Polarcus Petrelex 3D Marine Seismic Survey 2019-2020

Environment Plan

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The business of sustainability

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EP Summary

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Acronyms and Abbreviations

Name	Description
$	Dollars (Australian dollars unless specified otherwise)
%	Percent
‘	Minutes
“	Seconds
°	Degrees
°C	Degrees Celsius
µg l^{-1}	Micrograms per litre
3D	Three-dimensional
4D	Four-dimensional
ABARES	Australian Bureau of Agricultural and Resource Economics
ADF	Australian Defence Force
ADIOS	Automated Data Inquiry for Oil Spills
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AHS	Australian Hydrographic Service
AIS	Automatic Identification System
ALARP	As low as reasonably practicable
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
AMSA JRCC	Australian Maritime Safety Authority Joint Rescue Coordination Centre
ANSI	American National Standard Institute
ANZECC	Australian and New Zealand Environment Conservation Council
APASA	Asia-Pacific ASA
API	American Petroleum Institute gravity (A measure of how heavy or light a petroleum liquid in comparison to water)
APPEA	Australian Petroleum Production and Exploration Association
BIA	Biologically Important Area
BOM	Bureau of Meteorology
BWMP	Ballast Water Management Plan
BWM-T	Class notation for vessels with ballast water treatment complying with International Convention for the Control and Management of Ship’s Ballast Water and Sediments
CEO	Chief Executive Officer
CFA	Commonwealth Fisheries Association
CLEAN-DESIGN	Class notation for vessels that are designed, built and operated in a way that gives additional protection to the environment
COLREGS	International Regulations for Preventing Collisions at Sea
COO	Chief Operations Officer
cP	Centipoise (unit of viscosity)

Name	Description
CPUE	Catch Per Unit Effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
cui / cu. in.	Cubic inches
CV	Curriculum Vitae
dB	Decibel
DBCA	Department of Biodiversity, Conservation and Attractions (WA)
DEWHA	Department of the Environment, Water, Heritage and the Arts (now DoEE) (Commonwealth)
DFAT	Department of Foreign Affairs and Trade (Commonwealth)
DMIRS	Department of Mines, Industry Regulations and Safety (WA)
DNER	Department of Natural Environmental Resources (NT)
DNVGL	Det Norske Veritas
DO	Dissolved Oxygen
DoCA	Department of Communications and the Arts (Commonwealth)
DoEE	Department of the Environment and Energy (Commonwealth)
DoF	Department of Fisheries (now DPIRD) (WA)
DoIIS	Department of Industry, Innovation and Science (Commonwealth)
DoNP	Director of National Parks (Commonwealth)
DoT	Department of Transport (WA)
DPAW	Department of Parks and Wildlife (now DBCA) (WA)
DPIR	Department of Primary Industry and Resources (Fisheries) (WA)
DPIRD	Department of Primary Industries and Regional Development (formerly Department of Fisheries) (WA)
EEZ	Exclusive Economic Zone
EHSQ	Environment, Health, Safety and Quality
EMBA	Environment that may be affected
EMS	Environmental Management System
ENVID	Environmental Risk Assessment
EP	Environment Plan
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPO	Environmental Performance Outcome
EPS	Environmental Performance Standard
ERM	Environmental Resources Management Australia Pty Ltd
ERP	Emergency Response Plan
ESD	Ecologically Sustainable Development
GFW	Global Fishing Watch
GHG	Greenhouse Gas
GPS	Global Positioning System
GRT	Gross Registered Tonnes

Name	Description
HF	High Frequency
HSE	Health, Safety and Environment
Hz	Hertz
Hz	Hertz
IAGC	International Association of Geophysical Contractors
IAPP	International Air Pollution Prevention
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IMO	International Maritime Organization
IMS	Invasive marine species
IOGP	International Association of Oil and Gas Producers
IOPP	International Oil Pollution Prevention
IPIECA	International Petroleum Industry Environmental Conservation Association
ISO	International Organisation for Standardisation
ISO	International Organisation for Standardisation
ISPP	International Sewage Pollution Prevention
ITOPF	International Tanker Owners Pollution Federation
IUCN	International Union for the Conservation of Nature
IWC	International Whaling Commission
JANSF	Joint Authority Northern Shark Fishery (WA)
JASCO	JASCO Applied Science
JBG	Joseph Bonaparte Gulf
JBGMP	Joseph Bonaparte Gulf Marine Park
JHA	Job Hazard Analysis
KEFs	Key Ecological Features
KLC	Kimberley Land Council
km	Kilometres
km^2	Square kilometres
KPMF	Kimberley Prawn Managed Fishery (WA)
LF	Low Frequency
LNG	Liquefied Natural Gas
m	Metres
m/s	Metre per second
m^2	Square metres
m^3	Cubic metres
MAFMF	Marine Aquarium Fish Managed Fishery (WA)
MARPOL	(Marine Pollution) International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978
MBC	Maritime Border Command
MC	Measurement Criteria

Name	Description
MF	Medium Frequency
MFO	Marine Fauna Observer
MGO	Marine Gas Oil
MMF	Mackerel Managed Fishery (WA)
MMSI	Maritime Mobile Service Identity
MNES	Matters of National Environmental Significance
MOP	Marine Oil Pollution
MOSCP	Marine Oil Spill Contingency Plan
MOU	Memorandum of Understanding
MSDS	Material Safety Data Sheet
MSS	Marine Seismic Survey
MUZ	Multiple Use Zone
National Plan	National Plan for Maritime Environmental Emergencies
NAUT-AW	Vessel class notation for enhanced nautical safety, incorporating a grounding avoidance system
NAXA	Northern Australia Exercise Area
NDSMF	Northern Demersal Scalefish Managed Fishery
NERP	National Environmental Research Program
NKMP	North Kimberley Marine Park
NLC	Northern Land Council
nm	Nautical Miles
NMFS	National Marine Fisheries Service
NMR	North Marine Region
NNTT	National Native Title Tribunal
NOAA	National Oceanic and Atmospheric Administration
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NOPTA	National Offshore Petroleum Titles Administrator
NOx	Nitrogen Oxides
NPF	Northern Prawn Fishery
NPFI	Northern Prawn Fishing Industry Pty Ltd
NRSMPA	National Representative System of Marine Protected Areas
NSW	New South Wales
NTEPA	Northern Territory Environment Protection Authority
NTSC	Northern Territory Seafood Council
NWMR	North-west Marine Region
NWS	North-west Shelf
OBN	Ocean Bottom Nodes
ºC	Degrees Centigrade
ONLF	Offshore Net and Line Fishery (NT)

Name	Description
OPEP	Oil Pollution Emergency Plan
OPGGS (E) Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
OPGGS Act	*Offshore Petroleum and Greenhouse Gas Storage Act 2006*
OPIC	Offshore Petroleum Incident Coordination
OPRC	Oil Pollution Preparedness, Response and Cooperation
OSMP	Oceanic Shoals Marine Park
OSRC	Oil Spill Response Coordination
PAM	Passive Acoustic Monitoring
PK	Peak Pressure
PMI	Potential Mortality Injury
POB	Persons On Board
Polarcus	Polarcus Seismic Limited
POLREP	Oil Pollution Reports
POMP	Pearl Oyster Managed Fishery (WA)
PPA	Pearl Producers Association
ppm	Parts per million
psi	pounds per square inch
PTS	Permanent Threshold Shift
PTTEP	PTTEP Australasia (Ashmore Cartier)
QA/QC	Quality Assurance / Quality Control
QLD	Queensland
SA	South Australia
SDS	Safety Data Sheets
SEL	Sound Exposure Level
SEWPaC	Department of Sustainability, Environment, Water, Population and Communities (now DoEE)
SIMAP	Spill Impact Model Application Package
SITREPS	Situation Reports
SOLAS	Safety of Life at Sea
SOPEP	Shipboard Oil Pollution Emergency Plan
SPRAT	Species Profile and Threats Database
SPS	Special Purpose Ships
SPZ	Special Purpose Zone
SRA	Stock Reduction Analysis
SSMF	Specimen Shell Managed Fishery (WA
SSV	Sound Source Verification
State Hazard Plan	State Hazard Plan for Maritime Environmental Emergencies

Name	Description
STCW95	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1995 Revision
TEC	Threatened Ecological Communities
TTS	Temporary Threshold Shift
UAE	United Arab Emirates
ULSTEIN	Ulstein Group, provider of ship designs, shipbuilding and solutions in power and control systems, heavylift, crane & barge services
UNCLOS	United Nations Convention on the Law of the Sea
UV	Ultraviolet
UXO	Unexploded Ordnances
WA	Western Australia
WAFIC	Western Australia Fishing Industry Council
WANCSF	North Coast Shark Fishery (WA)
WHP	Wellhead Platform
WTO	Wildlife Trade Operation
μPa^2	Micropascals

1. INTRODUCTION

The Petrelex 3D Marine Seismic Survey (MSS) is a three-dimensional multi-client seismic survey proposed to be undertaken by Polarcus Seismic Limited (Polarcus) in Commonwealth waters of the Petrel Sub-basin (in the Bonaparte Basin), offshore from north-west Australia.

1.1 Purpose

This Environment Plan (EP) has been prepared to meet the requirements of the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) and the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS (E) Regulations). It aims to demonstrate that the Petrelex 3D MSS will be undertaken in a manner consistent with the principles of ecologically sustainable development (ESD) and carried out such that environmental impacts and risks will be reduced and managed to as low as reasonably practicable (ALARP) and acceptable levels.

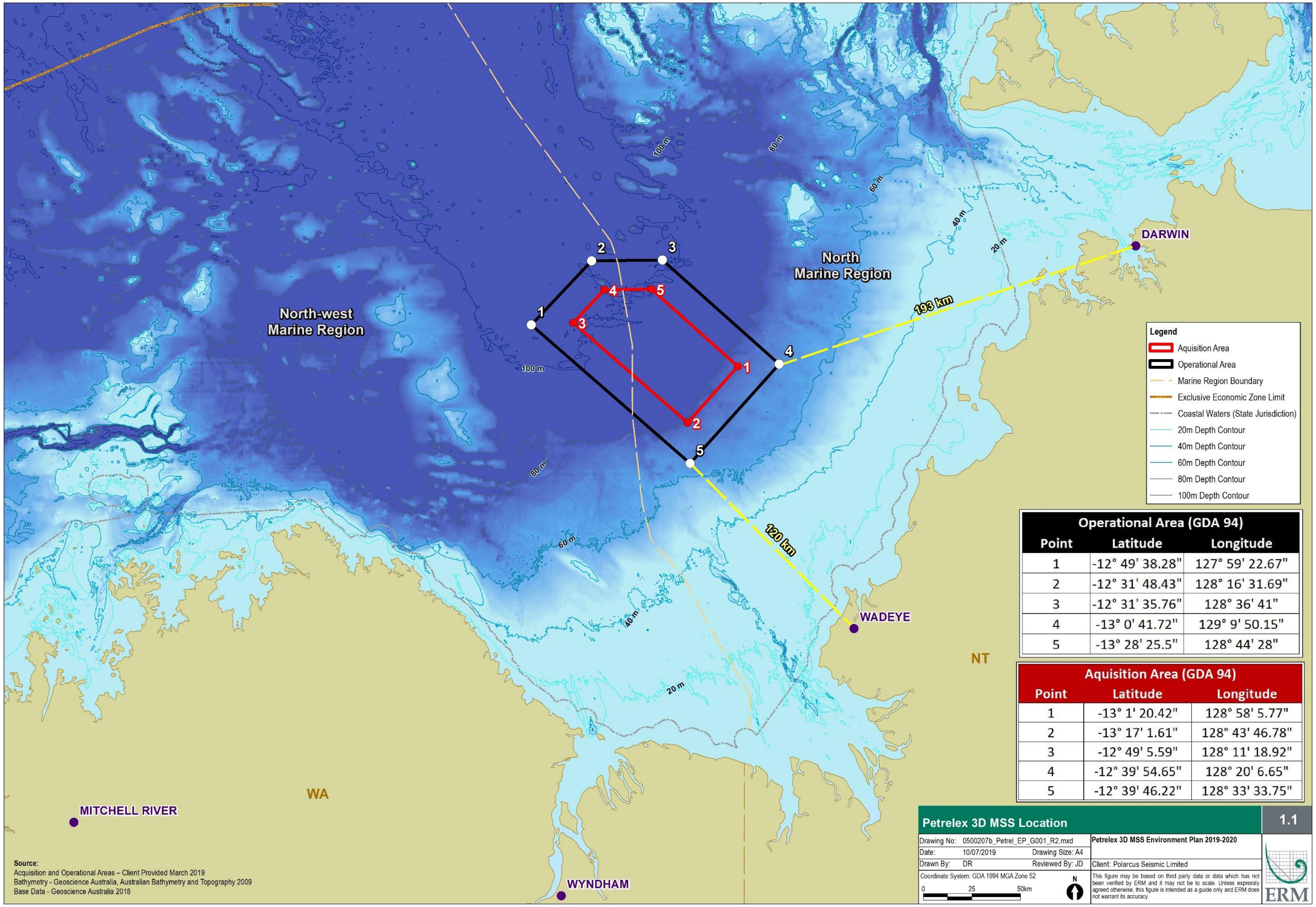
1.2 Scope

The scope of this EP addresses the petroleum activity—a marine seismic survey—and associated activities as described in Section 3.

In particular, the scope of this EP covers 3D seismic acquisition within the defined Acquisition Area (Figure 1-1) and associated line turns, run-ins, run-outs, seismic testing and support activities within the defined Operational Area (Figure 1-1). The timeframe of this EP is from acceptance of the EP until 31 December 2020.

The petroleum activity is defined as commencing at the point when the seismic array equipment is first deployed within the Operational Area, until the seismic vessel has demobilised and departed from the Operational Area following completion of the survey.

The scope of this EP does not include the periods when the survey and support vessels are not engaged in survey or associated activities, such as during cyclone avoidance, maintenance activities outside of the Operational Area, port calls, or vessel mobilisation/demobilisation to/from the Operational Area. During these periods the seismic vessel and support vessels are deemed to be operating under the Commonwealth *Navigation Act 2012* and not performing a petroleum activity.



Operational Area (GDA 94)		
Point	Latitude	Longitude
1	-12° 49' 38.28"	127° 59' 22.67"
2	-12° 31' 48.43"	128° 16' 31.69"
3	-12° 31' 35.76"	128° 36' 41"
4	-13° 0' 41.72"	129° 9' 50.15"
5	-13° 28' 25.5"	128° 44' 28"

Aquisition Area (GDA 94)		
Point	Latitude	Longitude
1	-13° 1' 20.42"	128° 58' 5.77"
2	-13° 17' 1.61"	128° 43' 46.78"
3	-12° 49' 5.59"	128° 11' 18.92"
4	-12° 39' 54.65"	128° 20' 6.65"
5	-12° 39' 46.22"	128° 33' 33.75"

Figure 1-1 Petrelex 3D MSS Location

1.3 Proponent Details

Polarcus Seismic Limited (Polarcus) is an innovative marine geophysical service company with a pioneering environmental agenda, delivering high-end towed streamer data acquisition and advanced on-board processing and imaging services globally. Polarcus operates a fleet of high-performance 3D seismic vessels, incorporating leading-edge technologies for improved safety, data quality and operational efficiency, to fully meet customer needs from large exploration to 4D surveys.

The Polarcus Headquarters is based in Dubai, United Arab Emirates (UAE), and the company has three regional sales and marketing offices located in Houston, London and Singapore. Polarcus employs approximately 325 professionals worldwide and owns seven high-end marine seismic vessels.

Further information about Polarcus is available at their website at: https://www.polarcus.com/

1.3.1 *Titleholder and Nominate Liaison Person*

The titleholder's details are:

Company Name	Polarcus Seismic Limited (Polarcus)
Business Address	c/o Polarcus DMCC Reef Tower, Level 20 Jumeirah Lake Towers Cluster O PO Box 283373 Dubai United Arab Emirates (UAE)
Phone	+971 4 43 60 800
Fax	+971 4 43 60 808
Email	info@polarcus.com
Website	https://www.polarcus.com/
ACN/ABN	75 214 908 956

The titleholder's nominated liaison person is:

Contact Name	Antony Pedley
Position	Geoscience and Sales Manager
Postal Address	c/o Polarcus Asia Pacific Pte Ltd 1 Fullerton Road #02-01 One Fullerton Singapore 049213
Phone	+65 6408 3855
Email	Tony.Pedley@polarcus.com

2. ENVIRONMENTAL MANAGEMENT FRAMEWORK

This section identifies the laws, other approvals, standards or other environmental requirements that apply to the activity and are relevant to the activity's environmental management.

2.1 Legislation Requirements

2.1.1 *OPGGS Act and Associated Regulations*

The OPGGS Act provides the regulatory framework for all offshore petroleum exploration, production and greenhouse gas (GHG) activities in Commonwealth waters.

The related OPPGS (E) Regulations require titleholders to undertake their petroleum activity in accordance with an EP accepted by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA). This EP has to be prepared to meet the requirements of the OPPGS (E) Regulations.

2.1.2 *Other Applicable Legislation*

Other legislation relevant to the Petrelex 3D MSS is described in Table 2-1.

Table 2-1 Summary of Relevant Legislation

Legislation	Scope	Relevance
Environment Protection and Biodiversity Conservation Act 1999 and Environment Protection and Biodiversity Conservation Regulations 2000	This Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places and the commonwealth marine area, known as Matters of National Environmental Significance (MNES).	Assessment of likely impacts on Matters of National Environmental Significance (MNES) from survey activities are described in Section 7 and Section 8 and include controls such as adherence with the Environment Protection and Biodiversity Conservation (EPBC) Act 1999 Policy Statement 2.1 – Interaction between Offshore Seismic Exploration and Whales: Industry Guidelines; and EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with Cetaceans. A network of Australian Marine Parks (AMPs) has been proclaimed under the EPBC Act. Further details relating to AMPs are provided in Section 2.1.4.
Historic Shipwrecks Act 1976 and Historic Shipwrecks Regulations 1978	This Act protects historic wrecks (and associated relics) in Commonwealth waters that are more than 75 years old. Under this Act, historic shipwrecks are protected for their heritage values and maintained for recreational, scientific and educational purposes.	A search for historic shipwrecks was undertaken for the Operational Area as detailed in Section 4.6.4.
Australian Maritime Safety Authority Act 1990	This Act aims to promote maritime safety, protect the marine environment (from pollution from ships and other environmental damage caused by shipping), provide for a national search and rescue service and to promote the efficient provision of services by the Australian Maritime Safety Authority (AMSA).	Under this Act, any hydrocarbon spill to the marine environment, resulting from the survey must be reported. The Act also provides the framework for AMSA to respond to major spill incidents. Provisions to reimburse AMSA in the event of an oil spill are detailed in Section 0.
Protection of the Sea (Prevention of Pollution from Ships) Act 1983	The Act, in conjunction with the *Navigation Act 2012* and AMSA Marine Orders, gives effect to the MARPOL convention in Australia, and associated requirements for preventing pollution from ships at sea.	Pollution prevention controls and standards for the seismic vessel are detailed in Section 7.5.

Legislation	Scope	Relevance
Maritime Legislation Amendment (Prevention of Air Pollution from Ships) Act 2007	An Act to amend the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*, and for other purposes. This amended Act provides the protection of the sea from air pollution from ships.	Survey and support vessels hold an International Air Pollution Prevention Certificate (Section 7.6).
Navigation Act 2012	This Act regulates navigation and shipping including the requirements of the Safety of Life at Sea (SOLAS) Convention. A number of marine orders enacted under this Act apply directly to offshore petroleum exploration activities. This Act is the primary legislation that regulates ship and seafarer safety, shipboard aspects of protection of the marine environment, and employment conditions for Australian seafarers.	Applicable navigation and SOLAS controls for the survey and support vessels are detailed in Section 7.4.
Biosecurity Act 2015 and Biosecurity Regulation 2016	The Act assesses and manages the risk of pests and diseases entering Australian territory and causing harm to animal, plant and human health, the environment and the economy. It implements mandatory controls in the use of seawater as ballast in ships and the declaration of sea vessels voyaging out of and into Commonwealth waters.	This Act is applicable to the vessels transiting from outside of the Operational Area, which have the potential to introduce invasive marine species (IMS) to the marine environment of the Operational Area. Control measures relating to biosecurity are detailed in Section 8.8
Protection of the Sea (Harmful Antifouling Systems) Act 2006	This Act relates to the protection of the sea from the effects of harmful anti-fouling systems. It prohibits the use of harmful organotins in anti-fouling paints used on ships.	Harmful anti-fouling systems will not be used on vessels. Certification of anti-fouling coating on vessels is identified as a control and measurement criteria relevant to reducing the biosecurity risk of introduced marine species (Section 8.8).
Protection of the Sea (Powers of Intervention) Act 1983 and Protection of the Sea (Prevention of Pollution from Ships) (Orders) Regulations 1994	This Act provides AMSA with various responsibilities and powers to take measures and issue directions to prevent or respond to pollution of the sea by oil or other substances. Enacts part of the MARPOL convention in Australia in conjunction with the *Navigation Act 2012* (see above).	All vessels over 400 Gross Registered Tonnes (GRT) will have a Shipboard Oil Pollution Emergency Plan (SOPEP) in place (Section 10.3.2).

2.1.3 *International Agreements*

The principal international agreement (of which Australia is a signatory) affecting petroleum operations in Commonwealth waters is the United Nations Convention on the Law of the Sea, 1982 (UNCLOS), which became effective on 16 November 1994. UNCLOS enforces a comprehensive regime of law and order in global oceans and seas, establishing rules governing all uses of the oceans and their resources.

Australia is also a signatory to a number of other international conventions and agreements relevant to the Petrelex 3D MSS. Other relevant agreements are listed in Table 2-2.

Table 2-2 Summary of Relevant International Agreements

Legislation	Scope	Relevance
1996 Protocol to the 'Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972'	Contributes to the international control and prevention of marine pollution by prohibiting the dumping of certain hazardous materials. Under the 1996 Protocol, dumping is prohibited, except for materials on an approved list.	No dumping of any wastes or other matter from survey activities with the exception of those listed in Annex 1 of the Protocol (which will be discharged in line with MARPOL requirements).
Convention on the Conservation of Migratory Species of Wild Animals 1979 (Bonn Convention)	This Convention provides a global platform for conservation and the sustainable use of terrestrial, aquatic and avian migratory species throughout their range.	Control measures for the survey described in Section 7 and Section 8 aim to ensure risks and impacts to migratory species or their habitat are reduced to levels that are ALARP and acceptable.
Convention on Oil Pollution Preparedness, Response and Cooperation 1990 (OPRC 90)	This Convention establishes measures for dealing with marine oil pollution incidents nationally and in cooperation with other countries.	All vessels over 400 GRT will have a SOPEP in place (Section 10.3.2).
International Convention for the Prevention of Pollution from Ships 1973/1978 (MARPOL 73/78)	This Convention covers prevention of pollution of the marine environment by ships from operational or accidental causes. It includes regulations aimed at preventing and minimising pollution from ships (accidental and routine).	Prevention of ppollution in accordance with MARPOL requirements.
International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004	The Convention aims to prevent the spread of harmful aquatic organisms from one region to another, by establishing standards and procedures for the management and control of ships' ballast water and sediments.	Implemented through the *Biosecurity Act 2015* and Regulations 2016. Vessels will manage ballast in accordance with Australian Ballast Water Management Requirements (Section 8.7).

2.1.4 *Management of Protected Areas*

The Australian Marine Park (AMP) Network has been established around Australia as part of a National Representative System of Marine Protected Areas (NRSMPA), the primary goal of which is to establish and effectively manage a comprehensive, adequate and representative system of marine parks to contribute to the long-term conservation of marine ecosystems and protect marine biodiversity.

Under the EPBC Act, the AMP Network, and any zones within AMPs, must be assigned to an International Union for Conservation of Nature (IUCN) Category. Several types of zones are represented in the AMP Network, with the zoning scheme administered by Department of the Environment and Energy (Commonwealth) [DoEE]. The zones align to the IUCN categories as follows:

- Sanctuary Zone (IUCN Category Ia);
- National Park Zone (IUCN Category II);
- Recreational Use Zone (IUCN Category IV);
- Habitat Protection Zone (IUCN Category IV);
- Multiple Use Zone (IUCN Category VI);
- Special Purpose Zone (IUCN Category VI); and
- Special Purpose Zone (Trawl) (IUCN Category VI).

The Acquisition and Operational Areas do not overlap with any AMPs, however there are two AMPs located within the EMBA:

- Oceanic Shoals Marine Park (1 km from the Operational Area); and
- Joseph Bonaparte Gulf Marine Park (35 km from the Operational Area).

Both these marine parks are formally managed under the North Marine Region management framework. The North Marine Region is managed in accordance with the following values (DoNP 2017):

- Natural values – habitats, species and ecological communities within marine parks, and the processes that support their connectivity, productivity and function;
- Cultural values – living and cultural heritage recognising Indigenous beliefs, practices and obligations for country, places of cultural significance and cultural heritage sites;
- Heritage values – non-Indigenous heritage that has aesthetic, historic, scientific or social significance; and
- Socio-economic values – the benefit of the marine parks for people, businesses and the economy.

In making decisions regarding use in AMPs, the Director of National Parks (DoNP) will carefully consider the impacts and risks to these values for the relevant marine parks. Activities that have an EP accepted by NOPSEMA under the endorsed program may be conducted in accordance with the relevant petroleum title under the OPGGS Act and a class approval under this plan (DoNP 2017). Accordingly, activities covered by the endorsed NOPSEMA program do not require additional assessment by the DoNP because the endorsed program takes account of impacts and risks to marine park values in a manner that satisfies the DoNP.

The AMP values, zone objectives and management prescriptions relevant to the AMPs that overlap the EMBA for the Petrelex 3D MSS have been considered in the assessment of impacts and risks in this EP. A summary of the prescriptions relevant to this EP are provided in Table 2-3.

Table 2-3 Summary of Permitted Relevant Activities and Prescriptions in the AMP Zones that Overlap the EMBA

Zoning and IUCN Categories	Relevant AMPs	Purpose and Objectives	Relevant Activities Permitted in Zone	Relevant Management Prescriptions	Associated IUCN Management Principles (Schedule 8 of the EPBC Regulations 2000)
Multiple Use Zone IUCN Category VI	Oceanic Shoals Marine Park (2 km from the Operational Area). Joseph Bonaparte Gulf Marine Park (35 km from the Operational Area).	Managed to allow ecological sustainable use while conserving ecosystems, habitats and native species.	Mining operations (including exploration). Vessel transiting. Anchoring. Ballast water discharge and exchange. Disposal of waste from vessels (compliant with MARPOL).	Authorisation required for mining operations (including exploration); this activity is allowable in accordance with a permit, class approval or commercial activity licence or lease issued by the DoNP. Mining operations must be conducted in accordance with an authorisation (however described) under the OPGGS Act or the *Offshore Minerals Act 1994* to the extent those laws apply to the operations and are capable of operating concurrently with this plan. Commercial ships may transit through the North Marine Park Network subject to compliance with the prescriptions in the associated Management Plan (General use and access) and relevant prescriptions relating to the activity in which shipping is involved. Ballast water may be discharged or exchanged, subject to compliance with: a) the Australian ballast water management requirements and relevant state ballast water management arrangements; and b) relevant	**7.01** The reserve or zone should be managed mainly for the sustainable use of natural ecosystems based on these 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.

Zoning and IUCN Categories	Relevant AMPs	Purpose and Objectives	Relevant Activities Permitted in Zone	Relevant Management Prescriptions	Associated IUCN Management Principles (Schedule 8 of the EPBC Regulations 2000)
				Commonwealth and state legislation or international agreements (if any) relating to ballast water management. Waste may be disposed of from vessels to which the International Convention for the Prevention of Pollution from Ships (MARPOL) (Schedule 1) applies, in accordance with the requirements of MARPOL.	
Special Purpose Zone **IUCN Category VI**	Joseph Bonaparte Gulf Marine Park (35 km from the Operational Area)	Managed to allow specific activities though special purpose management arrangements while conserving ecosystems, habitats and native species. The zone allows or prohibits specific activities.	Mining operations (including exploration). Vessel transiting. Anchoring. Ballast waste discharge and exchange. Disposal of wastes from vessels (compliant with MARPOL).	Authorisation required for mining operations (including exploration); this activity is allowable in accordance with a permit, class approval or commercial activity licence or lease issued by the DoNP. Mining operations must be conducted in accordance with an authorisation (however described) under the OPGGS Act or the *Offshore Minerals Act 1994* to the extent those laws apply to the operations and are capable of operating concurrently with this plan. Commercial ships may transit through the North Marine Park Network subject to compliance with the prescriptions in the associated Management Plan (General use and access) and relevant prescriptions relating to the activity in	**7.01** The reserve or zone should be managed mainly for the sustainable use of natural ecosystems based on these 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.

Zoning and IUCN Categories	Relevant AMPs	Purpose and Objectives	Relevant Activities Permitted in Zone	Relevant Management Prescriptions	Associated IUCN Management Principles (Schedule 8 of the EPBC Regulations 2000)
				which shipping is involved. Ballast water may be discharged or exchanged, subject to compliance with: a) the Australian ballast water management requirements and relevant state ballast water management arrangements; and b) relevant Commonwealth and state legislation or international agreements (if any) relating to ballast water management. Waste may be disposed of from vessels to which the International Convention for the Prevention of Pollution from Ships (MARPOL) (Schedule 1) applies, in accordance with the requirements of MARPOL.	

2.1.5 *Conservation Advices and Recovery Plans*

When a native species or ecological community is listed as threatened under the EPBC Act, a conservation advice is developed to assist in its recovery. The Petrelex 3D MSS will be conducted in a manner consistent with conservation advice and recovery plans for species with the potential to be present in the Operational Area. Section 4.5.5 describes the species that listed as threatened under the EPBC Act, which have been identified to occur with the Operational Area.

Table 2-4 provides the conservation advice and/or recovery plans for species relevant to the Petrelex 3D MSS.

Table 2-4 Relevant Species with Conservation Advice and/or Recovery Plans

Species	Conservation Management Document	Applicable Actions and Management Measures	Relevant Sections in this EP
Humpback whale (*Megaptera novaeangliae*)	Threatened Species Scientific Committee. 2015. *Megaptera novaeangliae* (humpback whale) conservation advice (DoE 2015a).	■ All seismic surveys must be undertaken consistent with the EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales. Should a survey be undertaken in or near a calving, resting, foraging area, or a confined migratory pathway then Part B. Additional Management Procedures must also be applied. ■ For actions involving acoustic impacts (example pile driving, explosives) on humpback whale calving, resting, feeding areas, or confined migratory pathways site specific acoustic modelling should be undertaken (including cumulative noise impacts). ■ Should acoustic impacts on humpback calving, resting, foraging areas, or confined migratory pathways be identified a noise management plan should be developed. This can include: - The use of shutdown and caution zones; - Pre and post activity observations; - The use of marine mammal observers and / or Passive Acoustic Monitoring (PAM); and - Implementation of an adaptive management program following verification of the noise levels produced from the action (i.e. if the noise levels created exceed original expectations). ■ All cetaceans are protected in Commonwealth waters and, the EPBC Act requires that all collisions with whales in Commonwealth waters are reported. Vessel collisions can be submitted to the National Ship Strike Database at https://data.marinemammals.gov.au/report/shipstrike. ■ 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.	■ Collision / entanglement with equipment (Section 8.5) ■ Sound emissions (Section 0) ■ Hydrocarbon and chemical spills (Section 8.1 to 8.4).

Species	Conservation Management Document	Applicable Actions and Management Measures	Relevant Sections in this EP
		■ Enhance education programs to inform vessel operators of best practice behaviours and regulations for interacting with humpback whales.	
Blue whale (*Balaenoptera musculus)*	Department of Environment. 2015-2025. Conservation Management Plan for the Blue Whale (DoE 2015b).	■ 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. ■ EPBC Act Policy Statement 2.1—Interaction between offshore seismic exploration and whales is applied to all seismic surveys. ■ 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. ■ The Plan also refers to existing national mitigation/management measures that are important to blue whale recovery.	■ Collision / entanglement with equipment (Section 8.5) ■ Sound emissions (Section 0) ■ Hydrocarbon and chemical spills (Section 8.1 to 8.4).
Sei whale (*Balaenoptera borealis*)	Threatened Species Scientific Committee. 2015. *Balaenoptera borealis* (sei whale) conservation advice (DoE 2015c).	■ 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. ■ If required, additional management measures should be developed and implemented to ensure the ongoing recovery of sei whales; ■ Develop a national vessel strike strategy that investigates the risk of vessel strikes on sei Whales and also identifies potential mitigation measures. ■ Ensure all vessel strike incidents are reported in the National Vessel Strike Database.	■ Collision / entanglement with equipment (Section 8.5) ■ Sound emissions (Section 0)

Species	Conservation Management Document	Applicable Actions and Management Measures	Relevant Sections in this EP
Fin whale (*Balaenoptera physalus*)	Threatened Species Scientific Committee. 2015. Conservation Advice *Balaenoptera physalus* fin whale (DoE 2015d).	■ Once the spatial and temporal distribution (including biologically important areas) of fin 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. ■ If required, additional management measures should be developed and implemented to ensure the ongoing recovery of fin whales. ■ Develop a national vessel strike strategy that investigates the risk of vessel strikes on fin whales and also identifies potential mitigation measures. ■ Ensure all vessel strike incidents are reported in the National Vessel Strike Database.	■ Collision / entanglement with equipment (Section 8.5) ■ Sound emissions (Section 0)
Whale shark (*Rhincodon typus*)	Threatened Species Scientific Committee. 2015. Conservation Advice *Rhincodon typus* (whale shark) (DoE 2015e).	■ Minimise offshore developments and transit time of large vessels in areas close to marine features likely to correlate with whale shark aggregations (Ningaloo Reef, Christmas Island and the Coral Sea) and along the northward migration route that follows the northern Western Australian coastline along the 200 m isobath (as set out in the National Conservation Values Atlas).	■ Collision / entanglement with equipment (Section 8.5) ■ Sound emissions (Section 0)
Northern river shark (*Glyphis garricki*)	Department of the Environment. 2014. Approved Conservation Advice for *Glyphis garricki* (northern river shark) (DoE 2014a). Department of the Environment. 2015. Sawfish and River Sharks Multispecies Recovery Plan. (DoE 2015f).	■ Implement measures to reduce adverse impacts of habitat degradation and/or modification. ■ Performance Criteria for Objective 8d in the Recovery Plan is to adequately take into account and protect BIAs for sawfish and river sharks when assessing the impact of proposed activities in the marine environment (DoE 2015f).	■ Collision / entanglement with equipment (Section 8.5) ■ Sound emissions (Section 0)

Species	Conservation Management Document	Applicable Actions and Management Measures	Relevant Sections in this EP
Dwarf sawfish (*Pristis clavata*)	Threatened Species Scientific Committee. 2009. Approved Conservation Advice for *Pristis clavata* (dwarf Sawfish) (DEWHA 2009). Department of the Environment. 2015. Sawfish and River Sharks Multispecies Recovery Plan. (DoE 2015f).	■ Reduce and, where possible, eliminate any adverse impacts of marine debris on sawfish and river shark species noting the linkages with the Threat Abatement Plan for the Impact of Marine Debris on Vertebrate Marine Life (DoEE 2018). ■ Performance Criteria for Objective 8d in the Recovery Plan is to adequately take into account and protect BIAs for sawfish and river sharks when assessing the impact of proposed activities in the marine environment (DoE 2015f).	■ Liquid discharges and solid waste (Section 7.5). ■ Hydrocarbon and chemical spills (Section 8.1 to 8.4).
Largetooth sawfish (*Pristis pristis*)	Department of the Environment. 2014. Approved Conservation Advice for *Pristris pristris* (largetooth sawfish) (DoE 2014b). Department of the Environment. 2015. Sawfish and River Sharks Multispecies Recovery Plan. (DoE 2015f).	■ Implement measures to reduce adverse impacts of habitat degradation and/or modification. ■ Performance Criteria for Objective 8d in the Recovery Plan is to adequately take into account and protect BIAs for sawfish and river sharks when assessing the impact of proposed activities in the marine environment (DoE 2015f).	■ Liquid discharges and solid waste (Section 7.5). ■ Hydrocarbon and chemical spills (Section 8.1 to 8.4).
Green sawfish (*Pristis zijsron)*	Threatened Species Scientific Committee. 2008. Approved Conservation Advice for *Pristis zijsron* (Green Sawfish) (DEWHA 2008c).	■ Reduce and, where possible, eliminate any adverse impacts of marine debris on sawfish and river shark species noting the linkages with the Threat Abatement Plan for the Impact of Marine Debris on Vertebrate Marine Life (DoEE 2018). ■ Performance Criteria for Objective 8d in the Recovery Plan is to adequately take into account and protect BIAs for sawfish and river sharks when assessing the impact of proposed activities in the marine environment (DoE 2015f).	■ Liquid discharges and solid waste (Section 7.5). ■ Hydrocarbon and chemical spills (Section 8.1 to 8.4).

Species	Conservation Management Document	Applicable Actions and Management Measures	Relevant Sections in this EP
	Department of Environment. 2015. Sawfish and River Sharks Multispecies Recovery Plan (DoE 2015f).		
Leatherback turtle (*Dermochelys coriacea*)	Recovery Plan for Marine Turtles in Australia. Commonwealth of Australia 2017 – 2027 (DoEE 2017). Department of the Environment. 2008. Approved Conservation Advice for *Dermochelys coriacea* (Leatherback Turtle) (DEWHA 2008d).	The conservation advice for the leatherback turtle does not stipulate specific management actions relevant to the survey, given the key management actions detailed in the Recovery Plan for Marine Turtles (DoEE 2017) are applicable to leatherback turtles. The Recovery Plan for Marine Turtles in Australia identities a number of threats to marine turtles in Australian waters, the following of which are relevant to the Petrelex 3D MSS: ▪ marine debris ▪ chemical and terrestrial discharge ▪ light pollution ▪ vessel disturbance ▪ noise interference. The overall objective of the Recovery Plan is to improve the conservation status of marine turtle populations. Actions to achieve this include the management of anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to their survival, and ensure that biologically important behaviour can continue in Biologically Important Areas. Specific noise controls listed in the Recovery Plan include: ▪ A precautionary approach should be applied to seismic work, such that surveys planned to occur inside important internesting habitat should be scheduled outside the nesting season. ▪ In accordance with the EPBC Act Policy Statement 2.1 – Interactions between Offshore Seismic Exploration and Whales: Industry Guidelines, all seismic survey vessels operating in Australian waters must undertake a soft start during surveys irrespective of location and time of year of the survey. Although these guidelines are specifically designed for interactions with whales, the soft start provision may also afford protection for marine turtles.	▪ Collision / entanglement with equipment (Section 8.5). ▪ Sound emissions (Section 0). ▪ Liquid discharges and solid waste (Section 7.5). ▪ Artificial light (Section 7.7) ▪ Hydrocarbon and chemical spills (Section 8.1 to 8.4).

Species	Conservation Management Document	Applicable Actions and Management Measures	Relevant Sections in this EP
Green turtle (*Chelonia mydas*)	Recovery Plan for Marine Turtles in Australia. Commonwealth of Australia 2017 – 2027 (DoEE 2017).	The Recovery Plan for Marine Turtles in Australia (DoEE 2017) identities a number of threats to marine turtles in Australian waters, the following of which are relevant to the Petrelex 3D MSS: ■ marine debris ■ chemical and terrestrial discharge ■ light pollution ■ vessel disturbance ■ noise interference. Specific noise controls listed in the Recovery Plan include: ■ A precautionary approach should be applied to seismic work, such that surveys planned to occur inside important internesting habitat should be scheduled outside the nesting season. ■ In accordance with the EPBC Act Policy Statement 2.1 – Interactions between Offshore Seismic Exploration and Whales: Industry Guidelines, all seismic survey vessels operating in Australian waters must undertake a soft start during surveys irrespective of location and time of year of the survey. Although these guidelines are specifically designed for interactions with whales, the soft start provision may also afford protection for marine turtles.	■ Collision / entanglement with equipment (Section 8.5). ■ Sound emissions (Section 0). ■ Liquid discharges and solid waste (Section 7.5). ■ Artificial light (Section 7.7). ■ Hydrocarbon and chemical spills (Section 8.1 to 8.4).
Loggerhead turtle (*Caretta caretta*)	Recovery Plan for Marine Turtles in Australia. Commonwealth of Australia 2017 – 2027 (DoEE 2017).	The Recovery Plan for Marine Turtles in Australia (DoEE 2017) identities a number of threats to marine turtles in Australian waters, the following of which are relevant to the Petrelex 3D MSS: ■ marine debris ■ chemical and terrestrial discharge ■ light pollution ■ vessel disturbance ■ noise interference. The overall objective of the Recovery Plan is to improve the conservation status of marine turtle populations. Actions to achieve this include the management of anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to their survival, and ensure that biologically important behaviour can continue in Biologically Important Areas.	■ Collision / entanglement with equipment (Section 8.5). ■ Sound emissions (Section 0). ■ Liquid discharges and solid waste (Section 7.5). ■ Artificial light (Section 7.7). ■ Hydrocarbon and chemical spills (Section 8.1 to 8.4).

Species	Conservation Management Document	Applicable Actions and Management Measures	Relevant Sections in this EP
		Specific noise controls listed in the Recovery Plan include: ■ A precautionary approach should be applied to seismic work, such that surveys planned to occur inside important internesting habitat should be scheduled outside the nesting season. ■ In accordance with the EPBC Act Policy Statement 2.1 – Interactions between Offshore Seismic Exploration and Whales: Industry Guidelines, all seismic survey vessels operating in Australian waters must undertake a soft start during surveys irrespective of location and time of year of the survey. Although these guidelines are specifically designed for interactions with whales, the soft start provision may also afford protection for marine turtles.	
Hawksbill turtle (*Eretmochelys imbricata*)	Recovery Plan for Marine Turtles in Australia. Commonwealth of Australia 2017 – 2027 (DoEE 2017).	The Recovery Plan for Marine Turtles in Australia (DoEE 2017) identities a number of threats to marine turtles in Australian waters, the following of which are relevant to the Petrelex 3D MSS: ■ marine debris ■ chemical and terrestrial discharge ■ light pollution ■ vessel disturbance ■ noise interference. The overall objective of the Recovery Plan is to improve the conservation status of marine turtle populations. Actions to achieve this include the management of anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to their survival, and ensure that biologically important behaviour can continue in Biologically Important Areas. Specific noise controls listed in the Recovery Plan include: ■ A precautionary approach should be applied to seismic work, such that surveys planned to occur inside important internesting habitat should be scheduled outside the nesting season.	■ Collision / entanglement with equipment (Section 8.5). ■ Sound emissions (Section 0). ■ Liquid discharges and solid waste (Section 7.5). ■ Artificial light (Section 7.7). ■ Hydrocarbon and chemical spills (Section 8.1 to 8.4).

Species	Conservation Management Document	Applicable Actions and Management Measures	Relevant Sections in this EP
		■ In accordance with the EPBC Act Policy Statement 2.1 – Interactions between Offshore Seismic Exploration and Whales: Industry Guidelines, all seismic survey vessels operating in Australian waters must undertake a soft start during surveys irrespective of location and time of year of the survey. Although these guidelines are specifically designed for interactions with whales, the soft start provision may also afford protection for marine turtles.	
Flatback turtle (*Natator depressus*)	Recovery Plan for Marine Turtles in Australia. Commonwealth of Australia 2017 – 2027 (DoEE 2017).	The Recovery Plan for Marine Turtles in Australia (DoEE 2017) identities a number of threats to marine turtles in Australian waters, the following of which are relevant to the Petrelex 3D MSS: ■ marine debris ■ chemical and terrestrial discharge ■ light pollution ■ vessel disturbance ■ noise interference. The overall objective of the Recovery Plan is to improve the conservation status of marine turtle populations. Actions to achieve this include the management of anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to their survival, and ensure that biologically important behaviour can continue in Biologically Important Areas. Specific noise controls listed in the Recovery Plan include: ■ A precautionary approach should be applied to seismic work, such that surveys planned to occur inside important internesting habitat should be scheduled outside the nesting season. ■ In accordance with the EPBC Act Policy Statement 2.1 – Interactions between Offshore Seismic Exploration and Whales: Industry Guidelines, all seismic survey vessels operating in Australian waters must undertake a soft start during surveys irrespective of location and time of year of the survey. Although these guidelines are specifically designed for interactions with whales, the soft start provision may also afford protection for marine turtles.	■ Collision / entanglement with equipment (Section 8.5). ■ Sound emissions (Section 0). ■ Liquid discharges and solid waste (Section 7.5). ■ Artificial light (Section 7.7). ■ Hydrocarbon and chemical spills (Section 8.1 to 8.4).

Species	Conservation Management Document	Applicable Actions and Management Measures	Relevant Sections in this EP
Olive ridley turtle (*Lepidochelys olivacea*)	Recovery Plan for Marine Turtles in Australia. Commonwealth of Australia 2017 – 2027 (DoEE 2017).	The Recovery Plan for Marine Turtles in Australia (DoEE 2017) identities a number of threats to marine turtles in Australian waters, the following of which are relevant to the Petrelex 3D MSS: ■ marine debris ■ chemical and terrestrial discharge ■ light pollution ■ vessel disturbance ■ noise interference. The overall objective of the Recovery Plan is to improve the conservation status of marine turtle populations. Actions to achieve this include the management of anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to their survival, and ensure that biologically important behaviour can continue in Biologically Important Areas. Specific noise controls listed in the Recovery Plan include: ■ A precautionary approach should be applied to seismic work, such that surveys planned to occur inside important internesting habitat should be scheduled outside the nesting season. ■ In accordance with the EPBC Act Policy Statement 2.1 – Interactions between Offshore Seismic Exploration and Whales: Industry Guidelines, all seismic survey vessels operating in Australian waters must undertake a soft start during surveys irrespective of location and time of year of the survey. Although these guidelines are specifically designed for interactions with whales, the soft start provision may also afford protection for marine turtles.	■ Collision / entanglement with equipment (Section 8.5). ■ Sound emissions (Section 0). ■ Liquid discharges and solid waste (Section 7.5). ■ Artificial light (Section 7.7). ■ Hydrocarbon and chemical spills (Section 8.1 to 8.4).
Eastern Curlew (*Numenius madagascariensis*)	Department of the Environment. 2015. Conservation Advice *Numenius madagascariensis* eastern curlew (DoE 2015g).	The Conservation Plan for Curlew Sandpiper provides a framework to guide the conservation of this species and their habitat in Australia. The conservation plan identifies a number of key threats to migratory shorebirds, the following of which are relevant to the Petrelex 3D MSS: ■ Habitat modification (marine debris, pollution, chemical/terrestrial discharge) ■ Anthropogenic disturbance (presence of anthropogenic activity)	■ Collision / entanglement with equipment (Section 8.5). ■ Sound emissions (Section 0). ■ Liquid discharges and solid waste (Section 7.5). ■ Artificial light (Section 7.7). ■ Hydrocarbon and chemical spills (Section 8.1 to 8.4).

Species	Conservation Management Document	Applicable Actions and Management Measures	Relevant Sections in this EP
Curlew Sandpiper (*Calidris ferruginea*)	Department of the Environment. 2015. Conservation Advice Calidris ferruginea curlew sandpiper (DoE 2015h)	The Conservation Plan for Eastern Curlew provides a framework to guide the conservation of this species and their habitat in Australia. The conservation plan identifies a number of key threats to migratory shorebirds, the following of which are relevant to the Petrelex 3D MSS: ■ Habitat modification (marine debris, pollution, chemical/terrestrial discharge) ■ Anthropogenic disturbance (presence of anthropogenic activity)	■ Collision / entanglement with equipment (Section 8.5). ■ Sound emissions (Section 0). ■ Liquid discharges and solid waste (Section 7.5). ■ Artificial light (Section 7.7). ■ Hydrocarbon and chemical spills (Section 8.1 to 8.4).
Red Knot (*Calidris canutus*)	Threatened Species Scientific Committee. 2016. Conservation Advice *Calidris canutus* Red knot (DoE 2016).	The Conservation Plan for Red Knot provides a framework to guide the conservation of this species and their habitat in Australia. The conservation plan identifies a number of key threats to migratory shorebirds, the following of which are relevant to the Petrelex 3D MSS: ■ Habitat modification (marine debris, pollution, chemical/terrestrial discharge) ■ Anthropogenic disturbance (presence of anthropogenic activity)	■ Collision / entanglement with equipment (Section 8.5) ■ Sound emissions (Section 0). ■ Liquid discharges and solid waste (Section 7.5). ■ Artificial light (Section 7.7). ■ Hydrocarbon and chemical spills (Section 8.1 to 8.4).
Migratory Shorebirds	Wildlife conservation plan for migratory shorebirds (DoE 2015i).	The Conservation Plan for Migratory shorebirds provides a framework to guide the conservation of migratory shorebirds and their habitat in Australia. The conservation plan identifies a number of key threats to migratory shorebirds, the following of which are relevant to the Petrelex 3D MSS: ■ Habitat modification (marine debris, pollution, chemical/terrestrial discharge) ■ Anthropogenic disturbance (presence of anthropogenic activity)	■ Collision / entanglement with equipment (Section 8.5). ■ Sound emissions (Section 0). ■ Liquid discharges and solid waste (Section 7.5). ■ Artificial light (Section 7.7). ■ Hydrocarbon and chemical spills (Section 8.1 to 8.4).

Species	Conservation Management Document	Applicable Actions and Management Measures	Relevant Sections in this EP
Other threatened and migratory species	N/A	All other threatened and migratory species identified by the EPBC Protected Matters Search as potentially occurring within the Operational Area and EMBA, have no conservation advices and/or recovery plans. No applicable actions and/or management measures have been identified for these species.	N/A

2.2 Applicable Policies, Industry Standards and Guidelines

In addition to legislation and international agreements, the government policies, industry standards and guidelines outlined in Table 2-5 apply to the conduct of marine seismic surveys in Australian waters and have been taken into account in the planning of the Petrelex 3D MSS and the evaluation and management of impacts and risks in Section 7 and 8.

Table 2-5 Summary of Applicable Policies, Industry Standards and Guidelines

Guideline	Description
Australian Standard AS/NZS ISO 31000:2009 Risk Management—Principles and Process	Provides principles, framework and a process for managing risk. The risk assessment method used for this EP is aligned with this standard.
EPBC Regulations 2000 Part 8 – Interacting with cetaceans and whale watching	These guidelines are set to minimise the impacts on cetaceans in relation to cetacean interactions, whale watching and the exporting and importing of cetaceans. Relevant to this survey, these guidelines provide guidance on how to act appropriately when cetaceans are in the vicinity of vessels.
EPBC Act Policy Statement 2.1 – Interaction between Offshore Seismic Exploration and Whales: Industry Guidelines (DEWHA 2008e)	These guidelines encourage industry to minimise the likelihood of seismic activities causing injury or hearing impairment to whales, based on present scientific understanding.
Australian Ballast Water Management Requirements (Department of Agriculture and Water Resources 2017)	Provides guidance on how vessel operators should manage ballast water when operating within Australian seas in order to comply with the *Biosecurity Act 2015*, the aim of which is to manage the biosecurity risks posed by ballast water and sediments. They set out the obligations on vessel operators with regards to the management of ballast water and ballast tank sediment, including ballast water management systems, options for ballast water exchange, and vessel Ballast Water Management Plans.
National Biofouling Management Guidance for the Petroleum Production and Exploration Industry, (Commonwealth of Australia 2009)	This guidance aims to provide assistance in regards to minimising the amount of biofouling accumulating on vessels, infrastructure and submersible equipment and thereby minimising the risk of spreading marine pests around the Australian coastline.
NOPSEMA Information Paper IP1411: Consultation Requirements Under the OPGGS Environment Regulations 2009, Rev 2 (NOPSEMA 2014a)	Information Paper outlines the consultation requirements of the Environment Regulations as they apply to Environment Plans (EPs).
NOPSMEA Guidance Note GN0926: Notification and Reporting of Environmental Incidents, Rev 4 (NOPSEMA 2014b)	Outlines the requirements of notifying and reporting environmental incidents to NOPSEMA.
NOPSEMA Information Paper IPI765: Acoustic Impact Evaluation and Management (NOPSEMA 2018a)	The Information Paper good practice advice for the assessment and management of environmental impacts from acoustic emissions generated by seismic activities.

Guideline	Description
NOPSEMA Guidance Note GN1488: Oil Pollution Risk Management, Rev 2 (NOPSEMA 2018b)	Guidance note provides specific information on the content required in an OPEP and to articulate considerations that support the development of an acceptable EP submission in relation to oil pollution risks.
NOPSEMA Guidance Note GN1785: Petroleum Activities and Australian Marine Parks, Rev 0 (NOPSEMA 2018c)	The Guidance Note provides guidance on the key management arrangements and requirements that are relevant to petroleum and greenhouse gas activities that may affect Australian Marine Parks (AMPs).
NOPSEMA Guidance Note GN1344 Environment Plan Content Requirements, Rev 4 (NOPSEMA 2019a)	The purpose of this guidance note is to assist stakeholders in understanding the requirements for preparing and submitting an EP for assessment.
NOPSEMA Bulletin #1 Oil Spill Modelling (NOPSEMA 2019b)	The Bulletin provides advice on the application of stochastic modelling to support risk evaluations and application of deterministic modelling in response planning. The bulletin was released to promote good practice and ensure that the community is better informed about the purpose and interpretation of oil spill modelling and to ensure the outputs of oil spill modelling are meaningful.
DPIRD Fisheries Research Report No.288 - Risk Assessment of the Potential Impacts of Seismic Air Gun Surveys on Marine Finfish and Invertebrates in Western Australia (Webster et al. 2018)	Provides guidance on the potential risks posed by seismic surveys on finfish and invertebrates in waters off Western Australia. The Report is presents the outcomes of a workshop held by DPIRD. The risk assessment involved estimating the level of risk associated with seismic surveys, on the survival and/or the reproductive capacity of marine finfish and invertebrate individuals closest to the seismic source, for a period of 12 months directly following exposure.
International Association of Geophysical Contractors (IAGC) Environment Manual for Worldwide Geophysical Operations (IAGC 2013)	Provides the industry with useful information for conducting geophysical field operations in an environmentally sensitive manner.
IAGC Mitigation Measures For Cetaceans during Geophysical Operations (IAGC 2015)	Provides recommended mitigation measures for cetaceans during geophysical operations. IAGC recommends implementing the suggested controls (mentioned in the document) in the absence of regulations or guidelines.
IOGP Recommended monitoring and mitigation measures for cetaceans during marine seismic survey geophysical operations (IOGP 2017)	Provides recommendations on applying mitigation measures for cetaceans during geophysical operations. The measures outlined in this report are recommended for use during all marine seismic surveys that use compressed air source arrays, and are only intended for cetaceans (whales, dolphins and porpoises).
International Maritime Organisation (IMO) Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species (Biofouling Guidelines) (IMO 2011)	Provide a globally consistent approach to the management of biofouling. The approach was adopted by the Marine Environment Protection Committee (MEPC) in July 2011.

