible to the effects of spilled oil in their early life stages, particularly during egg and planktonic larval stages, which can become entrained in spilled oil. Contact with oil droplets can mechanically damage feeding and breathing apparatus of embryos and larvae (Fodrie and Heck, 2011). The toxic hydrocarbons in water can result in genetic damage, physical deformities and altered developmental timing for larvae and eggs exposed to even low concentrations over prolonged timeframes (days to weeks) (Fodrie and Heck, 2011). More subtle, chronic effects on the life history of fish because of exposure in early life stages to hydrocarbons include disruption to complex behaviour such as predator avoidance, reproductive and social behaviour (Hjermann et al., 2007). Prolonged exposure of eggs and larvae to weathered concentrations of hydrocarbons in water has also been shown to cause immunosuppression and allows expression of viral diseases (Hjermann et al., 2007).

Adult fish exposed to low hydrocarbon concentrations are likely to metabolise the hydrocarbons and excrete the derivatives, with studies showing that fish can metabolise petroleum hydrocarbons and that accumulated hydrocarbons are released from tissues when the fish is returned to hydrocarbon-free sea water. Several fish communities in these areas are demersal (i.e. living closer to the seabed) where concentrations of entrained hydrocarbons will be lower; any impacts are expected to be highly localised.

Marine fauna with gill-based respiratory systems are expected to have higher sensitivity to exposures of entrained contaminants. Therefore, the receptors most susceptible to dissolved hydrocarbons are fish and whale sharks. MDO does not tend to have a high proportion that dissolves – all three release locations predict low probabilities and low concentration to intersect with sensitive receptors.

Fish mortalities are rarely observed to occur as a result of hydrocarbon spills (International Tanker Owners Pollution Federation, 2011b). This has generally been attributed to the possibility that pelagic fish are able to detect and avoid surface waters underneath hydrocarbon spills by swimming into deeper water or away from the affected areas. Fish that have been exposed to dissolved aromatic hydrocarbons are capable of eliminating the toxicants once placed in clean water; hence, individuals exposed to a spill are likely to recover (King et al., 1996). Where fish mortalities have been recorded, the spills (resulting from the groundings of the tankers Amoco Cadiz in 1978 and the Florida in 1969) have occurred in sheltered bays. Further to this, laboratory studies have shown that adult fish can detect hydrocarbons in water at very low concentrations, and large numbers of dead fish have rarely been reported after hydrocarbon spills (Hjermann et al., 2007). This suggests that juvenile and adult fish can avoid water contaminated with high concentrations of hydrocarbons.

When first released, MDO has a higher toxicity due to the presence of the volatile components. Individual fish making contact close to the spill source at the time of the spill may be impacted. Fish presence is generally concentrated in waters closer to shore, therefore spills within the Trunkline Project Area are more likely to have a greater level of impact than that of a spill in the Offshore Project Area. Although fish presence may occur throughout the entire Scarborough Project area and defined EMBA, it is unlikely that a large number of fish will be affected at the sea surface above thresholds, as this is only <1-15% remaining on the surface after 7 days.

Mobile transient fauna are not expected to remain within entrained hydrocarbon plumes for an extended time. Therefore, no acute impacts or risks associated with entrained exposures from an unplanned MDO release are expected. Any impacts from this exposure are expected to result in localised short-term effects to limited small numbers of juvenile fish and prey species (larvae and planktonic organisms), which are not expected to affect population viability and recruitment of fish. Consequently, diverse fish assemblages are not expected to be significantly impacted.

Although potential impacts could include mortality or sub-lethal injury/illness of pelagic fish, this would be expected to comprise a small proportion of the resident and transitory population. Given hydrocarbon characteristics, expected rapid weathering to below impact thresholds and degradation of entrained fractions, and the mobile transient nature of fish, unplanned releases from Scarborough are not expected to have a substantial adverse effect on the population, or spatial distribution of fish; or substantially modify, destroy or isolate an area of important habitat for migratory species. Additionally, unplanned releases will not seriously disrupt the lifecycle of an ecologically significant proportion of any migratory fish species (i.e. whale sharks).

There are specific conservation advices for some fish species which identify habitat degradation / modification as a key threat. While generally no explicit management actions are identified, for some species there are specific requirements:

- Sawfish and river sharks: Identify risks to important habitat and measures needed to reduce those risks and implement measures to reduce adverse impacts of habitat degradation and/or modification (freshwater sawfish only).
- Whale shark: Minimise offshore developments and transit time of large vessels in areas close to marine features likely to correlate with Whale Shark aggregations and along the northward migration route.

These focus on measures to reduce adverse impacts of habitat degradation, which could include from unplanned hydrocarbon releases, although this is not explicit. Although these regions are at risk of exposure to hydrocarbons in the event of a release, in particular during the construction phase of the project (during trunkline installation), the impacts will be temporary as the MDO evaporates and degrades and moves with ocean currents.

As activities will take place within or adjacent to AMPs, there are principles, objectives and values to be considered. Natural values for the marine parks include:

- diverse fish communities for the Dampier, Gascoyne, Ningaloo or Montebello Marine Parks
- diverse fish communities specifically within the Continental slope demersal fish communities KEF for Gascoyne and Ningaloo Marine Parks
- whale shark foraging habitat BIAs for Montebello and Ningaloo Marine Parks.

The objective of the Habitat Protection Zone (IV) (Dampier, Gascoyne and Ningaloo Marine Parks) is to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while allowing activities that do not harm or cause destruction to seafloor habitats. The objective of the National Park Zone (II) (Dampier and Gascoyne Marine Parks) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible. The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species (refer to Section 3.6.2).

Modelling predicts that Dampier Marine Park is likely to be exposed to entrained, dissolved and surface hydrocarbons over the thresholds from the Mermaid Sound release location. The other two release locations are not predicted to expose Dampier Marine Park. The entrained fraction presents the worst-case, at a maximum concentration of 10,407 ppb (RPS, 2019d).

The Montebello Marine Park will be exposed to entrained, dissolved and surface hydrocarbons above exposure thresholds from the Montebello release scenario, which is to be expected, as the release point is inside the Marine Park. Ningaloo World Heritage Area and the Gascoyne Marine Park have a low probability of being intersected by entrained oil only (4% and 8% respectively).

While this results in exposure to hydrocarbons for some of the natural values of the marine parks, the impacts will be temporary as the MDO evaporates and degrades and moves with ocean currents.

Based on the assessment, the magnitude of a potential impact to fish associated with a release of hydrocarbons is slight. Receptor sensitivity of fish is high (high value fauna), and therefore the consequence of a release of hydrocarbons on fish is **Minor (D).**

<u>Marine Mammals</u>

A change in marine fauna behaviour or injury/mortality to marine mammals may occur due to a change in water quality following an unplanned hydrocarbon release.

Air-breathing fauna such as marine mammals are most at risk from surface exposures due to the high volatile components. Marine mammals that have direct physical contact with surface, entrained or dissolved aromatic hydrocarbons may suffer surface fouling, ingest hydrocarbons and inhale toxic vapours. This may result in the irritation of sensitive membranes such as the eyes, mouth, digestive and respiratory tracts and organs, impairment of the immune system or neurological damage (Helm et al., 2015). If prey (fish and plankton) are contaminated, this can result in the absorption of toxic components of the hydrocarbons (PAHs).

In a review of cetacean observations in relation to a number of large-scale hydrocarbon spills, Geraci (1988) found little evidence of mortality associated with hydrocarbon spills. However, behavioural disturbance (i.e. avoiding spilled hydrocarbons) was observed in some instances for several species of cetaceans. This suggests that cetaceans are able to detect and avoid surface slicks. While this reduces the potential for physiological impacts from contact with hydrocarbons, active avoidance of an area may disrupt behaviours such as migration, or displace individuals from important habitat, such as foraging, resting or breeding.

Because of the potential extent of moderate surface exposures, there is the potential for widespread exposure to marine fauna (whales, turtles, whale sharks, and seabirds).

When first released, MDO has a higher toxicity due to the presence of the volatile components. Individual cetaceans making contact close to the spill source at the time of the spill may be impacted. Cetacean presence is generally more concentrated in waters closer to shore with the exception of false killer whales. Spills within the Trunkline Project Area are therefore more likely to have a greater level of impact than that of a spill in the Offshore Project Area. Migratory BIAs for humpback and pygmy blue whales occur along the Trunkline Project Area. Although cetacean presence may occur throughout the Scarborough Project area and defined EMBA, it is unlikely that a large number of cetaceans will be affected at the sea surface above thresholds, as dependant on wind conditions, weathering predicts that less than 15% of hydrocarbon remains on the surface after ~7 days (RPS, 2019d).

Although potential impacts could include mortality or sub-lethal injury/illness of marine mammals, this would be expected to comprise a small proportion of the resident and transitory population. Given hydrocarbon characteristics, expected rapid weathering of surface oil to below impact thresholds, and the mobile transient nature of marine mammals and potential avoidance behaviour, unplanned releases from Scarborough are not expected to have a substantial adverse effect on the population, or spatial distribution of marine mammals; or substantially modify, destroy or isolate an area of important habitat for migratory species. Additionally, unplanned releases will not seriously disrupt the lifecycle of an ecologically significant proportion of any migratory species.

There are specific conservation advices for some species which identify noise interference and vessel disturbance as key threats. While hydrocarbon spills are not explicitly identified as a threat, the sei whale conservation advice does include the management of physical disturbance and development activities. No explicit management actions are identified relevant to hydrocarbon spills.

As activities will take place within or adjacent to AMPs, there are principles, objectives and values to be considered. Natural values for the marine parks include:

- humpback whale migratory pathways BIAs for Montebello, Dampier and Gascoyne Marine Parks

- pygmy blue whale foraging habitat and migratory pathways BIAs for Gascoyne and Ningaloo Marine Parks
- dugong nursing habitat BIAs for Ningaloo Marine Park.

Modelling predicts that the Montebello Marine Park has 100% probability of surface oil above the ecological (and socio-cultural) thresholds, which is to be expected, as one of the release points is inside the Marine Park. Surface oil weathers rapidly (depending on wind conditions), so this still presents a short-term change. The Dampier and Gascoyne Marine Parks have low probabilities of being intersected with surface oil over the ecological (and socio-cultural) thresholds (RPS, 2019d). Ningaloo Marine Park is not predicted to be contacted with any surface hydrocarbon over the ecological (and socio-cultural) thresholds.

While this results in exposure to hydrocarbons for some of the natural values of the marine parks, the impacts will be temporary as the MDO evaporates and degrades and moves with ocean currents.

Potential impacts are unlikely to lead to mortality or sub-lethal injury/illness of an EPBC-listed protected species.

Based on the assessment, the magnitude of a potential impact to marine mammals associated with a release of hydrocarbons is slight. Receptor sensitivity of marine mammals is high (high value fauna), and therefore the consequence of a release of hydrocarbons on marine mammals is **Minor (D).**

Marine Reptiles

A change in marine fauna behaviour or injury/mortality to marine reptiles may occur due to a change in water or sediment quality following an unplanned hydrocarbon release.

Marine reptiles can be impacted by surface exposure to hydrocarbons when they surface to breathe, and by shoreline accumulation of hydrocarbons when breeding and nesting. Adult sea turtles exhibit no avoidance behaviour when they encounter hydrocarbon spills (National Oceanic and Atmospheric Administration, 2010).

Hydrocarbons in surface waters may impact turtles when they surface to breathe and inhale toxic vapours. Their breathing pattern, involving large 'tidal' volumes and rapid inhalation before diving, results in direct exposure to petroleum vapours which are the most toxic component of the hydrocarbon spill (Milton and Lutz, 2003). This can lead to lung damage and congestion, interstitial emphysema, inhalant pneumonia and neurological impairment (National Oceanic and Atmospheric Administration, 2010). Contact with entrained hydrocarbons can result in hydrocarbon adherence to body surfaces, irritating mucous membranes in the nose, throat and eyes, leading to inflammation and infection (Gagnon and Rawson, 2010).

Oiling can also irritate and injure skin, which is most evident on pliable areas such as the neck and flippers (Lutcavage et al., 1995). A stress response associated with this exposure pathway includes an increase in the production of white blood cells, and even a short exposure to hydrocarbons may affect the functioning of their salt gland (Lutcavage et al., 1995).

When first released, MDO has a higher toxicity due to the presence of the volatile components. Individual turtles making contact close to the spill source at the time of the spill may be impacted. Turtle presence is generally more concentrated in waters closer to shore with infrequent presence of turtles as far offshore at the Offshore Project Area. Spills within the Trunkline Project Area are therefore more likely to have a greater level of impact than that of a spill in the Offshore Project Area. Breeding, foraging and internesting BIAs lie within the Trunkline Project Area and EMBA. Although turtle presence may occur throughout the Scarborough Project area and defined EMBA, it is unlikely that a large number of turtles will be affected at the sea surface above thresholds as weathering predicts that less than 15% of hydrocarbon remains on the surface after ~7 days (RPS, 2019d).

Hydrocarbons accumulated on sandy beaches may also potentially impact nesting females, incubating eggs and emerging hatchlings through direct contact with the hydrocarbon. Conservative modelling predicts that there is 1% probability of shorelines being contacted over the exposure threshold, for any release location, at WA Coastline and Dampier Archipelago, with the maximum local volume predicted to accumulate of only 3 m^3. The FPU location does not predict any shoreline contact.

Several significant nesting areas for turtles occur across the EMBA, in particular at the Montebello/Barrow/Lowendal Islands group, Muiron Island, Pilbara islands, Dampier Archipelago which have been identified as BIAs or habitat critical. Hence there is the potential to impact on nesting populations, which has the potential to affect species recruitment at a local population level.

The proximity of a potential spill from shore will determine how much hydrocarbons reach the shore, as MDO weathers rapidly, with less than 15% remaining to reach the shore after the first ~7 days. While the exact timing of the activity is unknown, the time of year can determine whether migratory species are present, and the type of activities being engaged in, for example nesting and hatching which begins in November, peaks in January-February, and end in April (DoEE, 2017c).

Impacts to sea snakes from direct contact with hydrocarbons are likely to result in similar physical effects to those recorded for marine turtles.

Although potential impacts could include mortality or sub-lethal injury/illness of marine reptiles, this would be expected to comprise a small proportion of the resident and transitory population. The significant turtle nesting areas predicted to be contact by hydrocarbons above the shoreline exposure threshold include Legendre and Rosemary Island (in the Dampier Archipelago group), however of only a worst-case accumulated volume of 3 m^3. Barrow Island may be contacted, but not above the threshold (RPS, 2019d). Given hydrocarbon characteristics, expected rapid weathering to below impact thresholds, and the mobile transient nature of individuals, unplanned releases from Scarborough are not expected to have a substantial adverse effect on the population, or spatial distribution of marine reptiles; or seriously disrupt the lifecycle of an ecologically significant proportion of any migratory species. In addition, the highest risks to sensitive areas are during the construction phase, which is relatively short-term (3-6 months).

Impacts to turtles from unplanned hydrocarbon releases are to be managed in accordance with the Recovery Plan for marine turtles in Australia (DoEE, 2017). The Recovery Plan identifies ensuring spill risk strategies and response programs include management for turtles and their habitats. In addition, there is in place approved Conservation Advice for the Short-nosed Sea snake (DSEWPaC, 2011), which includes ensuring there is no anthropogenic disturbance in areas where the species occurs, excluding necessary actions to manage the conservation of the species.

As activities will take place within or adjacent to AMPs, there are principles, objectives and values to be considered. Natural values for the marine parks include:

- marine turtle internesting BIAS for Dampier, Gascoyne and Ningaloo Marine Parks
- marine turtle internesting, foraging, mating and nesting habitat BIAs for Montebello Marine Park.

Based on the detailed risk evaluation, the magnitude of potential impacts to marine reptiles from unplanned hydrocarbon releases is assessed as no lasting effects (from change in fauna behaviour) and slight (from injury/mortality to fauna) and given the high value species present the risk consequence has been evaluated as slight and minor respectively.

Based on the assessment, the magnitude of a potential impact to marine reptiles associated with a release of hydrocarbons is no lasting effect. Receptor sensitivity of marine reptiles is high (high value fauna), and therefore the consequence of a release of hydrocarbons on marine reptiles is **Slight (E).**

Seabirds and Migratory Shorebirds

A change in marine fauna behaviour or injury/mortality to seabirds and migratory shorebirds may occur due to a change in water or sediment quality following an unplanned hydrocarbon release.

Seabirds and migratory birds are particularly vulnerable to contact with floating hydrocarbons, which may mat feathers. This may lead to hypothermia from loss of insulation and ingestion of hydrocarbons when preening to remove hydrocarbons. Both impacts may result in mortality (Hassan and Javed, 2011). Pathways of biological exposure that can result in impact may occur through ingesting contaminated fish (nearshore waters) or invertebrates (intertidal foraging grounds such as beaches, mudflats and reefs). Ingestion can also lead to internal injury to sensitive membranes and organs (International Petroleum Industry Environmental Conservation Association, 2004). Whether the toxicity of ingested hydrocarbons is lethal or sub-lethal will depend on the weathering stage and its inherent toxicity. Exposure to hydrocarbons may have longer term effects, with impacts to population numbers due to decline in reproductive performance and malformed eggs and chicks, affecting survivorship and losing adult birds.

When first released, MDO has a higher toxicity due to the presence of the volatile components. Individual birds making contact close to the spill source at the time of the spill may be impacted. Bird presence within the NW region is more concentrated in waters closer to shore with the potential for individual migratory birds within the Offshore Project Area. Spills within the Trunkline Project Area are therefore more likely to have a greater level of impact than that of a spill in the Offshore Project Area. Breeding and foraging BIAs for some bird species are present within the Trunkline Project Area and defined EMBA. Although bird presence may occur throughout the Scarborough Project area and defined EMBA, it is unlikely that a large number of birds will be affected at the sea surface above thresholds as this is only predicted for the first five days.

Offshore waters of the Project Area are potential foraging grounds for seabirds associated with the coastal roosting and nesting habitat, which includes the numerous islands along the Pilbara coast. Nearshore waters potentially impacted are utilised by seabirds and resident/non-breeding overwintering shorebirds for foraging and resting. Although breeding oceanic seabird species can travel large distances to forage in offshore waters, breeding seabirds tend to forage in nearshore waters near breeding colonies.

Shoreline hydrocarbons that may accumulate on beaches may also potentially impact nesting females, incubating eggs and emerging hatchlings through direct contact with the hydrocarbon. Conservative modelling predicts that there is 1% probability of shorelines being contacted over the exposure threshold, for any release location, at WA Coastline and Dampier Archipelago, with the maximum local volume predicted to accumulate of only 3 m^3. The FPU location does not predict any shoreline contact.

Several significant important habitats for seabirds and migratory shorebirds for key breeding/nesting areas, roosting areas and surrounding waters important foraging and resting areas nesting areas occur in the EMBA, in particular at Montebello/Barrow/Lowendal Islands group, Pilbara Islands, Muiron Islands and Rowley Shoals. Breeding BIAs for seabirds and shorebirds are primarily restricted to within tens of kilometres of emergent features. Hence in the event of significant hydrocarbon exposure there is the potential to impact on nesting populations, which has the potential to affect species recruitment at a local population level. The proximity of a potential spill from shore will determine how much hydrocarbons reach the shore, as MDO weathers rapidly, with less than 15% of hydrocarbon predicted to remain on the surface after ~7 days (RPS, 2019d). The time of year can determine whether migratory species are present, and the type of activities birds are engaging in.

Although potential impacts could include mortality or sub-lethal injury/illness of birds, this would be expected to comprise a small proportion of the resident and transitory population. The significant shorebird nesting areas predicted to be contact by hydrocarbons above the shoreline exposure threshold include Legendre and Rosemary Island (in the Dampier Archipelago group), however of only a worst-case accumulated volume of 3 m^3. Barrow Island may be contacted, but not above the shoreline exposure threshold (RPS, 2019d). However, given hydrocarbon characteristics, expected rapid weathering to below impact thresholds, and the mobile transient nature of individuals, unplanned releases from Scarborough are not to predicted to have a substantial adverse effect on the population, or spatial distribution of seabirds or migratory shorebirds; or seriously disrupt the lifecycle of an ecologically significant proportion of any migratory species, nor expected to substantially modify, destroy or isolate an area of important habitat for migratory species. In addition, the highest risks to sensitive areas are during the construction phase, which is relatively short-term (3-6 months).

There are specific conservation advices for some species which identify habitat degradation as the key threat. While generally no explicit management actions are identified, for some of the species, there is a general requirement to:

- manage disturbance at important sites which are subject to anthropogenic disturbance when the species is present (including the Greater Sand Plover, Large Sand Plover, Great Knot, Eastern Curlew, and Far Eastern Curlew)
- ensure there is no disturbance in areas where the species is known to breed (specific to the Australian Painted Snipe)
- ensure appropriate oil-spill contingency plans are in place for the subspecies' breeding sites which are vulnerable to oil spills (specific to the Australian Fairy Tern).

As activities will take place within or adjacent to AMPs, there are principles, objectives and values to be considered. Natural values for the marine parks include:

- seabird breeding habitat BIAs (Montebello, Dampier, Gascoyne and Ningaloo Marine Parks)
- seabird foraging habitat BIAs (Dampier and Ningaloo Marine Parks).

Impacts have potential widespread long-term impacts to species. Based on the assessment, the magnitude of a potential impact to seabirds and migratory shorebirds associated with a release of hydrocarbons is having no lasting effects (from change in fauna behaviour) and slight (from injury/mortality to fauna). Receptor sensitivity of seabirds and migratory shorebirds is high (high value fauna), and therefore the consequence of a release of hydrocarbons on seabirds and migratory shorebirds is **Slight (E).**

Coral

A change in habitat may occur due to a change in water or sediment quality following an unplanned hydrocarbon release.

Water soluble hydrocarbon fractions associated with surface slicks are also known to cause high coral mortality (Shigenaka, 2001) via direct physical contact of hydrocarbon droplets to sensitive coral species (such as the branching coral species). There is significant potential for lethal impacts due to the physical hydrocarbon coating of sessile benthos (e.g. by entrained hydrocarbons), with likely significant mortality of corals (adults, juveniles and established recruits) at the small spill-affected areas. This particularly applies to branching corals which are reported to be more sensitive than massive corals (Shigenaka, 2001).

Exposure to entrained hydrocarbons (≥500 ppb) has the potential to result in lethal or sub-lethal toxic effects to corals and other sensitive sessile benthos within the upper water column, including upper reef slopes (subtidal corals) and reef flat (intertidal corals). Sub-lethal effects to corals may include polyp retraction, changes in feeding, bleaching (loss of zooxanthellae), increased mucous production resulting in reduced growth rates and impaired reproduction (Negri and Heyward, 2000).

Should a hydrocarbon release occur at the time of coral spawning (at potentially affected coral locations), there is the potential for a significant reduction in successful fertilisation and coral larval survival, due to the sensitivity of coral in early life stages to hydrocarbons (Negri and Heyward, 2000). Such impacts are likely to result in the failure of recruitment and settlement of new population cohorts. In addition to direct impacts to coral, species associated with coral reef habitat, such as fish, may also be impacted as described above.

The general behaviour of MDO is that it will typically remain on the sea surface but can entrain into the upper water column under moderate wind conditions; however, sedimentation of oil droplets is not expected to occur. As such, exposure of coral habitats to hydrocarbon would only be relevant in shallow nearshore and/or intertidal waters.

Significant areas of coral are known to occur fringing the Montebello Islands, Barrow Island and the Muiron Islands, Dampier Archipelago (including Legendre and Rosemary Island) and Ningaloo Reef.

Montebello Marine Park has the highest probability of entrained hydrocarbon over the exposure threshold (70%), which is to be expected from the Montebello release location on the trunkline. The Dampier Marine Park and the Dampier Archipelago are the next most likely receptors impacted, and then Barrow and Muiron Islands and Ningaloo have <7% probability

In the event of a hydrocarbon spill, there is the potential for these coral reefs to be exposed to entrained and/or dissolved aromatic hydrocarbons concentrations that are considered to induce toxicity effects. Exposure to entrained hydrocarbons/dissolved aromatic hydrocarbons (≥500 ppb) has the potential to result in lethal or sublethal toxic effects to corals and other sensitive sessile benthos within the upper water column, including upper reef slopes (subtidal corals), reef flat (intertidal corals) and lagoonal (back reef) coral communities (with reference to Ningaloo Coast). As MDO can entrain into the upper water column under moderate wind conditions, this could result in impacts to the shallow water fringing coral communities/reefs of the offshore islands (e.g. Barrow/Montebello/Lowendal Islands) and also the mainland coast (e.g. Ningaloo Coast).

In the event of significant exposure, impacted coral reefs may experience long-term effects (i.e. recovery periods taking up to 10 years) due to their recovery relying on coral larvae from neighbouring coral communities that have either not been affected or only partially impacted. However, due to the short duration of the spill (i.e. instantaneous release, and short exposure time as documented by deterministic modelling), the confined spatial extent and the tendency of MDO to remain on the sea surface, significant exposure over a large scale is limited. Unplanned hydrocarbon releases from Scarborough are not expected modify, destroy, fragment, isolate or disturb an important or substantial area of habitat, such that an adverse impact on marine ecosystem functioning or integrity results.

Based on the assessment, the magnitude of a potential impact to coral associated with a release of hydrocarbons is moderate (i.e. medium-term impacts to ecosystem/habitat service on a far-field scale). Receptor sensitivity of coral is high (high value species), and therefore the consequence of a release of hydrocarbons on coral is **Major (B).**

Seagrass and Macroalgae

A change in habitat may occur due to a change in water or sediment quality following an unplanned hydrocarbon release.

Seagrass and macroalgal beds in the intertidal and subtidal zone may be susceptible to impacts from entrained hydrocarbons. Toxicity effects can also occur due to absorption of soluble fractions of hydrocarbons into tissues (Runcie et al., 2010). The potential for toxicity effects of entrained hydrocarbons may be reduced by weathering processes that should serve to lower the content of soluble aromatic components before contact occurs. Exposure to entrained hydrocarbons may result in mortality, depending on actual entrained aromatic hydrocarbon concentrations received and duration of exposure. Physical contact with entrained hydrocarbon droplets could cause sub-lethal stress, causing reduced growth rates and reduced tolerance to other stress factors (Zieman et al., 1984).

The general behaviour of MDO is that it will typically remain on the sea surface but can entrain into the upper water column under moderate wind conditions; however, sedimentation of oil droplets is not expected to occur. As such, exposure of seagrass or macroalgae to hydrocarbon would only be relevant in shallow nearshore and/or intertidal waters.

Significant seagrass and macroalgae communities are found in shallow waters surrounding islands of the Dampier Archipelago, Barrow Island and the Montebello Islands.

Modelling predicts that both Dampier Marine Park and Montebello Marine Park are predicted to be intersected with entrained hydrocarbons over the exposure thresholds (RPS, 2019d). In particular the Montebello Marine Park has a 70% probability, with high concentrations of entrained hydrocarbons. This is to be expected, as the release location modelled is within Park boundaries.

While areas where seagrass can occur may be exposed, given the hydrocarbon characteristics, expected rapid weathering to below impact thresholds, any exposure would be to a limited area and short-term, and as such unplanned hydrocarbon releases from Scarborough are not expected to result in a level of exposure to seagrass and macroalgae that would cause an adverse impact on marine ecosystem functioning or integrity results.

Based on the assessment, the magnitude of a potential impact to seagrass and macroalgae associated with a release of hydrocarbons is having no lasting effect. Receptor sensitivity of seagrass is high (high value habitat) and of macroalgae is low (low value habitat, homogenous), and therefore the consequence of a release of hydrocarbons on seagrass is **Slight (E)** and macroalgae is **Negligible (F).**

Mangroves

A change in habitat may occur due to a change in water or sediment quality following an unplanned hydrocarbon release.

Mangroves are considered to have a high sensitivity to hydrocarbon exposure. Mangroves can be impacted by heavy or viscous oil, or emulsification, that covers the trees' breathing pores thereby asphyxiating the subsurface roots, which depend on the pores for oxygen (IPIECA, 1993). Hydrocarbons deposited on the aerial roots can block the pores used to breathe, or interfere with the trees' salt balance, resulting in sub-lethal and potentially lethal effects. Mangroves can also take up hydrocarbons from contact with leaves, roots or sediments, and it is suspected that this uptake causes defoliation through leaf damage and tree death (Wardrop et al., 1987). Acute impacts to mangroves can be observed within weeks of exposure, whereas chronic impacts may take months to years to detect. Mangroves can also be impacted by entrained/dissolved aromatic hydrocarbons that may adhere to the sediment particles. In low energy environments, such as in mangroves, deposited sediment-bound hydrocarbons are unlikely to be removed naturally by wave action and may be deposited in layers by successive tides (National Oceanic and Atmospheric Administration, 2014).

Entrained hydrocarbon impacts may also include sub-lethal stress and mortality to certain sensitive biota in these mangrove and mud flat habitats, including infauna and epifauna. Larval and juvenile fish, and invertebrates that depend on these shallow subtidal and intertidal habitats as nursery areas, may be directly impacted due to the loss of habitats and/or lethal and sub-lethal in-water toxic effects. This may result in mortality or impair growth, survival and reproduction (Heintz et al., 2000). In addition, there is the potential for secondary impacts on shorebirds, fish, sea turtles, rays, and crustaceans that use these intertidal habitat areas for breeding, feeding and nursery habitat.

Shoreline loading may occur along some of the offshore islands and mainland coast for some spill scenarios. Conservative modelling predicts that there is 1% probability of shorelines being contacted over the exposure threshold, for any release location, at WA Coastline and Dampier Archipelago, with the maximum local volume predicted to accumulate of only 3 m^3. The FPU location does not predict any shoreline contact. Entrained hydrocarbons are predicted to intersect Dampier Archipelago and WA Coastline, which includes some areas of mangroves (RPS, 2019d).

Given potential spill locations are located away from shoreline habitats, and therefore there is a time period before exposure would occur, the volatile components (i.e. the components of the MDO that would coat and/or have other toxic effects) would already be reduced due to the natural rapid weathering characteristics of MDO. The proximity of a potential spill from shore will determine how much hydrocarbons reach the shore, as MDO weathers rapidly, with less than 15% of hydrocarbon predicted to remain on the surface after ~7 days.

Mangroves do have a high sensitivity to hydrocarbon contamination however, and a longer recovery time than other types of coastal habitats. However, given hydrocarbon characteristics, rapid weathering and offshore location of the Project Area, the low predicted volume ashore (3 m^3), unplanned releases from Scarborough are not expected to have a substantial adverse impact on marine ecosystem functioning or integrity.

Based on the assessment, the magnitude of a potential impact to mangroves associated with a release of hydrocarbons is having no lasting effect. Receptor sensitivity of mangroves is high (high value habitat), and therefore the consequence of a release of hydrocarbons on mangroves is **Slight (E).**

Shoreline Habitats

A change in habitat may occur due to a change in water or sediment quality following an unplanned hydrocarbon release.

Hydrocarbons that contact sandy shores may be incorporated into fine sediments through mixing in the surface layers from wave energy, penetration down worm burrows and root pores. Hydrocarbon in the intertidal zone can adhere to sand particles however high tide may remove some or most of the hydrocarbon back of the sediments. Accumulated hydrocarbons ≥ 100 g/m² could impact the survival and reproductive capacity of benthic epifaunal invertebrates living in intertidal habitat (French-McCay, 2009).

The impact of hydrocarbon on rocky shores will be largely dependent on the incline and energy environment. On steep/vertical rock faces on wave exposed coasts there is likely to be no impact from a spill event. However, a gradually sloping boulder shore in calm water can potentially trap large amounts of hydrocarbon (International Petroleum Industry Environmental Conservation Association, 2000). The impact of the spill on marine organisms along the rocky coast will depend on the toxicity and weathering of the hydrocarbon. Like sandy shores, accumulated hydrocarbons ≥100 g/m² could affect the epifauna along rocky coasts and impact the reproductive capacity and survival.

Tidal flats are susceptible to potential impacts from hydrocarbons as they are typically low energy environments and therefore trap hydrocarbons. The extent of oiling is influenced by the neap and spring tidal cycle and seasonal highs and lows affecting mean sea level. Potential impacts to tidal flats include heavy accumulations covering the flat at low tide. However, it is unlikely that hydrocarbon will penetrate the water-saturated sediments. Although, hydrocarbons can penetrate sediments through animal burrows and root pores.

The proximity of a potential spill from shore will determine how much hydrocarbons reach the shore, as MDO weathers rapidly, with less than 15% of hydrocarbon predicted to remain on the surface after ~7 days. Conservative modelling predicts there is only 1% probability of shorelines being contacted over the exposure threshold, for any release location, at WA Coastline and Dampier Archipelago.

Given hydrocarbon characteristics, rapid weathering and offshore location of the Project Area, the low predicted volume ashore (3 m^3), unplanned releases from Scarborough are not expected to have a substantial adverse impact on marine ecosystem functioning or integrity at exposed shorelines.

Based on the assessment, the magnitude of a potential impact to shoreline habitats associated with a release of hydrocarbons is having no lasting effect. Receptor sensitivity of shoreline habitat is low (low value habitat), and therefore the consequence of a release of hydrocarbons on shoreline habitats is **Negligible (F).**

Saltmarsh

A change in habitat may occur due to a change in water or sediment quality following an unplanned hydrocarbon release.

Oil can enter saltmarsh systems during the tidal cycles, if the estuary/inlet is open to the ocean. Similar to mangroves, this can lead to a patchy distribution of the oil and its effects, because different places within the inlets are at different tidal heights. Oil (in liquid form) will readily adhere to the marshes, coating the stems from tidal height to sediment surface. Heavy oil coating will be restricted to the outer fringe of thick vegetation, although lighter oils can penetrate deeper, to the limit of tidal influence.

Saltmarsh is considered to have a high sensitivity to hydrocarbon exposure. Saltmarsh vegetation offers a large surface area for oil absorption and tends to trap oil. Evidence from case histories and experiments shows that the damage resulting from oiling, and recovery times of oiled marsh vegetation, are very variable. In areas of light to moderate oiling where oil is mainly on perennial vegetation with little penetration of sediment, the shoots of the plants may be killed but recovery can take place from the underground systems. Good recovery commonly occurs within one to two years (IPIECA, 1994).

Areas of saltmarsh are known within the Dampier Archipelago and WA Coastline. Shoreline loading may occur along some of the offshore islands and mainland coast for some spill scenarios. Conservative modelling predicts that there is 1% probability of shorelines being contacted over the exposure threshold, for any release location, at WA Coastline and Dampier Archipelago, with the maximum local volume predicted to accumulate of only 3 m^3 (RPS, 2019d). The proximity of a potential spill from shore will determine how much hydrocarbons reach the shore, as MDO weathers rapidly, with less than 15% of hydrocarbon predicted to remain on the surface after ~7 days.

Given potential spill locations are located away from shoreline habitats, and therefore there is a time period before exposure would occur, the volatile components (i.e. the components of the MDO that would coat and/or have other toxic effects) would already be reduced due to the natural rapid weathering characteristics of MDO.

Given hydrocarbon characteristics, rapid weathering and offshore location of the potential release scenarios, the small predicted volume ashore (3 m^3), unplanned releases from Scarborough are not expected to have a substantial adverse impact on marine ecosystem functioning or integrity at the exposed shorelines.

Based on the assessment, the magnitude of a potential impact to saltmarsh associated with a release of hydrocarbons is having no lasting effect. Receptor sensitivity of saltmarsh is high (high value habitat), and therefore the consequence of a release of hydrocarbons on saltmarsh is **Slight (E).**

Key Ecological Features

A change in habitat may occur due to a change in water or sediment quality that could impact KEFs.

The Project Area intersects with three KEFs; and a further three KEFs have the potential to intersect with an unplanned release of hydrocarbons.

The values and sensitivities of these KEFs relate to seafloor features, and demersal fish species (i.e. that live close to the seafloor). Therefore, water depth can determine whether any in-water hydrocarbons can potentially interact with these values and sensitivities.

As MDO typically remains in the top ~10 m of the water column and rapidly weathers, in-water hydrocarbons are only likely to intersect with seafloor and demersal values in shallower waters. The water depths and potential impacts to the six relevant KEFs are summarised below:

- Exmouth Plateau KEF: intersects the Offshore Project Area. Values and sensitivities are related to seafloor features. Receptors on the seafloor are not expected to be impacted by a surface release of hydrocarbons, given the water depths in the Offshore Project Area (~930 m). However, these seafloor features may promote enhanced upwelling; potential impacts to plankton and fish are discussed above.
- Ancient Coastline KEF: intersects the Trunkline Project Area. The KEF includes areas of hard substrate and higher diversity and species richness relative to surrounding areas of predominantly soft sediment . Given the minimum water depth in this KEF is 115 m, seafloor receptors are unlikely to be impacted by a surface hydrocarbon release. However, the submerged coastline may facilitate mixing of the water column enhancing productivity. Combined with greater diversity of sessile benthic organisms, this may increase abundance of pelagic species such as fish and cetaceans, impacts to which are discussed above.
- Continental Slope Demersal Fish Communities KEF: intersects the Trunkline Project Area. The KEF represents high levels of endemism of demersal fish species. Considering the minimum water depths of this KEF are 220–500 m and 750–1000 m, impacts to demersal fish are unlikely to occur. However, the values of the KEF may support higher order consumers, such as pelagic fish and shark species, impacts to which are discussed above.
- Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula KEF: is ~130 km south-west of the Project Area but is assumed to intersect the EMBA. Aggregations of whale sharks, manta rays, humpback whales, sea snakes, sharks, predatory fish and seabirds are known to occur in the area due to its enhanced productivity, which are assessed above.
- Commonwealth waters Adjacent to Ningaloo KEF: The spatial boundary of this KEF, as defined in the Conservation Values Atlas, is defined as the waters contained in the existing Ningaloo AMP and is described below.
- Glomar Shoals: ~56 km east of the Project Area on the Rowley shelf at depths of 33 m to 77 m. The values of the KEF are high productivity and aggregations of marine life, impacts to which are discussed above.

Given the weathering characteristics of MDO, exposure would be restricted to surface (including the upper water column) and shoreline exposure; no interaction with benthic habitats in deep water areas is predicted. As such, for the potential release scenarios from Scarborough, there is unlikely to be substantial adverse impact on marine ecosystem functioning or integrity.

Based on the assessment, the magnitude of a potential impact to KEFs associated with a release of hydrocarbons is slight. Receptor sensitivity of KEFs is high (high value), and therefore the consequence of a release of hydrocarbons on KEFs is **Minor (D).**

<u>*AMPs*</u>

Quantitative stochastic spill modelling predicts the following parameters and worst-case probabilities (for all release locations) above the relevant exposure threshold at the AMPs:

- Montebello Marine Park: surface socio-cultural & ecological (100%), entrained (70%), dissolved (9%)
- Dampier Marine Park: surface socio-cultural (3%), surface ecological (2%), entrained (44%), dissolved (2%), shoreline (2%)
- Gascoyne Marine Park: surface socio-cultural & ecological (1%), entrained (8%)
- Shark Bay Marine Park: surface (<1%), entrained (<1%), dissolved (<1%), shoreline (<1%)
- Ningaloo Marine Park: surface (<1%), entrained (<1%), dissolved (<1%), shoreline (<1%)
- Carnarvon Canyon Marine Park: surface (<1%), entrained (<1%), dissolved (<1%).

Additionally, AMPs bounding the EMBA (Eighty Mile Beach, Abrolhos, Argo-Rowley Terrace) may be subject to low levels of exposure.

The conservation values of these areas have been previously described but include foraging and migratory pathways for some species of seabird, whale shark, turtles and whales. As the conservation values of these protected marine areas are so varied, there are multiple potential impact pathways, including changes in water quality, injury/mortality to marine fauna, change in fauna behaviour, change in aesthetic value, and change to the functions, interests or activities of other users (for evaluation of impacts to specific fauna receptors refer to previous individual receptor assessments).

The values of the AMPs have been evaluated in the sections above and it is determined that a spill is unlikely to result in significant impacts based on the nature of the spilled hydrocarbons.

Based on the assessment, the magnitude of a potential impact to AMPs associated with a release of hydrocarbons is slight. Receptor sensitivity of AMPs is high (high value), and therefore the consequence of a release of hydrocarbons on AMPs is **Minor (D).**

Protected Places

Quantitative spill modelling predicts the following parameters and worst-case probabilities (for all release locations) above the relevant exposure threshold at the following protected places (RPS, 2019):

- Barrow Island: surface (<1%), entrained/dissolved (1%), shoreline (<1%)
- Muiron Islands Marine Management Area-World Heritage Area: surface (<1%), entrained (7%), dissolved (<1%), shoreline (<1%)
- Montebello State Marine Park: surface (1%), entrained (4%), dissolved (1%), shoreline (<1%).

The conservation values of these areas have been previously described but include foraging and migratory pathways for some species of seabird, whale shark, turtles and whales. As the conservation values of these protected marine areas are so varied, there are multiple potential impact pathways, including changes in water quality, injury/mortality to marine fauna, change in fauna behaviour, change in aesthetic value, and change to the functions, interests or activities of other users. (For evaluation of impacts to specific fauna receptors refer to previous individual receptor assessments).

The values of the protected places have been evaluated and it is determined that a spill is unlikely to result in significant impacts based on the nature of the spilled hydrocarbons.

Based on the detailed risk evaluation, the magnitude of potential impact to protected places from unplanned hydrocarbon releases is assessed as slight.

Based on the assessment, the magnitude of a potential impact to protected places associated with a release of hydrocarbons is slight. Receptor sensitivity of protected places is medium (medium value), and therefore the consequence of a release of hydrocarbons on protected places is **Slight (E).**

Commonwealth and State Managed Fisheries

A change in marine fauna behaviour or injury or mortality to marine fauna – in particular to commercially targeted species, or their prey species (e.g. plankton) – can impact fisheries.

Fish exposure to hydrocarbon can result in 'tainting' of their tissues. Even very low levels of hydrocarbons can impart a taint or 'off' flavour or smell in seafood. Tainting is reversible through the process of depuration which removes hydrocarbons from tissues by metabolic processes, although it depends on the magnitude of the contamination. Fish have a high capacity to metabolise these hydrocarbons while crustaceans (such as prawns) have a reduced ability (Yender et al., 2002). Seafood safety is a major concern associated with spill incidents. Therefore, actual or potential contamination of seafood can affect commercial and recreational fishing and can impact seafood markets long after any actual risk to seafood from a spill has subsided (Yender et al., 2002).

A major spill could result in the establishment of an exclusion zone around the spill-affected area. There would be a temporary prohibition on fishing activities for a period and subsequent potential for economic impacts to affected commercial fishing operators. Additionally, hydrocarbon can foul fishing equipment such as traps and trawl nets, requiring cleaning or replacement.

MDO presence in the water would be restricted to the surface and upper water column only. Dissolved aromatics (i.e. the form that is bioavailable) are in such small concentrations in MDO that their effect in the marine environment is negligible; i.e. tainting from an MDO exposure is not considered likely to occur. Any exclusion zone established would be limited to the immediate vicinity of the release point, and due to the rapid weathering of MDO would only be in place days after release, therefore physical displacement to vessels is unlikely to be a significant impact.

The only Commonwealth Fishery expected to be active within the vicinity of the Project is the NWSTF. However, given the fishing method (i.e. trawl) and operations in deep water areas (>200 m) of this fishery, no significant impact from an MDO spill is predicted. Presence of hydrocarbon in areas used by State fisheries may occur, however given the type of hydrocarbon and duration of exposure, no significant impact from an MDO spill is expected to occur.

Although potential impacts could include mortality or sub-lethal injury/illness of pelagic fish (described in the specific receptor evaluation), this would be expected to comprise a small proportion of the resident and transitory population. Given hydrocarbon characteristics, expected rapid weathering to below impact thresholds, and the offshore location of the Project Area and low fishing effort, unplanned releases from Scarborough are not expected to have a substantial adverse effect on the sustainability of commercial fishing; or to interfere with other marine users.

As activities will take place within or adjacent to AMPs, there are principles, objectives and values to be considered. Tourism and fishing are listed as an important activity for social and economic values of the Dampier, Gascoyne, Ningaloo or Montebello Marine Parks.

Based on the assessment, the magnitude of a potential impact to commonwealth and state managed fisheries associated with a release of hydrocarbons is no lasting effect. Receptor sensitivity of commonwealth and state managed fisheries is high (high value marine user), and therefore the consequence of a release of hydrocarbons on commonwealth and state managed fisheries is **Slight (E).**

Tourism and Recreation and Cultural Values

A change in marine fauna behaviour, injury or mortality to marine fauna, change in aesthetic value and change to the functions, interests or activities of other users would impact tourism and recreation following an unplanned hydrocarbon release. Charter fishing, diving, snorkelling, whale, marine turtle and dolphin watching, and cruising are the main commercial tourism activities in and adjacent to the North-west Marine Region. With the exception of offshore charter fishing, most marine tourism activities occur in State waters (DEWHA, 2008a).

Recreational fishing tends to be concentrated in State waters adjacent to population centres, with highest records typically of areas such as Point Samson, Coral Bay and Carnarvon (DEWHA, 2008a).

Offshore waters of the Scarborough Project Area are not expected to support tourism. However, should shoreline contact occur, restricted access to beaches for a period of days to weeks may occur until natural weathering or tides and currents remove the hydrocarbons. Tourists and recreational users may also avoid areas due to perceived impacts, including after the hydrocarbon spill has dispersed.

Depending on the location of the spill, areas used for recreation and tourism, including the nearshore and shoreline, may be exposed to hydrocarbon. Any impact to receptors that provide nature-based tourism features (e.g. whales) may cause a subsequent negative impact to recreation and tourism activities. There is also potential for impacts to the wider service industry (hotels, restaurants and their supply chain) and local communities in terms of economic loss as a result of spill impacts to tourism. Recovery and return of tourism to pre-spill levels will depend on the size of the spill, effectiveness of any spill clean-up and change in any public misconceptions regarding the spill (Oxford Economics 2010). However, the relatively rapid weathering of MDO suggests that any impacts would be short-term and localised.

If surface oil reaches towns, it may coat recreation areas and infrastructure such as jetties / boat ramps, beaches, and potentially impact on access due to any clean-up or decontamination activities.

Conservative modelling predicts that there is only 1% probability of shorelines being contacted over the shoreline exposure threshold for accumulated hydrocarbons, for any release location, at WA Coastline and Dampier Archipelago, with the maximum local volume predicted to accumulate of only 3 m^3. Surface exposures have a low probability for both the socio-cultural and ecological thresholds <5%) of intersecting major tourism of industry (Dampier Archipelago, Barrow Island, WA Coastline).

It is acknowledged that the Dampier Archipelago (and other areas of the WA coastline) contain Indigenous sites of cultural importance (as described in Section 5.6.1.4 and Section 5.6.2). There is only a low probability of surface contact at the socio-cultural threshold with WA coastlines. It is determined that a spill is unlikely to result in significant impacts based on the nature of the spilled hydrocarbons (diesel).

The Australian Marine Parks also have historic and ongoing cultural significance to traditional owners (see Section 5.6.1). Impacts to the AMPs are described above (under AMPs).

Given hydrocarbon characteristics, expected rapid weathering to below impact thresholds, small volumes predicted ashore, and the offshore location of the Project Area, unplanned releases from Scarborough are not expected to interfere with other marine users to a greater extent than necessary.

As activities will take place within or adjacent to AMPs, there are principles, objectives and values to be considered, which include:

- recreation is listed as a social and economic value of the Montebello, Dampier, Gascoyne and Ningaloo Marine Parks

- tourism is a social and economic value of the Montebello and Ningaloo Marine Parks.

Modelling predicts the main impact is to Montebello Marine Park, as the potential release location is within the Park boundaries. This has been considered in this assessment, specifically with regards to the values for recreation and tourism.

Based on the assessment, the magnitude of a potential impact to tourism and recreation associated with a release of hydrocarbons is slight. The magnitude of a potential impact to cultural values is no lasting effect. Receptor sensitivity of tourism and recreation is medium and cultural values is high. Therefore the consequence of a release of hydrocarbons on tourism and recreation and cultural values is **Slight (E).**

Settlements

A change in aesthetic value and change to the functions, interests or activities of other users may impact settlements following an unplanned hydrocarbon release.

Important coastal settlements in the EMBA include Exmouth, Karratha, Dampier, Onslow, Port Hedland and Broome. If surface oil reaches towns, it may coat infrastructure such as jetties / boat ramps, beaches, and potentially impact on access due to any clean-up or decontamination activities.

Modelling predicts that there is only 1% probability of shorelines being contacted over the exposure shoreline exposure threshold for accumulated hydrocarbons, for any release location, at WA Coastline and Dampier Archipelago (RPS, 2019d), which may intersect with some settlements, such as Dampier and Karratha. Surface exposures have a low probability for both the socio-cultural and ecological thresholds of intersecting major tourism of industry (Dampier Archipelago, Barrow Island).

Given hydrocarbon characteristics, expected rapid weathering to below impact thresholds, small predicted volume ashore (approximately 3 m^3), and the offshore location of the Project Area, unplanned releases from Scarborough are not expected to cause significant harm to social surroundings.

Based on the assessment, the magnitude of a potential impact to settlements associated with a release of hydrocarbons is slight. Receptor sensitivity of settlements is medium (medium value user), and therefore the consequence of a release of hydrocarbons on settlements is **Slight (E).**

Defence

A change to the functions, interests or activities of other users may impact Defence following an unplanned hydrocarbon release.

In the event of a major spill, an exclusion zone may be established around the spill-affected area. This could impact Defence by restricting areas where training or exercises can be conducted, for a period of time. Any exclusion zone established would be limited to the immediate vicinity of the release point, and due to the rapid weathering of MDO would only be in place for days after release, therefore physical displacement to vessels is unlikely to be a significant impact.

If port areas are contacted by surface oil, it may coat infrastructure, and potentially impact Defence use of the port, due to any clean-up and decontamination activities.

Given hydrocarbon characteristics, expected rapid weathering to below impact thresholds, small volumes ashore, short duration of displacement, and the offshore location of the Project Area, unplanned releases from Scarborough are not expected to interfere with other marine users to a greater extent than necessary.

Based on the assessment, the magnitude of a potential impact to defence associated with a release of hydrocarbons is slight. Receptor sensitivity of defence is medium (medium value user), and therefore the consequence of a release of hydrocarbons on defence is **Slight (E).**

Shipping

A change to the functions, interests or activities of other users may impact shipping following an unplanned hydrocarbon release.

Shipping activity is widespread across the region, however main shipping channels appear to occur to the east of the offshore development area; and close to shore, are focused on the 12 ports in the North-West Marine Region.

In the event of a large spill, an exclusion zone may be established around the spill-affected area. This could result in exclusion of other users such as shipping vessels or vessels used by the mining and petroleum industries. Any exclusion zone established would be limited to the immediate vicinity of the release point, and due to the rapid weathering of MDO would only be in place for days after release, therefore physical displacement to vessels is unlikely to be a significant impact.

If surface oil reaches active ports, it may coat infrastructure, and potentially impact port activities or access due to any clean-up and decontamination activities.

Modelling predicts that there is only 1% probability of shorelines being contacted over the exposure threshold, for any release location, at WA Coastline and Dampier Archipelago, with the maximum local volume predicted to accumulate of only 3 m^3. This could potentially intersect with the Ports of Dampier or Barrow Island, however, is of very low volumes and would be unlikely to foul infrastructure and equipment.

Given hydrocarbon characteristics, expected rapid weathering to below impact thresholds, small volumes ashore, short duration of displacement, and the offshore location of the Project Area, unplanned releases from Scarborough are not expected to interfere with other marine users to a greater extent than necessary.

Based on the assessment, the magnitude of a potential impact to shipping associated with a release of hydrocarbons is slight. Receptor sensitivity of shipping is medium (medium value user), and therefore the consequence of a release of hydrocarbons on shipping is **Slight (E).**

Industry

A change in water quality and change to the functions, interests or activities of other users may impact industry following an unplanned hydrocarbon release.

Along the coastline, industries which depend upon marine water sources include ports, salt mines, LNG onshore processing facilities and desalination plants (Section 5.7.6). In the Project Area, industry is dominated by oil & gas activities.

The closest productive fields to Scarborough would be Chevron Australia's Jansz-Io fields, about 100 km to the east. However, all the infrastructure is subsea and is not expected to be impacted by an MDO spill.

In the event of a large spill, an exclusion zone may be established around the spill-affected area. This could result in exclusion of other users such as vessels used by the mining and petroleum industries.

Any exclusion zone established would be limited to the immediate vicinity of the release point, and due to the rapid weathering of MDO would only be in place days after release, therefore physical displacement to vessels is unlikely to be a significant impact.

If surface oil reaches active industry areas, such as causeways, Material Offloading Facilities, jetties, ports, it may coat infrastructure, and potentially impact activities or access due to any clean-up and decontamination activities. Hydrocarbons could also potentially contaminate seawater intakes for industries such as desalination plants, or Dampier Salt.

Surface exposures have a low probability (<3%) of intersecting major centres of industry (Dampier Archipelago, Barrow Island, WA Coastline). Modelling predicts that there is only 1% probability of shorelines being contacted over the exposure threshold, for any release location, at WA Coastline and Dampier Archipelago, with the maximum local volume predicted of only 3 m^3 (RPS, 2019d).

Given hydrocarbon characteristics, expected rapid weathering to below impact thresholds, small volumes predicted ashore, and the offshore location of the Project Area and distance to relevant industries, unplanned releases from Scarborough are not expected to interfere with other marine users than a greater extent than necessary. As modelling predicts the minimum time to shore is 53 hours, industry will have prior warning to close seawater intakes or potentially take other measures to avoid potential contamination.

Based on the assessment, the magnitude of a potential impact to industry associated with a release of hydrocarbons is slight. Receptor sensitivity of industry is medium (medium value user), and therefore the consequence of a release of hydrocarbons on industry is **Slight (E).**

7.2.6.3 Risk Evaluation

Industry data shows that vessel collisions are rare, with only 37 collisions reported from 1200 marine incidents in Australian waters from 2005-2012. Most vessel collisions involve damage to a forward tank which are generally double-lined and smaller than other tanks; therefore, the loss of the maximum credible scenario of 2,000 m3 is conservative and unlikely.

A detailed project wide quantitative risk assessment was undertaken for the Scarborough development. One aspect that was considered was the risk of vessel collision. This reported that the worst case incident involving a supply vessel was unlikely to result in a diesel release due to the speeds at which vessels operate. Such a collision may result in hull damage, however unlikely to cause a breach of the internal tanks. The assessment also stated that an impact by passing third-party vessels may cause more significant damage if these vessels are moving at greater speeds, however the frequency of such collisions has been estimated at 8E-05 per annum.

On this basis, while vessel collisions have occurred within industry, an event leading to a loss of the full tank inventory is less probable. Using the Woodside risk matrix, the likelihood of this event occurring was evaluated – as **Highly Unlikely**.

Modelling of 2,000 m^3 of MDO at the three release locations at the FPU and along the trunkline was undertaken by RPS (RPS, 2019d). Depending on wind conditions, weathering predicts that only <1 - 15% of hydrocarbon remains on the surface after ~7 days (RPS, 2019d), with a greater proportion entraining into the water column under strong, variable wind conditions. The nature of MDO means that only a small proportion dissolves in the water column, and the greatest proportion is on the surface or entrained.

Modelling predicts that the likelihood of shoreline contact is only 1%, with only very small accumulated volumes predicted ashore (3 m^3). As one of the release locations modelled is inside the Montebello Marine Park boundaries, this AMP has the highest probability of exposure above thresholds to unplanned hydrocarbon releases.

An unplanned release will result in localised and temporary changes in water and sediment quality, such as increased toxicity, which can potentially impact marine fauna and habitats; though sediments would only be intersected by hydrocarbons in shallow water and intertidal areas. Mobile fauna such as plankton, fish and marine mammals could experience mortality or sub-lethal injury/illness, however this would be expected to comprise a small proportion of the resident and transitory population, and to not have a substantial adverse effect on a population or spatial distribution, lifecycle, or important habitat. Due to the high levels of receptor sensitivity amongst marine fauna, this impact has been evaluated as **Minor (D)**.

The Dampier Archipelago supports a diverse number of both scleractinian and non-scleractinian (soft) corals. There would be potential for entrained hydrocarbons above threshold concentrations to reach reef habitat in the Dampier Archipelago (particularly from the Outside Mermaid Sound Scenario). Additionally, shallow coral habitats may be vulnerable to hydrocarbon coating by direct contact with surface hydrocarbons during periods when corals are tidally-exposed. This could result in impacts to the shallow water fringing coral communities/reefs of the offshore islands (e.g. Barrow/Montebello/Lowendal Islands) and also the mainland coast (e.g. Ningaloo Coast). Impacted coral reefs may experience long-term effects (i.e. recovery periods taking up to 10 years) due to their recovery relying on coral larvae from neighbouring coral communities that have either not been affected or only partially impacted. However, due to the short duration of the spill (i.e. instantaneous release, and short exposure time as documented by deterministic modelling), the confined spatial extent and the tendency of MDO to remain on the sea surface, the scale of potential consequences is limited. Due to the high levels of receptor sensitivity amongst marine fauna, this impact has been evaluated as **Major (B).**

It is not expected that an unplanned hydrocarbon release would interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted, due to the rapid weathering of MDO. Socioeconomic receptors have medium value (i.e. medium Receptor Sensitivity), and the impacts been evaluated as **Slight (E).**

Shoreline accumulation of hydrocarbons could potentially impact the incubation success, nesting and hatching emergence of marine turtles and shorebirds. As there are significant nesting areas in the EMBA, this has the potential to impact species recruitment at a local population level; however, it is not expected that the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species would be seriously disrupted, as only a maximum of $3m^3$ is predicted ashore, at only 1% probability. Therefore, the potential impacts to marine reptiles and seabirds and migratory shorebirds, both high sensitivity receptors, are **Minor (D).**

Therefore, the worst-case consequence of an unplanned hydrocarbon release has been evaluated as **Major (B)**; giving an overall risk rating of **Moderate (B1).**

7.2.6.4 Demonstration of Acceptability

While the event of a spill is not considered acceptable, the consequences of such an event on the receptors identified in the EMBA has been assessed against the acceptability criteria based on the risk evaluation in this section. Outcomes of this evaluation have been summarised below.

To meet the principles of ESD

Based on the assessment of the potential consequences of a spill on the receptors identified, it has been determined that the Scarborough development is consistent with the relevant principles of ESD:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- The principle of inter-generational equity – that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making.

In addition, in the event of a worst case scenario release of hydrocarbons, the Scarborough development will result in no significant impacts to receptors identified in the EMBA.

The above is based on outcomes of the risk evaluation, specifically:

- That an event resulting in the loss of a full tank of fuel (2000 m^3) is considered highly unlikely.

- Modelling of the worst case scenario predicts that only <1 - 15% of hydrocarbon remains on the surface after ~7 days (RPS, 2019d).
- Modelling predicts that the likelihood of shoreline contact is only 1%, with only very small accumulated volumes predicted ashore (3 m^3).

Internal Context

Hydrocarbon spill prevention and response will be managed in accordance with regulatory requirements, including Environment Plans, Oil Pollution Emergency Plans and a Well Operations Management Plan to manage credible spill risks, capability and response, which require acceptance by NOPSEMA. In addition, vessels will have a valid and appropriate Shipboard Oil Pollution Emergency Plan and/or Shipboard Marine Pollution Emergency Plan.

External Context

No stakeholder concerns have been raised with respect to unplanned hydrocarbon releases, or potentially impacted receptors.

Other Requirements

- Requirements of the Conservation Management Plans / Conservation Advice for the following species are met:
  - fish: sawfish and river sharks, whale sharks
  - seabirds and migratory shorebirds: Greater Sand Plover, Large Sand Plover, Great Knot, Eastern Curlew, Far Eastern Curlew, Australian Painted Snipe, Australian Fairy Tern
  - marine reptiles: short-nosed seasnake
  - marine mammals: sei whales,
- Requirements of the Recovery Plan for Marine Turtles in Australia (DoEE, 2017) have been met.
- With respect to unplanned hydrocarbon releases, activities associated with Scarborough will not be conducted in a manner inconsistent with the Objectives of the respective zones of the AMPs. This includes:
  - Montebello Marine Park

    The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species. Natural values of the marine park include diverse fish communities, and Biologically Important Areas for foraging habitat for whale sharks.
  - Dampier Marine Park

    The objective of the Habitat Protection Zone (IV) is to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while allowing activities that do not harm or cause destruction to seafloor habitats. The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible. Natural values of the marine park include diverse fish communities.
  - Gascoyne Marine Park

    The objective of the Habitat Protection Zone (IV) is to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while allowing activities that do not harm or cause destruction to seafloor habitats. The objective of the National Park Zone (II) is to provide for the protection and conservation of ecosystems, habitats and native species in as natural a state as possible. The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species. Natural values of the marine park include diverse fish communities, specifically within the Continental slope demersal fish communities KEF.

- Ningaloo Marine Park

  The objective of the Habitat Protection Zone (IV) is to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while allowing activities that do not harm or cause destruction to seafloor habitats. Natural values of the marine park include diverse fish communities, specifically within the Continental slope demersal fish communities KEF, and Biologically Important Areas for foraging habitat for whale sharks.

- Regulatory requirements for Environment Plans, Oil Pollution Emergency Plans and Well Operations Management plan are met.

  OPGGS(E) Regulations specify the requirement for an Oil Pollution Emergency Plan (OPEP) for petroleum activities. In the event of a spill, the OPEP will detail the response arrangements in order to reduce the potential consequence of the spill.

  Response strategies detailed in the OPEP will be developed specific for the activities proposed in the EP but may include:

  - **Source control**: In the event of a vessel collision resulting in a ruptured fuel tank, the most practical option involves the pumping of fuel into a secondary tank on board the same vessel.
  - **Monitoring and evaluation**: Provides information on the fate, nature and weathering of hydrocarbons within the marine environment, which will aid in identifying potential risks to receptors and help to inform other response strategies, response priorities and ongoing response (if required).
  - **Containment and recovery:** Boom and skimmer use during containment and recovery operations are an effective means of removing hydrocarbons from the surface layer, potentially reducing the overall impact. If used in conjunction with monitoring and modelling of spill trajectory, this method can be used to protect sensitive receptors.
  - **Protection and deflection:** Booms or other physical barriers may be used to inhibit the flow of hydrocarbons and protect environmental sensitivities through targeted boom protection and specific oil deflection.
  - **Shoreline:** In the event of a hydrocarbon spill resulting in shoreline contact, shoreline clean-up may be required, where accessible, to reduce shoreline loading. Clean-up techniques may be manual and / or mechanical depending on the shoreline type and accessibility to the affected area. Following the collection of spilled hydrocarbons, material will be appropriately disposed of at an onshore facility.
  - **Oiled wildlife response:** In the event of a hydrocarbon spill at the surface, if deemed appropriate, oiled wildlife response may be implemented in order to either deter species from an area affected by a spill or to capture affected species for treatment and rehabilitation.

Environmental Performance Outcome

To manage impacts to at or below the defined acceptable levels the following EPO has been applied:

EPO19.1: No release of hydrocarbons to the marine environment due to a vessel collision associated with the Scarborough development.

7.2.6.5 Summary of the Risk Assessment

Table 7-86 provides a summary of the risk assessment and acceptability for impacts from unplanned discharge of hydrocarbons to ecological receptors.

Table 7-86: Summary of risks, key management controls, acceptability, EPOs and residual risk rating for unplanned hydrocarbon releases

Receptor	Risk	Environmental Performance Outcome	Adopted control(s)	Receptor sensitivity	Risk Consequence	Likelihood	Risk rating	Acceptability
Sediment quality	Change in sediment quality	**EPO 19.1**: No release of hydrocarbons to the marine environment due to a vessel collision associated with the Scarborough development.	**CM26:** All vessels and facilities (appropriate to class) will comply with MARPOL 73/78, the Navigation Act 2012, the Protection of the Sea (Prevention of Pollution from Ships Act 1983 and subsequent Marine Orders including: • waste management requirements • management of spills aboard • emergency drills. **CM27:** Relevant Stakeholders will be notified of activities prior to commencement. **CM28:** Vessels will have in place a valid and appropriate Shipboard Oil Pollution Emergency Plan and/or Shipboard Marine Pollution Emergency Plan. Emergency	Low value (open water)	Negligible (F)	Highly Unlikely	Low	Acceptable
Water quality	Change in water quality			Low value (open water)	Negligible (F)	Highly Unlikely	Low	Acceptable
Plankton	Injury/ mortality to fauna			Low value (open water)	Negligible (F)	Highly Unlikely	Low	Acceptable
Fish	Change in fauna behaviour			High value species	Minor (D)	Highly Unlikely	Moderate	Acceptable
	Injury/ mortality to fauna			High value species	Minor (D)	Highly Unlikely	Moderate	Acceptable
Marine mammals	Change in fauna behaviour			High value species	Minor (D)	Highly Unlikely	Moderate	Acceptable
	Injury/ mortality to fauna			High value species	Minor (D)	Highly Unlikely	Moderate	Acceptable
Marine reptiles	Change in fauna behaviour			High value species	Slight (E)	Highly Unlikely	Low	Acceptable
	Injury/ mortality to fauna			High value species	Minor (D)	Highly Unlikely	Moderate	Acceptable

Receptor	Risk	Environmental Performance Outcome	Adopted control(s)	Receptor sensitivity	Risk Consequence	Likelihood	Risk rating	Acceptability
Seabirds and migratory shorebirds	Change in fauna behaviour		response activities will be implemented in accordance with the SOPEP/SMPEP. **CM29:** Environment Plans and Oil Pollution Emergency Plans will be accepted and in place, appropriate to the credible hydrocarbon spill scenario associated with activities during Scarborough. Emergency response activities will be implemented in accordance with the OPEP. **CM30:** Emergency response capability will be maintained in accordance with EP, OPEP and related documentation. **CM31:** Well Operations Management Plan accepted and in place for all wells, in accordance with the Offshore Petroleum and Greenhouse Gas Storage Act requirements, which include: • Blowout Preventer (BOP) installation during drilling operations • regular testing of BOP.	High value species	Slight (E)	Highly Unlikely	Low	Acceptable
	Injury/ mortality to fauna			High value species	Minor (D)	Highly Unlikely	Moderate	Acceptable
Coral	Change in habitat			High value habitat	Major (B)	Highly Unlikely	Moderate	Acceptable
Seagrass	Change in habitat			High value habitat	Slight (E)	Highly Unlikely	Low	Acceptable
Macroalgae	Change in habitat			Low value habitat (homogenous)	Negligible (F)	Highly Unlikely	Low	Acceptable
Mangroves	Change in habitat			High value habitat	Slight (E)	Highly Unlikely	Low	
Shoreline habitats	Change in habitat			Low value habitat	Negligible (F)	Highly Unlikely	Low	Acceptable
Saltmarsh	Change in habitat			High value habitat	Slight (E)	Highly Unlikely	Low	
KEFs	Change in habitat			High value	Minor (D)	Highly Unlikely	Moderate	Acceptable
AMPs	Change in habitat			High value	Minor (D)	Highly Unlikely	Moderate	Acceptable
Protected Places	Change in habitat			Medium value	Slight (E)	Highly Unlikely	Low	Acceptable

Receptor	Risk	Environmental Performance Outcome	Adopted control(s)	Receptor sensitivity	Risk Consequence	Likelihood	Risk rating	Acceptability
Commonwealth and State Managed Fisheries	Changes to the functions, interests or activities of other users			High value marine user	Slight (E)	Highly Unlikely	Low	Acceptable
Tourism and recreation and cultural values	Changes to the functions, interests or activities of other users			Medium value users (tourism and recreation)	Slight (E)	Highly Unlikely	Low	Acceptable
				High (cultural)	No lasting effect (F)			
	Changes in aesthetic value			Medium value users (tourism and recreation)	Slight (E)			
				High (cultural)	No lasting effect (F)			
Settlements	Changes to the functions, interests or activities of other users			Medium value users	Slight (E)	Highly Unlikely	Low	Acceptable
	Change in aesthetic value			Medium value users		Highly Unlikely		
Shipping	Changes to the functions, interests or activities of other users			Medium value users	Slight (E)	Highly Unlikely	Low	Acceptable
Industry	Changes to the functions, interests or activities of other users			Medium value	Slight (E)	Highly Unlikely	Low	Acceptable

Receptor	Risk	Environmental Performance Outcome	Adopted control(s)	Receptor sensitivity	Risk Consequence	Likelihood	Risk rating	Acceptability
Defence	Changes to the functions, interests or activities of other users			Medium value	Slight (E)	Highly Unlikely	Low	Acceptable

8 CUMULATIVE IMPACT ASSESSMENT

8.1 Context

So far, the assessment of impacts has focused on linear pathways from planned project activities and aspects to direct and indirect impacts on receptors. As described by the World Bank (IFC, 2013), effective impact and risk assessment should also assess impacts on a more holistic, whole-ecosystem level, considering the potential cumulative impacts of the proposed project, and any existing and future concurrent activities, on the existing environment.

This section provides a summary of cumulative impacts considered of relevance to Scarborough. Given the low likelihood of unplanned events (e.g. oil spills) arising during Scarborough, unplanned/non-routine events have not been considered in this assessment of cumulative impacts.

As described in Section 1.3, several large developments or proposed developments are located in close proximity to the Project Area. The Trunkline Project Area passes the Pluto LNG Platform (4 km), Stag Platform (8km), Wheatstone Platform (12.5 km), Reindeer Platform (19 km), Goodwyn Platform (51 km) and North Rankin Complex (64 km). The Offshore Project Area is further offshore from these existing developments (about 170 km from Pluto LNG Platform); however, the Equus field (located 70 km east of the Project Area) is planned to be developed during the life of Scarborough. Impacts and aspects associated with nearshore and onshore activities, both from Scarborough and other activities/developments, are assessed under separate approval mechanisms and are not considered further here.

Aside from oil and gas activities, the North West Marine Region is a busy hub for both fishing and commercial shipping. As described in Section 5.7.5, the Offshore Project Area is located within an area of low vessel traffic. However, major shipping routes pass over the Trunkline Project Area. Similarly, vessels operating as part of Commonwealth and State managed fisheries are likely to be present in the water surrounding the Trunkline Project Area, with less fishing occurring in the deep waters surrounding the Offshore Project Area.

This assessment will consider cumulative effects of other marine users, proposed developments, as well as all key stages and aspects of Scarborough, ensuring a holistic/lifecycle assessment of impacts.

8.2 Identification and Evaluation of Impacts

Cumulative impacts from Scarborough may occur in two ways:

- Aspect-based – Cumulative or combination effects may arise from other activities/projects resulting in the same aspects as those identified in this OPP.
- Receptor-based – Cumulative or combination effects on a receptor may arise, both from multiple aspects of Scarborough and similar/multiple aspects resulting from other activities/projects.

8.2.1 Aspect-based Cumulative Impacts

This section considers how the aspects arising from Scarborough may compound with similar aspects caused by other third-party activities/developments, to result in a cumulative impact. Other activities/developments include:

- Pluto LNG Project
- other Woodside and other operator activities currently under consideration
- Equus Field Development

- Commonwealth and State Managed Fisheries
- Commercial Shipping.

The aspects identified which were common to these activities/developments and Scarborough are those typically related to vessel movements, which include:

- physical presence (routine): displacement of other users
- light emissions
- routine and non-routine discharges: project vessels.

Cumulative impacts associated with emission of GHG, including the role of LNG in the context of global emissions, are discussed in Section 7.1.3.

Although seabed disturbance and planned discharges during trunkline installation and commissioning will occur close to the Pluto LNG development, there will be no similar aspects resulting from Pluto activities during that time, and therefore no cumulative impacts are expected.

During the life of the project, operational fluids will be discharged within the Offshore Project Area on a near-continuous basis. Although other activities/developments in the area will not be close enough for these discharge streams to interact, the extended duration of the impact means that cumulative impacts could occur from multiple sources of emissions or discharges from Scarborough alone. This aspect has therefore also been assessed below.

8.2.1.1 Physical Presence (Routine): Displacement of Other Users

During installation and commissioning of Scarborough additional vessel traffic will result in an increased likelihood of displacement of other users. Impacts from Scarborough have been assessed as temporary and localised as vessels come and go from the Project Area. The Trunkline Project Area is located within an area of increased shipping and fishing traffic, and the combination of installation/commissioning vessels plus shipping and fishing vessels may lead to cumulative impacts. However, given the short time frame of the installation, and the required exclusion zone around the installation vessel due to its low manoeuvrability, any cumulative impacts will be limited.

Once the installation phase of Scarborough is completed (trunkline installation, FPU and subsea infrastructure) vessel presence will be significantly reduced in the Project Area, reducing the potential for cumulative impacts to occur. During the operational phase of Scarborough, infrastructure such as the FPU and the trunkline will be present on a long-term basis, however given the location of the FPU is in a low sensitivity area for other users and the trunkline is buried at depths <40 m, cumulative impacts will be limited to the presence of subsea infrastructure including the trunkline in deep waters.

The consequence of cumulative impacts caused by displacement of other users has been evaluated as **Slight (E)** as the impact magnitude is sufficiently small. The impacts overall have been determined to be **acceptable** based on an evaluation against the criteria described in Section 7.1.5. No additional control measures are required.

8.2.1.2 Light Emissions

The light emitted during vessel operations, particularly during the construction phase has the potential to overlap with other light sources, including facilities and other vessels. Cumulative impacts from project vessels are considered in Section 7.1.1.

The Trunkline Project Area and Borrow Grounds Project Area overlap BIAs for internesting hawksbill, flatback, green and loggerhead turtles, and habitat critical (internesting buffer) for hawksbill, flatback and green turtles. Presence of marine turtles within the Trunkline Project Area is expected to peak during breeding periods (described in detail in Section 5.4.6.4). The closest nesting beaches to the Trunkline and Borrow Ground Project Areas are on Legendre Island (12 km and 6.5 km distance, respectively) and Rosemary Island (approximately 14 km away from the Trunkline Project Area at the closest point).

It is not credible that there would be cumulative light impacts along most of the trunkline route, as it is unlikely that turtles would be present given the waters depths (as outlined in Sections 5.4.6.4 and 7.1.1). There is no evidence, published or anecdotal, to suggest that internesting, mating, foraging or migrating turtles are impacted by light from offshore vessels. As such, light emissions from the vessels are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages (Pendoley, 2020a).

Light modelling undertaken for the Scarborough Project (Pendoley, 2020b) has predicted that light levels from project vessels will reduce to levels below the behavioural impacts threshold, for all moon phases within 2 km (see Section 7.1.1) and ambient levels within 6 km. The modelling has indicated it is not credible for project vessel light emissions to impact turtle behaviour at nesting beaches—this does not change upon consideration of cumulative impacts.

As presented in Section 7.1.1, it has been assessed that project lighting may result in Slight impact to marine turtles, with the only potential impact being the potential attraction of a small proportion of dispersing hatchlings to vessel operations in the easternmost portion of the Trunkline Project Area and the Borrow Ground Project Area. Although attraction to light sources may have consequences at the individual level (e.g. energy depletion and increased predation risk), the numbers that could be impacted is likely to be low and undetectable against normal population fluctuations.

As outlined in Section 5.7.5, commercial shipping traffic is high within the NWMR and the easternmost portion of the Trunkline Project Area falls within Pilbara Port Authority waters, with Port of Dampier waters extending from Dampier though State waters out to approximately KP 36.5 (in Commonweath waters). A requested 500 m safety exclusion zone will be present around the pipelay vessel during install activities.

While it is possbile that there could be temporary light "pooling" between project vessels and other vessels in the Dampier Port, it is unlikely that this would be sufficient to result in additional cumulative impacts to dispersing hatchlings.

Impacts resulting from light emissions, such as change in fauna behaviour, are short-term, and cease once the light source is removed. As outlined above, no cumulative impacts are expected from interaction between the lighting of project activities and other non-project light emissions.

8.2.1.3 Routine and Non-routine Discharges: Project Vessels

Routine and non-routine discharges from vessels include brine and cooling water, deck draining, treated bilge, food waste, and sewage and grey water. Particularly during installation and commissioning, Scarborough will result in an increase in vessel numbers and therefore an increase in vessel discharges.

Vessels associated with Scarborough will be mostly focused around the well/FPU location, >375 km from shore and significant distance from other activities/developments where existing vessel traffic is focused. Vessel discharges are controlled, and generally discharged when the vessel is moving to allow for the greatest dispersion rate and dissipation of any changes in water quality. As such, impacts are localised and temporary, and given the distance offshore and the low level of vessel traffic nearshore no cumulative impacts are expected.

8.2.1.4 Operational Fluids

Discharges of operational fluid includes subsea control fluids and PW. Any operational fluid discharged during hydrocarbon extraction and production, will contribute to other sources of waste within the region and may result in cumulative impacts to receptors. Discharges of subsea control fluids would be the most frequently discharged fluid at the well head site throughout operations and due to the small volumes, it is not expected that there will be cumulative impacts to receptors due to high levels of dispersion within the marine environment. For PW, there is the potential for a cumulative increase of impact to receptors within surface waters due to a range of other operational fluids that will be discharged throughout the life of the FPU. As values associated with the marine environment within the Offshore Project Area are low with no BIAs for protected species present, it is expected that the additional presence of PW within the water column will not result in an increased impact to receptors.

8.2.2 Receptor-based Cumulative Impacts

This section considers how receptors known to be impacted by individual aspects associated with Scarborough may be subject to additional impacts from alternate aspects (associated with Scarborough or other activities/developments), or which may be more sensitive to additional impacts due to a change in nature or state resulting from the initial aspect, leading to cumulative impacts to individual receptors/receptor groups. This section relates specifically to the aspects associated with Scarborough only, which result in cumulative impacts on receptors.

Cumulative impacts associated with emission of GHG, including the role of LNG in the context of global emissions, are discussed in Section 7.1.3.

8.2.2.1 Physical Environment

The physical environment within the Project Area is likely to be impacted throughout the project lifecycle. Other activities in the region (such as existing developments and other marine users) are well established, and their presence and impacts are included in the ambient or baseline environment considered in this assessment. Therefore, no cumulative impacts to the physical environment are expected from other activities/developments.

It is possible that cumulative impacts to the physical environment may occur from the different phases of Scarborough, especially impact to water quality and sediment quality. These are discussed further below. No cumulative impacts to ambient noise, air quality or light are expected from Scarborough.

Table 8-1 identifies aspects affecting receptors within the physical environment which may lead to cumulative impacts.

Table 8-1: Physical Environment which may be affected by Cumulative Impacts

Aspect	Sediments Quality	Water Quality
Physical presence (routine): Seabed disturbance		✓
Routine and non-routine discharges: Sewage and greywater	✓	
Routine and non-routine discharges: Food waste	✓	
Routine and non-routine discharges: Chemicals and deck drainage	✓	
Routine and non-routine discharges: Brine and cooling water	✓	
Routine and non-routine discharges: Operational fluids	✓	✓
Routine and non-routine discharges: Subsea installation and commissioning	✓	✓

Aspect	Sediments Quality	Water Quality
Routine and non-routine discharges: Drill cuttings and drilling fluids	✓	✓

Water Quality

Changes to water quality are likely from all stages in Scarborough, as the discharges and disturbances associated with the project phases vary the water composition at each impact location.

Intensive vessel activities during the trunkline installation activities, will result in multiple sources of vessel discharges including sewage and greywater, food waste, chemicals and deck drainage, and brine and cooling water. This has the potential to result in changes to the water quality. Modelling and studies generally show that impacts are short-term for vessels (construction periods result in vessels moving throughout the project areas), and long term for fixed facilities such as the FPU, and localised (i.e. In the order of less than 100 m for vessels, and < 500 m for larger facilities such as a MODU and FPU) (e.g. Shell, 2010; Frick et al., 2001; Woodside, 2014; Chevron, 2015).The high-energy marine environment throughout the Project Area will lead to rapid mixing and reduce the extent of any impacts and given this and that volume of discharges is relatively small (in the order of 10 m^3 /day for sewage and grey water from a support vessel as an example of scale given that this is the largest source of liquid discharge from a vessel) cumulative impacts from intensive vessel activities are not expected to exceed levels for acceptability. This has been determined based on acceptability criteria and consideration of the principles of ESD and other requirements, notably:

- The high energy marine environment means that discharges will be quickly dissipated and will not accumulate or result in long-term changes to water quality.
- There will be no irreversible change to the water quality.
- Discharges in the Montebello Marine Park will be limited to the construction period and only likely to occur short-term (in the order of weeks to months).