2.3 Titleholder's Environmental Management Framework

2.3.1 *Vision, Values and Policies*

Polarcus' stated vision is "to be a pioneer in an industry where the frontiers of seismic exploration are responsibly expanded without harm to our world." To achieve this vision, Polarcus ascribes to a number of values which are delivered through a series of commitments, including:

- Commitment to the Environment and Community (Appendix A); and
- Commitment to Health and Safety (Appendix B).

Copies of these commitments (or policy statements) are provided in Section 2.3.3 and a summary of their intent is provided in Table 2-6.

2.3.2 *Polarcus Management System*

Polarcus assure the delivery of their commitments through the Polarcus Management System, an integrated system addressing environment, safety and quality management. The Management System is based on OGP Report No. 510 (OGP-IPIECA 2014) and encompasses the four fundamentals of Leadership, Managing Risk, Continual Improvement and Implementation together with 10 Elements in a Plan, Do, Check and Act process. The Polarcus Management System carries a hierarchic structure with Commitment and Accountability at the top, leading into the process flow encompassing all company activities.

Polarcus' office and vessels are certified to ISO 9001:2015, ISO 14001:2015 & OHSAS 18001:2007 while also subscribing to the prestigious DNVGL Triple-E program, an Environmental and Energy Efficiency rating scheme for ships.

The planning, execution and follow-up of the Petrelex 3D MSS will be undertaken within the framework of the Polarcus Management System.

2.3.3 *Relevant Polarcus Documents*

Relevant Polarcus documents that define how the Petrelex 3D MSS will be implemented and are detailed in Table 2-6.

Table 2-6 Polarcus Documents

Documents	Summary of Relevant Information
Commitment to the Environment and the Community (refer to Appendix A).	This document provides a statement addressing Polarcus' goal to minimise their impact on the marine environment. Including a 'Zero Spills' target with regards to oil pollution. It also details their aim to actively reduce and recycle where possible, to make use of the latest technologies available to limit their environmental footprint and to operate responsibly to prevent environmental incidents from the first project planning stages through to project closure.
Commitment to Health and Safety (refer to Appendix B).	This document establishes Polarcus' risk management objectives and defines key terms. The objectives are to: ▪ Protect the company from those risks of significant likelihood and consequence in the pursuit of our strategic goals and objectives; ▪ Provide a consistent risk management framework in which the risks concerning company business processes and functions will be identified, considered and addressed in key approval, review and control processes;

Documents	Summary of Relevant Information
	■ Encourage a pro-active business environment rather than re-active management; ■ Provide assistance to and improve the quality of decision making; ■ Meet legal or statutory requirements; and ■ Assist in safeguarding our people, the environment, our property and our reputation.
Environmental Management Procedure	This procedure provides step by step guidance for managing environmental performance. It ensures that roles and responsibilities are clearly defined for all personnel concerned and that environmental issues are highlighted for every project. The procedure details the Company's expectations associated with the following topics: Pre-survey environmental planning, Pre-survey environmental checklist, environmental training and competency, and environmental auditing. It also establishes Company expectations associated with specific environmental risks, including those associated with: ■ Interactions with aquatic life; ■ Water travel; ■ Helicopters; ■ Seismic vessel operations; ■ Retrieval of lost equipment; ■ Use of small boats; ■ Use of support vessels; ■ Storage of fuels and oils; ■ Refuelling; ■ Engine exhausts; ■ Anchoring; ■ Waste management; and ■ Untreated sewage. This procedure is supported by a series of tools including audit and waste management checklists.
Risk Management Procedure	Provides a consistent risk management framework in which risks concerning Polarcus' business activities and tasks are identified, considered and addressed. The goal of the procedure is to eliminate or reduce the risks and effects of foreseeable hazards to a level that is considered both acceptable and ALARP. The procedure and its associated risk matrix have been used to identify and assess the impacts and risks for this EP, as described in Section 6.
Emergency Response Procedure and Emergency Response Plan	This Emergency Response Procedure establishes the overarching process and responsibilities for notifications of emergency situations. It also establishes the expectations for emergency response with the goal of: ■ Coordinating the response to an emergency, protecting the personnel, assets, environment, reputation and business of the company; ■ Ensuring clear lines of communication with onsite personnel, rescue centres and public authorities;

Documents	Summary of Relevant Information
	■ Establishing clear lines of communication between the company and next of kin; and ■ Managing relations with the media. These goals are delivered through the Emergency Response Plan, which establishes the chain of command, responsibilities and tasks of personnel involved in responding to emergencies.
Oil Spill Procedure	This procedure gives the Vessel Master overall responsibility for the safety of the vessel and personnel. It clarifies the use of the vessel's MARPOL 73/78 compliant SOPEP and establishes the framework for notifying and activating a response from the nearest coastal state. Per MARPOL 73/78 Annex I, all vessels over 400 gt will have a SOPEP. The Oil Pollution Emergency Plan (OPEP) supports this Oil Spill Procedure specific to the activities of the Petrelex 3D MSS (refer to Section 0).

3. DESCRIPTION OF THE ACTIVITY

3.1 Location

The Operational Area is located in Commonwealth waters of the Petrel Sub-basin (in the Bonaparte Basin), offshore from north-west Australia.

The Acquisition Area comprises the area within which 3D seismic acquisition will be undertaken and covers approximately 2,900 km^2 (Figure 1-1). The Acquisition Area is surrounded by a larger Operational Area (~7,150 km^2), for the purpose of line turns, run-ins, run-outs, seismic testing and support activities.

The Operational Area at its closest is approximately 90 km north-west of the Northern Territory (NT) coastline and 140 km north-east of the Kimberley coastline.

3.2 Activity Details

The core activity that forms the basis for this EP is the undertaking of a marine seismic survey. Associated activities in support of undertaking the seismic survey includes; refuelling and resupply, use of support vessels as required, and crew changes within the Operational Area. Associated activities are described in this section as appropriate, with a focus on those considered relevant to the assessment of environmental impact and risk.

Key details of the Petrelex 3D MSS relevant to the purpose and objectives of this EP are summarised in Table 3-1 and described below.

Table 3-1 Key Seismic Survey Details

Feature	Indicative Information
Seismic vessel	
Number	One purpose built seismic vessel
Class	ULSTEIN SX124/134 and DNVGL CLEAN-DESIGN
Length	90-92 m
Beam	19-21 m
Gross tonnage	6,500-7,500 tonnes
Fuel type	Marine Gas Oil (MGO)
Fuel capacity	1,540-1,925 m^3
Largest fuel tank size	280 m^3
Number of personnel	60
Seismic Source	
Type	Airgun / three subarrays
Size	2,495 cubic inches
Pressure	2,000 pounds per square inch (psi) (nominal)
Source levels (at 10-2,000 Hz) (Quijano et al. 2019)	255 dB re 1 μPa^{2}m^2 (PK) 228-230 dB re 1 μPa^{2}m^{2}s (SEL)

Feature	Indicative Information
Towing depth	5 – 10 m
Streamer	
Type	Solid
Number	10
Length	8,100 m (extending up to 8,900 m astern)
Spacing	112.5 m
Towing depth	Approximately 15 m
Seismic Activity	
Seismic vessel speed	Approximately 4-5 knots
Seismic line spacing	Approximately 562.5 m
Discharge interval	Approximately every 12.5 m (approximately every 5 seconds) along survey lines
Logistics	
Number of support vessels	Two (one chase vessel and one supply vessel)
Refuelling	At sea every 10 to 14 days
Crew change	Via helicopter transfers every 35 days

3.3 Seismic Vessel

3.3.1 *Overview*

Seismic data acquisition will be undertaken by one purpose-built, state of the art Polarcus-owned and operated seismic vessel, although final confirmation of the exact seismic vessel has yet to be made.

The Polarcus seismic vessels, with the ULSTEIN SX124 and SX134 design types, are considered to be amongst the most environmentally sound seismic vessels in the market with diesel-electric propulsion, double hull and advanced ballast water treatment/bilge water cleaning systems. The seismic vessel carries a maximum of 60 persons on board (POB).

The Polarcus seismic vessels use a Marine Gas Oil (MGO) fuel and do not utilise heavy fuel oil. MGO is produced through distillation and as such, it contains a higher proportion of lighter hydrocarbons than other marine fuel types such as intermediate fuel oil or heavy fuel oil.

3.3.2 *Environmental Considerations in Design and Construction of Seismic Vessel*

Further, the seismic vessels meet the stringent Det Norske Veritas (DNVGL) CLEAN-DESIGN and BWM-T notations that regulate emissions to air and water. The seismic vessels have also received a DNVGL Vessel Emissions Qualification Statement verifying its ability to accurately measure and report specific emissions data, allowing operational performance to be optimised in real time to reduce the total emissions footprint. The Polarcus seismic vessels also carry the International Maritime Organization (IMO) Green Passport that regulates environmental and occupational health and safety risks through the life of the vessel, from shipbuilding to eventual recycling.

In addition to complying with the applicable local regulatory requirements for the protection of marine mammals in or around seismic operations, Polarcus follows standard industry practices for soft start procedures across all seismic operations. Polarcus also has a Passive Acoustic Monitoring (PAM) system available on board, designed to detect the presence of marine mammals by listening for their calls.

A number of measures have been taken by Polarcus to provide additional protection for vessel integrity, including double hull on the vessel and the additional requirements for compliance that enables the vessel to meet the DNVGL 2008 SPS notation for controlled stability and floatability. The DNVGL 2008 SPS notation is a class notation implemented to classify Special Purpose Ships. The vessel also has the DNVGL NAUT-AW class notation for enhanced nautical safety, incorporating a grounding avoidance system.

The vessels have multiple main engines, independent propeller shafts and split switchboards and additionally carry the DNVGL notation DYNPOS-AUTR that warrants the vessel has a redundant dynamic positioning system and an independent joystick system back-up. Taken together these features substantially reduce the risk of loss of control of the vessel, potentially enabling the operators to secure lower insurance premiums for operations around infrastructure, and enabling the safe recovery of in-sea equipment.

3.4 Seismic Source Operation

Polarcus intends to acquire approximately 2,900 km^2 of 3D seismic data in water depths of 73 - 107 m.

The seismic source selected for the survey is Polarcus' triple-source array, with an operating capacity of 2,495 cubic inches (cui), comprising three separate sub-arrays that will be discharged alternately ('flip-flop-flap' source configuration). The seismic survey vessel will tow the seismic source and a total of 10 streamers, along pre-determined survey lines within the Acquisition Area. The seismic survey vessel will typically acquire seismic data along a series of adjacent and parallel lines in a "racetrack"-like pattern. At the end of each line, the vessel will turn in a wide arc to position for another parallel line in the opposite direction. When the vessel completes the line, it will turn again to follow another line offset approximately 562.5 m from the first. This pattern is repeated until the required coverage is completed. Acquisition lines will be in a north-west to south-east orientation or north-east to south-west orientation[1]. Figure 3-1 represents an indicative seismic survey process.

The seismic source will be towed a short distance behind the seismic vessel at depths of 5 - 10 m. The ten solid hydrophone streamers, each measuring approximately 8,100 m in length, will be towed at a depth of approximately 15 m below the surface. The hydrophone streamers will be spaced 112.5 m apart.

Tail buoys will be used to maintain the position of the streamers in the water and clearly indicate the streamer ends. The streamers will be fitted with a self-inflating streamer recovery device so that the streamers will return to the surface if they go beyond a certain water depth. In addition, the tail buoys will be fitted with turtle guards, lights and radar reflectors installed. Depth monitoring and control devices positioned along the streamers will be used to maintain the preferred tow depth.

The survey will be conducted at a speed of approximately 4.5 knots. To ensure data integrity and minimise environmental impacts, a minimum separation distance of 40 km shall be maintained between the seismic vessel during data acquisition and other seismic vessels operating in the area.

Full-fold seismic data acquisition involving operation of the seismic source at full volume will occur within the Acquisition Area, although the seismic source will also be operated outside of the Acquisition Area during line run-outs, soft-starts, maintenance and testing.

[1] The acquisition direction has not yet been confirmed. Prior to survey commencement, stakeholders will be notified of the acquisition direction.

During line run-outs, the seismic source will typically be operated at full volume for the equivalent of half a streamer length (approximately 4 – 5 km) before the source is shut down and the seismic vessel commences the next line turn. Following completion of the line turn, the vessel will complete a run-in towards the Acquisition Area, which involves sailing in a straight line to allow the streamers to straighten prior to commencing acquisition. During these run-ins, soft-start procedures occur for a minimum of 30 minutes (approximately 4 – 5 km), which begins with the operation of the single smallest source element (i.e. 45 cui on the Polarcus triple-source array) and gradual ramp-up to include additional source elements until the seismic source is operated at full volume for the commencement of the acquisition line at the Acquisition Area boundary.

The seismic source may also be operated for short durations elsewhere in the Operational Area in a controlled manner; for the purpose of source maintenance and testing. These activities are infrequent and typically involve intermittent controlled discharges of individual source elements (i.e. single gun/cluster or single source array) for durations in the order of a limited number of testing shots. The output from the testing of a single gun/cluster is expected to range between 5-8 bar-m 0-P (234-238 dB re 1 µPa (PK)) and the testing of the largest sub-array is expected to be 44 bar-m 0-P (253 dB re 1 µPa (PK)).

Operation of the seismic source in all cases will be managed in accordance with the control measures and performance standards specified in this EP. The seismic source will not be operated outside of the Operational Area.

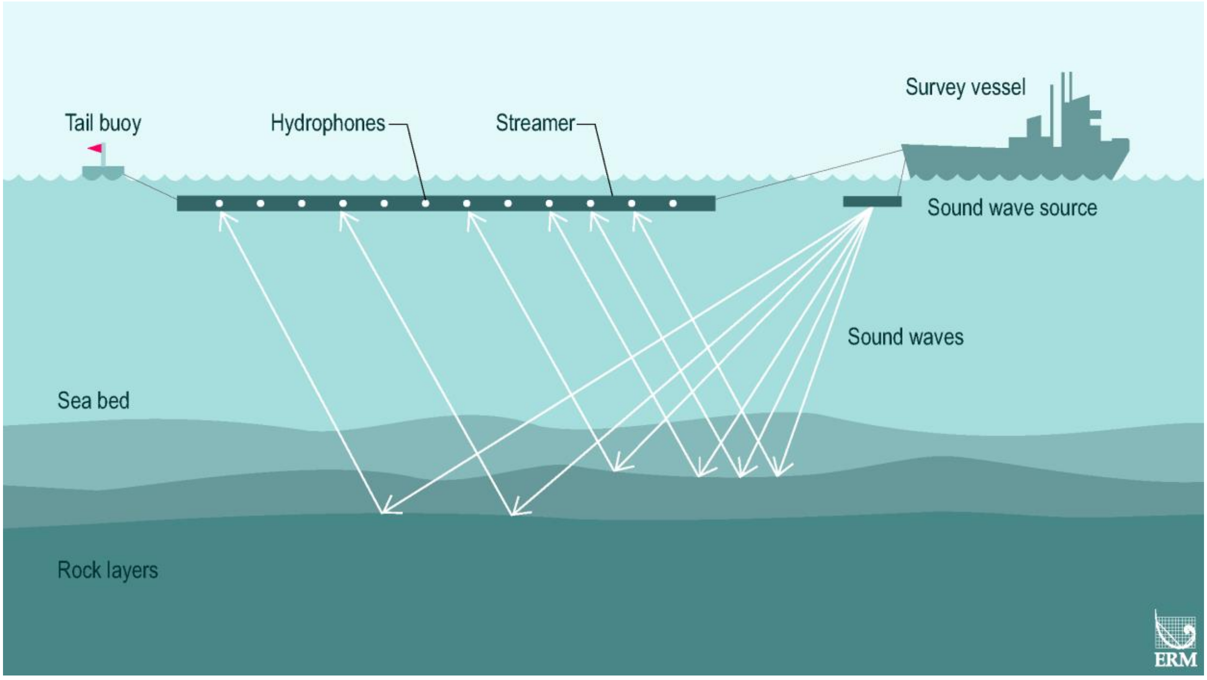


Figure 3-1 Indicative Seismic Survey Process

3.5 Support Activities

Two support vessels will be engaged for the Petrelex 3D MSS. These comprise:

- One support (or chase) vessel accompanying the seismic vessel to assist with managing potential interactions with other users of the area; and
- One supply vessel for resupply, refuelling, emergency towing and other support functions.

The supply vessel is selected such that it is of a sufficient size and power to tow a seismic vessel in the unlikely event that the seismic vessel loses power.

Refuelling and resupply at sea by a supply vessel is expected to occur approximately every 10 to 14 days during the survey. At-sea refuelling of the seismic vessel will only take place during daylight hours and within strict weather limit guidelines.

Crew changes are expected to occur every 35 days by helicopter.

3.6 Schedule

The Petrelex 3D MSS may commence as early as September 2019 and will be completed before 31 December 2020. However, the survey will not be undertaken during the period 1 August – 30 September 2020 (subject to change), due the Department of Defence undertaking a major military exercise within the Northern Australia Exercise Area (NAXA) (refer to Section 4.6.8). The survey will take a maximum of 64 days to acquire, with eight days' deployment/retrieval and two days' local transit to and from port.

The precise timing of the survey is subject to NOPSEMA's acceptance of the EP, weather conditions, vessel availability and other operational considerations, and will take into account the seasonality of environmental sensitivities, where practicable. The exact start and end dates of the survey will be communicated to stakeholders (in accordance with the ongoing stakeholder consultation process described in Section 5.5).

4. DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 Overview

This chapter describes the environmental and socio-economic values and sensitivities within the Operational Area and the wider environment that may be affected (EMBA) by the proposed activity (see Figure 4-1). The EMBA is a conservative approximation of the furthest extent that may be affected in any credible impact scenario. In this case, the EMBA represents an unplanned release of marine diesel oil (MDO) as described in Section 8.1. The EMBA has been defined as a 40 km buffer around the boundary of the Operational Area (see Figure 4-1). This is based on the maximum extent of sea surface exposure above the moderate threshold (>10 g/m^2) for potential impact across three modelled seasons (summer, winter and transition). Further information on the EMBA is provided in Section 8.1.

Table 4-1 provides a summary of the values and sensitivities identified within the EMBA.

Table 4-1 Key Values and/or Sensitivities within the Operational Area and Wider EMBA

Environmental Value and/or Sensitivity	Section	Description
Key Ecological Features (KEFs)	4.3	The Operational Area partially overlaps with one KEF - the Pinnacles of the Bonaparte Basin. The wider EMBA overlaps with two KEFS - the Carbonate Bank and Terrace System of the Sahul Shelf and the Carbonate Bank and the Terrace System of the Van Diemen Rise.
Bathymetry	4.4.7	Water depths in the Operational Area range from approximately 65 m to 111 m, whilst the Acquisition Area ranges in depth from approximately 73 m to 107 m.
Benthic Habitats	4.5.2	The soft sediments that cover the majority of the Operational Area support relatively little seabed structure or sessile epibenthos. They are sparsely covered by sessile filter-feeding organisms and mobile invertebrates. The EMBA is expected to generally contain a similar benthic environment to the Operational Area, with the exception of habitats associated with hard-substrate KEFs in the north-east portion of the EMBA, which may support hard corals.
Fish Assemblages	4.5.3	No protected species habitats were identified as occurring in the Operational Area. A range of fish species including reef fish may be present in the EMBA with more abundance of species expected associated with the Pinnacles of the Bonaparte Basin.
Sharks and Rays	4.5.9	The Operational Area and EMBA do not overlap with any biologically important areas (BIA) for any threatened or migratory shark and ray species. However, largetooth sawfish, green sawfish, dwarf sawfish, narrow sawfish and northern river shark may be present within the Operational Area and EMBA due to overlap with the normal distribution area for these species. Whale sharks may transit through the area due to a wide species distribution, however no feeding, breeding or aggregation areas are located within the Operational Area or EMBA.

Environmental Value and/or Sensitivity	Section	Description
		Shortfin and longfin mako sharks may transit through the area, however no feeding, breeding or aggregation areas are located within the Operational Area or EMBA. Reef manta rays and giant manta rays may transit through the area, however no feeding, breeding or aggregation areas are located within the Operational Area or EMBA.
Marine Reptiles	4.5.7	Green, olive ridley, loggerhead and flatback turtles may be present in the Operational Area and EMBA. A foraging BIA for each of these species overlaps with the Operational Area. No BIAs for Leatherback and hawksbill turtles occur within the Operational Area or wider EMBA, however may transit through the region. Several species of seasnake may occur within the EMBA.
Seabirds	4.5.6	No seabird BIAs occur within the Operational Area or wider EMBA. However, the EMBA is adjacent to a foraging BIA for the lesser crested tern. This species breeds on islands off the north Kimberley coastline and may forage within the EMBA. Other seabirds may be present within the Operational Area during the survey, including threatened and migratory species.
Marine Mammals	4.5.8	No migratory, resting, feeding or calving areas for cetaceans overlap with the Operational Area or wider EMBA. Sei, blue, Bryde's and humpback whales may transit through deeper waters in the northern part of the EMBA. Other cetacean species may be present within the Operational Area as transitory individuals.
Commercial Fisheries	4.6.6	The Operational Area overlaps with the following active commercial fisheries: Commonwealth ■ Northern Prawn Fishery Western Australia ■ Northern Demersal Scalefish Managed Fishery ■ Mackerel Managed Fishery ■ Northern Shark Fishery Northern Territory ■ Demersal Fishery ■ Spanish Mackerel Fishery ■ Offshore Net & Line Fishery No additional fisheries overlap with the EMBA.
Petroleum Activities	4.6.10	No other seismic surveys are planned to occur within 150 km of the Petrelex 3D MSS during the proposed activity timing (September 2019 – December 2020).
Shipping	4.6.9	Heavy vessel traffic in the northern section of the Acquisition Area is expected due to vessels heading in and out of Darwin.

Environmental Value and/or Sensitivity	Section	Description
Defence Activities	4.6.8	The Operational Area and EMBA overlap with the Northern Australian Exercise Area (NAXA). The NAXA is the primary location of a biennial major military training exercise. The exercise is scheduled for 1 August – 30 September 2020. No seismic acquisition will occur during this period.
Australian Marine Parks	4.6.1.1	The Operational Area does not overlap with any AMPs. The EMBA overlaps with the following AMPs: ■ Oceanic Shoals Marine Park (2 km from the Operational Area) ■ Joseph Bonaparte Gulf Marine Park (35 km from the Operational Area)
State / Territory Marine Parks	4.6.1.2	The EMBA does not overlap with any State or Territory Marine Parks.

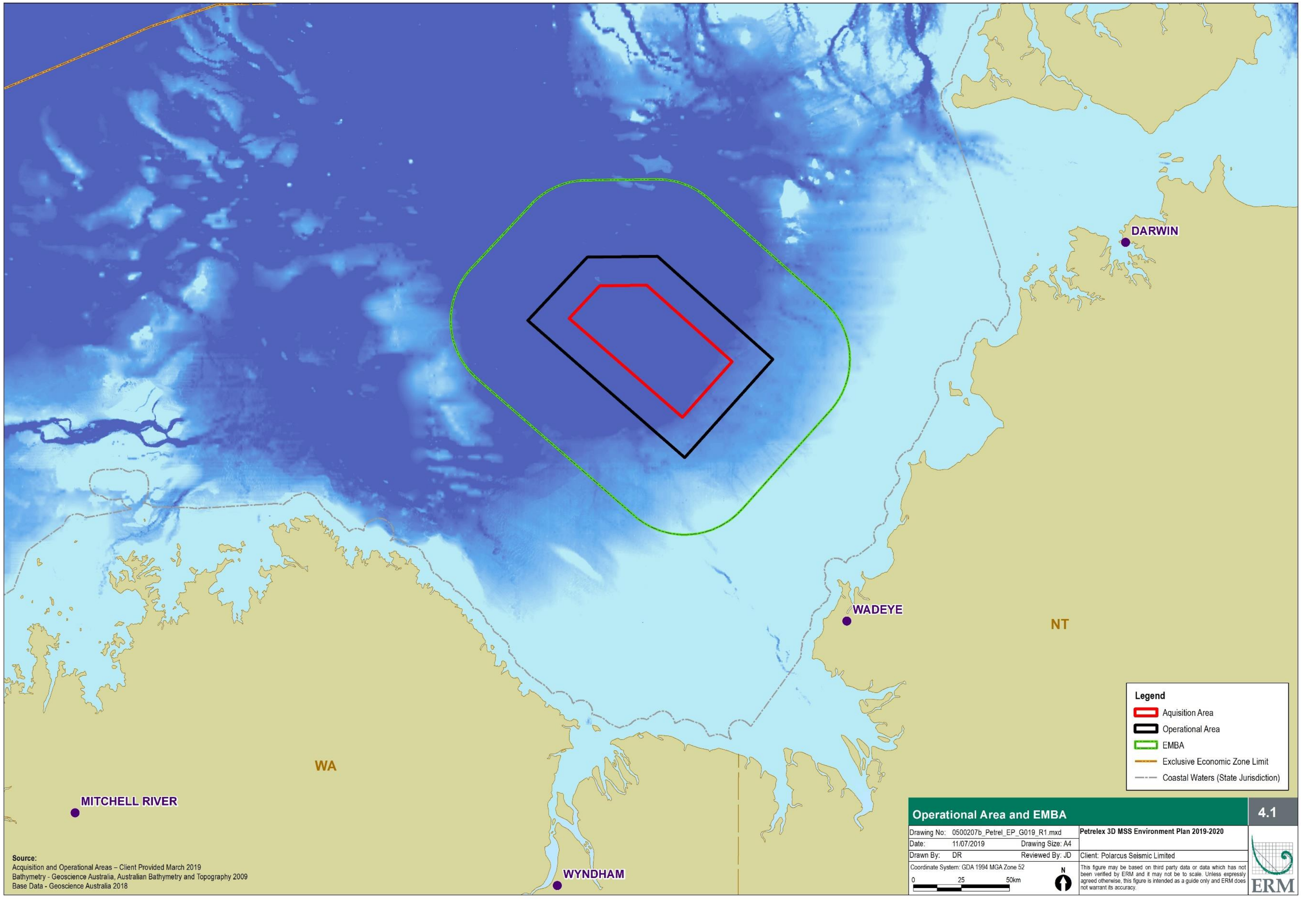


Figure 4-1 Operational Area and EMBA

4.1.1 *Data Sources*

The information provided in this section has been derived from desktop reviews. This includes peer reviewed journals, and government and industry reports. The key sources of information referred to in this section are from DoEE resources and published literature, including but not limited to:

- An EPBC Act Protected Matters Database search was conducted to identify listed threatened and migratory species, and Threatened Ecological Communities occurring in the Operational Area and wider EMBA.
- Species Profile and Threats (SPRAT) Database, which includes information about species and ecological communities protected under the EPBC Act, available at: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl.
- National Conservation Values Atlas, which includes information on Biologically Important Areas (BIAs) for protected species under the EPBC Act. These 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 (DSEWPaC 2012a).

4.2 Regional Environment

In 2008, the former Department of the Environment, Water, Heritage and the Arts (DEWHA) (now the DoEE) introduced marine bioregional planning. Under these plans, the Australian marine environment was categorised into six broad marine bioregions (Figure 4-2). Marine Bioregional Plans describe the marine environment and conservation values of each marine region, set out broad biodiversity objectives, identify regional priorities and outline strategies and actions to address these priorities (DoEE, n.d.).

The Petrelex 3D MSS is located on the boundary of the North Marine Region (NMR) and the North-west Marine Region (NWMR), with a large portion (approximately 4,900 km^2) of the Operational Area being located within the NMR (Figure 1-1). The Acquisition and Operational Areas are also located with the Bonaparte Gulf IMCRA v4 Mesoscale bioregion (Figure 4-3), whilst the EMBA partially overlaps with the Oceanic Shoals, Cambridge-Bonaparte and Anson Beagle mesoscale bioregions.

The Bioregional Plans for the NMR (DEWHA 2008a) and NWMR (DEWHA 2008b), which form part of the respective Bioregional Plans, have been used in conjunction with other relevant management plans, reports and published papers to inform this description of the existing environment.

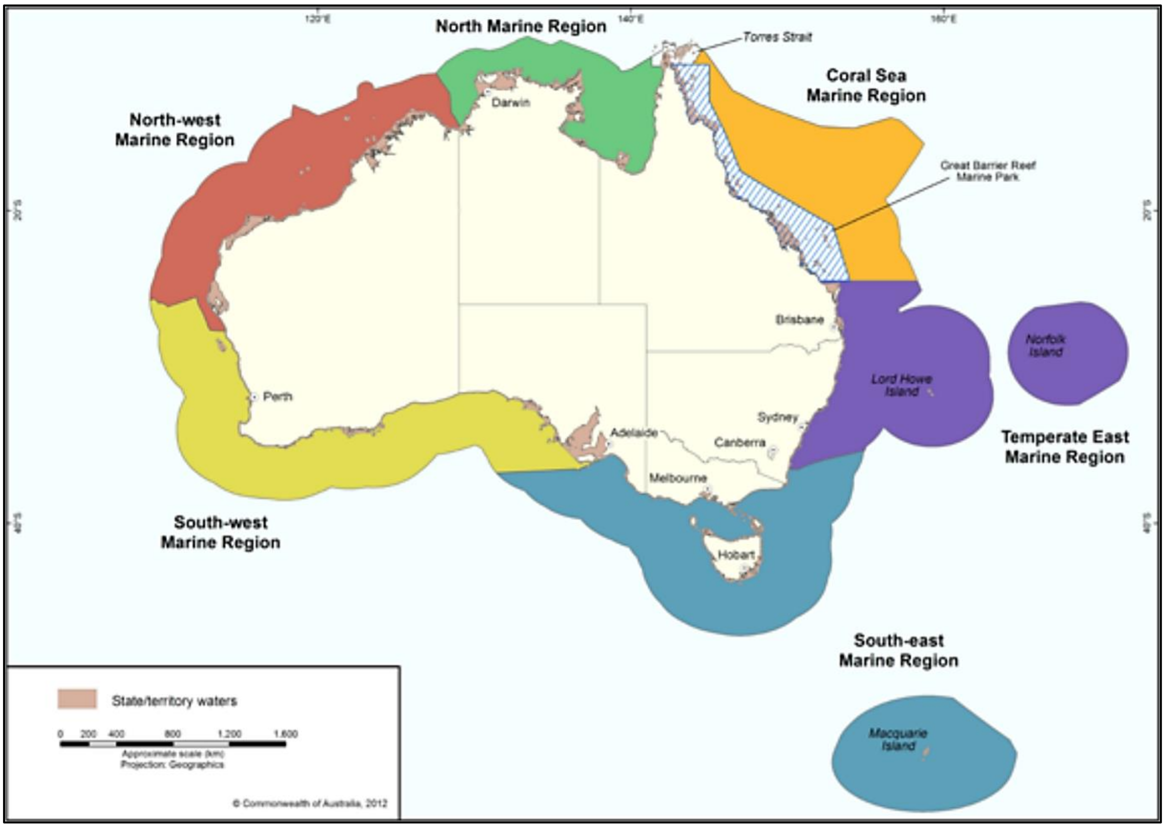


Figure 4-2 Marine Bioregions of Australia (DSEWPaC, 2012a)

4.2.1 *North Marine Region*

The NMR comprises Commonwealth waters from west Cape York Peninsula to the Western Australian-Northern Territory (WA-NT) border. The marine environment of the NMR is known for its high diversity of tropical species but relatively low endemism, in contrast to other bioregions. This region is highly influenced by tidal flows and less by ocean currents. The region is dominated by monsoonal climatic patterns characterised by a pronounced wet season and a generally dry season. Tropical cyclones are a dominant feature in the wet season (DEWHA 2008a).

4.2.2 *North West Marine Region*

The NWMR comprises Commonwealth waters from WA-NT border to Kalbarri, south of Shark Bay. The NWMR is characterised by the large area of continental shelf and continental slope, highly variable tidal regions and very high cyclone incidence Similar to NMR, The NWMR is characterised by shallow-water tropical marine ecosystems, which is home to globally significant populations of internationally threatened species (DEWHA 2008b).

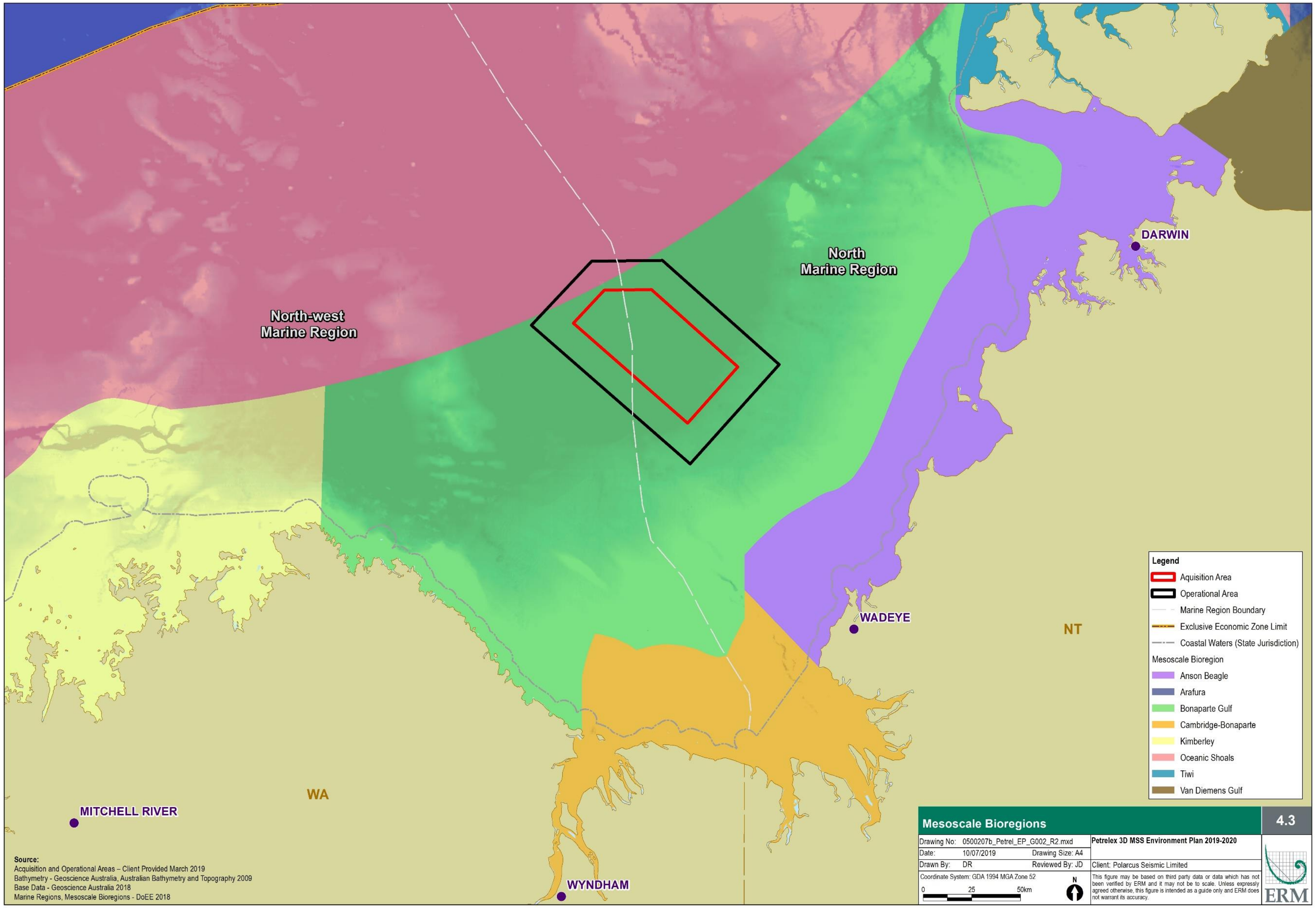


Figure 4-3 Mesoscale Bioregions

4.3 Key Ecological Features

Key ecological features (KEFs) are elements of the Commonwealth marine environment, which, based on current scientific understanding, are considered to be of regional importance for either the region's biodiversity or ecosystem function and integrity.

The Operational Area overlaps with the Pinnacles of the Bonaparte Basin KEF (Figure 4-4). Two pinnacles are located within the Operational Area (outside of the Acquisition Area) and rises to within 80 m of the water surface. In addition, the Carbonate Bank and Terrace System of the Sahul Shelf and the Carbonate Bank and Terrace System of the Van Diemen Rise KEFs are located within the EMBA (Figure 4-4). These KEFs are described in more detail below.

4.3.1 *Pinnacles of the Bonaparte Basin*

The limestone pinnacles of the Bonaparte Basin lie on the mid-outer shelf in the western Joseph Bonaparte Gulf. The Pinnacles of the Bonaparte Basin are defined as a KEF because they are a unique seafloor feature with ecological properties of regional significance.

The pinnacles provide areas of hard substrate in an otherwise soft sediment environment and are therefore important for sessile species. Pinnacles typically rise steeply from depths of about 80 m and emerge to within 30 m of the water surface, allowing light dependent organisms to thrive. Pinnacles that rise to within at least 45 m of the water surface support more biodiversity. Communities include sessile benthic invertebrates including hard and soft corals, sponges, whips, fans, bryozoans and aggregations of demersal fish species such as snappers, emperors and groupers (Brewer et al. 2007; Nichol et al. 2013). The pinnacles are also recognised as a biodiversity hotspot for sponges as they are home to more sponge species and different communities than the surrounding seafloor (NERP MBH 2014).

4.3.2 *Carbonate Bank and Terrace System of the Sahul Shelf*

The Carbonate banks and terrace system of the Sahul Shelf KEF is located in the western Joseph Bonaparte Gulf and to the north of Cape Bougainville and Cape Londonderry. The Operational Area is located approximately 32 km from the KEF. The Carbonate banks and terrace system of the Sahul Shelf is defined as a KEF for its role in enhancing biodiversity and local productivity relative to its surrounds as it is a unique seafloor feature supporting relatively high species diversity, making it regionally significant.

The KEF provides areas of hard substrate in an otherwise soft sediment environment, important for sessile species. Banks rise from depths of approximately 80 m to within 30 m of the surface. Banks that rise to within 45 m water depth support more biodiversity, such as communities of sessile benthic invertebrates including hard and soft corals, sponges, whips, fans and bryozoans (Brewer et al. 2007, Nichol et al. 2013). Brewer et al. (2007) also noted that banks within the KEF support aggregations of demersal fish species such as snappers, emperors and groupers.

The banks and shoals of the KEF are recognised as a biodiversity hotspot for sponges with more species and different communities than the surrounding seafloor (NERP MBH 2014). The KEF is also known as a foraging area for flatback, olive ridley and loggerhead turtles (DEWHA 2008b).

4.3.3 *Carbonate Bank and Terrace System of the Van Diemen Rise*

The Carbonate bank and terrace system of the Van Diemen rise lies on the north-eastern side of the Joseph Bonaparte Gulf (JBG), adjacent to the WA/NT border. This KEF is part of a larger system associated with the Sahul banks to the north and Londonderry rise to the west. It is characterised by terrace, banks, channels and valleys. The Carbonate bank and terrace system of the Van Diemen rise is defined as a KEF considered important for its role in enhancing biodiversity and local productivity relative to its surrounds and for supporting relatively high species diversity.

The carbonate banks and shoals found within the Van Diemen rise make up 80% of the banks and shoals, 79% of the channels and valleys, and 63% of the terrace found across the NMR. The banks, ridges and terraces of the Van Diemen rise are raised geomorphic features with relatively high proportions of hard substrate which support sponge and octocoral gardens. These, in turn, provide habitat to other epifauna by providing structure in an otherwise flat environment (Przeslawski et al. 2011).

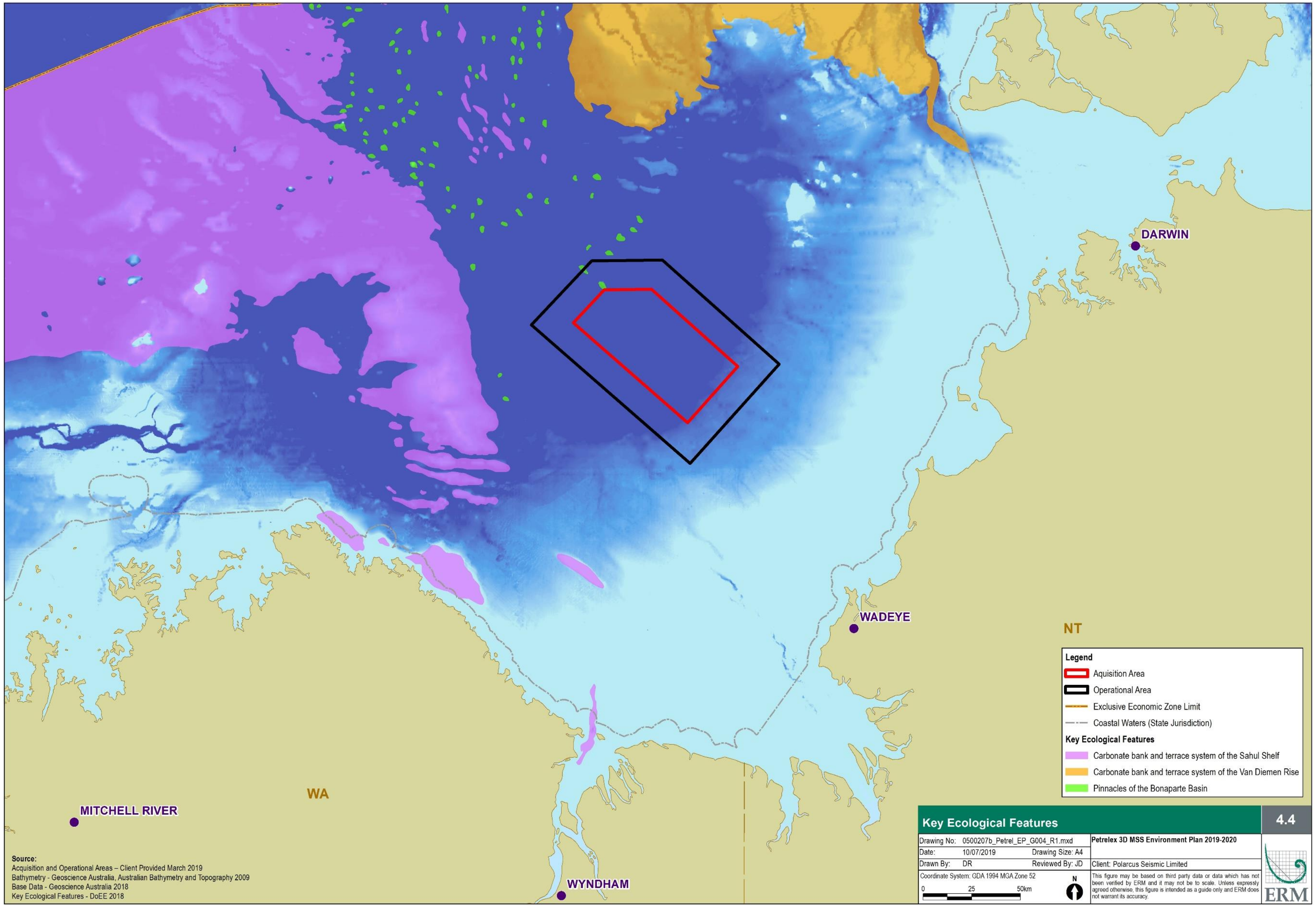


Figure 4-4 Key Ecological Features

4.4 Physical Environment

4.4.1 *Climate*

The region has a tropical monsoonal climate with two distinct seasons known as the North-west Monsoon or “wet season” (late October to mid-March) and the South-east Monsoon or “dry season” (May to mid-October). The North-west Monsoon is characterised by regular and high rainfall, particularly over coastal areas and during cyclones. This is due to large amounts of moisture being gathered as the monsoon crosses the sea from the Asian high-pressure belt on its way to the intertropical convergence zone, which migrates southward close to or over northern Australia. Conversely, the South-east Monsoon originates from the Southern Hemisphere high-pressure belt and is relatively dry and cool.

Tropical cyclones are common in the region, occurring between December and April (BoM 2019a). These phenomena result in severe storms with gale force winds and a rapid rise in water levels. Tropical cyclones usually form in an active monsoon trough, producing heavy rains, strong wind, large swells and storm surges. On average, about five cyclones occur each year in the NWMR, two of which make landfall and one of which is severe (Category 3 or higher). The chance of a severe cyclone occurring is highest in March and April (BoM 2019a).

Dum In Mirrie Airstrip, Channel Point, Port Keats Airport and Truscott are the closest weather stations to the Operational Area. A summary of the seasonal ranges in mean temperature, rainfall and wind speeds recorded are summarised in Table 4-2.

Table 4-2 Seasonal Mean Temperature, Rainfall and Wind Speed Ranges

Weather Station	Distance from Operational Area (km)	Season	Temperature (ºC)	Monthly Rainfall (mm)	Wind Speed (km/h)
Dum In Mirrie Airstrip	141	Wet	25.4 – 33.1	128.3 – 424.2	10.2 – 15.5
		Dry	18.3 – 32.3	1.0 – 60.7	9.5 – 15.7
Channel Point	105	Wet	24.7 – 32.3	130.1 – 459.8	5.4 – 10.7
		Dry	17.2 – 32.3	0.1 – 66.1	5.6 – 13.0
Port Keats Airport	111	Wet	20.2 – 34.4	80 – 312.2	No Data
		Dry	16.8 – 34.4	0.7 – 43.8	No Data
Truscott	205	Wet	25.2 – 35.1	28.6 – 325.0	No Data
		Dry	18.5 – 30.3	0.2 – 24.5	No Data

1. BoM 2019b, 2019c, 2019d and 2019e
2. Wind speed ranges include both 9 am and 3 pm conditions

4.4.2 *Tides*

The tides of the region are mixed and predominantly semi-diurnal (two high tides and two low tides per day), with well-developed spring to neap tidal variation (DEWHA 2008a). The oceanographic environment of the JBG features some of the largest tidal energies, with tidal sea level ranges exceeding 8 m along the western side of the Gulf during the spring tide (CSIRO 2005). There is a well-defined spring-neap lunar cycle, with spring tides occurring two days after the new and full moon.

Within the Bonaparte Gulf mesoscale bioregion, tides range from 2-3 m offshore (micro-tidal) rising to 3-4 m inshore (meso-tidal). The tidal ranges south-east of the Operational Area at Cape Ford (approximately 96 km south-east) were recorded between 0.46 m and 8.19 m in 2018 (BOM 2019f).

Superimposed on the astronomical tide are 'meteorological' tides resulting from changes in atmospheric pressure and strong onshore or offshore winds. Seasonal changes of mean sea level in Darwin are only ~0.15 m, and offshore the changes are expected to be considerably less and quite insignificant (~0.05 m) (RPS 2011).

4.4.3 *Waves*

Short period waves, within the JBG region are generated by local synoptic winds and are typically the largest during winter months when the south-easterly trade winds dominate (Maxwell et al. 2004).

Long period waves are influenced by swells generated in the Southern Ocean. In the Bonaparte Basin, the Southern Ocean swell is slightly higher during winter than in summer due to the northerly migration of swell-generating storms. The wave period and significant wave height generated by this swell is highly dependent on the exact location within the basin. For example, the JBG is protected from the Southern Ocean swell and therefore swells affecting the area are limited to those generated by cyclones or prolonged storm winds (Maxwell et al. 2004).

The region is a moderate-energy environment except when influenced by tropical cyclones which generate short-term major fluctuations in sea levels. Depending on the size, intensity, speed and relative location of the cyclone, swells generated may have periods of 6-18 s and wave heights of 0.5-9 m.

4.4.4 *Currents*

The Operational Area is dominated by surface currents heavily influenced by both tidal motions and the Indonesian Throughflow, which transports warm waters from the Pacific Ocean into the Indian Ocean through the Indonesian seas. The strength of the Indonesian Throughflow is seasonal with it being weakened during the wet season when the strong south-westerly winds cause intermittent reversals of the currents (Brewer et al. 2007).

The strengthening of the Indonesian Throughflow in the dry season coincides with the development of the prevailing south-westerly flowing Holloway Current, which transports waters from the Banda and Arafura seas and the Gulf of Carpentaria southwards along the shelf (DEWHA 2008b).

Circulation in the JBG is dominated by the large tidal currents, which rotate in a clockwise direction. Current speeds increase towards the shoreline and become increasingly directed longshore. These large currents are responsible for the generation of dune forms on the seabed, as noted in Admiralty Charts for the region (ENI 2006).

4.4.5 *Temperature and Salinity*

Sea temperatures and salinity in the region are heavily influenced by the warm, low salinity waters of the Indonesian Throughflow. Water temperatures in the region are among the highest in Australian waters and are high by global standards (DEWHA 2008a). However, during the North-west Monsoon, a thermocline flow of relatively cool water dominates resulting in the tropical Indian Ocean being cooled rather than warmed. Average surface water temperature in the area ranges from 26.4ºC to 29.7ºC (Table 4-3).

The Indonesian Throughflow transports low salinity water from the western Pacific Ocean through to the Indian Ocean (DEWHA 2008a). Salinity in the Operational Area ranges from 33.4 psu to 34.7 psu (Table 4-3). Modelled seawater salinity profiles in the Bonaparte Basin indicated that there is little variation in salinity through the water column, monthly or seasonally (RPS 2011).

Table 4-3 Monthly Average Sea Surface Temperature and Salinity in the Operational Area

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (ºC)	26.5	28.3	29.3	29.8	28.9	27.3	26.4	26.7	27.9	29.7	29.2	28.1
Salinity (psu)	34.6	34.4	34.6	34.6	34.6	34.7	34.6	33.2	34.3	34.5	34.8	34.7

NOAA 2019a and NOAA 2019b

Environmental Resources Management Australia Pty Ltd (ERM) undertook two marine baseline studies in 2010 (wet season) and 2011 (dry season) within the Bonaparte Basin (in particular within the following petroleum titles: WA-6-R, NT/RL, WA-27-R) for GDF SUEZ Bonaparte LNG (ERM 2011). The studies indicated that temperature gradients throughout the water column did not display a thermocline. Instead, a vertical gradient in seawater temperature was observed in which temperature decreased progressively from the surface to the bottom ranging from 32.1°C to 25.3°C (ERM 2011).

4.4.6 *Water Quality*

The Indonesian Throughflow brings in oligotrophic (low in nutrients) waters from the western Pacific Ocean through to the Indian Ocean (DEWHA 2008b). Exceptions in the region occur in the event of local or regional upwelling activity at the shelf break, where deeper, cooler nutrient rich water is brought to the surface (DEWHA 2008b). These upwelling activities include, but are not limited to, internal wave and tide regimes, horizontal shear due to strong tidal currents and tropical cyclones. However, understanding of the nature and spatial distribution of biological productivity in the region is limited (DEWHA 2008b).

The marine baseline studies undertaken by ERM in 2010 and 2011 showed that water quality in the Bonaparte Basin is relatively pristine with results typical of nutrient poor offshore northern Australian waters. The surveys measured dissolved oxygen (DO) concentrations and total suspended solids (TSS). DO concentrations range from a minimum of 3.64 mg/L (49.8%) near the seabed to 7.80 mg/L (117.2%) at the sea surface. DO was found to decrease with depth consistently. This is often linked to higher photosynthetic activity at the seawater surface and wave/wind generated mixing. These values are typical of unpolluted seawater (ERM 2011). TSS were largely not detected across the area during the time of sampling. The data represents relatively low suspended solid values as would be expected for offshore waters in the region (ERM 2011).

4.4.7 *Bathymetry and Geomorphology*

Water depths in the Operational Area range from approximately 65 m to 111 m, whilst the Acquisition Area ranges in depth from approximately 73 m to 107 m (Figure 1-1).

As mentioned in Section 4.3, the Operational Area overlaps with the Pinnacles of the Bonaparte Basin KEF. One of these pinnacles is located within Operational Area (outside the Acquisition Area) and rises to within 80 m of the surface of the water.

The bathymetry in parts of the JBG is influenced by the strong tidal movement and channels of the Ord, Keep, Victoria and Fitzmaurice rivers. A series of extensive sandbars, known as the King Shoals and Medusa Banks, have been generated in the south-west by the strong outflows of sediment-laden water from Cambridge Gulf. Similar sandbars can be found in the south-east of the JBG.

The JBG includes ten geomorphic features, with the inner comprising mostly shelf and the outer area comprising basin and the outer Gulf – Timor Sea comprising banks and terraces separated by deep/hole/valley features (Przeslawski et al. 2011).

The geomorphic features within the Operational Area (Figure 4-5) consist of:

- Shelf – low-relief expanses of unconsolidated sediment; and
- Basin – low-relief expanses of unconsolidated sediment.

Przeslawski et al. (2011) describe a habitat classification system based on regional-scale derivations of seascapes from combined interpolation of seven environmental factors in the JBG. The Operational Area is located predominantly in Seascape 2 (shelf, low exposure) and Seascape 3 (shelf, moderate conditions).