In addition, the activities are not inconsistent with the objective of the Multiple Use Zone (VI) for the Montebello Marine Park which is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species. This is because the multiple vessels activities associated with the trunkline installation will only result in temporary (weeks to months) and localised (in the order of less than 100 meters for vessels) changes in the water quality, and not result in significant impacts to the ecosystem, habitats and native species of the Montebello Marine Parks.

In consideration of this, plus other acceptability criteria (that is internal context and external context, noting that the Scarborough development is consistent with Woodside internal requirements and no specific concerns were raised regarding the potential impacts of the Scarborough development on water quality) the cumulative impact evaluated to be **acceptable**. No additional control measures are required.

To manage impacts to water quality to at or below the defined acceptable levels the following EPO have been applied:

EPO 6.1: Undertake Scarborough development in a manner that prevents a substantial change to water quality that may adversely impact on biodiversity, ecological integrity, social amenity or human health.

EPO 6.3: Changes to water quality in the Montebello Marine Park as a result of the trunkline installation will be not be inconsistent with the objective of the multiple use zone.

Sediment Quality

Similarly, changes to sediment quality are likely from all stages in Scarborough. Discharges at the seabed will result in changes in sediment quality, such as toxicity or changes to the sediment composition/granulometry. Modelling and studies show that impacts from planned/routine discharges are short-term and localised (e.g. IAOGP, 2016; Neff, 2005; BP Azerbaijan, 2013), and that sediments will quickly return to their baseline condition following discharge (Terrens et al., 1998; Neff, 2010).

The only interaction in sediment quality impacts is between drilling discharges (i.e. drill cuttings and fluids discharged at the seabed from the riserless sections) and installation/commissioning within the Offshore Project Area (i.e. discharge of installation fluids) and a very low rate of potential insoluble natural salt deposition from produced water. Subsea installation/FPU installation will not occur until drilling is complete. There will be a small area at each drill site (less than 1,000 m from the top-hole location) where sediment quality will be affected by drilling discharges, however given the time between drilling and scheduled installation/commissioning recovery of sediment quality will occur, and no cumulative impacts from these activities are expected.

8.2.2.2 Biological Environment

It is possible that cumulative impacts to the biological environment may occur from the different phases of Scarborough. To identify where cumulative impacts may occur, the full table of impacts to receptors was considered, in addition to aspects and impacts associated with other activities/developments. Where the location or timing of an impact coincides, or where impacts will affect a receptor in a short timeframe i.e. before recovery, the potential scope of cumulative impacts has been evaluation.

No cumulative impacts are expected to shoreline or nearshore habitats, such as seagrass and mangroves, or coral and macroalgae, plankton, fish or marine mammals. Impacts from the project will be limited in the near shore environment and the Borrow Grounds Project Area, and other activities/developments are unlikely to result in the same/similar aspects for the duration of any impact effects.

Intensive vessel activities during the trunkline installation activities, will result in multiple sources of discharges, light and physical presence with the potential to impact on plankton, fish, marine reptiles, marine mammals and seabirds and shorebirds.

A section of the Scarborough trunkline is located within the Montebello AMP, and this AMP is therefore identified as an affected receptor to impacts related to seabed disturbance during installation and commissioning. A section of the existing Pluto and Wheatstone trunklines are also located within the AMP. However the cumulative impact as a result of the presence of the Scarborough trunkline has been minimised by locating it adjacent to the existing Pluto trunkline for much of the route that traverses the AMP. There are no known third party activities/developments being undertaken in the same area and timeframe, therefore no cumulative impacts to Montebello AMP from a third party, other than existing infrastructure presence are expected.

Similarly, the proposed borrow ground is located adjacent to the Dampier AMP, however no impacts from seabed disturbance are expected to the area, and therefore no cumulative impacts to the Dampier AMP are expected.

The trunkline installation activities will however involve the short-term (a few months) presence of multiple construction vessels, that will generate aspects and potentially result in cumulative impacts to the marine parks.

Table 8-2 identified aspects affecting receptors within the biological environment which may lead to cumulative impacts.

Table 8-2: Biological Environment which may be affected by Cumulative Impacts

Aspect	Epifauna and Infauna	Plankton	Fish	Marine Mammals	Marine Reptiles	AMPs	KEFs
Routine light emissions					✓		
Routine acoustic emissions			✓		✓		
Physical presence (routine): Seabed disturbance	✓		✓		✓	✓	✓
Routine and non-routine discharges: Sewage and greywater							
Routine and non-routine discharges: Food waste							
Routine and non-routine discharges: Chemicals and deck drainage							
Routine and non-routine discharges: Brine and cooling water		✓	✓	✓			✓
Routine and non-routine discharges: Operational fluids	✓	✓	✓	✓	✓		✓
Routine and non-routine discharges: Subsea installation and commissioning							✓
Routine and non-routine discharges: Drilling							✓

Epifauna and Infauna

Epifauna and infauna are likely to be impacted throughout the drilling and installation and commissioning phases of Scarborough, primarily through seabed disturbance and subsea discharges during drilling operations. These cumulative impacts will occur within the Offshore Project Area and once the facility is operational, there will be no further lasting impacts to epifauna and infauna from planned activities.

Any impacts from seabed disturbance and subsea discharge are separately assessed as being localised and short-term, with no population effects expected. A literature review undertaken by Bakke et al. (2013) confirmed this, indicating the ecosystem and population-level effects from numerous drilling operations are not expected. Given the low sensitivity of benthic communities in the Offshore Project Area, any combination of effects is not expected to have a long-term or population level impact on epifauna and infauna, therefore no cumulative impacts are expected.

Within the Montebello marine park, the installation of the trunkline will be the primary source of impact to epifauna and infauna and no cumulative impacts are expected to occur.

Plankton/Fish/Marine Reptiles/Marine Mammals

The discharge of multiple waste streams from the FPU including cooling water and produced formation water has the potential to result in increased impacts to receptors in the water column including plankton, fish and marine mammals. At the Scarborough Offshore project area, marine reptiles may transit but are unlikely to be present in significant numbers close to the source of routine discharges. Significant habitat for marine reptiles is typically located in shallower waters close to nesting beaches which are not exposed to routine discharges from the FPU.

Cooling water will make up most of the liquid discharge stream (200,000 m^3/day cooling water compared with up to 77 m^3 /day produced water). The potential impacts to plankton, fish (including commercial fishing) and marine mammals that transit the area exposed to the cooling water and produced water discharge plumes are discussed in section 7.1.10 and 7.1.11 respectively. The combined discharge is not expected to result in impacts that would exceed acceptable levels given that:

- While this impact will occur for the duration of the activities which cause the discharges (e.g. FPU operations), the high energy marine environment means that discharges will be quickly dissipated and will not accumulate or result in long-term changes to water quality.
- The impact assessment demonstrates that impacts to water quality will not result in irreversible environmental damage.
- The location of the discharge is not within an important habitat for a migratory fish species and as such there is no predicted impacts to any important habitats.
- The Offshore Project Area is located within a distribution BIA for pygmy blue whale. However, it is expected that individual pygmy blue whales found within the Offshore Project Area will be transient, and not performing behaviours (such as foraging and resting) which require them to stay in any location for an extended period of time. Individuals encountering the cooling water plume will be able to move away, limiting impacts and avoiding injury / mortality occurring.
- The discharge will not result in any exposure to Australian Marine Parks.
- In addition to cumulative impacts from discharges, fish species will be exposed to acoustic emissions and seabed disturbance that will present additional stressors. The acoustic emissions during the operations phase (and overlapping with the routine discharges) will be restricted to within close distances of the acoustic sources (see Section 7.1.4.4) and may trigger behavioural responses close to the source, however given this area is not considered an important habitat for fish, nor subject to high levels of commercial fishing, this impact is not predicted to be significant. The more significant acoustic emissions will occur during piling activities a part of construction and will not result in cumulative impacts with stressors during the operation phase.

In consideration of this, plus other acceptability criteria (that is internal context and external context, noting that the Scarborough development is consistent with Woodside internal requirements and no specific concerns were raised regarding the potential) the cumulative impact to water quality and receptors potentially exposed is evaluated to be **acceptable**. No additional control measures are required.

To manage impacts to marine species to at or below the defined acceptable levels EPO have been identified for each aspect in the Section 7.

Marine Reptiles

Marine reptiles will exhibit a change in behaviour from both light emissions and acoustic emissions.

Increased vessel activity during the installation and commissioning phase means that impacts associated with seabed disturbance, light and acoustic emissions from existing vessel traffic may be increased in intensity/severity as a result of the additional vessel movements. The Trunkline Project Area and Borrow Grounds Project Area intercept with BIAs for internesting hawksbill, flatback, green and loggerhead turtles, and habitat critical (internesting buffer) hawksbill, flatback, and green turtles. The Trunkline Project Area and Borrow Grounds Project Area intercept with BIAs for internesting hawksbill, flatback, green and loggerhead turtles, and habitat critical (internesting buffer) hawksbill, flatback and green turtles. Presence of marine turtles in the Trunkline Project Area are expected to peak during breeding periods (described in detail in Section 5.4.6.4). The closest nesting beaches to Trunkline and Borrow Ground Project Areas are Legendre Island (12 km and 6.5 km distance, respectively) and Rosemary Island (approximately 14 km away from the Trunkline Project Area at the closest point).

Light modelling undertaken for the Scarborough Project (Pendoley 2020b, APPENDIX L) has predicted that light levels from project vessels will reduce to levels below the behavioural impacts threshold, for all moon phases within 2 km and ambient levels within 6 km (see section 7.1.1).

Continuous acoustic emissions from vessel activity will result in changes in behaviour, such as avoidance and change in swimming direction and speed. Injury is not expected from vessel sound sources. For continuous noise emissions associated with the vessels It is possible that, with increased vessel traffic, there could be an overlap in the disturbance area from vessel based acoustic emissions.

Additionally, seabed disturbance will potentially impact on marine turtles through some loss of marine turtle foraging habitat noting that such foraging habitat is widely represented in the region and any loss is expected to be negligible. Surveys of the trunkline route have not indicated the presence of any unique or limiting benthic foraging habitat for marine turtles within the trunkline corridor.

Considering this, there is potential for an increased impact to marine reptiles from a combination of project vessels, and vessels associated with other activities/developments, specifically in the region close to turtle nesting sites. Impacts to turtles are to be managed in accordance with the Recovery plan for marine turtles in Australia (DoEE, 2017), including “to manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival”.

The cumulative impacts of the increased vessels activity will present a level of risk potentially greater that of each of the sources of impact alone (as described throughout section 7), however the resulting impact will not be inconsistent with the principles of ESD, the objectives of the zoning for the AMPS, nor the requirements of the Recovery Plan in that:

- Total numbers of marine reptiles will vary (as described in Section 5.4.6), peaking during breeding periods. Construction activities are in the order of a few months when working within the Montebello Marine Park, and in the order of a few months (estimated to be approximately 8 weeks) when working adjacent to the Dampier Marine Park.
- For all three species of marine turtle there is no overlap between the Trunkline and Borrow Grounds project areas and foraging BIAs. The overlap between both project areas and habitat critical for marine turtles is extremely small, with the vast majority of suitable and foraging habitat remaining avtside these project areas and available for utilisation.
- The Trunkline and Borrow Grounds project areas are not likely to represent important inter-nestink, green and hawksbill turtles, and any displacement of individuals from the small areas of overlap with habitat critical will not result in any significant impacts at a population level.

Potential impacts generally have a low level of consequence and will likely result in minor behavioural changes which will revert once the individual is outside of the impact area. Therefore, any potential increased impact will be short-term (limited to the duration of construction activities) and localised (within the areas identified for trunkline installation, and within a few kilometres as a result of the light extent), with installation and commissioning activities limited to the initial stages of Scarborough. As such, any cumulative impacts to marine turtles from light emissions, acoustic emissions and seabed disturbance will occur on an individual level andin population level/significant effectson of this, plus other acceptability criteria (that is internal context and external context, noting that the Scarborough development is consistent with Woodside internal requirements and no specific concerns were raised regarding the potential impacts of the Scarborough development on marine reptiles) the cumulative impact evaluated to be **acceptable**. No additional control measures are required.

To manage impacts to marine reptiles to at or below the defined acceptable levels the following EPO have been applied:

EPO 6.4: Undertake Scarborough development in a manner that will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity results.

EPO 6.5: Seabed Disturbance from trunkline installation within the Montebello Marine Park will be limited to less than 0.07%of the total park area.

EPO 6.6: Trunkline installation and borrow ground activities will be undertaken in a manner that aims to avoid the displacement of marine turtles from important foraging habitat or from habitat critical during nesting and internesting periods.

KEFs

The Project Area lies within three KEFs:

- Exmouth Plateau (Offshore Project Area and Trunkline Project Area)
- Continental Slope Demersal Fish Communities (Trunkline Project Area)
- Ancient Coastline at 125 m depth contour (Trunkline Project Area).

The primary impact to the values associated with KEFs will occur from seabed disturbance, particularly during installation of the Trunkline Project Area. Physical habitat modification is not listed as a potential concern for Exmouth Plateau KEF or Ancient Coastline at 125 m depth contour KEF and therefore impacts to the values of these KEFs are not anticipated. Physical habitat modification is listed as a potential concern for the Continental Slope Demersal Fish Communities KEF; however, the total impact area is small, and impacts will be highly localised to the Trunkline Project Area.

The Offshore Project Area, where discharges will occur, is within the Exmouth Plateau KEF. The Exmouth Plateau is defined as a KEF as it is a unique seafloor feature with ecological properties of regional significance, which apply to both the benthic and pelagic habitats within the feature (Section 5.5.1). While the discharge, which include a combination of brine and cooling water and produced water is to occur within the Exmouth Plateau KEF, this is at a significant distance (>150 km) from the location that has been identified as having increased productivity according the Brewer et al., 2007. Subsequently it is not anticipated that this discharge will result in impacts to the ecological integrity of the KEF.

There are no planned emissions or discharges within the Continental Slope Demersal Fish Communities KEF, as most discharges occur within the Offshore Project Area. Therefore, no cumulative impacts to KEFs are expected.

8.2.2.3 Socio-Economic Environment

The socio-economic environment in the North West Marine Region is of considerable importance to the local economy. Other marine users/activities within the region may be affected by the addition of Scarborough when considered in conjunction with other activities/developments in the area. These impacts are likely to be more severe in the nearshore area, and during high-intensity phases of Scarborough such as installation and commissioning, specifically trunkline installation. Once the project is operational, the additional vessel movements in the area will have limited impact on other marine users, and no cumulative impacts are expected for the remaining lifecycle of the project.

Potential impacts to socio-economic receptors have been identified throughout the Impact Assessment provided in Section 7. The assessment concludes that impacts from displacement of other users will be **Slight (E)** and acceptable, and no other aspects are expected to have impacts on social, economic or heritage receptors. On that basis, it has also been assumed that cumulative impacts to socio-economic receptors will not occur.

8.3 Summary

This cumulative impact assessment has shown that there is little cross-over in spatial extent of aspects, both within the project and between Scarborough and other activities/developments. The majority of emissions and discharges, particularly those which will occur during the full lifecycle of the project, will be made within the Offshore Project Area, which is remote and unlikely to result in interactions with other activities/developments.

When considering potential cumulative impacts on receptors, it is clear that in most cases the phased approach of development proposed for Scarborough will alleviate the potential for cumulative pressure on receptors, allowing recovery/return to baseline conditions between impact events. It is still possible that individuals will experience combination effects from multiple impact events in the vicinity of the Offshore Project Area, however this is not predicted to occur on a population level for any receptors. Where cumulative impacts are predicted, i.e. light emissions on marine reptiles, the assessment concludes that no significant impacts will occur, and any cumulative impacts will be acceptable.

9 ENVIRONMENTAL MANAGEMENT IMPLEMENTATION APPROACH

9.1 Overview

Scarborough will be undertaken in accordance with the OPP. This will be implemented by ensuring that all petroleum activities are within the scope of the accepted OPP, and the adoption of controls and EPOs specified in the OPP in any future petroleum activity EPs.

9.1.1 Woodside Management System

The Woodside Management System (WMS) described in Section 2 provides a structured framework of documentation to set common expectations governing how all activities will be undertaken.

The WMS comprises of four elements: Compass & Policies; Expectations; Processes & Procedures; and Guidelines. Procedures under the WMS will specify what steps, by whom and when are required to carry out an activity or a process. Further detail related to implementation of the OPP is provided in the following sections.

9.2 Roles and Responsibilities

Key roles and responsibilities for Woodside and Contractor personnel in relation to the implementation and management of EPOs identified in this OPP are described in Table 9-1.

In addition to these identified roles, it is the responsibility of all Woodside employees and contractors to implement the Woodside Corporate Health, Safety, Environment and Quality Policy in their areas of responsibility and that the personnel are suitably trained and competent in their respective roles

Table 9-1: Roles and responsibilities

Title (role)	Environmental Responsibilities
Office-based Personnel	
Woodside Project Manager	• Ensure implementation of the Environment Plans which will be produced to support the Scarborough OPP. • Ensure systems and procedures are in place to manage the activity so it is undertaken as per the relevant standards and commitments in this OPP • Ensure that contractors meet environmental related contractual obligations
Woodside Delivery Manager (FPU, SURF, Pipelay, Dredging)	• Ensure environment expectations are understood by team members in line with the commitments set out in this OPP • Communicate environment performance, relevant information and Lessons Learnt to team members and contractors • Ensure application of contractor's management of environment requirements, in accordance with the OPP
Woodside Environment Adviser	• Track compliance with environmental performance outcomes as per the requirements of this OPP • Prepare environmental component of relevant Induction Package • Provide advice to relevant Woodside personnel and contractors to assist them to understand their environment responsibilities
Woodside Drilling Superintendent	• Ensures the drilling program meets the requirements detailed in this OPP
Woodside Drilling and Subsea Engineers	• Ensure all chemicals and drill fluids proposed to be discharged are assessed and approved as per the requirements of the OPP and subsequent EPs
Woodside Corporate Affairs Adviser	• Prepare and implement the Stakeholder Consultation Plan for Petroleum Activities Program

Title (role)	Environmental Responsibilities
Woodside Marine Assurance Superintendent	• Conduct relevant audit and inspection to confirm vessels are compliant with relevant Marine Orders and Woodside Marine Charters Instructions requirements to meet safety, navigation and emergency response requirements
Offshore/Contractor Personnel	
MODU/FPU Offshore Installation Manager (OIM)	• Ensure the management system and procedures are implemented • Ensure personnel receive an environmental induction that meets the requirements specified in this OPP
Woodside Site Representative	• Ensure Scarborough Project scopes are undertaken as detailed in this OPP and subsequent EPs • Ensure the management measures detailed in this OPP are implemented on the MODU/FPU/Vessel
Offshore HSE Adviser /Vessel HSE Advisors	• Support Woodside Site Representatives to ensure that the controls detailed in this OPP relevant to offshore activities are implemented and assist in collection and recording of evidence of implementation (other controls are implemented, and evidence collected onshore) • Ensure periodic environmental inspections/reviews are completed and corrective actions from inspections are developed, tracked and closed out in a timely manner
Vessel Master	• Ensure the vessel management system and procedures are implemented • Ensure Scarborough Project scopes are undertaken as detailed in this OPP and subsequent EPs • Ensure personnel commencing work on the vessel receive an environmental induction that meets the requirements specified in this OPP
Vessel Logistics Coordinators	• Ensure waste is managed on the relevant support vessels and sent to shore as per the Contractor Waste Management Plan
Contractor Project Manager	• Ensure that activities are undertaken in accordance with this OPP, as detailed in the Woodside approved Contactor Environmental Management Plan • Ensure personnel commencing work on the project receive a relevant environmental induction that meets the requirements specified in this OPP

9.3 Emergency Preparedness and Response

Woodside will have an Emergency Response Plan (ERP) in place for all future petroleum activities. The ERP provides procedural guidance specific to the activity to control, coordinate and response to an emergency or incident including hydrocarbon spills.

Under Regulations 14(8) the Implementation Strategy for petroleum activity EPs must contain an oil pollution emergency plan (OPEP) and provide for the updating of the OPEP. Regulation 14(8AA) outlines the requirements for the OPEP which must include adequate arrangements for responding to and monitoring of oil pollution.

A significant hydrocarbon spill during the petroleum activities proposed as a part of Scarborough is unlikely but should such an event occur it will be managed. Woodside has in place an overarching plan to manage oil spills from Woodside activities and facilities. This will be supported by specific plans that provide tactical response guidance to the activity/area.

9.4 Monitoring of EPO Implementation

The effective application of EPOs provided in this OPP will be demonstrated through the implementation of subsequent EPs. EPOs associated with planned impacts will generally be demonstrated through successful implementation of controls, environmental performance standards and associated measurement criteria specific to the activity for which an EP is being developed.

To ensure the requirements are met, Woodside and its contractors will undertake a program of monitoring during execution of the petroleum activities. The program of monitoring will be described in detail in the EPs for the specific activities and will make use of tools and systems that are appropriate to the activity, and the project teams.

Note that measurement criteria may include environmental monitoring programs, however these are not required where there is high confidence in the effectiveness of controls and the potential for environmental impact is low. Where an unplanned event (e.g. hydrocarbon spill or other discharge) results in the potential for environmental harm, the incident reporting and investigation process will identify if there is the potential for environmental impacts. This process will provide sufficient information to determine if the EPO has not been achieved.

9.4.1 Auditing

During the execution of project activities, environmental performance auditing will be undertaken to:

- Identify potential new, or changes to existing environmental impacts and risk, and methods for reducing these to ALARP,
- Confirm that any controls that are applied to ensure impacts and risks are acceptable are effective, and
- Confirm compliance with the controls and EPS detailed in future EPs.

Further details including the schedule for environmental performance auditing will be provided in future EPs for petroleum activities.

9.5 Reporting

In order to meet the environmental performance outcomes outlined in this OPP Woodside will undertake external reporting at a number of levels. These reporting arrangements are outlined below.

9.5.1 Environmental Performance Reporting

In accordance with applicable environmental legislation for the activity, Woodside is required to report information on environmental performance to NOPSEMA during the implementation of Environment Plans including:

- Monthly Recordable Incident Reports – submitted monthly to NOPSEMA, with details of recordable incidents that have occurred during the Petroleum Activity for the previous month (if any)
- Environmental Performance Report – submitted annually to NOPSEMA in accordance with the Environment Regulations. The report will address compliance with EPOs outlines in this EP, and controls and standards outlined in subsequent EPs.

9.5.2 Recordable Incidents

A recordable incident as defined under Regulation 4 of the Environment Regulations as an incident arising from the activity that:

- *‘breaches an environmental performance outcome or environmental performance standard, in the EP that applies to the activity, that is not a reportable incident’.*

Any breach of the environmental performance outcomes will be raised as an incident and managed as per the notification and reporting requirements outlined below and the Woodside Health, Safety and Environment Event Reporting and Investigation Procedure.

NOPSEMA will be notified of all recordable incidents, according to the requirements of Regulation 26B (4), not later than 15 days after the end of the calendar month using the NOPSEMA Form – Recordable Environmental Incident Monthly Summary Report.

9.5.3 Reportable Incidents

A reportable incident as defined under Regulation 4 of the Environment Regulations as an incident relating to the activity that

- *'has caused, or has the potential to cause, moderate to significant environmental damage'.*

NOPSEMA will be notified of all reportable incidents, according to the requirements of Regulations 26, 26A and 26AA of the Environment Regulations:

- report all reportable incidents to the regulator (orally) as soon as practicable, but within two hours of the incident or of its detection by Woodside
- provide a written record of the reported incident to NOPSEMA, the National Offshore Petroleum Titles Administrator (NOPTA) and the Department of the responsible State Minister (DMIRS) as soon as practicable after the oral reporting of the incident
- complete a written report for all reportable incidents using a format consistent with the NOPSEMA Form FM0929 – Reportable Environment Incident which must be submitted to NOPSEMA as soon as practicable, but within three days of the incident or of its detection by Woodside
- provide a copy of the written report to NOPTA and DMIRS, within seven days of the written report being provided to NOPSEMA.

9.6 Management of Change

Management of changes relevant to this OPP, concerning the scope of the activity description (Section 4) including review of advances in technology at stages where new equipment may be selected, changes in understanding of the environment, including all current advice on species protected under EPBC Act and current requirements for Australian Marine Parks (Section 5) and potential new advice from external stakeholders (Section 10) will be managed in accordance with Woodside's Commonwealth Environmental Approvals Procedure (WM1050PF10239249).

Woodside's Commonwealth Environmental Approvals Procedure provides guidance on the Environment Regulations that may trigger a revision and resubmission of approvals. The procedure also provides guidance on what constitutes a significant new risk or increase in risk. A risk assessment will be conducted in accordance with the Environmental Risk Management Methodology (Section 6) to determine the significance of any potential new environmental impacts or risks not provided for in this OPP.

Minor changes where a review of the activity and the environmental risks and impacts of the activity do not trigger a requirement for a revision, will be considered a 'minor revision'. Minor administrative changes to this OPP, where an assessment of the environmental risks and impacts is not required (e.g. document references, terminology, etc.), will also be considered a 'minor revision'. Minor revisions as defined above will be made to this OPP using Woodside's document control process.

9.7 Implementing Requirements of the OPP in Future EPs

Broadly, the purpose of an environment plan is for the titleholder to firstly identify the proposed petroleum activity's impacts on and risks to the receiving environment. Secondly, the titleholder must set out control measures to reduce the identified environmental impacts and risks of the activity and describe how and to what standard of performance those measures will be implemented and throughout the life of the activity including emergency situations. Table 9-2, Table 9-3, Table 9-4, Table 9-5 and Table 9-6 provide a summary of Key Management Controls and Environmental Performance Outcomes relative to each aspect of the project.

Table 9-2: Drilling Key Management Controls and Environmental Performance Outcomes

Aspect	Receptor	EPO	Impact / Risk	Adopted control(s)
Routine atmospheric emissions affecting Air Quality	Air quality	EPO 2.1	Change in air quality	**Well flow-back, Drilling** **CM2:** Vessel and MODU compliance with Marine Order 97 (Marine Pollution Prevention – Air Pollution), including: • International Air Pollution Prevention (IAPP) Certificate, required by vessel class • use of low sulphur fuel when available • Ship Energy Efficiency Management Plan (SEEMP), where required by vessel class • onboard incinerator to comply with Marine Order 97. **CM3:** Optimisation of flaring to allow the safe and economically efficient operation of the facility.
Routine Greenhouse Gas Emissions	Climate	EPO 3.1 EPO 3.2	Climate change	**Well flow-back** **CM5:** Reporting of GHG emissions as per regulatory requirements.
Routine acoustic emissions	Ambient Noise	EPO 4.1 EPO 4.2 EPO 4.3	Change in ambient noise	**VSP** **CM6:** Woodside VSP Procedure implemented while VSP operations are undertaken to avoid prolonged exposure to marine fauna.
	Fish		Change in fauna behaviour Injury/mortality to marine fauna	
	Marine Reptiles		Change in fauna behaviour Injury/mortality to marine fauna	
	Marine Mammals		Change in fauna behaviour Injury/mortality to fauna	
Physical presence (routine): Seabed disturbance	Water quality	EPO 6.1 EPO 6.4 EPO 6.9	Change in water quality	**Drilling Operations** **CM12:** Infrastructure will be positioned on the seabed within design footprint to reduce seabed disturbance.
	Epifauna and infauna		Change in habitat	
	Marine Turtles		Change in habitat Injury or mortality	
	KEFs		Change in habitat Change in water quality Injury or mortality	

Aspect	Receptor	EPO	Impact / Risk	Adopted control(s)
	AMPs		Change in habitat Change in water quality	
Routine and non-routine discharges: Drilling	Sediment Quality	EPO 13.1 EPO 13.2 EPO 13.3 EPO 13.4 EPO 13.5 EPO 13.6	Change in sediment quality	**Drilling operations** **CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **CM19:** WBM will be used during drilling activities as the first preference. Where WBM cannot meet required technical specifications, NWBM may be used following technical justification. **CM20:** Bulk overboard discharge of NWBM is prohibited. **CM21:** Drill cuttings returned to the MODU will be processed to reduce oil on cuttings to < 6.9% by weight on wet cuttings (measured as a well average only including sections drilled with NWBM) prior to discharge. **CM22:** Drill cuttings returned to the MODU will be discharged below the waterline.
	Water Quality		Change in water quality	
	Plankton		Injury/ mortality to fauna	
	Epifauna and infauna		Injury/ mortality to fauna	
	KEFs		Change in habitat	
Unplanned Discharge: Chemicals	Water quality	EPO 14.1	Change in water quality	**Drilling operations** **CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **CM15:** Implementation of waste management procedures which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.
Unplanned hydrocarbon release	Sediment quality	EPO 19.1	Change in sediment quality	**Drilling Operations** **CM26:** All vessels and facilities (appropriate to class) will comply with MARPOL 73/78, the Navigation Act 2012, the Protection of the Sea (Prevention of Pollution from Ships Act 1983 and subsequent Marine Orders including: • waste management requirements • management of spills aboard • emergency drills. **CM27:** Relevant Stakeholders will be notified of activities prior to commencement. **CM28:** Vessels will have in place a valid and appropriate Shipboard Oil Pollution Emergency Plan and/or Shipboard Marine Pollution
	Water quality		Change in water quality	
	Plankton		Injury/ mortality to fauna	
	Fish		Change in fauna behaviour Injury/ mortality to fauna	
	Marine mammals		Change in fauna behaviour Injury/ mortality to fauna	
	Marine reptiles		Change in fauna behaviour Injury/ mortality to fauna	

Aspect	Receptor	EPO	Impact / Risk	Adopted control(s)
	Seabirds and migratory shorebirds		Change in fauna behaviour Injury/ mortality to fauna	Emergency Plan. Emergency response activities will be implemented in accordance with the SOPEP/SMPEP. **CM29:** Environment Plans and Oil Pollution Emergency Plans will be accepted and in place, appropriate to the credible hydrocarbon spill scenario associated with activities during Scarborough. Emergency response activities will be implemented in accordance with the OPEP. **CM30:** Emergency response activities will be implemented in accordance with the OPEP the vessel SOPEP/SMPEP. **CM31:** Emergency response capability will be maintained in accordance with EP, OPEP and related documentation. Well Operations Management Plan accepted and in place for all wells, in accordance with the Offshore Petroleum and Greenhouse Gas Storage Act requirements, which include: • Blowout Preventer (BOP) installation during drilling operations • regular testing of BOP.
	Coral		Change in habitat	
	Seagrass		Change in habitat	
	Macroalgae		Change in habitat	
	Mangroves		Change in habitat	
	Shoreline habitats		Change in habitat	
	Saltmarsh		Change in habitat	
	KEFs		Change in habitat	
	AMPS		Change in habitat	
	Protected Places		Change in habitat	
	Commonwealth and State Managed Fisheries		Changes to the functions, interests or activities of other users	
	Tourism and recreation		Changes to the functions, interests or activities of other users Changes in aesthetic value	
	Settlements		Changes to the functions, interests or activities of other users Changes in aesthetic value	
	Shipping		Changes to the functions, interests or activities of other users	
	Industry		Changes to the functions, interests or activities of other users	
	Defence		Changes to the functions, interests or activities of other users	

Table 9-3: Installation and Commissioning Key Management Controls and Environmental Performance Outcomes

Aspect	Receptor	EPO	Impact	Adopted control(s)
Routine acoustic emissions	Ambient Noise	EPO 4.1 EPO 4.2 EPO 4.3 EPO 4.4	Change in ambient noise	**Installation of FPU** **CM7:** For impact piling activities, Woodside will implement the soft start procedure at the commencement of piling activities and shut down zones during the activity. **CM8:** EPBC Regulations 2000 Part 8 Division 8.1 Interacting with cetaceans. **CM37:** Impact piling activities required for FPU installation will not occur during the peak migration periods for the northern migration of the pygmy blue whale (May and June) and southern migration (November and December).
	Fish		Change in fauna behaviour Injury/mortality to marine fauna	
	Marine Reptiles		Change in fauna behaviour Injury/mortality to marine fauna	
	Marine Mammals		Change in fauna behaviour Injury/mortality to fauna	
Physical presence (routine): Displacement of Other Users	Commonwealth Managed Fisheries	EPO 5.1 EPO 5.2	Changes to the function interests or activities of others	**Pre-lay survey, Installation of FPU, Installation of subsea infrastructure, Trunkline installation** **CM10:** Notify Australian Hydrographic Service (AHS) of activities and movements prior to activity commencing. **CM11:** Notify representatives of State and Commonwealth fisheries of activities.
	State Managed Fisheries			
	Shipping			
	Industry			
Physical presence (routine): Seabed disturbance	Water quality	EPO 6.1 EPO 6.2 EPO 6.3 EPO 6.4 EPO 6.5 EPO 6.6 EPO 6.7 EPO 6.8	Change in water quality	**Pre-lay survey, Installation of FPU, Installation of subsea infrastructure, Trunkline installation, Trunkline stabilisation** **CM12:** Infrastructure will be positioned on the seabed within design footprint to reduce seabed disturbance. **CM33:** A 250m buffer zone will be implemented between the offshore borrow ground and the Dampier AMP **CM34:** Development of a management framework for dredging and backfill activities based on water quality to manage activities to achieve EPO 6.2 and EPO 6.4
	Epifauna and infauna		Change in habitat	
	Marine turtles		Change in habitat Injury or mortality	
	KEFs		Change in habitat Change in water quality Injury or mortality	
	AMPs		Change in habitat Change in water quality	
Routine and non-routine discharges: Subsea	Sediment quality	EPO 12.1 EPO 12.2 EPO 12.3	Change in sediment quality	**Installation of FPU, Installation of subsea infrastructure, Commissioning** **CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints.
	Water quality		Change in water quality	
	Plankton		Injury/ mortality to fauna	

Aspect	Receptor	EPO	Impact	Adopted control(s)
installation, and commissioning	Epifauna and infauna	EPO 12.4 EPO 12.5	Injury/ mortality to fauna	
	KEFs		Change in water quality Change in sediment quality	
Physical presence (unplanned) - Seabed disturbance	Epifauna and infauna	EPO 16.1 EPO 16.2 EPO 16.3	Change in habitat Injury/ mortality to fauna	**<u>Trunkline installation</u>** **CM12:** Infrastructure will be positioned on the seabed within design footprint to reduce seabed disturbance.
	KEFs		Change in habitat	
Physical presence (unplanned) - IMS	Epifauna and infauna Coral Macroalgae Seagrass	EPO 17.1 EPO 17.2 EPO 17.3 EPO 17.4	Change in ecosystem dynamics	**<u>Installation of FPU, installation of subsea infrastructure, trunkline installation</u>** **CM24:** Compliance with the Woodside Invasive Marine Species Management Plan. **CM25:** Requirements of the Australian Ballast Water Management to be met.
	Industry Shipping Defence		Changes to the functions, interests or activities of other users	
Unplanned hydrocarbon release	Sediment quality	EPO 19.1	Change in sediment quality	**<u>Commissioning</u>** **CM26:** All vessels and facilities (appropriate to class) will comply with MARPOL 73/78, the Navigation Act 2012, the Protection of the Sea (Prevention of Pollution from Ships Act 1983 and subsequent Marine Orders including: • waste management requirements • management of spills aboard • emergency drills. **CM27:** Relevant Stakeholders will be notified of activities prior to commencement. **CM28:** Vessels will have in place a valid and appropriate Shipboard Oil Pollution Emergency Plan and/or Shipboard Marine Pollution Emergency Plan. Emergency response activities will be implemented in accordance with the SOPEP/SMPEP. **CM29:** Environment Plans and Oil Pollution Emergency Plans will be accepted and in place, appropriate to the credible hydrocarbon spill
	Water quality		Change in water quality	
	Plankton		Injury/ mortality to fauna	
	Fish		Change in fauna behaviour Injury/ mortality to fauna	
	Marine mammals		Change in fauna behaviour Injury/ mortality to fauna	
	Marine reptiles		Change in fauna behaviour Injury/ mortality to fauna	
	Seabirds and migratory shorebirds		Change in fauna behaviour Injury/ mortality to fauna	
	Coral		Change in habitat	

Aspect	Receptor	EPO	Impact	Adopted control(s)
	Seagrass		Change in habitat	scenario associated with activities during Scarborough. Emergency response activities will be implemented in accordance with the OPEP. **CM30:** Emergency response activities will be implemented in accordance with the OPEP the vessel SOPEP/SMPEP. **CM31:** Emergency response capability will be maintained in accordance with EP, OPEP and related documentation. Well Operations Management Plan accepted and in place for all wells, in accordance with the Offshore Petroleum and Greenhouse Gas Storage Act requirements, which include: • Blowout Preventer (BOP) installation during drilling operations • regular testing of BOP.
	Macroalgae		Change in habitat	
	Mangroves		Change in habitat	
	Shoreline habitats		Change in habitat	
	Saltmarsh		Change in habitat	
	KEFs		Change in habitat	
	AMPS		Change in habitat	
	Protected Places		Change in habitat	
	Commonwealth and State Managed Fisheries		Changes to the functions, interests or activities of other users	
	Tourism and recreation		Changes to the functions, interests or activities of other users	
			Changes in aesthetic value	
	Shipping		Changes to the functions, interests or activities of other users	
	Industry		Changes to the functions, interests or activities of other users	
	Settlements		Changes to the functions, interests or activities of other users	
			Change in aesthetic value	
	Defence		Changes to the functions, interests or activities of other users	

Table 9-4:Operations Key Management Controls and Environmental Performance Outcomes

Aspect	Receptor	EPO	Impact	Adopted control(s)
	Ambient light	EPO 1.1	Change in ambient light	**FPU Operations**

<table>
<tr><th>Aspect</th><th>Receptor</th><th>EPO</th><th>Impact</th><th>Adopted control(s)</th></tr>
<tr><td rowspan="2">Routine light emissions</td><td>Seabirds and migratory shorebirds</td><td rowspan="2">EPO 1.2
EPO 1.3
EPO 1.4</td><td rowspan="2">Change in fauna behaviour</td><td rowspan="2">CM1: Lighting will be limited the minimum required for navigational and safety requirements, with the exception of emergency events.</td></tr>
<tr><td>Marine reptiles</td></tr>
<tr><td>Routine atmospheric emissions affecting Air Quality</td><td>Air quality</td><td>EPO 2.1</td><td>Change in air quality</td><td><u>FPU Operations</u>
CM2: Vessel and MODU compliance with Marine Order 97 (Marine Pollution Prevention – Air Pollution), including:
• International Air Pollution Prevention (IAPP) Certificate, required by vessel class
• use of low sulphur fuel when available
• Ship Energy Efficiency Management Plan (SEEMP), where required by vessel class
• onboard incinerator to comply with Marine Order 97.
<u>Hydrocarbon Processing</u>
CM3: Optimisation of flaring to allow the safe and economically efficient operation of the facility.</td></tr>
<tr><td>Routine Greenhouse Gas Emissions</td><td>Climate</td><td>EPO 3.1
EPO 3.2</td><td>Climate change</td><td><u>FPU Operations, Hydrocarbon Processing</u>
CM4: Facilities will be designed and operated to optimise energy efficiency, including:
• The FPU will be designed to have no continuous operational flaring
• Design optimisation to reduce direct GHG emissions to ALARP
• development of energy management plans prior to operations
• Fuel and flare analysis, baselining and forecasting throughout the life of operations
• Annual setting of energy efficiency improvement and flare reduction targets
• Ongoing optimisation of energy efficiency through periodic opportunity identification workshops/studies, evaluation and implementation.</td></tr>
</table>

Aspect	Receptor	EPO	Impact	Adopted control(s)
				CM5: Reporting of Scarborough scope 1 GHG emissions as per regulatory requirements. **CM38:** Develop and implement a Program to support EPO 3.2 relating to third party GHG emissions which will include the following: • Working with the natural gas value chain to reduce methane emissions in third party systems (e.g. regasification and distribution), such as through the adoption of the Methane Guiding Principles. • Promoting the role of LNG in displacing higher carbon intensity fuels • Supporting the development of new technologies to reduce higher carbon intensive energy sources • Advocacy for stable policy frameworks that reduce carbon emissions. • Monitoring the global energy outlook including the demand for lower carbon intensive energy such as LNG and displacing higher carbon intensive fuels. • Mechanisms to ensure adaptive management of these measures for the duration of the project in accordance with the Environment Regulations, including regular reviews in conjunction with relevant operations Environment Plan revision cycles.
Routine acoustic emissions	Ambient Noise	EPO 4.1 EPO 4.2 EPO 4.3	Change in ambient noise	**<u>FPU Operations, Hydrocarbon Extraction</u>** **CM8:** EPBC Regulations 2000 Part 8 Division 8.1 Interacting with cetaceans.
	Fish		Change in fauna behaviour Injury/mortality to marine fauna	
	Marine Reptiles		Change in fauna behaviour Injury/mortality to marine fauna	
	Marine Mammals		Change in fauna behaviour Injury/mortality to fauna	
Physical presence (routine):	Commonwealth Managed Fisheries	EPO 5.1 EPO 5.2	Changes to the function interests or activities of others	**<u>FPU Operations</u>** **CM10:** Notify Australian Hydrographic Service (AHS) of activities and movements prior to activity commencing.
	State Managed Fisheries			

Aspect	Receptor	EPO	Impact	Adopted control(s)
Displacement of Other Users	Shipping Industry			**CM11:** Notify representatives of State and Commonwealth fisheries of activities.
Routine Discharges: Sewage and Greywater	Water quality	EPO 7.1	Change in water quality	**FPU Operations** **CM13:** Compliance with relevant MARPOL, Commonwealth requirements and subsequent Marine Order requirements for sewage management.
Routine Discharges: Food Waste	Water quality	EPO 8.1	Change in water quality	**FPU Operations** **CM14:** Compliance with relevant MARPOL, Commonwealth requirements and subsequent Marine Order requirements for waste discharges. **CM15:** Implementation of waste management procedures which provides for safe handling and transportation, segregation and storage and appropriate classification of all waste generated during Scarborough.
Routine Discharges: Chemicals and Deck Drainage	Water quality	EPO 9.1	Change in water quality	**FPU Operations** **CM17:** Compliance with relevant MARPOL, Commonwealth requirements and subsequent Marine Order requirements for planned discharges. **CM15:** Implementation of waste management procedures which provides for safe handling and transportation, segregation and storage and appropriate classification of all waste generated during Scarborough.
Routine Discharges: Brine and Cooling Water	Water quality Plankton Fish Marine mammals KEFs Commercial Fisheries	EPO 10.1 EPO 10.2 EPO 10.3 EPO 10.4 EPO 10.5 EPO 10.6 EPO 10.7 EPO 10.8 EPO 10.9	Change in water quality Injury/ mortality to fauna Injury/ mortality to fauna Injury/ mortality to fauna Change in water quality Injury/ mortality to fauna	**FPU Operations** **CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints.
	Water quality	EPO 11.1	Change in water quality	**Hydrocarbon extraction, Hydrocarbon processing**

Aspect	Receptor	EPO	Impact	Adopted control(s)
Routine and non-routine discharges: Operational Fluids	Sediment quality	EPO 11.2 EPO 11.3 EPO 11.4 EPO 11.5 EPO 11.6	Change in sediment quality	**CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **CM18:** Development of a management framework for produced formation discharges.
	Plankton		Injury/ mortality to fauna	
	Epifauna and infauna		Injury/ mortality to fauna	
	KEFs		Change in habitat	
Unplanned Discharges: Chemicals	Water quality	EPO 14.1	Change in water quality	**FPU Operations** **CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **CM15:** Implementation of waste management procedures which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.
Unplanned Discharges: Solid Waste	Water Quality	EPO 15.1 EPO 15.2 EPO 15.3 EPO 15.4 EPO 15.5 EPO 15.6 EPO 15.7 EPO 15.8 EPO 15.9	Change in water quality	**FPU Operations** **CM23:** Project vessels compliant with Marine Order 95 (pollution prevention – Garbage). **CM15:** Implementation of waste management procedures which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.
	Migratory Shorebirds and Seabirds		Injury/mortality to fauna	
	Fish			
	Marine Mammals			
	Marine Reptiles			
Unplanned hydrocarbon release	Sediment quality	EPO 19.1	Change in sediment quality	**All activities** **CM26:** All vessels and facilities (appropriate to class) will comply with MARPOL 73/78, the Navigation Act 2012, the Protection of the Sea (Prevention of Pollution from Ships Act 1983 and subsequent Marine Orders including: • waste management requirements • management of spills aboard • emergency drills. **CM27:** Relevant Stakeholders will be notified of activities prior to commencement.
	Water quality		Change in water quality	
	Plankton		Injury/ mortality to fauna	
	Fish		Change in fauna behaviour	
			Injury/ mortality to fauna	
	Marine mammals		Change in fauna behaviour	
			Injury/ mortality to fauna	
	Marine reptiles		Change in fauna behaviour	

Aspect	Receptor	EPO	Impact	Adopted control(s)
			Injury/ mortality to fauna	**CM28:** Vessels will have in place a valid and appropriate Shipboard Oil Pollution Emergency Plan and/or Shipboard Marine Pollution Emergency Plan. Emergency response activities will be implemented in accordance with the SOPEP/SMPEP. **CM29:** Environment Plans and Oil Pollution Emergency Plans will be accepted and in place, appropriate to the credible hydrocarbon spill scenario associated with activities during Scarborough. Emergency response activities will be implemented in accordance with the OPEP. **CM30:** Emergency response activities will be implemented in accordance with the OPEP the vessel SOPEP/SMPEP. **CM31:** Emergency response capability will be maintained in accordance with EP, OPEP and related documentation. Well Operations Management Plan accepted and in place for all wells, in accordance with the Offshore Petroleum and Greenhouse Gas Storage Act requirements, which include: • Blowout Preventer (BOP) installation during drilling operations • regular testing of BOP
	Seabirds and migratory shorebirds		Change in fauna behaviour	
			Injury/ mortality to fauna	
	Coral		Change in habitat	
	Seagrass			
	Macroalgae			
	Mangroves		Change in habitat	
	Shoreline habitats		Change in habitat	
	Saltmarsh		Change in habitat	
	KEFs		Change in habitat	
	AMPS		Change in habitat	
	Protected Places		Change in habitat	
	Commonwealth and State Managed Fisheries		Changes to the functions, interests or activities of other users	
	Tourism and recreation		Changes to the functions, interests or activities of other users	
			Changes in aesthetic value	
	Shipping		Changes to the functions, interests or activities of other users	
	Industry		Changes to the functions, interests or activities of other users	
	Settlements		Changes to the functions, interests or activities of other users	
			Change in aesthetic value	
	Defence		Changes to the functions, interests or activities of other users	

Table 9-5: Decommissioning Key Management Controls and Environmental Performance Outcomes

Aspect	Receptor	EPO	Impact	Adopted control(s)
Physical presence (routine): Seabed disturbance	Water quality	EPO 6.1 EPO 6.4 EPO 6.9	Change in water quality	**Removal of subsea infrastructure** **CM12:** Infrastructure will be positioned on the seabed within design footprint to reduce seabed disturbance.
	Epifauna and infauna		Change in habitat	
	Marine turtles		Change in habitat Injury or mortality	
	KEFs		Change in habitat Change in water quality Injury or mortality	
	AMPs		Change in habitat Change in water quality	
Routine and non-routine discharges: Drilling	Sediment Quality	EPO 13.1 EPO 13.2 EPO 13.3 EPO 13.4 EPO 13.5	Change in sediment quality	**Well Abandonment** **CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **CM19:** WBM will be used during drilling activities as the first preference. Where WBM cannot meet required technical specifications, NWBM may be used following technical justification. **CM20:** Bulk overboard discharge of NWBM is prohibited. **CM21:** Drill cuttings returned to the MODU will be processed to reduce oil on cuttings to < 6.9% by weight on wet cuttings (measured as a well average only including sections drilled with NWBM) prior to discharge. **CM22:** Drill cuttings returned to the MODU will be discharged below the waterline.
	Water Quality		Change in water quality	
	Plankton		Injury/ mortality to fauna	
	Epifauna and infauna		Injury/ mortality to fauna	
	KEFs		Change in habitat	
Unplanned hydrocarbon release	Sediment quality	EPO 19.1	Change in sediment quality	**All Activities** **CM26:** All vessels and facilities (appropriate to class) will comply with MARPOL 73/78, the Navigation Act 2012, the Protection of the Sea (Prevention of Pollution from Ships Act 1983 and subsequent Marine Orders including: • waste management requirements • management of spills aboard
	Water quality		Change in water quality	
	Plankton		Injury/ mortality to fauna	
	Fish		Change in fauna behaviour Injury/ mortality to fauna	
	Marine mammals		Change in fauna behaviour	

Aspect	Receptor	EPO	Impact	Adopted control(s)
			Injury/ mortality to fauna	• emergency drills. **CM27:** Relevant Stakeholders will be notified of activities prior to commencement. **CM28:** Vessels will have in place a valid and appropriate Shipboard Oil Pollution Emergency Plan and/or Shipboard Marine Pollution Emergency Plan. Emergency response activities will be implemented in accordance with the SOPEP/SMPEP. **CM29:** Environment Plans and Oil Pollution Emergency Plans will be accepted and in place, appropriate to the credible hydrocarbon spill scenario associated with activities during Scarborough. Emergency response activities will be implemented in accordance with the OPEP. **CM30:** Emergency response activities will be implemented in accordance with the OPEP the vessel SOPEP/SMPEP. **CM31:** Emergency response capability will be maintained in accordance with EP, OPEP and related documentation. Well Operations Management Plan accepted and in place for all wells, in accordance with the Offshore Petroleum and Greenhouse Gas Storage Act requirements, which include: • Blowout Preventer (BOP) installation during drilling operations • regular testing of BOP.
	Marine reptiles		Change in fauna behaviour	
			Injury/ mortality to fauna	
	Seabirds and migratory shorebirds		Change in fauna behaviour	
			Injury/ mortality to fauna	
	Coral		Change in habitat	
	Seagrass		Change in habitat	
	Macroalgae		Change in habitat	
	Mangroves		Change in habitat	
	Shoreline habitats		Change in habitat	
	Saltmarsh		Change in habitat	
	KEFs		Change in habitat	
	AMPS		Change in habitat	
	Protected Places		Change in habitat	
	Commonwealth and State Managed Fisheries		Changes to the functions, interests or activities of other users	
	Tourism and recreation		Changes to the functions, interests or activities of other users	
			Changes in aesthetic value	
	Shipping		Changes to the functions, interests or activities of other users	
	Industry		Changes to the functions, interests or activities of other users	
	Settlements		Changes to the functions, interests or activities of other users	

Aspect	Receptor	EPO	Impact	Adopted control(s)
			Change in aesthetic value	
	Defence		Changes to the functions, interests or activities of other users	

Table 9-6: Support Operations Key Management Controls and Environmental Performance Outcomes

Aspect	Receptor	EPO	Impact	Adopted control(s)
Routine light emissions	Ambient light	EPO 1.1 EPO 1.2 EPO 1.3 EPO 1.4 EPO 1.5	Change in ambient light	**MODU, Vessel Operations** **CM1:** Lighting will be limited the minimum required for navigational and safety requirements, with the exception of emergency events.
	Seabirds and migratory shorebirds		Change in fauna behaviour	
	Marine reptiles			
Routine atmospheric emissions affecting Air Quality	Air quality	EPO 2.1	Change in air quality	**MODU, Vessel Operations** **CM2:** Vessel and MODU compliance with Marine Order 97 (Marine Pollution Prevention – Air Pollution), including: • International Air Pollution Prevention (IAPP) Certificate, required by vessel class • use of low sulphur fuel when available • Ship Energy Efficiency Management Plan (SEEMP), where required by vessel class • onboard incinerator to comply with Marine Order 97.
Routine acoustic emissions	Ambient Noise	EPO 4.1 EPO 4.2 EPO 4.3	Change in ambient noise	**Vessel Operations** **CM8:** EPBC Regulations 2000 Part 8 Division 8.1 Interacting with cetaceans.
	Fish		Change in fauna behaviour Injury/mortality to marine fauna	
	Marine Reptiles		Change in fauna behaviour Injury/mortality to marine fauna	
	Marine Mammals		Change in fauna behaviour Injury/mortality to fauna	

Aspect	Receptor	EPO	Impact	Adopted control(s)
Physical presence (routine): Displacement of Other Users	Commonwealth Managed Fisheries	EPO 5.1 EPO 5.2	Changes to the function interests or activities of others	**<u>MODU, Vessel and Helicopter Operations</u>** **CM9:** Vessels to adhere to the navigation safety requirements including the Navigation Act 2012 and any subsequent Marine Orders. **CM10:** Notify Australian Hydrographic Service (AHS) of activities and movements prior to activity commencing. **CM11:** Notify representatives of State and Commonwealth fisheries of activities.
	State Managed Fisheries			
	Shipping			
	Industry			
Physical presence (routine): Seabed disturbance	Water quality	EPO 6.1 EPO 6.4 EPO 6.9	Change in water quality	**<u>MODU, Vessel and ROV Operations</u>** **CM12:** Infrastructure will be positioned on the seabed within design footprint to reduce seabed disturbance.
	Epifauna and infauna		Change in habitat	
	Marine turtles		Change in habitat Injury or mortality	
	KEFs		Change in habitat Change in water quality Injury or mortality	
	AMPs		Change in habitat Change in water quality	
Routine Discharges: Sewage and Greywater	Water quality	EPO 7.1	Change in water quality	**<u>MODU, Vessel Operations</u>** **CM13:** Compliance with relevant MARPOL, Commonwealth requirements and subsequent Marine Order requirements for sewage management.
Routine Discharges: Food Waste	Water quality	EPO 8.1	Change in water quality	**<u>MODU, Vessel Operations</u>** **CM14:** Compliance with relevant MARPOL, Commonwealth requirements and subsequent Marine Order requirements for waste discharges. **CM15:** Implementation of waste management procedures which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.
Routine Discharges: Chemicals and Deck Drainage	Water quality	EPO 9.1	Change in water quality	**<u>MODU, Vessel Operations</u>** **CM17:** Compliance with relevant MARPOL, Commonwealth requirements and subsequent Marine Order requirements for planned discharges.

Aspect	Receptor	EPO	Impact	Adopted control(s)
				CM15: Implementation of waste management procedures which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.
Routine Discharges: Brine and Cooling Water	Water quality	EPO 10.1 EPO 10.2 EPO 10.3 EPO 10.4 EPO 10.5 EPO 10.6 EPO 10.7 EPO 10.8	Change in water quality	**MODU, Vessel Operations** **CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints.
	Plankton		Injury/ mortality to fauna	
	Fish		Injury/ mortality to fauna	
	Marine mammals		Injury/ mortality to fauna	
	KEFs		Change in water quality	
	Commercial Fisheries		Injury/ mortality to fauna	
Unplanned Discharges: Chemicals	Water quality	EPO 14.1	Change in water quality	**All Activities** **CM16:** Chemicals will be selected with the lowest practicable environmental impacts and risks subject to technical constraints. **CM15:** Implementation of waste management procedures which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.
Unplanned Discharges: Solid Waste	Water Quality	EPO 15.1 EPO 15.2 EPO 15.3 EPO 15.4 EPO 15.5 EPO 15.6 EPO 15.7 EPO 15.8 EPO 15.9	Change in water quality	**MODU, Vessel Operations** **CM23:** Project vessels compliant with Marine Order 95 (pollution prevention – Garbage). **CM15:** Implementation of waste management procedures which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.
	Migratory Shorebirds and Seabirds		Injury/mortality to fauna	
	Fish			
	Marine Mammals			
	Marine Reptiles			
Physical presence (unplanned) - Seabed disturbance	Epifauna and infauna	EPO 16.1 EPO 16.2 EPO 16.3	Change in habitat Injury/ mortality to fauna	**MODU, Vessel Operations** **CM12:** Infrastructure will be positioned on the seabed within design footprint to reduce seabed disturbance.
	KEFs		Change in habitat	
	Epifauna and infauna	EPO 17.1	Change in ecosystem dynamics	**MODU, Vessel Operations**

Aspect	Receptor	EPO	Impact	Adopted control(s)
Physical presence (unplanned) - IMS	Coral	EPO 17.2 EPO 17.3 EPO 17.4		**CM24:** Compliance with the Woodside Invasive Marine Species Management Plan. **CM25:** Requirements of the Australian Ballast Water Management to be met.
	Seagrass			
	Macroalgae			
	Industry Shipping Defence		Changes to the functions, interests or activities of other users	
Physical presence (unplanned) - Collision with Marine Fauna	Marine Mammals	EPO 18.1 EPO 18.2 EPO 18.3 EPO 18.4 EPO 18.5	Injury to/ mortality of fauna	**<u>Vessel Operations</u>** **CM8:** EPBC Regulations 2000 Part 8 Division 8.1 Interacting with cetaceans. **CM32**: Marine fauna interaction mitigation measures to be considered and implemented as appropriate during the EP process.
	Marine reptiles			
Unplanned hydrocarbon release	Sediment quality	EPO 19.1	Change in sediment quality	**<u>MODU, Vessel, Helicopter Operations</u>** **CM26:** All vessels and facilities (appropriate to class) will comply with MARPOL 73/78, the Navigation Act 2012, the Protection of the Sea (Prevention of Pollution from Ships Act 1983 and subsequent Marine Orders including: • waste management requirements • management of spills aboard • emergency drills. **CM27:** Relevant Stakeholders will be notified of activities prior to commencement. **CM28:** Vessels will have in place a valid and appropriate Shipboard Oil Pollution Emergency Plan and/or Shipboard Marine Pollution Emergency Plan. Emergency response activities will be implemented in accordance with the SOPEP/SMPEP. **CM29:** Environment Plans and Oil Pollution Emergency Plans will be accepted and in place, appropriate to the credible hydrocarbon spill scenario associated with activities during Scarborough. Emergency response activities will be implemented in accordance with the OPEP.
	Water quality		Change in water quality	
	Plankton		Injury/ mortality to fauna	
	Fish		Change in fauna behaviour Injury/ mortality to fauna	
	Marine mammals		Change in fauna behaviour Injury/ mortality to fauna	
	Marine reptiles		Change in fauna behaviour Injury/ mortality to fauna	
	Seabirds and migratory shorebirds		Change in fauna behaviour Injury/ mortality to fauna	
	Coral		Change in habitat	
	Seagrass			
	Macroalgae			

Aspect	Receptor	EPO	Impact	Adopted control(s)
	Mangroves		Change in habitat	**CM30:** Emergency response activities will be implemented in accordance with the OPEP the vessel SOPEP/SMPEP. **CM31:** Emergency response capability will be maintained in accordance with EP, OPEP and related documentation. Well Operations Management Plan accepted and in place for all wells, in accordance with the Offshore Petroleum and Greenhouse Gas Storage Act requirements, which include: • Blowout Preventer (BOP) installation during drilling operations • regular testing of BOP.
	Shoreline habitats		Change in habitat	
	Saltmarsh		Change in habitat	
	KEFs		Change in habitat	
	AMPS		Change in habitat	
	Protected Places		Change in habitat	
	Commonwealth and State Managed Fisheries		Changes to the functions, interests or activities of other users	
	Tourism and recreation		Changes to the functions, interests or activities of other users	
			Changes in aesthetic value	
	Shipping		Changes to the functions, interests or activities of other users	
	Industry		Changes to the functions, interests or activities of other users	
	Settlements		Changes to the functions, interests or activities of other users	
			Change in aesthetic value	
	Defence		Changes to the functions, interests or activities of other users	

10 CONSULTATION

10.1 Overview

Stakeholder consultation and engagement is an integral component of the environmental impact assessment and environmental authorisation process for OPPs.

This section describes Woodside's approach, as the Operator of Scarborough, to stakeholder consultation broadly, and for the development of Scarborough specifically. It will be updated in response to the formal OPP public review process to be undertaken in 2019.

Woodside's objectives for stakeholder consultation are to:

- improve stakeholder awareness and understanding of the development of Scarborough
- provide stakeholders with opportunities to obtain information about Scarborough including the physical, ecological and socio-economic and cultural environment that may be affected, the potential impacts that may occur, and the prevention and mitigation measures proposed to avoid or minimise those impacts
- gain feedback from stakeholders on their concerns about the development of Scarborough and where possible, address stakeholder concerns through further activities, or by implementing additional mitigation measures.

Preliminary consultation commenced with interested and affected stakeholders in February 2018 as part of a planned, integrated and consistent approach to stakeholder engagement for of Woodside's proposed Burrup Hub opportunities (including the Browse to North West Shelf (NWS) Project, Scarborough, Pluto Train 2, NWS Project Extension and Pluto-NWS Interconnector). Consultation aims to be inclusive, transparent, voluntary, respectful and two-way. Consultation was completed by email, letter, phone call or meeting.

Consultation activities will continue to complement an overarching approach to stakeholder consultation for Woodside's Burrup Hub opportunities and will be phased throughout the OPP process. Concurrently, Woodside is completing a voluntary social impact assessment to assess the social opportunities and impacts arising from the proposed Burrup Hub projects. Woodside is employing a participatory approach, consulting stakeholders and gaining input into the identification and assessment of these impacts and opportunities.

10.2 Stakeholder Identification

The process for stakeholder consultation as undertaken by Woodside as the Operator of Scarborough included the identification of stakeholders and their relevance to the project. Table 10-1 presents a preliminary summary of stakeholders and stakeholder groups that are interested in, or likely to be affected by the development of Scarborough. This list is not exhaustive and additional stakeholders may be identified as part of the ongoing consultation.

Stakeholders identified include stakeholders known as a result of Woodside's ongoing activities in Western Australia, as well as those identified through engagements with regulators, government agencies, desktop research and regional contacts.

Table 10-1: Identified stakeholders

Commonwealth Government	
Australian Customs Service – Border Protection Command	National Offshore Petroleum Titles Administrator (NOPTA)
Australian Hydrographic Service (AHS)	Office of Federal Minister for Resources and Northern Australia
Australian Maritime Safety Authority (AMSA)	Office of Shadow Minister for Environment
Department of Industry, Innovation and Science (DoIIS)	Office of Shadow Minister for Resources
National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA)	Senator Pat Dodson
Department of Agriculture, Water and the Environment (formerly the Department of the Environment and Energy (DoEE))	Shadow Minister for Environment; Water
Federal Minister for Environment; Member for Durack	Parks Australia (a division of the Department of Environment and Energy)
Australian Fisheries Management Authority (AFMA)	Department of Agriculture and Water Resources – Biosecurity
State Government	
Australian Industry Participation Authority	Department of Health
Department of Primary Industries and Regional Development (DPIRD)	LandCorp
Department of Transport (DoT)	Environmental Protection Authority Services
Department of Water and Environmental Regulation (DWER)	Member for the Pilbara
Pilbara Ports Authority (PPA)	Office of State Minister for Mines and Petroleum
Department of Jobs, Tourism, Science and Innovation (DJTSI)	Office of the Leader of the Opposition, Public Sector Management, State Development, Jobs and Trade and Federal-State Relations
Department of Communities, Housing Division Pilbara	Office of the Minister for Fisheries
Department of Defence	Office of the Premier & Minister for State Development
Department of Education	Office of the State Minister for Environment
Department of Planning, Lands and Heritage	Office of the State Minister for Regional Development
Department of Primary Industries and Regional Development (DPIRD)	Office of the State Minister for Transport, Planning and Lands
Upper House Member for Mining and Pastoral	Office of the State Treasurer, Minister for Finance, Energy and Aboriginal Affairs
Department of Mines, Industry Regulation and Safety (DMIRS)	Western Australian Museum (Maritime Archaeology Department)
Department of Biodiversity, Conservation and Attractions (DBCA)	
Traditional Owner Groups, Local Government, Community, Educational Institutions and eNGOs	
Ngarluma Yindjibarndi Foundation	Wong-Goo-Tt-Oo
Murujuga Aboriginal Corporation (MAC)	Yaburara and Coastal Mardudhunera Aboriginal Corporation
City of Karratha	Australian Conservation Foundation
Conservation Council of Western Australia	Wilderness Society

World Wildlife Foundation – Australia	World Wildlife Fund (WWF)
International Fund for Animal Welfare (IFAW)	Friends of Australian Rock Art
Greenpeace	Market Forces
Australia Maritime and Fisheries Academy	Karratha Airport
Australian Conservation Foundation	Pilbara Development Commission
Karratha and Districts Chamber of Commerce and Industry	Karratha Visitors Centre
Karratha Community Liaison Group (includes Karratha Districts Chamber of Commerce and Industry, Dampier Community Association, Karratha Community Association, City of Karratha, Regional Development Australia, Pilbara Development Commission, Pilbara Ports Authority, Ngarluma Yindjibarndi Foundation Ltd and Yara Pilbara)	Karratha Heritage Group (includes Yindjibarndi Aboriginal Corporation, Yaburara and Coastal Mardudhunera Aboriginal Corporation, Wong-Goo-Tt-Oo, Ngarluma Aboriginal Corporation)
Tourism WA	
Industry	
Australian Petroleum Production and Exploration Association (APPEA)	Chamber of Minerals and Energy of Western Australia (CME)
Australian Marine Oil Spill Centre (AMOSC)	Oil and gas operators
Pilbara Ports Authority (PPA)	
Fisheries	
Commonwealth Fisheries Association (CFA)	Pearl Producers Association
Commonwealth commercial fisheries, including: • North West Slope Trawl • Western Tuna and Billfish Fishery • Southern Bluefin Tuna.	State commercial fisheries, including: • Pilbara Trap and Trawl Fishery • Nickol Bay and Onslow Prawn Fisheries.
Recfishwest	Australian Southern Bluefin Tuna Association (ASBTIA)
MG Kailis	Western Australian Indigenous Tourism Operators Council (WAITOC)
Dampier Island Tourism	Western Australia Fishing Industries Council (WAFIC)
Charter boat operators and recreational fishers	

10.3 Stakeholder Mapping to Scarborough Impacts and Risks

As a part of ongoing stakeholder consultation, the relevant stakeholders will be provided information relating to their specific functions, interests and activities. An initial assessment of the stakeholders' functions, interests and activities has been undertaken based on previous work with these stakeholders in the region and the preliminary impact assessment conducted for the project.

Functions, interests and activities have been mapped to the identified impacts and risks (as described in Section 7) in Table 10-2 and outlined by stakeholder group in Table 10-3. This will continue to be reviewed and updated as the assessment progresses and in response to the stakeholder feedback received.

Table 10-2: Stakeholder impact mapping

Receptor	Impact	Commonwealth Government	State Government	Traditional Owner Groups, Local Government, Organisations, Community, Educational Institutions and eNGOs	Industry/ Shipping/ Defence	Fisheries
Marine Sediments	Change in sediment quality	✓	✓			
Water Quality	Change in water quality	✓	✓			
Air Quality	Change in air quality	✓	✓	✓		
Climate	Change in climate	✓	✓	✓		
Ambient Light	Change in ambient light	✓	✓			
Ambient Noise	Change in ambient noise	✓	✓			
Plankton	Injury/mortality to fauna	✓	✓			
Epifauna and Infauna	Change in habitat	✓	✓	✓		
	Injury/mortality to fauna	✓	✓	✓		
	Change in ecosystem dynamics	✓	✓	✓		
Coral	Change in habitat	✓	✓	✓		
	Injury/mortality to fauna	✓	✓	✓		
	Change in ecosystem dynamics	✓	✓	✓		
Seagrass	Change in habitat	✓	✓	✓		
	Injury/mortality to fauna	✓	✓	✓		
	Change in ecosystem dynamics	✓	✓	✓		
Macroalgae	Change in habitat	✓	✓	✓		
	Injury/mortality to fauna	✓	✓	✓		
	Change in ecosystem dynamics	✓	✓	✓		

Receptor	Impact	Commonwealth Government	State Government	Traditional Owner Groups, Local Government, Organisations, Community, Educational Institutions and eNGOs	Industry/ Shipping/ Defence	Fisheries
Saltmarsh	Change in habitat	✓	✓	✓		
	Injury/mortality to fauna	✓	✓	✓		
	Change in ecosystem dynamics	✓	✓	✓		
Mangroves	Change in habitat	✓	✓	✓		
	Injury/mortality to fauna	✓	✓	✓		
	Change in ecosystem dynamics	✓	✓	✓		
Shoreline Habitats	Change in habitat	✓	✓	✓		
Seabirds and Migratory Shorebirds	Injury/mortality to fauna	✓	✓	✓		
	Change in fauna behaviour	✓	✓	✓		
Fish	Injury/mortality to fauna	✓	✓	✓		✓
	Change in fauna behaviour	✓	✓	✓		✓
Marine Mammals	Injury/mortality to fauna	✓	✓	✓		
	Change in fauna behaviour	✓	✓	✓		
Marine Reptiles	Injury/mortality to fauna	✓	✓	✓		
	Change in fauna behaviour	✓	✓	✓		
KEFs	Change in water quality	✓	✓	✓		
	Change in sediment quality	✓	✓	✓		
	Change in habitat	✓	✓	✓		
	Injury/mortality to fauna	✓	✓	✓		

Receptor	Impact	Commonwealth Government	State Government	Traditional Owner Groups, Local Government, Organisations, Community, Educational Institutions and eNGOs	Industry/ Shipping/ Defence	Fisheries
AMPs	Change in habitat	✓	✓	✓		
Commonwealth Managed Fisheries	Changes to the functions, interests or activities of other users	✓	✓	✓		✓
State Management Fisheries	Changes to the functions, interests or activities of other users	✓	✓	✓		✓
Tourism and Recreation	Changes to the functions, interests or activities of other users	✓	✓	✓		✓
	Change in aesthetic values	✓	✓	✓	✓	✓
Shipping	Changes to the functions, interests or activities of other users	✓	✓	✓	✓	
Defence	Changes to the functions, interests or activities of other users	✓	✓	✓	✓	
Industry	Changes to the functions, interests or activities of other users	✓	✓	✓	✓	
Settlements	Changes to the functions, interests or activities of other users	✓	✓	✓	✓	
	Change in aesthetic values	✓	✓	✓	✓	
Protected Places	Changes to the functions, interests or activities of other users	✓	✓	✓		

Table 10-3: Stakeholder Aspect mapping

Impact/Risk	Commonwealth Government	State Government	Traditional Owner Groups, Local Government, Organisations, Community, Educational Institutions and eNGOs	Industry/ Shipping/ Defence	Fisheries
Planned					
Routine light emissions	✓	✓	✓		
Routine atmospheric and greenhouse gas emissions	✓	✓	✓		
Routine acoustic emissions	✓	✓	✓		✓
Physical presence – Displacement of other users	✓	✓	✓	✓	✓
Physical presence – Seabed disturbance	✓	✓	✓		
Routine and non-routine discharges: Sewage and Greywater	✓	✓			
Routine discharges: Food wastes	✓	✓			
Routine and non-routine discharges: Chemicals and Deck Drainage	✓	✓			
Routine and non-routine discharges: Brine and Cooling water	✓	✓			
Routine and non-routine discharges: Operational Fluids	✓	✓	✓		
Routine and non-routine discharges: Subsea installation and commissioning	✓	✓	✓		
Routine and non-routine discharges: Drilling	✓	✓	✓		
Unplanned					
Unplanned discharges: Chemicals	✓	✓	✓		
Unplanned discharges: Solid waste	✓	✓	✓		
Physical presence (Unplanned) - Seabed disturbance	✓	✓	✓		
Physical presence (Unplanned) - IMS	✓	✓	✓	✓	
Physical presence (Unplanned) - Collision with Marine Fauna	✓	✓	✓		
Unplanned Hydrocarbon Release	✓	✓	✓	✓	✓

10.4 Stakeholder Consultation Approach

Woodside, as Operator of Scarborough is undertaking a phased program of consultation:

- **Phase 1:** Preliminary consultation undertaken during the impact assessment process and preparation of the OPP.
- **Phase 2**: Formal consultation under the public review process of the draft OPP by NOPSEMA.
- **Phase 3**: Ongoing consultation during project planning and execution.

10.4.1 Phase 1: Preliminary Consultation

Preliminary consultation is focused on key relevant stakeholders. It primarily aims to:

- introduce stakeholders to the development
- inform stakeholders of the work being undertaken to assess impacts relevant to their functions, interests and activities
- provide them with the opportunity to comment on the baseline assumptions made in relation to interactions with Scarborough and add new or different information
- inform them of the project timeframes and the mechanisms by which they can receive further updates or provide additional comment
- be provided with a point of contact or other information source for the project.

Preliminary consultation commenced in early 2018 and is built on the broader consultation and engagement process that Woodside has in place for the region. It undertaken up until the point of formal consultation under the OPP process.

Phase 1 consultation activities include the following tasks:

- Develop a dedicated project website https://www.woodside.com.au/our-business/burrup-hub/scarborough-to-pluto which includes a detailed video explaining key characteristics of the proposal, information regarding the approvals, up-to-date fact sheets and point of contact.
- Have Scarborough fact sheets available on the project website and provided directly to key stakeholders via email or in person, including dedicated fact sheets on:
    - pipelay and dredging management
    - oil spill management and response
    - some of the key issues associated with Scarborough.
- Host community forums and group meetings including information sessions that were held on the 15th and 16th May 2019 in Karratha and Roebourne. These sessions allowed for broader engagement to validate initial data, obtain broader community input and allow for further identification of potential mitigation and management measures for Scarborough. The timing of these activities was intended to be prior to, the release of the draft OPP and formal public consultation process (Phase 2).
- Provide information to key stakeholders, including details of Scarborough and key milestones including approval submissions.

- Provide project updates on the project website and Woodside's social media channels, including key project updates provided by ASX Announcements, Media Releases, quarterly, half yearly and annual reporting as appropriate and required.

A summary of the Phase 1 consultation activities undertaken to date are provided in Table 10-4, which includes consultation undertaken up until the point of formal public release of the OPP draft (Phase 1).

Table 10-4: Table of Phase 1 preliminary stakeholder consultation activities

Date	Activity	Stakeholders Involved	Summary of Engagement
9 March 2018	Karratha Community Liaison Group	Attended by City of Karratha, LandCorp and Pilbara Development	Regular quarterly meeting, provided an overview of the Burrup Hub, including the Scarborough acquisition.
26 April 2018	Quarterly Karratha heritage meeting	Ngarluma Aboriginal Corporation, Yindjibarndi Aboriginal Corporation, Yaburara and Coastal Mardudhnuera Aboriginal Corporation, Wong-Goo-Tt-Oo	Regular quarterly meeting with Traditional Owner groups. Provided an update on approvals pathways and schedule for Burrup Hub projects including Scarborough.
8 June 2018	Karratha Community Liaison Group	Attended by City of Karratha, Karratha Districts Chamber of Commerce and Industry, Pilbara Ports Authority, Department of Environment, Ngarluma Yindjibarndi Foundation Ltd, Department of Local Government, Arts, Culture and Sport and WA Police.	Regular quarterly meeting, provided an update on the Burrup Hub, including Scarborough
12 June 2018	Burrup Hub meeting including Scarborough Project	Murujuga Aboriginal Corporation	Provided an update on the Burrup Hub, including Scarborough, heritage management and governance.
19 June 2018	Scarborough Project Update Meeting	Department of the Environment and Energy, Office of the Environmental Protection Authority and NOPSEMA.	Provided an overview of Scarborough.
27 July 2018	Scarborough Project Update Meeting	Department of the Environment and Energy	Provided an overview of Scarborough.
6 September 2018	Quarterly Karratha heritage meeting	Ngarluma Aboriginal Corporation, Yindjibarndi Aboriginal Corporation, Yaburara and Coastal Mardudhnuera Aboriginal Corporation, Wong-Goo-Tt-Oo	Regular quarterly meeting with Traditional Owner groups. Provided an update on approvals pathways and schedule for Burrup Hub projects including Scarborough.
7 September 2018	Karratha Community Liaison Group	Attended by City of Karratha, WA Police, Karratha Community	Provided an overview of the Burrup Hub activities and key environmental approvals required, including Scarborough.

Date	Activity	Stakeholders Involved	Summary of Engagement
		Association, Department of Education, Horizon Power, Pilbara Ports Authority, Pilbara Development Commission, Department of Sport and Recreation, Karratha Districts Chamber of Commerce and Industry	
11 September 2018	Burrup Hub meeting including Scarborough Project	Murujuga Aboriginal Corporation	Provided an update on the Burrup Hub, including Scarborough, approvals pathways, schedule and proposed engagement approach.
19 September 2018	Burrup Hub meeting including Scarborough Project	Office of the WA Minister for Environment	Provided an update on the Burrup Hub, including Scarborough, approvals pathways and schedule.
19 September 2018	Burrup Hub meeting including Scarborough Project	Office of the WA Premier and Minister for State Development	Provided an update on the Burrup Hub, including Scarborough.
20 September 2018	Burrup Hub meeting including Scarborough Project	Department of Industry, Innovation and Science	Provided an update on the Burrup Hub, including Scarborough.
20 September 2018	Burrup Hub meeting including Scarborough Project	Office of the Shadow Minister for Environment	Provided an update on the Burrup Hub, including Scarborough.
27 September 2018	Office of the Leader of the Opposition, Public Sector Management, State Development, Jobs and Trade and Federal-State Relations	Office of the Leader of the Opposition, Public Sector Management, State Development, Jobs and Trade and Federal-State Relations	Provided an update on the Burrup Hub, including Scarborough.
27 September 2018	Burrup Hub meeting including Scarborough Project	National Offshore Petroleum Titles Administrator	Provided an update on the Burrup Hub, including Scarborough
28 September 2018	Burrup Hub Update Meeting	Department of the Environment and Energy	Provided an update on approvals for Burrup Hub projects, including Scarborough.

Date	Activity	Stakeholders Involved	Summary of Engagement
28 September 2018	Burrup Hub meeting including Scarborough Project	Office of the Federal Minister for Resources and Northern Australia	Provided an update on approvals for Burrup Hub projects, including Scarborough.
2 October 2018	Burrup Hub meeting including Scarborough Project	Office of the State Treasurer, Minister for Finance, Energy and Aboriginal Affairs	Provided an update on the Burrup Hub, including Scarborough
2 October 2018	Burrup Hub meeting including Scarborough Project	Office of the State Minister for Transport, Planning and Lands	Provided an update on the Burrup Hub, including Scarborough
10 October 2018	Burrup Hub Update Meeting	Office of the Environmental Protection Authority	Provided an update on the Burrup Hub, including Scarborough, approvals pathway and schedule.
12 October 2018	Scarborough Project Update Meeting	Department of Jobs, Tourism, Science and Innovation	Provided an overview of Scarborough, including agreement with government.
12 October 2018	Burrup Hub meeting including Scarborough Project	Shadow Minister for Northern Australia	Provide update on approvals for Burrup Hub projects including Scarborough.
12 October 2018	Burrup Hub meeting including Scarborough Project	Senator for WA [redacted]	Provided update on approvals for Burrup Hub projects including Scarborough.
12 October 2018	Burrup Hub meeting including Scarborough Project	Kimberley Land Council	Provided update on approvals for Burrup Hub projects including Scarborough
18 October 2018	Scarborough Project Update Meeting	Department of Jobs, Tourism, Science and Innovation	Consultation on the key components of Scarborough and details of the Scarborough development Agreement.
18 October 2018	Scarborough Project Update Meeting	Member for Kimberley [redacted]	Provide update on approvals pathways and schedule for Burrup Hub projects including Scarborough
19 October 2018	Burrup Hub meeting including Scarborough Project	Office of the WA Minister for Regional Development	Provided update on approvals for Burrup Hub projects including Scarborough.
1 November 2018	Scarborough Project Update Meeting	Department of Jobs, Tourism, Science and Innovation	Consultation on the key components of Scarborough and details of the Scarborough development Agreement.