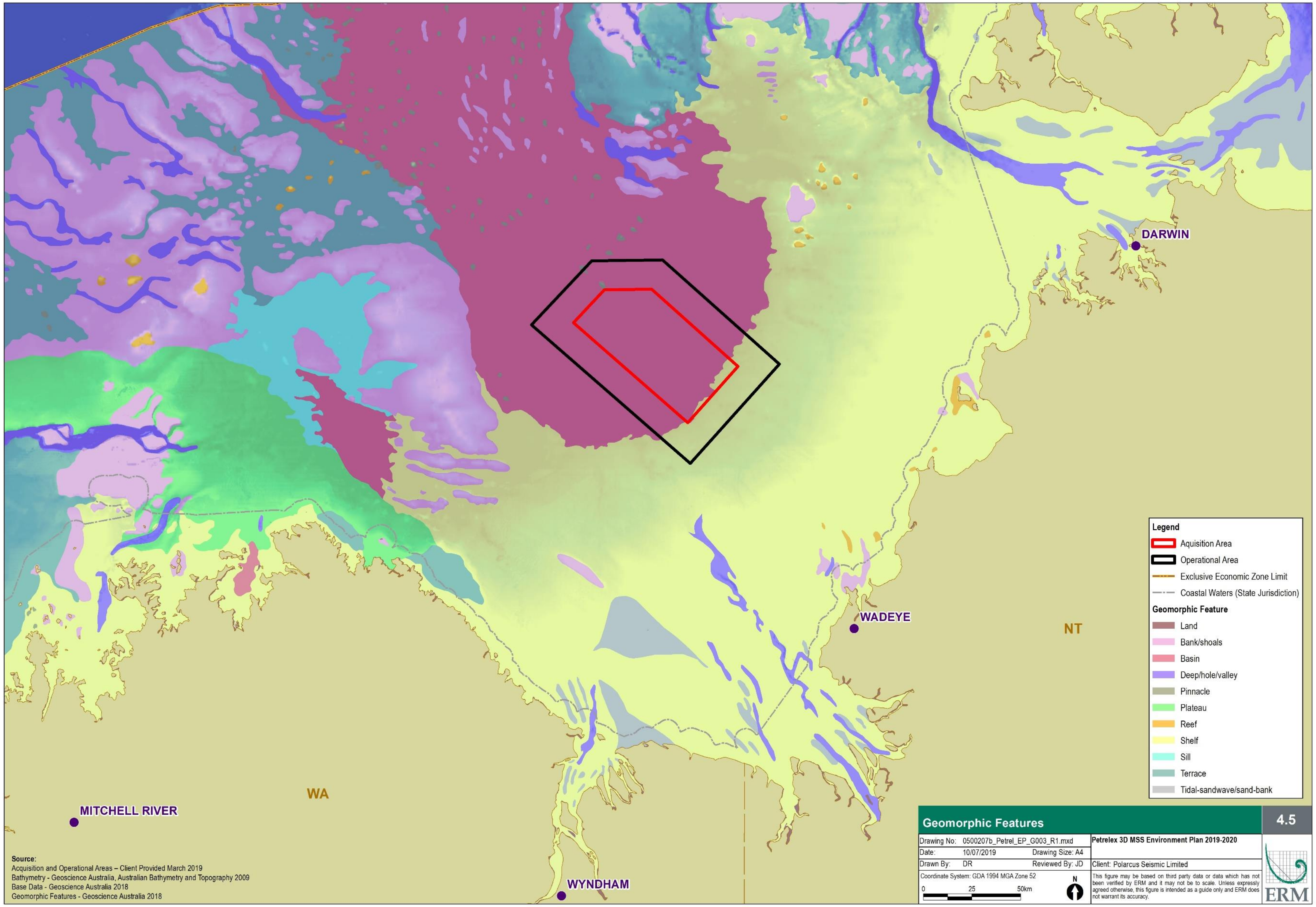


Figure 4-5 Geomorphic Features

4.4.8 *Sedimentology*

The continental shelf in the JBG is the widest in Australia, extending up to 400 km from the shore. Most of the inner shelf is characterised by relatively flat expanses of soft sediment seabed with localised rocky outcrops, gravel deposits and sands banks. The soft sediments in the region typically consist of sandy and muddy substrate, occasionally made up of patches of coarser sediments (Baker et al. 2008). The inner shelf section of the JBG receives significant loads of sediments from several large rivers including the Daly and Victoria rivers (Przeslawski et al. 2011).

The distribution of seabed sediments in the JBG and contained within the Sahul Shelf reflect the present-day oceanographic condition and display a distinct seaward fining pattern (Lees 1992, in Baker et al. 2008).

Sediment sampling undertaken by ERM in 2010 and 2011 within WA-6-R and NT/RL confirms that the area is mainly dominated by sand, with similar smaller gravel, silt and clay proportions (ERM 2011).

4.5 Biological Environment

4.5.1 *Plankton Communities*

Plankton consists of microscopic organisms typically divided into phytoplankton (algae) and zooplankton (fauna including larvae). Plankton play a major role in the trophic system with phytoplankton being a primary producer and zooplankton a primary consumer. Phytoplankton rapidly multiply in response to bursts of nutrient availability and are subsequently consumed by zooplankton that in turn are consumed by other fauna species.

Nutrients and planktonic organisms (including many species of larval recruits) are transported to and from the JBG by the southerly movement of the Indonesian Throughflow and the south-east and north-west monsoonal wind driven currents. The primary driver of planktonic primary productivity in the region is from seasonal influences.

4.5.1.1 Phytoplankton

In the tropical northern regions of Australia, higher phytoplankton concentrations (as indicated by surface chlorophyll concentrations) generally occur during the winter months (June to August) and are lower in summer (December to February).

Phytoplankton assemblages recorded by ERM in 2010 and 2011 in the JBG were characteristic of offshore tropical waters. Phytoplankton assemblages were dominated by the cyanobacteria during the 2010 wet season survey, which comprised 99.7% of identified algal cells. During 2011 dry season survey, diatoms (Bacillariophyceae) dominated the phytoplankton assemblage. Overall, phytoplankton densities were typical of offshore oceanic waters and indicative of a classically oligotrophic (low nutrient) system as is the case across offshore Western Australia and the Timor Sea which feeds the Leeuwin Circulation in the NWMR (ERM 2011).

4.5.1.2 Larval Fish and Zooplankton

Sampling undertaken by ERM (2011) indicated that larval fishes in the JBG were found to be dominated by Serranidae (cods) and Lutjanidae (snappers), both of which are commercially targeted species in the region. Larval fish density varied seasonally with the 2011 dry season recording highest densities of larval fishes in the zooplankton. This seasonal effect is consistent with the notion of an extended spawning season (and possibly planktonic larval duration) of the species dominating the larval fish assemblage in the area (ERM 2011).

Zooplankton sampling indicated that copepods represented the most dominant group within the macro-zooplankton assemblage in both the 2010 wet season and 2011 dry season. The density of these macro-zooplankton varied significantly among seasons, with an overall greater density of these animals recorded during the 2010 wet season. The greater density of macro-zooplankton may be indicative of higher primary productivity in the summer months fuelling population increases of the zooplankton (secondary productivity) at this time.

Overall zooplankton density varied at the level of the assemblage with statistically distinct assemblages found within both the 2010 wet season and 2011 dry season.

4.5.2 *Benthic Habitats and Communities*

The distribution of benthic fauna depends on water depth, the substrate and sediment characteristics, the nature of the substrate and available food. The soft sediment habitats that cover the majority of the Acquisition Area support relatively little seabed structure or sessile epibenthos. They are sparsely covered by sessile filter-feeding organisms (e.g. gorgonians, sponges, ascidians and bryozoans) and mobile invertebrates (e.g. echinoderms, prawns and detritus-feeding crabs) (Brewer et al. 2007; DEWHA 2008a). Previous surveys in the JBG have not recorded seagrass or macroalgae beyond coastal habitats (Brewer et al. 2007).

The benthic habitats and communities associated with the various geomorphic features identified by Przeslawski et al. (2011) and Brewer et al. (2007) are outlined below.

- Shelf – sediment plains that are swept by strong tidal currents and are subject to large influxes of suspended sediment and freshwater, particularly during the wet season. Support diverse infaunal communities that play a key ecological role by contributing to nutrient cycling and sediment turnover (bioturbation) at the local scale. Low abundance of crustaceans, echinoderms and sessile epifauna.
- Banks/shoals - elevated features with a relatively high proportion of hard substrate that support patches of moderately dense octocoral and sponge gardens which in turn provide habitat for other epifauna and cryptofauna. Banks support high numbers of epifaunal species. Infaunal species richness is moderately high in bank sediments. Very few macroalgae (including *Halimeda*) or reef-forming hard corals were recorded.
- Basin - low-relief expanses of unconsolidated sediment, and the available biological data suggests that these habitats are dominated by infauna with limited epifauna.
- Pinnacles - upwelling of nutrient-rich water, hard substrate in an otherwise soft sediment environment. They are important for sessile benthic invertebrates including hard and soft corals, sponges, whips, fans, bryozoans.

As evident in Figure 4-6, the dominant habitat type across most of the Operational Area is infaunal plains, which are characterised by flat, soft substrates with occasional rocky outcrops, scattered epifauna and biota dominated infauna. The EMBA features various geomorphic features including basins, shelves, banks and shoals, and pinnacles.

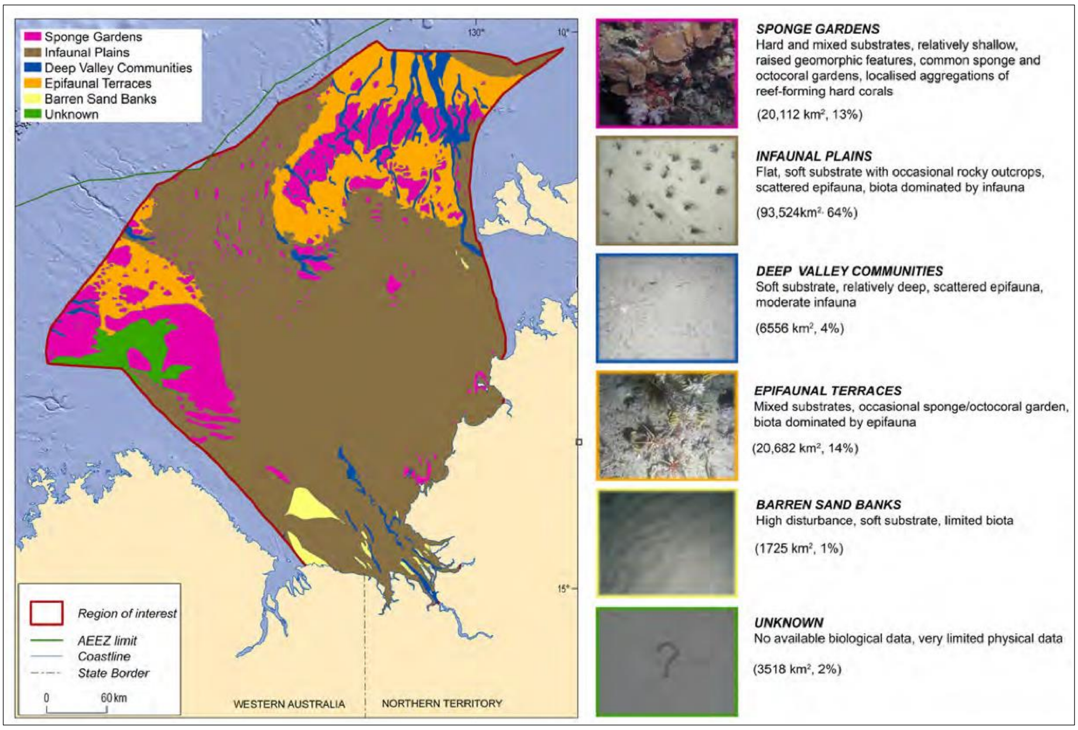


Figure 4-6 Distribution of Habitats and Biological Communities in the JBG (Przeslawski et al. 2011)

Studies conducted on the infauna within the Blacktip Project area (40 km south of the Operational Area and within the EMBA) found infauna to be diverse and abundant, with two major phyla, Arthropoda (crustaceans) and Annelida (polychaete worms) contributing over 80% of the total number of individuals (Woodside 2004). Arthropoda species recorded include tanaids (shrimps), brachyurans (crabs) and grammarid amphipods. The Annelida were diverse comprising of 36 families, with the most abundant families being Terebellidae, Spionidae, Onphidae, Maldanidae and Ampharetidae. Members of these families are mainly tube-dwelling worms that feed on detrital material on the surface or in the surface sediments.

4.5.2.1 Crustaceans

In a study of prawn trawl bycatch in the JBG, which included sampling locations within the EMBA, Tonks et al. (2008) found that four crustacean species dominated the invertebrate component of the bycatch: *Charybdis callianassa* (Portunidae); *Trachypenaeus gonospinifer* (Penaeidae); *Metapenaeopsis novaeguineae* (Penaeidae); and *Solenocera australiana* (Solenoceridae).

The dominant prawn species of the JBG are the penaeid species, namely tiger prawn (*Penaeus esculentus*), banana prawn (*P. merguiensis*) and red-legged banana prawn (*P. indicus*). These species occur in coastal waters to depths of approximately 200 m, and are widely distributed through subtropical and tropical waters from Western Australia to New South Wales (Jones and Morgan 1994). Shallower inshore waters act as nursery grounds for juveniles, such as the river and tidal creek systems of the JBG. Small numbers of prawns can also be found in mangrove habitats. More is known about the distribution and abundance of prawns in the JBG compared to other crustaceans because a number of species are commercially harvested.

As discussed in detail in Section 4.6.6, prawns are commercially targeted in areas of the JBG, mainly in the west of the gulf and in Fog Bay (Northern Territory). The juvenile prawns that migrate offshore to the fishery come from mangrove nursery habitats from the Victoria River in the east of the Gulf, to the Ord River and Cambridge Gulf in the west, forming a very extensive migration throughout the lower region of the JBG. Although there is no data on the exact timing of the migration, it is likely to be from February to April and October to December. Migration of the juveniles is thought to be triggered by rainfall and river discharge.

There are occasional reports of very large catches of some species such as the cornflake or swimming crab (*Charybdis callianassa*), which are believed to be because of spawning aggregations of this species (Brewer et al. 2007).

4.5.2.2 Molluscs

The JBG has relatively low mollusc species diversity, with less than 100 species recorded in the region (Walker et al. 1996). Squid are a large bycatch of the Northern Prawn Fishery (NPF), and may occur periodically in large numbers in the area, although very little is known regarding the distribution of squid in the area.

4.5.3 ***Fish Assemblages***

Demersal bycatch records from the NPF in the JBG indicate that the bioregion's demersal communities have a relatively high biomass and further suggest that the bioregion is an area of high species diversity.

The Protected Matters Database search identified 24 pipefish species, four seahorse species, one pipehorse species and one seagragon that may potentially occur in the wider EMBA. Seahorses (*Hippocampus* spp.) and pipefish (*Solegnathus* spp.) are among the site-associated fish genera (DSEWPaC 2012b). The species group report card – bony fishes (DSEWPAC 2012b), which supplements and supports the NWMR and NWR bioregional plans, states that almost all syngnathids (pipefish, seahorses and pipehorses) live in nearshore and inner shelf habitats, usually in shallow, coastal waters, among seagrasses, mangroves, coral reefs, macroalgae dominated reefs, and sand or rubble habitats with temperate water species predominately inhabit seagrasses and macroalgae, while tropical species are primarily found among coral reefs. A review of information on habitat preference and water depth range has been conducted for the 30 syngnathid species identified in the protected matters search (Table 4-4). The water depths of the Operational Area range from 67 m – 111 m. Only six species have been recorded in water depths greater than 67 m. Therefore, the majority of the identified species are not expected to occur across the flat, soft substrates that predominate throughout the Operational Area. These species are more likely to be associated with habitats found in coastal waters of the JBG.

Seahorses and pipefishes have been recorded as bycatch in the region from trawl operations of the NPF (DSEWPaC 2012b), however, no pipefish, seahorse or pipehorse species were identified in a study of species composition of prawn trawl bycatch undertaken approximately 30 km south of the Operational Area (Tonks et al. 2008).

A marine baseline survey undertaken by ERM (2011) recorded a total of 22 genera representing 17 families. The most common families by density were Terapontidae (grunters), Nemipteridae (threadfin breams), and Lutjanidae (snappers). Terapontidae and Nemipteridae are small scavenging opportunists that are often caught as bycatch in demersal trawl and trap fisheries in the NMR. The lutjanids are larger predatory fishes targeted by commercial and recreational fishers in tropical Australia. These species assemblages are known to occur in coastal waters to depths of approximately 200 m, and are widely distributed through subtropical and tropical waters from Western Australia (ERM 2011).

Tonks et al. (2008) identified 112 teleost fish species from 61 families from 53 NPF commercial trawls over two years. The species with the highest mean catch rates were glassy bombay duck (*Harpadon translucens*), threadfin scat (*Rhinoprenes pentanemus*), largehead hairtail (*Trichiurus lepturus*), blackfin threadfin (*Polydactylus nigripinnis*) and smooth croaker (*Johnius laevis*).

As described in Section 4.4.7 and shown in Figure 4-6, the Operational and Acquisition areas predominantly overlap with the infaunal plains habitat type (Przelawski et al. 2011). The Operational Area also overlaps with two other benthic habitat types:

- Sponge gardens – characterised by hard and mixed substrates, relatively shallow water depths, raised geomorphic features, common sponge and octocoral gardens and localised aggregations of reef-forming hard corals.
- Deep valley communities – soft substrates, relatively deep water depths, scattered epifauna and moderate infauna.

It is likely that the only habitat within the Operational Area that may support significant assemblages of site-attached fish are the sponge gardens that may occur on the shallow shoal/bank located in the north-eastern part of the Operational Area and EMBA. While the Pinnacles of the Bonaparte Basin KEF overlaps with the Operational Area, the only known pinnacle within the Operational Area (and outside the Acquisition Area) rises to a minimum depth of 80 m and is not expected to support site-attached fish assemblages. Site-attached fish are expected to occur in water depths less than 50 m.

Table 4-4 Summary of Habitat Preference and Depth Range for Syngnathid Species that May Occur within the Operational Area

Assemblage	Species	Habitat	Depth Range (m)
Low reef	Corrugated Pipefish, Barbed *Bhanotia fasciolata*	Demersal individuals are most common in reef and tidepool habitats. This species lives openly on muddy or silty substrates in depths of 3-25 m	3-25
Low reef	Three-keel Pipefish *Campichthys tricarinatus*	Sand, coral rubble, algae (including *Sargassum*), isolated coral knolls, soft corals, small sponges, low coral outcrops, sheltered reef and rocky islets	3-11
Low reef/ bedrock/ terraces	Pacific Short-bodied Pipefish, Short-bodied Pipefish *Choeroichthys brachysoma*	Commonly occurs in seagrass, reef and coral habitats in depths of less than 5 m. They also can be found in coral and shell rubble, coral rock, beach rock, sandstone terraces, isolated rock pools, caves, lagoons, mud, sand, and silt	0-24
Low reef	Pig-snouted Pipefish *Choeroichthys suillus*	Occurs in inshore reef habitats or in association with coral knolls, live corals, coral rubble, shell rubble, coral rock, ledges, sand, seagrass and algae	1-14
Low reef	Fijian Banded Pipefish, Brown-banded Pipefish *Corythoichthys amplexus*	This species prefers protected coral habitats, also found in shallow reefs as well as deep walls, with algae and is known from clear coastal to outer reef crests	0-31
Low reef	Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish *Corythoichthys flavofasciatus*	Association with fringing coral reefs, coral reef crests, reef flats, live corals (including *Acropora*), gorgonians, limestone rock platforms, soft corals, dead corals, algae, encrusting organisms, rubble, rocky shores, gutters, drop-offs, bomboras, pools, caves and sand.	0-30
Low reef	Australian Messmate Pipefish, Banded Pipefish *Corythoichthys intestinalis*	Sand, coral or 'grass' bottoms. They occur on sheltered coastal reefs, often in silty habitat among algae as well as on coral slopes, reef flats, reef edges, bomboras, live corals (including *Acropora*), soft corals, dead corals, rocky shore, mangroves, seagrass, sand rubble, rock rubble, caves, lagoons, mud, sand and silt.	0-10
Low reef	Schultz's Pipefish *Corythoichthys schultzi*	Common on rubble and in corals. It also occurs on sand and among reef on crests and slopes in protected habitats	0-30
Low reef	Roughridge Pipefish *Cosmocampus banneri*	Coral reefs (including outer reefs), ledges, lagoons, live corals, rock, sponges, sand and rubble	6 - 30

Assemblage	Species	Habitat	Depth Range (m)
Low reef	Banded Pipefish, Ringed Pipefish *Doryrhamphus dactyliophorus*	Free-swimming fishes that are usually found at the front of caves or reef overhangs. This species inhabits protected coastal reefs, in large caves or among boulders with long-spined urchins	10-25
Low reef	Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish *Doryrhamphus excisus*	Free-swimming benthic fishes found in various reef habitats in coastal to outer reefs, and usually stay close to small caves or narrow crevices into which they retreat when threatened	0-49
Low reef	Cleaner Pipefish, Janss' Pipefish *Doryrhamphus janssi*	Found in various reef habitats in coastal to outer reefs, and usually stay close to small caves or narrow crevices	5-30
Low Reef	Tiger Pipefish *Filicampus tigris*	It is usually seen in estuaries on rubbly, sandy or weedy bottoms	2-30
Low Reef	Brock's Pipefish *Halicampus brocki*	Occurs on coral and rocky reefs with algae. Inhabits patches of coral and macro-algae on coastal reefs	3-45
Low Reef	Red-hair Pipefish, Duncker's Pipefish *Halicampus dunckeri*	A reef associated species usually found on sandy and algal-rubble habitats	1-25
Deep	Mud Pipefish, Gray's Pipefish *Halicampus grayi*	Inhabits silty and muddy soft bottoms on the continental shelf from inshore bays to deep offshore areas to 100 m.	0-100
Low Reef	Spiny-snout Pipefish *Halicampus spinirostris*	Inhabits shallow coral rubble areas in lagoons and intertidal zones of inshore coral reefs	5-10
Low Reef	Ribboned Pipehorse, Ribboned Seadragon *Haliichthys taeniophorus*	Inhabits a variety of inshore shallow water areas including weedy regions bordering open substrates, coral reefs, rocky, gravel, sandy and muddy substrates; also associated with sponges, algae, hydroids, shells and seagrass	0-18
Shallow	Beady Pipefish, Steep-nosed Pipefish *Hippichthys penicillus*	Found in lower reaches of streams and rivers, seagrass beds in estuaries and other shallow inshore habitats	0-5
Deep	Spiny Seahorse, Thorny Seahorse *Hippocampus histrix*	Inhabits areas with both hard and soft bottoms, often attached to soft corals or sponges at 10-95 m, usually 15-40 m. Also found on shallower algae-rubble or rocky reef areas	5-95
Low Reef	Spotted Seahorse, Yellow Seahorse *Hippocampus kuda*	Inhabits coastal bays, harbours and lagoons, sandy sediments in rocky littoral zones, macroalgae and seagrass beds, mangroves, muddy bottoms, and shallow reef flats.	0-55

Assemblage	**Species**	**Habitat**	**Depth Range (m)**
Low Reef	Flat-face Seahorse *Hippocampus planifrons*	Inhabits algal and rubble reefs in shallow bays from the intertidal	0-20
Deep	Hedgehog Seahorse *Hippocampus spinosissimus*	Benthic in inner reef waters on rubble substrates and in sponge and seagrass habitats near coral reefs; often attached to corals in deep current-prone channels between reefs or islands	20-70
Low Reef	Tidepool Pipefish *Micrognathus micronotopterus*	Usually inhabits shallow inshore reefs and tidepools, amongst sparse seagrasses and algae-rubble, in depths from 1-5 m, although individuals have been collected from depths to 10 m.	1-10
Deep	Pallid Pipehorse, Hardwick's Pipehorse *Solegnathus hardwickii*	Mostly known from trawled specimens captured from 12 m to 100 m depth, though it has been collected in depths of up to 180 m.	12-180
Deep/ shelf	Gunther's Pipehorse, Indonesian Pipefish *Solegnathus lettiensis*	Benthic inhabitant of outer continental shelf waters and has been captured from depths of 42-180 m. Trawl bycatch records in 150-180 m water depths in Australia.	42-180
Low Reef	Robust Ghostpipefish, Blue-finned Ghost Pipefish *Solenostomus cyanopterus*	Reef associated	0-10
Low Reef	Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish *Syngnathoides biaculeatus*	Inhabits shallow, protected waters of bays, lagoons and estuaries including mangrove areas, in association with seagrass beds and macroalgae	0-10
Low Reef	Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish *Trachyrhamphus bicoarctatus*	Inhabits sheltered coastal lagoon and reef areas on sandy and rubble habitats amongst seagrasses and macroalgae at 1–30 m. Has been recorded to 42 m	1-42
Deep	Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish *Trachyrhamphus longirostris*	Most specimens have been trawled or dredged from muddy to sandy-bottom habitats in depths of 16-91 m, in association with sand, rubble, seagrasses, algae, sponges, sea pens and hydroids.	16-91

Sources: DoEE (2019a); Bray and Thompson (2019); Austin and Pollom (2019); Froese and Pauly (2019).

4.5.4 *Spawning of Commercially Targeted Species*

Section 4.6.6 describes the Commonwealth and State-managed commercial fisheries with activities in the Operational Area and EMBA. Seasonal spawning periods for commercial species occur throughout the year.

The spawning seasons for a number of key commercially targeted species occur in the wider region. The WA DPIRD (Fisheries) and NT DPIR (Fisheries) have indicated that the species in Table 4-5 may spawn within the JBG.

Based on information from the Northern Prawn Fishery Industry (NPFI), commercial prawn species such as banana, tiger and endeavour prawns may spawn within the survey area. Advice provided to industry by the NPFI in relation to marine seismic surveys in the region (i.e. Santos Fishburn 3D MSS and Santos Beehive 3D MSS), is that banana prawns spawn offshore near the fishing grounds throughout the year with two spawning peaks: the late dry season (September - November) and the late wet season (March - May). These peak spawning periods for banana prawns are within the survey timing (September 2019 – December 2020).

Spawning in endeavour prawns occurs throughout the year. Blue endeavour prawns have spawning peaks in March and September. Red endeavour prawns have a spawning peak in September - December. Based on the endeavour prawns spawning habitat preferences it is unlikely that they would spawn in the offshore area of the survey. The peak spawning period for brown tiger prawns is between July and October.

A twelve-month-old female prawn can produce hundreds of thousands of eggs at a single spawning and may spawn more than once in a season. The eggs sink to the bottom after release, where they hatch into larvae within about 24 hours. Less than 1% of these offspring survive the two to four-week planktonic larval phase to reach suitable coastal nursery habitats where they may settle. After one to three months on the nursery grounds, the young prawns move offshore onto the fishing grounds.

It is noted that during the consultation process for the Santos Fishburn 3D MSS, the Peal Producers Association (PPA) noted that the JBG has a variable distribution of *Pinctada maxima* (silver lipped pearl oyster). *P. maxima* are known to be sparsely distributed in the JBG out to the 100 m isobath. The species spawns in the spring months of September or October, with primary spawning from the middle of October to December. A smaller secondary spawning occurs in February and March (Hart et al. 2016).

Table 4-5 Summary of Commercially Targeted Species within and around the Operational Area

Species	Description	Spawning	Relevance to EP
Goldband snapper (Pilbara stock) (*Pristipomoides multidens*)	Goldband snapper occur in continental shelf waters in depths between 50-200 m. The species is known to form large schools in proximity to shoals, areas of hard flat bottom and offshore reefs. Juveniles typically occur on uniform sedimentary habitat with no relief (Newman et al. 2008). Goldband snapper are serial spawners and spawn throughout their range.	Kimberley: November – May (extended peak spawning period) Northern Territory: September – March	Given the known distribution and habitat depths, goldband snapper may occur and spawn within the Operational Area.
Rankin cod (*Epinephelus multinotatus*)	Rankin cod are a demersal species distributed along the North-west Western Australia from the Abrolhos Islands to Cape Leveque in depths ranging from 5 – 150 m. They are generally found in warm coastal waters in association with drop-offs and deep rocky reefs. Juveniles are generally found in inshore coral reefs.	June – December and March (peaks August – October)	Given the known distribution and habitat depths, Rankin cod may occur and spawn within the Operational Area.
Red emperor (*Lutjanus sebae*)	Red emperor are widely distributed across the continental shelf and found in depths ranging from 10 – 180 metres. The species is associated with reefs, lagoons, epibenthic communities, limestone sand flats and gravel patches (Newman et al 2018). During the spawning period females release multiple batches of eggs over a wide area.	September – June (bimodal peaks September – November and January – March)	Given the known distribution and habitat depths, red emperor may spawn within the Operational Area.
Blue-spotted emperor (*Lethrinus punctulatus*)	The blue-spotted emperor is distributed primarily in WA waters from around Geraldton to Darwin. The species is found in depths from 5 – 110 m, often in association with shallow reef, sand and mud areas. Low levels of heterogeneity indicates extensive connectivity between populations over large distances (Moran et al. 1993).	July – March (extended peak spawning period)	Given the known distribution and habitat depths, blue-spotted emperor may spawn within the Operational Area.
Spanish mackerel (*Scomberomorus commerson*)	Spanish mackerel are a widely distributed pelagic species found throughout Indo-West Pacific waters in depths of up to 50 m. Spanish mackerel spawning occurs in coastal waters. They are serial spawners and alongshore dispersal of eggs maintains genetic homogeneity. Oil within the eggs keep them near the surface where water temperatures are higher and where hatchlings have greater access to plankton. Eggs hatch 24 hours after fertilisation.	September – January (peak spawning)	Given the known distribution and habitat depths, the species is highly unlikely to spawn in the Operational Area, but may spawn in the wider EMBA.

4.5.5 *Threatened and Migratory Species*

A search of the EPBC Act Protected Matters Database was undertaken to identify the likelihood of occurrence of listed marine fauna within the Operational Area and EMBA (i.e. a 40 km buffer around the Operational Area). The results of the search inform the assessment of planned events in Section 7, as well as unplanned events in Section 8 associated with the Petrelex 3D MSS. It should be noted that the EPBC Protected Matters database is a general database that conservatively identifies areas in which protected species have the potential to occur.

The results of the EPBC Protected Matters Search are provided in Table 4-6. The search identified 19 threatened species and 38 migratory species (which is inclusive of the aforementioned threatened species) as occurring the EMBA. No threatened ecological communities (TECs) were identified. The full list of species identified from the Protected Matters Search Tool (PMST) is provided in the EPBC Act Protected Matters Search Report (Appendix C).

Table 4-6 Threatened and Migratory Species that May Occur within the Operational Area and EMBA

Species	Scientific Name	Common Name	Status	Operational Area	EMBA
Birds	*Calidris canutus*	Red Knot	Endangered, Migratory	✓	✓
	Calidris ferruginea	Curlew Sandpiper	Critically Endangered, Migratory	✓	✓
	Numenius madagascariensis	Eastern Curlew, Far Eastern Curlew	Critically Endangered, Migratory	✓	✓
	Anous stolidus	Common Noddy	Migratory	✓	✓
	Calonectris leucomelas	Streaked Shearwater	Migratory	✓	✓
	Fregata ariel	Lesser Frigatebird, Least Frigatebird	Migratory	✓	✓
	Fregata minor	Great Frigatebird, Greater Frigatebird	Migratory	✓	✓
	Actitis hypoleucos	Common Sandpiper	Migratory	✓	✓
	Calidris acuminata	Sharp-tailed Sandpiper	Migratory	✓	✓
	Calidris melanotos	Pectoral Sandpiper	Migratory	✓	✓
	Pandion haliaetus	Osprey	Migratory		✓
Reptiles	*Caretta caretta*	Loggerhead Turtle	Endangered, Migratory	✓	✓
	Chelonia mydas	Green Turtle	Vulnerable, Migratory	✓	✓
	Dermochelys coriacea	Leatherback Turtle	Endangered, Migratory	✓	✓
	Eretmochelys imbricata	Hawksbill Turtle	Vulnerable, Migratory	✓	✓
	Lepidochelys olivacea	Olive Ridley Turtle, Pacific Ridley Turtle	Endangered, Migratory	✓	✓
	Natator depressus	Flatback Turtle	Vulnerable, Migratory	✓	✓

Species	Scientific Name	Common Name	Status	Operational Area	EMBA
	Crocodylus porosus	Salt-water Crocodile, Estuarine Crocodile	Migratory	✓	✓
Mammals	*Balaenoptera borealis*	Sei Whale	Vulnerable	✓	✓
	Balaenoptera edeni	Bryde's Whale	Migratory	✓	✓
	Balaenoptera musculus	Blue Whale	Endangered	✓	✓
	Balaenoptera physalus	Fin Whale	Vulnerable	✓	✓
	Megaptera novaeangliae	Humpback Whale	Vulnerable, Migratory	✓	✓
	Orcinus orca	Killer Whale, Orca	Migratory	✓	✓
	Tursiops aduncus	Spotted Bottlenose Dolphin (Arafura/Timor Sea populations)	Migratory	✓	✓
	Dugong dugon	Dugong	Migratory		✓
	Sousa chinensis	Indo-Pacific Humpback Dolphin	Migratory		✓
Fish, Sharks and Rays	*Carcharodon carcharias*	White Shark, Great White Shark	Vulnerable, Migratory	✓	✓
	Glyphis garricki	Northern River Shark, New Guinea River Shark	Endangered	✓	✓
	Pristis pristis	Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish	Vulnerable, Migratory	✓	✓
	Pristis zijsron	Green Sawfish, Dindagubba, Narrowsnout Sawfish	Vulnerable, Migratory	✓	✓
	Rhincodon typus	Whale Shark	Vulnerable, Migratory	✓	✓
	Isurus oxyrinchus	Shortfin Mako, Mako Shark	Migratory	✓	✓

Species	Scientific Name	Common Name	Status	Operational Area	EMBA
	Isurus paucus	Longfin Mako	Migratory	✓	✓
	Manta alfredi	Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray	Migratory	✓	✓
	Manta birostris	Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray	Migratory	✓	✓
	Anoxypristis cuspidata	Narrow Sawfish, Knifetooth Sawfish	Migratory	✓	✓
	Pristis clavata	Dwarf Sawfish, Queensland Sawfish	Vulnerable, Migratory		✓

The following sections describe the listed threatened and migratory species potentially occurring within the Operational Area and wider EMBA, as identified in the PMST searches and Table 4-6.

4.5.6 *Seabirds*

Many migratory shorebirds (including those frequenting offshore islands) and seabird species are known to occur in the NWMR and NMR. Migratory shorebird species forage and rest in the region on their way between Northern Hemisphere breeding grounds and Northern Australian feeding grounds, known as the East Asian–Australasian Flyway. Seabird species spend the majority of their lives foraging across large distances over the open ocean and many also breed within the region.

There is no emergent land within the Operational Area or EMBA to support breeding colonies of seabirds. The closest known breeding sites occur at the three estuaries at the head of the JBG (located approximately 150 km away from the Operational Area) (the Keep, Victoria and Fitzmaurice rivers), which support seabird and shorebird colonies of 10,000–15,000 birds. Extensive areas of shorebird and waterbird feeding habitat are associated with the mangroves and mudflats in this region. The Anson Bay to Fog Bay area, on the eastern side of the JBG, is one of the most important areas for colonial waterbird breeding in the NT. There is extensive shorebird feeding and roosting habitat in Fog Bay, Anson Bay and the Little Moyle River (DEWHA 2008b). Given coastal habitats support large migratory populations, seabirds may fly over the Operational Area during migrations.

In addition, the Operational Area is located approximately 115 km from a number of bird species BIAs in the region (Figure 4-7). There is no information concerning the populations of seabirds utilising the waters of the Operational Area. However, the distributions of many common seabirds overlap the Bonaparte Basin (DEWHA, 2008b).

There are 23 bird species considered to be ecologically significant to the NWMR; that is, they are either endemic to the region, have a high number of interactions with the region (nesting, foraging, roosting or migrating) or have life history characteristics that make them susceptible to population decline. In addition, there are 11 bird species considered to be ecologically significant to the NMR, due to the presence of important feeding sites in the NMR. Of these species, three threatened and migratory and eight migratory bird species were identified by a search of the EPBC Act Protected Matters Database as potentially occurring in the Operational Area and EMBA through foraging, feeding or other related behaviours (Table 4-6). A description of the distribution, habitat, life stages and likely presence within and around the Operational Area of these bird species during the Petrelex 3D MSS is provided in Table 4-7.

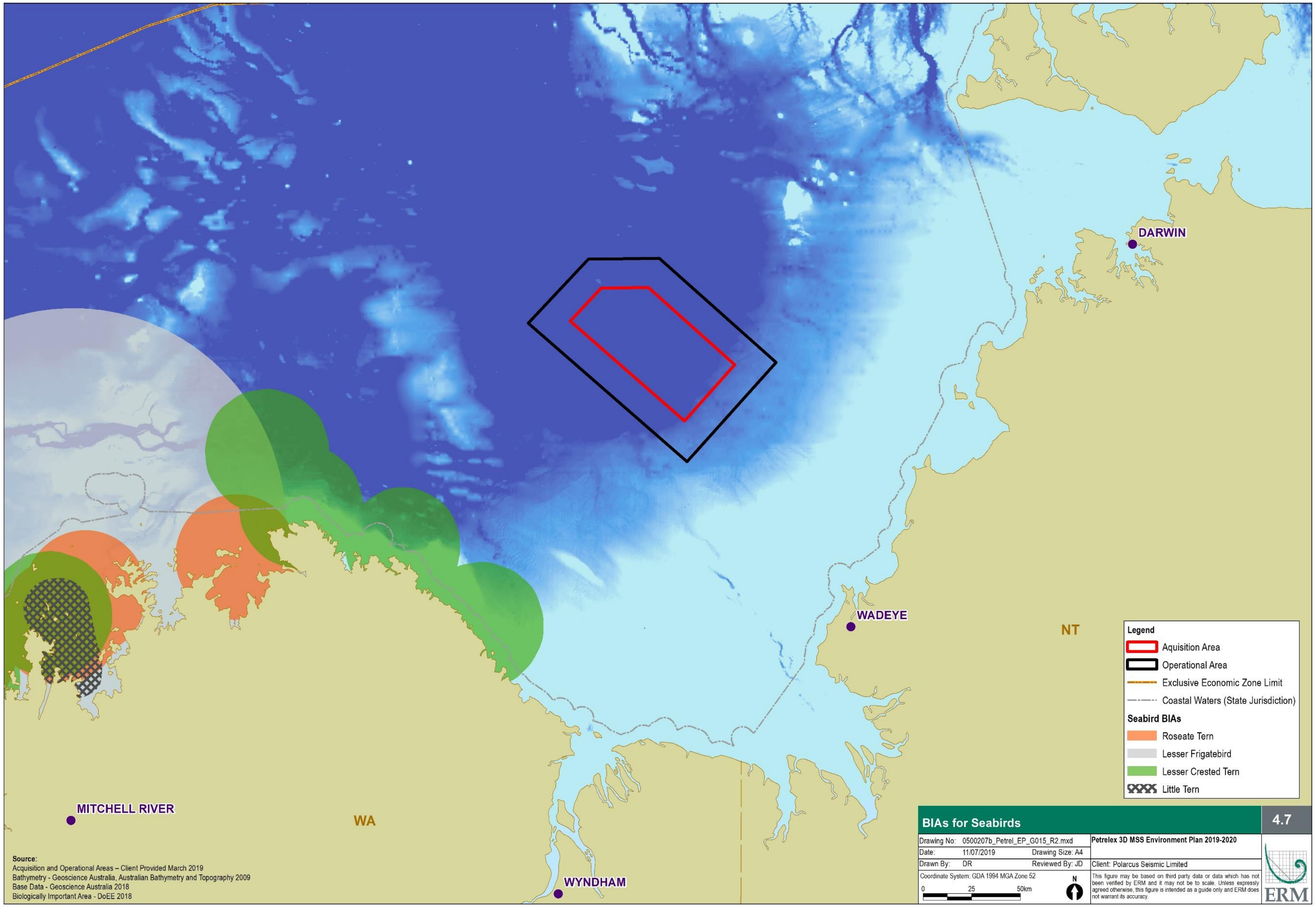


Figure 4-7 Biological Important Areas for Seabirds

Table 4-7 Threatened and Migratory Seabirds

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
Red Knot *Calidris canutus*	Endangered, Migratory	■ The red knot is common in all the main suitable habitats around the coast of Australia, very large numbers are regularly recorded in northern Australia. The closest area to the survey, where the species was recorded in large numbers, is along the coastal from Fog Bay to Peron Island North (120 km from the Operational Area). ■ In Australasia, the red knot mainly inhabits intertidal mudflats, sandflats and sandy beaches of sheltered coasts or shallows pools on exposed wave-cut rock platforms or coral reefs. ■ The red knot usually forages in soft substrate near the edge of water on intertidal mudflats or sandflats exposed by low tide. At high tide, they may feed at nearby lakes, sewage ponds or floodwaters. They have also been observed foraging on thick algal mats in shallow water and in shallow pools on crests of coral reefs. ■ The red knot is diurnal and nocturnal. In non-breeding areas, feeding activity is regulated by tide; they feed less just before and after high tide. The red knot is omnivorous and eats mostly worms, bivalves, gastropods, crustaceans and echinoderms. ■ The red knot lays eggs in June and nests on open vegetated tundra or stone ridge, often close to a clump of vegetation. The red knot is migratory, breeding in the high Artic and moving south to non-breeding between 58° N and 50 °S. ■ Peak numbers of this species in the NWMR and NMR are usually between September and October.	Given the range and distribution of this species, the survey is likely to encounter low numbers of this species in the Operational Area during September/October. Higher population densities may be encountered in the nearshore waters of the wider EMBA.
Curlew Sandpiper *Calidris ferruginea*	Critically Endangered, Migratory	■ The curlew sandpiper's breeding areas are mainly restricted to the Arctic (DoEE 2019a). This species does not breed in Australia. ■ Within Australia, curlew sandpipers occur around the coasts while also being widespread inland, though in smaller numbers (DoEE 2019a). ■ This species forages mainly on invertebrates, including worms, molluscs, crustaceans, and insects, as well as seeds. Outside Australia, they also forage on shrimp, crabs and small fish. Curlew sandpipers usually forage in water, near the shore or on bare wet mud at the edge of wetlands (DoEE 2019a).	Given the distribution of this coastal wetland bird species, the survey is likely to encounter low numbers of this species in the Operational Area, during the April/May period. Higher population densities may be encountered in the coastal waters of the wider EMBA.

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
		■ The species move into certain areas in Australia during northward migration in April, fatten up, and migrate out of Australia during May. They start returning to the area in August and throughout September (Chatto 2003).	
Eastern Curlew, Far Eastern Curlew *Numenius madagascariensis*	Critically Endangered, Migratory	■ Within Australia, the eastern curlew has a primarily coastal distribution. They have a continuous distribution from Barrow Island and Dampier Archipelago, WA, through the Kimberley and along the NT, QLD, and NSW coasts and the islands of Torres Strait. Elsewhere they are patchily distributed (DoEE 2019a). ■ This species does not breed in Australia, rather in the Northern Hemisphere summer, between early May and late June (DoEE 2019a). They start to departure early March and begin to arrive back in late July. ■ During the non-breeding season in Australia, the eastern curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass (Zosteraceae) (DoEE 2019a).	Given the distribution of this coastal wetland bird species, the survey is likely to encounter low numbers of this species in the Operational Area. Higher population densities may be encountered in the coastal waters of the wider EMBA.
Common Noddy *Anous stolidus*	Migratory	■ In Australia, the common noddy occurs mainly in the ocean off the QLD coast, but the species also occurs off the north-west and central WA coast. ■ During the breeding season, the common noddy usually occurs on or near islands, on rocky islets and stacks with precipitous cliffs, or on shoals or cays of coral or sand. When not at the nest, individuals will remain close to the nest, foraging in the surrounding waters. During the Non-breeding period, the species occurs in groups throughout the pelagic zone. Birds may nest in bushes, saltbush, or other low vegetation. The seasonality of breeding varies greatly between sites. At some locations, birds breed annually and at other locations birds breed twice a year (spring to early summer and again at autumn). ■ The common noddy feeds mainly on fish, although they are known to also take squid, pelagic molluscs, medusa and aquatic insects. ■ The closest breeding BIA for this species is located at East Arnhem approximately 810 km east of the Operational Area.	Given the wide distribution of the species and preferred habitat, the species may be present in low numbers in the Operational Area and in the wider EMBA.

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
Streaked Shearwater *Calonectris leucomelas*	Migratory	■ 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 and Higgins 1990). Whilst the species does not breed in Australia, it is known to forage in the NMR, in particular north-west of the Wellesley Islands (1,140 km from the Operational Area). ■ The streaked shearwater feeds mainly on fish and squid. ■ The streaked shearwater is a colonial breeder that lays a single egg in a burrow. Colonies are usually in a well-forested area (Birdlife 2019a).	Given the distribution of the species and preferred habitat, the species may be present in low numbers in the Operational Area and EMBA during the October - May period.
Lesser Frigatebird, Least Frigatebird *Fregata ariel*	Migratory	■ The lesser frigatebird is usually seen in tropical or warmer waters off northern WA, NT, QLD and northern NSW. The species forages in the NMR and breeds in areas adjacent to the region (Marchant and Higgins 1990). ■ The species is usually pelagic and often found far from land, but is also found over shelf waters, in inshore areas, and inland over continental coastlines (Marchant and Higgins 1990). ■ The lesser frigatebird breeds in mangroves or bushes, and even on bare ground. It feeds mainly on fish (especially flying-fish) and squid, but also on seabird eggs and chicks, carrion and fish scraps (Birdlife 2019b). ■ The closest biologically important breeding area of this species is at Kimberley and Pilbara coasts approximately 147 km west of the Operational Area.	Given the distribution of the species and preferred habitat, this species may be present in the Operational Area and EMBA in low numbers.
Great Frigatebird, Greater Frigatebird *Fregata minor*	Migratory	■ Great frigatebirds are found in tropical waters globally. The species breeds on small, remote tropical and sub-tropical islands, in mangroves or bushes and occasionally on bare ground. ■ Great frigatebird feeds on fish, squid and chicks of other bird species. ■ Breeding is known to occur between May to June and in August (DoEE 2019a). ■ A BIA has been identified at Ashmore Reef and Cartier Island for the species to highlight breeding and foraging behaviours in the area (approximately 550 km away from the Operational Area).	Given the distribution of the species and preferred habitat, this species may be present in the Operational Area in low numbers. Higher population densities may be encountered in the coastal waters of the wider EMBA.

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
Common Sandpiper *Actitis hypoleucos*	Migratory	■ Distributed along all coastlines of Australia and many areas inland, the common sandpiper is widespread in small numbers. ■ Generally, the species forages in shallow water and on bare soft mud at the edges of wetlands. Birds sometimes venture into grassy adjoining wetlands and mangroves. ■ Typically, the common sandpiper eats molluscs such as bivalves, crustaceans such as amphipods and crabs and a variety of insects (DoEE 2019a). ■ The common sandpiper breeds in Eurasia and moves south for the boreal winter, with most of the western breeding populations wintering in Africa, and eastern breeding populations wintering in South Africa and Australia. Individuals usually arrive in Western Australia from July onwards.	Given the distribution of the species and preferred habitat, this species may be present in the Operational Area in low numbers. Higher population densities may be encountered in the coastal waters of the wider EMBA.
Sharp-tailed Sandpiper *Calidris acuminata*	Migratory	■ The sharp-tailed sandpiper spends the non-breeding season in Australia with small numbers occurring regularly in New Zealand (NZ). Most of the population migrates to Australia, mostly to the south-east and are widespread in both inland and coastal locations. In WA, they are widely distributed from Cape Arid to Carnarvon, around coastal plains of the Pilbara Region to south-west and east Kimberly Division. In NT, the most important area is the area from Darwin to Murgenella Creek and the Port McArthur. ■ In Australasia, the sharp-tailed sandpiper prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emerged grass or low vegetation. ■ The sharp-tailed sandpiper forages on seeds, worms, molluscs, crustaceans and insects. ■ The sharp-tailed sandpiper migrates to Australia in late June, early July, departing the breeding grounds. The species then departs the non-breeding grounds in Australia by April/March (DoEE 2019a).	Given the wide distribution of this species and the migratory pattern, it is likely this species will be encountered in low numbers within the Operational Area and wider EMBA.
Pectoral Sandpiper *Calidris melanotos*	Migratory	■ In Australasia, the species is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands. ■ The pectoral sandpiper is omnivorous, consuming algae, seeds, crustaceans, arachnids and insects. While feeding, they move slowly, probing with rapid strokes. They walk slowly on grass fringing water. ■ In WA, the species is rarely recorded. It has been observed at the Nullarbor Plain, Reid, Stoke's Inlet, Grassmere Lake, Warden Lake, Dalyup and Yellilup Swamp, Swan River, Benger Swamp, Guraga Lake, Wittecarra, Harding River, coastal Gascoyne, the Pilbara and the Kimberley. In NT, the species habitat likely occurs along the coastal of Darwin, which is 180 km away from the Operational Area.	Given the wide distribution and migration pattern, this species may be present in the Operational Area and wider EMBA in low numbers or isolated individuals/groups.

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
Osprey *Pandion haliaetus*	Migratory	■ The osprey is most abundant in northern Australia, where high population densities occur in remote areas. The breeding range of the osprey extends around the northern coast of Australia (including many offshore islands) from Albany in WA to Lake Macquarie in NSW. ■ Ospreys occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. ■ Ospreys mainly feed on fish, especially mullet where available, and rarely take molluscs, crustaceans, insects, reptiles, birds and mammals. The species usually forage diurnally, but have also been observed hunting prey at night. ■ Osprey breeds from April to February in Australia.	Given the preferred coastal habitat, the species is unlikely to be present in the Operational Area. Higher population densities may be encountered in the coastal waters of the wider EMBA.

4.5.7 *Marine Reptiles*

4.5.7.1 Marine Turtles

Marine turtles have similar life cycle characteristics, which include migration from foraging areas to mating and nesting areas. All species with the exception of flatback turtles have an oceanic pelagic stage before moving to nearshore waters to breed. The region is considered to be significant for supporting large feeding and nesting turtle populations.

Six threatened and migratory marine turtle species were identified in the EPBC Act Protected Matters Database search as having the potential to occur in the Operational Area and EMBA. A description of their distribution, habitats, life stages and likely presence within and around the Operational Area during the survey is provided in Table 4-8.

There are several BIAs for turtle species in the region, including along the coastline and offshore islands in close proximity to the Operational Area. Foraging BIAs for loggerhead, flatback, olive-ridley and green turtles overlap with the Operational Area (Figure 4-8). However, no internesting, or nesting BIAs overlap with the Operational Area or wider EMBA (refer to Figure 4-9).

More recently, the DoEE has identified “habitat critical to the survival of marine turtle species” in the Recovery Plan for Marine Turtles in Australia (DoEE, 2017). It should be noted that this is different to Critical Habitat to Survival, as defined under the *EPBC Act*. No habitat critical to the survival of a marine turtle species occurs within the Operational Area or wider EMBA. Cape Domett is the closest nesting and internesting Habitat Critical BIA to the Operational Area and EMBA and is designated for flatback turtles. It is located approximately 150 km south of the Operational Area (Figure 4-10).

4.5.7.2 Sea Snakes

Sea snakes are essentially tropical in distribution, and habitats reflect influences of factors such as water depth, nature of seabed, turbidity and season (Heatwole and Cogger 1993). Some species have extensive distributions and individuals may cover large distances, while other species have limited home ranges (Heatwole and Cogger 1993). Most sea snake species tend to be found in the shallower parts of the region to allow for increased benthic foraging time (DEWHA 2008b).

Sea snakes that inhabit coral reefs in the region (e.g. Ashmore Reef, located approximately 535 km to the west of the Operational Area) live out their lives within a few hectares with little movement between the reefs (Guinea 2013; PTTEP 2013). The distance between reefs in the region and the deep water between reefs inhibits migration and supports the concept that sea snakes at each reef form a discrete ‘management unit’ for each species and prevents species from occupying all reefs (PTTEP 2013).

At least 20 species of sea snake occur within the region (DEWHA 2008b). Amongst these species, 18 listed marine sea snake species were identified by the PMST search as potentially occurring in the Operational Area and EMBA, however none of these species are threatened.

No coral reefs occur within the Operational Area and therefore sea snakes are expected to occur only in low numbers.

4.5.7.3 Crocodiles

One migratory crocodile species, the salt-water crocodile was identified in the EPBC Act Protected Matters Database search as potentially occurring in the EMBA. The salt-water crocodile is found in Australian coastal waters, estuaries, lakes, inland swamps and marshes. The species has a tropical distribution that extends across the northern coastline of Australia (Webb et al. 1987). The salt-water crocodile has been known to inhabit the Daly and Moyle rivers (approximately 120 km south-east of the Operational Area).

Further details on its habitats, life stages and likely presence within and around the Operational Area is provided in Table 4-8.

Table 4-8 Threatened and Migratory Marine Reptiles

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
Loggerhead Turtle *Caretta caretta*	Endangered, Migratory	▪ The loggerhead turtle has a global distribution and occurs in eastern, northern and western parts of Australia (Limpus 2008). Loggerhead turtles are known to show fidelity to both their foraging and breeding areas and can make reproductive migrations of over 2,600 km between foraging and nesting areas (DoEE 2019a). The species are known to forage nearshore, in water depths up to approximately 50 to 60 m (DoEE 2019a). ▪ In WA, the species nests on the Muiron Islands (approximately 1,790 km away) and on the beaches of North West Cape (approximately 1,830 km away) (DoEE 2019a; Guinea 1995). The species is known to nest between October and February, with a peak in December (DoEE 2019a). ▪ As a juvenile, this species feeds on algae, pelagic crustaceans, molluscs and flotsam, whilst as an adult it feeds on gastropod molluscs, clams, jellyfish, starfish, coral, crabs and fish (DoEE 2019a). ▪ Loggerhead turtles are known to forage around the Pinnacles of the Bonaparte Basin and the Carbonate bank and terrace of the Sahul Shelf KEFs. ▪ The Acquisition and Operational Areas overlap with a foraging BIA for loggerhead turtles (refer to Figure 4-8).	There is a small overlap between the north-west corner of the Operational Area and a foraging BIA for the species. Therefore, foraging and transient turtles may occur within the Operational Area and wider EMBA.
Green Turtle *Chelonia mydas*	Vulnerable, Migratory	▪ Distributed globally throughout tropical and subtropical waters, with WA supporting one of the largest green turtle populations in the world. Green turtles nest, forage and migrate across tropical northern Australia (DoEE 2019a). ▪ The closet biologically important internesting area is in the northern part of the Tiwi Islands (approximately 223 km away) (refer to Figure 4-9). ▪ Ashmore Reef and Cartier Island (approximately 547 km away) support a genetically distinct population in the region and provide critical nesting and inter-nesting habitats (DoEE 2019a; Environment Australia 2003). Green turtles have been recorded to nest mainly on West Island at Ashmore Reef. They mainly nest at Ashmore Reef and Cartier Island during the mid-summer months (December to February) occasionally occurring year round, while the peak hatching period is March to April (DSEWPaC 2012a; Guinea 1995; Guinea 2013).	The Operational Area overlaps with a foraging BIA for the species. Therefore, foraging and transient turtles may occur within the Operational Area and wider EMBA.