Date	Activity	Stakeholders Involved	Summary of Engagement
9 November 2018	Scarborough Project Update Meeting	Ngarluma Yindjibarndi Foundation	Provide update on approvals for Burrup Hub projects.
12 November 2018	Scarborough Project Update Meeting	Nyamba Buru Yawuru	Discussion regarding Burrup Hub developments and environmental approvals information.
14 November 2018	Scarborough Project Update Meeting	Friends of Australian Rock Art	Burrup Hub environmental approvals briefing.
19 November 2018	Scarborough Project Update Meeting	Chamber of Minerals and Energy of Western Australia Inc NOPSEMA	Provided update on approvals for Burrup Hub projects.
19 November 2018	Scarborough Project Update Meeting	Pilbara Ports Authority	Provided an update on Scarborough, including the dredging and stabilisation scope.
23 November 2018	Scarborough Project Update Meeting	Member of Legislative Council-Mining and Pastoral Region	Provide update on approvals for Burrup Hub projects including Scarborough.
29 November 2018	Scarborough Project Update Meeting	Dampier Technical Advisory and Consultative Committee (TACC) (includes Pilbara Ports Authority, Department of Biodiversity Conservation and Attraction, Department of Transport, Rio Tinto, Department of Environment and Energy, Department of Planning Lands and Heritage, Department of Primary Industries and Regional Development, Toll, Water Corp, Department of Jobs, Tourism, Science and Innovation, Murujuga Land & Sea Unit)	Provided an update on Scarborough, including dredging and stabilisation scope.
29 November 2018	Quarterly Karratha heritage meeting	Ngarluma Aboriginal Corporation, Yindjibarndi Aboriginal Corporation, Yaburara and Coastal Mardudhnuera Aboriginal Corporation, Wong-Goo-Tt-Oo	Regular quarterly meeting with Traditional Owner groups. Provided an update on approvals pathways and schedule for Burrup Hub projects including Scarborough.
11 December 2019	Scarborough Project Update Meeting	Western Australian Marine Science Institution (WAMSI) Dredging Node	Provided an update on Scarborough, including dredging and stabilisation scope.

Date	Activity	Stakeholders Involved	Summary of Engagement
		(includes Australian Institute of Marine Science, WAMSI, Department of Water and Environmental Regulation)	
12 December 2018	Scarborough Project Update	Murujuga Aboriginal Corporation	Provided an update on Scarborough, proposed shore crossing activities and discussion on future engagement and opportunities to work together.
24 December 2018	Email notification to stakeholders of State Waters referral	Nyamba Buru Yawuru Wilderness Society Australian Government ([redacted]) Australian Fisheries Management Authority Western Australian Fishing Industry Council Ngarluma Yindjibarndi Foundation Department of Primary Industries and Regional Development Australian Conservation Foundation Department of Biodiversity, Conservation and Attractions - Parks and Wildlife Service World Wildlife Fund Greenpeace Friends of Australian Rock Art Recfishwest Australian Hydrographic Service WA Department of transport Member for Mining and Pastoral regions Member for Kimberley Australian Marine Oil Spill Centre (AMOSC)	Provided an update on Scarborough and advice of the referral of activities in State Waters to the EPA and DEE, and proposed submission of an OPP to NOPSEMA.

Date	Activity	Stakeholders Involved	Summary of Engagement
		Murujuga Aboriginal Corporation (MAC) Kimberley Land Council (KLC) Karratha and District Chamber of Commerce and Industry Dampier Community Association Karratha Community Association Regional Development Australia LandCorp Pilbara Ports Authority Yara Pilbara Fertilisers Pearl Producers Association Charter boat operators and recreational fishers	
9 January 2019	Burrup Hub meeting including Scarborough Project	Murujuga Aboriginal Corporation	Ongoing engagement and progress update on Woodside's Burrup Hub, including Scarborough.
11 January 2019	Email notification to stakeholders of State Waters referral	Australian Maritime Safety Authority	Provided an update on Scarborough and advice of the referral of activities in State waters to the EPA and DEE, and proposed submission of an OPP to NOPSEMA. AMSA reviewed the placement of the moorings and cross referenced them with Traffic data. Shows trunkline crosses charted shipping fairways where vessel traffic is heavy. Woodside to provide Marine Safety Information as per AMSA's request.
21 January 2019	Marine Parks Studies Meeting	CSIRO	Provided an update on Scarborough. CSIRO discussed 2017 NWS survey and results from 11 sites in Australian Marine Parks (AMP) (3 in Dampier AMP and 8 in Montebello AMP) that have been analysed for a report soon to be released to Parks.
22 January 2019	Scarborough Project Update Meeting	Department of the Environment and Energy	Provide update on approvals for Burrup Hub projects and referral of activities in State waters. Discussion around Sea Dumping Permits and dredging (State and Commonwealth waters).
22 January 2019	Burrup Hub meeting including Scarborough Project	Department of Industry, Innovation and Science	Provided an update on the Burrup Hub projects, including Scarborough, schedule and environmental approvals.

Date	Activity	Stakeholders Involved	Summary of Engagement
24 January 2019	Burrup Hub meeting including Scarborough Project	Murujuga Aboriginal Corporation	Meeting to discuss ongoing engagement on the Burrup Hub, including Scarborough.
29 January 2019	Scarborough Project Update Meeting	Department of Primary Industries and Regional Development	Provided an overview of Scarborough, including environmental approvals and stakeholder engagement moving forward.
30 January 2019	Scarborough Project Update Meeting	Department of the Environment and Energy – Australian Marine Parks Division	A meeting was held with Parks Australia, where Woodside presented an overview of Scarborough with particular focus on activities relevant to Australian Marine Parks. Figures used in the presentation showed clearly the route of the proposed Scarborough Trunkline through the Montebello Marine Park Multiple Use Zone (MUZ), as well as proposed ROV video transects and sampling locations along the trunkline route to support a benthic habitat study. An overview was also provided of proposed dredging and spoil disposal locations associated with the trunkline preparation, with a figure clearly showing proximity to Dampier Marine Park. An associated towed/drop camera survey was discussed in relation to the potential Borrow Ground north of Dampier Marine Park, also accompanied by several figures supporting the methodology that had been used, in addition to transect locations and results from the survey. Further discussion re outcomes of the spill modelling is proposed for a meeting scheduled on the 11 April 2019. Parks Australia requested access to a copy of reports when they could become available. When asked what specific information Parks Australia would be looking to be presented within the OPP. Feedback was that consideration of relevant BIAs and KEFs, within discussion was important and an assessment against values (where they interact with the project). It was also recommended that details be provided regarding the representativeness of the area where the project area interacts with AMPs be discussed. Parks Australia summarised the objectives for each zone type, including the Multiuse zones (such as the area which the Scarborough Trunkline intersects) .[37] This feedback regarding BIA's, KEFs and AMP Objectives has been used within the OPP and during discussion of acceptable levels of impact (Table 6.3) for the Australian Marine Parks impacted by the project. Further discussion regarding outcomes of the spill modelling was proposed for a meeting scheduled on the 11 April 2019.

[37] *Feedback provided by Parks Australia during the meeting which has been presented within the OPP was endorsed by Parks Australia as an accurate record of consultation.*

Date	Activity	Stakeholders Involved	Summary of Engagement
5 February 2019	Burrup Hub meeting including Scarborough Project	Department of Transport	Provided an overview of the Burrup Hub, including Scarborough. Discussion regarding Scarborough, environmental approvals and approaches to marine oil pollution and maritime transport emergencies.
7 February 2019	Burrup Hub meeting including Scarborough Project	City of Karratha	Provided an update on Burrup Hub projects, including Scarborough, and environmental approvals.
8 March 2019	Karratha Community Liaison Group	Attended by Ngarluma Yindjibarndi Foundation Ltd, City of Karratha, Landcorp, WA Police, Dept Local Govt and Communities, Pilbara Ports, Karratha Districts Chamber of Commerce and Industry, Regional Development Australia, Pilbara Development Commission and Dampier Community Association	Provided a briefing on the environmental approvals process including the Scarborough Offshore Project Proposal and highlighted opportunities for public comment.
13 March 2019	Burrup Hub meeting including Scarborough Project	Office of the Environmental Protection Authority	Monthly update of Burrup Hub developments provided which included updates on Scarborough State and Commonwealth waters approvals.
15 March 2019	Montebello Research Results Update	Department of the Environment and Energy – Australian Marine Parks Division	Secondary meeting with Department of Parks undertaken which presented preliminary findings of ROV video transects in Montebello AMP. No specific comments regarding ROV footage results were made.[38]
18 March 2019	Burrup Hub meeting including Scarborough Project	Department of the Environment and Energy	Update on progress towards environmental approvals which included updates on Scarborough State and Commonwealth waters approvals.
28 March 2019	Scarborough Project Update Meeting	NOPTA	Quarterly Scarborough JV update.
5 April 2019	Scarborough Project Update Meeting	Dampier Technical Advisory and Consultative Committee (TACC) (includes Pilbara Ports Authority, Department of Biodiversity Conservation and Attraction,	Provided an update on Scarborough and progression of Environmental Approvals including the OPP and State waters Referral.

[38] *Feedback provided by Parks Australia during the meeting which has been presented within the OPP was endorsed by Parks Australia as an accurate record of consultation.*

Date	Activity	Stakeholders Involved	Summary of Engagement
		Department of Transport, Rio Tinto, Department of Environment and Energy, Department of Planning Lands and Heritage, Department of Primary Industries and Regional Development, Toll, Water Corp, Department of Jobs, Tourism, Science and Innovation, Murujuga Land & Sea Unit)	
11 April 2019	Scarborough Project Update Meeting	Department of Environment and Energy – Australian Marine Parks Division	Update provided on Scarborough, environmental approvals and marine park studies. Particular focus was the presentation of plume modelling results and figures from proposed use of the offshore borrow ground, and the presentation of oil spill modelling result including EMBAs and Spill modelling outputs. Parks provided feedback regarding; - Presentation of figures and ensuring parks were accurately represented within the OPP (which has been addressed); - Asked questions regard the public consultation process/expected levels of interest in the OPP (which were discussed and satisfied at the time); and - Asked questions around entrained components of oil spill modelling and how this relates to environmental impacts (which was discussed and satisfied at the time). With the exception of the discussion points above no specific comments regarding modelling results were made.[39]
13 May 2019	Burrub Hub full council briefing, including Scarborough	City of Karratha councillors	Provided an update on woodside's Burrup Hub developments, including Scarborough.
15-16 May 2019	Burrup Hub public information sessions in Karratha and Roebourne	Various Karratha and Roebourne community members	Broad engagement with Karratha and Roebourne community members on issues and opportunities relevant to Burrup Hub developments, including Scarborough.
29 May 2019	Email	Department of Environment and Energy – Director of National Parks (DNP) via Assessments & Authorisations Branch (Canberra)	Email sent to DNP via A/g Assistant Director – Assessments & Authorisations detailing Scarborough project and interfaces and potential impacts to the Montebello AMP (Multiple Use zone) and the Dampier AMP (Habitat Protection

[39] *Feedback provided by Parks Australia during the meeting which has been presented within the OPP was endorsed by Parks Australia as an accurate record of consultation.*

Date	Activity	Stakeholders Involved	Summary of Engagement
			Zone). Provided fact sheets and confirmed meetings and material provided to Australian Marine Parks Division. Offered to arrange a meeting in Canberra or over the phone to discuss further.
6 June 2019	Quarterly Karratha heritage meeting	Attended by Ngarluma Aboriginal Corporation, Yaburara and Coastal Mardudhnuera Aboriginal Corporation and Wong-Goo-Tt-Oo Aboriginal Corporation.	Update on Scarborough and environmental approvals, including public comment periods.
7 June 2019	Karratha Community Liaison Group meeting	Attended by the city of Karratha; Pilbara Development Commission; LandCorp; Regional Develop Australia; and Pilbara Port Authority.	Update on Scarborough and environmental approvals, including public comment periods for the OPP and DSDMP.
10 June 2019	Email	Department of Environment and Energy – Director of National Parks (DNP) via Assessments & Authorisations Branch (Canberra)	Email sent to DNP via A/g Assistant Director – Assessments & Authorisations reaffirming offer for a meeting and welcoming further feedback to that which we had already received from the Australian Marine Parks Division.

10.4.2 Phase 2 Formal OPP Consultation

The OPP assessment process includes the publication of the OPP on the NOPSEMA website and a period of public consultation which gives all relevant and interested stakeholders an opportunity to review and provide comment. Phase 2 consultation also enables engagement with those stakeholders that were not identified to be potentially impacted by the proposed development, and as such were not consulted with in Phase 1.

The formal public review of an OPP is undertaken for a period of between 4 – 12 weeks as determined by NOPSEMA. It was determined by NOPSEMA that an 8-week formal consultation period would apply for the Scarborough OPP and the formal consultation period ran from 5 July 2019 until 30 August 2019.

All public comment is provided to NOPSEMA who provide a copy of the comments received to Woodside as Operator of Scarborough for their consideration to update to the draft OPP. Following the public comment period, the proponent prepares a consultation report and final OPP for assessment by NOPSEMA.

The consultation report for the OPP is available in (Appendix M). Woodside has summarised and assessed the merits of each comment received in the consultation report and has amended the OPP as appropriate. All responses provided are those of Woodside as the proponent.

The process for assessment of the OPP, including the formal public review process, is summarised in Figure 10-1.

A summary of Phase 2 consultation activities undertaken to date by Woodside is provided in Table 10-5. The table includes consultation undertaken from the point of formal public release of the OPP.

Table 10-5: Table of Phase 2 stakeholder consultation activities undertaken to date

Date	Activity	Stakeholders Involved	Summary of Engagement
11 July 2019	Fact sheet emailed	Stakeholders identified in Table 10.1 above	An email was sent to stakeholders identified in Table 10.1 informing them of the submission of the OPP to NOPSEMA and the public comment period.
15 July 2019	Email	Department of Environment and Energy – Director of National Parks (DNP) and Australian Marine Parks Division	An email was sent to DNP (via MarineParks@environment.gov.au) and Australian Marine Parks Division (via Director, Marine Parks Management West) informing them of the submission of the OPP to NOPSEMA and the public comment period together with an offer to meet and discuss further if required. For background a copy of previous email correspondence from 29th May and 10th June to DNP was also attached.
August 2019	Direct correspondence	Commercial in Confidence	Woodside, on behalf of the Scarborough JV, undertook discussions and assessments of various concepts with other parties, including this stakeholder. A number of discussions took place between this stakeholder and Woodside representatives in 2018. The OPP does not include the concepts discussed with this stakeholder as, following an internal assessment of their merits, they were deemed not to provide development opportunities within the current development timeline. Woodside wrote to this stakeholder in August 2019 to explain in detail the reasons for this assessment and to reiterate future options for cooperation, including possible backfill development opportunities.
11 August 2019	Email	Western Australian Fishing Industry Council	An email attaching fact sheets, fisheries maps and offering to provide any further information required was sent.
16 August 2019	Email	Department of Primary Industries and Regional Development	An email attaching fact sheets, fisheries maps and offering to provide any further information required was sent.
30 August 2019 2 September 2019	Response to OPP – formal comment period	Murujuga Aboriginal Corporation (MAC)	On the afternoon that the OPP public comment period closed on 30 August 2019, the Murujuga Aboriginal Corporation (MAC) lodged a request for a two-week extension to comment on the OPP. In response to this request, Woodside's Indigenous Affairs Manager met with MAC's CEO on 2 September 2019. Woodside explained the proposed Scarborough development area and and asked whether there was a specific issue MAC had wished to raise. While MAC advised of its intention to make comment on the Dredging and Spoil Disposal Management Plan required by the Western Australian Environmental Protection Authority as part of its assessment of the proposed development, MAC responded that it did not have any particular concerns about the OPP. MAC further advised, the intention for requesting an extension was to reserve its right to comment, if necessary. Consequently, MAC was advised it would be unlikely Woodside would support an extension and MAC confirmed it would

Date	Activity	Stakeholders Involved	Summary of Engagement
			accept a decision not to extend the comment period. No further action was recorded. Woodside will continue to work with MAC and Traditional Owner representatives as the proposed Scarborough development is progressed.
6 September	Meeting	Department of Environment and Energy	Update provided on submission of OPP and period of response to comments.
20 September 2019	Letter offering further engagement	Department of Primary Industries and Regional Development	A letter, following up on the 16 August email, was sent to Deputy Director General for Sustainability and Biosecurity. The letter offered further information or briefing on the OPP and related matters. Receipt of the letter was acknowledged.
28 November 2019	Phone call	Department of Environment and Energy – Director of National Parks (DNP) via Assessments & Authorisations Branch (Canberra)	Conversation with DNP via the Assessments and Authorisations team regarding previous consultation and the requirement for evidence of consultation to support the OPP. Woodside offered to provide further information in writing or through a detailed briefing and indicated a written response to previous communication would be appreciated.
10 December 2019	Email and phone call	Department of Environment and Energy – Director of National Parks (DNP) and Australian Marine Parks Division	As a follow-up to previous correspondence an email was sent to DNP (via MarineParks@environment.gov.au) and Australian Marine Parks Division (via Director, Marine Parks Management West). The email reiterated that the proposed Scarborough trunkline route passes through the Montebello AMP and that the proposed borrow ground is adjacent to Dampier AMP. Further detail was provided on relevant updates made in response to recent consultation with NOPSEMA. These specifically addressed Woodside's assessment of acceptable levels of impact and associated EPOs for Montebello and Dampier AMPs. The relevant revised OPP section was attached and written feedback and/or advice was requested. The email was followed up with a further phone call to the Assessments and Authorisations team confirming that communications had been received.
17 December 2019	Email	Department of Environment and Energy – Director of National Parks (DNP) and Australian Marine Parks Division	Email from DNP (via MarineParks@environment.gov.au) requesting further information. Woodside responded with maps of Pluto and proposed Scarborough trunklines, borrow ground location and definitions for dredge modelling thresholds.
20 December 2019	Email	Department of Environment and Energy – Director of National Parks (DNP) and Australian Marine Parks Division	Woodside received an email from DNP (via MarineParks@environment.gov.au) requesting Woodside provide more information as to how the proposed activity takes into account Australian marine parks and considers the impacts and risks of all activities in the context of the management plan objectives and values including cultural, heritage and socio-economic values. Additionally, further information was sought on

Date	Activity	Stakeholders Involved	Summary of Engagement
			justification of pipeline route and borrow ground location and DNP provided initial comments on Environmental Performance Outcomes (EPOs) that Woodside developed to manage impacts to marine parks to at or below the defined acceptable levels.
31 December 2019	Email	Department of Environment and Energy – Director of National Parks (DNP) and Australian Marine Parks Division	Woodside responded to DNP's email including initial EPO comments by providing a link to the latest version of the OPP and pointing to relevant sections of the document and summarising our response to key matters raised. Woodside also provided a map showing the zone of influence for pipeline stabilisation activities with backfill material sourced from offshore borrow ground, overlaid with the Dampier Marine Park and relevant zone boundaries. In addition Woodside offered to provide a detailed briefing to relevant Parks Australia representatives in early January to resolve any outstanding concerns.
9 January 2020	Meeting	Department of Environment and Energy – Director of National Parks (DNP) and Australian Marine Parks Division	Woodside held a meeting on 9 January 2020 with Parks Australia. Representatives from Parks Australia included: • Senior Marine Parks Officer – Assessments & Authorisations (Canberra) • Director Authorisations and Compliance (Canberra) • Manager Authorisations (Canberra) • Director West Management (Hobart) • A/g Manager North-west Management (Hobart) Various Woodside representatives were also in attendance including Scarborough engineering leads (Subsea Intervention Lead and Subsea and Pipelines Engineering Lead). The meeting provided a forum to discuss with Parks Australia the proposed project, further clarify items raised in the Parks Australia email (dated 20 December), and to discuss the requirements of the OPP, the predicted impacts of the proposed activity on marine parks, the basis for Woodside's determination of acceptability and the resulting proposed EPOs. Woodside presented the proposed activity, including providing detail to support the site selection (for both the trunkline route and the borrow ground) and proposed methods to undertake activities. Woodside presented and explained predicted impacts to the marine parks including: • Exposure (Zone of Influence) into the Dampier Marine Park habitat protection zone during the activities undertaken within the borrow ground.

Date	Activity	Stakeholders Involved	Summary of Engagement
			• The absence of predicted impacts to benthic biota (Zone of Moderate Impact) within the Dampier Marine Park associated with the borrow ground activities. • Disturbance of up to 0.07% of the Montebello Marine Park. Woodside also discussed and confirmed with Parks Australia that Woodside's assessment of the Scarborough development considers all impacts and risks including values identified for the marine parks. Woodside presented and discussed with Parks Australia the case provided in the OPP which demonstrates that the predicted impacts and risks are not inconsistent with the objectives of the zones of the marine parks and allows for protection of the values including cultural, heritage and socio-economic values. Woodside also outlined the process for development of activity specific performance standards in future EPs to reduce risks and impacts to ALARP to further protect marine park values. Woodside also presented and discussed with Parks Australia the justification for the trunkline route, and the borrow ground and how these were considered in the alternatives assessment section of the OPP, and noted that further consideration of controls will be provided as part of demonstration that risks and impacts are reduced to ALARP in subsequent project EPs, as required under the OPGGS (Environment) Regulations. Woodside provided to Parks Australia an approximate schedule for EP preparation and submission, noting that these documents would provide more detail (including ALARP demonstration) and include further consultation with Parks Australia. Parks Australia confirmed that information provided in the 31 December email including the revised OPP together with information presented at the 9 January meeting had addressed their concerns. Parks Australia and Woodside agreed that the consultation requirements have been met for this phase of the project (OPP). Further detailed activity specific information will be provided as part of the consultation process for each of the subsequent EPs.

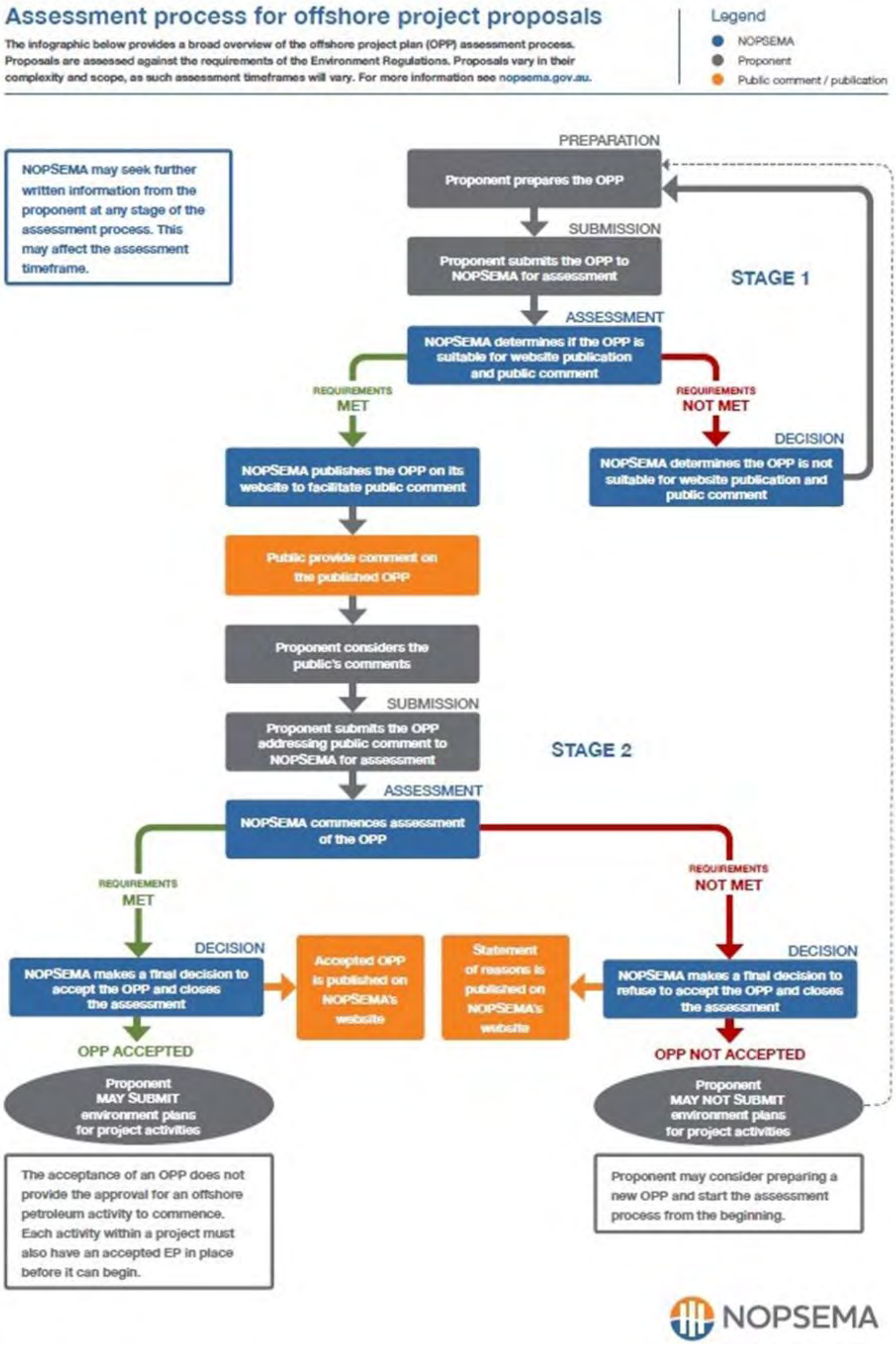


Figure 10-1: NOPSEMA assessment process for offshore project proposals

10.4.3 Phase 3: Ongoing Consultation

On acceptance of the OPP, Woodside as Operator will continue to consult with stakeholders during the preparation of EPs and execution of Scarborough.

Consultation is a formal requirement under Regulation 11A and 14(9) of the Environment Regulations. Accordingly, Woodside will conduct further stakeholder assessment and consultation with relevant stakeholders to inform decision-making and planning for the petroleum activities being undertaken as a part of this project.

Stakeholders identified for consultation in support of the Petroleum Activities Program will be monitored and updated as required, with any feedback from these stakeholders given consideration for future activities.

All proposed engagement and consultation will be planned for in a Stakeholder Engagement Plan, and outcomes of consultation will be tracked and recorded by Woodside.

11 REFERENCES

Abascal, F.J., Quintans, M., Ramos-Cartelle, A., Mejuto, J. 2011. *Movements and environmental preferences of the shortfin mako, Isurus oxyrinchus, in the southeastern Pacific Ocean.* Marine Biology 158: pp1175–1184.

Abdellatif, E.M., Ali, O., Khalil, I.F., Nyonje, B. 1993. *Effects of sewage disposal into the White Nile on the plankton community*. Hydrobiologia 259(3): pp195-201. DOI: 10.1007/BF00006599

Abdul Wahab MA, Fromont J, Pineda MC, Strehlow B, Duckworth A, Jones R, Webster N. 2019. *Defining thresholds and indicators of filter feeder responses to dredging-related pressures - final synthesis report*. Report of Theme 6 – prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth, Western Australia 26 pp

Abdul Wahab, M.A., Radford, B., Cappo, M., Colquhoun, J., Stewar, M., Depczynski, M., Miller, K., Heyward, A. 2018. *Biodiversity and spatial patterns of benthic habitat and associated demersal fish communities at two tropical submerged reef ecosystems*. Springer-Verlag GmbH Germany, part of Springer Nature.

Advisian. 2019a. *Scarborough Offshore Benthic Marine Habitat Assessment*. Prepared for Woodside Energy Ltd. Advisian WorleyParsons Group.

Advisian. 2019b. *Montebello Marine Park Benthic Habitat Survey*. Prepared for Woodside Energy Ltd. Advisian WorleyParsons Group.

Advisian. 2019c. *Dampier Marine Park Benthic Habitat Survey*. Prepared for Woodside Energy Ltd. Advisian WorleyParsons Group.

American Chemistry Council. 2006*. A Comparison of the Environmental Performance of Olefin and Paraffin Synthetic Base Fluids (SBF)*. November 2006. American Chemistry Council.

Amoser, S.& Ladich, F. 2003. *Diversity in noise-induced temporary hearing loss in otophysine fishes*. Journal of the Acoustical Society of America 113: pp2170–2179.

AMSA Marine Notice 15/2012.

Andriguetto-Filho, J.M., Ostrensky, A., Pie, M.R, Silva, U.A., Boeger, W.A. 2005. Evaluating the impact of seismic prospecting on artisanal shrimp fisheries. Continental Shelf Research: 25.

ANSUL. 2007. *Environmental Impact of ANSULITE® AFFF Products*. Technical Bulletin Number 52. Form No. F 82289-3, Ansul Incorporated.

Apache. 2013. Coniston Novara Phase 2 Drilling EP Summary. Apache Energy. Perth, Australia.

APPEA. 2017. *Key Statistics 2017*. Australian Petroleum Production & Exploration Association. Accessed at: https://www.appea.com.au/wp-content/uploads/2017/04/Key-Stats-2017_web.pdf (Accessed 11 October 2017).

Arthur, K.E., Boyle, M.C. & Limpus, C.J. 2008. *Ontogenetic changes in diet and habitat use in green sea turtles (Chelonia mydas) life history*. Marine Ecology Progress Series, 362, 303-311.

Asian - Australasian Flyway; Population Estimates and Internationally Important Sites. Wetlands International. Wetlands International - Oceania. Canberra, Australia.

Aube, M.; Franchomme-Fosse, L.; Robert-Staehler, P.; Houle, V. 2005. Light pollution modelling and detection in a heterogeneous environment: Toward a night-time aerosol optical depth retrieval method. Proc. Spie, 5890, 248–256, DOI:10.1117/12.615405.

Australia, 2015. Australia's Intended Nationally Determined Contribution to a new Climate Change Agreement.

Australian Institute of Marine Science (AIMS). 2014. *AIMS 2013 Biodiversity survey of Glomar Shoal and Rankin Bank (Report prepared by the Australian Institute of Marine Science for Woodside Energy Ltd.)*. Australian Institute of Marine Science, Townsville.

Australian Institute of Marine Science (AIMS). 2014. *The AIMS Index of Marine Industry*. AIMS: Australia's tropical marine research agency. Australian Government.

Axelrad, D.M., Poore, G.C.B., Arnott, G.H., Bault, J., Brown, V., Edwards, R.R.C, Hickman, N. 1981. *The Effects of Treated Sewage Discharge on the Biota of Port Phillip Bay, Victoria, Australia*. Estuaries and Nutrients, Contemporary Issues in Science and Society. The Human Press Inc.

Azis, P.K.A., Al-Tisan, I.A., Daili, M.A,m Green, T.N., Dalvi, A.G.I., Javeed, M.A. 2003. *Chlorophyll and plankton of the Gulf coastal waters of Saudi Arabia bordering a desalination plant*. Desalination 154: pp291-302

Baker, C., Potter, A., Tran, M., Heap, A.D. 2008. *Sedimentology and geomorphology of the northwest marine region: a spatial analysis (Geoscience Australia Record No. 2008/07)*. Geoscience Australia, Canberra.

Bakke T, Klungsøyr J & Sanni S (2013). Environmental impacts of produced water and drilling waste discharges from the Norwegian offshore petroleum industry. Marine Environmental Research 92: 154-169.

Balcazar, N. E., Tripovich, J. S., Klinck, H., et al. 2015. *Calls reveal population structure of blue whales across the southeast Indian Ocean and southwest Pacific Ocean*. Journal of Mammalogy 96: 1184– 1193.

Balcom, B.J., Graham, B.D., Hart, A.D., Bestall, G.P. 2012. *Benthic impacts resulting from the discharge of drill cuttings and adhering synthetic based drilling fluid in deep water*. SPE 157325. Paper presented at the SPE/APPEA International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production, Perth, Australia.

Bamford, M., Watkins, D., Bancroft, W., Tischler, G., Wahl, J. 2008. *Migratory shorebirds of the East Asian-Australasian flyway: population estimates and internationally important sites*. Wetlands International – Oceania, Canberra.

Bannister, J., Kemper, C.M., Warneke, R.M. 1996. *The action plan for Australian cetaceans*. Australian Nature Conservation Agency, Canberra.

Barry J., Buck, K., Kochevar, R., Nelson, D., Fujiwara, Y., Goffredi, S., Hashimoto, J. 1996. *Methane-based symbiosis in a mussel, Bathymodiolus platifrons, from cold seeps in Sagami Bay, Japan*. Invertebrate Biology I21(1): 47-54.

Batten, S.D., Allen, R.J.S., Wotton, C.O.M. 1998. *The effects of the sea empress oil spill on the plankton of the southern Irish Sea*. Mar. Pollut. Bull. 36: pp764–774.

Bejder, M., Johnston, D., Smith, J., Friedlaender, A., Bejder, L. 2016. *Embracing conservation success of recovering humpback whale populations: Evaluating the case for downlisting their conservation status in Australia.* Marine Policy 66: 137–141.

Bell, C. B., Moro, D. & Pendoley, K. 2016 *Patterns and pathways: marine construction and patterns of dispersal in hatchling flatback turtles at Barrow Island.* Proceedings of the 34th Annual Symposium on Sea Turtle Biology and Conservation: 2014 International Sea Turtle Symposium, New Orleans Louisiana 10 – 17 April 2014. NOAA Technical Memorandum NMFS-SEFSC ; 701

Bertolino, C. 2006. *Seagrasses of the Port of Dampier: Distribution, Abundance, and Morphology.* School of Plant Biology, The University of Western Australia Honours: 99.

BHP Billiton. 2004. *Stybarrow Development Draft EIS*. BHP Billiton, Perth, Australia.

Biota 2009 *Turtle Monitoring at Bells Beach and Selected Rookeries of the Dampier Archipelago: 2008/09 Season*. Report for Rio Tinto Iron Ore.

BirdLife International. 2018. *IUCN Red List for birds*. Downloaded from http://www.birdlife.org (Accessed 20/12/2018).

BirdLife International. 2018. *Species factsheet: Anous stolidus*. Accessed at http://www.birdlife.org (Accessed 20/12/2018).

BirdLife International. 2018. *Species factsheet: Pterodroma mollis*. Downloaded from http://www.birdlife.org (Accessed 20/12/2018).

Bishop, S., Francis, M., Duffy, C., Montgomery, J. 2006. *Age, growth, maturity, longevity and natural mortality of the shortfin mako shark (Isurus oxyrinchus) in New Zealand waters*. Marine and Freshwater Research 57: 143–154.

Bjorndal, K.A. 1997. *Foraging Ecology and Nutrition in Sea Turtles*. In: The Biology of Sea Turtles (eds. P.L. Lutz & J.A. Musick), Vol. 1, pp. 199-231. CRC Press, Boca Raton.

Black, K.P., Brand, G.W., Grynberg, H., Gwyther, D., Hammond, L.S., Mourtikas, S., Richardson, B.J., Wardrop, J.A. 1994. *Production facilities*. In: *Environmental implications of offshore oil and gas development in Australia – the findings of an independent scientific review*. Swan, J.M., Neff, J.M., Young, P.C. (eds) Australian Petroleum Exploration Association. Sydney. pp 209–407

Blakeway, D. & Radford, B. T. M. 2004. *Sceractinian Corals of the Dampier Port and inner Mermaid Sound: species list, community composition and distributional data.* Corals of the Dampier Harbour: Their Survival and Reproduction during the Dredging Programs. University of Western Australia, Crawley, Western Australia.

Blumenthal, J.M., Austin, T.J., Bothwell, J.B., Broderick, A.C., Ebanks-Petrie, G., Olynik, J.R., Orr, M.F., Solomon, J.L., Witt, M.J. & Godley, B.J. 2009. *Diving behavior and movements of juvenile hawksbill turtles Eretmochelys imbricata on a Caribbean coral reef*. Coral Reefs, 28: 55–65.

BMT Oceanica, 2016. *Offshore canyons of Western Australia: Cape Range Canyon literature review and Enfield Canyon 2015 environment survey* (Report No. 1247_003/2 Rev 1). BMT Oceanica Pty Ltd, Perth.

Boehm, P.D., Turton, D., Ravel, A., Caudle, D., French, D., Rabalais, N., Spies, R., Johnson, J. 2001. *Deepwater Program: Literature Review, Environmental Risks of Chemical Products Used in Gulf of Mexico Deepwater Oil and Gas Operations*. Vol. 1. Technical Report. OCS Study MMS 2001-011. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Bolten, A.B. 2003. Variation in Sea Turtle Life History Patterns: Neritic vs Oceanic Developmental Stages. In: The Biology of Sea Turtles, Volume II (eds P.L. Lutz, J.A. Musick & J. Wyneken), Vol. 2, pp. 243-257. CRC Press, Boca Raton.

Bond, T., Partridge, J.C., Tayllor, M.D., Cooper, T.F., Mclean, D.L. 2018. *The influence of depth and a subsea pipeline on fish assemblages and commercially fished species*. PLoS ONE 13(11): e0207703. https://doi.org/10.1371/journal.pone.0207703

BP (2013) Shah Deniz Stage 2 (SD2) Project, Environmental and Social Impact Assessment. Accessed at <https://www.bp.com/en_az/caspian/sustainability/environment/env-and-social-documentation/ShahdenizESIAs/ESIA.html>

Branch T., et al. 2007. Past and present distribution, densities and movements of blue whales *Balaenoptera musculus* in the Southern Hemisphere and northern Indian Ocean. Mammal Review. 37:116–175

Brewer, D.T., Lyne, V., Skewes, T.D., and Rothlisberg, P. 2007. *Trophic Systems of the North West Marine Region*. A Report to The Department of the Environment, Water, Heritage and the Arts, by CSIRO Marine and Atmospheric Research: pp156.

Bruce, B. 2013. *Shark futures: a synthesis of available data on mako and porbeagle sharks in Australasian waters.* Current and future directions (Tactical Research Fund No. FRDC 2011/045). Fisheries Research and Development Corporation, Canberra.

Bull, C.M., Burzacott, D., 2002. Changes in climate and in the timing of pairing of the Australian lizard, Tiliqua rugosa: a 15-year study. Journal of Zoology 256, 383–387. https://doi.org/10.1017/S0952836902000420

Bureau of Meteorology (BoM). N.d. *Tropical Cyclones Affecting Pilbara*. Australian Government. Accessed at http://www.bom.gov.au/cyclone/history/wa/pilbara.shtml

C & R Consulting. 2009. *Impacts of Plastic Debris on Australian Marine Wildlife*. Prepared for The Department of the Environment, Water, Heritage and the Arts. Accessed at https://www.environment.gov.au/system/files/resources/0b16bb3c-59c3-4af9-b047-f29b735e65b2/files/marine-debris-cr-consulting.pdf

Cai, W., Cowan, T., 2006. SAM and regional rainfall in IPCC AR4 models: Can anthropogenic forcing account for southwest Western Australian winter rainfall reduction? Geophysical Research Letters 33. https://doi.org/10.1029/2006GL028037

Calgary. 25p. Clancy, G.P. 2005. *Feeding behaviour of the osprey (Pandion haliaetus) on the north coast of New South Wales.* Corella 29: pp91–96.

CALM (1990) *Dampier Archipelago Nature Reserves Management Plan 1990 – 2000.* Department of Conservation and Land Management.

CALM. 2005. *Indicative Management Plan for the Proposed Dampier Archipelago Marine Park and Cape Preston Marine Management Area*. Department of Conservation and Land Management, Western Australia.

Campana, S.E., Marks, L., Joyce, W. 2005. *The biology and fishery of shortfin mako sharks (Isurus oxyrinchus) in Atlantic Canadian waters.* Fisheries Research 73: pp341–352. Doi:10.1016/j.fishres.2005.01.009.

Cardinale, Pablo; Greig, Lorne. 2013. *Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets*. International Finance Corporation, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/17842 License: CC BY 3.0 IGO.

Cassata, L. & Collins, L.B. 2008. *Coral Reef Communities, Habitats, and Substrates in and near Sanctuary Zones of Ningaloo Marine Park*. Journal of Coastal Research 24, Issue 1: pp139 – 151.

Ceccarelli, D., McCrea, I., Collis, M. and Nicoll, R., 2011. Australia's Last Great Whale Haven – Cetacean distribution and conservation needs in the north-west marine region. International Fund for Animal Welfare, November 2011. 72 pp.

Chaloupka, M. 2018. Delambre Island Turtle Nesting Census, Presentation to DBCA / NWS committee 8/5/2018. https://rstudio-pubs-static.s3.amazonaws.com/448533_0eb04559be1c4df4934c9f69b22b9256.html

CHARM Implementation Network (CIN). 2004. A User Guide for the Evaluation of Chemicals used and Discharged Offshore. A CIN revised CHARK III Report 2004. Chemical Hazard Assessment and Risk Management (CHARM). User Guide Version 1.4.

Chevron Australia Pty Ltd. 2014. *Wheatstone project conservation significant marine fauna interaction management plan (No. WS0-0000-HES-PLN-CVX-000-00037-000 Rev 5).* Chevron Australia Pty Ltd, Perth.

Chevron. 2015. *Wheatstone Project Offshore Facilities and Produced Formation Water Discharge Management Plan: Stage 1*. Doc No: WS0-0000-HES-PLN-CVX-000-00101-000. Accessed at https://australia.chevron.com/-/media/australia/our-businesses/documents/wheatstone-emp-offshore-facilities-water-discharge-mgmt-plan-stage-1.pdf.