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
		■ The closest nesting area of this species is at Cassini Island, approximately 296 km west of the Operational Area (refer to Figure 4-9). ■ Female green turtles go into an inter-nesting cycle after each nesting occurrence. The inter-nesting cycle takes approximately two weeks once nesting starts. The females spend this period in shallow waters beyond the reef edge, where they visit different substrates, occupy different depths and move up to tens of kilometres from the nesting beach. ■ The species primarily forages in shallow benthic habitats (<10 m) such as tropical tidal and subtidal coral and rocky reef habitat or inshore seagrass beds, feeding on seagrass beds or algae mats (Hazel et al. 2009; DoEE 2019a). Large feeding aggregations of green turtles are present at Ashmore Reef. It is the only reef recorded on the Sahul Shelf, where such large numbers of green turtles gather to feed (Guinea 2013). ■ The species undertakes extensive post-nesting migrations from foraging areas to traditional breeding areas, and has been recorded as migrating up to 2,600 km from nesting beaches (DoEE 2019a). One tagged female made a post-breeding migration through the Operational Area from Ashmore Reef to the Cobourg Peninsula in north-western NT (Limpus 2008). ■ Adult green turtles feed on seagrass, sponges and algae. ■ The pinnacles of the Bonaparte Basin are thought to be a KEF where green turtles transverse between foraging and nesting grounds. The majority of Operational Area overlaps a foraging BIA for this turtle species (refer to Figure 4-8).	
Leatherback Turtle *Dermochelys coriacea*	Endangered, Migratory	■ Leatherback turtles are pelagic feeders, spending extended periods of time in tropical, subtropical and temperate open ocean waters (Limpus 2009). The species has been recorded feeding in the coastal waters of all Australian States and Territories in low densities. ■ Nesting occurs on tropical beaches and subtropical beaches (Marquez 1990) but no major centres of nesting activity have been recorded in Australia. The species is understood to migrate from Australian waters to breed at larger rookeries in neighbouring countries such as Indonesia, Papua New Guinea and Solomon Islands between December and January (DoE 2015a).	Given the species distribution, and low density population in Australian waters, the presence of the species within the Operational Area and EMBA is expected to be low.

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
		■ Leatherback turtle forage on pelagic soft bodied creatures (such as jellyfish, squid, salps, siphonophores and tunicates) all year round in Australian waters (DoEE 2019a) ■ The closest confirmed internesting site for the leatherback turtle is at the Cobourg Peninsula (DoEE 2019a), approximately 362 km north-east of the Operational Area.	
Hawksbill Turtle *Eretmochelys imbricata*	Vulnerable, Migratory	■ Hawksbill turtles are found in tropical, subtropical and temperate waters, with nesting mainly confined to tropical beaches (Limpus and Miller 2008). The hawksbill turtle is commonly found in the NWMR and NMR, nesting extensively along the coasts and foraging in the region. However, no hawksbill turtle nesting stocks are known to occur within the JBG (DoEE 2017). ■ Australia has the largest breeding population of hawksbill turtles in the world (Limpus 2008). ■ Hawksbill turtles nest year round, with a peak between October and December (DEWHA 2008a). Internesting females are known to stay within approximately 20 km of nesting beaches. ■ The species is highly migratory and is known to migrate long distances between nesting and foraging areas (ranging from 35 to 2,400 km) (DoEE 2019a). ■ As a juvenile, the hawksbill turtle feeds on plankton in the open ocean and then feeds on sponges, hydroids, cephalopods, gastropods, jellyfish, seagrass and algae as an adult (DoEE 2019a). ■ The north-east subpopulation breeds throughout the year with a peak nesting period during July to October (DoEE 2019a), whilst breeding in the WA population peaks around October to January. ■ In the NMR, the closest internesting area to the Operational Area is located at the Cobourg Peninsula, approximately 362 km north-east.	Given the species wide distribution in Australian waters, transient turtles may occur within the Operational Area and wider EMBA.
Olive Ridley Turtle, Pacific Ridley Turtle *Lepidochelys olivacea*	Endangered, Migratory	■ The olive ridley turtle has a worldwide tropical and subtropical distribution and is known to occur in both Western Australia and Northern Territory (DSEWPaC 2012c). Whilst nesting has been recorded in Western Australia, it is far more common in the Northern Territory (DoEE 2019a).	The Operational Area overlaps with a foraging BIA for the species. Therefore, foraging and transient turtles may occur within the Operational Area and wider EMBA.

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
		■ The olive ridley turtle is known to primarily forage in in soft-bottom habitats ranging in depths from 6 – 35 m. They are also known to forage in pelagic waters (DSEWPaC 2012a). ■ The olive ridley turtle is known to forage in the western Joseph Bonaparte Depression and Gulf. ■ Although olive ridley turtles nest all year round nesting activity peaks around April to November, with the majority of nesting occurring from the Arnhem Land coast (including Bathurst Island, a biologically important internesting area) to the north-western coast of Cape York Peninsula (DoEE 2019a). After nesting, olive ridley turtles are known to migrate up to 1,050 km to various foraging areas (DoEE 2019a) including the Pinnacles of the Bonaparte Basin and the Carbonate bank and terrace system of the Sahul Shelf KEFs (DSEWPaC 2012a). ■ Adult turtles forage for crabs, shrimp, tunicates, jellyfish, salps and algae in depths ranging from several metres to over 100 m (DoEE 2019a). ■ The Operational Area overlaps with a foraging BIA for this turtle species (refer to Figure 4-8). The closet internesting area is off the coast of Fog Bay, approximately 120 km away (refer to Figure 4-9).	
Flatback Turtle *Natator depressus*	Vulnerable, Migratory	■ The flatback turtle is only found in Australian waters and some nearby waters in Indonesia and Papua New Guinea. ■ The species is commonly found in the NWMR and NMR, nesting in northern Australia and foraging in the region. ■ Breeding occurs all year round, however, in northern Australia most nesting occurs between June and August (DoEE 2019a). The nearest nesting beach for flatback turtles to the Operational Area is at Cape Domett (approximately 150 km south). The Cape Domett nesting population appears to be one of the largest known nesting populations of this species, with an estimated yearly population in the order of several thousand turtles. Flatback turtles nest at Cape Domett throughout the year and peak nesting occurs during August and September (Whiting et al. 2008). ■ Flatback turtles lack an oceanic phase and remain in the surface waters of the continental shelf and once the pelagic stage of its life is completed, they move to sub-tidal soft bottomed habitats inshore, feeding on benthic organisms.	There is a small overlap between the north-west corner of the Operational Area and a foraging BIA for the species. Therefore, foraging and transient turtles may occur within the Operational Area and wider EMBA.

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
		■ Flatback turtles have a wide foraging range with individuals that nest on the Pilbara coast dispersing to feeding areas extending from Exmouth Gulf to the Tiwi Islands (DSEWPaC 2012a). ■ Adult flatbacks are primarily carnivorous, feeding on soft-bodied invertebrates. Juveniles eat gastropod molluscs, squid, siphonophores, and limited data indicate that cuttlefish, hydroids, soft corals, crinoids, molluscs and jellyfish are also eaten (DoEE 2019a). ■ The species has been recorded foraging in depths less than 10 m to over 40 m on the carbonate bank and terrace of the Sahul Shelf KEF and around the Pinnacles of the Bonaparte Basin KEF. ■ The northern part of the Operational Area overlaps with a foraging BIA for this turtle species (refer to Figure 4-8). ■ Cape Domett is a nesting and internesting Habitat Critical BIA for flatback turtles, which is approximately 150 km south of Operational Area (Figure 4-10).	
Salt-water Crocodile, Estuarine Crocodile *Crocodylus porosus*	Migratory	■ The salt-water crocodile is found in Australian coastal waters, estuaries, lakes, inland swamps and marshes. The species' distribution ranges from Rockhampton in QLD) throughout coastal NT to King Sound (near Broome) in WA (DoEE 2019a). ■ The salt-water crocodile has been found in most major river systems in WA and the NT. The species mostly occurs in tidal rivers, coastal floodplains and channels, billabongs and swamps up to 150 km inland from the coast (DoEE 2019a). ■ The salt-water crocodile's primary food sources are crustaceans, insects and mammals; however, only larger individuals ate mammals. In areas of higher salinity (mangroves), the salt-water crocodile eats larger volumes of crab and a smaller volume of shrimp and insects. ■ Preferred nesting habitat of the salt-water crocodile includes elevated, isolated freshwater swamps that do not experience the influence of tidal movements. Floating rafts of vegetation also provide important nesting habitat. In the Northern Territory, most nest sites are found on the north-west banks of rivers. The species nest during the wet season with peak nesting during January and February.	Given that the nearest salt-water crocodile habitats are in the Daly and Moyle rivers, approximately 120 km south-east of the Operational Area, the presence of the species within the Operational Area and EMBA is likely to be infrequent.

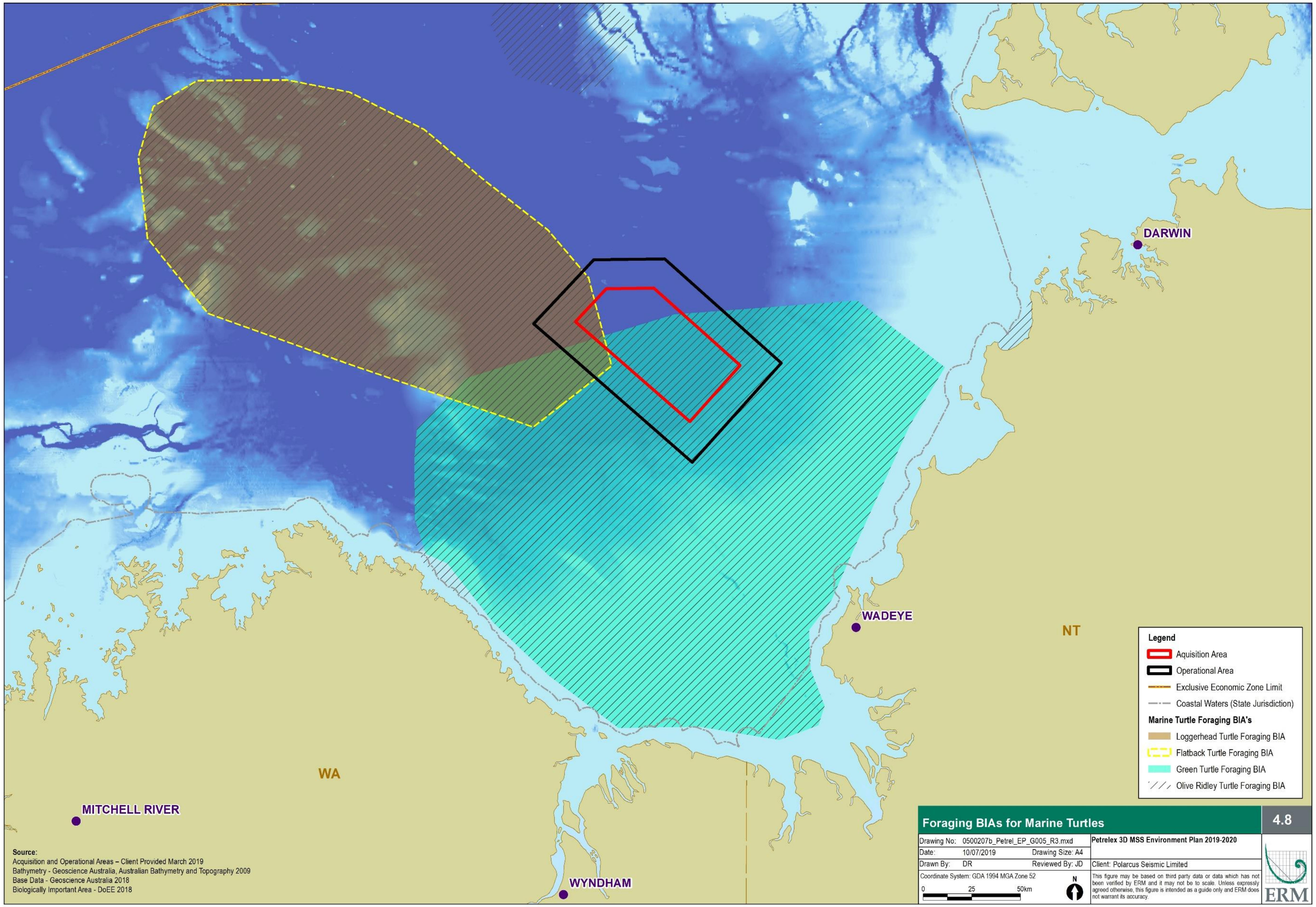


Figure 4-8 Foraging Biological Important Areas for Marine Turtles

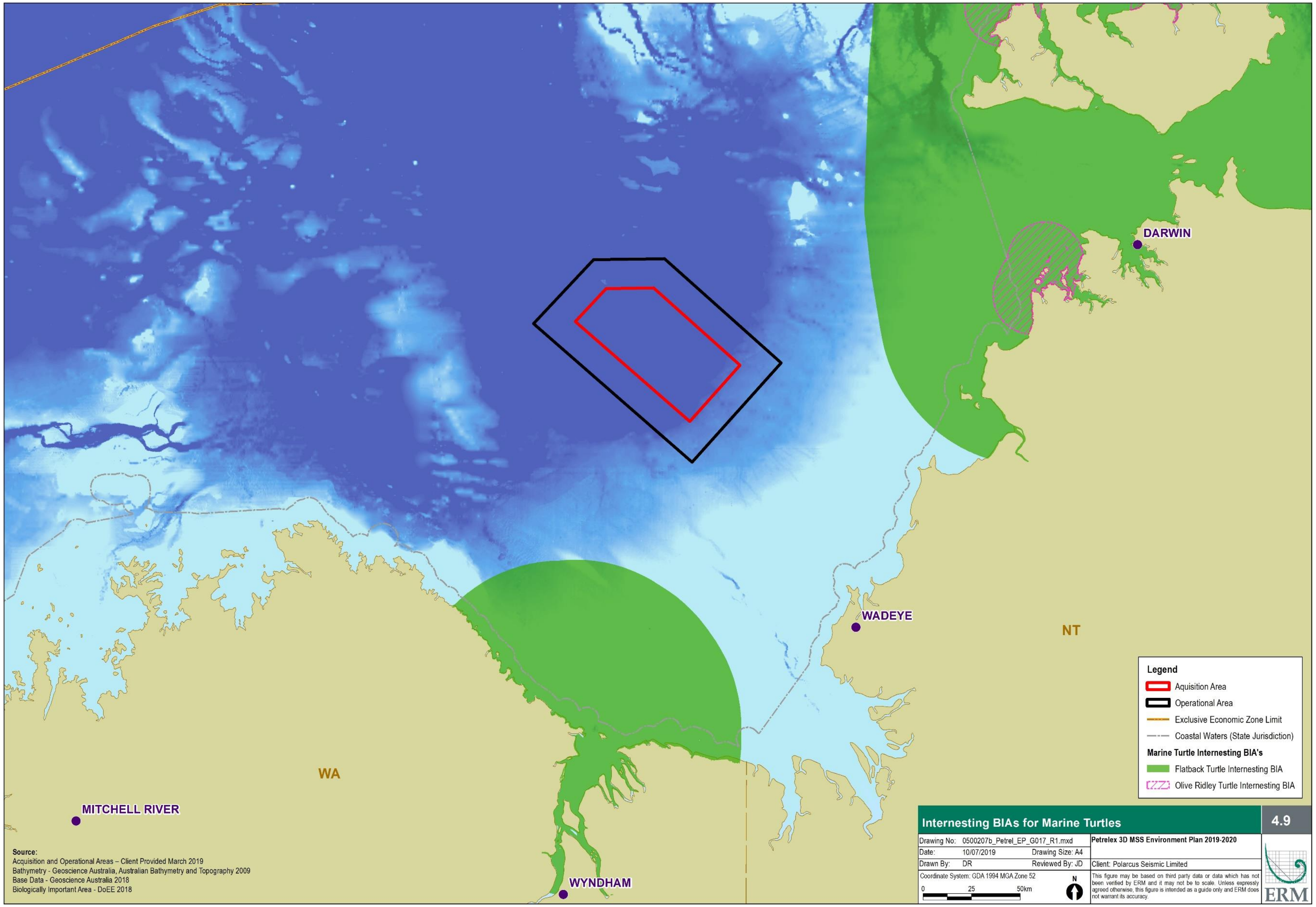


Figure 4-9 Internesting Biological Important Areas for Marine Turtles

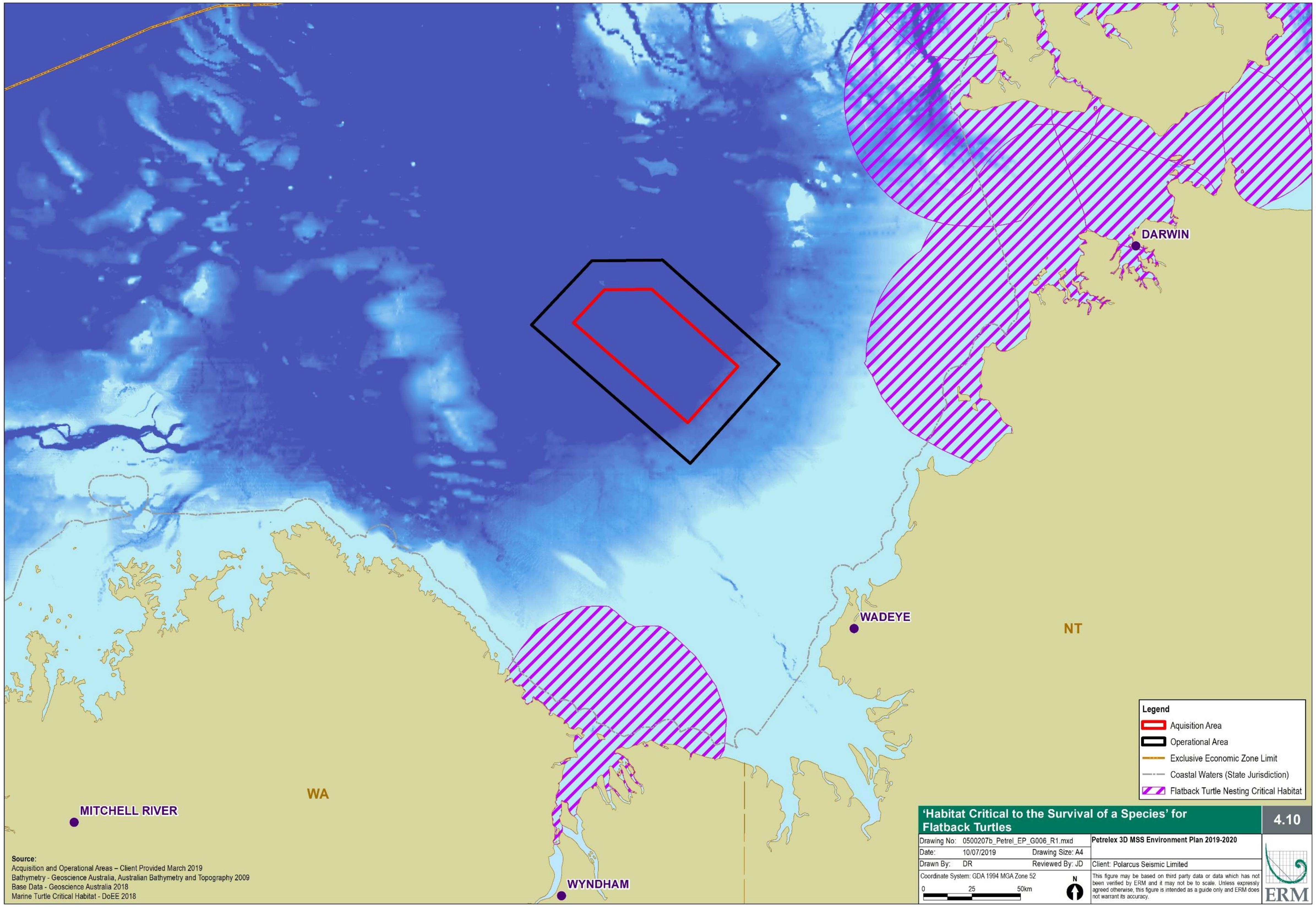


Figure 4-10 'Habitat Critical to the Survival of a Species' for Flatback Turtles

4.5.8 *Marine Mammals*

Several species of marine mammals are known to occur in the region and have wide distributions that are associated with feeding and migration patterns linked to reproductive cycles. There are nine species known to occur regularly in the NMR, including three species of whale and six species of dolphin (DSEWPC 2012d). In the NWMR, 27 species occur regularly including sixteen species of whale and at least eleven species of dolphin (DSEWPC 2012e).

Three threatened, one threatened and migratory, and five migratory marine mammal species were identified by a search of the EPBC Act Protected Matters Database as potentially occurring in the Operational Area and EMBA (Table 4-6).

Cetacean species, such as the pygmy blue whale and humpback whale, are known to transit between Southern Ocean feeding grounds and tropical water breeding grounds. However, some cetacean species (e.g. bottlenose dolphin and Indo-Pacific humpback dolphin) are thought to be resident in the region throughout the year (DEWHA 2008b).

Dugongs are also present in the region, preferring shallow waters along the coast and around shoals where seagrass habitats are available (DEWHA 2008a). Ashmore Reef Marine Park (approximately 517 km away from the Operational Area) is known to support a small genetically distinct population of dugongs. The Operational Area is unlikely to support dugong populations, due to the open ocean location, water depths and lack of suitable habitat.

A description of the identified threatened and/or migratory marine mammals is provided in Table 4-9, including their distribution, migratory movements, preferred habitat and likely presence within the Operational Area and EMBA.

No BIAs are located within the Operational Area or EMBA. The closest BIAs to the Operational Area are:

- The Australian snubfin dolphin breeding/calving BIA is located along the Kimberley coastline approximately 135 km from the Operational Area (Figure 4-11). Therefore, encounters within the Operational Area are unlikely or would be limited to low numbers. The species was not identified in the EPBC Act Protect Matters Search results for the Operational Area.
- The Indo-Pacific humpback dolphin foraging BIA is located along the Kimberley coastline approximately 143 km from the Operational Area (Figure 4-11). The Indo-Pacific humpback dolphin also has breeding and foraging BIAs located near Darwin Harbour and in Camden Sound (approximately 125 km and 370 km from the Operational Area, respectively). Therefore, encounters within the Operational Area are unlikely or would be limited to low numbers.
- The spotted bottlenose dolphin foraging and breeding BIAs are located near Darwin Harbour and in Camden Sound (approximately 125 km and 370 km from the Operational Area, respectively) (refer to Figure 4-11).
- Pygmy blue whale migration and distribution BIAs pass along the shelf edge at depths between 500 m and 1,000 m. The Operational Area does not overlap with these BIAs. The BIAs are located approximately 285 km north of the Operational Area.
- The humpback whale migration, breeding and calving BIAs extend along the length of the coast of Western Australia, to its northernmost extent offshore of the Kimberley region. The northern boundary of the BIA is approximately 370 km south-west from the Operational Area.

Table 4-9 Threatened and Migratory Marine Mammals

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
Sei Whale *Balaenoptera borealis*	Vulnerable	■ Sei whales are moderately large whales growing up to 18 m in length. The species is less studied than other whales and its population status, distribution and movements are not well understood. ■ There are no known mating or calving areas in Australia. ■ The movements and distributions of sei whales are unpredictable and not well documented with information suggesting that they have the same general pattern of migration as most other baleen whales, although it is timed a little later and they do not move to such high latitudes (DoEE 2019a). ■ Sei whales feed intensively between the Antarctic and subtropical convergences and mature animals may also feed in higher latitudes. ■ Sei whales feed on planktonic crustacea, in particular copepods and amphipods.	Given the wide ranging nature of this species, lack of nearby important habitat and a preference for deeper offshore waters, the presence of the species within the Operational Area and wider EMBA is likely to be limited.
Blue Whale *Balaenoptera musculus*	Endangered	■ Blue whales are the largest living animals, growing to a length of over 30 m and weighing up to 180 tonnes. In Australia, there are two recognised sub-species of blue whale; the Antarctic or true blue whale (*Balaenoptera musculus intermedia*) and the pygmy blue whale (*B. m. brevicauda*) (DoEE 2019a). ■ As true blue whales feed primarily in polar waters, it is considered that all blue whales sighted in Australian waters are pygmy blue whales. ■ The pygmy blue whales feed in Antarctic waters between December and April and may also feed opportunistically while migrating (DoEE 2019a). ■ The pygmy blue whale migrates from Antarctic summer feeding grounds to lower temperate and/or tropical latitudes for mating and calving (Bannister et al. 1996). The waters off Australia are used by the species to migrate from feeding grounds to calving grounds and are recognised as a BIA. ■ The following information is known about the pygmy blue whale migration along the western coast of Australia:	Given, the absence of known foraging, resting and calving habitat, presence within the Operational Area and EMBA is likely to be infrequent and consist of transitory individuals during migration months.

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
		- The population around southern Australia commence heading north along the WA coast towards Indonesian waters from April to May (McCauley 2011). - Individuals have been recorded by satellite tags to travel along the shelf break along the WA coast up to North West Cape, after which they continued in a north-east directional route to Indonesia, west of the Operational Area (Double et al. 2014). - They are expected to pass the latitude of the Operational Area between April and August on their northerly migration and between late October and December on their southerly migration (McCauley 2011). Based on recent satellite tracking data (Double et al. 2014), five tagged whales on their northern migration passed the latitude of the Operational Area during April and May (Double et al 2014). - The migration extends to the Banda and Molucca Seas near Indonesia, where calving is understood to occur (Double et al. 2014). ■ Pygmy blue whales prefer to travel alone or in small groups (McCauley 2011; Gilmour et al. 2013). ■ The nearest aggregation area for the pygmy blue whale in Australian waters occurs at the Perth Canyon, approximately 2,516 km south-west of the Operational Area (DoEE 2019a). The nearest aggregation area to the Operational Area lies in Indonesian waters, in the Banda and Molucca seas, approximately 900 km north of the Operational Area. This area is used by pygmy blue whales between May and September (Double et al. 2014). The timing of this aggregation suggests that the Banda and Molucca seas are feeding and calving grounds for pygmy blue whales.	
Fin Whale *Balaenoptera physalus*	Vulnerable	■ The fin whale is the second-largest whale species, after the blue whale. ■ Fin whales occur from polar to tropical waters, but rarely in inshore waters (DoEE 2019a). Fin whales are widely distributed in both hemispheres between latitudes 20–75° S (Mackintosh 1966). This species is also common in temperate waters, the Arctic Ocean and Southern Ocean.	Given the wide ranging nature of this species, lack of nearby important habitat and a preference for deeper offshore waters, the presence of the species within the Operational Area and wider EMBA is likely to be limited.

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
		■ There is insufficient data to prescribe migration times and routes for fin whales, however recent sightings in Australian waters include summer and autumn months. Fin whale calls have been detected in Antarctic waters from February to July (DoEE 2019a). ■ Fin whales feed intensively in high latitudes and may feed to some extent in lower latitudes, depending upon prey availability and locality. Fin whales feed on planktonic crustacea, some fish and cephalopods (crustaceans). ■ Fin whales are killed by ship strikes more than any other whale, which may be due to surface feeding (DoEE 2019a).	
Humpback Whale *Megaptera novaeangliae*	Vulnerable, Migratory	■ Humpback whales occur globally and throughout Australian waters with their distribution being influenced by migratory pathways and aggregation areas for resting, breeding and calving. There are two genetically distinct populations of humpback whales in Australia (west coast and east coast) (DoEE 2019a). ■ The humpback whale annual migration from the summer feeding grounds in Antarctica to the breeding and calving grounds in Camden Sound (approximately 370 km west of the Operational Area) occurs between May and October. ■ Camden Sound forms the northern extent of the humpback whale migration BIA (Figure 4.3). The numbers of humpback whales at Camden Sound peak between June and September each year (DoEE 2019a). The migration corridor tends to be within the 200 m isobath (Jenner et al. 2001). ■ The west coast population of the humpback whale is thought to be increasing in size by about 9% per year (DoEE 2019a; Bejder et al. 2015); estimates conducted suggest that in 2008 the population migrating up the WA coast was at 21,750 individuals (Hedley et al. 2011).	Given, the absence of known foraging, resting and calving habitat, presence within the Operational Area and EMBA is likely to be infrequent and consist of transitory individuals during migration months.
Bryde's Whale (*Balaenoptera edeni*)	Migratory	■ Bryde's whales are distributed throughout oceanic and inshore, tropical and warm temperate waters, between 40˚N and 40˚S year-round (DOE 2015). They have been recorded off all states of Australia, with the exception of the Northern Territory (DOE 2015). ■ The inshore form of the Bryde's whale is typically limited to the 200 m depth contour and breeds and calves year-round, whilst the offshore form is found in	No specific feeding or breeding grounds have been discovered off Australia and given the distance to the closest known aggregation area at Ningaloo Reef (approximately 1,800 km away), the presence of the species within the

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
		deeper waters (500 to 1,000 m) and breeds and calves over several months during winter (Best et al. 1984; Kato 2002). ■ The nearest known area of aggregation is Ningaloo Reef (approximately 1,800 km away) (DOE 2015). Aerial surveys carried out in 2009, between mainland Australia and Scott Reef (approximately 260 km away) recorded Bryde's whales in low numbers (RPS 2010). Between September 2006 and June 2009 sea noise loggers deployed within Scott Reef also recorded Bryde's whales calls year round (McCauley 2011; RPS 2010).	Operational Area and wider EMBA is likely to be infrequent.
Killer Whale, Orca *Orcinus orca*	Migratory	■ The killer whale is found in all of the world's oceans, from the Arctic and Antarctic regions to tropical seas (DoEE 2019a). The species has been recorded in all the coastal waters of Australia, with concentrations reported in Tasmania, and common sightings in South Australia and Victoria. ■ Sightings of the killer whale around the Australian coast are typically recorded along the continental slope and shelf, and predominantly in the vicinity of seal colonies, which are not known to exist in the region (DEWHA 2008b). ■ No areas of significance and no determined migration routes have been identified for this species within waters off WA (DoEE 2019a). ■ The specific diet of killer whales in Australian waters is not known, but there are reports of attacks on dolphins, young humpback whales, blue whales, sperm whales, dugongs and Australian sea lions. ■ There are no BIA for killer whales near the Operational Area, however they have been reported within the Oceanic Shoals Marine Park (approximately 2 km from the Operational Area).	Given the wide ranging nature of this species, lack of nearby important habitat and a preference for coastal waters, the presence of the species within the Operational Area is unlikely. Presence within the wider EMBA is also likely to be limited.
Indo-Pacific Humpback Dolphin *Sousa chinensis*	Migratory	■ Indo-Pacific humpback dolphins occur in coastal lagoons and enclosed bays with mangrove forests and seagrass beds, but are also found in open coastal waters around islands and coastal cliffs in association with rock or coral reefs. The species usually occurs close to the coast, generally at depths of up to 20 m, but the species has been seen 55 km offshore in shallow water. ■ Indo-Pacific humpback dolphins eat a wide variety of coastal and estuarine-associated fishes, as well as reef, littoral and demersal fish species.	Given the location of the BIAs relative to the Operational Area, the species may be encountered within the Operational Area.

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
		■ The species does not appear to undergo large-scale seasonal migrations, although seasonal shifts in abundance have been observed (DoEE 2019a). ■ A breeding BIA for Indo-Pacific humpback dolphins' is located in Darwin Harbour, with its northern boundary approximately 160 km away from the Operational Area (see Figure 4-11). ■ The closest foraging BIA for this species is located in Vansittart Bay on the Anjo Peninsula, which is approximately 183 km west of the Operational Area (see Figure 4-11).	
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) *Tursiops aduncus*	Migratory	■ The spotted bottlenose dolphin occurs in tropical and subtropical coastal and shallow offshore waters of the Indian Ocean, Indo-Pacific region and the western Pacific Ocean (DoEE 2019a). ■ The species is typically found close to shore, within approximately 1 km from the nearest land or oceanic islands, or in water depths of less than 30 m. ■ Knowledge of the species seasonal migration and breeding is largely unknown, however it is inferred that only the Arafura-Timor Sea population is migratory. ■ BIAs identified for foraging and breeding during April to November, include Darwin Harbour (approximately 160 km away from the Operational Area) and near Camden Sound (approximately 370 km south-west of the Operational Area) (see Figure 4-11). ■ Bottlenose dolphins have been recorded within the Oceanic Shoals Marine Park (2 km from the Operational Area.	Given the species preference for shallow water and close proximity to shore, the presence of the species within the Operational Area is likely to be limited. The species may occasionally be present in the coastal region of the EMBA.
Dugong *Dugong dugon*	Migratory	■ Some of the coastal waters adjacent to the region support significant populations of dugongs, including Shark Bay, which has an estimated population of around 10,000 individuals (DSEWPaC 2012d). Dugongs are also known to occur along the coast throughout the Kimberley to the WA-NT border; however, population estimates for these areas are not available (DSEWPaC 2012d). ■ Dugongs inhabit protected shallow coastal areas, such as wide shallow bays and mangrove channels. Although the patterns of dugong movement in Western	The PMST search identified the species as potentially occurring within the EMBA, and not within the Operational Area. Due to the species' foraging BIA being located 560 km from the Operational Area, absence of suitable habitat and preference for shallow waters, presence

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
		Australia are not well understood, it is thought that dugongs move in response to seagrass and water temperature. ■ Dugongs feed primarily on seagrass in shallow waters less than 10 m deep and mostly above 3 m depth (Burbidge et al. 2014). A survey carried out in northern Australia between 1994 and 2001 using time-depth recorders deployed on 15 dugongs logged a total of 39,507 dives. The survey identified that dugongs spend the majority of their time in water depths of less than 3 m (Chilvers et al. 2004). ■ The closest foraging BIA is located south of Ashmore Reef (approximately 560 km north-west of the Operational Area). Ashmore Reef supports a population of less than 50 individuals that are genetically distinct from other Australian populations. The reef provides breeding and feeding habitats, with seagrass beds of the reef flats and lagoon their preferred food source. Breeding occurs year round at Ashmore Reef (DoEE 2019a). ■ Dugongs have been reported to occur along the coastline in the JBG from Cape Hay to Point Pearce, with the main populations concentrated around Dorcherty Island (Woodside 2004), approximately 100 km south-east of the Operational Area.	of the species within the EMBA is likely to be limited.

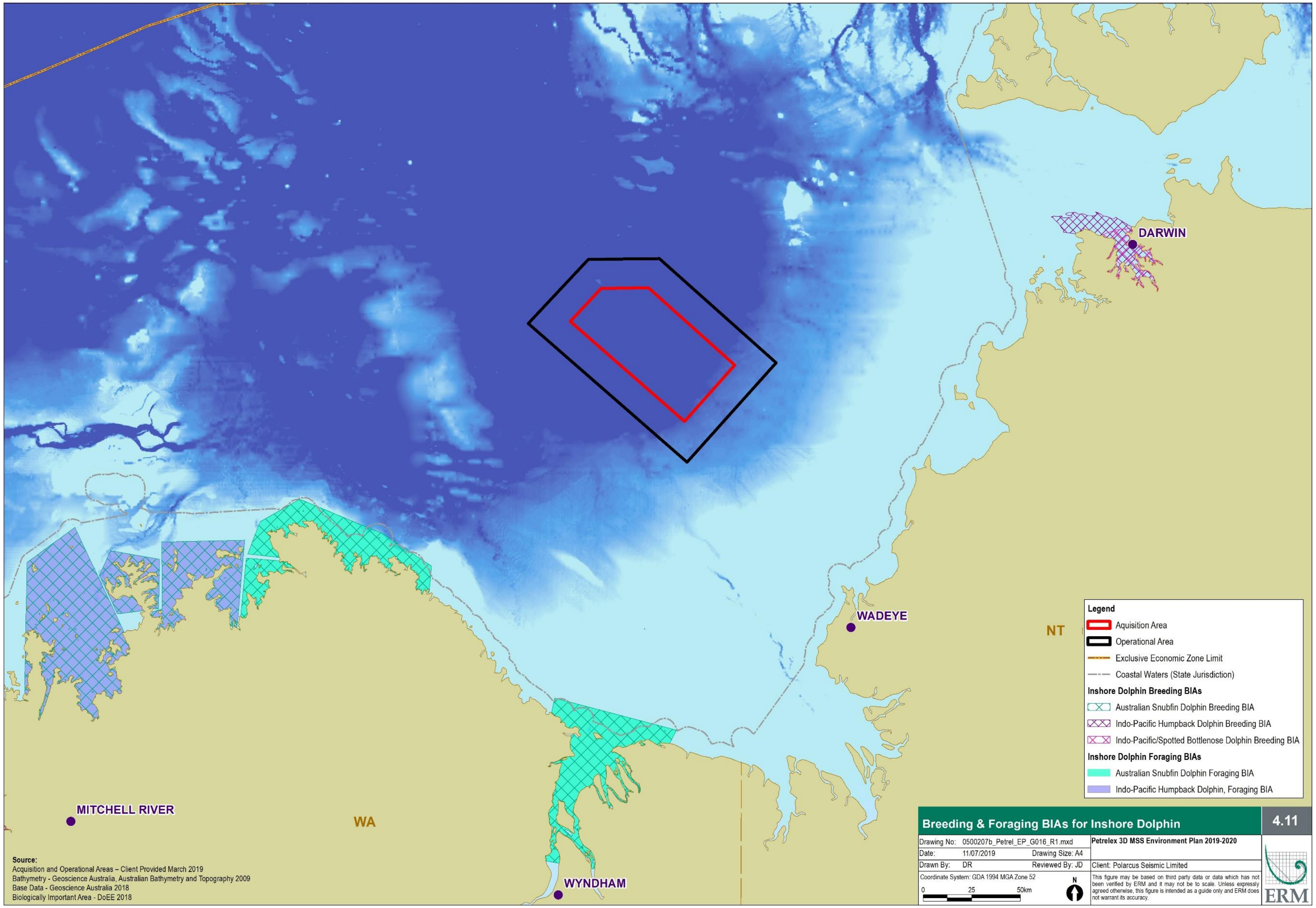


Figure 4-11 Breeding and Foraging Biological Important Areas for Inshore Dolphins

4.5.9 *Sharks and Rays*

The region experiences high species richness of shark, sawfish and rays stemming from the diversity of marine environments (DSEWPaC 2012a). There are approximately 500 shark and sawfish species globally, with 94 of these found in the region (i.e. 19% of the world's shark species) (DEWHA 2008b).

One threatened, four threatened and migratory, and five migratory shark and ray species were identified by a search of the EPBC Act Protected Matters Database as potentially occurring in and around the Operational Area. A description of the distribution, migration movements, preferred habitat and life stages of the shark and ray species identified, and commentary on their likely presence in the Operational Area, is provided in Table 4-10.

No BIAs for sharks or rays were identified to occur within the Operational Area or EMBA. The closest BIA is the foraging BIA for the whale shark, located along the 200 m isobath of the northern WA coastline (approximately 252 km from the Operational Area) (Figure 4-12).

Table 4-10 Threatened and Migratory Sharks and Rays

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
Northern River Shark, New Guinea River Shark *Glyphis garricki*	Endangered	■ Northern river sharks are elasmobranchs capable of living and moving between freshwater and seawater. The species utilises rivers, tidal sections of large tropical estuarine systems, macro tidal embayment's, inshore and offshore marine habitats. ■ Northern river sharks are believed to be endemic to Australia and southern New Guinea. ■ The northern river shark is known to occur in WA and the NT, occupying both marine and freshwater environments including the JBG, Daly River, Adelaide River and the South and East Alligator rivers.	Given the species preferred estuarine habitat, the presence of the species within the Operational Area is expected to be low. The species may be present in the coastal region of the wider EMBA.
Dwarf Sawfish, Queensland Sawfish *Pristis clavata*	Vulnerable, Migratory	■ The dwarf sawfish usually inhabits shallow (2–3 m deep) coastal waters and estuarine habitats. Its distribution is thought to extend north from Cairns around the Cape York Peninsula in QLD, across northern Australian waters to the Pilbara coast in Western Australia (DoEE 2019a). ■ The dwarf sawfish uses its rostrum to stun schooling fish by sideswiping or threshing while swimming through a school. The main prey species is popeye mullet (*Rhinomugil nasutus*) ■ The closest foraging BIA for dwarf sawfish in the area is located along the eastern shore of Camden Sound, over 400 km away from the Operational Area.	Given the species preferred coastal habitat, and the location of the foraging BIA, the presence of the species within the Operational Area is expected to be low. The species may be present in the coastal region of the wider EMBA.
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish *Pristis pristis*	Vulnerable, Migratory	■ The freshwater sawfish is a marine/estuarine species that spends its first three–four years in freshwater growing to about half its adult size (4 m+) (Allen 2000 pers. comm.). Juveniles and sub-adult freshwater sawfish predominantly occur in rivers and estuaries, while large mature animals tend to occur more often in coastal and offshore waters up to 25 m depth (DoEE 2019a). ■ In northern Australia, this species appears to be confined to freshwater drainages and the upper reaches of estuaries, occasionally being found as far as 400 km from the sea. It is likely to occur within the Carbonate bank and terrace system of the Sahul Shelf KEF. ■ The freshwater sawfish feeds on fishes and benthic invertebrates. The saw is used to stun schooling fish, such as mullet, and for extracting molluscs and small crustaceans from the benthic sediment.	Given the species preferred estuarine habitat, and the location of the foraging BIA, the presence of the species within the Operational Area is expected to be low. The species may be present in the coastal region of the wider EMBA.

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
		■ The nearest freshwater sawfish foraging BIA is at King Sound, approximately 646 km away from the Operational Area.	
Green Sawfish, Dindagubba, Narrowsnout Sawfish *Pristis zijsron*	Vulnerable, Migratory	■ The green sawfish occurs in both inshore and offshore marine coastal waters of northern Australia. Its current known distribution stretches from Broome in Western Australia around northern Australia and down the east coast as far as Jervis Bay, NSW (DoEE 2019a). ■ The green sawfish has been recorded in inshore marine waters, estuaries, river mouths, embankments and along sandy and muddy beaches (Peverell et al. 2004). They have also been recorded in very shallow water (<1 m) to offshore trawl grounds in over 70 m of water (Stevens et al. 2005). ■ The Carbonate bank and terrace system of the Sahul Shelf KEF is known to support green sawfish (Donovan et al. 2008). A portion of this KEF overlaps with the eastern portion of the Operational Area. ■ The closest foraging BIA for green sawfish in the area is located along the eastern shore of Camden Sound, over 400 km away from the Operational Area.	Given green sawfish are known to occur in the JBG (both adults and juveniles), the species may be encountered in low numbers in the Operational Area. The species may be present in higher numbers in the coastal region of the wider EMBA.
Whale Shark *Rhincodon typus*	Vulnerable, Migratory	■ The whale shark occurs in both tropical and temperate waters with a typically oceanic and cosmopolitan distribution (Colman 1997). They are most commonly recorded in WA, the Northern Territory and Queensland, although they have been sighted occasionally in New South Wales and Victoria. ■ According to the DoEE's Conservation Advice on whale sharks, the species is known to aggregate at Christmas Island (approximately 2,500 km away) between December and January and at Ningaloo Reef (approximately 1,800 km away) between March and July to feed on krill and baitfish associated with coral spawning events (DoEE 2019a). ■ The whale shark migration between Christmas Island and Ningaloo Reef is expected to occur in deep waters away from the Operational Area between January and March (Colman 1997). ■ The population participating in the Ningaloo aggregation is estimated to comprise between 300 and 500 individuals, although the total population size in the region is unknown (Meekan et al. 2006).	Due to the species widespread distribution and highly migratory nature, individuals may transit through the Operational Area. Given the recorded migratory routes in the region, the cosmopolitan distribution of the species and location of the foraging BIA, whale sharks may be encountered in the Operational Area and EMBA in low numbers.

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
		■ The eastern boundary of whale shark BIA for foraging (the northern WA coastline along the 200 m isobath) is approximately 252 km west of the Operational Area (Figure 4-12). Whale sharks are known to forage within the BIA during Spring.	
Shortfin Mako Shark, Mako Shark *Isurus oxyrinchus*	Migratory	■ The shortfin mako is a pelagic species with a circumglobal, wide-ranging oceanic distribution in tropical and temperate seas (Mollet et al. 2000). The shortfin mako is found in tropical and warm-temperate seas in water depths up to 500 m. The species is rarely found in waters cooler than 16 °C, and is occasionally found close inshore where the continental shelf is narrow (Cailliet et al. 2009). ■ It is widespread in Australian waters having been recorded in offshore waters all around the continent's coastline with exception of the Arafura Sea, the Gulf of Carpentaria and Torres Strait (TSSC 2014). ■ Shortfin makos are also highly migratory and travel large distances.	Given the species distribution in deep offshore waters, the presence of the species within the Operational Area and wider EMBA is expected to be low.
Longfin Mako Shark *Isurus paucus*	Migratory	■ Longfin makos inhabit oceanic and pelagic habits, typically in tropical regions. They are a highly mobile species and have a wide-ranging distribution (DSEWPaC 2012b) but are rarely encountered. ■ Whilst assumed to be a deep-water shark, sightings on the ocean surface, and the species' diet, suggest a broader depth range (Rigby et al. 2019). ■ In Australian waters, the species is found from Geraldton, in WA, and north to Port Stephens in New South Wales (Last and Stevens 2009).	Given the species distribution in deep offshore waters, the presence of the species within the Operational Area and wider EMBA is expected to be low.
Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray *Manta alfredi*	Migratory	■ The reef manta ray is found around the northern coast of Australia between south-western Australia, and central New South Wales (DoEE 2019a). ■ This species is often resident in or along productive near-shore environments, such as island groups, atolls or continental coastlines. This species tends to inhabit warm tropical or sub-tropical waters (Marshall et al. 2018a). The species is commonly sighted inshore, however is also found around offshore coral reefs, rocky reefs and seamounts (Marshall et al. 2018a). ■ Movement patterns are likely site-specific and correlated with cycles in productivity. Individuals have been documented to make seasonal migrations of several hundred kilometres as well as daily migrations of almost 70 km (Marshall et al. 2018a).	Given the species is generally associated with nearshore environments, the presence of the species within the Operational Area is expected to be limited. The species may be present in higher numbers coastal region of the wider EMBA.

Species	Protection Status	Distribution, Habitat and Life Stages	Presence in the Operational Area and EMBA
Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray *Manta birostris*	Migratory	▪ The giant manta ray has a widespread distribution along the coast of Australia and is also known to seasonally migrate between aggregation sites (Marshall et al. 2018b). ▪ The giant manta ray is commonly sighted along productive coastlines with regular upwelling, oceanic island groups and particularly offshore pinnacles and seamounts (Marshall et al. 2018b). This species has been recorded within the Oceanic Shoals Marine Park (Nichol et al. 2013). ▪ The giant manta ray lives in tropical, marine waters worldwide, and occasionally in temperate seas between latitudes 30°N and 35°S (Australian Museum 2014). ▪ The year-round population of giant manta rays present at Ningaloo Reef extends to Exmouth from mid- May through to mid-September.	Given the species wide-distribution, the presence of the species within the Operational Area is expected to be low. The species may be present in higher numbers in the coastal region of the wider EMBA.
Narrow Sawfish, Knifetooth Sawfish *Anoxpristis cuspidata*	Migratory	▪ The exact distribution of the Narrow Sawfish is uncertain, but it is highly likely that its full range extended from Indo-Australian Archipelago to Japan and South Korea. ▪ The Narrow Sawfish is a benthic-pelagic species that inhabits estuarine, inshore and offshore waters to at least 40 m depth (Last and Stevens 2009). Inshore and estuarine waters are critical habitats for juveniles and pupping females, whilst adults predominantly occur offshore (Peverell 2005).	Given the species wide-distribution, the presence of the species within the Operational Area is expected to be low. The species may be present in higher numbers in the coastal region of the wider EMBA.

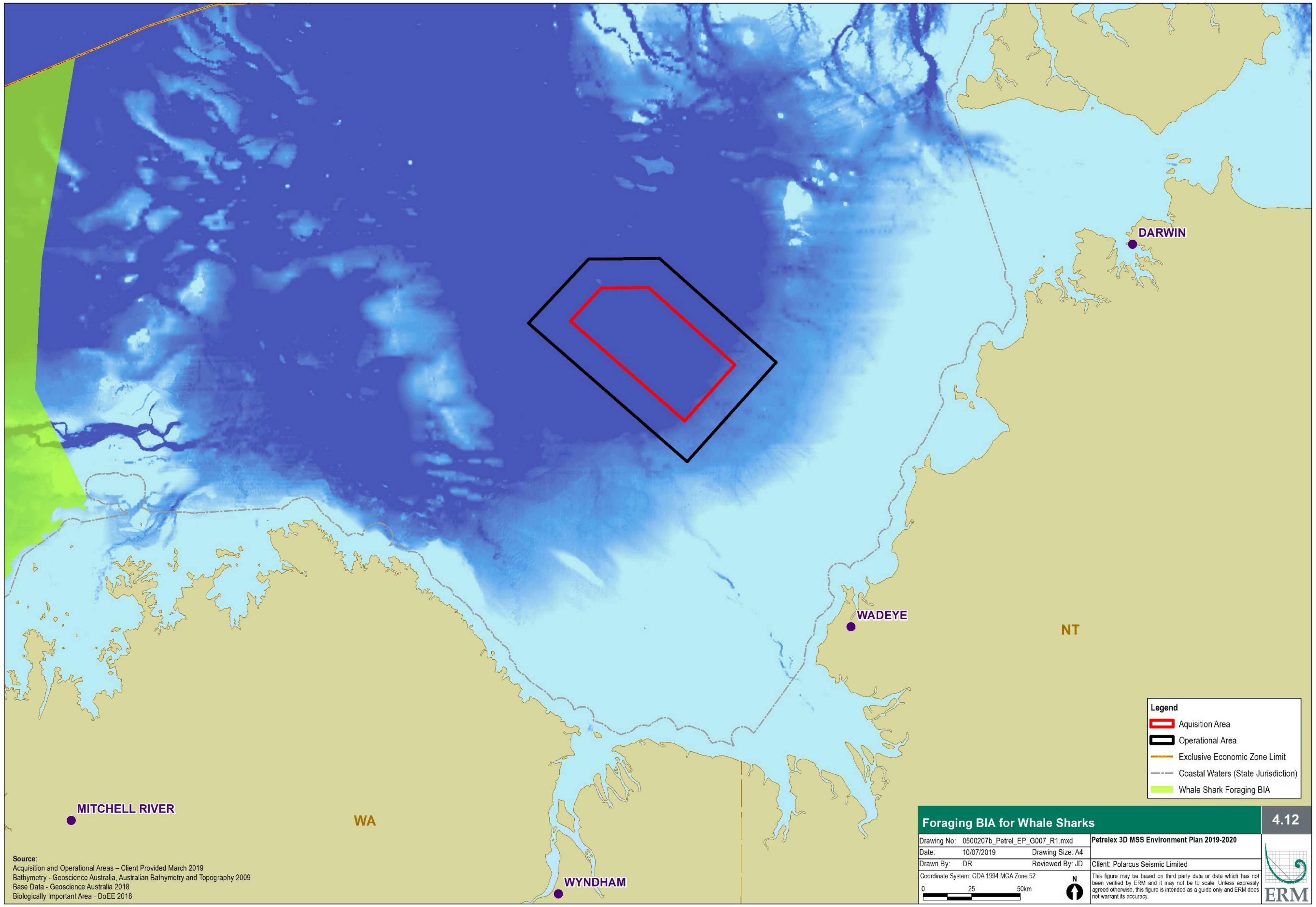


Figure 4-12 Foraging Biological Important Area for Whale Sharks

4.5.10 *Timing of Key Ecological Sensitivities*

Table 4-11 summarises the approximate timing of key ecological sensitivities that may occur within or in proximity to the Operational Area.

Table 4-11 Timing of Key Biological Sensitivities

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Seabird: Migration	x	x	x	x	x	x	x	x	x	x	x	x
Flatback turtle: Nesting						x	x	x	x			
Green turtle: Nesting	x	x	x								x	x
Olive ridley turtle: Nesting				x	x	x	x	x				
Loggerhead, olive ridley, green and flatback turtles: Foraging	x	x	x	x	x	x	x	x	x	x	x	x
Pygmy blue whale (northern migration)				x	x	x	x	x				
Pygmy blue whale (southern migration)										x	x	x
Humpback whale (aggregation at Camden Sound)						x	x	x	x			
Indo-Pacific/Spotted bottlenose dolphin: Breeding, Foraging and Calving (Darwin Harbour)				x	x	x	x	x				
Australian Snubfin dolphin: Foraging and Breeding (Ord River)	x	x	x	x	x	x	x	x	x	x	x	x
Whale shark: Foraging									x	x	x	

4.6 Socio-Economic Environment

4.6.1 *Protected Areas*

4.6.1.1 Commonwealth

The Australian Marine Park (AMP) Network has been established around Australia as part of the NRSMPA, the primary goal of which is to establish and effectively manage a comprehensive, adequate and representative system of marine parks to contribute to the long-term conservation of marine ecosystems and protect marine biodiversity.

Under the EPBC Act, the Australian Marine Park Network, and any zones within them, must be assigned to an International Union for Conservation of Nature (IUCN) Category. These are described in Section 2.1.4.

The Acquisition and Operational Areas do not overlap with any AMPs, however there are two AMPs located within the EMBA:

- Oceanic Shoals Marine Park (the Multiple Use Zone is located 2 km north-west of the Operational Area); and
- Joseph Bonaparte Gulf Marine Park (the Special Purpose Zone is located 35 km south-east of the Operational Area).

Both these marine parks are formally managed under the North Marine Region management framework (Section 2.1.4).

Joseph Bonaparte Gulf Marine Park

The Joseph Bonaparte Gulf Marine Park (JBGMP) (Figure 4-13) is located approximately 15 km west of Wadeye, Northern Territory, and approximately 90 km north of Wyndham, Western Australia, in the JBG. The JBGMP is assigned IUCN Category VI and includes two zones assigned under this plan: Special Purpose Zone (VI) and Multiple Use Zone (VI). This marine park is part of North Marine Parks Network.

The Operational Area is located approximately 35 km from the JBGMP Special Purpose Zone (SPZ) and approximately 60 km from the Multiple Use Zone (MUZ). Commercial activities, such as fishing, tourism, and oil and gas exploration, are permitted within the JBGMP Multiple Use Zone and Special Purpose Zone.