Chevron. 2017a. [Web page] *Wheatstone Project*. https://australia.chevron.com/our-businesses/wheatstone-project

Chevron. 2017b. [Web page] *Gorgon Project*. https://www.chevronaustralia.com/our-businesses/gorgon.

Chidlow, J., Gaughan, D., McAuley, R. 2006. *Identification of Western Australian grey nurse shark aggregation sites: final report to the Australian Government, Department of Environment and Heritage (Fisheries Research Report No. 155). Department of Fisheries, Perth.*

Christian, J. R., Mathieu, A., Buchanan, R.A. 2004. Chronic Effects of Seismic Energy on Snow Crab (Chionoecetes opilio). Environmental Funds Project No. 158. Fisheries and Oceans Canada.

Church, John.A., Hunter, John.R., Mcinnes, K., White, Neil.J., 2006. Sea-level rise around the Australian coastline and the changing frequency of extreme events. Australian Meteorological Magazine 55, 253–260. https://doi.org/10.1016/j.gloplachs.2006.04.001

Climate Change Authority, 2014. Reducing Australia's Greenhous Gas Emissions - Targets and Progress Review.

Cohen, A., Gagnon, M.M., Nugegoda, D. 2005. *Alterations of Metabolic Enzymes in Australian Bass, Macquaria novemaculeata, After Exposure to Petroleum Hydrocarbons*. Archives of Environmental Contamination Toxicology 49 (2): pp200-205.

Commonwealth of Australia. 2008. *National Biofouling Management Guidance for Petroleum Production and Exploration Industry*. Accessed at http://www.marinepests.gov.au/marine_pests/publications/Documents/Biofouling_guidance_petroleum.pdf>

Commonwealth of Australia. 2009. *National biofouling management guidelines for the petroleum production and exploration industry*. Marine Pests. Accessed at http://www.marinepests.gov.au/Documents/petroleum-exploration-biofouling-guidelines.pdf

Commonwealth of Australia. 2015a. *Conservation management plan for the blue whale: A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 2015–2025.* Department of the Environment, Canberra.

Commonwealth of Australia. 2015b. *Sawfish and river shark multispecies recovery plan (Recovery Plan).* Department of the Environment, Canberra.

Commonwealth of Australia. 2015c. *Sawfish and Riversharks Multispecies Recovery Plan*. Department of the Environment. Australian Government. Accessed at http://www.environment.gov.au/system/files/resources/062794ac-ef99-4fc8-8c18-6c3cd5f6fca2/files/sawfish-river-sharks-multispecies-recovery-plan.pdf

Commonwealth of Australia. 2015d. *Sawfish and river sharks multispecies issues paper.* Department of the Environment, Canberra.

Commonwealth of Australia, 2019. Climate Solutions Package [WWW Document]. URL http://www.environment.gov.au/system/files/resources/bb29bc9f-8b96-4b10-84a0-46b7d36d5b8e/files/climate-solutions-package.pdf

Commonwealth of Australia 2020. *National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds*. January 2020.

Coulson, M., Ferguson, S., Bullen, T., Wheeler, F., 2010. Carbon Capture Options for LNG Liquefaction, in: Sixteenth International Conference on Liquefied Natural Gas, April. pp. 18–21

Couturier, L.I.E., Jaine, F.R.A., Townsend, K.A., Weeks, S.J., Richardson, A.J., Bennett, M.B. 2011. *Distribution, site affinity and regional movements of the manta ray, Manta alfredi (Krefft, 1868), along the east coast of Australia.* Marine and Freshwater Research 62: 628. Doi:10.1071/MF10148.

Cranmer, G .1988. *Environmental survey of the benthic sediments around three exploration well sites*. Report No 88/02. Report to the United Kingdom Offshore Operators Association. Aberdeen University Marine Studies Ltd, Aberdeen, UK: pp33.

CSIRO. 2008. *Burrup Peninsula Air Pollution Study: Report for 2004/2005 and 2007/2008*. CSIRO Marine and Atmospheric Research, Australia.

CSIRO 2008b. *Toxicity of Chlorine and its Major By-products in Seawater: A Literature Review*.

CSIRO, 2017. Climate Change in Australia [WWW Document]. URL https://www.climatechangeinaustralia.gov.au/en/

CSIRO, 2015. Implications of climate change for Australia's biodiversity [WWW Document]. URL https://www.csiro.au/en/Research/LWF/Areas/Ecosystems-biodiversity/Monitoring-biodiversity/Biodiversity-and-climate-change (accessed 6.4.19)

Currie, D.R. & Isaacs, L.R. 2005*. Impact of exploratory offshore drilling on benthic communities in the Minerva gas field, Port Campbell, Australia*. Marine Environmental Research 59. 217-233.

Daan, R. & Mulder, M. 1996*. On the short-term and long-term impact of drilling activities in the Dutch sector of the North Sea*. ICES Journal of Marine Science 53. 1036-1044.

Dai, A., 2013. Increasing drought under global warming in observations and models. Nature climate change 3, 52.

Dafo Fomtec AB. 2013. *Safety Data Sheet: Fomtec FFFP 3% ICAO*. Issued 11 November 2013. Dafo Fomtec AB, Sweden.

Dalen, J., Knutsen, G.M. 1986. *Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic exploration*. In: Merklinger, H.M. (Ed.), Progress in Underwater Acoustics. Plenum Press, New York: pp93–102.

D'Anastasi, B., Simpfendorfer, C. & van Herwerden, L. 2013. *Anoxypristis cuspidata*. The IUCN Red List of Threatened Species 2013: e.T39389A18620409. Accessed at https://www.iucnredlist.org/species/39389/18620409

Daniels, C.B. 1998. *Synthetic-Based Drilling Fluids: An assessment of the spatial distribution of toxicants in sediments from Gulf of Mexico drilling platforms*. Report prepared for the Office of Water. EPA/600/R-98/104.

DAWR. 2017. *Australian Ballast Water Requirements. Department of Agriculture and Water Resources*. version 7. http://www.agriculture.gov.au/SiteCollectionDocuments/biosecurity/avm/vessels/ballast/australian-ballast-water-management-requirements.pdf

Day, R.D., McCauley, R.M. Fitzgibbon, Q.P., Hartmann, K., Semmens, J.M. 2016. *Institute for Marine and Antarctic Studies, Assessing the impact of marine seismic surveys on southeast Australian scallop and lobster fisheries*. University of Tasmania, Hobart, October. CC BY 3.0.

Deakos, M., Baker, J., Bejder, L. 2011. *Characteristics of a manta ray Manta alfredi population off Maui, Hawaii, and implications for management.* Marine Ecology Progress Series 429: pp245–260. Doi:10.3354/meps09085.

Department of Agriculture and Water Resources (DAWR). 2018. MarinePestPlan 2018–2023: the National Strategic Plan for Marine Pest Biosecurity, Department of Agriculture and Water Resources, Canberra, May. CC BY 4.0.

Department of Agriculture, Fisheries and Forestry (DAFF). 2010. The relative contribution of vectors to the introduction and translocation of invasive marine species. Department of Agriculture, Fisheries and Forestry, Australian Government.

Department of Conservation and Land Management. 2005. *Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005–2015 (Management Plan No. 52).* Department of Conservation and Land Management, Perth.

DoEE, 2019. Climate change impacts in Australia.

Department of the Environment and Energy. 2017. Recovery Plan for Marine Turtles in Australia (2017-2027).

Department of the Environment and Energy, 2019. Loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases [WWW Document]. URL https://www.environment.gov.au/climate-change/climate-solutions-package (accessed 6.4.19).

Department of the Environment, 2019. *Physeter macrocephalus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat . Accessed Mon, 25 Nov 2019.

Department of Environment (DOE). 2015a. *Species Profile and Threats Database Balaenoptera edeni – Brydes Whale*. Department of the Environment and Energy. Australian Government.

Department of Environment and Conservation (DEC). 2007. *Management Plan for the Montebello / Barrow Islands Marine Conservation Reserves 2007-2017*. Environmental Protection Authority.

Department of Environment and Conservation. 2006. *Background quality of the marine sediments of the Pilbara coast*. Department of Environment and Conservation, Marine Technical Report. Series, No. MTR 1.

Department of Environment and Conservation. 2009. Marine Turtle Recovery Plan for Western Australia. Department of Environment and Conservation, Western Australia.

Department of Environment and Energy (DOEE). 2016. *Draft National Strategy for Mitigating Vessel Strike of Marine Mega-fauna*. Commonwealth of Australia.

Department of Environment and Water Resources (DEWR). 2007. The Humpback Whales of Eastern Australia. Department of Environment and Water Resources, Canberra.

Department of Environment. 2006. *Pilbara Coastal Water Quality Consultation Outcomes.* Environmental Values and Environmental Quality Objectives, Department of Environment, Government of Western Australia, Marine Series Report No. 1.

Department of Environmental Protection (DEP). 2002. *Monitoring of Ambient Air Quality and Meteorology during the Pilbara Air Quality Study*. Technical Series 113. Department of Environmental Protection. Government of Western Australia.

Department of Environmental Protection, 2001. Ningaloo Coast Strategic Management Framework. Government of Western Australia. Accessed at: https://www.environment.gov.au/system/files/pages/31a9e336-d04a-48cb-810b-76a2b53751ac/files/ningaloo-strategic-management-framework.pdf

Department of Fisheries (DoF). 2016. Fisheries Fact Sheet – Introduced Marine Species. Department of Fisheries, Government of Western Australia. Available from:http://www.fish.wa.gov.au/Documents/recreational_fishing/fact_sheets/fact_sheet_introduced_marine_species.pdf.

Department of Fisheries. 2010. A bycatch action plan for the Pilbara fish trawl interim managed fishery (Fisheries Management Paper No. 244). Department of Fisheries, Perth.

Department of Parks and Wildlife (DPaW). 2015. Barrow group nature reserves management plan 82. Department of Biodiversity, Conservation and Attractions. Government of Western Australia.

Department of Planning, Land and Heritage (DPLH). 2018. Aboriginal Heritage Inquiry System List of Registered Aboriginal Sites. Department of Indigenous Affairs. Department of Planning, Land and Heritage. Government of Western Australia.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), 2012a. Marine bioregional plan for the North-west Marine Region. Prepared under the Environment Protection and Biodiversity Conservation Act 1999.. http://www.environment.gov.au/topics/marine/marine-bioregional-plans/north-west

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC). 2012b. *Species group report card – seabirds.* prepared under the Environment Protection and Biodiversity Conservation Act 1999. Australian Government. Accessed at http://www.environment.gov.au/system/files/pages/0fcb6106-b4e3-4f9f-8d06-f6f94bea196b/files/north-report-card-seabirds.pdf

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC). 2013a. *Approved Conservation Advice for Rostratula australis (Australian painted snipe)*. Department of the Environment and Energy. Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/77037-conservation-advice.pdf

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC). 2013b. *Conservation Advice for Subtropical and Temperate Coastal Saltmarsh*. Canberra: Accessed at: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/118-conservation-advice.pdf

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC). 2012a. Marine bioregional plan for the North-west Marine Region. Prepared under the Environment Protection and Biodiversity Conservation Act 1999. Accessed at https://www.environment.gov.au/system/files/pages/1670366b-988b-4201-94a1-1f29175a4d65/files/north-west-marine-plan.pdf

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC). 2011. Approved Conservation Advice for Aipysurus apraefrontalis (Short-nosed Sea Snake). Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy. Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/1115-conservation-advice.pdf

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC). 2013a. Recovery Plan for the White Shark (Carcharodon carcharias). Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy. Accessed at http://www.environment.gov.au/system/files/resources/ce979f1b-dcaf-4f16-9e13-010d1f62a4a3/files/white-shark.pdf

Department of the Environment (DotE). 2013. *Matters of National Environmental Significance*. Significant impact guidelines 1.1. Environment Protection and Biodiversity Conservation Act 1999. Commonwealth of Australia. Accessed at http://www.environment.gov.au/system/files/resources/42f84df4-720b-4dcf-b262-48679a3aba58/files/nes-guidelines_1.pdf

Department of the Environment (DotE). 2018. Continental slope demersal fish communities. Species Profile and treats Database. Department of the Environment and Energy. Australian government. Accessed at https://www.environment.gov.au/sprat-public/action/kef/view/79;jsessionid=01AD87551D0DE1B0248C8722BE137004

Department of the Environment (DotE). 2019. *Balaenoptera musculus in Species Profile and Threats Database*. Department of the Environment, Canberra. Accessed at http://www.environment.gov.au/sprat

Department of the Environment .2018. *Anous stolidus in Species Profile and Threats Database*. Department of the Environment, Canberra. Accessed at http://www.environment.gov.au/sprat. (Accessed Thu, 20 December 2018).

Department of the Environment and Energy (DOEE). 2015c. Anoxypristis cuspidata — Narrow Sawfish, Knifetooth Sawfish. Species Profile and Threats Database. Australian Government. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=68448

Department of the Environment and Energy (DOEE). 2017. *Recovery Plan for Marine Turtles in Australia.* Department of the Environment and Energy, Canberra.

Department of the Environment and Energy (DOEE). 2017a. *Natator depressus – Flatback turtle*. Species Profile and Threats Database. Australian Government. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59257

Department of the Environment and Energy (DOEE). 2017b. *Caretta caretta – Loggerhead Turtle*. Species Profile and Threats Database. Australian Government. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1763

Department of the Environment and Energy (DOEE). 2017c. *Chelonia mydas — Green Turtle*. Species Profile and Threats Database. Australian Government. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1765

Department of the Environment and Energy (DOEE). 2017d. *Dermochelys coriacea - Leatherback turtle, Lethery Turtle, Luth*. Species Profile and Threats Database. Australian Government. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1768

Department of the Environment and Energy (DOEE). 2017e. Aipysurus apraefrontalis — *Short-nosed Seasnake*. Species Profile and Threats Database. Australian Government. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1115

Department of the Environment and Energy (DOEE). 2017f. *Pristis zijsron — Green Sawfish*. Species Profile and Threats Database. Department of the Environment and Energy. Accessed at http://www.environment.gov.au/sprat. (Accessed 7 Aug 2017).

Department of the Environment and Energy (DOEE). 2017g. *Eretmochelys imbricata — Hawksbill Turtle*. Species Profile and Threats Database, Department of the Environment and Energy. Accessed at http://www.environment.gov.au/sprat. (Accessed 24 Jul 2017).

Department of the Environment and Energy (DOEE). 2017h. *Lepidochelys olivacea — Olive Ridley Turtle*. Species Profile and Threats Database. Department of the Environment and Energy. Accessed at http://www.environment.gov.au/sprat. (Accessed 24 Jul 2017).

Department of the Environment and Energy (DOEE). 2018. *Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris*. Accessed at http://www.environment.gov.au/biodiversity/threatened/key-threatening-processes/harmful-marine-debris

Department of the Environment and Energy (DOEE). 2019. *Australain Wetland Database – Directory of Important Wettlands of Australia*. Accessed at https://www.environment.gov.au/water/wetlands/australian-wetlands-database/directory-important-wetlands

Department of the Environment and Energy. 2014. *Recovery plan for the grey nurse shark (Carcharias ehavi).* Department of the Environment, Canberra.

Department of the Environment and Energy. 2015a. *Wildlife Conservation Plan for Migratory Shorebirds.* Department of the Environment, Canberra.

Department of the Environment and Energy. 2018a. *Kogia breviceps — Pygmy Sperm Whale*. Species Profile and Threats Database. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=57 (Accessed 30th October 2018).

Department of the Environment and Energy. 2018b. Species Profile and Threats Database: *Kogia sima — Dwarf Sperm Whale*. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=58 (Accessed 30th October 2018).

Department of the Environment and Heritage (DEH). 2005a. *Blue, fin and sei whale recovery plan 2005–2010 (Recovery Plan).* Department of the Environment and Heritage, Canberra.

Department of the Environment and Heritage. 2007. *Australia's National Heritage – Dampier Archipelago*. Accessed at https://www.environment.gov.au/system/files/pages/5b14f51b-b7e1-432f-8049-1e653713607d/files/dampier-archipelago.pdf.

Department of the Environment, Water, Heritage and the Arts (DEWHA). 2010. *Legislative changes for recreational fishing of three shark species.* Department of the Environment, Water, Heritage and the Arts, Canberra.

Department of the Environment, Water, Heritage and the Arts (DEWHA). 2008a. *The North-west Marine Bioregional Plan, Bioregional Profile – A description of the ecosystems, conservation values and uses of the North-west Marine Region*. Australian Government.

Department of the Environment, Water, Heritage and the Arts (DEWHA). 2008b. *A Characterisation of the Marine Environment of the North-west Marine Region: Perth Workshop Report*. A summary of an expert workshop convened in Perth, Western Australia, 5–6 September 2007. Australian Government.

Department of the Environment, Water, Heritage and the Arts (DEWHA). 2012a. *Species group report card – seabirds and migratory shorebirds; Supporting the marine bioregional plan for the North-west Marine Region*. Australian Government.

Department of the Environment, Water, Heritage and the Arts (DEWHA). 2012b. *Species group report card – cetaceans; Supporting the marine bioregional plan for the North-west Marine Region*. Australian Government.

Department of the Environment, Water, Heritage and the Arts (DEWHA). 2012c. *Species group report card – marine reptiles; Supporting the marine bioregional plan for the North-west Marine Region*. Australian Government.

Department of the Environment, Water, Heritage and the Arts (DEWHA). 2012d. *Species group report card – sharks and sawfishes; Supporting the marine bioregional plan for the North-west Marine Region*. Australian Government.

Department of the Environment, Water, Heritage and the Arts (DEWHA). 2009. *Threat Abatement Plan for the impacts of marine debris on vertebrate marine life*. Commonwealth of Australia.

Department of the Environment. 2013b. *Pristis clavata — Dwarf Sawfish, Queensland Sawfish [WWW Document].* Species Profile and Threats Database. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=68447 (accessed 11.26.13).

Department of the Environment. 2014. *Approved Conservation Advice for Pristis pristis (largetooth sawfish).* Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy. Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/60756-conservation-advice.pdf

Department of the Environment. 2015. Conservation Management Plan for the Blue Whale. Accessed at https://www.environment.gov.au/system/files/resources/9c058c02-afd1-4e5d-abff-11cac2ebc486/files/blue-whale-conservation-management-plan.pdf.

Department of the Environment. 2016a. *Balaenoptera borealis [WWW Document].* Species Profile and Threats Database, Department of the Environment, Canberra.

Department of the Environment. 2016c. *Pandion cristatus — Eastern Osprey [WWW Document]. Species Profile and Threats Database*. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=952 (Accessed 8th Nov 2018).

Department of the Environment. 2018. *Apus pacificus.* Species Profile and Threats Database, Department of the Environment, *Canberra.* Accessed at http://www.environment.gov.au/sprat. (Accessed Mon, 19 Nov 2018).

Department of the Environment. 2018. *Ardenna carneipes*. Species Profile and Threats Database, Department of the Environment, Canberra. Accessed at: http://www.environment.gov.au/sprat (Accessed Thu, 20 December 2018).

Department of the Environment. 2018. *Calidris acuminate*. Species Profile and Threats Database. Department of the Environment, Canberra. Accessed at: http://www.environment.gov.au/sprat (Accessed Thu, 20 December 2018).

Department of the Environment. 2018. *Calidris alba*. Species Profile and Threats Database. Department of the Environment, Canberra. Accessed at http://www.environment.gov.au/sprat (Accessed Thu, 20 December 2018).

Department of the Environment. 2018. *Calidris canutus.* Species Profile and Threats Database. Department of the Environment, Canberra. Accessed at: http://www.environment.gov.au/sprat (Accessed Thu, 20 December 2018).

Department of the Environment. 2018. *Haliaeetus leucogaster*. Species Profile and Threats Database, Department of the Environment, Canberra. Accessed at http://www.environment.gov.au/sprat. (accessed Mon, 19 Nov 2018).

Department of the Environment. 2018. *Key Ecological Features.* Species Profile and Threats Database. Department of the Environment. Australian Government. Accessed at https://www.environment.gov.au/sprat-public/action/kef/search (Accessed June 2018).

Department of the Environment. 2018. *Limosa lapponica.* Species Profile and Threats Database, Department of the Environment, Canberra. Accessed at http://www.environment.gov.au/sprat. (Accessed Mon, 19 Nov 2018).

Department of the Environment. 2018. *Onychoprion anaethetus.* Species Profile and Threats Database. Department of the Environment, Canberra. Accessed at http://www.environment.gov.au/sprat (Accessed Thu, 20 December 2018).

Department of the Environment. 2018. *Pterodroma mollis*. Species Profile and Threats Database, Department of the Environment, Canberra. Accessed at http://www.environment.gov.au/sprat (Accessed Thu, 20 December 2018).

Department of the Environment. 2018. *Species Profile and Threats Database*. Department of the Environment. Australian Government. Accessed at http://www.environment.gov.au/sprat. (Accessed June 2018).

Department of the Environment. 2018. *Tringa nebularia*. Species Profile and Threats Database, Department of the Environment, Canberra. Accessed at http://www.environment.gov.au/sprat. (Accessed Mon, 19 Nov 2018).

Department of the Environment. 2018a. *Hydroprogne caspia – Caspian Tern. [WWW Document].* Species Profile and Threats Database. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=808

Department of the Environment. 2018b. *Limosa lapponica menzbier – Northern Bar-tailed Godwit, Bar-tailed Godwit (Menzbieri). [WWW Document].* Species Profile and Threats Database. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=86432

Department of the Environment. 2018c. *Tringa nebularia – Common Greenshank, Greenshank. [WWW Document].* Species Profile and Threats Database. Accessed at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=832

Director of National Parks (DNP). 2013. *North-West Commonwealth Marine Reserves Network Management Plan 2014-2024*. Director of National Parks, Canberra.

Director of National Parks (DNP). 2018. *North-west Marine Parks Network Management Plan 2018*. Director of National Parks, Canberra. ISBN: 978-0-9876152-3-7.

Dix, G.R., James, N.P., Kyser, T.K., Bone, Y., Collins, L.B. 2005. *Genesis and dispersal of carbonate mud relative to late quaternary sea-level change along a distally-steepened carbonate ramp (Northwestern Shelf, Western Australia).* Journal of Sedimentary Research 75: pp665–678.

Department of Fisheries. 2017. Annual Report to Parliament 2016/17. Department of Fisheries, Government of Western Australia. Accessed at: http://www.fish.wa.gov.au/Documents/annual_reports/annual_report_2016-17.pdf

Dokulil, M.T. 1994. *Environmental control of phytoplankton productivity in turbulent turbit systems*. Hydrobiologia 289 (1-3): pp65-72.

Double, M., Gales, N., Jenner, K., Jenner, M. 2010. *Satellite tracking of south-bound female humpback whales in the Kimberley region of Western Australia.* Australian Marine Mammal Centre, Hobart.

Double, M., Jenner, K., Jenner, M.-N., Ball, I., Laverick, S., Gales, N. 2012b. *Satellite tracking of pygmy blue whales (Balaenoptera musculus brevicauda) off Western Australia.* Australian Marine Mammal Centre, Hobart.

Double, M., Jenner, K., Jenner, M.-N., Childerhouse, S., Laverick, S., Gales, N. 2012a. *Satellite tracking of northbound humpback whales (Megaptera novaeangliae) off Western Australia.* Australian Marine Mammal Centre, Hobart.

Double, M.C., Andrews-Goff, V., Jenner, K.C.S., Jenner, M.-N., Laverick, S.M., Branch, T.A., Gales, N.J. 2014. *Migratory movements of pygmy blue whales (Balaenoptera musculus brevicauda) between Australia and Indonesia as revealed by satellite telemetry.* PloS one 9(4): e93578. Accessed at https://doi.org/10.1371/journal.pone.0093578

Duckworth, A., Giofre, N., Jones, R., 2017. *Coral morphology and sedimentation*. Marine Pollution Bulletin. doi: 10.1016/j.marpolbul.2017.08.036.

Duke, N.C., Kovacs, J.M., Griffiths, A.D., Preece, L., Hill, D.J., Van Oosterzee, P., Mackenzie, J., Morning, H.S., Burrows, D., 2017. Large-scale dieback of mangroves in Australia's Gulf of Carpentaria: a severe ecosystem response, coincidental with an unusually extreme weather event. Marine and Freshwater Research 68, 1816–1829.

Dunlop, J., 2009. The population dynamics of tropical seabirds establishing frontier colonies on islands off south-western Australia. Marine Ornithology 37, 99–105.

Dunlop, J., Wooller, R., Cheshire, N. 1988. *Distribution and abundance of marine birds in the Eastern Indian Ocean.* Marine and Freshwater Research 39: pp661–669.

Dunlop, M., Hilbert, D., Ferrier, S., House, A., Liedloff, A., Prober, S., Smyth, A., Martin, T., Harwood, T., Williams, K., Fletcher, C., Murphy, H., 2012. The Implications of Climate Change for Biodiversity, Conservation and the National Reserve System: Final Synthesis. CSIRO Climate Adaptation Flagship. https://doi.org/10.4225/08/5850384d796c6

Dunlop, R. A., Noad, M.J., McCauley, R.D., Scott-Heywart, L., Kniest, E., Slade, R., Paton, D., Cato, D.H. 2017. *Determining the behavioural dose–response relationship of marine mammals to air gun noise and source proximity*. The Company of Biologists Ltd. Journal of Experimental Biology 220, 2878-2886 doi:10.1242/jeb.160192.

Duran, N. & Dunbar, S.G. 2015. *Differences in diurnal and nocturnal swimming patterns of olive ridley hatchlings in the Gulf of Fonseca, Honduras*. Journal of Experimental Marine Biology and Ecology, 472, 63 - 71.

Ecotox Services Australia, 2013. Toxicity Assessment of an Enfield and Marine Diesel Sample. Report prepared for Woodside Energy Ltd.

Ellers, O., 1995. *Discrimination Among Wave-generated Sounds by a Swash-riding Clam*: 189.

Energy News Bulletin. 2017. [Web page] Equus bound for domgas. http://www.energynewsbulletin.net/on-the-record/news/1265328/equus-bound-domgas.

Energy News Bulletin. 2018. [Web page] *Chevron announces Gorgon's next phase*. http://www.energynewsbulletin.net/production/news/1336218/chevron-announces-gorgon's-next-phase

Environment Australia. 2002. *Ningaloo marine park (Commonwealth waters) management plan.* Environment Australia, Canberra.

Environment Australia. 2003. *Recovery plan for marine turtles in Australia.* Department of the Environment and Heritage, Canberra.

Erftemeijer, P.L., Riegl, B., Hoeksema, B.W. and Todd, P.A. 2012. Environmental impacts of dredging and other sediment disturbances on corals: a review. Marine Pollution Bulletin 64: 1737–1765.

ERM. 2012. *Scarborough FLNG – Potential for Coastline Nitrogen Dioxide Impacts*. Report prepared for ExxonMobil, by Environmental Resources Management Australia. Report Reference: 0163644.

ERM. 2013. *Scarborough Project Oil Spill modelling Study*. Exxon Mobil Scarborough. Reference: 0176695.

ERM. 2013a. *Scarborough Marine Studies – Environmental Characterisation Report*. Report prepared for Esso Australia Pty Ltd, by Environmental Resources Management Australia. Report Reference: 0177357.

ERM. 2018. Scarborough Floating Liquified Natural Gas (FLNG) Project Cooling Water Discharge Study. Esso Australia Resources Pty Ltd. Reference: 0176695

European Maritime Safety Agency (EMSA). 2016. *The Management of Ship-Generated Waste On-board Ships*. CE Delft. CHEW. Accessed at http://www.emsa.europa.eu/news-a-press-centre/external-news/item/2925-the-management-of-ship-generated-waste-on-board-ships.html

Exon, N.F., Willcox, J.B. 1980. *The Exmouth Plateau: Stratigraphy, structure, and petroleum potential*. Department of Natural Development & Energy. Bureau of Mineral Resources, Geology and Geophysics. Bulletin 199. Australian Government Publishing Service, Canberra.

Falkner, I., Whiteway, T., Przeslawski, R. and Heap, A.D. 2009. *Review of ten key ecological features (KEFs) in the North-west Marine Region*. Record 2009/13, Geoscience Australia, Canberra.

Field, C.D., 1995. Impact of expected climate change on mangroves. Hydrobiologia 295, 75–81. https://doi.org/10.1007/BF00029113

Finneran, J. J., & Jenkins, A. K. 2012. *Criteria and thresholds for US Navy acoustic and explosive effects analysis*. SPAWAR Systems Centre Pacific, San Diego.

Fisher D J, Burton D T, Yonkos L T, et al, 1999. The relative acute toxicity of continuous and intermittent exposures of chlorine and bromine to aquatic organisms in the presence and absence of ammonia, Water Research, 33(3), 760-768.

Fitzsimmons, N.N., Tucker, A.D., Limpus, C.J. 1995. *Long-Term Breeding Histories of Male Green Turtles and Fidelity to a Breeding Ground.* Marine Turtle Newsletter 68: pp2-4. Zoology Department, University of Queensland. Queensland Department of Environment and Heritage.

Fletcher, W.J., & Santoro, K, 2009. *State of the fisheries report 2008/09*. Western Australian Department of Fisheries, Perth.

Fodrie, F.J., Heck, K.L. Jr. 2011. *Response of coastal fishes to the Gulf of Mexico oil disaster*. PLoS ONE 6: e21609. doi:10.1371/journal.pone.0021609

French, D.P., Schuttenberg, H.Z., Isaji, T. 1999. *Probabilities of Oil Exceeding Thresholds of Concern: Examples from an Evaluation for Florida Power and Light*. AMOP 99 Technical Seminar, June 2-4, 1999, Calgary, Alberta, Canada: pp243-270.

French-McCay, D. 2009. *State-of-the-art and research needs for oil spill impact assessment modelling*. Applied Science Associates, Inc. South Kingstown, RI, USA.

Frick, W.E., Roberts P.J.W., Davis L.R., Keyes, J., Baumgartner, D.J., George, K.P. 2001. *Dilution Models for Effluent Discharges*. 4th Edition (Visual Plumes) – DRAFT. U.S. EPA Environmental Standards Division.

Fromont, J. 2004. *Porifera (sponges) of the Dampier Archipelago, Western Australia: habitats and distribution, in Diana S Jones (ed), Marine biodiversity of the Dampier Archipelago Western Australia 1998–2002:* report of the results of the Western Australian Museum/Woodside Energy Partnership. Records of the Western Australian Museum. Supplement No. 66: 69–100.

Fromount, F. Wahab, M.A.A. Gomez, O. Ekins, M. Grol, M. Hooper, J. N. A. 2017. *Sponges of the north west of Western Australia: biogeography and considerations for dredging related research*. Theme 6 report, project 6.2. Report prepared for the WAMSI Dredging Science Node. Western Australia Marine Science Institution.

Fugro. 2010. *Report on the Activity 2a Deepwater Field Development Geophysical AUV Survey, North West shelf, Australia*, Volume 1. Report for ExxonMobil, Perth, Australia. Australia, Canberra.

Fugro. 2011. *Scarborough LNG Project Metocean Measurement Programme*. Report for ExxonMobil, Perth, Australia.

Fugro. 2012. *Scarborough Time Series, Temperature Statistics, and Current Profiles*. Report for ExxonMobil, Perth, Australia.

Fugro. 2012. *Scarborough Time Series, Temperature Statistics, and Current Profiles*. Report for ExxonMobil, Perth, Australia.

Furnas, M. (2007). *Intra-seasonal and inter-annual variations in phytoplankton biomass, primary production and bacterial production at North West Cape, Western Australia: Links to the 1997–1998 El Niño event*. Cont Shelf Res 27: 958–980.

Gage, J.D. 1996. *Why are there so many species in deep water sediments?* Journal of Experimental Marine Biology and Ecology 200: pp257–286.

Gagnon, M.M., Rawson, C. 2010. *Montara well release: Report on necropsies from birds collected in the Timor Sea.* Curtin University. Perth, Western Australia. 20pp.

Gales, N., M. Double, S. Robinson, C. Jenner, M. Jenner, E. King, J. Gedamke, S. Childerhouse & D. Paton (2010). *Satellite tracking of Australian humpback (Megaptera novaeangliae) and pygmy blue whales (Balaenoptera musculus brevicauda*). Australian Marine Mammal Centre. Australian Antarctic Division.

Gales, R.S.1982. Effects of Noise of Offshore Oil and Gas Operations on Marine Mammals – n Introductory Assessment. Technical Report 884(1). Prepared for the Bureau of Land Management, Department of Interior. Naval Ocean Systems Center. San Diego, California.

Gallaway, B.J. 1981. *An ecosystem analysis of oil and gas development on the Texas-Louisiana continental shelf*. U.S. Fish and Wildlife Service. Office of Biological Services, Washington, D.C. FWS/OBS-81/27.

Garcia, E., Cróquer, A., Bastidas, C., Bone, D., Ramos, R. 2011. *First environmental monitoring of offshore gas drilling discharges in the Deltana Platform, Venezuela. Ciencias Marinas*. 37141-155.

Gaston KJ, Duffy JP, Gaston S, Bennie J, Davies TW (2014) Human alteration of natural light cycles: causes and ecological consequences. Oecologia 176:917–931

Gaughan, D.J. and Santoro, K. (eds). 2018. *Status Reports of the Fisheries and Aquatic Resources of Western Australia 2016/17: The State of the Fisheries*. Department of Primary Industries and Regional Development, Western Australia.

Gavrilov, N. McCauley, R.D. 2018. *Southbound migration corridor of pygmy blue whales off the northwest coast of Australia based on data from ocean bottom seismographs*. The Journal of the Acoustica Society of America. 144, EL281. Accessed at https://asa.scitation.org/doi/10.1121/1.5063452?utm_source=AIP%20Publishing&utm_medium=email&utm_campaign=9994213__ALERT_TOC_jas_20181101&dm_i=1XPS,5Y7L1,JPOTW2,NAW4T,1

Gedamke, J., Robinson, S.M. 2010. *Acoustic survey for marine mammal occurrence and distribution off East Antarctica (30-80°E) in January-February 2006*. Deep Sea Research Part II: Topical Studies in Oceanography 57:968-981.

Geiling, N. 2014. *Artic Shipping: Good for Invasive Species, Bad for the Rest of Nature*. Smithsonian Magazine. Available at: https://www.smithsonianmag.com/ science-nature/global-warmings-unexpected-consequence-invasive-species-180951573/?no-ist

Geoconsult. 2005. Pluto AUV Survey 2005, Volume 1 of 18, Part 1 Summary of Results.

Geraci, J.R. & St. Aubin, D.J. 1988. *Synthesis of Effects of Oil on Marine Mammals*. Report to U.S. Department of the Interior, Minerals Management Service. Atlantic OCS Region. OCS Study. MMS 88 0049, Battelle Memorial Institute, Ventura, CA, pp292.

Gill P., Morrice M., Page B., Pirzl R., Levings A., Coyne M. 2011. *Blue whale habitat selection and within-season distribution in a regional upwelling system off southern Australia*. Marine Ecology Progress Series 421:243–263.

Gill P.C. 2002. *A blue whale (Balaenoptera musculus) feeding ground in a southern Australian coastal upwelling zone*. Journal of Cetacean Research & Management 4:179–184.

Gill, P.C., Pirzl, R., Morrice, M.G., Lawton, K. 2015. *Cetacean diversity of the continental shelf and slope off southern Australia*. The Journal of Wildlife Management.

Gilmour, J., Speed, C.W., Babcock, R., 2016. Coral reproduction in Western Australia. PeerJ 4, e2010. https://doi.org/10.7717/peerj.2010

Gleiss, A., Wright, S., Liebsch, N. & Wilson, R. 2013. *Contrasting diel patterns in vertical movement and locomotor activity of whale sharks at Ningaloo Reef*. Marine Biology 160(11): pp2981-2992.

Gollasch, S., Macdonald,E., Belson, S., Botnen, H., Christensen, J.T., Hammer, J.P., Houvenaghel, G., Jelmert, A., Lucas, I., Masson, D., Mccollin, T., Olenin, S., Persson, A., Wallentinus, I., Westeyn, L.P.M.J., Wittling, T. *Life in Ballast Tanks*.

Gophen, M. 2015. *The Impact of Turbidity on Zooplankton Densities in Lake Kinneret (Israel)*. Migal Open Journal of Modern Hydrology 05(04): pp87-94. Scientific Research Institute, Kiryat Shmone. Israel. DOI: 10.4236/ojmh.2015.54008

Gotz, T., Hastie, G., Hatch, L., Raustein, O., Southall, B., Tasker, M., et al. 2009. *Overview of the impacts of anthropogenic underwater sound in the marine environment*. OPSAR commission.

Government of Western Australia, 2019. WA GHG Emissions Policy for Major Projects

Graham, P.W., Hayward, J, Foster, J., Story, O.1 and Havas, L. 2018, GenCost 2018. CSIRO, Australia.

Gratwicke, B., Speight, M.R. 2005. *The relationship between fish species richness, abundance and habitat complexity in a range of shallow tropical marine habitats.* Journal of Fish Biology 66: pp650–667.

Great Barrier Reef Marine Park Authority (GBRMPA). 2012. *A vulnerability assessment for the Great Barrier Reef: Dwarf Minke Whales*. Commonwealth of Australia.

Green, K., 2006. Effect of variation in snowpack on timing of bird migration in the Snowy Mountains of south-eastern Australia. Emu 106. https://doi.org/10.1071/MU05060

Griffith, J.K. 2004. *Scleractinian corals collected during 1998 from the Dampier Archipelago, Western Australia*. In: (ed.) Jones, D.S., Report on the results of the Western Australian Museum/Woodside Energy Ltd. exploration of the marine biodiversity of the Dampier Archipelago 1998–2002.

Groom, C. J. and Coughran, D. K. 2012. *Three decades of cetacean strandings in Western Australia: 1981 to 2010.* Journal of the Royal Society of Western Australia 95: pp63–76.

Groom, C. J., Coughran, D. K. and Smith, H. C. 2014. *Records of beaked whales (family Ziphiidae) in Western Australian waters.* Marine Biodiversity Records 7: e50.

Groom, R.A., Lawler, I.R. & Marsh, H. 2004. *The risk to dugongs of vessel strike in the Southern Bay Islands area of Moreton Bay*. Report to Queensland Parks and Wildlife Service. School of Tropical Environment Studies and Geography. James Cook University.

Guinea, M., Limpus, C., Whiting, S. 2004. *Marine snakes, in: Description of Key Species Groups in the Northern Planning Area.* National Oceans Office, Hobart: pp137–146.

Guinea, M.L. & Whiting S.D. 2005. *Insights into the distribution and abundance of sea snakes at Ashmore Reef*. The Beagle (Supplement 1): pp199-206.

Guinea, M.L. 1995. *The sea turtles and sea snakes of Ashmore Reef Nature Reserve*. Darwin: Northern Territory University: pp67.

Gyuris, E. 1994. *The rate of predation by fishes on hatchlings of the green turtle (Chelonia mydas).* Coral Reefs, 13:137-144.

Hannay, D., MacGillivray, A., Laurinolli, M &., Racca, R. 2004*, Source Level Measurements from 2004 Acoustics Programme*. Sakhalin Energy: pp66.

Hamann, M., Limpus, C.J., Hughes, G., Mortimer, J.A., & Pilcher N.J. 2006. *Assessment of the Conservation Status of the Leatherback Turtle in the Indian Ocean and South-East Asia.* Bangkok. IOSEA Marine Turtle MoU Secretariat. pp 174.

Hart, A., & Crowe, K. 2015. *Specimen shell managed fishery status report*, in: Fletcher, W., Santoro, K. (Eds.), Status Reports of the Fisheries and Aquatic Resources of Western Australia 2014/15: The State of the Fisheries. Department of Fisheries, Perth, pp306–308.

Harvey, E., Wenger, A., Saunders, B., Newman, S., Wilson, S., Travers, M., Browne, N., Rawson, C., Clarke, D., Hobbs, J.P., Mcilwain, J., Evans, R., Erftemeijer, P., Mclean, D. and Depczynski, M., 2016. *Effects of dredging-related pressures on critical ecological processes for finfish: a review and possible management strategies*. Report of Theme 8 – Projects 8.1 & 8.2 prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth, Western Australia, 91 pp.

Hassan, A., Javed, H. 2011. *Effects of Tasman Spirit oil spill on coastal birds at Clifton, Karachi coast, Pakistan*. Journal of Animal and Plant Sciences 21: pp333–339.