The Marine Park contains a number of prominent shallow seafloor features including an emergent reef system, shoals, and sand banks. It is near an important wetland systems including the Ord River floodplain Ramsar site and provides connectivity between the nearshore and sea environments. The Marine Park includes habitats connecting to and complementing the adjacent Western Australian North Kimberley Marine Park.

The JBGMP includes examples of ecosystems representative of the Northwest Shelf Transition— a dynamic environment influenced by strong tidal currents, monsoonal winds, cyclones and wind generated waves. The large tidal ranges and wide intertidal zones near the Marine Park create a physically dynamic and turbid marine environment.

The key ecological feature in the JBGMP is the Carbonate bank and terrace system of the Sahul Shelf—characterised by terraces, banks, channels and valleys supporting sponges, soft corals, sessile filter feeders, polychaetes and ascidians.

The JBGMP 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 foraging habitat for marine turtles and the Australian snubfin dolphin.

Oceanic Shoals Marine Park

The Oceanic Shoals Marine Park (OSMP) (Figure 4-13) is located west of the Tiwi Islands, approximately 155 km north-west of Darwin, Northern Territory and 305 km north of Wyndham, Western Australia. It extends to the limit of Australia's Exclusive Economic Zone (EEZ). The OSMP covers an area of 71,743 km^2 and water depths from less than 15 m to 500 m, and is the largest marine park in the North Marine Parks Network. The southern boundary of the OSMP is located approximately 2 km from the Operational Area.

The OSMP includes examples of ecosystems representative of the Northwest Shelf Transition— a dynamic environment influenced by strong tidal currents, upwellings of nutrient rich waters, and a range of prominent seafloor features. The pinnacles, carbonate banks and shoals within the marine park are sites of enhanced biological productivity.

Key ecological features (KEFs) of the OSMP are:

- Carbonate bank and terrace systems of the Van Diemen Rise - an area characterised by terraces, banks, channels and valleys supporting sponges, soft coral, polychaetes, ascidians, turtles, snakes and sharks.
- Carbonate bank and terrace system of the Sahul Shelf - an area characterised by terraces, banks, channels and valleys, supporting sponges, soft corals, sessile filter feeders, polychaetes and ascidians.
- Pinnacles of the Bonaparte Basin - an area that contains the largest concentration of pinnacles along the Australian margin, where local upwellings of nutrient-rich water attract aggregations of fish, seabirds and turtles.
- Shelf break and slope of the Arafura Shelf - an area characterised by continental slope, patch reefs and hard substrate pinnacles that support over 280 demersal fish species.

The OSMP 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 foraging and internesting habitat for marine turtles.

4.6.1.2 State/Territory

A review of the WA/NT marine parks and reserves did not identify any current or proposed marine parks or reserves within or adjacent to the EMBA. The closest State/Territory marine park is the North Kimberley Marine Park (NKMP), located within WA waters 135 km south of the Operational Area (DPaW 2016).

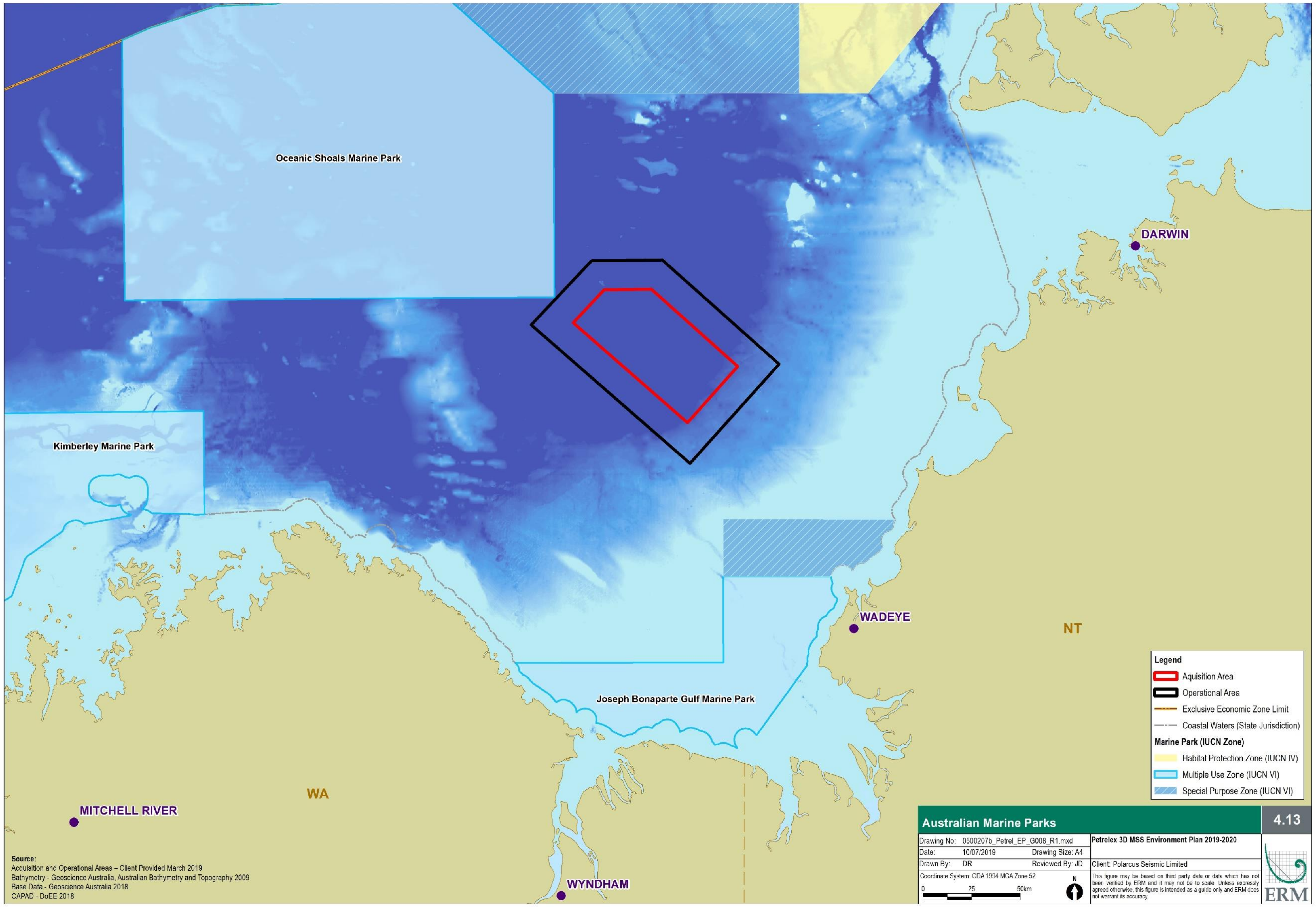


Figure 4-13 Australian Marine Parks

4.6.2 *World Heritage and National Heritage Areas*

There are no World Heritage Properties or National Heritage Sites within the Operational Area or EMBA. The Operational Area is located over 500 km to the north of the nearest World Heritage Property and National Heritage Site, namely the Purnululu National Park.

4.6.3 *Wetlands of International Importance*

There are no marine or coastal Wetlands of International Importance in the vicinity of the Petrelex 3D MSS. The nearest Wetland of International Importance is the Ord River Floodplain Ramsar Site, located on the eastern side of Cambridge Gulf (WA), over 165 km to the south-west of the Operational Area. The Ord River Floodplain is located outside of the EMBA and therefore will not be impacted by the proposed activity.

4.6.4 *Marine Archaeology*

Historic shipwrecks are recognised and protected under the *Historic Shipwrecks Act 1976* that protects historic wrecks and associated relics. Under the Act, all wrecks more than 75 years old are protected, together with their associated relics regardless of whether their actual locations are known. The Commonwealth minister responsible for the environment can also make a declaration to protect any historically significant wrecks or articles and relics that are less than 75 years old.

A search of the National Shipwreck and Relics database identified one shipwreck as occurring within the Operational Area. The *Sedco Helen*, wrecked in 1970, is located in the north of the Acquisition Area, in depths of approximately 100 m.

4.6.5 *Native Title*

A search of the National Native Title Tribunal (NNTT) Register did not identify any Native Title areas within the Operational Area. The nearest National Native Title Tribunal Registered place is at Bradshaw Station, approximately 182 km south-east of the Operational Area.

The Operational Area does overlap with the Representative Aboriginal Torres Strait Islander Body Area of the Northern Land Council and the Kimberley Land Council Aboriginal Corporation (NNTT 2019).

4.6.6 *Commercial Fisheries*

4.6.6.1 Commonwealth Managed Fisheries

The Australian Fisheries Management Authority (AFMA) manages more than 20 fisheries on behalf of the Commonwealth Government and is bound by objectives under the *Fisheries Management Act 1991*.

Commonwealth managed commercial fisheries with the licence to operate within the Operational Area and EMBA are described in Table 4-12.

Table 4-12 Relevant Commonwealth Managed Fisheries

Fisheries	Description of Licensed Area / Fishing Effort	Fishing Method	Primary Target Species	Operating Season	Estimated Catch (tonnes/Season)	Overlap with the Operational Area (Y/N)	Relevance to Petrelex 3D MSS
Western Tuna and Billfish Fishery	Operates in Australian's EEZ and high seas of Indian Ocean. However, in recent years effort has been concentrated off south-west WA and SA (AFMA 2018a).	Pelagic longline, minor line (hand line, rod and reel, troll and poling) and purse seine	Broadbill swordfish, bigeye tuna, yellowfin tuna, albacore tuna	All year	322	Y	Tuna and billfish species are known to spawn throughout the continental shelf and slope waters of the Indian Ocean. The most recent reports indicate that the Western Tuna and Billfish Fishery does not operate in the Bonaparte Basin. During the consultation process for Polarcus Zénaïde 3D MSS in 2017, AFMA advised Polarcus that the Western Tuna and Billfish Fishery does not operate in the Bonaparte Basin and will not be impacted by the proposed activity. Therefore, the Western Tuna and Billfish Fishery was not consulted and is not considered further in the EP.
Southern Bluefin Tuna Fishery	Covers the entire Australian Fishing Zone (AFZ), which is 3 to 200 nm from the Australian coast (AFMA 2018b). Most of Australian catch is taken in the Great Australian Bight, with no current effort in WA.	Pelagic longline or purse seine	Southern bluefin tuna	All year	5,334	Y	It is understood, that southern bluefin tuna typically spawn south of Java, outside of the Operational Area. There is no effort currently reported in WA or the NT and there is no potential for interactions with the Petrelex 3D MSS. Therefore, the Southern Bluefin Tuna Fishery was not consulted and is not considered further in the EP.

Fisheries	Description of Licensed Area / Fishing Effort	Fishing Method	Primary Target Species	Operating Season	Estimated Catch (tonnes/Season)	Overlap with the Operational Area (Y/N)	Relevance to Petrelex 3D MSS
Western Skipjack Fishery	Covers the AFZ, and extends westward from the South Australian/Victorian border around the coast of Australia to Cape York Peninsula in QLD (AFMA 2018c). There has been no catch or effort in the WSTF since the 2008–09 fishing season.	Purse seine, a small amount of pole-and-line	Skipjack tuna	November to June	0	Y	Skipjack tuna are known to spawn throughout the continental shelf and slope waters of the Indian Ocean. The fishery is not currently in operation, and therefore is not considered further in the EP. There will be no interaction with the Petrelex 3D MSS.
Northern Prawn Fishery	Operates from the JBG across to the Gulf of Carpentaria (AFMA 2018d). In 1981, fishing effort peaked at 40,000 fishing days and more than 250 vessels. Three decades later, it has reduced to around 8,000 days of effort and 52 vessels. The majority of fishing is conducted in coastal waters outside of the Operational Area. The main fishing area for the NPF is the Gulf of Carpentaria, with low intensity within the JBG.	Otter trawl gear, a quad rig comprising four trawl nets	Banana prawns, tiger prawns, endeavour prawns, others (squid, bugs and scampi)	1 April to 15 June and 1 August to 1 December	6,602	Y	The JBG comprises about 30,000 km^2 of the westernmost portion of the NPF. Fishing takes place in waters 35–70 m deep, with most fishing effort between 50 and 60 m. During stakeholder consultation, NPFI confirmed that negligible fishing activity occurs in the Operational Area, however fishing activity does occur in close-proximity. The main fishing area in the JBG is understood to be approximately 5 km to the south of the Operational Area and is, therefore, not expected to be affected by the presence of seismic vessels or seismic sound emissions. It is possible however, that prawn trawl vessels may occasionally occur further offshore close to or within the Operational Area.

Fisheries	Description of Licensed Area / Fishing Effort	Fishing Method	Primary Target Species	Operating Season	Estimated Catch (tonnes/Season)	Overlap with the Operational Area (Y/N)	Relevance to Petrelex 3D MSS
							Therefore, there is a potential for interaction with the Petrelex 3D MSS.

As presented in Table 4-12, the NPF is the only Commonwealth managed fishery that actively fishes within the Operational Area and EMBA. Further information on the NPF is provided below.

Northern Prawn Fishery

The NPF operates off Australia's northern coast from Cape York (QLD) to Cape Londonderry (WA) (AFMA 2018d). The NPF is restricted to 52 vessels. The area of the NPF is shown in Figure 4-14. The main fishing area for the NPF is the Gulf of Carpentaria, with low intensity within the JBG.

Figure 4-15 shows the area of fishing activity in the JBG for 2013-2017, based on data presented in the annual ABARES Fishery Status Report.

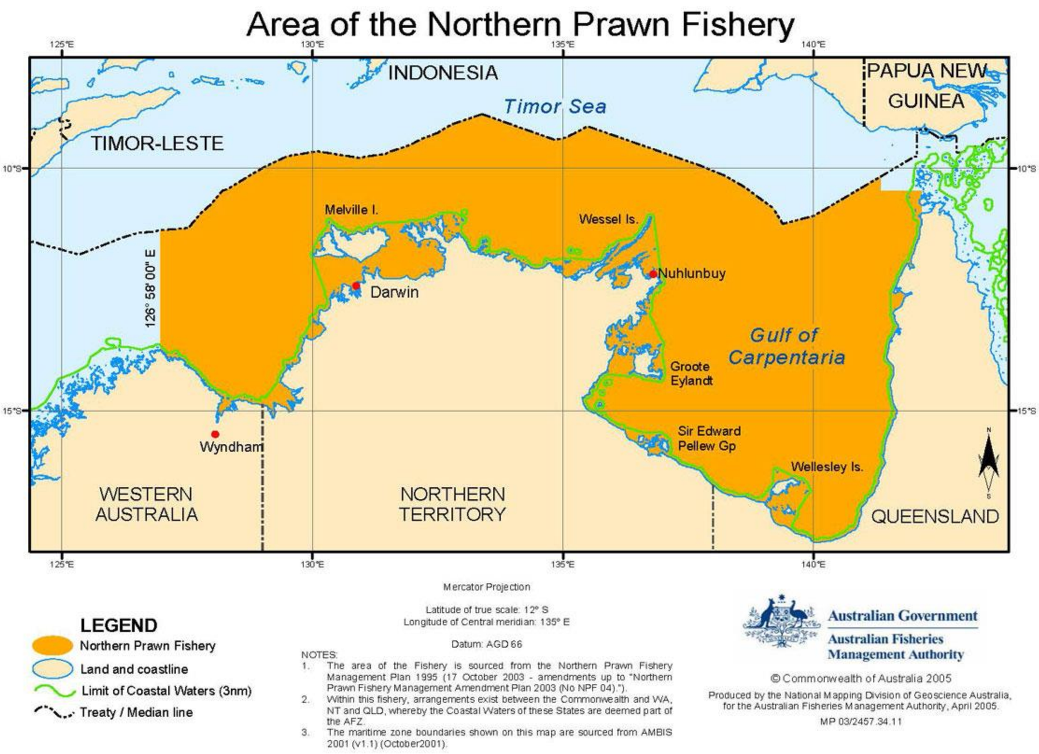


Figure 4-14 Northern Prawn Fishery Area

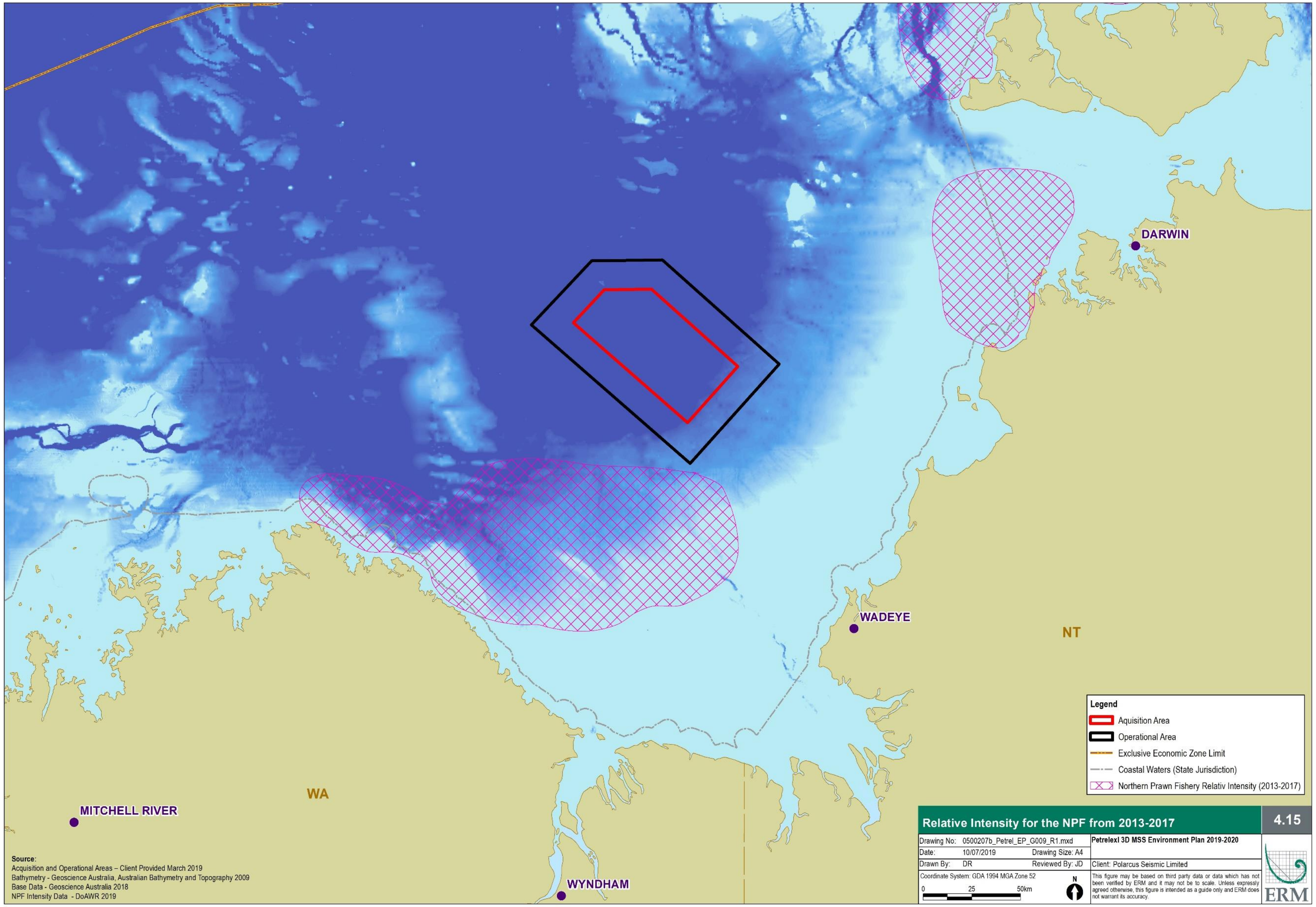


Figure 4-15 NPF fishing areas reporting low intensity (<0.1 day/km^2) fishing or higher between 2013 and 2017 (adapted from ABARES Annual Fishing Reports)

The following information in regards to the NPF in general is sourced from the ABARES 2018 Fishery Status Report (Patterson et al. 2018) except where noted. Information relating to the activities of the NPF within the JBG has been sourced from:

- Loneragan et al. (2002);
- AFMA (2018);
- Laird (2017);
- Jarrett et al. (2015); and
- Information obtained from NPFI during the stakeholder consultation process.

The NPF is managed through a combination of input controls (limited entry, seasonal closures, permanent area closures, gear restrictions and operational controls) that are implemented under the Northern Prawn Fishery Management Plan 1995.

The NPF uses otter trawl gear to target a range of tropical prawn species. White banana prawn and two species of tiger prawn (brown and grooved) account for around 80% of the landed catch. In recent years, many vessels have transitioned from using twin gear to mostly using a quad rig comprising four trawl nets—a configuration that is more efficient.

White banana prawn (*Fenneropenaeus merguiensis*) is mainly caught during the day on the eastern side of the Gulf of Carpentaria, whereas red-legged banana prawns (*F. indicus*) is mainly caught in the JBG. Byproduct species include endeavour prawns (*Metapenaeus* spp.), scampi (*Metanephrops* spp.), bugs (*Thenus* spp.) and saucer scallops (*Amusium* spp.).

The total catch in 2016 for the NPF was 5,807 t at a value of $124.0 million, and in 2015 it was 7,825 t at a value of $106.8 million. Annual catches tend to be quite variable from year to year because of natural variability in the banana prawn component of the fishery.

The NPF operates during two seasons. The first season is from 1 April to 15 June, and during this time banana prawns are mainly caught. Conversely, during the second season (1 August – 1 December) tiger prawns are predominately caught. Either season has the potential to end early depending on the total catch.

The following information has been obtained from the AFMA website (http://www.afma.gov.au/portfolio-item/prawns/) except where noted.

Banana prawns inhabit tropical and subtropical coastal waters. They are found over muddy and sandy bottoms in coastal waters and estuaries. Juveniles inhabit small creeks and rivers in sheltered mangrove environments. White banana prawns can generally be found at depths of 16 - 25 m but can occur to depths of 45 m. Red-legged banana prawns are found at depths of 35 - 90 m.

Tiger prawns inhabit coastal waters to depths of 200 m. Adult brown tiger prawns are found over coarse sediments. Adult grooved tiger prawns are found in fine mud sediments. Juvenile tiger prawns are found in shallow waters, often in association with seagrass beds, and sometimes on top of coral reef platforms. Spawning occurs throughout the year, in both inshore and offshore areas for brown tiger prawns and in offshore areas for grooved tiger prawns. Brown tiger prawns have a spawning peak between July and October. Grooved tiger prawns have a spawning peak in August-September, with a secondary peak in February.

Endeavour prawns inhabit tropical coastal waters. Blue endeavour prawns can be found over sandy or mud-sand substrates to depths of about 60 m. Red endeavour prawns prefer muddy substrates and have been found to depths of 95 m. Juvenile blue endeavour prawns are commonly associated with seagrass beds in shallow estuaries, while juvenile red endeavour prawns are more widely distributed across seagrass beds, mangrove banks, mud flats and open channels. Spawning occurs throughout the year. Blue endeavour prawns have spawning peaks in March and September. Red endeavour prawns have a spawning peak in September to December. Based on the endeavour prawns spawning habitat preferences it is unlikely that they would spawn in the offshore area of the survey location.

Advice from the NPFI during the development of the Santos Fishburn EP is that prawn species reach a commercial size at six months, and can live for up to two years. Larger sized prawns have a higher price tag. Growth rates vary considerably between species and sexes, with females generally growing faster and to a larger size than males. Most species are sexually mature at six months, but fecundity increases with age. A twelve-month-old female can produce hundreds of thousands of eggs at a single spawning and may spawn more than once in a season. The eggs sink to the bottom after release, where they hatch into larvae within about 24 hours. Less than 1% of these offspring survive the two to four-week planktonic larval phase to reach suitable coastal nursery habitats where they may settle. After one to three months on the nursery grounds, the young prawns move offshore onto the fishing grounds.

During the 2016 season, a total of 2,904 tonnes of banana prawns, 2,158 tonnes of tiger prawns and 374 tonnes of endeavour prawns were caught.

NPF Activity in the JBG

In the JBG the NPF the catch is comprised primarily of banana prawns (mainly *F. indicus* and some *F. merguiensis*), with a very minor catch of tiger and endeavour prawns (Laird 2017).

The JBG comprises about 30,000 km^2 of the westernmost portion of the NPF (Figure 4-14). Fishing for the *F. indicus* is permitted day and night in both NPF fishing seasons. Fishing takes place in waters 35–70 m deep, with most fishing effort between 50 and 60 m. The trawling regime for this species is similar to the tiger prawn sub-fishery in other regions of the NPF, where the total duration of individual trawls are usually long (~3 h). Although the JBG fishery comprises less than 5% of the area of the NPF, it contributes about 65% of the NPF's red-legged banana prawn catch and around 20% of the NPF's total banana prawn catch (combined *F. merguensis* and *F. indicus*) (Loneragan et al. 2002).

Advice from the NPFI provided as part of the consultation process for the Santos Fishburn 3D MSS EP is that there is not a lot of information known about the spawning season for *F. merguiensis*, but research to date indicates that *F. indicus* prawns spawn offshore near to the fishing area throughout the year with two spawning peaks: the late dry season (September-November) and the late wet season (March-May). The larvae move inshore and then wash out as juveniles with the wet season floods.

As described in Loneragan et al. (2002), the offshore fishery for red-legged banana prawns (*F. indicus*) takes place in the north-western offshore waters of the JBG (in water depths of 50-80 m). Thus, the juvenile phase of *F. indicus* is found in estuarine habitats up to 120 km south and 240 km east-southeast of the southern and eastern limits of the JBG *F. indicus* fishery. The juvenile phase of *F. merguiensis* is found in estuarine habitats in the western JBG, about 50 km to the south west of the *F. indicus* fishery, offshore. Although these mangrove habitats are the closest inshore habitats to the fishery, they are not used by *F. indicus*. These results suggest that the larvae of *F. indicus* resulting from spawning in the fishing area, are advected large distances to the south and east to their nursery habitats (Figure 4-16). They also imply that the emigrating juveniles and sub-adults migrate from the mangrove nursery habitats, north and west, across shallower sand substrates (30 – 40 m deep) to the deeper-water fishery (on mud substrates about 50-80 m deep).

The migration of juvenile *F. indicus* in the JBG appears to be split into two periods, with the migration of the main cohort occurring between November and March, with a possible second cohort migrating from April to June (Neil Loneragan, CSIRO Division of Marine Research, pers. comm., April 2000). Migration of the juveniles is thought to be triggered by rainfall and river discharge.

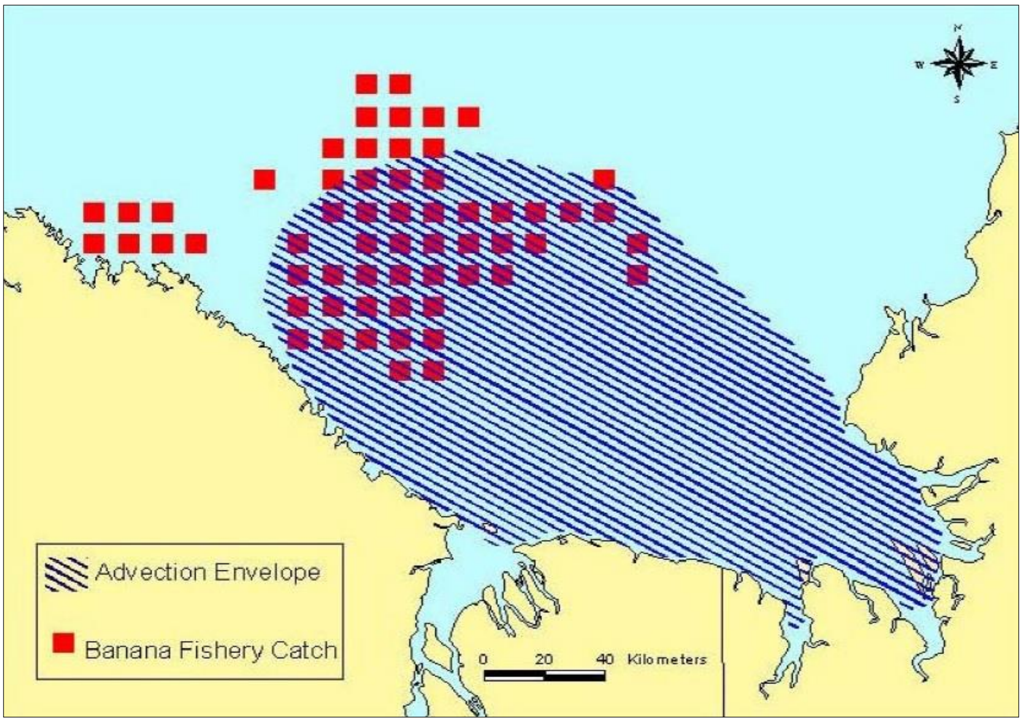


Figure 4-16 Size of the Probable Advection Envelope for Postlarval *F. indicus* in the JBG (Loneragan et al. 2002)

A seasonal closure for the NPF in the JBG exists in the period 31 March – 15 June (Figure 4-17) (AFMA 2018d). The seasonal closure is an exclusion zone in place for all licence holders within the NPF, and the purpose of this closure is to protect small juvenile prawns as they migrate offshore to deeper waters in the southern JBG, where the adults are targeted during the trawling operations. Any catch south of the seasonal closure line is taken in the second fishing season only (August to November), whereas catch taken north of the closure line is taken during both the first and second seasons.

The Petrelex 3D MSS is not located within this exclusion zone (Figure 4-17). According to the Northern Prawn Fishery Directions and Closures (AFMA 2018d), the seasonal closure in the JBG will be implemented for the 2019/20 season.

Due to the large tidal range (6–8 m) in the JBG and its reputed influence on prawn abundance in the region, *F. indicus* are fished on the neap tides, when tidal range and currents are minimal (Tonks et al. 2008). Thus, over a tide cycle, fishing effort is high on the late spring-neap, neap and early neap-spring tides, and low to non-existent at other times when the fleet moves to fishing grounds north of Melville Island and Port Essington, outside the JBG. The extra steaming time that this fishing pattern generates, together with the remoteness of the JBG and the lower price of *F. indicus* in comparison to other species of prawns, makes the JBG a less attractive area to fish than other parts of the NPF. As a result, the annual fishing effort in the JBG fishery is mostly dependent on the catch levels elsewhere in the NPF; if catches are good elsewhere, effort in JBG is low (Loneragan et al. 2002).

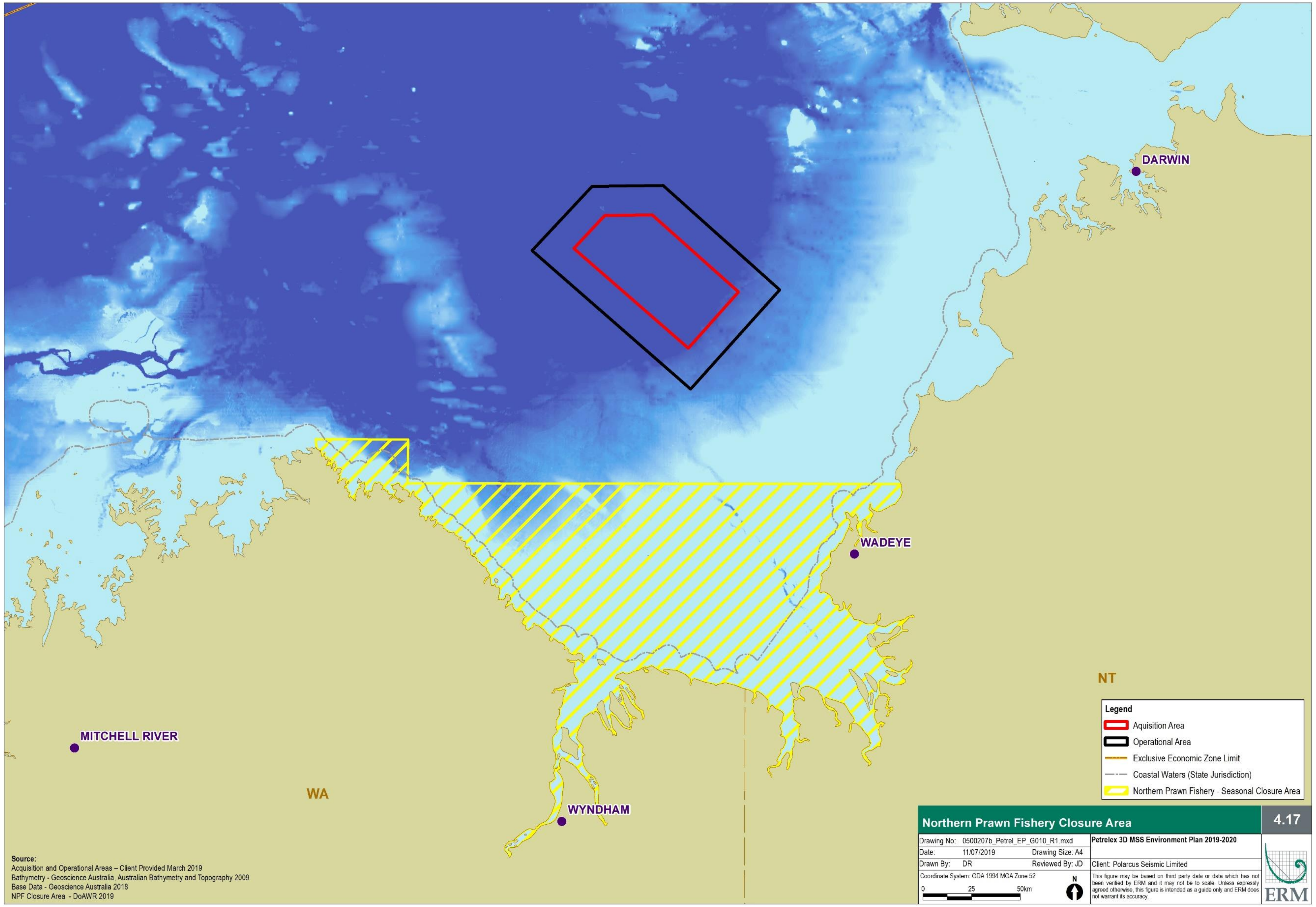


Figure 4-17 Northern Prawn Fishery Closure Area

4.6.6.2 Western Australian Managed Fisheries

WA State commercial fisheries are managed by the Department of Primary Industries and Regional Development (Fisheries) under the *Fish Resources Management Act 1994*, Fisheries Resources Management Regulations 1995, relevant gazetted notices and licence conditions and applicable Fishery Management Plans.

WA managed commercial fisheries with the licence to operate within the Operational Area and EMBA are described in Table 4-13.

Table 4-13 Relevant Western Australian Managed Fisheries

Fisheries	Description of Licensed Area / Fishing Effort	Fishing Method	Primary Target Species	Operating Season	Estimated Catch (tonnes/Season)	Overlap with the Operational Area (Y/N)	Relevance to Petrelex 3D MSS
Northern Demersal Scalefish Managed Fishery (NDSMF)	North-west coast of WA in the waters east of longitude 120° E to the edge of the AFZ. The fishery is divided into two fishing areas; an inshore sector (Area 1) and an offshore sector (Area 2). Area 2 is further divided into zones. Zone A is an inshore area, Zone B comprises the area with most historical fishing activity and Zone C is an offshore deep slope area representing waters deeper than 200 m (Fletcher et al. 2017).	Primarily trap, some line	Demersal scale fish (red emperor, goldband snapper, cod species)	All year	1,228 t	Y	Area 2 (Zone A) of the fishery overlaps with the Operational Area, with fishing effort reporting all year. It is understood, the target species for the NDSMF spawn throughout their range on the continental shelf. In 2014, the total effort was 616 standard fishing days in in Zone A, 985.6 standard fishing days in Zone B and 1,100 standard fishing days in Zone C (Fletcher and Santoro 2014). A review of the NDSMF catch data indicates that the area surrounding the Operational Area is not significant for catches. Historical catch data obtained from FishCube indicates low fishing activity within the Operational Area (i.e. 8 tonnes caught by five vessels over the last six years). Fishing effort in the Operational Area is expected to be low. Therefore, while there is the potential for interaction with the Petrelex 3D MSS, such interactions would be infrequent.

Fisheries	Description of Licensed Area / Fishing Effort	Fishing Method	Primary Target Species	Operating Season	Estimated Catch (tonnes/Season)	Overlap with the Operational Area (Y/N)	Relevance to Petrelex 3D MSS
Mackerel Managed Fishery (MMF)	The Mackerel Managed Fishery mainly operates between Geraldton and the WA/NT border. It comprises of three areas: Area 1 – Kimberley, Area 2 – Pilbara and Area 3 – Gascoyne/West Coast (Fletcher et al. 2017).	Trolling or handline	Spanish and grey mackerel	April – November	Target 246-410 t. 2014/15 catch 302 t.	Y	Area 1 of the fishery overlaps with the Operational Area, with fishing effort reported all year. In 2013 there were three licences operating in Area 1 of the fishery. In 2013, the majority of the catch was taken in Area 1, reflecting the tropical distribution of mackerel species (Fletcher et al. 2017). Historical catch data obtained from FishCube indicates that no fishing has occurred within the Operational Area since 2013. Fishing activity is generally limited to less than 70 m depth. Fishing effort in the Operational Area is expected to be low. Therefore, while there is the potential for interaction with the Petrelex 3D MSS, such interactions would be infrequent.
North Shark Fisheries (Joint Authority Northern Shark Fishery and WA North Coast	The Operational Area overlaps with the licence boundary of the Joint Authority Northern Shark Fishery (JANSF). Limited to no fishing activity has been recorded in both fisheries since 2008/09 as they do not have a Wildlife Trade Operation (WTO) accreditation that allows export of product from the	Line fishing	Sandbar shark, blacktip shark	All year	0	Y	Target shark species pupping and nursery areas are understood to be located in nearshore/coastal waters and outside of the Operational Area. During stakeholder consultation, WAFIC advised that the fishery may potentially recommence fishing in late 2019/2020. If fishing recommences in 2019/2020, there is the potential for interaction with the Petrelex 3D MSS.

Fisheries	Description of Licensed Area / Fishing Effort	Fishing Method	Primary Target Species	Operating Season	Estimated Catch (tonnes/Season)	Overlap with the Operational Area (Y/N)	Relevance to Petrelex 3D MSS
Shark Fishery)	fishery thus making the fishery unprofitable.						However, given the range of target species, fishing effort in the Operational Area is expected to be low, and interactions infrequent.
Pearl Oyster Managed Fishery (POMF)	Quota based dive fishery operating in shallow coastal waters of the North West Shelf (Fletcher et al. 2017). The fishery is split into 4 zones: ■ Zone 1 – North West Cape to longitude 119°30´ E; ■ Zone 2 – East of Cape Thouin and south of latitude 18°14´ S; ■ Zone 3 – West of longitude 125°20´ E and north of latitude 18°14´ S; and ■ Zone 4 - East of longitude 125°20´ E to the WA/Northern Territory border. Pearl oyster shell fishing has not been reported in Zone 1 since 2008 (Fletcher and Santoro 2014). In 2013, catch was only taken in Zone 2/3 (Fletcher et al. 2017).	Drift diving, harvesting legal-sized oysters by hand	Indo-Pacific, silver-lipped pearl oysters	All year	Number of individuals: 685,888	Y	The Operational Area is located within the actively fished Zone 3. However, the Operational Area is located away from the Kimberley coastline where aquaculture licences and pearling leases are located, and where pearl fishing/diving occurs (<50 m depth) (Fletcher et al. 2017). The northern extent of commercial fishing and commercial stocks is the Lacepede Islands (Fletcher et al. 2017), which are located approximately 780 km to the south-west of the Operational Area. Historic catch data obtained from FishCube confirms that there has been no fishing activity within the Operational Area in the last five years. Therefore, there is no potential for interaction with the Petrelex 3D MSS. The Acquisition Area is located 200 km from the nearest aquaculture licences and pearling leases. Sound propagation is not expected to occur over these distances particularly given the complex coastal topography and coastal embayments. Potential impacts to the POMF are not assessed further in this EP.

Fisheries	Description of Licensed Area / Fishing Effort	Fishing Method	Primary Target Species	Operating Season	Estimated Catch (tonnes/Season)	Overlap with the Operational Area (Y/N)	Relevance to Petrelex 3D MSS
	Diving activities start in January and are typically conducted for 6 months of the year. Diving occurs in depths of less than 23 m during 6-12 days over the neap tidal cycle, with dives lasting no more than 40 minutes.						
Marine Aquarium Fish Managed Fishery (MAFMF)	The Marine Aquarium Fish Managed Fishery operates in WA's state waters from the Northern Territory border in the north through to the South Australian border in the south. The effort is spread over a total gazetted area of 20,781 km^2 (Fletcher et al. 2017). There are 12 licences in the fishery of which 10 were in operation in 2013. Effort in the fishery has decreased from 981 fishing days (2007) to 494 fishing days in 2013, with 61 fishing days of this total effort being exclusively for land hermit crabs only (Fletcher et al. 2017). While the MAFMF operates throughout all Western	Dive based, hand net operating from small boats	This fishery has the capacity to target more than 950 species of marine aquarium fish. Coral, live rock, algae, seagrass and invertebrates under the Prohibition on Fishing (Coral, 'Live Rock' and Algae) Order 2007 are also permitted (e.g. 383 species were landed in 2013).	All year	Over 19,300 individual fish were landed in 2012 (223 species).	Y	The fishery occurs in WA State waters and is typically more active in waters between Esperance and Broome with higher levels of effort around the Capes region, Perth, Geraldton, Exmouth and Dampier (Fletcher et al. 2017). As the fishery targets small fish and coral in shallow State waters and no activity is known to occur along the north Kimberley coast, the fishery is not expected to be directly or indirectly affected by the presence of seismic and support vessels, or by sound emissions. This fishery is therefore not considered further in this assessment.

Fisheries	Description of Licensed Area / Fishing Effort	Fishing Method	Primary Target Species	Operating Season	Estimated Catch (tonnes/Season)	Overlap with the Operational Area (Y/N)	Relevance to Petrelex 3D MSS
	Australian waters, catches are relatively low in volume due to the special handling requirements of live fish (Fletcher et al. 2017).						
Beche de Mer Managed Fishery	Primarily based in the northern half of WA from Exmouth Gulf to the Northern Territory border, although fishers have access to all WA waters (with the exception of a number of specific closures around the Dampier Archipelago, Cape Keraudren, Cape Preston and Cape Lambert, the Rowley Shoals and the Abrolhos Islands) (Fletcher et al. 2017). None of the six licenced vessels fished for beche-de-mer in 2013 (Fletcher et al. 2017). Fishing effort has steadily been declining since 2008 (196 tonnes). Fishing activity within the Western Australian fisheries is in a resting phase (Fletcher et al. 2017).	Diving or wading, collection by hand	Sea cucumbers, 99% of the catch being sandfish (*Holothuria scabra*)	All year	0	Y	Fishing activity level is currently nil. Most of the fishing is concentrated in shallower coastal areas using diving and wading techniques and therefore away from the Operational Area. Given the location and water depths in the Operational Area and the current inactivity of this fishery, it is not expected to be directly or indirectly affected by the survey or sound emissions. This fishery is therefore not considered further in this assessment.

Fisheries	Description of Licensed Area / Fishing Effort	Fishing Method	Primary Target Species	Operating Season	Estimated Catch (tonnes/Season)	Overlap with the Operational Area (Y/N)	Relevance to Petrelex 3D MSS
Specimen Shell Managed Fishery (SSMF)	The fishing area includes all Western Australian waters between the high water mark and the 200 m isobath, with some concentration of effort in areas adjacent to population centres such as Broome, Karratha, Shark Bay, metropolitan Perth, Mandurah, the Capes area and Albany (Fletcher et al. 2017). This is a limited entry fishery with 32 licences in the fishery, 18 of them being active and 11 of them being regularly active. A maximum of two divers are allowed in the water per licence at any one time (Fletcher and Santoro 2014). Effort has decreased from 1,057 fishing days in 2009 to 745 fishing days in 2013 (Fletcher et al. 2017).	Collected by hand	196 species collected in 2012 (equivalent to 12 shell per day)	All year	8,896 shells	Y	Similar to the MAFMF, the SSMF is typically more active in shallow coastal waters. Given the location and water depths in which the fishery typically operates, this fishery or target species are not expected to be directly or indirectly affected by the presence of seismic and support vessels, or by sound emissions. This fishery is therefore not considered further in this assessment.

As presented in Table 4-13, the NDSMF, MMF and Northern Shark Fishery are the only Western Australian managed commercial fisheries that actively fish within the Operational Area and EMBA. Further information on these fisheries are provided below.

Northern Demersal Scalefish Managed Fishery

In the Kimberley, the NDSMF operates off WA's coast in waters east of 120° E longitude. The NDSMF is managed primarily through input controls in the form of an annual fishing effort capacity, with supplementary gear controls and area closures.

The fishery is permitted to use hand lines, droplines and fish traps, although the NDSMF has essentially operated as a trap based fishery since 2002. The NDSMF principally targets red emperor and goldband snapper, with a number of species of snappers (Lutjanidae), cods (Epinephelidae) and emperors (Lethrinidae) comprising the majority of the remainder of the catch (Fletcher and Santoro 2015).

The fishery is further divided into two fishing areas; an inshore sector (Area 1) and an offshore sector (Area 2). The Northern Demersal Scalefish Managed Fishery Management Plan 2000 was amended in 2013 to formalise the previous voluntary industry agreement which further divides the offshore sector (Area 2) into three zones; A, B and C. Zone B comprises the area with most of the historical fishing activity. Zone A is an inshore developmental area and Zone C is an offshore deep slope developmental area representing waters deeper than 200 m (Fletcher and Santoro 2015). The Petrelex 3D MSS is located within Area 2, Zone A.

In 2014, the total catch for the NDSMF was reported at 1,111 t, of which Zone B contributed 960 t. The total catch of goldband snapper in 2014 in the NDSMF (499 t) was similar to that reported in 2013 (493 t). Catch levels of goldband snapper have remained high (> 450 t) since the peak catch of 523 t reported in 2010. The last five years represent the highest reported landings of this species, continuing an overall trend of increasing catches since 2005. The total catch of red emperor in 2014 was 132 t, which is similar to the red emperor catch levels reported over the past four years (2010-2013).

Mackerel Managed Fishery

The MMF is divided into three zones, Area 1 - Kimberley (121°E to WA/NT border), Area 2 - Pilbara (114°E to 121°E) and Area - 3 Gascoyne (27°S to 114°E), which encompass the entire coastline of WA from the Northern Territory (NT) border to Cape Leeuwin in the south-west (Fletcher and Santoro 2015).

The primary target species of the MMF is the Spanish mackerel (*Scomberomorus commerson*), which is fished commercially between Geraldton (in the Gascoyne/West Coast Sector) and the Northern Territory border (Kimberley Sector).

The MMF was made a fully managed fishery in 2012 and operates under an Individual Transferable Quota (ITQ) system which includes the setting of Total Allowable Commercial Catches (TACCs) for each area of the fishery, allocation of the entitlement to take quota in the form of units, and establishment of minimum unit holding requirements to operate in the Fishery.

Licence holders may only fish for mackerel by trolling or hand-line. There are currently only 14 licences in the Kimberley management area. A total of 14 vessels operated during the 2014 season with three vessels within the Kimberley area (Fletcher and Santoro 2015). A total of 673 fishing days of effort were reported targeting Spanish mackerel in 2014, with more than 53% of effort days reported from the Kimberley area.

Estimates of catches are monitored through mandatory logbook systems with the total catch of Spanish mackerel in the 2014 season estimated at 322 tonnes. The target catch (and effort) for Spanish mackerel is between 246 – 410 tonnes for the three management zones. The reported catch from the Kimberley area of 193.8 t was within the area's acceptable catch range (110 – 205 t).

Northern Shark Fishery

The Northern Shark Fishery comprises the State-managed WA North Coast Shark Fishery (WANCSF) in the Pilbara and western Kimberley, and the Joint Authority Northern Shark Fishery (JANSF) in the eastern Kimberley. The Operational Area overlaps with the licence boundary of the JANSF (Figure 4-18).

The primary species caught via line fishing of the JANF is sandbar shark and blacktip shark. Target shark species pupping and nursery areas are understood to be located in nearshore/coastal waters and outside of the Operational Area.

Limited to no fishing activity has been recorded in both fisheries since 2008/09, as they do not have a WTO accreditation that allows export of product from the fishery thus making the fishery unprofitable.

During stakeholder consultation, WAFIC advised that the fishery may potentially recommence fishing in late 2019/2020.

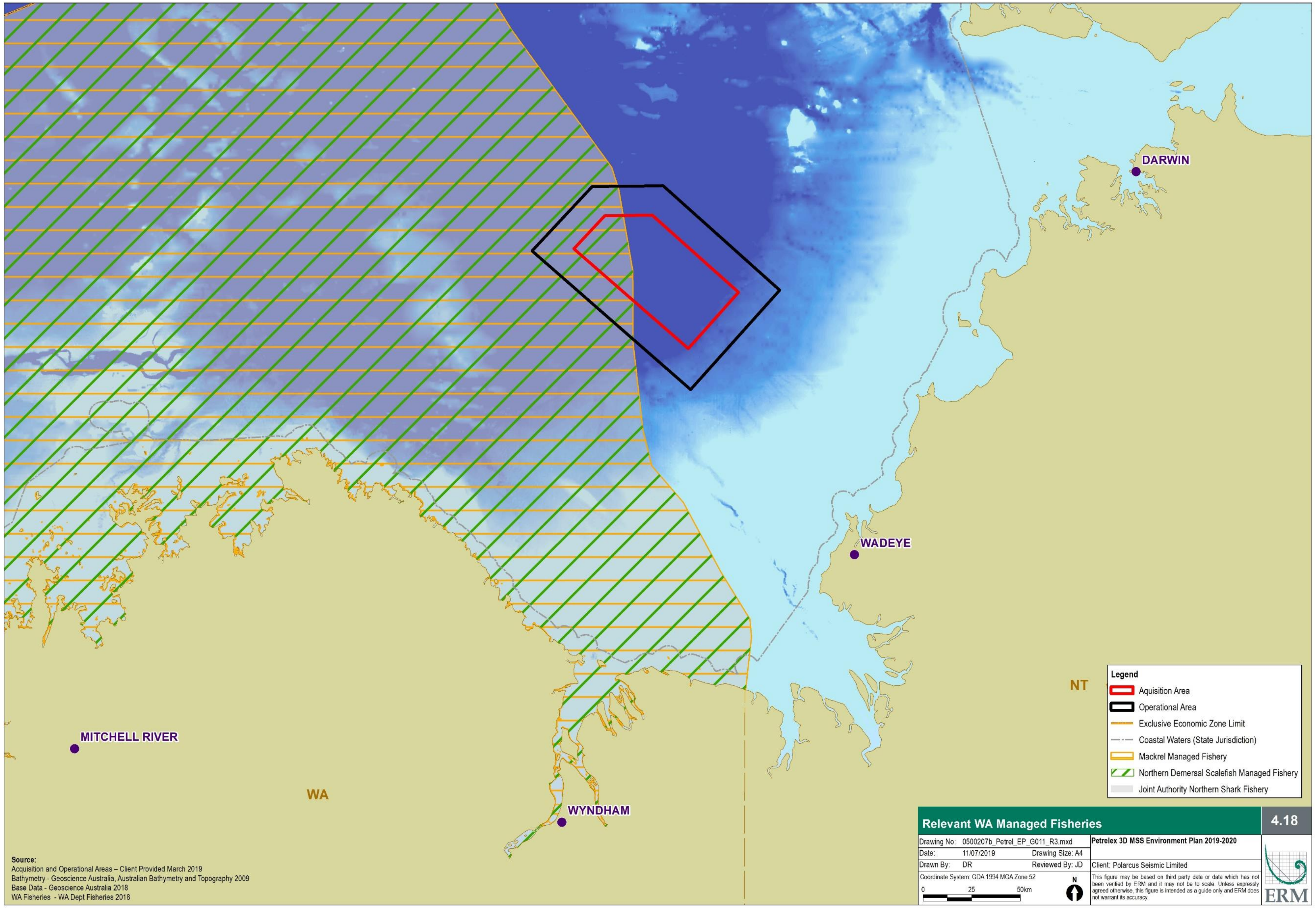


Figure 4-18 Relevant WA Managed Fisheries

4.6.6.3 Northern Territory Managed Fisheries

Northern Territory fisheries are managed by the NT Department of Primary Industry and Resources (DPIR) (Fisheries). Wild harvest fisheries are managed under the *Fisheries Act 1988* and Fisheries Regulations 1992 and management plans.

The information presented in this section has predominantly been sourced from recent DPIR fisheries reports. Polarcus, via engagement with individual licence holders, the NTSC and NT DPIR (Fisheries) has tried to obtain more recent and more detailed information about where the Fishery licensees actively fish to be able to undertake a more robust assessment of impacts, however, to date this information has not been made available.

NT managed commercial fisheries with the licence to operate within the Operational Area and EMBA are described in Table 4-14.

Table 4-14 Relevant Northern Territory Managed Fisheries

Fisheries	Description of Licensed Area / Fishing Effort	Fishing Method	Primary Target Species	Operating Season	Estimated Catch (tonnes/Season)	Overlap with the Operational Area (Y/N)	Relevance to Petrelex 3D MSS
Demersal Fishery	Demersal fishing is allowed from 15 nm from the low water mark to the outer boundary of the Australian fishing zone, excluding the area of the Timor Reef Fishery (DPIR 2019a). In 2016, seven vessels were active in the Demersal Fishery with a reported total catch of 3,463 t, including 2,510 t of red snappers and 318 t of goldband snappers (DPIR 2016). There are currently 18 active licences (DPIR 2019a).	Vertical lines, drop lines, finfish long-lines, baited fish traps and semi-demersal trawl nets in two multi-gear areas.	Goldband snapper, red snapper, saddletail snapper and crimson snapper.	All year	2,500 t of red snapper, and 400 t of goldband snapper	Y	The Operational Area overlaps with Area A and Area B of the Demersal Fishery. DPIR (Fisheries) advised during the consultation process that the Demersal Fishery has been active in the JBG in the last five years, and therefore there is potential for interactions with the Petrelex 3D MSS.
Spanish Mackerel Fishery	Commercial fishing for Spanish mackerel is permitted from the high water mark to the outer boundary of the AFZ. The Spanish Mackerel Fishery is a limited entry fishery, with catch managed via input controls (DPIR 2019b). A total 346 t of fish were harvested by Spanish Mackerel Fishery licencees in 2015 (DPIR 2016).	Troll lines, floating hand lines and rods.	Spanish mackerel	All year	450 t	Y	The primary fishing grounds include waters near Bathurst Island, New Year Island, the Wessel Islands around to Groote Eylandt and the Sir Edward Pellew Group of islands. Fishing generally takes place around reefs, headlands and shoals. DPIR (Fisheries) advised during the consultation process that the Spanish Mackerel Fishery has been active in the JBG in the last five years, and therefore there is potential for interactions with the Petrelex 3D MSS.