Hayward, J.A. and Graham, P.W. 2017, Electricity generation technology cost projections: 2017-2050, CSIRO, Australia.

Hazel, J., Lawler, I.R., Marsh, H. and Robson, S. 2007. *Vessel speed increases collision risk for the green turtle Chelonia mydas*. Endangered Species Research 3, pp105–113.

Heap, A. D. & P. T. Harris. 2008. *Geomorphology of the Australian margin and adjacent seafloor*. Australian Journal of Earth Sciences 55:555-585.

Heatwole, H., Cogger, H.G. 1993. *Chapter 36: Family Hydrophiidae, in: Fauna of Australia.* Australian Government Publishing Service, Canberra.

Heck, K. Jr. Hays, C. Orth, R. 2003. A Critical Evaluation of the Nursery Role Hypothesis for Seagrass Medows. Marine Ecology Progres Series, 253: pp123-136.

Helm, R.C., Costa, D.R., DeBruyn, T.D., O'Shea, T.J., Wells, R.S., Williams, T. M. 2015. *Overview of Effects of Oil Spills on Marine Mammals*. in Handbook of Oil Spill Science and Technology (ed. M. Fingas), John Wiley & Sons, Inc., Hoboken, NJ. doi: 10.1002/9781118989982.ch18.

Hewitt, C.L., Campbell, M.L., Thresher, R.E., Martin, R.B. 1999. *Marine Biological Invasions of Port Phillip Bay, Victoria. Centre for Research on Introduced Marine Pests, Technical report no. 20*. CSIRO Marine Research Hobart, Australia.

Hewitt, C.L., Campbell, M.L., Thresher, R.E., Martin, R.B., Boyd, S., Cohen, B.F., Currie, D.R., Gomon, M.F., Keogh, M.J., Lewis, J.A., Lockett, M.M., Mays, N., McArthur, M.A., O'Hara, T.D., Poore, G.C.B., Ross, D.J., Storey, M.J., Watson, J.E., Wilson, R.S. 2004, *Introduced and cryptogenic species in Port Phillip Bay, Victoria, Australia*'. Marine Biology 144.pp182–202.

Heyward, A., Jones, R., Travers, M., Burns, K., Suosaari, G., Colquhoun, J., Case, M., Redford, B., Meekan, M., Markey, K., Schenk, T., O'Leary, R.A., Brooks, K., Tinkler, P., Cooper, T., Emslie, M., 2012. *Monta: 2011 shallow reef surveys at Ashmore, Cartier and Seringapatam reefs (Monitoring Study No. S6B Coral Reefs)*. Australian Institute of Marine Science, Townsville.

Heyward. A., Fromont. J., Schonberg CHL, Colquhoun J. Radford, B., Gomex, O. (2010). *The sponge gardens of Ningaloo Reef, Western Australia*. Open Mar Biol J 4:3-111

Higgins, P.J. & S.J.J.F. Davies, eds. 1996. *Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons*. Melbourne, Victoria: Oxford University Press.

Hindwood, J.B., Poots, A.E., Dennis, L.R., Carey, J.M., Houridis, H., Bell, R.J., Thomson, J.R., Boudreau, P., Ayling, A.M. 1994. *Drilling activities*. In: Swan, J.M., Neff, J.M., Young, P.C., (eds) Environmental Implications of offshore oil and gas development in Australia: findings of an independent scientific review. Australian Petroleum Production and Exploration Association, Canberra, pp123–207.

Hjermann, D. melsom, A. Dingsør, G.E., Durrant, J.M., Eikeset, A.M., Røed, L.P., Ottersen, G., Storvik, G., Stenseth, N.C. 2007. *Fish and oil in the Lofoten–Barents Sea system: synoptic review of the effect of oil spills on fish populations.* Marine Ecology Progress Series 339: pp 283-299.

Hodgson, A., J. 2004. *Dugong behaviour and responses to human influences*. PhD Thesis submission. James Cook University.

Hodge, W., Limpus, C.J., & Smissen, P. 2007. *Queensland turtle conservation project: Hummock Hill Island nesting turtle study December 2006* Conservation Technical and Data Report (pp. 1-10). Queensland, Australia: Environmental Protection Agency.

Hoegh-Guldberg, O., 1999. Climate change, coral bleaching and the future of the world's coral reefs. Marine and freshwater research 50, 839–866.

Hoegh-Guldberg, O., Jacob, D., Taylor, M., Bindi, M., Brown, S., Camilloni, I., Diedhiou, A., Djalante, R., Ebi, K.L., Engelbrecht, F., Guiot, J., Hijioka, Y., Mehrotra, S., Payne, A., Seneviratne, S.I., Thomas, A., Warren, R., Zhou, G., 2018. Impacts of 1.5oC Global Warming on Natural and Human

Systems, in: Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty.

Hoenner, X., Whiting, S.D., Hamann, M., Limpus, C.J., Hindell, M.A., & McMahon, C.R. 2016. High-resolution movements of critically endangered hawksbill turtles help elucidate conservation requirements in northern Australia. Marine and Freshwater Research, http://dx.doi.org/10.1071/MF15013

Holloway, P.E. 1988. *Physical Oceanography of the Exmouth Plateau Region, North-western Australia*. Australian Journal of Marine and Freshwater Research 39: pp589–606.

Hook, S., Batley, G., Holloway, M., Irving, P., Ross, A. 2016. *Oil Spill Monitoring Handbook*. CSRIO Publishing.

Houde, E.D. and Zastrow, C.E., 1993. Ecosystem- and taxon-specific dynamic and energetics properties of larval fish assemblages. Bulletin of Marine Science 53 (2): 290–335.

How, J. and Nardi, K. 2014. *West Coast Deep Sea Crustacean Managed Fishery Status Report* In: In: Status Reports of the Fisheries and Aquatic Resources of Western Australia 2013/14: The State of the Fisheries eds. W.J. Fletcher and K. Santoro, Department of Fisheries, Western Australia: pp133-136. Accessed at http://www.fish.wa.gov.au/Documents/sofar/status_reports_of_the_fisheries_and_aquatic_resources_2013-14.pdf

Hu, Z., H. Hu, & Huang, Y. 2018) *Association between nighttime artificial light pollution and sea turtle nest density along Florida coast: A geospatial study using VIIRS remote sensing data.* Environmental Pollution, 239: 30-42.

Hughes, L., 2011. Climate change and Australia: key vulnerable regions. Regional Environmental Change 11, 189–195

Hughes, L., 2003. Climate change and Australia: Trends, projections and impacts. Austral Ecology 28, 423–443. https://doi.org/10.1111/j.1442-9993.2003.tb00266.x

Hughes, T.P., Kerry, J.T., Álvarez-Noriega, M., Álvarez-Romero, J.G., Anderson, K.D., Baird, A.H., Babcock, R.C., Beger, M., Bellwood, D.R., Berkelmans, R., Bridge, T.C., Butler, I.R., Byrne, M., Cantin, N.E., Comeau, S., Connolly, S.R., Cumming, G.S., Dalton, S.J., Diaz-Pulido, G., Eakin, C.M., Figueira, W.F., Gilmour, J.P., Harrison, H.B., Heron, S.F., Hoey, A.S., Hobbs, J.-P.A., Hoogenboom, M.O., Kennedy, E.V., Kuo, C., Lough, J.M., Lowe, R.J., Liu, G., McCulloch, M.T., Malcolm, H.A., McWilliam, M.J., Pandolfi, J.M., Pears, R.J., Pratchett, M.S., Schoepf, V., Simpson, T., Skirving, W.J., Sommer, B., Torda, G., Wachenfeld, D.R., Willis, B.L., Wilson, S.K., 2017. Global warming and recurrent mass bleaching of corals. Nature 543, 373.

Huisman, J.M., Jones, D.S., Wells, F.E., Burton, T. 2008. *Introduced marine biota in Western Australian waters*. Records of Western Australian Museum 24: pp1-44.

Human, B. A. and McDonald, J. I. 2009. *Knowledge review and gap analysis: Resource condition monitoring in the Pilbara and Kimberley regions of Western Australia*. Coastal and Marine Resource Condition Monitoring - Scoping Project. Final NRM Report, Project 073007 - Part 1. Department of Fisheries, Government of Western Australia: pp192. Accessed at http://www.fish.wa.gov.au/Documents/research_reports/frr197.pdf

Hyland, J., Hardin, D., Steinhauer, M., Coats, D., Green, R., Neff, J. 1994. *Environmental impact of offshore oil development on the outer continental shelf and slope off Point Arguello, California*. Marine Environmental Research 37. 195-229.

IFSEC Global. 2008. *Environmental impact of foam*. IFSEC and FIREX International. Accessed at https://www.ifsecglobal.com/uncategorized/environmental-impact-of-foam/

IFSEC Global. 2014. *Environmental impact of foam*. Viewed online on 22 June 2016 at http://www.ifsecglobal.com/environmental-impact-of-foam/

IMCRA Technical Group. 1998. *Interim Marine and Coastal Regionalisation for Australia: an ecosystem-based classification for marine and coastal environments*. Version 3.3. Environment Australia, Commonwealth Department of the Environment. Australian Government.

International Association of Oil & Gas Producers (IAOPG). 2016. *Environmental Fates and Effects of Ocean Discharge of Drill Cuttings and Associated Drilling Fluids from Offshore Oil and Gas Operations.* Prepared by Sanzone, D.M., Neff, J.M., Lewis, D., Vinhateiro, N., Blake, J.

International Petroleum Industry Environmental Conservation Association. 2004. *A guide to oiled wildlife response planning* (IPIECA Report Series No. 13). International Petroleum Industry Environmental Conservation Association, London.

International Tanker Owners Pollution Federation [ITOPF]. 2011. *Effects of oil pollution on the Marine Environment*. Technical Information Paper. Accessed at http://www.itopf.com/fileadmin/data/Documents/TIPS%20TAPS/TIP13EffectsofOilPollutionontheMarineEnvironment.pdf.

Intergovernmental Panel on Climate Change (IPCC), 2014. AR5 Synthesis Report: Climate Change 2014.

International Energy Agency (IEA), 2019. Global Energy & CO_2 Status Report. The latest trends in energy and emissions in 2018 [WWW Document]. URL https://www.iea.org/geco/emissions/ (accessed 7.2.19).

IPCC, 2011. Summary for Policymakers, IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. Cambridge University Press, United Kingdom and New York, NY, USA.

IPIECA. 1993. *Biological impacts of oil pollution: Mangroves*. Proceedings of the IPIECA, International Petroleum Industry Environmental Conservation Association, (IPIECA' 90), London.

IPIECA. 1994. *Biological Impacts of Oil Pollution: Saltmarshes*. IPIECA Report Series Vol 6.

IRC. 2011. *Review of Diesel Toxicity to the Marine Environment*. Commissioned by Apache Energy, DOC NO: E-REP-00-101-400-REV-0.

IRCE. 2003. Environmental monitoring of drilling discharges in shallow water habitats.

Irvine, L. G., Thums, M., Hanson, C. E., McMahon, C. R. and Hindell, M. A. 2017. *Evidence for a widely expanded humpback whale calving range along the Western Australian coast*. Marine Mammal Science DOI: 10.1111/mms.12456.

IUCN 2013. IUCN Red List of Threatened Species: Narrow Sawfish *Anoxypristis cuspidate*. Accessed at: https://www.iucnredlist.org/species/39389/141789456

James, N.P., Bone, Y., Kyser, T.K., Dix, G.R. and Collins, L.B., 2004. *The importance of changing oceanography in controlling late Quaternary carbonate sedimentation on a high-energy, tropical, oceanic ramp: north-western Australia*. Sedimentology 51, pp1179–1205. doi:10.1111/j.1365-3091.2004.00666.x.

JASCO Applied Sciences .2015. *Acoustic Characterisation of Subsea Choke Valve. Results from North West Shelf Measurements*.

Jenkins G.P. & McKinnon L. 2006. *Channel Deepening Supplementary Environment Effects Statement – Aquaculture and Fisheries*. Primary Industries Research, Victoria.

Jenner, K., Jenner, M., McCabe, K. 2001. *Geographical and temporal movements of humpback whales in Western Australian waters.* APPEA Journal 41: pp692–707.

Jensen, A.S. & Silber, G.K. 2004. *Large whale ship strike database*. NOAA Technical Memorandum NMFS-OPR.

Jimenez-Arranz, G., Glanfield, R., Banda, N., Wyatt, Roy. 2017. *Review on Existing Data on Underwater Sounds produced by the Oil and Gas Industry*. Prepared by Seiche Ltd. Submitted to E*P Sound & Marine Life (JIP).

Johnstone, R.E. and Storr G.M. (1998). *Handbook of Western Australian Birds.* Volume 1 - Non Passerines, Emu to Dollarbird. Western Australian Museum: Perth.

Jones, D. (ed.) 2004. *Report on the results of the Western Australian Museum/Woodside Energy Ltd. partnership to explore the marine biodiversity of the Dampier Archipelago Western Australia 1998–2002*. Western Australian Museum Supplement No. 66. Perth, Western Australia.

Jones, R., Bessel-Browne, P., Fisher, R., Klonowski, W. and Slivkoff, M. 2016. Assessing the impacts of sediments from dredging on corals. Marine Pollution Bulletin 102: 9-29.

Jones, D.O.B., Gates, A.R., Lausen, B. 2012. *Recovery of deep-water megafaunal assemblages from hydrocarbon drilling disturbance in the Faroe−Shetland Channel*. Marine Ecology Progress Series 461: 71-82.

Jones, D.O.B., Hudson, I.R. & Bett, B.J. 2006. *Effects of physical disturbance on the cold-water megafaunal communities of the Faroe-Shetland Channel*. Marine Ecology Progress Series 319: pp43-54.

Jones R, Fisher R, Bessell-Brown P, Negri A, Duckworth A (2019) Theme 4 | Synthesis Report: Defining thresholds and indicators of coral response to dredging-related pressures. Western Australian Marine Science Institution (WAMSI). Perth, Western Australia pp. 36.

Kamrowski R.L., Limpus C., Pendoley K. & Hamann M. 2014. *Influence of industrial light pollution on the sea-finding behaviour of flatback turtle hatchlings.* Wildlife Research, 41: 421-434

Kastelein, R.A., 2008. *Effects of vibrations on the behaviour of cockles (bivalve molluscs).* Bioacoustics: 17.

Kyba, C.C.M., Ruhtz, T., Fischer, J. & Hölker, F. 2011. *Cloud coverage acts as an amplifier for ecological light pollution in urban ecosystems.* PLoS ONE, 6(3), e17307.

Keesing, J.K. (Ed.) 2019. *Benthic habitats and biodiversity of the Dampier and Montebello Australian Marine* Parks. Report for the Director of National Parks. CSIRO, Australia.

Kinhill Pty Ltd. 1998. *East Spar Benthic Survey*. Biological Monitoring Program.

Kjeilen-Eilertsen, G., Trannum, H., Jak, R., Smit, M., Neff, J., Durell, G. 2004. Literature report on burial: derivation of PNEC as component in the MEMW model tool. Environmental Risk Management System (ERMS).

Kobryn, H.T., Woulters, K., Beckley, L.E., Heege, T. 2013. *Ningaloo Reef: Marine Habitats Mapped Using a Hyperspectral Sensor*. PLoS ONE 8(7). e70105. doi:10.1371/journal.pone.0070105.

Koops, W., Jak, R.G., van der Veen, D.P.C. 2004. *Use of Dispersants In Oil Spill Response To Minimize Environmental Damage To Birds And Aquatic Organisms.* Interspill.

Kostyvchenko, L.P. 1973. *Effects on elastic waves generated in marine prospecting on fish eggs in the Black Sea*. Hydrobiological Journal, 9: pp45 – 48.

Ladich, F. and Fay, R.R. 2013. *Auditory evoked potential audiometry in fish.* Reviews in Fish Biology and Fisheries doi:10.1007/s11160-012- 9297-z.

Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S., Podesta, M. 2001. *Collisions between ships and whales*. Marine Mammal Science 17: pp35-75.

Langham, N. & Hulsman, K. 1986. *The Breeding Biology of the Crested Tern Sterna bergii*. Emu 86: pp23-32. DOI: 10.1071/MU9860023. Accessed at https://www.researchgate.net/publication/259240622_The_Breeding_Biology_of_the_Crested_Tern_Sterna_bergii

Last, P., Lyne, V., Yearsley, G., Gledhill, D., Gommon, M., Rees, T. and White, W. 2005. *Validation of national demersal fish datasets for the regionalisation of the Australian continental slope and outer shelf (>40 m depth).* Australian Government Department of the Environment and Heritage and CSIRO Marine Research, Australia.

Lenhardt, M.L. 1994. *Seismic and very low frequency sound induced behaviours in captive loggerhead marine turtles (Caretta caretta)*. In: Bjorndal, K.A., Bolten, A.B., Johnson, D.A., Eliazar, P.J. (eds) 1994. Proceedings of the 14th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS—SEFSC-351, 323.

LeProvost, Dames & Moore. 1994*. Proposal to continue dredging of shellsand on Success Bank (1994 to 1996): Cockburn Cement Limmited: consultative environmental review / [Le Provost Dames & Moore]*. Western Australia. Environmental Protection Authority.

Lester, L.A., Avery, H.W., Harrison, A.S., E.A. Standora. 2013. *Recreational Boats and Turtles: Behavioral Mismatches Result in High Rates of Injury*. PLoS ONE 8(12): e82370. http://dx.doi.org/10.1371%2Fjournal.pone.0082370

Li, H., Haugen, G., Ditaranto, M., Berstad, D., Jordal, K., 2011. Impacts of exhaust gas recirculation (EGR) on the natural gas combined cycle integrated with chemical absorption CO_2 capture technology. Energy Procedia 4, 1411–1418.

Limia, J.M. 1996. *Seabed surveys: the best means to assess the environmental impact of drilling fluid discharges*. SPE 36048: pp803–813. Society of Petroleum Engineers, Inc. Richardson, TX.

Limpus, C.J. 2009. A Biological Review of Australian Marine Turtles. Brisbane, Queensland. Queensland Government Environmental Protection Agency. pp 324.

Limpus, C.J., A. Fleay & Guinea M. 1984. *Sea turtles of the Capricornia section, Great Barrier Reef.* Royal Society Queensland Symposium, pp. 61-78

Limpus, C.J. & Maclachlin, N. 1979. *Observations on the leatherback turtle, Dermochelys coriacea (L.), in Australia.* Australian Wildlife Research, 6: 105-116.

Limpus, C.J. & Maclachlin, N. 1994. *The conservation status of the Leatherback Turtle, Dermochelys coriacea, in Australia.* In: James, R, ed. Proceedings of the Australian Marine Turtle Conservation Workshop, Gold Coast 14-17 November 1990. Page(s) 63-67. Queensland Department of Environment and Heritage. Canberra: ANCA.

Limpus, C.J. 2007. *A biological review of Australian marine turtles. 5. Flatback turtle, Natator depressus (Garman)*. Queensland Government Environmental Protection Agency, Brisbane.

Limpus, C.J. 2008a. *A biological review of Australian marine turtles. 1. Loggerhead turtle, Caretta caretta (Linnaeus)*. Queensland Government Environmental Protection Agency, Brisbane.

Limpus, C.J. 2008b. *A biological review of Australian marine turtles. 2. Green turtle, Chelonia mydas (Linnaeus)*, A biological review of Australian marine turtles. Queensland Government Environmental Protection Agency, Brisbane.

Limpus, C.J. 2009. *A biological review of Australian marine turtles. 3. Hawksbill turtle, Eretmochelys ehaviour (Linnaeus)*, A biological review of Australian marine turtles. Queensland Government Environmental Protection Agency, Brisbane.

Limpus, C.J. & Kamrowski, R.L. 2013. *Ocean-finding in marine turtles: The importance of low horizon elevation as an orientation cue.* Behaviour, 150: 863-893.

Lin, Q. Mendelssogn, I.A. 1996. *A Comparative Investigation of the Effects of South Louisiana Crude Oil on the Vegetation of Fresh, Brackish and Salt Marshes.* Marine Pollution Bulletin 32, No. 2: pp202-209.

Loehr, L.C., Beegle-Krause, C.-J., George, K., McGee, C.D., Mearns, A.J., Atkinson, M.J. 2006. *The significance of dilution in evaluating possible impacts of wastewater discharges from large cruise ships*. Marine Pollution Bulletin 52: pp681–688.

Lohmann, C.M.F. & Lohmann, K.J. 1992. *Geomagnetic orientation by sea turtle hatchlings.* In Proceedings of the 12th International Symposium on Sea Turtle Biology and Conservation (eds J.I. Richardson & T.H. Richardson), Jekyll Island.

Lohmann, K.J., Witherington B.E., Lohmann C.M.F. & Salmon M. 1997. *Orientation, navigation, and natal beach homing in sea turtles, in The Biology of Sea Turtles.* Volume I, P.L. Lutz and J.A. Musick, Editors., CRC Press: Washington D.C. p. 107-135.

Longcore T., and Rich C. (2004). *Ecological light pollution*. Front Ecol Environ 2:191–198

Lutcavage, M., Lutz, P., Bossart, G., Hudson, D. 1995. *Physiologic and clinicopathologic effects of crude oil on loggerhead sea turtles.* Archives of Environmental Contamination and Toxicology 28: pp417–422.

Mackie, M., Nardi, A., Lewis, P., Newman, S. 2007. *Small pelagic fishes of the north-west marine region.* Department of Fisheries, Perth.

Maftei, A., King, E.J. and Flores M.C. 2013. *The Gorgon Field: an overview*. In: Keep, M. and Moss, S.J. (eds). The Sedimentary Basins of Western Australia 4. Proceedings of the Petroleum Exploration Society of Australia Symposium, Perth: pp23.

Marchant, S & Higgins, PJ (eds) 1990, Handbook of Australian, New Zealand and Antarctic birds, volume 1: ratites to ducks, part A: ratites to petrels, Oxford University Press, Melbourne

Marchant, S. and Higgins, P.J. 1990. *Handbook of Australian, New Zealand and Antarctic Birds*. Volume One: Ratites to Ducks. Oxford University Press, Melbourne.

Margvelashvili, N., Andrewartha, J., Condie, S., Herzfeld, M., Parslow, J., Sakov, P. & Waring, J. 2006. *Modelling Suspended Sediment Transport on Australia's North West Shelf, Technical Report No. 7*. CSIRO Marine and Atmospheric Research, North West Shelf Joint.

Marshall, A., Bennett, M., Kodja, G., Hinojosa-Alvarez, S., Galvan-Magana, F., Harding, M., Stevens, G., Kashiwaga, T. 2011. *Manta birostris (Chevron Manta Ray, Giant Manta Ray, Oceanic Manta Ray, Pacific Manta Ray, Pelagic Manta Ray) [WWW Document].* The IUCN Red List of Threatened Species. Accessed at http://www.iucnredlist.org/details/198921/0 (accessed 10.12.15).

Marshall, A.D., Compagno, L.J., Bennett, M.B. 2009. *Redescription of the genus Manta with resurrection of Manta alfredi (Krefft, 1868) (Chondrichthyes; Myliobatoidei; Mobulidae).* Zootaxa 2301: 1–28.

Marshall Day Acoustics 2019. *Scarbrough Gas USA/B Development. Underwater Noise Modelling Study.* Report for Woodside Energy Ltd. (Available within APPENDIX E).

Matishov, G. 1992. *The reaction of bottom-fish larvae to airgun pulses in the context of the vulnerable Barents Sea ecosystem*. Fisheries and Offshore Petroleum Exploitation 2nd International Conference, Bergen, Norway.

Matthews, M.N.R. 2012. *Underwater Sound Propagation from an Airgun Array in Baffin Bay: Shell 2012 Seismic Surveys in Baffin Bay Blocks 5 & 8*. Version 3.0. JASCO Applied Sciences.

Maylan, A. 1995. *Behaviour ecology of the Caribbean green turtle (Chelonia mydas)* in the *internesting habitat*. Biology and Conservation of the Sea Turtles. K. A Bjorndal, Smithsonian Institute: 67.

Mcauley, R.D., Jenner, C.K. 2010. *Migratory patterns and estimated population size of pygmy blue whales (Balaenoptera musculus brevicauda) traversing the Western Australian coast based on passive acoustics*. Intenational Whaling Commission.

McCauley, R. Bannister, J. Burton, C. Jenner, C. Rennie, S. Salgado, Kent C. 2004. *Western Australian exercise area blue whale project.* Final summary report, Milestone 6. Centre for Marine Science & Technology, Report 2004-29 . Curtin University, Bentley, Western Australia.

McCauley, R., Duncan, A. 2011. *Sea noise logger deployment, Wheatstone and Onslow, April 2009 to November 2010 (Technical Report No. R2011-23).* Centre for Marine Science and Technology, Curtin University of Technology, Perth.

McCauley, R.D. 1994. *Seismic Surveys*. In: *Environmental implications of offshore oil and gas development in Australia - the findings of an independent scientific review*. Swan, J.M., Neff, J.M. and Young, P.C. (Eds.). APEA. Sydney, pp19-121.

McCauley, R.D. 1998. *Radiated underwater noise measured from the drilling rig ocean general, rig tenders Pacific Ariki and Pacific Frontier, fishing vessel Reef Venture and natural sources in the Timor Sea, Northern Australia*. Prepared by Rob McCauley for Shell Australia.

McCauley, R.D. 2011. *Fugro Scarborough Sea Noise Logger Program: January 2010 to January 2011*. Report prepared for Fugro Survey and Exxon Mobil, by Centre for Marine Science and Technology, Curtin University. Project CMST 874, Report R2011-50.

McCauley, R.D. 2012. *Underwater Noise Generated by the Cossack Pioneer FPSO and its Translational to the Proposed Vincent Petroleum Field*. Prepared for Woodside Energy. Centre for Marine Science and Technology Curtin University. University of technology Perth Western Australia

McCauley, R.D. and Jenner, C. 2010. *Migratory patterns and estimated population size of pygmy blue whales (Balaenoptera musculus brevicauda) traversing the Western Australian coast based on passive acoustics*, Paper SC/62/SH26 presented to the International Whaling Committee Scientific Committee, 2010 (unpublished)

McCauley, R.D., Day, R.D., Swadling, Kerrie, M., Fitzgibbon, Q.P., Watson, R.A., Semmens, M.J. 2017. *Widely used marine seismic survey air gun operations negatively impact zooplankton*. Centre for Marine Science and Technology, Curtin University.

McCauley, R.D., Fewtrell, J., Duncan, A.J., Jenner, C., Jenner, N-M., Penrose, J.D., Prince, R.I.T., Adhitya, A., Murdoch, J., CcCabe, K. 2000. *Marine Seismic Surveys – A Study of Environmental implications*. APPEA Journal.

McCauley, R.D., Fewtrell, J., Popper, A.N. 2003. *High intensity anthropogenic sound damages fish ears*. The journal of the acoustical society of America, 113(1): pp638-642.

McCauley, RD. 2009. *Sea Noise Logger Deployment Scott Reef: 2006–2008 – Whales, Fish and Seismic Survey.* Report produced for Woodside Energy Limited 88.

McClatchie, S., Middleton, J., Pattiaratchi, C., Currie, D., and Kendrick, G. 2006. *The South-west Marine Region: Ecosystems and Key Species Groups*. Department of the Environment and Water Resources. Australian Government.

McDonald, S.F., Hamilton, S.J., Buhl, K.J., Heisinger, J. F. 1996. *Acute toxicity of fire control chemicals to Daphnia magna (Straus) and Selenastrum capricornutum (Printz)*. Ecotoxicology and Environmental Safety 33: pp62–72.

McGregor, F., Keulen, M. V., Waite, A., and Meekan, M. (2008). *Foraging ecology and population dynamics of the manta ray, Manta birostris in lagoonal waters of Ningaloo Reef, Western Australia*. In ‘Joint Meeting of Ichthyologists and Herpetologists. American Elasmobranch Society Devil Ray Symposium, Montreal, 23–28 July 2008’. Abstract 0338.

McGurk, M.D. 1986. *Natural mortality of marine pelagic fish eggs and larvas: role of spatial patchiness*. Mar. Ecol. Prog. Ser. Vol. 34:227–242, 20985. Available from: http://hcrs.co/wp-content/uploads/Hay%20Egg%20Loss%20Folder/McGurk%201986.pdf

McInnes, K., 2015. Wet Tropics Cluster Report, in: Ekström, M., Whetton, P., Gerbing, C., Grose, M., Webb, L., Risbey, J. (Eds.), Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports. CSIRO and Bureau of Meteorology, Australia.

McIntyre, A.D. & Johnson, R. 1975. *Effects of nutrient enrichment from sewage in the sea*. In: ALH Gameson, ed. Discharrge of sewage from sea outfalls. New Yorl: Pergamon Press. pp131-141.

McKenna M.F., Calambokidis, J., Oleson, E.M., Laist, D.W., and Goldbogen, J.A. 2015 *Simultaneous tracking of blue whales and large ships demonstrates limited behavioural responses for avoiding collision*. Endangered species Research 27: pp219–232.

McKinley, A., Johnston, E.L. 2010. *Impacts of contaminant sources on marine fish abundance and species richness: a review and meta-analysis of evidence from the field*. Evolution & Ecology Research Centre, School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney. Marine Ecological Progress Series 420: pp175–191.doi: 10.3354/meps08856

McLean D, Partridge J., Bond T, Birt M., Bornt K., Langlois T. 2017 *Using industry ROV videos to assess fish associations with subsea pipelines.* Cont Shelf Res.;141: pp76–97.

McLean, D.L., Taylor, M.D., Partridge, J.C., Gibbons, B., Langlois,T.J., Malseed, B.E., Smith, L.D., & Bond, T. 2018. *Fish and habitats on wellhead infrastructure on the north west shelf of Western Australia.* Continental Shelf Research, 164: 10-27,

McLean D.L., Vaughan, B.I., Malseed, B.E., & Taylor, M.D. 2020. *Fish-habitat associations on a subsea pipeline within an Australian Marine Park*. Marine Environmental Research, 153: 1-14.

McLeay L.J. 2009. *The life history characters, reproductive constraints and foraging strategies of a neritic seabird, the crested tern*. PhD thesis, University of Adelaide, Australia.

McLeay LJ, Page B, Goldsworthy SD, Paton DC, Teixeira C, Burch P, Ward TM. 2010. *Foraging behaviour and habitat use of a short-ranging seabird, the crested tern*. Marine Ecology Progress Series 411:271-283Meagher & LeProvost. 1979. *Marine environment of Dampier Archipelago.* Woodside Petroleum Development Pty Ltd, Perth.

McLoughlin, R.J., & Young, P.C. 1985. *Sedimentary provinces of the fishing grounds of the North West Shelf of Australia: grain-size frequency analysis of surficial sediments*. Australian Journal of Marine and Freshwater Research, 36: pp671-81.

Meekan, M. G. , Wilson , S. G., Halford , A. and Retzel, A. 2001. A comparison of catches of fishes and invertebrates by two light trap designs, in tropical NW Australia. Marine Biology 139: 373–381.

Melton, H.R., Smith, J.P., Martin, C.R., Nedwed, T.J., Mairs, H.L. Raught, D.L. 2000. *Offshore Discharge of Drilling Fluids and Cuttings -A Scientific Perspective on Public Policy*.

Mercury Firesafety. 2013. *Safety Data Sheet: Fomtec ARC Miljo 3x3*. Issued 12 August 2013. Mercury Firesafety, Melville, Western Australia.

Milton, SL & Lutz, P. 2003. *Physiological and Genetic Response to Environmental Stress*. The Biology of Sea Turtles 2. CRC Press, Boca Raton: pp163.

Mineur, F., Johnson, M.P., Maggs, C.A. Stegenga, H. 2007, *Hull fouling on commercial ships as a vector of macroalgal introduction*., Marine Biology 151: pp1299–1307.

Miyazaki, S., Stagg, H. 2013. *Exmouth Plateau [WWW Document].* Geoscience Australia: National Geological Provinces Online Database. Accessed at http://www.ga.gov.au/provexplorer/provinceDetails.do?eno=30351 (Accessed 8.30.16).

Möller, L., Attard, C., Double, M., Paton, D., Bilman, K. 2015. Australian Marine Mammal Centre Final Report; Season 2015. Australian Marine Mammal Centre Australian Antarctic Division. Accessed at: https://data.marinemammals.gov.au/common/documents/grants/2013/13_43_Moller_Attard.pdf

Mollet, H., Cliff, G., Pratt Jr, H., Stevens, J. 2000. *Reproductive biology of the female shortfin mako, Isurus oxyrinchus Rafinesque, 1810, with comments on the embryonic development of lamnoids*. Fishery Bulletin – National Oceanic and Atmospheric Administration 98(2): pp2pp-318.

Moody, C.A. & Field, J.A. 2000. *Perfluorinated Surfactants and the Environmental Implications of Their Use in Fire-Fighting Foams*. Environmental Science and Technology, 34 (18): pp3864–3870.

Morgan, D., Whitty, J., Phillips, N. 2010. *Endangered sawfishes and river sharks in Western Australia.* Centre for Fish and Fisheries Research, Murdoch University, Perth.

Morrice, M. G. 2004. *Killer whales (Orcinus orca) in Australian territorial waters.* In T. Paper (Ed.): Deakin University, Victoria. Australia. IWC report SC/59/SM7

Mortimer, J.A. and Portier, K.A. 1989. *Reproductive Homing and Internesting Behavior of the Green Turtle (Chelonia mydas) at Ascension Island, South Atlantic Ocean*. American Society of Ichthyologists and Herpetologists (ASIH) 4: pp962-977.

Mosher, J.L. 1972. *The responses of Macoma balthica (bivalve) to vibrations*. Proceedings of the Malacological Society of London: 40.

MScience, 2018a, Marine Habitat Mapping: Dampier and Cape Lambert 2017. Unpublished report MSA264R01 to Rio Tinto, Perth Western Australia, pp13.

MScience, 2018b, Extent and Intensity of Turbid Plumes around the Pluto Trunkline Dredging Program 2009. Unpublished report MSA271R01 to Worley Parsons, Perth Western Australia, pp31.

MScience. 2010. *Pluto LNG Development: Final Report on Coral and Water Quality Monitoring: 5 Oct 2010*. Report: MSA93R160, Unpublished Report to Woodside Burrup Pty Ltd Contract OC00002273 by MScience Pty Ltd, Perth, WA.

MScience. 2019. *Woodside Scarborough dredging threshold levels for model interrogation*. MScience Pty Ltd, West Perth, WA, Australia.

Mrosovsky, N. & Shettleworth, S.J. 1968. *Wavelength preferences and brightness cues in the water finding behaviour of sea turtles.* Behaviour, 32: 211-257.

National Energy Resources Australia (NERA). 2017. *Environmental Plan Reference Case Planned discharge of sewage, putrescible waste and grey water*. Department of Industry, Innovation and Science. Australian Government.

National Energy Resources Australia (NERA). 2018. Environment Plan Reference Case Anchoring of Vessels and Floating Facilities. Department of Industry, Innovation and Science. Australian Government.

National Industrial Chemicals Notification and Assessment Scheme (NICNAS).2014 . *Public Report - File No: STD/1473 and STD/1474*.

National Marine Fisheries Service (NMFS). 2005. *Marine Mammal Acoustic Thresholds*. National Oceanic and Atmospheric Administration (NOAA) Fisheries Wet Coast Region. Accessed at https://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/threshold_guidance.html

National Oceanic and Atmospheric Administration. 2010. *Oil and sea turtles: Biology, planning and response*. National Oceanic and Atmospheric Administration, Washington.

National Resource Damage Assessment (NRDA). 2012. *Status Update for the Deepwater Horizon oil Spill.* Gulf Spill Restoration. NOAA.

Nedwed, T., Smith, J. P., Melton, R. 2006. *Fate of non-aqueous drilling fluid cuttings discharged from a deepwater exploration well*. In SPE International Health Safety & Environment Conference. Abu Dhabi, UAE, 2-4 April 2006. SPE98612.

Neff, J.M. 2005. *Composition, Environmental Fates, and Biological Effect of Water based Drilling Muds and Cuttings Discharges to the Marine Environment: A Synthesis and Annotated Bibliography.* Submitted to PERF.

Neff, J.M. 2010. *Fate and Effects of Water Based Drilling Muds and cuttings in Cold Water Environments*. Neff & Associates LLC. Shell Exploration and Production Company.

Neff, J.M., Bothner MH, Maciolek NJ & Grassle JF (1989). Impacts of exploratory drilling for oil and gas on the benthic environment of Georges Bank. Marine Environmental Research 27: 77-114

Negri, A.P., Heyward, A.J., 2000. *Inhibition of fertilization and larval metamorphosis of the coral Acropora millepora (Ehrenberg, 1834) by petroleum products*. Marine Pollution Bulletin 41: pp420–427.

Neuparth, T., Costa, F.O. & Costa, M.H. 2002. *Effects of Temperature and Salinity on Life History of the Marine Amphipod Cammarus locusta*. Implications for Ecotoxicological Testing. Ecotoxicology 11: pp61-73.

Newell RC, Seiderer LJ and Hitchcock DR (1998). *The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed*. Oceanography and Marine Biology: an Annual Review 1998. Vol. 36: 127-78.

Newman, S., Wakefield, C., Skepper, C., Boddington, D., Jones R. and Smith, E. 2017. North Coast Demersal Resource Status Repor 2017. Department of Primary Industries and Regional Development. Accessed at: http://www.fish.wa.gov.au/Documents/sofar/status_reports_of_the_fisheries_and_aquatic_resources_2016-17.pdf

Norment, C.J., Green, K., 2004. Breeding ecology of Richard's Pipit (Anthus novaeseelandiae) in the Snowy Mountains. Emu-Austral Ornithology 104, 327–336.

Nowacek, D.P., Thornet, L.H., Johnston, D.W., Tyack, P.L. 2007. *Responses of cetaceans to anthropogenic noise*. Mammal Society, Mammal Review, 37: pp81–115.

O'Hara, J. & Wilcox, J.R. 1990. *Avoidance responses of loggerhead turtles, Caretta caretta, to low frequency sound.* Copeia 1990 2: pp564-567.

O'Hara, P.D. & Morandin, L.A. 2010. *Effects of sheens associated with offshore oil and gas development on the feather microstructure of pelagic seabirds*. Marine Pollution Bulletin 60: pp672-678.

Ocean Affinity. 2018.. *Base Case Slope ROV Investigation Field Report. Scarborough development – Trunkline Route Deepwater Geophysical Survey 2018*. Report for Woodside Energy Ltd. Document Number OIF-OPS-PR-013.

Offshore: Risk & Technology Consulting Inc. 2002. *Post mortem failure assessment on MODUs during Hurricae Lili* (MMS Order No. 0103PO72450). Minerals Management Service, Houston.

Oliver, G.A. & Fisher, S.J. 1999. *The Persistence and Effects of Non-Water Based Drilling Fluids on Australia's North West Shelf: Progress Findings from Three Seabed Surveys*. APPEA Journal pp. 647–662.

OSPAR. 2009. *Assessment of impacts of offshore oil and gas activities in the North-East Atlantic*. OSPAR Commission.

Oxford Economics, 2010. Potential impact of the Gulf oil spill on tourism. Prepared for the US Travel Association, 27.

Owen K., Dunlop R. A., Monty J. P., Chung D., Noad M. *J., Donnelly D., et al. 2016. Detecting* surface-feeding behavior by rorqual whales in accelerometer data. Mar. Mamm. Sci. 32:327–348.

Owens, E.H. & Sergy, G.A. 1994. *Field guide to the documentation and description of oiled shorelines*. Environment Canada, Edmonton, Alberta.

Parnell, P.E. 2003. *The effects of sewage discharge on water quality and phytoplankton of Hawai'ian Coastal Waters*. Marine Environmental Research 44: pp293-311.

Parr, W., Clarke, S.J., Van Dijk, P. Morgan, N. 1998. *Turbidity in English and Welsh tidal waters*. WRc Report No. CO 4301. Report for English Nature. WRc Medmenham, Bucks.

Parry, G.D. & Ganson, A. 2006. The effect of seismic surveys on catch rates of rock lobsters in western Victoria, Australia. Fisheries Research. Elsevier B.V.

Patterson, H., Noriega, R., Georgeson, L., Larcombe, J. and Curtotti, R. 2017. *Fishery status reports 2017*. Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.

Patterson, H., Noriega, R., Georgeson, L., Larcombe, J. and Curtotti, R., Williams, A., Helidoniotis, F., Nicol, S. 2018. *Fishery status reports 2018*. Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra. Department of Agriculture and Water Resources. Australian Government.