Fisheries	Description of Licensed Area / Fishing Effort	Fishing Method	Primary Target Species	Operating Season	Estimated Catch (tonnes/Season)	Overlap with the Operational Area (Y/N)	Relevance to Petrelex 3D MSS
	There are currently 15 active licences (DPIR 2019b).						
Offshore Net and Line Fishery	The Offshore Net and Line Fishery is a quota managed fishery. Fishing is permitted from the low water mark to the outer boundary of the AFZ to the extent the waters are waters relevant to the Northern Territory (DPIR 2018). A total of 522 t of fishes were harvested by Offshore Net and Line Fishery licencees in 2015 (DPIR 2016). There are currently 11 active licences.	Demersal long lines, pelagic long lines, longlines and pelagic nets.	Black-tip sharks and grey mackerel	All year	435 t of blacktip shark, 122 t of spot-tail shark and 535 t of grey mackerel	Y	Most fishing is done in the coastal zone within 12 nm of the coast, and immediately offshore in the Gulf of Carpentaria (approx. 1,080 km from the Operational Area). DPIR (Fisheries) advised during the consultation process that the Offshore Net and Line Fishery has been active in the JBG in the last five years, and therefore there is potential for interactions with the Petrelex 3D MSS.
Pearl Oyster Managed Fishery	Operates from the high water mark to the outer boundary of the Australian fishing zone, 200 nautical miles offshore. There are currently five active licences.	Hand harvest	*Pinctada maxima*	All year	138,0000 oysters	Y	DPIR (Fisheries) advised that the harvesting of pearl culture oysters stopped in 1994, when hatchery produced oysters became readily available for culture. Since this period, there has been irregular harvest of pearl oysters from the Bonaparte Basin. Fishing efforts are restricted to water depths less than 35 m. Therefore, there is no potential for interactions with the Petrelex 3D MSS.

Fisheries	Description of Licensed Area / Fishing Effort	Fishing Method	Primary Target Species	Operating Season	Estimated Catch (tonnes/Season)	Overlap with the Operational Area (Y/N)	Relevance to Petrelex 3D MSS
Aquarium Fishery	The NT Aquarium Fishery is a small-scale, multi-species fishery. It includes freshwater, estuarine and marine habitats to the outer boundary of the AFZ, which is 200 nautical miles offshore. According to the NTSC, the fishery has 11 licences and around three boats are active each year (NTSC 2017).	Hand harvest	Aquarium – rainbowfish, catfish and scats. Invertebrates – hermit crabs, snails, whelks and hard/soft corals.	All year	No information publically available.	Y	Freshwater and estuarine species are generally collected between the Adelaide and Daly rivers, while most marine species are collected within 100 km of Nhulunbuy and Darwin. Information obtained from the Chair of the Aquarium Fishery Licence Committee during the consultation process for the Santos Bethany 3D MSS confirmed that licence holders typically scuba dive to a maximum of 30 m and one operator operates at Evan Shoal, east of Lyndoch Shoal, Blackwood Shoal and Money Shoal in Arufura Sea and within the Timor Reef Fishery Area. Therefore, there is no potential for interactions with the Petrelex 3D MSS.

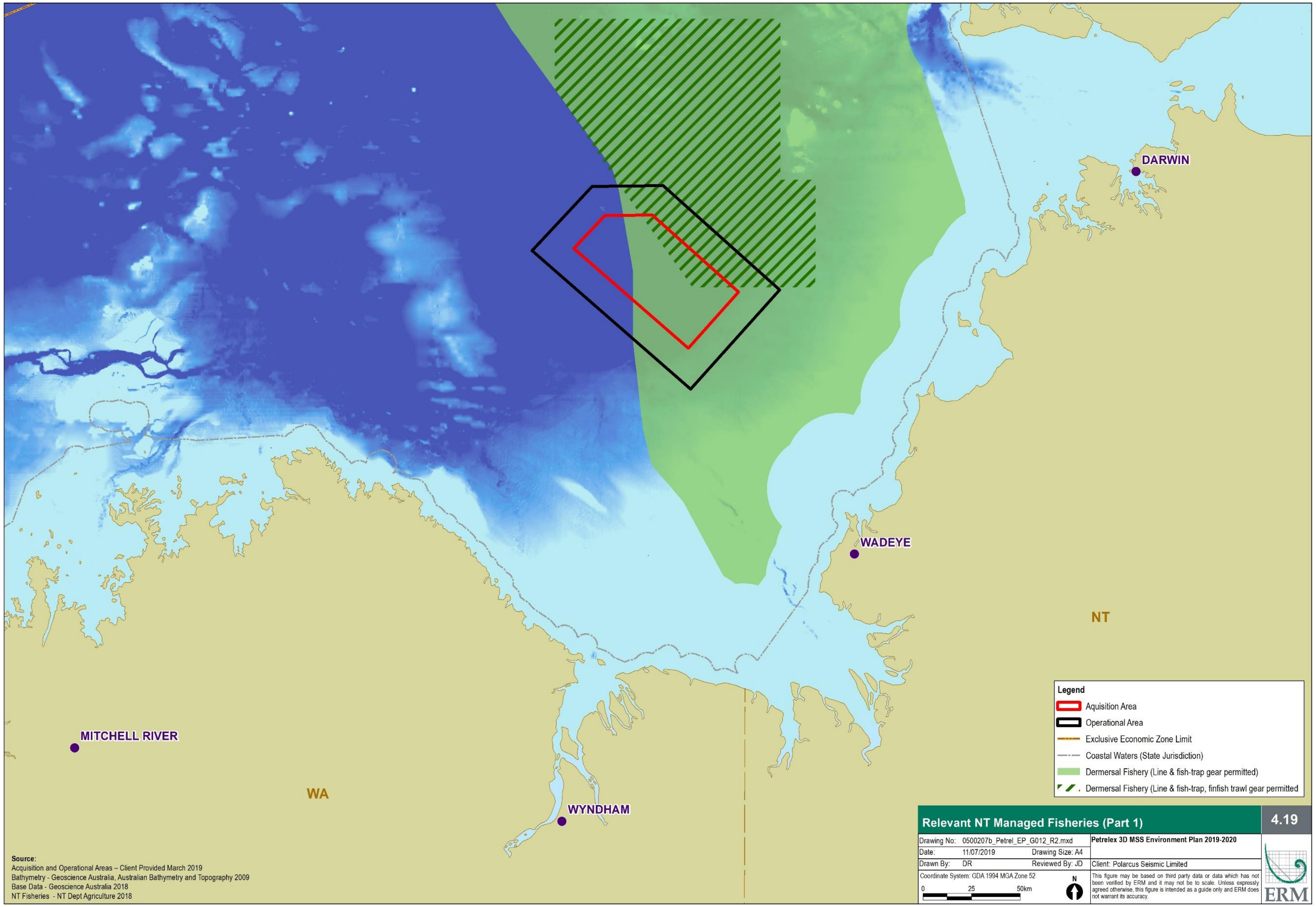


Figure 4-19 Relevant NT Fisheries (1)

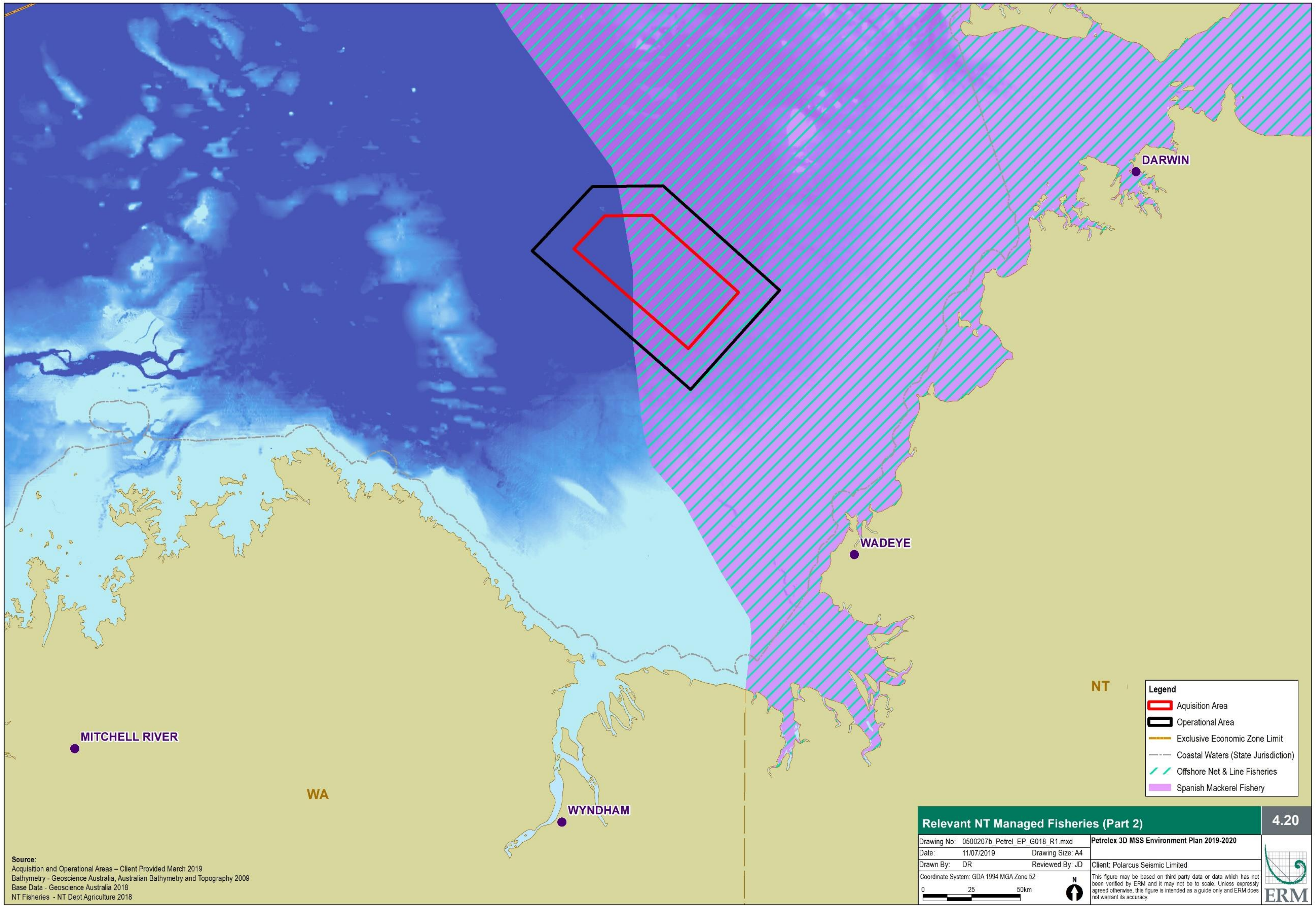


Figure 4-20 Relevant NT Fisheries (2)

As presented in Table 4-14, the Demersal Fishery, Spanish Mackerel Fishery and Offshore Net and Line Fisheries are the only NT managed commercial fisheries that actively fish within the Operational Area and EMBA. Further information on these fisheries are provided below.

Demersal Fishery

The NT Demersal Fishery extends from 15 nm from the low water mark to the outer limit of the AFZ (excluding the area of the Timor Reef Fishery) and targets a range of tropical snappers (*Lutjanus* spp. and *Pristipomoides* spp.). In 2016, seven vessels were active in the Demersal Fishery with a reported total catch of 3,463 t, including 2,510 t of red snappers and 318 t of goldband snappers.

The harvest by the Demersal Fishery is limited through a set of total allowable catches (TACs) applied to goldband snappers (*Pristipomoides* spp.) (400 t), red snappers (*L. malabaricus* and *L. erythropterus*) (2,500 t) and a "grouped fish" category (915 t). The latter group includes all fishes other than barramundi (*Lates calcarifer*), king threadfin (*Polydactylus macrochir*), Spanish mackerel, shark and mud crabs (*Scylla* spp.) (DPIR 2019a).

Demersal Fishery licensees harvested 3478.3 t of fishes in 2016. Red snappers and goldband snappers formed the bulk of the harvest (72.4% and 9.3%, respectively) with painted sweetlip (*Diagramma labiosum*) being the primary byproduct species (5.2%) along with redspot emperor (2.7%). Reported bycatch (by weight) during 2016 was less than 1% of the drop-line and trap harvest and the average bycatch recorded by observers for the trawl harvest in 2016 was 24.4% (DPIR 2019a).

In 2016, the total commercial catch of goldband snapper was 546.2 t, of which 60% was taken by the Demersal Fishery. The status of goldband snapper from the Arafura and Timor seas was assessed using data up to 2016 using a stochastic Stock Reduction Analysis (SRA) model. The outputs of this model estimated egg production to be around 65 to 70% of unfished levels and the current harvest rate is below that required to achieve maximum sustainable yield. This level of fishing mortality is well above conventional target levels and is unlikely to cause the stock to be recruitment overfished (DPIR 2019a).

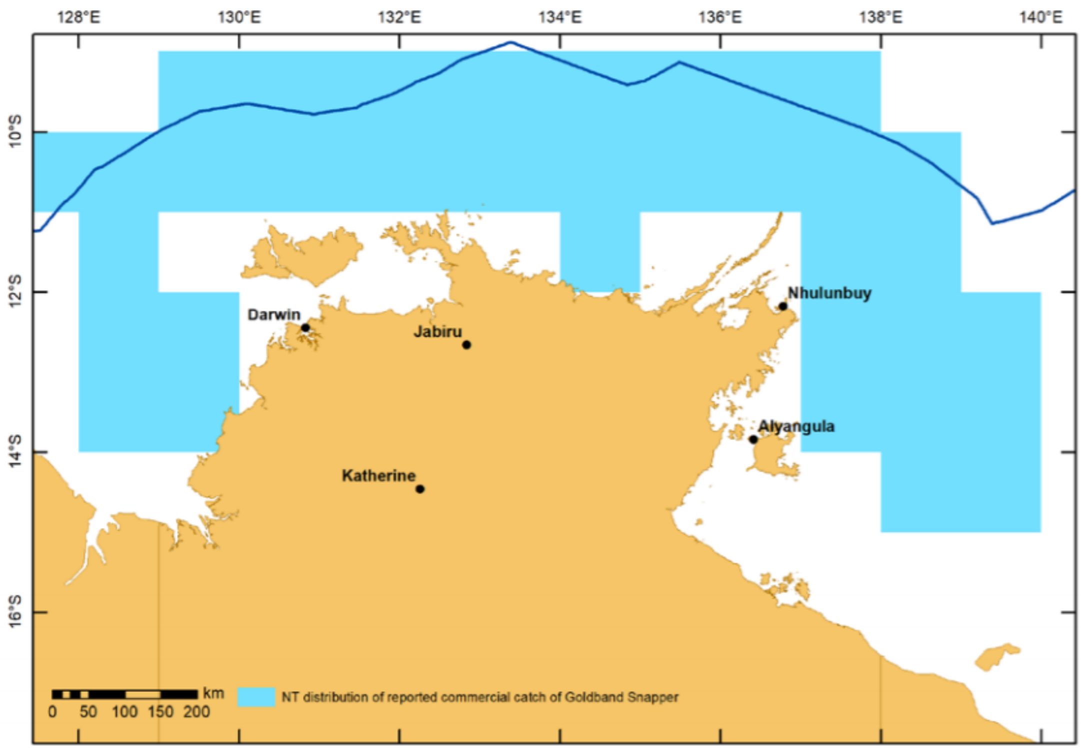


Figure 4-21 Distribution of the Reported Commercial Catch of Goldband Snapper in 2016

The north-eastern portion of the Acquisition Area overlaps the Demersal Fishery Area 2, where line and fish-trap gear are permitted and demersal trawls nets are excluded (Figure 4-19).The northern extent of the Operational Area and EMBA overlap Area 1 of the Demersal Fishery where line, fish-trap and finfish trawl gear are all permitted.

Traps used in the fishery are set on the seabed with an identifying float on the sea surface. The fishery is monitored primarily through logbook returns, which operators are required to fill out on a daily basis during fishing operations. The logbooks provide detailed catch and effort information, as well as information on the spatial distribution of the fishing operations.

Catch and effort for trap vessels varies from year to year. The NT Government (2014) states that the substantial variability in trap effort since 2009 generally reflects movement between the Demersal Fishery and the nearby Timor Reef Fishery. The NT Government (2014) states that Stock Reduction Analysis evidence suggests that this is not due to changes in fish abundance or sustainability concerns that the fluctuating CPUE reflects the small number of operators and their developing knowledge of the fishery.

The Demersal Fishery covers an area of ~ 343,000 km^2. The Operational Area covers ~ 5,186 km^2 of the Demersal Fishery (1.5%) and the Acquisition Area covers ~ 2,350 km^2 of the Demersal Fishery (0.7%).

A review of publically available Automatic Identification System (AIS) data for commercial fishing vessels via Global Fishing Watch (GFW) revealed that three fishing vessels were present within the Operational Area and EMBA in 2018. These fishing vessels were identified as being vessels within the Demersal Fishery. The majority of the vessel activity occurred north of the Operational Area, within the line, fish-trap and trawl permitted area (GFW 2019).

Spanish Mackerel Fishery

The NT Spanish Mackerel Fishery extends seaward from the high water mark to the outer limit of the AFZ and targets Spanish mackerel (*Scomberomorus commerson*) using trolled lures or baited lines. The primary fishing grounds include waters near Bathurst Island, New Year Island, the Wessel Islands around to Groote Eylandt and the Sir Edward Pellew Group of islands. The Operational Area and EMBA overlap with the fishery (refer to Figure 4-20).

Licencees typically fish from a mother ship and dories, with a maximum of two dories permitted per licence. They may use any number or combination of troll lines, floating hand lines or rods. Operators generally troll two to four lines behind a dory and up to eight lines from a mother boat.

Commercial catches and catch rates of Spanish mackerel gradually increased from 1986 to 2006, before declining to an average catch of about 350 tonnes (t) per annum and a catch rate of 300 kg per day. Both commercial catches and catch rates of the commercial sector of the Spanish Mackerel Fishery have since increased to peak at their highest level of 446.5 t (2016) and 389 kg per day (2012). A total 290 t of fish were harvested by Spanish Mackerel Fishery licencees in 2014 (DPIR 2019b).

Spanish Mackerel Fishery licencees harvested 452.3 t of fish in 2016. Almost all (99%) of this catch was Spanish mackerel with the remaining 1% comprising grey mackerel. A small number of trevallies were recorded as bycatch during 2016. The total value of the catch in this fishery is estimated at $4.13 million (DPIR 2019a).

Current biomass levels are well within sustainable limits and suggest that this stock is not considered to be recruitment overfished and the current level of fishing mortality is unlikely to cause the stock to become recruitment overfished. The NT Spanish Mackerel stock is classified as a sustainable stock.

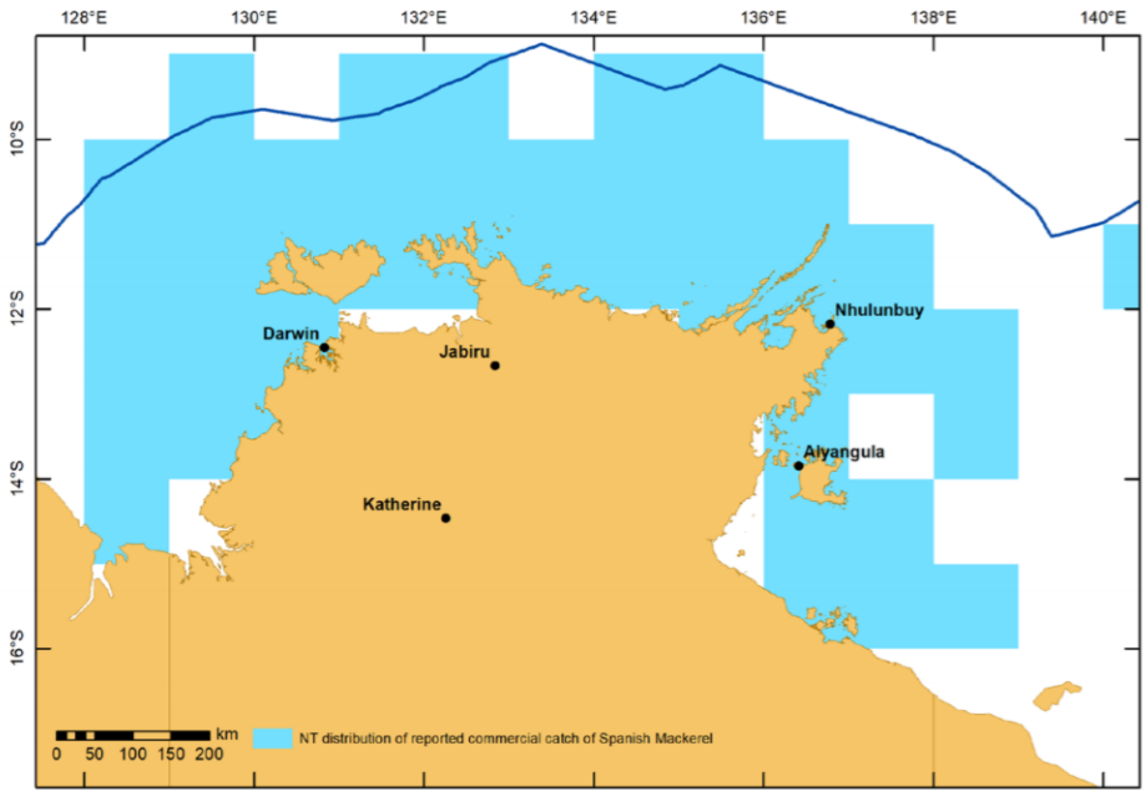


Figure 4-22 Distribution of the Reported Commercial Catch of Spanish Mackerel in 2016

Offshore Net and Line Fishery

The NT Offshore Net and Line Fishery (ONLF) extends seaward from the high water mark to the outer limit of the AFZ and targets Australian blacktip sharks (*Carcharhinus tilstoni*), common blacktip sharks (*C. limbatus*) and grey mackerel (Scomberomorus semifasciatus). The Operational Area and EMBA overlap with the ONLF (refer to Figure 4-20).

Demersal long-lines can be used throughout the fishery whereas pelagic gillnets and pelagic long-lines can only be used beyond 2 nm and 3 nm of the coast, respectively. Pelagic gillnets are the primary gear used by this fishery and are generally set within 15 nm of the coast. Long-lines have not been used in the fishery since 2013, primarily as a result of the drop in the price of shark fins.

Licencees can use nets up to 2,000 m in length, but most choose to use nets in the order of 1,000 m to 1,500 m. The drop of the net must not exceed 100 meshes and the size of each mesh panel typically ranges from 160 mm to 185 mm when stretched. Pelagic gillnets are weighted and have a buoyed headline. Pelagic long-lines must not exceed 15 nm in length and cannot have more than 1,000 snoods (hooks) attached. Automated baiting gear is prohibited (DPIR 2019c).

Licencees harvested 471.8 t of fishes in 2016. Grey mackerel formed the bulk of the harvest (71.4%) followed by the blacktip shark group (7.7%) and Spanish mackerel (4.9%). The primary byproduct species were bull sharks (2.2%), tiger sharks (1.7%) and queenfish (1.5%). Bycatch (by weight) was less than 1% of the harvest in 2016 (DPIR 2019c).

Most of grey mackerel caught in the NT are taken from the north-west stock. In 2016, this represented a catch of 283 t. The north-west stock is not considered to be recruitment overfished and the current level of fishing mortality is unlikely to cause the stock to become recruitment overfished (DPIR 2019c).

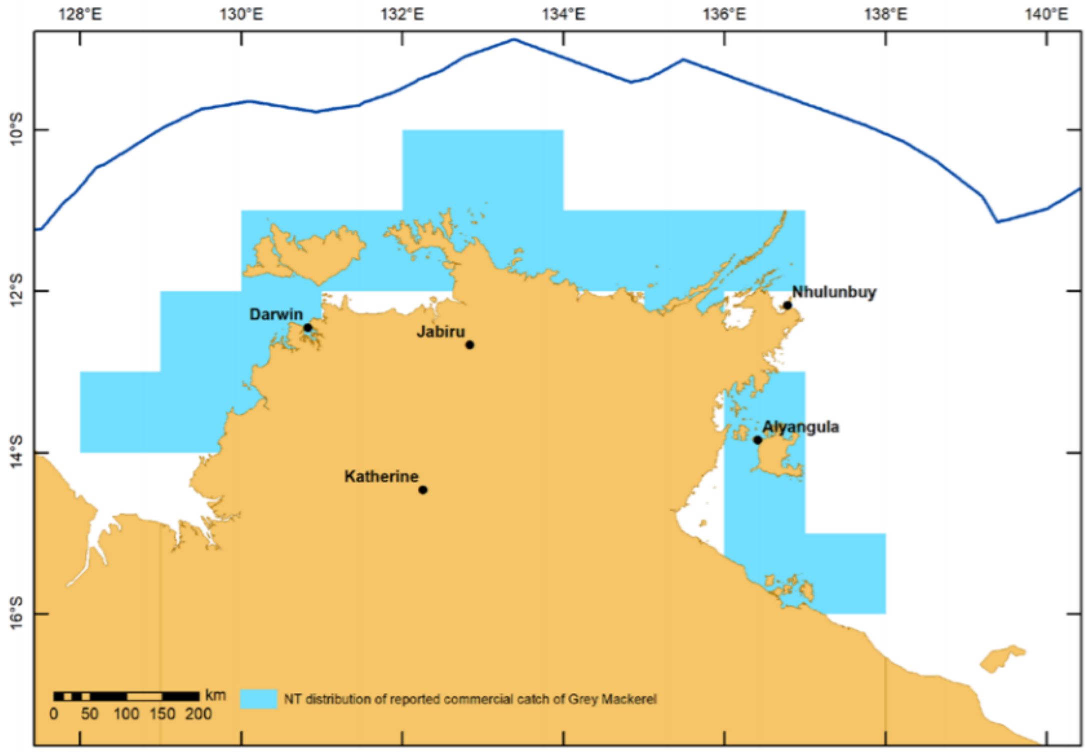


Figure 4-23 Distribution of the Reported Commercial catch of Grey Mackerel in 2016

4.6.7 *Tourism and Recreation*

Most recreational and tourism activities in the region occur predominantly in State/Territory waters adjacent to population centres, such as Broome and Darwin. Tourism in the region typically peaks during the dry season (May to October), which includes activities such as recreational fishing, diving, snorkelling, wildlife watching and boating (DSEWPaC 2012a). Charter vessels may occasionally transit through the Operational Area and wider EMBA between Darwin and the northern Kimberley coastline.

Recreational fishing is allowed in the JBG, however interactions with tourism activities are considered unlikely due to the remoteness and predominantly deep waters of the Operational Area.

4.6.8 *Defence Activities*

Australian Border Force and Australian Defence Force vessels undertake civil and maritime surveillance within the region with the primary purpose of monitoring the passage of illegal entry vessels and illegal fishing activity within these areas. Refugees seeking asylum in Australia are also known to utilise the area, travelling between Indonesia and Australia.

The Acquisition and Operational areas overlap the North Australian Exercise Area (NAXA) a maritime military zone administered by the Australian Defence Force. The NAXA is used by the Royal Australian Air Force and the Royal Australian Navy for military operations including live weapons and missile firings.

The NAXA is the primary location of the KAKADU training exercise that operates biannually. The exercise involves numerous naval ships from various countries participating in the waters off Darwin and Northern Australia. Exercise KAKADU is Australia's premier international maritime exercise, bringing together navies and air forces from the Asian, Pacific and Indian Ocean regions to test integration and war fighting abilities. Access will be restricted to all vessels and aircraft within the Due Regard Area (DRA).

During consultation with the Department of Defence (Defence), the DoD informed Polarcus that the Petrelex 3D MSS would potentially impact the scale of manoeuvre of surface units during the exercise. Defence proposed that the Petrelex 3D MSS is completed no later than 30 August 2020, or alternatively commencing after the 16 September 2020, as this would be of mutual benefit to both Polarcus and the Defence removing the possibility of unintended impacts on each other's activities.

Additionally, the Defence advised that unexploded ordinance (UXO) may be present on and in the sea floor of the Operational Area. According to the Defence UXO Database, the Operational Area is located within a former air-to-air weapons range, and may be affected by UXOs (Defence 2019). Polarcus have assessed the risk associated with the presence of UXOs and determined that since the towed array is not expected to interact with the seabed under normal operations, no credible scenarios occur where UXOs present a risk to the activity.

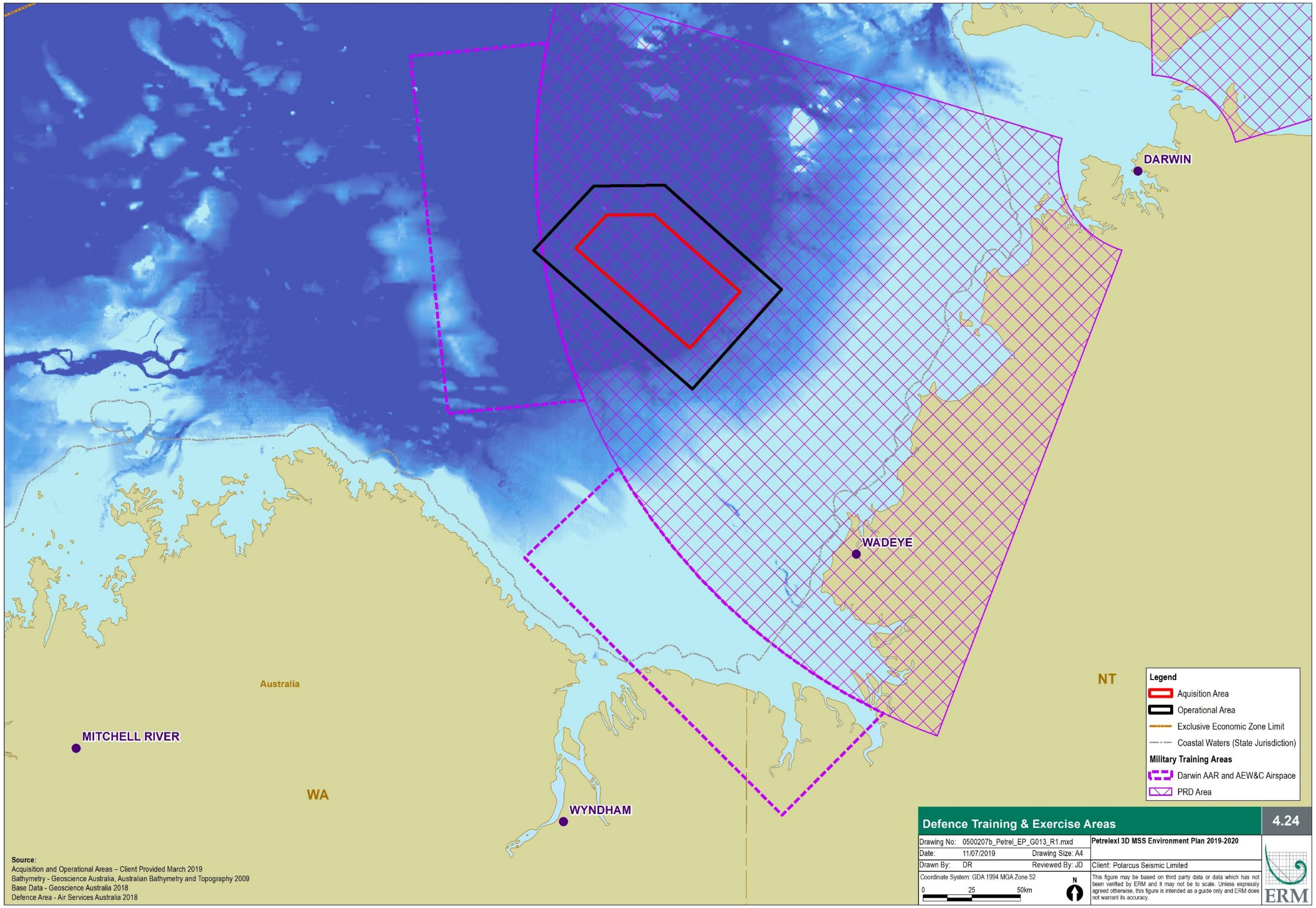


Figure 4-24 Defence Exercise and Training Areas

4.6.9 *Shipping Industry*

Darwin’s close proximity to South-east Asia makes the surrounding area a key shipping region. The Australian Maritime Safety Authority (AMSA) has identified high traffic shipping volumes in close proximity to the Darwin Harbour, around operating petroleum fields and along key shipping routes to and from South-east Asia and to and from petroleum fields.

Data obtained from AMSA shows heavy vessel traffic in the northern section of both the Acquisition and Operational Areas, due to vessels heading in and out of Darwin (Figure 4-25).

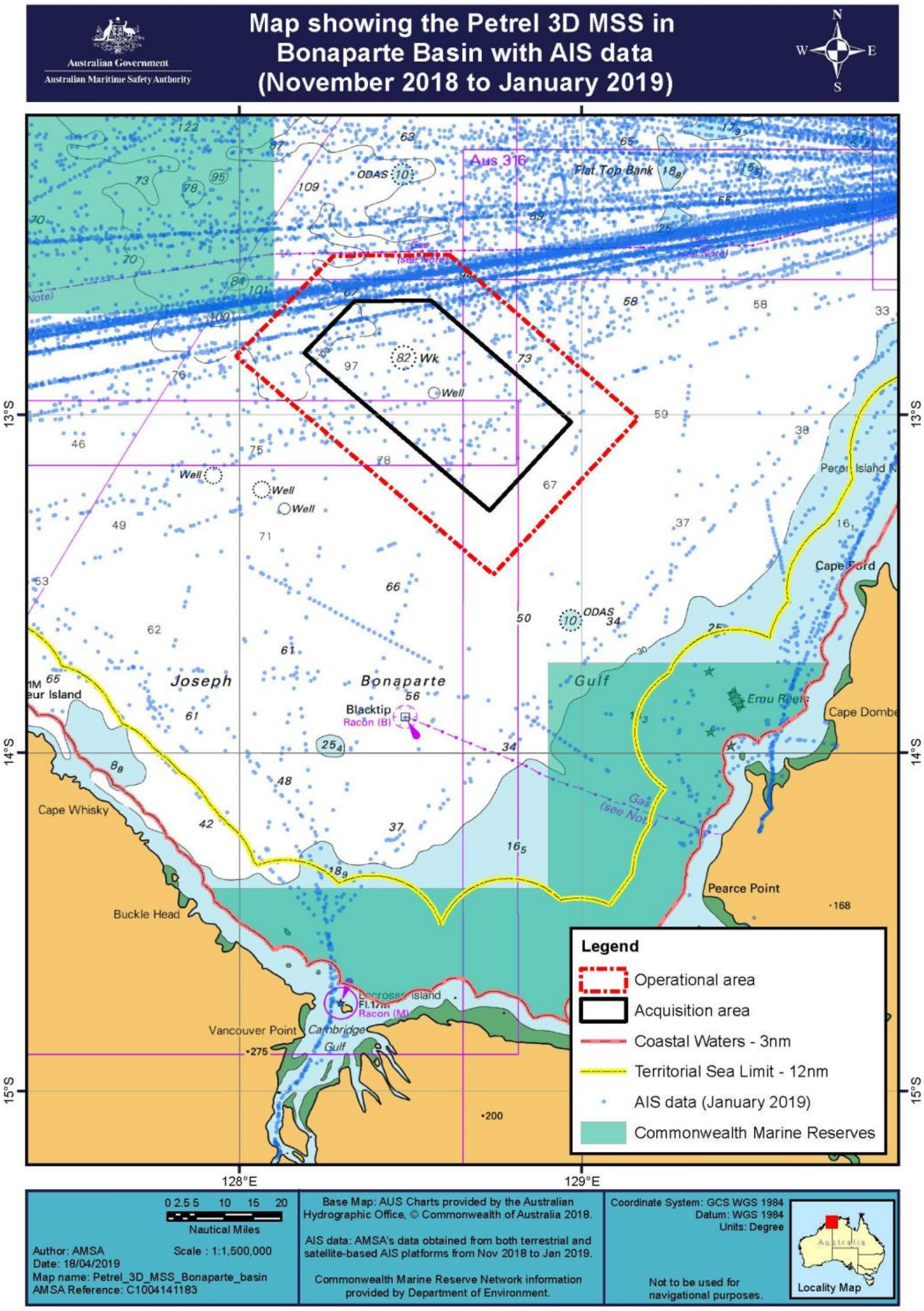


Figure 4-25 Shipping Traffic Plot (AIS data Nov 2018 – Jan 2019)

4.6.10 *Petroleum Exploration and Production*

The Bonaparte Basin is an established hydrocarbon province with a number of commercial operations such as the Blacktip Field operated by Eni Australia B.V. Petroleum titleholders with titles within the Operational Area are listed in Table 4-15 and shown in Figure 4-26.

Over the scheduled period of the Petrelex 3D MSS, no other seismic surveys are currently planned to occur in the region (at the time of EP submission to NOPSEMA). However, Polarcus will endeavour to minimise the potential for interaction between simultaneous seismic surveys (should any occur at the same time as the Petrelex 3D MSS) to minimise both potential disruptions to operations as well as potential cumulative sound impacts to the environment.

It is also noted that the nature of multi-client operations is such that data is acquired and sold to multiple petroleum block titleholders. Like Polarcus, the other seismic operators will have sought commercial undertakings with petroleum block titleholders for the 3D data they acquire over a specific area.

For commercial reasons, it is very unlikely that a petroleum block titleholder would purchase data from more than one multi-client operator for the same area, and as such, it is likely that not all of the surveys (and possibly only one) will actually proceed.

Table 4-15 Oil and Gas Permits within 150 km of the Operational Area

Permit	Permit type	Operator	Distance from Operational Area
WA-6-R	Retention Lease	Neptune Energy Bonaparte Pty Limited	-
NT/RL1	Retention Lease	Neptune Energy Bonaparte Pty Limited	-
NT/P84	Exploration Permit	Santos Offshore Pty Ltd	3 km
WA-454-P	Exploration Permit	Santos Offshore Pty Ltd	7 km
WA-27-R	Retention Lease	Bonaparte Gas and Oil Pty Ltd	15 km
WA-69-R	Retention Lease	Eni Australia B.V.	20 km
WA-40-R	Retention Lease	Bonaparte Gas and Oil Pty Ltd	27 km
WA-33-L	Production Licence	Eni Australia B.V.	44 km
WA-488-P	Exploration Permit	Finniss Offshore Exploration Pty Ltd	46 km
WA-522-P	Exploration Permit	Woodside Energy Ltd.	71 km
WA-407-P	Exploration Permit	Octanex Bonaparte Pty Ltd	100 km

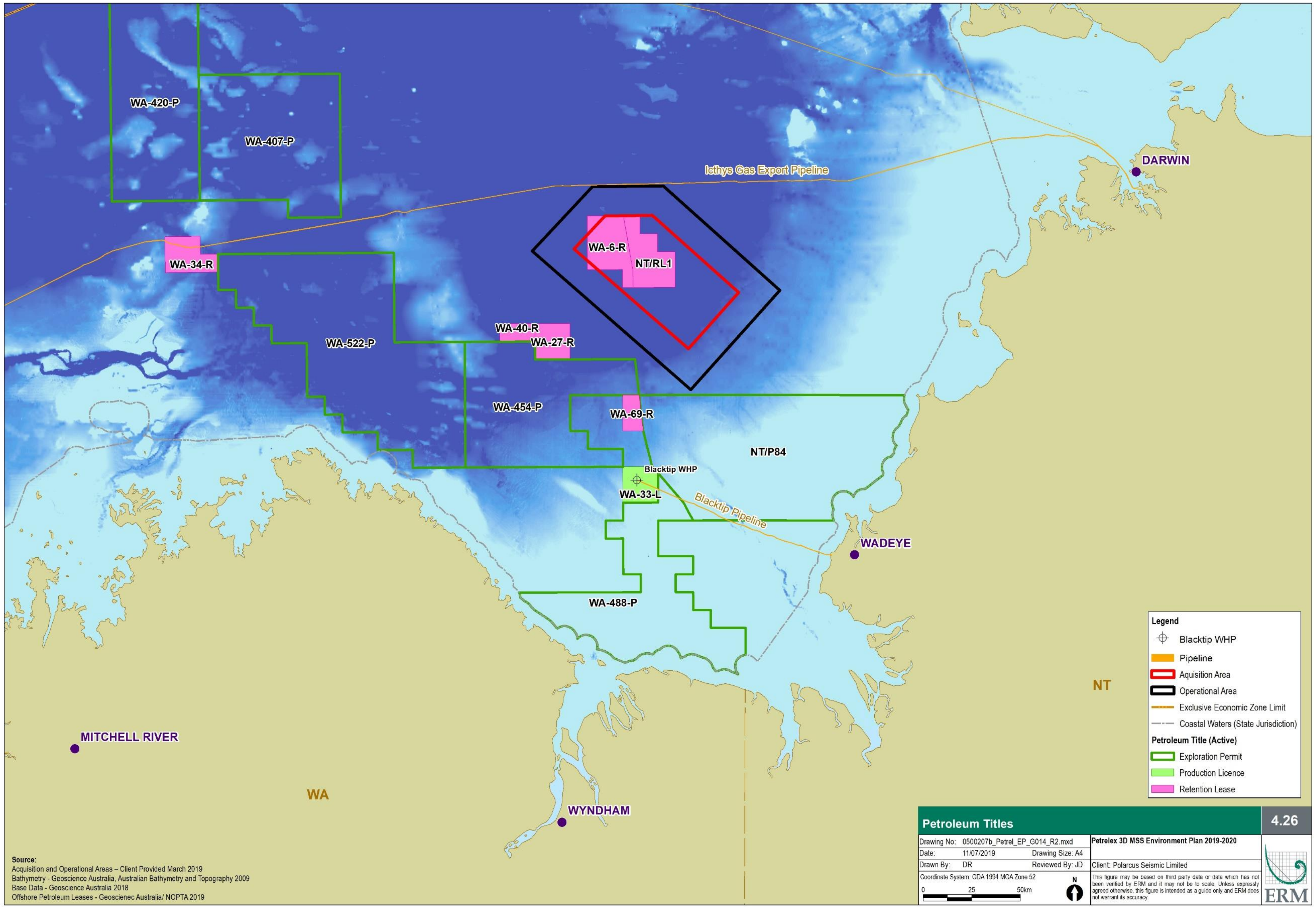


Figure 4-26 Petroleum Titles

5. STAKEHOLDER CONSULTATION

For the purposes of this EP, and in accordance with Regulation 11A of the OPPGS (E) Regulations 2009, relevant stakeholders are defined as person(s) whose functions, interests or activities may be affected by the activities to be carried out under this EP.

5.1 Consultation Approach

Consultation has been planned and undertaken with the aim of:

- Informing relevant stakeholders of the Petrelex 3D MSS;
- Collecting information about the stakeholders' interests and activities in the Operational Area; and
- Providing stakeholders with the opportunity to ask questions and raise concerns or issues about the proposed activity.

The consultation approach employed by Polarcus has been guided by the following material:

- NOPSEMA Information Paper IPI411 - Consultation requirements under the OPGGS (E) Regulations 2009, Rev 2, December 2014 (NOPSEMA 2014);
- NOPSEMA Brochure - Requirements for consultation and public comment on petroleum activities in Commonwealth waters – August 2018 (NOPSEMA 2018d);
- NOPSEMA Brochure – Public Comment on Environment Plans – March 2019 (NOPSEMA 2019c)
- AFMA - Petroleum industry consultation with the commercial fishing industry (AFMA 2019);
- DoIIS Offshore Petroleum and Greenhouse Gas Activities: Consultation with Australian Government agencies with responsibilities in the Commonwealth Marine Area (DoIIS 2016); and
- WA Department of Fisheries Guidance Statement: Oil and gas industry consultation with the Department of Fisheries (DoF 2013).

5.2 Relevant Stakeholders

Relevant stakeholders were identified by considering the interests and activities that occur within the Operational Area and EMBA. The survey activities, timing and potential environmental impacts and risks of both planned and potentially unplanned events were also taken into account during the stakeholder identified process.

For the consultation process Polarcus has used the requirements in the OPGGS (E) Regulations in regards to a relevant person:

- Each Department or agency of the Commonwealth to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant;
- Each Department or agency of a State or the Northern Territory to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant;
- The Department of the responsible State Minister, or the responsible Northern Territory Minister;
- Person or organisation whose functions, interests or activities may be affected by the activities to be carried out under the environment plan, or the revision of the environment plan; and
- Any other person or organisation that the titleholder considers relevant.

A summary of the assessment process undertaken to determine stakeholder relevancy is provided in Table 5-1.

Polarcus understands additional stakeholders may be identified as part of ongoing consultation. Should additional stakeholders be identified prior to, or during the survey, these stakeholders will be contacted, provided with sufficient information and invited to provide feedback.

Table 5-1 Assessment of Relevant Stakeholders

Stakeholder	Relevant (Y/N)	Reasoning / Validation
Each Department or agency of the Commonwealth to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant		
Australian Fishing Management Authority (AFMA)	Y	Responsible for managing Commonwealth fisheries and the implementation of Commonwealth fisheries policy.
Australian Hydrographic Service (AHS)	Y	Responsible for the publication and distribution of nautical products and other information required for the safety of ships navigating in Australian waters. Polarcus are required to notify AHS a minimum of 3 weeks prior to the commencement of activities.
Australian Maritime Safety Authority (AMSA)	Y	The Australian Maritime Safety Authority (AMSA) is a Commonwealth agency responsible for maritime safety, protection of the marine environment from ship-sourced pollution and maritime and aviation search and rescue. AMSA also implements and enforces a range of legislation relevant to the Commonwealth marine area, which give effect to Australia’s obligations under various international treaties and conventions including the MARPOL International Convention for the Prevention of Pollution from Ships. Domestic legislation includes the *Navigation Act 2012* and the Protection of the Sea legislation.
Department of Agriculture and Water Resources (DAWR)	Y	Responsible for managing biosecurity (including biosecurity for marine pests). The Department implements and enforces the *Biosecurity Act 2015* (including implementing ballast water requirements). The Department is a relevant agency where an offshore activity has the potential to transfer marine pests.
Department of Communications and the Arts (DoCA)	Y	The Department of Communications and the Arts has responsibility for Schedule 3A of the Telecommunications Act 1997 that is administered by the Australian Communications Media Authority (ACMA). The Telecommunications Act 1997 provides for submarine cable protection zones to be declared around international submarine cables that are considered to be of national significance.

Stakeholder	Relevant (Y/N)	Reasoning / Validation
Department of Defence (DoD)	Y	The Australian Defence Force (ADF) utilises several maritime exercise areas in Australian waters to perform a unique role in support of Australia's strategic and national security interests. DoD is a relevant agency where the activity may impact on operational requirements. The Operational Area overlaps with the NAXA.
Department of Foreign Affairs and Trade (DFAT)	N	DFAT promote and protect Australia's interest internationally and contribute to global stability and economic growth. DFAT are a relevant agency where a proposed activity may cross or impact on waters outside of Australia's maritime jurisdiction. Given, the Petrelex 3D MSS does not impact waters outside of the Commonwealth Marine Area, consultation with DFAT is not required.
Department of Industry, Innovation and Science (DoIIS)	Y	DoIIS regulate oil and gas activities in Australian waters under the OPGGSA 2006.
Department of the Environment and Energy (DoEE)	N	DoEE administers the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the *Historic Shipwrecks Act 1976* and the *Environment Protection (Sea Dumping) Act 1981*, all of which have some application in the Commonwealth Marine Area. The Department is not considered a relevant agency for consultation purposes under the Environment Regulations. The Petrelex 3D MSS does not trigger any of the DoEE's other functions, interests and activities, hence the Department has been assessed as not being a relevant stakeholder.
Director of National Parks (DoNP)	Y	The DoNP is the statutory authority responsible for administration, management and control of Australian Marine Parks (AMP). The DoNP was consulted for the activity, given the Oceanic Shoals Marine Park and Joseph Bonaparte Gulf Marine Park is located in close proximity, 2 km and 35 km respectively.
Maritime Border Command (MBC)	N	MBC coordinates national awareness and response efforts to protect Australia's interests in the Australian maritime jurisdiction. MBC is a multi-agency taskforce that utilises assets assigned from Australian Border Force (ABF) and the ADF to conduct civil maritime operations. MBC has previously advised Polarcus that contact be made with the agency at the time of operation instead of during the EP development stage. Based on this information consultation is not required.
National Native Title Tribunal (NNTT)	Y	The NNTT is an independent agency responsible for administration of the *Native Title Act 1993.* The NNTT was initially contacted to understand the baseline environment and potential Native Title interest.

Stakeholder	Relevant (Y/N)	Reasoning / Validation
Each Department or agency of a State or the Northern Territory to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant		
WA Department of Biodiversity, Conservation and Attractions (DBCA)	N	Responsible for managing WA parks, forests and reserves to conserve wildlife, provide sustainable recreation and tourism opportunities, protect communities and assets from bushfire and achieve other land, forest and wildlife management objectives. Given, the activity is not located within any State marine parks; consultation with the DBCA is not required.
WA Department of Primary Industries and Regional Development (Fisheries)	Y	Responsible for managing WA fisheries and aquatic ecosystems, assessment and monitoring of fish stocks, enforcement and education, biosecurity management and licensing commercial and recreational fishing activity, including commercial aquaculture. DPIRD Fisheries has been consulted, given the Petrelex 3D MSS has the potential to impact WA managed fisheries.
WA Department of Transport (DoT)	N	Control agency for marine pollution emergencies if impact to State waters. DoT Offshore Petroleum Industry Guidance Note "Marine Oil Pollution: Response and Consultation Arrangements" (December 2017) - Section 10.1 requires petroleum titleholders to consult with DoT for activities that have the potential to cause a marine pollution emergency in State Waters. Based on oil spill modelling, WA State waters are not likely to be impacted by a marine diesel spill from a vessel; therefore, consultation with the DoT is not required.
NT Department of Transport – Marine Safety Branch		Control agency for marine pollution emergencies if impact to NT waters. Based on oil spill modelling, NT waters are not likely to be impacted by a marine diesel spill from a vessel; therefore, consultation with the Department is not required.
NT Department of Primary Industry and Resources (Fisheries)	Y	Responsible for managing NT fisheries and aquatic ecosystems. The Department has been consulted, given the Petrelex 3D MSS has the potential to impact NT managed fisheries.
NT Department of Environment and Natural Resources	Y	NT DENR is responsible for protecting the environment and natural resources in the Northern Territory. The NT DPIR advised Polarcus to consult with the Department, as the Department is involved in marine megafauna projects.
The Department of the responsible State Minister, or the responsible Northern Territory Minister		

Stakeholder	Relevant (Y/N)	Reasoning / Validation
WA Department of Mines, Industry Regulation and Safety (DMIRS)	Y	Consultation required as per DMP Consultation Guidance Note (For the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009).
NT Department of Primary Industry and Resources (Mines and Energy)	Y	Department manages and governs energy operations, policy and titles within the NT.
Person or organisation whose functions, interests or activities may be affected by the activities to be carried out under the environment plan, or the revision of the environment plan		
WA Northern Demersal Scalefish Managed Fishery (NDSMF)	Y	Area 2 (Zone A) of the fishery overlaps with the Operational Area, with fishing effort reporting all year. All licence holders have been contacted. Additional information on the fishery can be found in Section 4.6.6.
WA Mackerel Managed Fishery (MMF)	Y	Area 1 of the fishery overlaps with the Operational Area, with fishing effort reported all year. All licence holders have been contacted. Additional information of the fishery can be found in Section 4.6.6.
Northern Shark Fisheries (WA Joint Authority Northern Shark Fishery	Y	The fishery is currently not in operation. However, WAFIC that the fishery intends to recommence fishing in 2019/20. All licence holders have been contacted. Additional information on the fishery can be found in Section 4.6.6.
WA Pearl Oyster Managed Fishery (POMF)	N	The Operational Area is located within the actively fished Zone 3. Consultation has been undertaken with the Pearl Producers Association (PPA). Additional information on the fishery can be found in Section 4.6.6.
NT Demersal Fishery	Y	The Operational Area overlaps with Area A and Area B of the Demersal Fishery All licence holders have been contacted. Additional information on the fishery can be found in Section 4.6.6.
NT Offshore Net & Line Fishery (ONLF)	Y	NT DPIR advised that the Offshore Net and Line Fishery has been active in the JBG in the last five years. All licence holders have been contacted. Additional information on the fishery can be found in Section 4.6.6.

Stakeholder	Relevant (Y/N)	Reasoning / Validation
NT Spanish Mackerel Fishery	Y	NT DPIR advised that the Spanish Mackerel Fishery has been active in the JBG in the last five years. All licence holders have been contacted. Additional information on the fishery can be found in Section 4.6.6.
NT Pearl Oyster Fishery	Y	NT DPIR advised that the harvesting of pearl culture oysters that there has been irregular harvest of pearl oysters from the Bonaparte Basin, since 1994. All licence holders have been contacted. Additional information on the fishery can be found in Section 4.6.6.
Commonwealth Fisheries Association (CFA)	Y	The CFA is non-profit organisation and is the peak body representing the collective rights, responsibilities and interests of a diverse commercial fishing industry in Commonwealth-regulated fisheries.
Western Australian Fishing Industry Council (WAFIC)	Y	WAFIC represents professional fishing, pearling and aquaculture enterprises, processors and exporters in Western Australia.
Pearl Producers Association (PPA)	Y	The PPA is the peak representative organisation of The Australian South Sea Pearling Industry.
Northern Prawn Fishing Industry Pty Ltd (NPFI)	Y	The NPFI is a collective of trawler operators, processors and marketers acting together as a single voice for the industry in the Northern Prawn Fishery (NPF). Under co-management arrangements, the NPFI is responsible for a number of functions including the management of catch and effort information, managing the crew member observer program and pre-season briefings.
Northern Prawn Fishery (QLD) Trawl Association Inc.	Y	Association represents trawl operators in the Northern Prawn Fishery.
Northern Territory Seafood Council (NTSC)	Y	NTSC represents the seafood industry in the NT. Licence holders within the NT-managed fisheries are members of the NTSC.
Australian Southern Bluefin Tuna Industry Association (ASBTIA)	Y	ASBTIA is the peak body representing Southern Bluefin Tuna ranching companies in Australia.
Any other person or organisation that the titleholder considers relevant		

Stakeholder	Relevant (Y/N)	Reasoning / Validation
Australian Marine Oil Spill Centre (AMOSC)	Y	The Australian Marine Oil Spill Centre is an organisation set up by the petroleum industry to enable a quick and effective response to oil spills around the Australian coastline. AMOSC operates Australia's major marine spill response equipment stockpile for the Australian oil and gas industry on 24hr stand-by for rapid response anywhere around the Australian coast.
Kimberley Land Council (KLC)	Y	KLC is the peak Indigenous body in the Kimberley region working with Aboriginal people to secure native title recognition, conduct conservation and land management activities and develop cultural business enterprises.
Northern Land Council (NLC)	Y	NLC is an independent statutory authority of the Commonwealth. The NLC is also the Native Title Representative Body for the northern region – including the Tiwi Islands and Groote Eylandt.
Recfishwest	Y	The organisation is the peak fishing recreational body.
The Wilderness Society	Y	The Wilderness Society is an Australian, community-based, not-for-profit non-governmental environmental advocacy organisation with interests in the oil and gas industry.
World Wildlife Fund	Y	The international non-governmental organisation works in the field of the wilderness preservation, and the reduction of human impact on the environment. WWF is interested in receiving information from titleholders on offshore oil and gas activities.
Save the Kimberley	Y	Environmental non-government organisation operating in the Kimberley region.
Environs Kimberley	Y	Environmental non-government organisation operating in the Kimberley region.
ENI Australia B.V.	Y	Nearby petroleum titleholder.
Melbana Energy Limited / Finniss Offshore Exploration Pty Ltd	Y	Nearby petroleum titleholder.
Beach Energy Limited / Lattice Energy Limited	Y	Nearby petroleum titleholder.
Woodside Energy Limited	Y	Nearby petroleum titleholder.
Santos Offshore Pty Ltd	Y	Nearby petroleum titleholder.

5.3 Consultation Method

Stakeholder consultation has been undertaken by Environmental Resources Management (ERM) on behalf of Polarcus. The process undertaken is detailed in Table 5-2.

Where stakeholders could only be contacted via post (e.g. fishery licence holders) or phone, the appropriate communication channels were used, whereby those parties were either sent hard copies of the information sheet or contacted via phone to relay the corresponding details of the information sheet.

Follow-up emails and phone calls were undertaken as required following the distribution of relevant information.

Where concerns, objections or claims have been raised by stakeholders, these have been addressed in the assessment of environmental impacts and risks (Section 7 and Section 8). Stakeholders have been informed of how Polarcus has assessed the issues and if any relevant controls have been adopted to reduce the potential impacts and risks to ALARP and acceptable levels.

Table 5-2 Consultation Process

Stage	Timing	Information Provided
Initial Stakeholder Notification	April 2019	A notification was distributed to stakeholders providing information on the Petrelex 3D MSS, and associated EP. An information sheet and map was issued.
Follow-up Notification	May/June 2019	Follow-up emails and phone calls were undertaken as required to those stakeholders who had not yet responded to the initial notification.
Public Comment Period Open	TBC	A notification will be issued to stakeholders advising of the 30-day public comment period. The notification will include details of how to make a comment. Stakeholders are also advised of the change in survey name from ‘Petrel’ to ‘Petrelex’.
EP Under Assessment	TBC	A notification will be issued to stakeholders following the public comment period, and upon commencement of NOPSEMA’s assessment of the EP.
EP Acceptance	TBC	A notification will be issued to stakeholders with information on the acceptance of the EP. In addition, stakeholders will be advised of the scheduled survey commencement date (if possible).

5.4 Consultation Results

A summary of the key issues and concerns raised by stakeholders during consultation, including an assessment of the merits of objections and claims are included in Appendix D. Full copies of stakeholder correspondence are contained in the Sensitive Matters Report.

5.5 Ongoing Stakeholder Consultation and Notifications

5.5.1 *Stakeholder Consultation*

Polarcus will continue to engage with the applicable Commonwealth and Western Australian authorities and other relevant stakeholders (as identified during the course of the consultation described here) prior to and during the Petrelex 3D MSS, as appropriate. This includes ongoing engagement to inform stakeholders about key milestones and activities and any other relevant information or changes.

Ongoing stakeholder consultation commitments are outlined in Table 5-3. Some stakeholders will be contacted solely for regulatory or operational notification purposes and these notification requirements are outlined separately in Section 5.5.2.

In addition, where an email address is available for fishery licence holders, Polarcus will provide regular updates (i.e. 48hr look-ahead notifications) throughout the survey (providing that the stakeholder has registered for the service).

The Consultation Log prepared to support consultations for this EP (Appendix D) will be kept live and used as a tool to trigger and record ongoing consultation. Additional stakeholders may be identified throughout the course of the survey, thus, these new stakeholders will be contacted and given the opportunity to provide feedback as relevant.

New feedback or concerns regarding the survey may be raised by stakeholders, over the life of the EP. Should any additional concerns be raised, or new information be provided by existing or new stakeholders prior to, or during the survey, these concerns and/or information will be assessed for their merits and a response provided. As required, follow-up actions, including triggers for further consultation with relevant stakeholders, will be managed through the Polarcus Management of Change and New Information Procedure (refer to Section 10.2.3) and, where relevant, in accordance with the provisions of Regulations 11A, 16 and 17 of the OPGGS (E) Regulations.

Table 5-3 Ongoing Consultation Requirements

Trigger / Event	Stakeholders	Timing	Method and Information
Prior to Survey Commencement			
Planned survey commencement date confirmed	All stakeholders, excluding agencies and organisations identified in Section 5.5.2 that have separate regulatory or operational notification requirements.	To be sent at least four weeks prior to the scheduled acquisition commencement date.	Emails and/or letters to include: ■ Proposed commencement date ■ Proposed duration and/or completion date ■ Location and coordinates ■ Details of communication (e.g. daily look-ahead) during the survey and details of how to register for updates
During Survey			
Daily update	All stakeholders who have registered for daily look-ahead emails.	Daily	Email detailing: ■ Location/survey lines planned for upcoming 48 hour period, including coordinates ■ On-the-water interaction/ safety requirements or advice ■ Any other on-the-water progress updates (e.g. schedule delays)
N.B. On-the-water communication to vessels via radio will also be undertaken as required.			
Survey Completion			
Survey complete	All stakeholders, excluding agencies and organisations identified in Section 5.5.2 that have separate regulatory or operational notification requirements.	Within two weeks of completion and demobilisation from Operational Area.	Emails and/or letters to include: ■ Completion date
Environment Plan and Activity Updates			

Trigger / Event	Stakeholders	Timing	Method and Information
Public Comment Period	All stakeholders, excluding agencies and organisations identified in Section 5.5.2 that have separate regulatory or operational notification requirements.	To be sent within five days of public comment period opening.	Notification to stakeholders advising of the public comment period.
NOPSEMA acceptance of the EP		To be sent within one week of the EP Summary being published.	Notification confirming date of acceptance and including URL to EP Summary on NOPSEMA website.
Significant modification of the Activity as defined in Section 10.2.3.		As soon as identified	Email or letter notification followed by meetings, phone calls, email or other correspondence as required. Initial notification shall provide opportunity for stakeholders to comment. Stakeholders to be provided with sufficient information and time to review and respond to information and matters should be reasonably addressed prior to resubmission of the EP.
New stage (increase in Acquisition Area, Operational Area or EP timeframe, as defined in Section 10.2.3.			
Revision and resubmission of the accepted EP			

5.5.2 *Notifications*

A number of Government agencies and organisations are identified as requiring notification prior to, during and/or after the survey. The required notifications are summarised in Table 5-4.

Note that notifications in the event of a spill event are summarised in Section 10.3.6.

Table 5-4 Survey Notifications

Agency / Organisation	Notification / Contact Details	Timing
Prior to Survey Commencement		
Australian Hydrographic Service (AHS)	Email: datacentre@hydro.gov.au	3 weeks prior to commencement of the survey for inclusion in fortnightly Notice to Mariners.
Department of Defence	Email: Offshore.Petroleum@defence.gov.au	Five weeks prior to commencement of the survey.
NOPSEMA	Notify using the Regulation 29 Notification Form available at https://www.nopsema.gov.au/environmental-management/notification-and-reporting/	At least 10 days prior to commencement of the survey.
WA Department of Mines, Industry Regulation and Safety (DMIRS)	Email: petroleum.environment@dmp.wa.gov.au to provide notification of commencement date	Approximately 1 week prior to commencement of the survey.
AMSA Joint Rescue Coordination Centre (AMSA JRCC)	Email: rccaus@amsa.gov.au or Phone: 1800 641 792 or +61 2 6230 6811 for AUSCOAST warning broadcasts 24-48 hours before operations commence. AMSA's JRCC will require the vessels details (including vessel name, call sign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone) and area of operation and need to be advised when the survey is planned to start and end.	24-48 hours before commencement of the survey.
Australian Border Force	Email: broome@customs.gov.au and broome.shipping@border.gov.au regarding vessel and crew arrival in Broome (or other port / office if required).	Prior to the vessel arriving in Australia.
Department of Agriculture and Water Resources (DAWR)	Email regarding Pre-Arrival Reporting and quarantine requirements prior to arrival in Australian Territorial Waters. The Department's Maritime National Coordination Centre: 1300 004 605 or via MARS online reporting.	No later than 12 hours prior to the vessel arriving in Australian territorial waters.
National Offshore Petroleum Titles Administrator (NOPTA)	Email: reporting@nopta.gov.au to provide notification of commencement	48 hours prior to commencement of the survey.
During the Survey		

Agency / Organisation	Notification / Contact Details	Timing
AMSA JRCC	Report daily updates on survey progress and vessel position to AMSA JRCC (Email: rccaus@amsa.gov.au; Phone: 1800 641 792 or +61 2 6230 6811). AMSA's JRCC will require the vessels details (including vessel name, call sign and Maritime Mobile Service Identity (MMSI)).	Daily
NOPTA	Weekly seismic report to resources@nopta.gov.au (refer to AA/SPA requirements).	Weekly
Completion of Survey		
AMSA JRCC	Notify AMSA JRCC upon completion of survey phase (Email: rccaus@amsa.gov.au; Phone: 1800 641 792 or +61 2 6230 6811). AMSA's JRCC will require the vessels details (including vessel name, call sign and Maritime Mobile Service Identity (MMSI)).	Upon completion of the survey (i.e. demobilisation from Operational Area)
AHS	Email: datacentre@hydro.gov.au.	Within two weeks of completion of the survey for inclusion in fortnightly Notice to Mariners.
NOPSEMA	Notify using the Regulation 29 Notification Form available at https://www.nopsema.gov.au/environmental-management/notification-and-reporting/.	Within 10 days of completion of the survey.
NOPTA	Email: reporting@nopta.gov.au to provide notification of completion.	Upon completion of the survey.
WA DMIRS	Email: petroleum.environment@dmirs.wa.gov.au to provide notification of commencement.	Within approximately one week following completion other survey.
Department of Defence	Email: Offshore.Petroleum@defence.gov.au	Within two weeks of completion of the survey.
Completion of the EP		
NOPSEMA	Regulation 25A of the Environment Regulations provides that the operation of an environment plan ends when the titleholder notifies NOPSEMA that: ■ the activity or activities to which the plan relates have ended; and ■ all of the obligations under the environment plan have been completed; and ■ NOPSEMA accepts the notification.	When ■ the activity or activities to which the plan relates have ended; and ■ all of the obligations under the environment plan have been completed.

Agency / Organisation	Notification / Contact Details	Timing
	Titleholders may provide NOPSEMA with written notification directly by email, letter, or by using the form available at https://www.nopsema.gov.au/environmental-management/notification-and-reporting/ Written notifications can be submitted via the SecureFile Transfer service on the NOPSEMA website or by email to submissions@nopsema.gov.au	
Change of Titleholder / Nominated Liaison Person or Contact Details		
NOPSEMA	Notify NOPSEMA if there is a change in the titleholder, a change in the titleholder's nominated liaison person or a change in the contact details for either the titleholder or the liaison person. Email: submissions@nopsema.gov.au.	When there is a change in the titleholder, a change in the titleholder's nominated liaison person or a change in the contact details for either the titleholder or the liaison person.

6. RISK ASSESSMENT METHOD

6.1 Approach

The risk assessment was undertaken in accordance with the Polarcus Risk Assessment Procedure, Risk Management Procedure and the Polarcus Risk Matrix. The Polarcus Risk Assessment and Risk Management procedures are aligned with the Australian Standard/New Zealand Standard (AS/NZS) ISO 31000:2009 Risk Management and Handbook 203:2012 Managing Environment-related Risk (Standards Australia/Standards New Zealand 2009 and 2012, respectively).

The risk assessment process consisted of the following steps:

- Identification of potential environmental impacts and risks associated with the seismic survey's planned activities and credible unplanned events (Section 6.2);
- Identification of physical, biological, and socioeconomic receptors within the environment that may be affected by the activities (planned and unplanned), as well as identification of particular environmental values and sensitivities (Section 6.3);
- Evaluation of the potential consequences of these impacts and risks to the identified receptors with legal requirements and inherent design in place but without other controls, and determination of the 'inherent' risk (Section 6.4);
- Identification of appropriate alternative, additional or improved controls (i.e. those in addition to legal requirements and inherent design) to reduce impacts and risks to levels that are demonstrably ALARP (Section 6.5);
- Evaluation of the residual impacts and risks with the proposed controls in place (Section 6.6);
- Evaluation of whether the impacts and risks are reduced to acceptable levels (Section 0); and
- Development of environmental performance outcomes, performance standards, and measurement criteria (Section 6.8).

A risk assessment workshop was undertaken in April 2019, to identify and assess the risks associated with the survey. The workshop was supported by background literature and discussions with relevant seismic operations personnel, vessel management personnel and environmental specialists. The identification of risks and the selection of appropriate controls for these risks were also informed by Polarcus' experience in conducting other seismic surveys in Australia and elsewhere.

The following sections detail how the risk assessment steps were completed.

6.2 Impact and Risk Identification

For this activity, Polarcus has defined impacts and risks as follows:

- **Impacts** result from activities that by their very nature will result in a change to the environment or a component of the environment, whether adverse or beneficial. Impacts are an inherent part of the activity. For example, there will be underwater sound emissions with associated impacts from the seismic source and vessel activity.
- **Risks** result from activities where a change to the environment or component of the environment may occur from the activity (i.e., there may be consequences if the incident event occurs). Risk is a combination of the consequences of an event and the associated likelihood of its occurrence. For example, a hydrocarbon spill may occur if a vessel's fuel tank is punctured by a collision incident during the survey. The risk of this event is determined by assessing the consequence of the impact (using factors such as the type and volume of fuel and the nature of the receiving environment) and the likelihood of this event happening (which may be determined qualitatively or quantitatively).

The survey's planned activities and credible unplanned (i.e. accidental) events were reviewed to identify the sources of potential adverse effects on the environment. The context of the planned activities and unplanned events was established for the risk and impact identification process by considering the following proposed and indicative aspects:

- Location of the Operational and Acquisition Areas;
- Timing of the survey;
- Equipment type and arrangement;
- Vessel type and specifications;
- Associated logistics (e.g. refuelling, crew change, resupply, etc.); and
- Potential interaction with environmental features, values, sensitives and stakeholders.

Consultation was conducted with relevant personnel, including those involved in the management and planning of the survey as well as those with experience in risk and impact identification for seismic surveys or other offshore vessel activities. In addition, appropriate oil spill response activities were identified in consultation with emergency response personnel and environmental specialists.

The following impacts and risks were identified:

- Noise emissions: seismic source;
- Noise emission: cumulative seismic sound;
- Noise emissions: vessels and helicopter;
- Physical presence: interference with other marine users;
- Discharge: liquid waste management;
- Atmospheric emissions: vessels and equipment;
- Artificial light emissions: vessels;
- Hydrocarbon and chemical spills;
- Physical presence: collision / entanglement with marine fauna;
- Physical presence: loss of equipment;
- Discharge: loss of hazardous or non-hazardous solid waste; and
- Introduction of invasive marine species: biofouling and ballast water.

6.3 Identification of Receptors, Values and Sensitivities

The characteristics of the environment that may be affected by planned activities or credible unplanned events were identified through the review of publically available literature and stakeholder consultation. The characteristics considered included ecosystems and their constituent parts, natural and physical resources, the qualities and characteristics of locations, heritage values and social, economic and cultural features.

Receptors, values and sensitivities were identified for the Operational Area and its surroundings, taking into account areas that may be affected directly or indirectly by the survey activities (both planned and unplanned). In this respect, representative oil spill modelling was used (as described in detail in Section 8.1) to identify receptors, values and sensitivities within the EMBA associated with a credible worst case oil spill scenario.

The description of the existing environment provided in Section 4 also reflects the timeframe, nature and the scale of the activity.

6.4 Evaluation of Environmental Impacts and Inherent Risk

The potential adverse environmental impacts from each identified impact and risk were determined and the inherent risk evaluated. The inherent risk considers the potential adverse environmental impacts worst credible environmental impact if only regulatory requirements and inherent design controls were in place to reduce the consequence or its likelihood of occurrence.

The identification and evaluation of potential adverse impacts was informed by:

- Experienced environmental practitioners and subject-matter experts (e.g. in the effects of underwater sound on marine fauna);
- Experienced environmental consultants (e.g. for oil spill modelling);
- Knowledge of the existing environment, its values, sensitivities, and regional importance;
- Predictive modelling (e.g. for sound emissions and oil spills); and
- Available scientific and research literature.

The inherent risk was determined using the Polarcus Risk Matrix (Figure 6-1) and interpreted in accordance with Table 6-1 (further descriptions of consequence) and Table 6-2 (interpretation of risk). In addition to the descriptions of consequence presented in the Polarcus Risk Matrix, further descriptions were developed to cover other environmental impacts besides those related to discharges volumes. Where several potential impacts were identified for an activity, the consequence and likelihood categories were determined based on the worst credible potential impact. Those categories took into account experience of workshop participants and industry history.

People	Environment	Property Value Technical	Reputation	Security	Severity	Never Heard Of "A"	Rarely Occurs "B"	Occasionally Occurs "C"	Regularly Occurs "D"	Occurs All the Time "E"
No health effect. No Injury	No Discharge	Less than $ 5K	No Impact	No Harm	0					
Slight work related illness FAC	Slight Discharge <5 liters	Less than $ 50K.	Slight Impact	Slight Breach Handled Internally	1					
Minor work related illness RWC or MTC	Minor Discharge >5 liters - <100	Less than $500K	Minor Impact Limited Exposure	Minor breach Local Authorities	2					
Extensive work related illness. LTI	Extensive Discharge >100 liters - <1m^3	Less than $5M.	Extensive Impact National Exposure	Extensive Breach Threat to Operations	3					
Fatality or Major illness	Major Discharge >1m^3 - <10m^3	Less than $10M	Major Impact Regional Exposure	Major Breach Loss of Operations	4					
Fatalities or Major Illnesses (multiples)	Massive Discharge >10m^3	Exceeding $10M.	Massive Impact International Exposure	Massive Breaches Company Lockdown	5					

Manage for Continuous Improvement	Incorporate Risk Reduction Measures	Intolerable Risk – All Stop

Figure 6-1 Polarcus Risk Matrix

Table 6-1 Further Descriptions of Environmental Consequences

Severity Ranking	Severity Label	Description
0	None	No environmental consequences
1	Slight	Slight environmental damage where restoration can be handled internally and no breaches of legislative requirements have been made
2	Minor	Large-scale damage to the environment with no lasting effects, restoration can be handled internally and a single breach of legislative requirements
3	Extensive	Environmental damage requiring external resources for restoration and involving many breaches of legislative requirements
4	Major	Severe environmental damage requiring extensive measures for restoration and involving widespread breaches of legislative requirements
5	Massive	Persistent severe environmental damage resulting in ongoing breaches of legislative requirements and major financial consequences

Table 6-2 Interpretation of Risk

Risk Ranking	Interpretation
LOW RISK	No additional controls are required if ALARP. Consideration may be given to effective solutions or improvements that impose no significant cost burden. Monitoring is required to ensure that the controls are maintained.
MEDIUM RISK	Efforts should be made to reduce the risk, but the cost of prevention should be measured and limited. Risk reduction methods should be implemented within a defined time period.
HIGH RISK	Work should not be started or continued until the risk has been reduced to an acceptable level. If it is not possible to reduce the risk even with unlimited resources, work has to remain prohibited.

6.5 Identification of Controls and Demonstration of ALARP

If the inherent risk is determined to be low, Polarcus considers the control measures adopted to be sufficient to demonstrate that potential impacts and risks are managed to ALARP. However, Polarcus considers the implementation of additional controls when there is the potential to further reduce the likelihood of the impact occurring (i.e. preventative) and/or reduce the consequence of the impact (i.e. mitigation).

In accordance with the Polarcus Risk Management Procedure, the following hierarchy of controls was applied:

- **Eliminate**: Redesign the activity or substitute a substance so the impact/risk is removed or eliminated;
- **Reduce**: Replace the materials or process with a less hazardous one and one which does not introduce another impact/risk;
- **Isolate**: Measures to prevent the impact/risk escalating;

- **Control**: Identifying and implementing procedures, administrative controls, competency and training; and
- **Discipline**: Ensuring that all controls are monitored, reviewed and enforced.

Controls were required to be reasonable and practicable where both the cost of implementation and the potential effect(s) on the technical scope of the survey were acceptable and did not outweigh the benefits gained. Controls were identified during the environmental risk assessment workshop drawing on the experience of personnel involved in the seismic survey design and execution. Where necessary, controls were then refined as part of the ALARP demonstration process.

The following criteria were used to determine where impacts and risks were ALARP;

- No reasonably practicable alternatives/substitutes to the activity are available that could eliminate, isolate or provide a net reduction in the risk to environmental values or sensitivities.
- No reasonably practicable additional controls (e.g. engineering, administrative or procedural controls) are available that could provide a net reduction in the risk to environmental values or sensitivities.
- No reasonably practicable improvements are available that could increase the effectiveness of adopted control measures in terms of functionality, availability, reliability, survivability, independence and compatibility.

In making this determination, consideration was given to trade-offs of implementing the alternatives or additional controls in terms of cost, technical, environmental, safety and logistical implications.

6.6 Evaluation of Residual Risk

Residual risk was evaluated taking into account the identified controls and the anticipated effectiveness of these using the Polarcus Risk Assessment Matrix. The resulting risk was further investigated to determine whether any additional controls or efforts were required to meet the goal of the Polarcus Risk Management Procedure. The interpretation of risk levels is shown in Table 6-2.

6.7 Demonstration of Acceptability

The following criteria were used to determine whether impacts and risks are acceptable:

- The level of risk residual is determined to be low or medium (Table 6-2).
- The seismic activity and the identified control measures are compliant with applicable legislation.
- The seismic activity and the identified control measures are consistent with Conservation Advice, Recovery Plans, and/or other industry guidelines and standards and corporate policies, standards and procedures.
- The seismic activity and the identified impacts and risks will not result in a significant or long-term impact to the values of Australian Marine Parks, and the activity is not inconsistent with the Management Prescriptions or IUCN Reserve Management Principles of the Zones.
- The seismic activity and the identified control measures are consistent with the following principles of Ecologically Sustainable Development, as set out in Section 3A of the EPBC Act, and the precautionary principle where relevant:
  - 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 that 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; and
  - improved valuation, pricing and incentive mechanisms should be promoted.
- Relevant stakeholder objections, claims, concerns or information have been considered during the assessment of impacts and risks and selection of control measures, where they are considered to have merit.
- Acceptable levels are evaluated independently of the ALARP process and the acceptability criteria are considered when selecting the environmental performance outcomes that apply to managing a particular impact or risk.

Polarcus considers an impact or risk to be unacceptable when, despite the application of all reasonable practicable control measures, the residual risk is still determined to be high. In these circumstances, Polarcus will not undertake the activity until the residual risk rating is reduced to either low or medium (Table 6-2).

6.8 Environmental Performance Outcomes, Standards and Measurement Criteria

To meet the requirements of Regulation 13 (7) of the OPGGS (E) Regulations, environmental performance outcomes, performance standards, and measurement criteria have been identified in Section 9. These terms are defined as follows:

- Environmental Performance Outcome (EPO) – a measurable level of performance required for the management of the environmental aspects of the activity to ensure the environmental impacts or risks will be of an acceptable level;
- Environmental Performance Standard (EPS) – a statement of performance required of an adopted control measure to manage impacts and risks to ALARP and acceptable levels; and
- Measurement Criteria (MC) – defines the measure by which environmental performance will be measured to determine whether the EPO has been met.

Table 9-1 provides a summary of the EPO, EPS and MC relevant to the Petrelex 3D MSS.

7. ENVIRONMENTAL RISKS AND MANAGEMENT – PLANNED

This section presents the evaluation of the environmental impacts and risks completed for planned / routine aspects of the Petrelex 3D MSS using the methodology described in Section 6.

In accordance with regulation 13(5) of the OPGGS (E) Regulations, each subsection is structured to include:

- an assessment summary that includes the source of predicted impacts and risks, receptors that may be affected, adopted control measures and a summary of the inherent and residual risk evaluation;
- a detailed evaluation of impacts and risks (including sources, potential events, likelihood and consequences) of the survey and estimate of the magnitude of the impacts and risks
- identification of the control measures to be used to reduce impacts and risks and demonstration of ALARP; and
- demonstration that impacts and risks are reduced to 'acceptable levels'.

A summary of the residual risk rankings for all impacts and risks identified and assessed in this Section are summarised in Table 7-1.

Table 7-1 Residual Environmental Impact and Risk Summary

Impact/Risk	EP Section No.	Residual Risk		
		Consequence	Likelihood	Risk Ranking
Noise Emissions: Seismic Source*	0	Minor (2)	Occasional (B)	**Low**
Noise Emissions: Cumulative Seismic Sound	7.2	Slight (1)	Rare (B)	**Low**
Noise Emissions: Vessels, Helicopter and Mechanical Equipment	7.3	Slight (1)	Occasional (C)	**Low**
Physical Presence: Interference with Other Marine Users	7.4	Minor (2)	Occasional (C)	**Low**
Discharge: Liquid Waste Management	7.5	Slight (1)	Rare (B)	**Low**
Atmospheric Emissions: Vessels and Mechanical Equipment	7.6	Slight (1)	Rare (B)	**Low**
Artificial Light Emissions: Vessels	7.7	Slight (1)	Rare (B)	**Low**

* The residual risk ranking is based on the ranking of the most sensitive receptor.

7.1 Noise Emissions: Seismic Source

7.1.1 *Assessment Summary*

Source of Impact / Risk

Acquisition of the Petrelex 3D MSS will involve the use of a seismic source, consisting of an airgun array with a maximum capacity of 2,495 cui, towed at a water depth of 6 m. The source will be used to generate acoustic pulses by periodically discharging compressed air into the water column, at intervals of approximately five seconds as the vessel transits along pre-determined survey lines within the Acquisition Area.

The seismic source may also be operated (at or below full power) for short durations elsewhere in the Operational Area in a controlled manner; for the purpose of source maintenance and testing (refer to Section 3.4)

The 2,495 cui seismic source will produce far-field[2] source levels up to a maximum of 255 dB re 1 μPa^2m^2 (PK) and per-pulse source sound exposure levels (SEL) of 228-230 dB re 1 μPa^2m^2s (at 10–2,000 Hz) in the vertical direction beneath the array.

- Underwater noise can affect marine fauna in three main ways:
  - By causing direct physical effects on hearing or other organs. Hearing loss may be temporary (temporary threshold shift – TTS), or permanent (PTS), with PTS considered to represent injury;
  - Through disturbance leading to behavioural changes or displacement of fauna. The occurrence and intensity of disturbance is highly variable and depends on a range of factors relating to the animal and situation; and
  - By masking or interference with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey).

Receptors

Without appropriate control measures in place, noise emitted from the seismic source used during the Petrelex 3D MSS has the potential to cause impacts to a range of sensitive receptors, including:

- Cetaceans;
- Marine reptiles;
- Seabirds;
- Fishes and elasmobranchs;
- Benthic invertebrates;
- Zooplankton;
- Fish spawning;
- Commercial fisheries; and
- Marine protected areas.

Adopted Control Measures	EPS #
Minimum source size selected (2,495 cui) to acquire survey data and meet the geophysical objectives of the survey.	1.1
Part A of EPBC Policy Statement 2.1 will be applied in full to mitigate potential impacts to whales , including: ■ Observation zone: 3+ km horizontal radius from the seismic source. ■ Low power zone: 2 km horizontal radius from the seismic source. ■ Shut-down zone: 500 m horizontal radius from the seismic source. ■ Pre-Start-up Visual Observations	1.2

[2] The zone where, to an observer, sound originating from an array of sources (or a spatially distributed source) appears to radiate from a single point. The distance to the acoustic far-field increases with frequency.

■ Soft-start Procedures ■ Start-up Delay Procedures ■ Operational Shut-down and Low-power Procedures ■ Night-time and Low Visibility Procedures ■ Sighting Reports	
Two MFOs will be available on board the seismic vessel to manage shift duties during daylight hours during the survey.	1.3
A 500 m shut-down zone from the operating source, as per the shut-down zone for whales in EPBC Act Policy Statement 2.1, will also be applied to turtles.	1.4
A 500 m shut-down zone from the operating source, as per the shut-down zone for whales in EPBC Act Policy Statement 2.1, will also be applied to whale sharks.	1.5
Crew, survey personnel and MFOs will be briefed in the marine fauna observation, separation distance estimation, controls and reporting requirements relevant to this EP.	1.6

Details of Residual Impacts and Risks

Given the adopted controls, the potential impacts of noise emissions from the seismic source on marine fauna, and on the designated values of the OSMP and JBGMP, during acquisition of the Petrelex 3D MSS are considered to be slight and short-term, and restricted to temporary behavioural changes (avoidance) in any isolated individuals that may transit the area in close proximity to the operating seismic source. With the control measures in place, the Petrelex 3D MSS will not result in any significant impacts to any commercial fisheries operating within or adjacent to the Operational Area.

Receptor	Risk Ranking	Consequence	Likelihood	Risk
Cetaceans	Inherent Risk	Slight (1)	Occasional (C)	Low
	Residual Risk	Slight (1)	Rare (B)	Low
Marine Reptiles	Inherent Risk	Slight (1)	Occasional (C)	Low
	Residual Risk	Slight (1)	Rare (B)	Low
Seabirds	Inherent Risk	Slight (1)	Rare (B)	Low
	Residual Risk	Slight (1)	Rare (B)	Low
Fishes and Elasmobranchs	Inherent Risk	Slight (1)	Occasional (C)	Low
	Residual Risk	Slight (1)	Occasional (C)	Low
Benthic Invertebrates	Inherent Risk	Slight (1)	Rare (B)	Low
	Residual Risk	Slight (1)	Rare (B)	Low
Zooplankton	Inherent Risk	Slight (1)	Occasional (C)	Low
	Residual Risk	Slight (1)	Occasional (C)	Low
Fish Spawning	Inherent Risk	Minor (2)	Rare (B)	Low
	Residual Risk	Minor (2)	Rare (B)	Low
Commercial Fisheries	Inherent Risk	Minor (2)	Occasional (C)	
	Residual Risk	Minor (2)	Rare (B)	Low
Marine Protected Areas	Inherent Risk	Slight (1)	Rare (B)	Low
	Residual Risk	Slight (1)	Rare (B)	Low

7.1.2 *Detailed Evaluation of Impacts and Risks*

The area over which seismic sound may adversely impact marine species depends upon multiple factors including characteristics of the sound source, the extent of sound propagation relative to the location of receptors, and the sensitivity and range of spectral hearing of different species (Slabbekoorn et al. 2010; Popper and Hawkins 2012). A description of the seismic sound source and acoustic modelling of sound propagation are provided in Section 7.1.2.1 and 7.1.2.2 respectively. A detailed evaluation of marine fauna sensitivity to sound and assessment of potential impacts is provided in Section 7.1.2.37.1.2.4.

7.1.2.1 Seismic Sound Source

Seismic sound is characterised by high energy pulses of low frequency sound. The frequency of the sound produced from each seismic pulse is primarily less than 2 kHz, with the highest levels at frequencies in the range of 10-500 Hz (McCauley 1994).

The 2,495 cui seismic source for the Petrelex 3D MSS was modelled by JASCO Applied Sciences (JASCO) to determine acoustic source levels using their Airgun Array Source Model (Quijano et al. 2019). The modelling predicted the 2,495 cui seismic source to produce far-field[3] source levels up to a maximum of 255 dB re 1 μPa^{2}m^2 (PK) and per-pulse source sound exposure levels (SEL) of 228-230 dB re 1 μPa^{2}m^{2}s (at 10–2,000 Hz) in the vertical direction beneath the array.

The rate of sound attenuation from the seismic source is dependent on local sound propagation characteristics, including seawater temperature and salinity profiles, water depth, bathymetry and the geoacoustic properties of the seabed (McCauley 1994). While the seismic pulses are directed downwards, horizontal propagation may be detected over long distances due to the high intensity and low frequency properties of the sound source. Acoustic modelling of sound propagation from the seismic source is presented in Section 7.1.2.2.

Sound Source Verification

In 2018, a measurement program was conducted to validate the source signature predictions of JASCO's Airgun Array Source Model. The validation program measured source levels for four Polarcus airgun arrays, including the 2,495 cui array that will be used for acquisition of Petrelex 3D MSS, and was conducted in 80 m water depth with an array passing directly over the recorder on the seafloor. This sound source verification (SSV) process was conducted towards the end of the Polarcus Zénaïde 3D MSS, within the Acquisition Area for this survey. The SSV process determined that, for the 2,495 cui array, the maximum measured PK was 220.7 dB re 1μPa. The measurement study results were used to validate the modelled far-field source levels through a comparison between the measured received sound levels and predicted received sound levels at a real receiver point in the far-field of the source. The predictions were made using a wavenumber integral model coupled to the airgun source model. The program measured received sound levels in the endfire, broadside and vertical directions, and as the results showed good agreement with the modelling results, provided a validation of the complete modelled source signatures for the 2,495 cui array (McPherson et al. 2018a, 2018b).

7.1.2.2 Acoustic Modelling of Sound Propagation

To assess the potential magnitude and extent of impacts from underwater noise produced during the Petrelex 3D MSS, Polarcus commissioned JASCO to model sound propagation at several locations that were representative of the different water depths, bathymetry and seabed properties within the Acquisition Area (Quijano et al. 2019) (refer to Appendix E).

The objective of this acoustic modelling study was to evaluate the potential effects of sound on marine fauna including cetaceans, marine reptiles, fishes, elasmobranchs, benthic invertebrates and

[3] The zone where, to an observer, sound originating from an array of sources (or a spatially distributed source) appears to radiate from a single point. The distance to the acoustic far-field increases with frequency.

zooplankton, and on socio-economic receptors such as commercial fisheries and marine protected areas. Modelling considered the 2,495 cui seismic source, towed at a 6 m depth behind the survey vessel.

Underwater acoustic propagation models were used in conjunction with the modelled array signature to estimate sound levels over a large area around the source. Single pulse sound fields were predicted at two defined locations within the Acquisition Area, and accumulated sound exposure fields were predicted for two representative scenarios for likely survey operations over 24 hours, allowing for two different tow directions or azimuths (Scenario 1: NW-SE; and Scenario 2: NE-SW – refer to Figure 7-1).

The modelling methodology considered source directivity and range-dependent environmental properties in each of the areas assessed. Estimated underwater acoustic levels are presented as sound pressure levels (SPL), zero-to-peak pressure levels (PK), peak-to-peak pressure levels (PK-PK), and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL) as appropriate for different sound exposure thresholds. A conservative sound speed profile that would be most supportive of sound propagation conditions for the period of the survey (i.e. worst case) was defined and applied to all modelling.

The analysis considered the distances away from the seismic source at which the sound exposure thresholds for marine fauna (outlined in Section 7.1.2.3 and 7.1.2.4) were reached. In addition to the sound exposure thresholds, the distance to an unweighted single pulse SEL of 160 dB re 1 $\mu Pa^2 \cdot s$ was modelled to assess the size of the low-power zone required under the EPBC Act Policy Statement 2.1 (DEWHA 2008b).

Contours of the modelled underwater sound fields were computed, sampled either as the maximum value over all modelled depths (maximum-over-depth: MOD) or at the seafloor for the two single pulse locations, and for the two cumulative SEL_{24h} scenarios. The modelled distances for each of the sound exposure thresholds were computed from these contours. Two distances relative to the source are reported for each sound level:

1. R_{max} - the maximum range to the given sound level over all azimuths; and
2. R95% - the range to the given sound level after the 5% farthest points were excluded.

The difference between R_{max} and R95% depends on the source directivity and the non-uniformity of the acoustic environment. In some environments a sound level contour might have small anomalous isolated fringes in which case the literal use of R_{max} can misrepresent the area of the region exposed to such effects. In these instances R95% is considered more representative. In environments that have bathymetric features that affect sound propagation then the R95% neglects to account for these and therefore R_{max} might better represent the region of effect in specific directions. For this impact assessment the R_{max} values have been considered.

The results of the sound propagation modelling are presented in relation to the relevant sound exposure thresholds for marine fauna groups in Section 7.1.2.4.

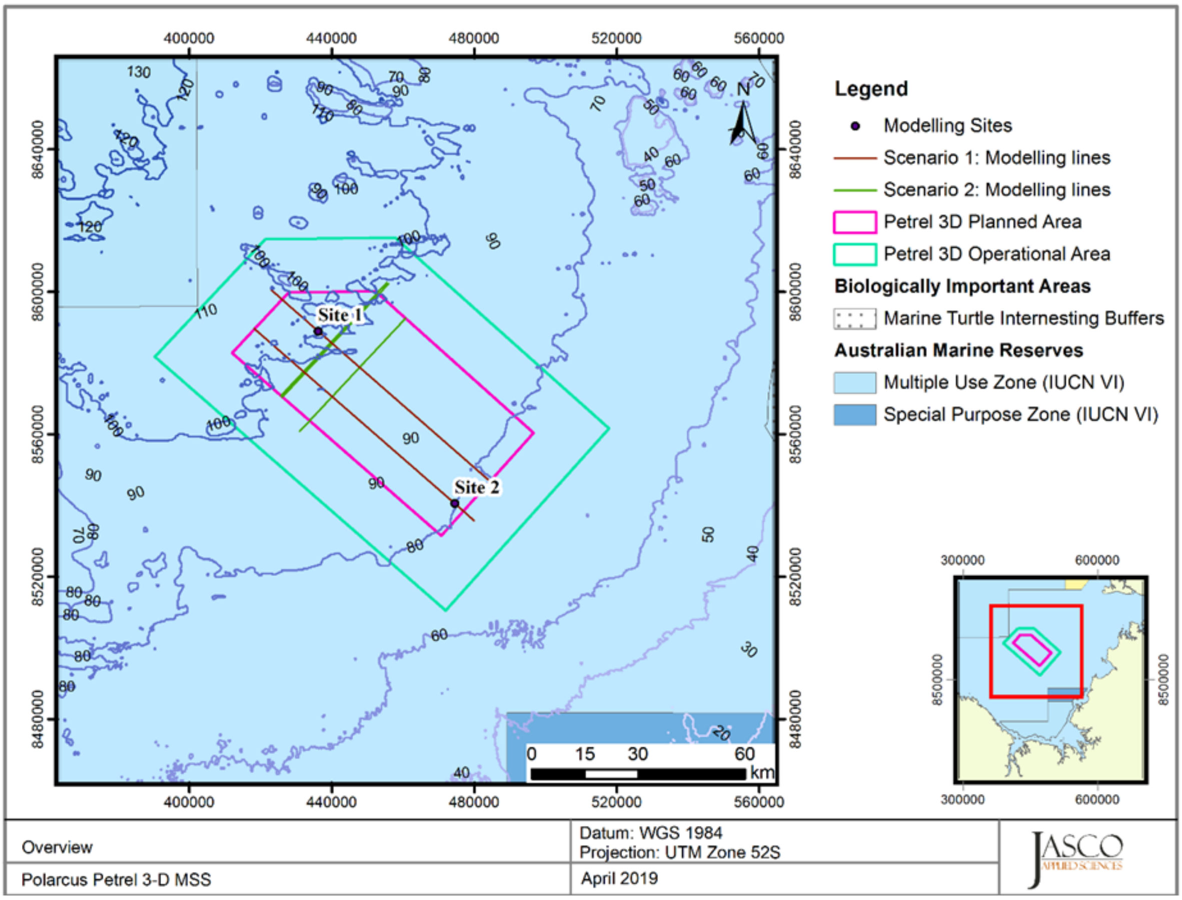


Figure 7-1 Petrelex 3D MSS Acoustic Modelling – Overview of Single Pulse Sites and SEL_{24h} Scenarios

7.1.2.3 Sound Exposure Thresholds

The levels of acoustic exposure that may result in injury or behavioural changes in marine fauna is an area of increasing research. Due to differences in experimental design, methodology and units of measure, comparison of studies to determine sound exposure thresholds can be difficult. On assessment of the available science, thresholds have been defined for informing the impact assessment, and interpreting the numerical noise modelling. These sound exposure thresholds are detailed for each receptor in Section 7.1.2.4. They have been selected on the basis that they include standard thresholds, thresholds suggested by the best available science, and sound levels presented in the scientific literature for species with no suggested thresholds.

Noise thresholds have been defined for both the per-pulse sound energy released, as well as the total sound energy (accumulated) that marine fauna is subjected to over a defined period of time. For recent regulatory assessments of seismic surveys, the period of total sound energy integration (i.e. accumulation) has been typically defined as 24 hours; hence, this was the period used for modelling and in this assessment. For fish this period is based on available research (Popper et al. 2014) which found fish experiencing TTS in hearing recovered to normal hearing levels within 18 to 24 hours, and for marine mammals the period is required to be either 24 hours or the length of the activity, whichever is shorter (NMFS 2018).

Importantly, the 24-hour accumulated sound metric reflects the dosimetric impact of noise levels within 24 hours based on the assumption that an animal is consistently exposed to such noise levels at a fixed position. More realistically, marine mammals and many fish (pelagic and some demersal) would not stay in the same location or at the same range for 24 hours. Popper et al. (2014) discuss the complications in determining a relevant sound exposure period of mobile seismic surveys, as the levels received by the receptor change between impulses due to the mobile source. For marine mammals and many fish, sound exposures at the closest point to the seismic source are the primary exposures contributing to a receptor's accumulated level (Gedamke et al. 2011). Hence, thresholds based on a 24-hour exposure period are considered to be a conservative measure of potential effect.

7.1.2.4 Impact Assessment

Cetaceans

Species Sensitivity and Sound Exposure Thresholds

Physiological impacts such as physical damage to the auditory apparatus, e.g., loss of hair cells or permanently fatigued hair cell receptors, can occur in marine mammals when they are exposed to intense or moderately intense sound levels and could cause permanent or temporary loss of hearing sensitivity. While the loss of hearing sensitivity is usually strongest in the frequency range of the emitted noise, it is not limited to the frequency bands where the noise occurs but can affect a broader hearing range. This is because animals perceive sound structured by a set of auditory bandwidth filters that proportionately increase in width with frequency.

Exposure to sufficiently intense sound may lead to an increased hearing threshold in any living animal capable of perceiving acoustic stimuli. If this shift is reversed and the hearing threshold returns to normal, the effect is called a temporary threshold shift (TTS). The onset of TTS is often defined as threshold shift of 6 dB above the normal hearing threshold (Southall et al. 2007). If the threshold shift does not return to normal, the residual shift is called a permanent threshold shift (PTS). PTS is hearing loss from which marine fauna do not recover (permanent hair cell or receptor damage). PTS is considered injurious in marine mammals.

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). Injury to the hearing apparatus of a marine animal may result from a fatiguing stimulus measured in terms of SEL, which considers the sound level and duration of the exposure signal. Intense sounds may also damage the hearing apparatus independent of duration, so an additional metric of PK is needed to assess acoustic exposure injury risk.

The sound exposure thresholds applied for cetaceans in the acoustic modelling study, and in this impact assessment, are summarised in Table 7-2, and are explained in more detail in the acoustic modelling report (Appendix E). Frequency weighting is also explained in Appendix A.3 of the acoustic modelling report (Appendix E). The peak pressure levels (PK) and frequency-weighted accumulated sound exposure levels (SEL) presented in Table 7-2 are from the U.S. National Oceanic and Atmospheric Administration (NOAA) Technical Guidance (NMFS 2018) for the onset of Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) in marine mammals. The marine mammal behavioural threshold presented in Table 7-2 is based on the current interim U.S. National Marine Fisheries Service (NMFS) (NMFS 2014) level of 160 dB re 1 µPa SPL for impulsive sound sources.

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. 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. There is, however, considerable individual difference in all TTS-related parameters between subjects and species tested so far.

There are no published data on the sound levels that cause PTS in marine mammals. The NMFS (2018) criteria incorporate the best available science to estimate PTS onset in marine mammals from sound energy (SEL24h), or very loud, instantaneous peak sound pressure levels. Hence, PTS effects in marine mammals should be viewed as theoretical, as they have never actually been demonstrated in either captive or wild animals.

Table 7-2 SPL, SEL_{24h}, and PK Thresholds for Acoustic Effects on Cetaceans

Hearing group	NMFS (2014)	NMFS (2018)			
	Behaviour	PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
	Unweighted SPL (dB re 1 μPa)	Frequency Weighted SEL_{24h} (dB re 1 μPa²·s)	PK (dB re 1 μPa)	Frequency Weighted SEL_{24h} (dB re 1 μPa²·s)	PK (dB re 1 μPa)
Low-frequency (LF) cetaceans	160	183	219	168	213
Mid-frequency (MF) cetaceans		185	230	170	224
High-frequency (HF) cetaceans		155	202	140	196

*Dual metric acoustic thresholds for impulsive sounds: use whichever results in the largest isopleth for calculating PTS onset.

Impact Assessment

The type and scale of the effect of seismic sound on cetaceans will depend on a number of factors including the level of exposure, the physical environment, the location of the animal in relation to the sound source, how long the animal is exposed to the sound, the exposure history, how often the sound repeats (repetition period) and the ambient sound level. The context of the exposure plays a critical and complex role in the way an animal might respond (Gomez et al. 2016; NMFS 2016). Without appropriate control measures in place, noise emissions from the seismic source have the potential to impact cetaceans by causing changes to hearing (PTS and TTS) as a result of high sound levels at close range to the seismic source, or behavioural disturbance impacts (refer to the sound exposure thresholds for PTS, TTS and behavioural disturbance described above).

As described in Section 4.5.8, no BIAs for cetaceans are located within or adjacent to the Operational Area or EMBA. The closest cetacean BIAs to the Operational Area are:

- Australian snubfin dolphin breeding/calving BIA, located along the Kimberley coastline approximately 135 km from the Operational Area (Figure 4-11);
- Indo-Pacific humpback dolphin foraging BIA, located along the Kimberley coastline approximately 143 km from the Operational Area (Figure 4-11);
- Indo-Pacific humpback dolphin and spotted bottlenose dolphin breeding and foraging BIAs, located near Darwin Harbour approximately 125 km from the Operational Area (Figure 4-11);
- Pygmy blue whale migration and distribution BIAs, located approximately 285 km north of the Operational Area; and
- Humpback whale migration, breeding and calving BIAs, located approximately 370 km south-west from the Operational Area.

As summarised in Table 4-9, there is the possibility that a number of cetacean species may be present in the Operational Area and wider EMBA during acquisition of the survey including those listed above and others such as sei, fin, killer and Bryde's whales.

The presence of these cetacean species within the Operational Area during acquisition of the survey is likely to be limited to occasional transits of isolated individuals or small pods.

No high-frequency (HF) cetaceans are likely to be present in the Operational Area and surrounding waters, and accordingly the impact assessment is focused on low-frequency (LF) cetaceans (baleen whales) and mid-frequency (MF) cetaceans (toothed whales and dolphins). It is noted that while dugongs were identified as potentially occurring in the EMBA through a PMST search, they are not expected to occur in or around the Operational Area due to the absence of suitable shallow water habitats. Impacts to dugong as a result of underwater from the seismic source are therefore not expected and are not addressed in this assessment.

Table 7-3 presents the results of the acoustic modelling study for maximum predicted R_{max} distances to PTS (injury), TTS and behavioural response thresholds for cetaceans, for all modelled scenarios (two single impulse sites and two multiple pulse scenarios). The results for the thresholds applied for cetacean PTS and TTS consider both metrics (single pulse PK and multiple pulse SEL_{24h}). In accordance with NMFS (2018) recommendations, the longest distance associated with either metric is required to be applied for an impact assessment.

Table 7-3 Maximum Predicted Horizontal Distances (R_{max}) to PTS (Injury), TTS and Behavioural Response Thresholds in Cetaceans, for All Modelled Scenarios

Hearing Group	Sound Exposure Threshold	R_{max} distance (km)
PTS		
LF-cetaceans	219 dB re 1 µPa (PK)	0.03
	183 dB re 1 µPa^2.s (SEL_{24h})	2.43#
MF-cetaceans	230 dB re 1 µPa (PK)	<0.02
	185 dB re 1 µPa^2.s (SEL_{24h})	-
TTS		
LF-cetaceans	213 dB re 1 µPa (PK)	0.07
	168 dB re 1 µPa^2.s (SEL_{24h})	30.1#
MF-cetaceans	224 dB re 1 µPa (PK)	<0.02
	170 dB re 1 µPa^2.s (SEL_{24h})	-
Behavioural Response		
LF-cetaceans	160 dB re 1 µPa (SPL)	7.48
MF-cetaceans		

Model does not account for shutdowns. A dash indicates that the threshold is not reached.

As shown in Table 7-3, considering the NMFS (2018) SEL_{24h} threshold criterion, LF-cetaceans (such as pygmy blue whales and humpback whales) are predicted to experience PTS at a maximum predicted distance of 2.43 km from the nearest survey line, based on application of the multiple pulse SEL_{24h} threshold across all water depths modelled (maximum-over-depth: MOD). For MF-cetaceans the maximum predicted distance to PTS effects reduces to <20 m, based on the application of the single pulse PK metric (the SEL_{24h} threshold was not exceeded).

The maximum predicted distance to the TTS thresholds for LF-cetaceans is 30.1 km from the nearest survey line, based on application of the multiple pulse SEL_{24h} threshold. This zone of potential TTS effects does not overlap any of the cetacean BIAs within the JBG. For MF-cetaceans the maximum predicted distance to TTS effects reduces to <20 m, based on the application of the single pulse PK metric.

As discussed above, the 24-hour SEL is a cumulative metric that reflects the dosimetric (measured dose) impact of noise levels over a period of 24 hours based on the assumption that an animal is consistently exposed to such noise levels at a fixed position. The modelling results show that the corresponding SEL_{24h} radii for LF-cetaceans were larger than those for peak pressure criteria, but they represent a worst-case scenario that is overly conservative and unlikely to occur. More realistically, whales would not stay in the same location or at the same range for 24 hours. This would particularly be the case for an animal migrating through offshore waters that don't represent critical habitat or a narrow restricted migratory pathway. Therefore, a reported radius for SEL_{24h} criteria does not mean that a whale travelling within this radius of the source will experience PTS or TTS, but rather that an animal could be exposed to the sound levels associated with these effects if it remained in that range for 24 hours (Quijano et al. 2019).

As shown in Table 7-3, predicted maximum R_{max} distances to PTS and TTS thresholds for LF-cetaceans based on the single pulse (PK) metric are considerably lower than those predicted using the multiple pulse SEL_{24h} thresholds. Application of the 219 dB re 1 µPa (PK) PTS threshold and of the 213 dB re 1 µPa (PK) TTS threshold indicates that predicted R_{max} radii from individual shot points are in the range of 30–70 m—i.e. a whale would have to be within a very close distance of the source (tens of metres) to be exposed to sound levels from a single pulse high enough to cause PTS or TTS effects.

The predicted maximum distance to the NMFS (2014) marine mammal behavioural threshold (single pulse 160 dB re 1 µPa SPL), for both LF and MF-cetacean, is approximately 7.5 km, across all water depths modelled (refer Table 7-3).

Injury (PTS) effects are predicted to occur in LF-cetaceans only within 30 m of the seismic source, based on the application of the single pulse PK metric. This potential impact is highly unlikely to occur given the control measures that will be in place during acquisition of the survey. The concept of an individual whale remaining within a range of 2.43 km (maximum predicted distance for PTS, based on the SEL_{24h} metric) from the operating seismic source for a full 24-hour period is not credible. Furthermore, the control measures include implementation of a shut-down zone of 500 m and a low-power zone of 2 km under Part A of EPBC Policy Statement 2.1, which will further reduce the risk of injury.

TTs effects are predicted to occur in LF-cetaceans only within 70 m of the seismic source, based on the application of the single pulse PK metric. Based on the SEL_{24hr} metric, the maximum predicted distance for TTS is 30.1 km. However, as described above in relation to PTS, it is not credible that a whale would be consistently exposed to noise levels at a fixed position over a 24 hour period. Should an individual remain within the range for potential impact, some recoverable TTS could occur. The likelihood of TTS occurring is further reduced by the implementation of a shut-down zone of 500 m and a low-power zone of 2 km under Part A of EPBC Policy Statement 2.1.

The potential impacts of noise emissions from the seismic source on cetaceans during acquisition of the Petrelex 3D MSS are considered to be slight and short-term, and most likely limited to temporary behavioural changes (avoidance) in individuals.

Summary

Based on the duration of the survey, the absence of critical habitats for any species of cetacean (i.e. feeding, breeding, calving areas) or a constricted migratory pathway within the Operational Area and surrounding waters, and the control measures proposed, predicted noise levels from seismic acquisition are not considered likely to cause injury (PTS) effects, or any ecologically significant impacts at a population level for any species of cetacean that may be present within or adjacent to the Operational Area during the survey.

Taking into account the adopted controls, the consequence of occasional short-term and localised disturbance to cetaceans is Slight (1). The likelihood of this consequence occurring is Rare (B) and the residual risk is considered to be Low.

Marine Reptiles

Species Sensitivity and Sound Exposure Thresholds

Hearing has been studied in only a few individual marine turtles. Turtles have been shown to respond to low frequency sound, with indications that they have the highest hearing sensitivity in the frequency range 100‑700 Hz.