Pearce, A., Buchan, S., Chiffings, T., D'Adamo, N., Fandry, C., Fearns, P., Mills, D., Phillips, R. amd Simpson, C. 2003. *A review of the oceanography of the Dampier Archipelago, Western Australia*. The Marine Flora and Fauna of Dampier, Western Australia. Western Australian Museum, Perth: pp. 13–50.

Pears and Williams, 2005. *Potential effects of artificial reefs on the Great Barrier Reef: background paper*. CRC Reef Research Center Technical Report No. 60. CRC Reef Research Centre. 33 p

Pearson, W. H., Skalski, J. R., Sulkin, S. D. & Malme, C. I. 1994. *Effects of seismic energy releases on the survival and development of zoeal larvae of dungeness crab (Cancer magister)*. Marine Environmental Research, 38: pp93-113.

Pendoley, K.L. 2005. *Sea turtles and the environmental management of industrial activities in North West Western Australia.* Murdoch University. Division of Science and Engineering.

Pendoley, K. 2005. *Sea Turtles and Industrial Activity on the North West Shelf, Western Australia*. PhD dissertation, Murdoch University, Perth, Australia.

Pendoley, K. & Kamrowski, R.L. 2015. *Influence of horizon elevation on the sea-finding behaviour of hatchling flatback turtles exposed to artificial light glow.* Marine Ecology Progress Series, 529: 279-288.

Pendoley, K., Whittock P.A., Vitenbergs A. & Bell, C. 2016. Twenty years of turtle tracks: marine turtle nesting activity at remote locations in the Pilbara, Western Australia. Australian Journal of Zoology, 64: 217–226.

Pendoley 2020a. Scarborough Desktop Lighting Impact Assessment. Report prepared for Advisian (on behalf of Woodside Energy). Available in Appendix K.

Pendoley 2020b. Scarborough Light Modelling. Report prepared for Advisian (on behalf of Woodside Energy). Available in Appendix L.

Petroleumstilsynet. 2014. *Anchor line failures Norwegian continental shelf 2010-2014* (Report No. 992081). Petroleumstilsynet, Stavanger.

Pierce, S.J. & Norman, B. 2016. Rhincodon typus. The IUCN Red List of Threatened Species 2016: e.T19488A2365291. http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T19488A2365291.en. Downloaded on 09 April 2019.

Pilbara ports Authority (PPA). 2018. Pilbara Ports Authority Annual Report 2017 – 18. Department of transport, Planning and Lands. Accessed at https://www.pilbaraports.com.au/PilbaraPortsAuthority/media/Documents/ABOUT%20THE%20PORT/Corporate%20Governance/Annual%20Reports/2312-PPA-AR-2018-interactive.pdf

PPA. 2019. Pilbara Ports Authority Annual Report 2018 – 19. Department of transport, Planning and Lands. Accessed at https://www.pilbaraports.com.au/PilbaraPortsAuthority/media/Documents/ABOUT%20THE%20PORT/Corporate%20Governance/Annual%20Reports/2019/2019-PPA-Annual-Report-Reduced.pdf

Pilcher N., Enderby S., Stringell T. & Bateman L. 2000. *Nearshore turtle hatchling distribution and predation, in Sea turtles of the Indo-Pacific: research management and conservation.* Proceedings of the Second ASEAN Symposium and Workshop on Sea Turtle Biology and Conservation, N. Pilcher and G. Ismail, Editors. ASEAN Academic Press: London.

Pineda, M-C., Strehlow, B., Duckworth, A. and Webster, N.S., 2017a. *Effects of dredging-related stressors on sponges: laboratory experiments*. Report of Theme 6 - Project 6.4. Prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth Western Australia.

Pitcher, C.R., Miller, M., Morello, E., Fry, G., Strzelecki, J., McLeod, I., Slawinski, D., Ellis, N., Thomson, D., Bearham, D., Keesing, J., Donovan, A., Mortimer, N. Babcock, R., Fromont, J, Gomez, O., Hosie, A., Hara, A., Moore, G., Morrison, S., Kirkendale, L., Whisson, C., Richards, Z., Bryce, M., Marsh, L., Naughton, K., O'Loughlin, M., O'Hara, T., Boddington, D., Huisman, J. 2016. *Environmental Pressures: Regional Biodiversity — Pilbara Seabed Biodiversity Mapping & Characterisation*. Final report, CSIRO Oceans & Atmosphere, Published Brisbane.

Plotkin, P. (2003). *The Biology of Seaturtles, Volume 2 – Chapter 8*: Adult Migrations and Habitat Use. CRC Press LLC.

Popper, A. N., Hawkins, A. D., Fay, R. R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W. T., Gentry, R., Halvorsen, M. B., Løkkeborg, S., Rogers, P., Southall, B. L., Zeddies, D., and Tavolga, W. N. 2014. *Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report*. ASA S3/SC1.4 TR-201.4 prepared by ANSI Accredited Standards Committee.

Popper, A.N. & Hawkins, A.D. 2018. *The importance of particle motion to fishes and invertevrates*. J Acoust Soc Am 143(1): pp470.

Preen, A. 2004. *Distribution, abundance and conservation status of dugongs and dolphins in the southern and western Arabian Gulf*. Biological Conservation Vol 118(2): pp205-218.

Preen, A., Marsh, H., Lawler, I., Prince, R., Shepherd, R. 1997. *Distribution and abundance of dugongs, turtles, dolphins and other megafauna in Shark Bay, Ningaloo Reef and Exmouth Gulf, Western Australia.* Wildlife Research 24: pp185–208.

Prieto, R., Janiger, D., Silva, M.A., Waring, G.T., Gonçalves, J.M. 2012. *The forgotten whale: a bibliometric analysis and literature review of the North Atlantic sei whale Balaenoptera borealis.* Mammal Review 42: pp235–272. Doi:10.1111/j.1365-2907.2011.00195.x.

Ramirez-Llodra, E., Brandt, A., Danovaro, R., De Mol, B., Escobar, E., German, C.R., Levin, L.A., Martinez Arbizu, P., Menot, L., Buhl-Mortensen, P., Narayanaswamy, B.E., Smith, C.R., Tittensor, D.P., Tyler, P.A., Vanreusel, A. and Vecchione, M. 2010. *Deep, Diverse and Definitely Different: Unique Attributes of the World's Largest Ecosystem*. Biogeosciences, 7: pp2851–2899.

Rich C, Longcore T (eds) (2006) Ecological consequences of artificial night lighting. Island Press, Washington, USA

Richardson, A.J., Matear, R.J. & Lenton, A. 2017. *Potential impacts on zooplankton of seismic surveys*. CSIRO Oceans and Atmosphere. APPEA. Australia. 34pp.

Richardson, W. J., Greene, C. R., Maime, C. I. and Thomson, D. H. 1995. *Marine Mammals and Noise*. Academic Press, San Diego, California.

Ritchie, E.G., Bolitho, E.E., 2008. Australia's savanna herbivores: bioclimatic distributions and an assessment of the potential impact of regional climate change. Physiological and Biochemical Zoology 81, 880–890.

Roberts, L. & Elliot, M. 2017. *Good or bad vibrations? Impacts of anthropogenic vibration on the marine epibenthos.* Institute of Estuarine and Coastal Studies (IECS). University of Hull, United Kingdom.

Roberts, L., Cheesman, S., Breithaupt, T., and Elliott, M. 2015. *Sensitivity of the mussel Mytilus edulis to substrate-borne vibration in relation to anthropogenically generated noise*. Mar. Ecol. Prog. Ser. 538: pp185-195.

Roberts, L., Harding, H.R., Voellmy, I., Bruintjes, R., Simpson, D., Radford, A.N., Breithaupt, T., Elliot, M. 2016. *Exposure of benthic invertebrates to sediment vibration: from laboratory experiments to outdoor simulated pile-driving.* Acoustical Society of America.

Ross, D. G. 1987. *Mechanics of Underwater Noise*. Los Altos, CA, Peninsula Publishing.

Ross, D. G. 1993. *On ocean underwater ambient noise*. Acoustics Bulletin January/February:

Rosser, N., Gilmour, J. 2008. *New insights into patterns of coral spawning on Western Australian reefs.* Coral Reefs 27: pp345–349.

RPS 2010. *Humpback Whale Survey Report*. Report produced for Woodside Energy Limited. 173 pp.

RPS 2011. *Environment Plan, Deep Water Northwest Shelf Australia MC2D Survey, Public Summary*. RPS Group. Perth, Australia.

RPS 2016. *Rio Tinto Pilbara Ports: Dredge spoil placement stability study*, provided to Rio Tinto Iron Ore and Woodside Energy Ltd, Perth, WA, Australia.

RPS 2019a. *Advisian Scarborough Cooling Water Discharge Modelling Results*. Prepared for Advisian on behalf of Woodside Energy Ltd. RPS Group.

RPS 2019b*. Advisian Scarborough Produced Water Discharge Modelling Results*. Prepared for Advisian on behalf of Woodside Energy Ltd. RPS Group.

RPS 2019c*. Advisian Scarborough Hydrotest Discharge Modelling Results*. Prepared for Advisian on behalf of Woodside Energy Ltd. RPS Group.

RPS 2019d*. WEL Scarborough development Quantitative Spill Risk Assessment - Preliminary Results*. Prepared for Advisian on behalf of Woodside Energy Ltd. RPS Group.

RPS 2019e*. WEL Scarborough Project Dredged Sediment Dispersion Modelling*. Prepared for Advisian on behalf of Woodside Energy Ltd. RPS Group.

RPS Bowman Bishaw Gorham. 2007. *Gorgon Project – Marine Baseline Survey July/August 2006*. Prepared for Chevron Australia, Perth, Western Australia.

RPS Environment and Planning. 2012. *Analysis of sea noise in the Greater Western Flank survey area, September 2010 to August 2011.* RPS Environment and Planning Pty Ltd, Perth.

Runcie, J., Macinnis-Ng, C., Ralph, P. 2010. *The toxic effects of petrochemicals on seagrassess - literature review*. Institute for Water and Environmental Resource Management, University of Technology Sydney, Sydney.

Saeed S, Nandita D, Ismail AS, et al. (2019) Toxicity to residual chlorine: Comparison of sensitivity of native Arabian Gulf species and non-native species. International Journal of Scientific Research in Environmental Science and Toxicology, 4(1):1-11.

Salgado Kent, C., Jenner, C., Jenner, M., Bouchet, P. and Rexstad, E. 2012*. Southern Hemisphere breeding stock D humpback whale population estimates from North WestCape, Western Australia*. J. Cetacean Res. Manage. 12(1): 29–38.

Salmon, M., Wyneken, J., Fritz, E. & Lucas, M. 1992. *Sea finding by hatchling sea turtles: role of brightness, silhouette and beach slope orientation cues*. Behaviour, 122: 56-77.

Salmon, M. & Witherington, B. 1995. *Artificial lighting and seafinding by loggerhead hatchlings: Evidence for lunar modulation.* Copeia*,* 1995: 931 – 938.

Salmon, M. 2003. *Artificial night lighting and sea turtles.* Biologist, 50: 163-168.

Samaran F., Adam O., Guinet C. 2010a. *Detection range modeling of blue whale calls in Southwestern Indian Ocean*. Applied Acoustics 71:1099–1106.

Samaran F., et al. 2013. *Seasonal and geographic variation of southern blue whale subspecies in the Indian Ocean*. PLoS ONE 8:e71561.

Sanderfoot V, Holloway T (2017) *Air Pollution impacts on avian species via inhalation exposure and associated outcomes*. Environmental Research Letters 12: 8.

Schaefer, T. 2013. *Aquatic Impacts of Firefighting Foams*. Whitepaper. Form Number F-2012007, Solberg.

Scholik, A.R. & Yan, H.Y. 2002. *Effects of boat engine noise on the auditory sensitivity of the fathead minnow, Pimephales promelas*. Environmental Biology of Fishes 63: pp203–209.

Sepulveda, C., Kohin, S., Chan, C., Vetter, R., Graham, J. 2004. *Movement patterns, depth preferences, and stomach temperatures of free-swimming juvenile mako sharks, Isurus oxyrinchus, in the Southern California Bight.* Marine Biology 145: pp191–199.

Shaw, R. F., Lindquist, D. C., Benfield, M. C., Farooqi, T., Plunket, J. T. 2002. *Offshore petroleum platforms: functional significance for larval fish across longitudinal and latitudinal gradients*. Prepared by the Coastal Fisheries Institute, Louisiana State University. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2002-077, p. 107.

Shell. 2009. *Prelude Floating LNG Project Draft Environmental Impact Statement*. Shell Development (Australia) Propriety Limited. EPBC 2008/4146. Accessed at https://www.shell.com.au/promos/sustainability/prelude-eis/_jcr_content.stream/1475632907147/505e8ebcbe61edd3af48354d6e0e890f45e59406e0c9b8c78cf8e65476386652/prelude-eis.pdf

Shell. 2010. *Prelide Floating LNG Project EIS Supplement-Response to Submissions*. Shell Development (Australia) Proprietary Limited. EPBC 2008/4146.

Sheppart et al. 2006. *Movement heterogeneity of dugongs, Dugong dugon (Müller), over large spatial scales*. Journal of Experimental Marine Biology and Ecology Vol. 334 pp64–83. School of Tropical Environment Studies and Geography. James Cook University. Townsville 4811. Australia.

Shigenaka, G., 2001. *Toxicity of oil to reef building corals: a spill response perspective* (NOAA Technical Memorandum No. NOS OR&R 8). National Oceanic and Atmospheric Administration, Seattle.

Simmonds, M., Dolman, S. & Weilgart, L. 2004. *Oceans of Noise. Whale and Dolphin Conservation Society*. Wiltshire.

Simpson, C.J., Cary, J.L., Masini, R.J. 1993. *Destruction of corals and other reef animals by coral spawn slicks on Ningaloo Reef, Western Australia.* Coral Reefs 12: pp185–191. Doi:10.1007/BF00334478.

Sinclair Knight Merz (SKM). 2006. *Northwest Shelf Cumulative Environmental Impact Study – Offshore Marine Cumulative Assessment*. Report prepared for Woodside Energy Pty Ltd by Sinclair Knight Merz, Perth, WA.

SKM. 1996. *East Spar Gas Field Long Term Environmental Monitoring Program*. Preproduction survey. Report prepared by Sinclair Knight Merz for WMC Resources, Perth.

Sleeman, J.C., Meekan, M.G., Fitzpatrick, B.J., Steinberg, C.R., Ancel R. Bradshaw, C.A.J. 2010. *Oceanographic and atmospheric phenomena influence the abundance of whale sharks at Ningaloo Reef.* Western Australia. Journal of Experimental Marine Biology and Ecology 382: pp77-81.

Sleeman, J.C., Meekan, M.G., Wilson, S.G., Jenner, K.C.S., Jenner, M.N., Boggs, G., Bradshaw, C.J.A. 2007. *Biophysical correlates of relative abundances of marine megafauna at Ningaloo Reef, Western Australia*. Marine and Freshwater Research Vol. 58: pp608-623.

Smith, M.E., Kane, A.S., Popper, A.N. 2004. Acoustical stress and hearing sensitivity in fishes: does the linear threshold shift hypothesis hold water? The Journal of Experimental Biology 207: pp3591-3602. doi:10.1242/jeb.01188.

Smith, M.E., Coffin, A.B., Miller, A.B., Miller, D.L., Popper, A.N. 2006. *Anatomical and functional recovery of the goldfish (Carassius auratus) ear following noise exposure*. Journal of Experimental Biology 209: pp4193-4202; doi: 10.1242/jeb.02490.

Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., Miller, H.L., 2007. Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Song, J., Mathieu, A., Soper, R. F., Popper, A. N. 2006. *Structure of the inner ear of bluefin tuna Thunnus thynnus.* J. Fish Biol. 68, 1767–1781.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene Jr C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A and Tyack, P.L. 2007. *Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations*. Aquatic Mammals 33 (4): pp411–414.

Spalding, M.D., Brown, B.E., 2015. Warm-water coral reefs and climate change. Science 350, 769–771.

Stafford K. M., Bohnenstiehl D. R., Tolstoy M., Chapp E., Mellinger D. K., Moore S. E. 2004. *Antarctic type blue whale calls recorded at low latitudes in the Indian and eastern Pacific Oceans*. Deep-Sea Research II 51:1337–1346.

Stafford K. M., Chapp E., Bohnenstiel D. R., Tolstoy M. 2011. *Seasonal detection of three types of "pygmy" blue whale calls in the Indian Ocean*. Marine Mammal Science 27:828–840.

Starbird, C.H. & Hills, A.M. 1992. *Telemetry studies of the internesting movements and behaviour of hawksbill sea turtles (Eretomchelys imbricata) around Buck Island Reef National Monument, St Croix US Virgin Islands*. Proceedings of the Twelfth annual workshop of sea turtle biology and conservation, Jekyll Island, Georgia, NOAA Technical Memorandum NMFS- SEFSC-361, pp134. *Statement*. EPBC 2013/7079. November 2014. Woodside Energy, Perth WA.

Stapput, K. & Wiltschko, W. 2005. *The sea-finding behavior of hatchling olive ridley sea turtles, Lepidochelys olivacea, at the beach of San Miguel (Costa Rica).* Naturwissenschaften, 92(5): 250-253.

Statton, J., McMahon, K., Armstrong, P., et al., 2017. *Determining light stress bio-indicators and thresholds for a tropical multi-species seagrass assemblage*. Report of Theme 5 – Project 5.5.3. Prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth Western Australia.

Steffen, W., Burbidge, A.A., Hughes, L., Kitching, R., Lindenmayer, D., Musgrave, W., Staford Smith, M., Werner, P., 2009. Australia´s biodiversity and climate change: A strategic assessment of vulnerability of Australia´s biodiversity to climate change. A report to the Natural resource Management Ministerial Council commissioned by Australian Government. CSIRO Publishing.

Stevens, J., McAuley, R., Simpfendorfer, C., Pillans, R. 2008. *Spatial distribution and habitat utilisation of sawfish (Pristis spp.) in relation to fishing in northern Australia*. CSIRO Marine and Atmospheric Research, Hobart.

Stevens, J., Pillans, R., Salini, J. 2005. *Conservation assessment of Glyphis sp. A (speartooth shark), Glyphis sp. C (northern river shark), Pristis microdon (freshwater sawfish) and Pristis zijsron (green sawfish).* CSIRO Marine Research, Hobart.

Stevens, J.D., Bradford, R.W., West, G.J. 2010. *Satellite tagging of blue sharks (Prionace glauca) and other pelagic sharks off eastern Australia: depth behaviour, temperature experience and movements.* Marine Biology 157: pp575–591.

Stoneburner, D.L. 1982. *Satellite Telemetry of Loggerhead Sea Turtle Movement in the Georgia Bight. American Society of Ichthyologists and Herpetologists (ASIH) 2: pp*400-408.

Sun, C, Shimizu, K & Symonds, G 2016. *Numerical modelling of dredge plumes: a review*, report of Theme 3 - Project 3.1.3 prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth, WA, Australia, 55 pp.

Swan, J.M., Neff, J.M., Young, P.C. 1995. Environmental implications of offshore oil and gas development in Australia: the findings of an independent scientific review / Independent Scientific Review Committee. Independent Scientific Review Committee (Australia). Australian Petroleum Exploration Association (APEA).

Tang, K.W., Gladyshev, M.I., Dubovskaya, O.P., Kirillin, G. and Grossar, H-P., 2014. Zooplankton carcasses and non-predatory mortality in freshwater and inland sea environments. Journal of Plankton Research, 36: 597–612.

Taylor, J. G.; Pearce, A. F. *Ningaloo Reef currents: implications for coral spawn dispersal, zooplankton and whale shark abundance*. Journal of the Royal Society of Western Australia. 1999; 82:57-65.

Terrens, G.W., Gwyther, D., KeoughM.J., Tait, R.D. 1998. *Environmental assessment of synthetic based drilling mud discharges to Bass Strait, Australia*. SPE 46622. p1–14 In: 1998 SPE International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production. Caracas, Venezuela, 7-10 June 1998. Society of Petroleum Engineers, Inc. Richardson, TX.

Thums, M., Whiting, S.D, Reisser, J.W., Pendoley, K.L., Pattiaratchi C.B., Harcourt, R.G., Mcmahon, C.R. & Meekan, M.G. 2013. *Tracking sea turtle hatchlings—A pilot study using acoustic telemetry.* Journal of Experimental Marine Biology and Ecology, 440:156 - 163.

Thums, M., Whiting, S.D, Reisser, J.W., Pendoley, K.L., Pattiaratchi C.B., Proietti, M., Hetzel, Y., Fisher, R. & Meekan, M.G. 2016. *Artificial light on water attracts turtle hatchlings during their near shore transit.* Royal Society Open Science 3: http://doi:10.1098/rsos.160142

Thorburn, D.C., Morgan, D.L., Rowland, A.J., Gill, H.S., Paling, E. 2008. *Life history notes of the critically endangered dwarf sawfish, Pristis clavata, Garman 1906 from the Kimberley region of Western Australia.* Environmental Biology of Fishes 83: pp139–145.

Thornhill, D.J., Struck, T.H., Ebbe, B., Lee, R.W., Mendoza, G.F., Levin, L.A. and Halanych, K.M. 2012. *Adaptive radiation in extremophilic Dorvilleidae (Annelida): diversification of a single colonizer or multiple independent lineages?* Ecology and Evolution 2(8): pp1958–1970.

Threatened Species Scientific Committee (TSSC). 2008a. Conservation Advice:.Dermochelys coriacea (Leatherback Turtle). Department of Sustainability, Environment, Water, Population and

Communities. Department of the Environment and Energy. Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/1768-conservation-advice.pdf

Threatened Species Scientific Committee (TSSC). 2008b. Approved Conservation Advice for Green Sawfish. Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy. Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/68442-conservation-advice.pdf

Threatened Species Scientific Committee (TSSC). 2009. Approved Conservation Advice for Pristis clavate (Dwarf Sawfsh). Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/68447-conservation-advice.pdf

Threatened Species Scientific Committee (TSSC). 2011. *Conservation advice for Sterna nereis nereis (Fairy tern).* Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy.

Threatened Species Scientific Committee (TSSC). 2011b. *Sternula nereis nereis (fairy tern) listing advice.* Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy. Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/82950-listing-advice.pdf

Threatened Species Scientific Committee (TSSC). 2014. *Listing Advice Isurus oxyrinchus shortfin mako shark*. Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy. Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/79073-listing-advice.pdf (Accessed 9 October 2018).

Threatened Species Scientific Committee (TSSC). 2015a. Conservation Advice:.Balaenoptera borealis sei whale. Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy. Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/34-conservation-advice-01102015.pdf

Threatened Species Scientific Committee (TSSC). 2015b. Conservation Advice:.Balaenoptera physalus fin whale. Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy. Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/37-conservation-advice-01102015.pdf

Threatened Species Scientific Committee (TSSC). 2015c. Conservation Advice: Medaptera novaeangliae humpback whale. Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy. Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/38-conservation-advice-10102015.pdf.

Threatened Species Scientific Committee (TSSC). 2015d. *Approved Conservation Advice for Rhincodon typus (whale shark)*. Threat Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy. Accessed at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/66680-conservation-advice-01102015.pdf. (Accessed 10 October 2018).

Threatened Species Scientific Committee (TSSC). 2015e. Conservation Advice Calidris ferruginea curlew sandpiper. Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/856-conservation-advice.pdf

Threatened Species Scientific Committee (TSSC). 2015f. Conservation Advice Numenius madagascariensis eastern curlew. Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/847-conservation-advice.pdf

Threatened Species Scientific Committee (TSSC). 2016a. Conservation Advice Calidris canutus Red knot. Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/855-conservation-advice-05052016.pdf

Threatened Species Scientific Committee (TSSC). 2016b. Conservation Advice Limosa lapponica bauera Bar-tailed godwit (western Alaskan). Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy Accessed at http://www.environment.gov.au/biodiversity/threat ened/species/pubs/86380-conservation-advice-05052016.pdf

Threatened Species Scientific Committee (TSSC). 2016c. Conservation Advice Conservation Advice Limosa lapponica menzbieri Bar-tailed godwit (northern Siberian). Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/86432-conservation-advice-05052016.pdf

Threatened Species Scientific Committee (TSSC). 2016d. Conservation Advice Charadrius leschenaultia Greater sand plover. Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/877-conservation-advice-05052016.pdf

Threatened Species Scientific Committee (TSSC). 2016e. Conservation Advice Calidris tenuirostris Great knot. Department of Sustainability, Environment, Water, Population and Communities. Department of the Environment and Energy Accessed at http://www.environment.gov.au/biodiversity/threatened/species/pubs/862-conservation-advice-05052016.pdf

Threatened Species Scientific Committee. 2009. *Approved conservation advice for Pristis clavata (dwarf sawfish).* Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Tomajka, J., 1985. *Vybrané fyzikálne a chemické ukazovatele*. In M. Ertl et al., Hydrocenózy jazier Tatranského národného parku. Laboratórium rybárstva a hydrobiológie, Bratislava: pp67–84 (Final res. rep., in Slovak).

Tourism WA. 2017. *Western Australia cruising Sanpshot*. Government of Western Austalia. Accessed at https://www.tourism.wa.gov.au/About%20Us/Documents/DESTINATION%20DEVELOPMENT%20247_CRUISE%20SNAPSHOT%20V2%20FINAL.pdf

Townsend, C.H., 1935. The Distribution of Certain Whales as Shown by Logbook Records of American Whaleships. *Zoologica* **19**:1–50.

Tripovich, J.S., Klinck, H., Nieukirk, S. L., et al. 2015. *Temporal segregation of the Australian and Antarctic blue whale call types (Balaenoptera musculus spp.).* Journal of Mammalogy 96: 603– 610.

Truscott, Z., Booth, D.T. & Limpus, C.J. 2017. *The effect of on-shore light pollution on seaturtle hatchlings commencing their off-shore swim.* Wildlife Research 3(5): 127-134.

Tucker, J.K., Janzen, F.J., and Paukstis, G.L. 1995. *Oxytocin induced nesting behavior in females of the red-eared turtle, Trachemys scripta elegans, without oviductal eggs*. Herpetological Review 26: 138.

Tzioumis, V. and Keable, S. (eds). 2007. *Description of Key Species Groups in the East Marine Region, Final Report – September 2007*. Australian Museum.

UN Environment, 2018. Emissions Gap Report 2018.

UNFCCC, 2016. Paris Agreement.

United nations Educational, Scientific and Cultural Organisation (UNESCO). 2011. *Ningaloo Coast*. World Heritage Convention.

United nations Educational, Scientific and Cultural Organisation (UNESCO). 1991. *Shark Bay*. World Heritage Convention.

United Nations Environment Programme (UNEP). 1985. GESMAP: Thermal discharges in the marine environment. UNEP Regional Seas Reports and Studies No. 45.

URS. 2000. *Values and Threats Proposed Dampier Archipelago Multiple Use Conservation Reserve and Dampier Port Limits*. Report prepared for Woodside Energy Limited, by URS Australia Pty Ltd.

URS. 2003. *Review of Coral Surveillance Monitoring for the ChEMMS Programme*. Report prepared for Woodside Energy Limited, by URS Australia Pty Ltd.

URS. 2004. *Chemical and Ecological Monitoring of Mermaid Sound, Annual Report 2004*. Report prepared for Woodside Energy Limited, by URS Australia Pty Ltd.

US EPA. 2002. *Cruise Ship Plume Tracking Survey Report*. Report EPA842-R-02-001, Office of Water, Washington, DC.

Vanderlaan, A.S.M. & Taggart, C.T. 2007. *Vessel collisions with whales: the probability of lethal injury based on vessel speed*. Marine Mammal Science 23: pp144-156.

Vik, E.A., Dempsey, S., Nesgård, B.S. 1996. *Evaluation of available test results from environmental studies of synthetic based drilling muds*. Version 4. Aquateam Report Number: 96-010. OLF Project. Acceptance Criteria for Drilling Fluids. Aquateam-Norwegian Water Technology Centre. Oslo, Norway: pp127.

Vik, E.A., Nesgard, B.S., Berg, J.D., Dempsey, S.M. 1996. *Factors Affecting Methods for Biodegradation Testing of Drilling Fluids for Marine Discharge*. In: SPE International Conference on Health, Safety, and the Environment, New Orleans, LA. SPE 35981.

Volkman, J.K., Miller, G.J., Revill, A.T., Connell, D.W. 2004. *'Oil spills*.' In Environmental Implications of offshore oil and gas development in Australia - the findings of an independent scientific review. Edited by Swan, J.M., Neff, J.M. and Young, P.C. Australian Petroleum Exploration Association. Sydney.

von Brandis, R.G., Mortimer, J.A., & Reilly, B.A. 2010. *In-Water Observations of the Diving Behaviour of Immature Hawksbill Turtles, Eretmochelys imbricata, on a Coral Reef at D'Arros Island, Republic of Seychelles*. Chelonian Conservation and Biology, 9(1): 26–32.

Walker, D.I., McComb, A.J. 1990. *Salinity Response of the Seagrass Amphibolis antarctica (Labill.) Sonder et Aschers.: an Experimental Validation of Field Results.* Botany Department. University o[Western Australia. 36: pp359-366.

Walkuska, G., Wilczek, A., 2010. Influence of Discharged Heated Water on Aquatic Ecosystem Fauna. Polish Journal of Environmental Studies, 19(3): 547-552.

Walsh GE (1978) *Toxic effects of pollutants on Plankton*. In: Butler GC, editor. Principles of Ecotoxicology. John Wiley & Sons, Inc., New York. 257–274.

Waples, K. and Raudino, H. 2018. *Setting a course for marine mammal research in Western Australia.* Pacific Conservation Biology 24: pp289–303.

Wardrop, J. A., Butler, A. J. & Johnson, J. E. 1987. *Field study of the toxicity of two oils and a dispersant to the mangrove Avicennia Marina.* Marine Biology, 96(1): pp151-156.

Water Corperation. 2017. *Southern Seawater Desalination Plant Marine Environment Monitoring Annual Report 17 January 2016 to 16 January 2017*.

Water Corporation. 2000. *Environmental Information for Burrup Peninsula Desalinated and Seawater Supplies*.

Webster, L., Russle, M., Hussy, I., Packer, G., Dalgarno, E.J., Craig, A., Moore, D.C., Jaspars, M., Moffat, C.F. 2012b. *Environmental Assessment of the Elgin Gas Field Incident – Report 5, Fish and Sediment Update*. Marine Scotland Science Report 17/12. Department of Chemistry, University of Aberdeen, Old Aberdeen, AB24 3UE, Scotland, UK. Accessed at file:///C:/Users/Coe%20Jerinic/Downloads/Environmental_Assessment_of_the_Elgin_Gas_Field_In.pdf

Webster, L., Russle, M., Hussy, I., Packer, G., Dalgarno, E.J., Moore, D.C., Moffat, C.F. 2012a. *Environmental Assessment of the Elgin Gas Field Incident – Report 3, Water Update*. Marine Scotland Science Report 12/12. Accessed at https://www2.gov.scot/Resource/0039/00392291.pdf

Webster, L., Russle, M., Hussy, I., Packer, G., Philips, L.A., Dalgarno, E.J., Moore, D.C., Moffat, C.F. 2012c. *Environmental Assessment of the Elgin Gas Field Incident – Report 4, Fish Muscle.* Marine Scotland Science Report 13/12. Accessed at https://www.researchgate.net/profile/Colin_Moffat/publication/265974707_Environmental_Assessment_of_the_Elgin_Gas_Field_Incident_-_Report_4_Fish_Muscle/links/54ba50680cf253b50e2bcdec/Environmental-Assessment-of-the-Elgin-Gas-Field-Incident-Report-4-Fish-Muscle.pdf

Weligart, L.S. 2007. *A Briefe review of Known Effects of Noise on Marine Mammals*. International Journal of Comparative Psychology 20: pp159-168.

Western Australian Department of Environment and Conservation (WA DEC). 2009. *Marine turtles in Western Australia: Loggerhead Turtle*. Accessed at: http://www.naturebase.net/content/view/2462/1401.

Wilson, B., 2013. The Biogeography of the Australian North West Shelf. Elsevier. https://doi.org/10.1016/C2012-0-00618-7

Whinney J, Jones R, Duckworth A, Ridd P (2016) *Continuous in situ monitoring of sediment deposition in shallow benthic environments.* Report of Theme 4 - Project 4.4 of the Western Australian Marine Science Institution (WAMSI) Dredging Science Node. Perth, Western Australia, 25 pp.

Whiting, S. D. 2000. *The ecology of immature green turtle and hawksbill turtles foraging on two reef systems in Northwestern Australia*. Unpublished PhD thesis, Northern Territory University, Darwin.

Whiting, S. 2004. *The sea turtle resources of Cocos (Keeling) Islands, Indian Ocean*. (Biomarine International: Darwin.)

Whiting, A.U. 2018. *Analyses of turtle track count data from Rosemary Island, Dampier Archipelago: 1990 to 2017.* Unpublished report to the Parks and Wildlife Service, Department of Biodiversity, Conservation and Attractions, Pilbara Region.

Whittock, P.A., Pendoley, K.L. & Hamann, M. 2014. *Internesting distribution of flatback turtles Natator depressus and industrial development in Western Australia*. Endangered Species Research: 26(10): pp25-38. 10.3354/esr00628.

Whittock P.A, Pendoley K.L. & Hamann, M. 2016b. *Flexible foraging: post-nesting flatback turtles on the Australian continental shelf.* Journal of Experimental Marine Biology and Ecology, 477: 112–119.

Whittock, P.A., Pendoley, K.L. & Hamann, M. 2016a. *Using habitat suitability models in an industrial setting: the case for internesting flatback turtles*. Ecosphere, 7(11): e01551. 10.1002/ecs2.1551.

Williams, A., Koslow, J.A., Last, P.R. 2001. *Diversity, density and community structure of the demersal fish fauna of the continental slope off Western Australia (20 to 35°S)*. Marine Ecology Progress Series 212: pp247–263.

Williams, S.E., Bolitho, E.E., Fox, S., 2003. Climate change in Australian tropical rainforests: an impending environmental catastrophe. Proceedings of the Royal Society of London. Series B: Biological Sciences 270, 1887–1892.

Williamson, P.C., Sumner, N.R., and Malseed, B.E.. 2006. A 12-month survey of recreational fishing in the Pilbara region of Western Australia during 1999-2000. Fisheries Research Report No. 153, 2006. Accessed at: http://fish.wa.gov.au/documents/research_reports/frr153.pdf

Wilson, S.G., Polovina, J. J., Stewart, B.S. and Meekan, M.G. 2006. *Movements of whale sharks (Rhincodon typus) tagged at Ningaloo Reef, Western Australia.* Marine Biology 148: pp1157–1166.

Wilson, S.K., Babcock, R.C., Fisher, R., Holmes, T.H., Moore, J.A.Y., Thomson, D.P. 2012. *Relative and combined effects of habitat and fishing on reef fish communities across a limited fishing gradient at Ningaloo.* Marine Environmental Research 81: pp1–11. Doi:10.1016/j.marenvres.2012.08.002.

Wilson, S.K., Depczynski, M., Fisher, R., Holmes, T.H., O'Leary, R.A., Tinkler, P., 2010. *Habitat associations of juvenile fish at Ningaloo Reef, Western Australia: The importance of coral and algae*. PloS ONE 5: e15185. Doi:10.1371/journal.pone.0015185.

Wilson, P., Thums, M., Pattiaratchi, C., Meekan, M., Pendoley, K., Fisher, R. & Whiting, S. 2018. *Artificial light disrupts the nearshore dispersal of neonate flatback turtles Natator depressus*. Marine Ecology Progress Series, *600*, 179-192. doi: https://doi.org/10.3354/meps12649

Wilson, P., Thums, M., Pattiaratchi, C., Whiting, S., Pendoley, K., Ferreira, L. C. & Meekan, M. 2019. *High predation of marine turtle hatchlings near a coastal jetty.* Biological Conservation, 236: 571-579.

Wilson, .P Thums, M., Pattiaratchia, C., Whiting, S., Meekan, M. & Pendoley, K. (submitted) *Nearshore wave characteristics as cues for swimming orientation in flatback turtle hatchlings.*

Witherington, B.E. 1992. *Behavioral responses of nesting sea turtles to artificial lighting.* Herpetologica, 48: 31–39.

Witherington, B.E., Martin, E. 2003. *Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches.* 3rd ed. rev. Florida Marine Research Institute Technical Report TR-2: pp73 and 84

Wolanski, E., 1994. Physical Oceanographic Processes of the Great Barrier Reef. CRC Press.

Wood, J., Southall B.L., Tollit, D.J. 2012. *PG&E offshore 3 D Seismic Survey Project EIR-Marine Mammal Technical Report.* SMRU Ltd.

Wood, J., Southall, B.L. & Tollit, D.J. 2012. *PG&E offshore 3-D Seismic Survey Project Environmental Impact Report–Marine Mammal Technical Draft Report*. SMRU Ltd.

Woodside Energy Ltd. 2005. *The Vincent Development Draft Environmental Impact Statement*. Woodside Energy Limited. Perth, Australia.

Woodside Energy Ltd. 2006. *Pluto LNG Development: Draft Public Environment Report/Public Environment Review, EPBC Referral 2006/2968*. Woodside Energy Limited. Perth, Australia.

Woodside Energy Ltd. 2008. Torosa South - 1 (TS-1) *Pilot Appraisal well, Environmental Monitoring Program - Development of Methodologies Part 1 (p51)*. Report produced by Environmental Resources Management and SKM.

Woodside Energy Ltd. 2009. *Pluto LNG Project Spoil Ground 5A Survey Report*.

Woodside Energy Ltd. 2011. *Browse LNG Development, Draft Upstream Environmental Impact Statement*. EPBC Referral 2008/4111 (November 2011).

Woodside Energy Ltd. 2013. *Goodwyn Alpha (GWA) Facility Operations Environment Plan Summary*. Woodside Energy Limited. Perth, Australia.

Woodside Energy Ltd. 2014. *Browse FLNG Development Draft Environmental Impact Statement.*

Woodside Energy Ltd. 2016, [Web page] *Pluto Facilities*. http://www.woodside.com.au/Our-Business/Producing/Pages/Pluto.aspx#.WDdYR_67o-U.

Woodside Energy Ltd. 2018. [Web page] *Australia Developments*. http://www.woodside.com.au/Our-Business/Developing/Pages/Australia-Developments.aspx#.WqCu4vlubmF.

Woodside Energy Ltd. 2018. *Scarborough development – Shallow Water Geophysical & Geotehnical Survey 2018*. Controlled Ref No:SA0009SX0000001

Woodside Energy Ltd (WEL) 2018b, Pluto trunkline PSDs, extract of geotechnical survey field report provided to RPS by Woodside Energy Ltd, Perth, WA, Australia

Woodside Energy Ltd, 2019, Scarborough Dredging and Spoil Disposal Management Plan. https://www.epa.wa.gov.au/sites/default/files/PER_documentation2/Scarborough%20Dredging%20and%20Spoil%20Disposal%20Management%20Plan.pdf

Wright, A.J., Soto, N.A., Baldwin, A.L., Bateson, M., Beale, C.M., Clark, C., Deak, T., Edwards, E.F., Fernández, A., Godinho, A., Hatch, L.T., Kakuschke, A., Lusseau, D., Martineau, D., Romero, L.M., Weilgart, Linda.S., Wintle, B.A., Notarbartolo-di-Sciara, G., Martin, V. 2007. *Do Marine Mammals Experience Stress Related to Anthropogenic Noise?* International Journal of Comparative Psychology. 20, pp274-316.

Wysocki, L.E., Davidson III, J.W., Smith, M.E., Frankel, A.S., Ellison, W.T., Mazik, P.M., Popper, A.N., Bebak, J. 2007. *Effects of aquaculture production noise on hearing, growth, and disease resistance of rainbow trout Oncorhynchus mykiss.* Aquicultire 272, Issues 1-4: pp687-697.

Yender, R., Michel, J., Lord, C. 2002. *Managing seafood safety after and oil spill*. National Oceanic and Atmospheric Administration, Seattle.

Zieman, J.C., Orth, R., Phillips, R.C., Thayer, G., Thorhaug, A. 1984. *Effects of oil on seagrass ecosystems*, in: Cairns Jr., J., Buikema, A.L. (Eds.), Restoration of Habitats Impacted by Oil Spills. Butterworth-Heinemann, Boston: pp37–64.