Thresholds of 232 dB re 1 µPa (PK) for PTS effects and 226 dB re 1 µPa (PK) for TTS effects (Finneran et al. 2017), were applied for this impact assessment. A behavioural response threshold of 166 dB re 1 µPa SPL (NSF 2011), along with a sound level associated with an increased level of behavioural response of 175 dB re 1 µPa (SPL) (Moein et al. 1995; McCauley et al. 2000a, 2000b; NSF 2011) were also applied for this impact assessment.

Sea snake responses to seismic survey sound emissions are not well studied and thus conservatively assumed to be similar to that of turtles as described above.

Impact Assessment

The Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017) identifies acute noise interference from anthropogenic noise sources, such as seismic surveys, as a threat to the WA stocks of green, loggerhead and flatback turtles in the JBG region (refer to Table 2-4).

Without appropriate control measures in place, noise emissions from the seismic source have the potential to impact marine reptiles (turtles and seasnakes) by causing changes to hearing (PTS and TTS) as a result of high sound levels at close range to the seismic source, or behavioural disturbance impacts.

As described in Section 4.5.7, there are several BIAs for marine turtle species in the region, including those along the coastline in the JBG, in close-proximity to the Operational Area. The Operational Area overlaps with the foraging BIA for green, loggerhead, flatback and olive ridley turtles. The Operational Area also overlaps with the Pinnacles of the Bonaparte Basin KEF, and there are two individual pinnacles that are located within the Operational Area (and outside the Acquisition Area). However, water depths on the tops of these pinnacles are in the range of approximately 80 – 92 m, and therefore are highly unlikely to represent foraging habitats for any turtle species. Minimum water depths within the Operational Area are approximately 65 m, and as described in Section 4.5.7.1, it is unlikely that any areas in the JBG with water depths greater than 40 m represent important foraging areas for turtles.

The proposed timing for acquisition of the Petrelex 3D MSS (within the period September 2019 to December 2020) means that there could be overlap with the nesting and breeding seasons for green, flatback and olive ridley turtles in the region (refer to Table 4-11). At the closest point, the eastern corner of the Operational Area is located at least 44 km from the boundary of the 'Habitat Critical' for flatback turtles on the eastern side of the JBG (refer to Figure 4-10).

Similarly, the southern corner of the Operational Area is located at least 85 km from the boundary of the 'Habitat Critical' surrounding Cape Domett (refer to Figure 4-10). Hence, only isolated individuals are expected to transit occasionally through the Operational Area during acquisition of the survey.

At least 20 species of sea snake occur within the region (DEWHA 2008a). Amongst these species, no threatened and 18 listed marine sea snake species were identified to potentially occur in the Operational Area from a search of the EPBC Act Protected Matters Database. No coral reefs occur within or in close proximity to the Operational Area, and therefore sea snakes are expected to occur in very low numbers, if at all.

Table 7-4 presents the results of the acoustic modelling study for maximum predicted R_{max} distances to PTS, TTS and behavioural response thresholds in turtles for all modelled scenarios (two single pulse sites and two multiple pulse scenarios).

Table 7-4 Maximum Predicted Horizontal Distances (R_{max}) to PTS (Injury), TTS and Behavioural Response Thresholds in Turtles, for All Modelled Scenarios

Potential Impact	Sound Exposure Threshold	Distance R_{max} (km)
PTS	232 dB re 1 µPa (PK)	<0.02
TTS	226 dB re 1 µPa (PK)	<0.02
Behavioural response	175 dB re 1 µPa (SPL)*	1.59
	166 dB re 1 µPa (SPL)#	4.53

#Thresholds for turtle behavioural response to impulsive noise (NSF 2011).
*Threshold for turtle behavioural response to impulsive noise (Moein et al. 1995).

As shown in Table 7-4, the Finneran et al. (2017) PK turtle injury (PTS) and TTS threshold criteria of 232 dB re 1 µPa (PTS) and 226 dB re 1 µPa (TTS) were not exceeded at a distance greater than 20 m from the centre of the seismic array. Because the array is not a point source (measuring approximately 14 x 8 m in the horizontal plane), the actual effect range from the edge of the array will be less than 20 m. The NMFS criterion (NSF 2011) for behavioural effects in turtles (166 dB re 1 µPa SPL) could be exceeded within a distance of approximately 4.5 km of the operating array, and the Moein et al. (1995) criterion of 175 dB re 1 µPa (SPL) could be exceeded within 1.6 km of the array.

Summary

As described above, at the closest point, the Operational Area is located at least 44 km from the nearest 'Habitat Critical' for flatback turtles in the JBG. Whilst the Operational Area overlaps foraging BIAs for green, loggerhead, flatback and olive ridley turtles in the JBG, the relatively deep water depths and absence of shallow pinnacles or banks within the Operational Area mean that the area is unlikely to represent significant foraging habitat for turtles. Occurrence of turtles within the Operational Area, and in adjacent waters, is likely to be limited to isolated individuals transiting through these waters.

The potential impacts of noise emissions from the seismic source on green, flatback, loggerhead, and olive ridley turtles during acquisition of the Petrelex 3D MSS are considered to be slight and short-term, and restricted to temporary behavioural changes (avoidance) in any isolated individuals that may transit the area in close proximity to the operating seismic source. Based on the timing and duration of the survey, the separation distances to nesting BIAs and 'Habitat Critical' areas, and the control measures proposed, predicted noise levels from seismic acquisition are not considered likely to cause PTS effects, displace any individuals from internesting BIAs or 'Habitat Critical' areas, or result in any ecologically significant impacts at a population level for any species of turtle that may be present within or adjacent to the Operational Area during the survey.

Seasnake responses to seismic survey sound emissions are not well studied and thus conservatively assumed to be similar to that of turtles. Seasnakes tend to occur in shallow coastal and inland waters associated with coral reefs and are not expected to be common in the Operational Area. Therefore, impacts are likely to be limited to occasional disturbances to transient individuals. The potential consequence to sea snake populations is considered to be insignificant.

Taking into account the adopted controls, the consequence of occasional short-term and localised disturbance to marine reptiles is Slight (1). The likelihood of this consequence occurring is Rare (B) and the residual risk is considered to be Low.

Seabirds

As described in Section 4.5.6, three threatened and migratory, and nine migratory seabird species were identified by a search of the EPBC Act Protected Matters Database as potentially occurring in the Operational Area, through foraging, feeding, breeding or other related behaviours. Seabird species that spend the majority of their lives within the region breed at locations along the coast of Australia and at offshore islands. At the closest point, the Operational Area is located approximately 100 km from a breeding and foraging BIA for the lesser crested tern along the north Kimberley coastline in the western extent of the JBG (refer Figure 4-7). There are no other seabird BIAs in the JBG in proximity to the Operational Area.

Impacts to foraging seabirds have not been observed previously during seismic surveys. Only birds diving and foraging within the Operational Area have the potential to be exposed to increased sound levels generated by the operating seismic source while diving for small pelagic fishes near the sea surface. Such behaviours may result in a startle response during diving. Birds resting on the surface of the water in proximity to the seismic vessel have limited potential to be affected by sound emissions underwater due to the limited transmission of sound energy between the water/air interface, but may be startled by seismic pulses in close proximity to the seismic source. However, given the likely avoidance response from fish and other prey species in waters immediately surrounding the seismic source, birds are unlikely to forage near the operating seismic source. In the unlikely event that birds dive and forage near the seismic source, this is likely to only affect individual birds, resulting in a startle response with the affected birds expected to move away from the area as a result. The consequence of this is expected to be negligible and impacts at a population level are extremely unlikely to occur. Lesser crested terns will not be displaced from the wider areas of the breeding and foraging BIAs in the south-western JBG.

The behaviour and distribution of some fishes may be affected for short periods during and after exposure to the seismic source, which may result in short-term and localised changes in the distribution of target prey species for some seabirds. However, these effects are unlikely to be discernible to foraging birds in the context of the normal movements and variation in the distribution of fishes. The behaviours and distribution of prey at any one time will remain largely unaffected in the Operational Area. Therefore, impacts to seabird populations are highly unlikely to occur.

Summary

Taking into account the adopted controls, the consequence of occasional short-term and localised disturbance to seabirds is Slight (1). The likelihood of this consequence occurring is Rare (B) and the residual risk is considered to be Low.

Fishes and Elasmobranchs

Species Sensitivity and Sound Exposure Thresholds

The most relevant metric for perceiving underwater sound for most fish species is particle motion but, with the exception of few species (Popper and Fay 2011; Popper et al. 2014), there is an almost complete lack of relevant data on particle motion sensitivity in fishes (Popper and Hawkins 2018). The majority of fish species detect sounds from below 50 Hz up to 500-1,500 Hz. A smaller number of species can detect sounds to over 3 kHz, while a very few species can detect sounds to well over 100 kHz. The critical issue for understanding whether an anthropogenic sound affects hearing is whether it is within the hearing frequency range of a fish and loud enough to be detectable above background ambient noise. For this impact assessment, it is assumed that all fishes can detect signals below 500 Hz and so can 'hear' the seismic source.

The modelling study assessed the ranges for quantitative threshold criteria based on the Popper et al. (2014) guidelines, and considered both PK and SEL_{24h} metrics for both water column and seafloor associated with mortality/PMI and impairment in the following groups:

- I - Fish without a swim bladder (also appropriate for sharks in the absence of other information);
- II - Fish with a swim bladder that do not use it for hearing;
- III - Fish that use their swim bladders for hearing; and
- Fish eggs and fish larvae.

The sound exposure thresholds applied for fishes and elasmobranchs (sharks and rays) in the acoustic modelling study, and in this impact assessment, are summarised in Table 7-5 and explained in more detail in the acoustic modelling report (Appendix E).

It is noted that while thresholds for fish mortality have been included for consideration in this assessment based on the Popper et al. (2014) guidelines, no studies to date have demonstrated direct mortality of adult fish in response to airgun emissions, even when fired at close proximity (within 1–7 m) (DFO 2004; Boeger et al. 2006; Popper et al. 2016; Carroll et al. 2017). Although some fish deaths have been reported during cage experiments, these were more likely caused by experimental artefacts of handling or confinement stress (Hassel et al. 2004, as cited in NSW DPI 2014). For free-swimming fish that are able to move away from seismic sources as they approach, the potential for lethal physical damage from airgun emissions is even further nullified. However, reef or bottom-dwelling fish that show greater site attachment may be less inclined to flee from a seismic sound source and experience greater effects as a consequence.

Despite mortality being a possibility for fish exposed to airgun sounds, Popper et al. (2014) do not reference an actual occurrence of this effect. In Popper et al. (2014) pile driving data was used as a proxy as the research to date had not identified a threshold level were mortality has been observed. Since the publication of that report, newer studies have further examined the question of possible mortality. Popper et al. (2016) adds further information to the possible levels of impulsive seismic airgun sound to which adult fish can be exposed without immediate mortality. They found that the two fish species in their study (pallid sturgeon and paddlefish), with body masses in the range 200–400 g, exposed to a single shot of a maximum received level of either 231 dB re 1 μPa (PK) or 205 dB re 1 $\mu Pa^2 \cdot s$ (SEL), remained alive for seven days after exposure and that the probability of mortal injury did not differ between exposed and control fish. They also found no difference in injuries between fish exposed closest to the source compared to those further away. Thus, this study, using an actual seismic source, did not show mortality at a level higher than the mortality, potential mortal injury and recoverable injury to the threshold of 207 dB re 1 μPa (PK) applied in this impact assessment.

ERM (2017) conducted a detailed literature review of potential fish mortality and physical injury as a result of exposure to seismic sources. Only three studies of the 23 reviewed observed direct mortality of exposed fish:

- Booman et al. (1996) – at received levels (RL) of 241-231 dB PK;
- Weinhold and Weaver (1972) – at RL of 234 dB PK; and
- Matishov (1992) – at RL of 220 dB PK.

In each case mortalities occurred to caged fish that were constrained within very close proximity to the airguns (<2 m). The results of the Matishov (1992) study should be treated with some caution, given the lack of detail provided for this experiment.

Eleven other studies did not observe mortality effects or injury likely to result in mortality, at RL levels ranging from 246-220 dB PK. Fanta (2004) found no mortality or physical damage in coral reef fishes exposed in cages to RL ranging from 235-215 dB PK. The relevance of the findings of this study are regarded as high, given that the RL were measured and that the experiment involved exposure of 15 different fish species to a full commercial seismic array (3,090 cui) at a minimum exposure distance of 45 m. Wardle et al. (2001) did not observe any mortality or physical damage in free-ranging temperate reef fish exposed to RL of 218 dB PK, at a minimum exposure distance of 5.3 m. Again, the relevance of the results of this experiment is regarded as high, in that the RL were measured rather than estimated.

Based on the above studies, the thresholds of 207 and 213 dB re 1 μPa (PK) applied in this impact assessment for potential mortality and recoverable injury in fishes are considered to be highly conservative.

Table 7-5 Sound Thresholds for Seismic Sound Exposure for Fish, Fish Eggs and Larvae, Adapted from Popper et al. (2014)

Type	Mortality and Potential Mortal Injury	Impairment			Behaviour
		Recoverable Injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	>219 dB SEL_{24h} or >213 dB PK	>216 dB SEL_{24h} or >213 dB PK	>>186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	210 dB SEL_{24h} or >207 dB PK	203 dB SEL_{24h} or >207 dB PK	>>186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{24h} or >207 dB PK	203 dB SEL_{24h} or >207 dB PK	186 dB SEL_{24h}	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate
Fish eggs and fish larvae	>210 dB SEL_{24h} or >207 dB PK	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Peak sound level (PK) dB re 1 µPa; SEL_{24h} dB re 1µPa^2·s. All exposure thresholds are presented as sound pressure, even for fish without swim bladders, since no data for particle motion exist. Relative risk (high, moderate, or low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

Impact Assessment

As described in Section 4.5.3 and Section 4.5.9, the Operational Area and surrounding waters represent habitat for a range of bony fishes (teleosts) and elasmobranchs (sharks and rays), including pelagic, demersal and benthic assemblages. These fish assemblages include species and stocks that are targeted by commercial fisheries in the region (e.g. goldband snapper, red emperor and Spanish mackerel). The Operational Area is located at least 244 km from the whale shark foraging BIA that extends northwards across the North West Shelf and the Browse Basin along the 200 m isobath (refer to Figure 4-12).

The EPBC Protected Matters Search (refer Section 4.5.3) identified 24 pipefish species, four seahorse species, one pipehorse species and one seadragon that may potentially occur in the Operational Area and surrounding waters. Pipefish and seahorses occur in nearshore and coastal waters comprising suitable habitat, such as seagrass, mangrove, coral reef and sandy habitats around coastal islands and shallow reef areas. Due to water depth range within the Operational Area (65 - 111 m) and absence of suitable habitat, pipefish and seahorses are unlikely to occur within the Operational Area and surrounding waters. Consequently, these listed marine species are not considered in this impact assessment.

The Operational Area overlaps the Pinnacles of the Bonaparte Basin key ecological feature (KEF). As described in Section 4.3.1, the pinnacles provide areas of hard substrate in an otherwise soft sediment environment and are therefore important for sessile species. Rising steeply from depths of about 80 m some pinnacles emerge to within 30 m of the water surface, allowing light dependent organisms to thrive. Pinnacles that rise to within 45 m water depth support more biodiversity. Communities include sessile benthic invertebrates including hard and soft corals, sponges, whips, fans, bryozoans and aggregations of demersal fish species such as snappers, emperors and groupers (Brewer et al. 2007; Nichol et al. 2013).

Without appropriate control measures in place, noise emissions from the seismic source have the potential to impact fishes and elasmobranchs by causing mortality / potential mortal injury (PMI), recoverable injury and hearing impairment (TTS and masking) as a result of high sound levels at close range to the seismic source, or behavioural disturbance impacts at greater distances.

Table 7-6 presents the results of the acoustic modelling study for maximum predicted R_{max} distances to mortality/PMI, recoverable injury and TTS thresholds in fishes in the Operational Area. Data are presented for the both the water column (MOD) and at the seafloor. The results are further summarised in Table 7-7.

Table 7-6 Maximum Predicted Distances (R_{max}) to Mortality/PMI, Injury and TTS Thresholds for Fish and Fish Eggs and Larvae for Single Pulse and SEL_{24h} Modelled Scenarios, for Both Water Column and at the Seafloor

Marine Fauna Group	Potential Impact	Sound Exposure Threshold	Maximum-over-depth (MOD)		Seafloor	
			R_{max} (km)	Area (km²)	R_{max} (km)	Area (km²)
I Fish: No swim bladder (incl. sharks)	Mortality/PMI	219 dB re 1 µPa²·s (SEL_{24h})	0.05	6.4	-	-
		213 dB re 1 µPa (PK)	0.07	NR*	0.07	NR*
	Recoverable injury	216 dB re 1 µPa²·s (SEL_{24h})	0.05	11.7	-	-
		213 dB re 1 µPa (PK)	0.07	NR*	0.07	NR*
	TTS	186 dB re 1 µPa²·s (SEL_{24h})	3.08	945.3	5.06	888.6
II Fish: Swim bladder not involved in hearing (particle motion detection)	Mortality/PMI	210 dB re 1 µPa²·s (SEL_{24h})	0.05	12.8	-	-
		207 dB re 1 µPa (PK)	0.16	NR*	0.21	NR*
	Recoverable injury	203 dB re 1 µPa²·s (SEL_{24h})	0.05	12.8	NR*	NR*
		207 dB re 1 µPa (PK)	0.16	NR*	0.21	NR*
	TTS	186 dB re 1 µPa²·s (SEL_{24h})	3.08	945.3	5.06	888.6
III Fish: Swim bladder involved in hearing (primarily pressure detection)	Mortality/PMI	207 dB re 1 µPa²·s (SEL_{24h})	0.05	12.8	-	-
		207 dB re 1 µPa (PK)	0.16	NR*	0.21	NR*
	Recoverable injury	203 dB re 1 µPa²·s (SEL_{24h})	0.05	12.8	-	-
		207 dB re 1 µPa (PK)	0.16	NR*	0.21	NR*
	TTS	186 dB re 1 µPa²·s (SEL_{24h})	3.08	945.3	5.06	888.6
Fish eggs and larvae	Mortality/PMI	210 dB re 1 µPa²·s (SEL_{24h})	0.05	12.8	-	-
		207 dB re 1 µPa (PK)	0.16	NR*	0.21	NR*
	Injury	Popper et al. (2014) relative risk criteria#	(N) Moderate; (I) Low; (F) Low			
	TTS		N) Moderate; (I) Low; (F) Low			

*Not relevant. A dash indicates the threshold was not reached. #Relative risk (high, moderate or low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

Table 7-7 Summary of Maximum Distances to Injury and TTS Onset in Fish, Fish Eggs and Larvae for Single Pulse and SEL_{24h} Modelled Scenarios

		Water Column	Seafloor

Marine Fauna Group	Impact Criteria	Metric associated with longest distance to impact criteria	R_{max} (km)	Metric associated with longest distance to impact criteria	R_{max} (km)
I - Fish: No swim bladder (incl. sharks)	Injury	PK	0.07	PK	0.21
	TTS	SEL_{24h}	3.08	SEL_{24h}	5.06
II - Fish: Swim bladder not involved in hearing III – Fish: Swim bladder involved in hearing	Injury	PK	0.16	PK	0.21
	TTS	SEL_{24h}	3.08	SEL_{24h}	5.06
Fish eggs and larvae	Injury	PK	0.16	PK	0.21

The following fish types have been identified for this assessment:

- Site-attached species associated with the Pinnacles of the Bonaparte Basin KEF;
- Demersal fish species, including key commercial indicator species such as tropical snappers and emperors (families Lutjanidae and Lethrinidae);
- Pelagic fish species, including key commercial indicator species such as Spanish mackerel; and
- Whale sharks.

Pinnacles of the Bonaparte Basin KEF

As shown in Table 7-6, the maximum predicted R_{max} distances to the injury thresholds of 213 dB re 1 µPa (PK) and 207 dB re 1 µPa (PK) at the seafloor for all hearing groups of fishes, and for fish eggs and larvae, range from 70-210 m. The maximum predicted R_{max} distance to the TTS threshold of 186 dB re 1 µPa^2·s (SEL_{24h}) at the seafloor for all hearing groups of fishes is 5.1 km.

As described above, the Operational Area for the Petrelex 3D MSS overlaps two pinnacles within the defined KEF. There are no pinnacles within the Acquisition Area. The area of overlap between the KEF and the Operational Area is approximately 13.7 km^2, which represents approximately 4.4% of the designated area of the KEF (309.5 km^2). Given the maximum predicted R_{max} distances for injury and TTS effects of up to 210 m and 5.1 km, respectively, there is the potential for some fishes at the seafloor to experience recoverable injury and TTS effects.

Given the maximum predicted R_{max} distance to injury effects in Group I fishes (with no swim bladder) of 70 m (refer to Table 7-6), and the water depths of the two pinnacles (82 – 90 m) in the Operational Area, there is a very low likelihood that any Group I fishes inhabiting the Pinnacles of the Bonaparte Basin KEF would experience these effects.

Any potential injury to Group II and Group III fishes and to fish eggs and larvae, or TTS effects to all groups within the Pinnacles of the Bonaparte Basin KEF is not likely to be ecologically significant at a population level for the following reasons:

- Limited spatial and temporal overlap with the KEF - ~4.4% of the total area of the KEF, and 64 days of seismic acquisition.
- The sound exposure thresholds applied are highly conservative and the criteria predicting the largest impact ranges (across all of the modelled sites and scenarios) have been utilised, providing further conservatism in the impact assessment.
- The area of potential impact assumes that the area will receive the same sound levels at the same time for the period of a survey, which is not the case. The received sound levels at a location will reduce and increase as the seismic vessel moves through the area during a survey.

- The area of potential impact for the assessed species is a low proportion of the area they are likely to inhabit. Thus, population effects are not likely as there is a significant proportion of the population that remains unaffected.
- The potential area of impact for fish TTS is assessed as being acceptable based on hearing loss (and subsequent decrease in fitness) being temporary and recovery taking place in a relatively short timeframe after the source array has moved away from the exposed fish, and the sound levels are reduced. Popper et al. (2005) reports that fish that showed TTS recovered to normal hearing levels within 18-24 hours.
- Popper (2018) in his expert review of TTS for the Santos Bethany 3D MSS[4], which considered similar fish species as present within and adjacent to the Petrelex 3D MSS Operational Area, noted:
  - It is highly unlikely that there would be physical damage to fishes as a result of the survey unless the animals are very close to the source (perhaps within a few metres).
  - Most fishes in the Bethany region (and given the similarity in fish species, this also applies for the Petrelex 3D MSS Operational Area and surrounding waters), being species that do not have hearing specialisations, are not likely to have much (if any) TTS as a result of the Bethany 3D Survey.
  - If TTS takes place, its level is likely to be sufficiently low that it will not be possible to easily differentiate it from normal variations in hearing sensitivity. Even if fishes do show some TTS, recovery will start as soon as the most intense sounds end, and recovery is likely to even occur, to a limited degree, between seismic pulses. Based on very limited data, recovery within 24 hours (or less) is very likely.
  - Nothing is known about the behavioural implications of TTS in fishes in the wild. However, since the TTS is likely very transitory, the likelihood of it having a significant impact on fish fitness is very low.

Based on the qualitative approach applied in Popper et al. (2014) the likelihood of behavioural effects occurring is assessed as high within tens of metres of the seismic source (refer to Table 7-6). Site-attached fish communities at 82 - 90 m depth (on the pinnacles) are therefore not likely to exhibit behavioural responses to noise emissions from the seismic source.

Demersal Fish Species

As shown in Table 7-6, the maximum predicted R_{max} distance to the injury threshold at the seafloor for the hearing group of fishes with swim bladders (Group II and III, which would represent most demersal fish), is 210 m. The maximum predicted R_{max} distances to the injury thresholds for adult fish (with swim bladder), and fish eggs and larvae, in the water column is 160 m. Therefore, injury effects could occur to demersal fishes at or close to the seafloor within or adjacent to the Acquisition Area. However, these effects are not likely to be significant for the reasons outlined above. Demersal fish species, such as snapper and emperor, though not as strong swimmers as pelagic fish species, cannot be regarded as 'site-attached' as they are able to move away from an approaching seismic source.

Based on the maximum predicted R_{max} distances to the TTS threshold (~3.1 km in the water column and ~5.1 km at the seafloor; refer to Table 7-7) individuals in demersal fish communities at or close to the seafloor within the Acquisition Area could experience TTS effects. However, these effects are not likely to be significant for the reasons outlined above. TTS effects are unlikely to occur as an individual would have to remain within a range of ~5.1 km of the operating seismic source for a full 24-hour period to be exposed to sound levels that could cause TTS. This is not a credible or realistic scenario.

[4] The Bethany 3D MSS had a seismic source size of 2,380 in^3, which is comparable to the seismic source size (2,495 in^3) for the Petrelex 3D MSS.

Pelagic Fish Species

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 (Group II). As a group, they seem able to detect mid-range frequencies (~300-1,000 Hz).

As shown in Table 7-7, the maximum predicted R_{max} distance to the injury threshold in the water column for the hearing groups of fishes with swim bladders (Groups II and III), is 160 m (refer to Table 7-7). The maximum predicted R_{max} distance to the TTS threshold in the water column for all fish hearing groups is ~3.1 km.

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 a seismic source. Individuals would have to remain within ranges of approximately 3.1 km of the operating seismic 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 an operating seismic source that approaches within a few tens of metres of them.

Whale Sharks

The Operational Area is located at least 244 km from the whale shark foraging BIA that extends northwards across the North West Shelf and the Browse Basin along the 200 m isobath (refer Figure 4-12). It is possible that individual whale sharks may transit through the Operational Area for the Petrelex 3D MSS.

No sound exposure thresholds currently exist for acoustic impacts from seismic sources to sharks. As a conservative and precautionary approach, the Popper et al. (2014) exposure guidelines for fish with no swim bladder for injury; 213 dB re 1 μPa (PK) and 219 dB re 1 $\mu Pa^2 \cdot s$ (SEL_{24h}); and TTS (186 dB re 1 $\mu Pa^2 \cdot s$ (SEL_{24h}), have been used for this assessment.

As shown in Table 7-7, the maximum predicted R_{max} distance to the injury threshold in the water column for the hearing group of fishes without swim bladders, is 70 m. The maximum predicted R_{max} distance to the TTS threshold for this fish hearing group is ~3.1 km. Again, it is important to appreciate that individual whale sharks would have to remain within a range of approximately 3.1 km of the operating seismic source (which is also moving) for a full 24 hour period to be exposed to sound levels that could cause TTS.

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 the Popper et al. (2014) guidelines, which detail that there is the potential for high risk of behavioural impacts in fish species near the seismic source (tens of metres) with the level of risk declining to low at thousands of metres from the seismic source.

Seismic noise has not been identified as a threat to whale sharks (or other shark species identified that may be present in the region) in either the Approved Conservation Advice (TSCC 2015) or previously in force Whale Shark Recovery Plan 2005 – 2010 (DEH 2005). Noise pollution is not identified as a pressure to whale sharks in the Marine Bioregional Plan for the NWMR (DSEWPaC 2012), or in the Ningaloo Coast: World Heritage nomination report (Commonwealth of Australia 2010).

Summary

The potential impacts of noise emissions from the seismic source on fishes and elasmobranchs during the Petrelex 3D MSS are considered to be localised and of no lasting effect, and restricted to temporary behavioural changes (avoidance) in any isolated individuals that may transit the area in close proximity to the operating seismic source.

Based on the timing and duration (up to 64 days) of seismic acquisition, and the control measures that will be implemented, predicted noise levels from seismic acquisition are not considered likely to cause injury or TTS effects, or result in any ecologically significant impacts at a population level for any species of fishes that may be present within or adjacent to the Operational Area during the Petrelex 3D MSS.

Taking into account the adopted controls, the consequence of occasional short-term and localised disturbance to fishes and elasmobranchs is Slight (1). The likelihood of this consequence occurring is Occasional (C) and the residual risk is considered to be Low

Benthic Invertebrates

Species Sensitivity and Sound Exposure Thresholds

Research is ongoing into the relationship between sound and its effects on marine invertebrates such as crustaceans, including the relevant metrics for both effect and impact.

Marine invertebrates lack a gas-filled bladder and are thus unable to detect the pressure component of sound waves. However, all cephalopods as well as some bivalves, echinoderms and crustaceans have a sac-like structure called a statocyst, which includes a mineralised mass (statolith) and associated sensory hairs (Carroll et al. 2017).

Cephalopods have epidermal hair cells which help them to detect particle motion in their immediate vicinity (Kaifu et al. 2008). Decapods have similar sensory setae on their body (Popper et al. 2001) and antennae which may be used to detect low-frequency vibrations (Montgomery et al. 2006).

The statocyst organs, found in a wide range of invertebrates, are utilised by animals to maintain their equilibrium and orientation and to direct their movements through the water. Their functions include the detection of gravitational forces and linear accelerations. Although there is little information available on the functioning of these sensory organs, it has been suggested that marine invertebrates are sensitive to low-frequency sounds and that this sensitivity is not directly linked to sound pressure but to particle motion detection (André et al., 2016; Roberts et al., 2016; Edmonds et al., 2016). The statocysts may play a key role in controlling the behaviour responses of invertebrates to a wide range of stimuli. Water depth and seismic source size are related to the particle motion levels at the seafloor, with larger arrays and shallower water being related to higher particle motion levels, more likely relevant to effects on benthic invertebrates.

At the seafloor interface, crustaceans and bivalves are subject to particle motion stimuli from several acoustic or acoustically-induced waves. These include the particle motion associated with an impinging sound pressure wave in the water column (the incident, reflected, and transmitted portions), substrate acoustic waves, and interface waves of the Scholte type. However, it is unclear which aspect(s) of these waves is/are most relevant to the animals, either when they normally sense the environment or their physiological responses to loud sounds so there is not enough information to establish similar criteria and thresholds as done for marine mammals and fish. Including recent research, such as Day et al. (2016a), current literature does not clearly define an appropriate metric or identify relevant levels (pressure or particle motion) for an assessment. This includes the consideration of what particle motion levels lead to a behavioural response, or mortality. Therefore, at this stage, we cannot propose authoritative thresholds to inform the impact assessment. However, levels can be determined for pressure metrics presented in literature to assist the assessment.

For crustaceans, a PK-PK sound level of 202 dB re 1 μPa (Payne et al. 2008) is considered to be associated with no impact, and therefore applied in this impact assessment. Additionally for context, the PK-PK sound levels determined for crustaceans in Day et al. (2016a), 209–212 dB re 1 μPa are also considered in this impact assessment.

Additionally, a threshold of 226 dB re 1 µPa PK was modelled and used for this impact assessment, for comparison to Heyward et al. (2018) with regard to potential impacts to sponges and corals.

Impact Assessment

There has recently been a number of comprehensive reviews of seismic noise impacts to invertebrates; Carroll et al. (2017), Edmunds et al. (2016) and DPIRD (Webster et al. 2018). Studies specific to prawn species are limited, however, a number of studies have been undertaken on decapods with a range of effects to no effects identified. As such studies of species in the same scientific order (Decapoda) have been used to provide an indication of how sensitive prawns are when exposed to sound waves.

Edmonds et al. (2016) undertook a review and critical evaluation of crustacean sensitivity to loud impulsive, low frequency underwater noise typically produced by seismic surveys. They identified that sensitivity to underwater noise is shown by the Norway lobster and closely related crustacean species, including juvenile stages. They concluded that current evidence supports physiological sensitivity to local, particle motion effects of sound production. The DPIRD review (Webster et al. 2018) also supported that there was no evidence in the current literature of direct mortality of crustaceans from seismic exposure. A range of physiological responses have been identified in some studies, however, the received sound levels are typically at levels that would be received within a few hundred metres from the sound source or have been from repeated exposure at the same sound levels which is not realistic in an actual survey.

Day et al. (2016a) found airgun exposure caused damaged statocysts in rock lobsters (*Jasus edwardsii*) up to a year later. However, no such effects were detected in snow crabs after exposure to 200 shots at 10 s intervals and 17–31 Hz) (Christian et al. 2003). For these studies, measured received noise levels were 209-212 dB re 1 µPa (PK-PK) and 197-237 dB re 1 µPa (PK-PK), respectively. Day et al. (2016a) also found that the rock lobster showed delayed time to right itself after exposure to airguns and that two out of three experiments found no difference in tail extension reflex, while one showed exposed lobsters had a 23% decrease 14 days after exposure. In contrast, no differences in righting time were detected in the American lobster (*Homarus americanus*) 9, 65, or 142 days after exposure to airgun noise (Payne et al. 2008). For these studies, measured received noise levels were 209-212 dB re 1 µPa (PK-PK) and 202 dB re 1 µPa (PK-PK), respectively.

Day et al. (2016a) identified no changes to haemolymph biochemistry in rock lobsters up to 120 days post exposure, though a reduction in haemocyte cell numbers was identified. Seismic exposure also had a consistent and prolonged negative effect on lobster total haemocyte count (THC) for up to 120 days post-exposure, with decreases in THC ranging from 23% to 60% in the four experiments potentially compromising their immune system. THC is commonly used as an assessment of stress and is suggested to be related to immune competency and health status of crustaceans. Payne et al. (2008) found no effects of seismic surveys on American lobster haemolymph biochemistry but possible reduction in calcium. In contrast, Christian et al. (2003, 2004) found no chronic or long-term effects on stress bioindicators in haemolymph. Andriguetto-Filho et al (2005) also carried out histopathological studies on gonadal and hepatopancreatic tissue and reported that there was no damage that could be associated with exposure to a four airgun array with a source peak pressure of 196 dB re 1 µPa at 1 m within shallow waters (2-15 m).

It is likely that the mechanism of impacts for invertebrates, such as prawns, are not from sound pressure, but rather from particle motion. However, what is unknown is what particle motion levels lead to a behavioural response, as described in Day et al. (2016a), or mortality. Water depth and seismic source array size are related to the particle motion levels at the seafloor, with larger arrays and shallower water being related to higher levels, which can then be related to effects on prawns. Despite the results presented in Day et al. (2016a), the science around which metrics relate to an effect, and the relationship therefore to impact, is still an area of ongoing research. While the pressure related metrics identified in Day et al. (2016a) have been used to estimate the area of potential impact from seismic surveys in some impact assessments, the literature available does not clearly define either the metric, which should be used, or any associated level to use while conducting an assessment.

In lieu of a suitable proxy, and because prawns have the potential to be in either the water column or on the substrate, an understanding of level for pressure related metrics at which impacts were identified gives some mechanism for being able to understand the area of potential impact from the Petrelex 3D MSS. As Payne et al. (2008) identified no effects on righting time in lobster at 202 dB re 1 µPa (PK-PK), and Day et al. (2016a) found effects at 209 dB re 1 µPa (PK-PK), the level of 202 dB re 1 µPa (PK-PK) has been applied in this assessment as a precautionary threshold to determine potential impacts.

Accordingly, a range of sound exposure thresholds, from 202 dB re 1 µPa PK-PK to 212 dB re 1 µPa PK-PK, based on the findings of the Payne et al. (2008) and Day et al. (2016a) studies, were applied in the acoustic modelling study, and have been applied for this impact assessment (refer to

Table 7-8).

Table 7-8 Maximum Predictsed Distances (R_{max}) to Effect Thresholds for Crustaceans at the Seafloor, for Both Single Pulse Sites

Sound Exposure Threshold (PK-PK)	R_{max} (m)
212 dB re 1 µPa	202
211 dB re 1 µPa	260
210 dB re 1 µPa	279
209 dB re 1 µPa	293
202 dB re 1 µPa	681

As shown in

Table 7-8, at a sound exposure threshold of 209 dB re 1 µPa PK-PK, maximum predicted R_{max} distance was 293 m.

The PK sound level at the seafloor directly underneath the seismic source was estimated for both single pulse modelling sites, and compared to the sound level of 226 dB re 1 µPa PK for sponges and corals (Heyward et al. 2018). It was found that the level was not reached at either of the two sites.

As described above, the Operational Area overlaps with two pinnacles within the defined KEF. There is no overlap between the KEF and the Acquisition Area. The area of overlap between the KEF and the Operational Area is approximately 13.7 km^2, which represents approximately 4.4% of the designated area of the KEF (309.5 km^2). Given the maximum predicted R_{max} distance for impacts to crustaceans of 293 m, there is the potential for some crustaceans on the seafloor within the KEF to experience sound levels that could result in some low-level, sub-lethal effects (e.g. impairment of reflexes, damage to statocysts and reduction in numbers of haemocytes). These sub-lethal effects could result in a reduction in fitness to some individuals. However, it is unlikely that this would occur to the majority of individuals at the pinnacles overlapped by the Operational Area, therefore, impacts at a population level due to reduced fitness would be unlikely as there would be sufficient unaffected individuals to maintain the population.

At received noise levels of 209 dB re µPa (PK-PK) (Day et al. 2016b) did not observe any impacts to embryonic development, with hatched larvae found to be unaffected in terms of egg development, the number of hatched larvae, larval dry mass and energy content and larval competency (i.e. survival in adverse conditions); thus recruitment should be unaffected. Therefore, impacts at a population level due to reduced recruitment would be to occur.

Summary

The potential impacts of noise emissions from the seismic source on benthic invertebrates during the Petrelex 3D MSS are considered to be slight and short-term, as the activity is not likely to result in any ecologically significant impacts at a population level for any species of invertebrate that may be present on the seafloor within or adjacent to the Operational Area.

Taking into account the adopted controls, the consequence of occasional short-term and localised disturbance to benthic invertebrates is Slight (1). The likelihood of this consequence occurring is Rare (B) and the residual risk is considered to be Low.

Zooplankton

Species Sensitivity and Sound Exposure Thresholds

Plankton is a collective term for all marine organisms that are unable to swim against a current. This group is diverse and includes phytoplankton (plants) and zooplankton (animals), as well as fish and invertebrate eggs and larvae. There is no scientific information on the potential for noise-induced effect in phytoplankton and no functional cause-effect relationship has been established. Noise-induced effects on zooplankton, such as copepods, cladocerans, chaetognaths and euphausiids, have been investigated in a number of sound exposure experiments. Parry et al. (2002) studied the abundance of plankton after exposure to airgun sounds but found no evidence of mortality or changes in catch-rate at a population-level.

Zooplankton includes fish eggs and larvae that are transported by currents and winds and hence cannot take evasive behaviour to avoid seismic sources. With respect to the Petrelex 3D MSS, key spawning areas for commercially targeted fish species (assessed under “Fish spawning” below) have been identified as areas where zooplankton populations may be more important.

Larval fish species studied appear to have hearing frequency ranges similar to those of adults and similar acoustic startle thresholds (Popper et al. 2014). Swim bladders may develop during the larval stage and may render larvae susceptible to pressure-related injuries such as barotrauma. Effects of sound upon eggs, and larvae containing gas bubbles, is focused on barotrauma rather than hearing (Popper et al. 2014). Larval stages are often considered more sensitive to stressors than adult stages, but exposure to seismic sound reveals no differences in larval mortality or abundance for fish, crabs or scallops (Carroll et al. 2017).

For this impact assessment the sound exposure thresholds for mortality/PMI to fish eggs and larvae from Popper et al. (2014), have been applied (as described above in the impact assessment for fish and outlined below in Table 7-9). In addition, a threshold of 178 dB re 1 μPa PK-PK derived from the McCauley et al. (2017) study has also been applied as described below.

McCauley et al. (2017) found that after exposure to airgun sounds generated with a single airgun (150 cui) zooplankton abundance decreased and mortality in adult and larval zooplankton increased two-to three fold when compared with controls. In this large-scale field experiment on the impact of seismic activity on zooplankton, a sonar and net tows were used to measure the effects on plankton, and a maximum effect-range of horizontal 1.2 km was determined. The findings contradicted the conventional idea of limited and very localised impact of intense sound in general, and seismic airgun signals in particular, on zooplankton, with the results indicating that there may be noise-induced effects on these taxa and that these effects may even be negatively affecting ocean ecosystem function and productivity.

This study measured zooplankton abundance and the proportion of the population that was dead at three distances from a single 150 cui airgun—0, 200 and 800 m. The experiment estimated the proportion of the zooplankton that was dead, both before and after exposure to airgun noise, using net samples to measure zooplankton abundance, and bioacoustics to identify the distribution of zooplankton. In this study, copepods dominated the mesozooplankton (0.2-20 mm), and impacts were not assessed on microzooplankton (0.02-0.2 mm) or macrozooplankton (>20 mm). There was movement of water through the experimental area, which made interpreting their results more difficult (Richardson et al. 2017).

McCauley et al. (2017) provide three findings from the experiment to show that zooplankton were affected by the seismic source:

- the proportion of the mesozooplankton community that was dead increased two- to three-fold;
- the abundance of zooplankton estimated by net samples declined by 64%; and
- the opening of a "hole" in the zooplankton backscatter observed via acoustics.

They found that exposure to airgun noise significantly decreased zooplankton abundance, and increased the mortality rate from a natural level of 19% per day to 45% per day (on the day of exposure, and that these impacts were observed out to the maximum range assessed (1.2 km) (Richardson et al. 2017).

Scientists from CSIRO's Oceans and Atmosphere Business Units were contracted by APPEA to undertake a desktop study that: a) critically reviewed the methodologies and findings of the McCauley et al. (2017) experiment; and b) simulated the large scale impact of a seismic survey on zooplankton in the North West Shelf region, based on the mortality rate associated with airgun noise exposure reported by McCauley et al. (2017).

The CSIRO review of the McCauley et al. (2017) study found that there were three primary questions raised by the results of the experiment, all of which warrant further investigation (Richardson et al. 2017):

1. Why was there no attenuation of the impact with distance?

   There is no consistent decline in the proportion of zooplankton that are dead with increasing distance away from the airgun. The energy of the sound waves at a distance of 1.2 km is substantially lower than at the source.

2. Why was there an immediate decline in abundance?

   It is unclear why there would be a near immediate drop in zooplankton abundance as measured by net samples and acoustic data. If zooplankton were killed, they would not immediately sink from the surface layers, or be rapidly eaten. A drop in abundance would be more likely once the dead zooplankton either sunk to the bottom or were removed by predation. Richardson et al (2017) conclude it is difficult to explain this immediate decline in zooplankton abundance.

3. Was there sufficient replication to be confident in the study findings?

   The conclusions were based on a relatively small number of zooplankton samples. A total of 24 samples were collected – 2 tows each sampling time x 3 distances from the gun (0 m, 200 m, 800 m) x 2 levels (Control, Exposed) x 2 replicate experiments (Day 1, Day 2). This means that there were only 12 samples collected under conditions exposed to the airgun, six on each day of the two experiments. The main potential confounding explanation in the study would be that a different water mass entered the area on each day of the experiment and had lower abundance and higher quantities of dead zooplankton. Richardson et al. (2017) conclude that: *"although this is relatively unlikely it cannot be discounted because of the relatively few samples collected and only two replicate experiments conducted."*

Independently of the APPEA/CSIRO study, the International Association of Geophysical Contractors (IAGC) conducted its own review of the McCauley et al. (2017) paper. This review came to the following conclusion:

> *"While we found the study interesting, we are also troubled by the small sample sizes, the large day-to-day variability in both the baseline and experimental data, and the large number of speculative conclusions that appear inconsistent with the data collected over a two-day period. Both statistically and methodologically, this project falls short of what would be needed to provide a convincing case for adverse effects from geophysical survey operations."* (IAGC 2017).

The second component of the CSIRO study was to estimate the spatial and temporal impact of seismic activity on zooplankton on the Northwest Shelf from a large-scale seismic survey, considering mortality estimates of McCauley et al. (2017), and accounting for typical growth rates, natural mortality rates, and the ocean circulation in the region The approach modelled a hypothetical 3D survey (2,900 km^2 in size, over a 35-day period, in water depths of 300-800 m) on the edge of the North West Shelf during summer. To simulate the movement of zooplankton by currents, the researchers used a hydrodynamic model that seeded 0.5 million particles into CSIRO's Ocean Forecast Australia Model. Zooplankton particles could be hit multiple times by airgun pulses if they were carried by currents into the future survey path. The greatest limitation in this approach was accurate knowledge of the natural growth and mortality rates of zooplankton, and to address this the CSIRO researchers tested the sensitivity of the model to different recovery (growth-mortality) rates, and also the sensitivity of the results to ocean circulation by undertaking simulations with and without water motion (Richardson et al. 2017).

The results of the simulations that included ocean circulation showed that the impact of the seismic survey on zooplankton biomass was greatest in the *Survey Region* (defined as the survey acquisition area with a 2.5 km impact zone around it) (22% of the zooplankton biomass was removed) and declines as one moves beyond it to the *Survey Region + 15 km* (14% of biomass removed), and *the Survey Region + 150 km* (2% of biomass removed). The time to recovery (to 95% of the original level) for the *Survey Region* and *Survey Region + 15 km* recovery was 39 days (38-42 days) after the start of the survey and three days (2-6 days) after the end of the survey (Richardson et al. 2017).

The major findings of the CSIRO study were that there was substantial impact of seismic activity on zooplankton populations on a local scale within or close to the survey area, however, on a regional scale the impacts were minimal and were not discernible over the entire Northwest Shelf Bioregion. Additionally, the study found that the time for the zooplankton biomass to recover to pre-seismic levels inside the survey area, and within 15 km of the area, was only three days following the completion of the survey. This relatively quick recovery was due to the fast growth rates of zooplankton, and the dispersal and mixing of zooplankton from both inside and outside of the impacted region (Richardson et al. 2017).

Whilst the CSIRO modelling was carried out for the Northwest Shelf IMCRA Mesoscale Bioregion the findings of this study are directly applicable in determining the potential impacts of the Petrelex 3D MSS on zooplankton communities. The Bonaparte Gulf Mesoscale Bioregion, within which the Petrelex Operational Area is located, and the Northwest Shelf Mesoscale Bioregion are both located within the NWMR. The NWMR is distinguished from the other marine regions around Australia by its unique combination of features. These include a wide continental shelf, very high tidal regimes, very high cyclone incidence, unique current systems and its warm oligotrophic surface waters (Brewer et al. 2007). Whilst the Bonaparte Gulf Bioregion is located further to the north-east than the Northwest Shelf Bioregion, it also covers tropical waters of the continental shelf and has broad-scale ocean circulation dominated by the Indonesian Throughflow current system (Brewer et al. 2017).

Day et al. (2016b) found that *"seismic exposure did not result in a decrease in fecundity, either through a reduction in the average number of hatched larvae or as a result of high larval mortality; compromised larvae or morphological abnormalities"*. These results support the suggestion that early life stage crustaceans may be more resilient to seismic air gun exposure than other marine organisms (Pearson et al. 1994). Received levels were ~211 dB re 1 µPa (PK-PK; approximately 205 dB re 1 µPa PK) and as such are similar to those proposed by Popper et al. (2014).

Impact Assessment

As described above, the sound exposure thresholds used in this assessment for mortality/PMI to fish eggs and larvae from Popper et al. (2014), have been applied, as well as the 178 dB re 1 µPa PK-PK threshold derived from the McCauley et al. (2017) study (refer to Table 7-9).

Table 7-9 Maximum Predicted Distances (R_{max}) to Mortality/PMI Thresholds in the Water Column for Fish Eggs and Larvae, and Zooplankton

Sound exposure threshold	R_{max} (km)
210 dB re 1 µPa^2·s (SEL_{24h})	0.05
207 dB re 1 µPa (PK)	0.16
178 dB re 1 µPa PK-PK	6.95

As shown in Table 7-9, the maximum predicted R_{max} distance for mortality/PMI effects in fish eggs and larvae, based on application of the Popper et al. (2014) single pulse 207 dB re 1 µPa (PK) threshold is 160 m. Based on the application of the McCauley et al. (2017) threshold of 178 dB re 1 µPa PK-PK, the maximum predicted R_{max} distance increases to ~7 km.

Any potential mortality/PMI impacts to zooplankton communities have to be assessed in the context of natural mortality in these populations. Any mortality or mortal injury effects to zooplankton (including fish eggs and larvae) resulting from seismic noise emissions are likely to be inconsequential compared to natural mortality rates, which are very high—exceeding 50% per day in some species and commonly exceeding 10% per day (Tang et al. 2014). For example, in a review of mortality estimates (Houde and Zastrow 1993), the mean mortality rate for marine fish larvae was M = 0.24, a rate equivalent to a loss of 21.3% per day. In the experiment undertaken by McCauley et al. (2017) zooplankton mortality rate background levels were 19%. Sætre and Ona (1996) calculated that under the 'worst-case' scenario, the number of larvae killed during a typical seismic survey was 0.45% of the total population, and they concluded that mortality rates caused by exposure to airgun sounds are so low compared to natural mortality that the impact from seismic surveys must be regarded as insignificant.

Summary

The potential impacts of noise emissions from the seismic source on plankton during the Petrelex 3D MSS are considered to be slight and short-term, as the activity is not likely to result in any ecologically significant impacts at a population level for any fish eggs and larvae, or zooplankton that may be present in the water column within or adjacent to the Operational Area.

Taking into account the adopted controls, the consequence of occasional short-term and localised disturbance to zooplankton is Slight (1). The likelihood of this consequence occurring is Occasional (C) and the residual risk is considered to be Low.

Fish Spawning

Impact Assessment

High intensity impulsive sound emitted from the seismic source has the potential to result in behavioural changes in fish or masking of fish vocalisations, which may temporarily divert efforts away from spawning aggregations, egg production and recruitment success (Hawkins and Popper 2017). This impact assessment is focused on fish spawning and recruitment for relevant key indicator commercial fish species (refer to Table 4-5).

A spatial (area) analysis has been conducted to determine the overlap between the Acquisition Area and the depth ranges of key relevant key indicator fish species (Table 7-10).

Table 7-10 Spatial Overlap with Depth Ranges for Key Indicator Fish Species

Fish Species	Depth Range (m)	% of Spatial Overlap with the Acquisition Area*	
		Kimberley Stock	Northern Territory Stock
Goldband snapper	50-200	0.3%	0.8%
Red emperor	10-180	0.3%	0.7%
Blue-spotted emperor	5-110	0.3%	0.7%
Rankin cod	10-150	0.3%	0.7%

*The % of spatial overlap is based on the known depth ranges at which each species spawns within the Kimberley and Northern Territory management boundaries. It is important to note that these management boundaries may not necessarily represent the exact area at which the Kimberley and NT stocks spawn, however is a useful indicator for assessment purposes.

A temporal (duration) analysis has been conducted to determine the maximum overlap between the timing of the Petrelex 3D MSS and the spawning times of relevant key indicator species (Table 7-11).

Table 7-11 Temporal Overlap with Spawning Periods for Key Indicator Fish Species

Fish Species	Spawning Timing	% of Temporal Overlap*	
		Kimberley Stock	Northern Territory Stock
Goldband snapper	November to May (Kimberley) September – March (NT)	21%	19%
Red emperor	September – June	15%	15%
Blue-spotted emperor	July – March	14%	14%
Rankin cod	June – December and March	17%	17%

*The % of temporal overlap is based on the number of days each species may spawns within the Petrelex 3D MSS acquisition window (64 days between September 2019 – December 2020). Please note, the Kimberly and NT goldband snapper stocks have different spawning periods.

As shown in Table 7-10, there is minimal spatial overlap (0.3-0.8%) between the identified depth ranges for key indicator species (Kimberley and NT stocks) and the Acquisition Area. The largest spatial overlap (0.8%) is with the NT goldband snapper stock range. The temporal overlap with the spawning periods for key indicator species (Kimberley and NT stocks) range from 14% (blue-spotted emperor) to 21% (goldband snapper).

Localised and short-term disturbances resulting from a transient seismic source are unlikely to result in a discernible impact to demersal fish populations given that spawning and stock connectivity occurs over significantly larger geographic areas, over several months, involves the production of millions of eggs over multiple spawning events, and shows extremely high natural variation. If disturbance from the passing seismic source temporarily diverts effort away from egg production or happens to coincide with a spawning aggregation, it is acknowledged that spawning within that particular aggregation may be disrupted at that particular time. Spawning at that particular site may simply be delayed for a short period (minutes or hours) with fishes' motivation to spawn resuming once normal behaviours resume, although this may result in spawning during less favourable conditions (e.g. stage of tide). Fishes may delay spawning further until conditions are favourable again. However, for the purpose of this assessment, if it is conservatively assumed that an entire spawning event at an affected aggregation site is compromised by disturbance from the passing seismic source, impacts may still not be discernible from natural variation given that only that particular site is affected at that point in time; spawning will continue undisturbed elsewhere throughout the fishes' ranges and the majority of spawning aggregations in the region will be undisturbed. The affected fishes will also spawn again at multiple other times during the spawning season and so discernible impacts to recruitment and populations are not expected. While there may be multiple occasions during the seismic survey when the activity coincides with and disturbs an individual spawning event somewhere within the Acquisition Area, the acute nature of these disturbances is not expected to have a detrimental population level impact.

It is highly unlikely that the Petrelex 3D MSS will cause any significant impacts to spawning and recruitment in any key indicator commercial fish species given:

- the very short ranges to injury thresholds for fish eggs and larvae shown in Table 7-9 (160 m from the seismic source based on the Popper et al. 2014 thresholds);
- short impact ranges for any significant behavioural responses in adult fish (tens or hundreds of metres);
- the short temporal overlap (14% - 21%) between the timing of the survey, and spawning times for the key indicator species;
- the small extent of spatial overlap (0.3% - 0.8%) between the Acquisition Area and the identified depth ranges for the key indicator species; and

The stock assessments for a number of WA and NT commercially targeted species are based on the status of several key indicator species (including goldband snapper and red emperor). In particular, goldband snapper and red emperor are the key indicator species for the NDSMF and Demersal Fishery. Therefore, a further assessment is provided below for goldband snapper and red emperor.

Goldband Snapper and Red Emperor

Goldband snapper and red emperor lutjanids, which are known generally to be highly fecund, broadcast spawners, releasing numerous batches of pelagic eggs into the water column over an extended spawning period, up to several million eggs per year (Lloyd 2006; Newman et al. 2008).

Adult goldband snapper occur in continental shelf waters in depths of 50-245 m, in association with offshore reefs, shoals, and areas of hard flat bottom with occasional benthos or vertical relief, and often form large schools (Ovenden et al. 2004; Newman et al. 2008). ERM (2012) also recorded adult goldband snapper over relatively featureless sediment habitats in 80 m to 90 m water depths in the Montara, Padthaway, Bilyara and Tahbilk gas fields, in the Browse Basin, but did not observe this species at similar depths on the slopes of shoals in the region. Juveniles typically occur on uniform sedimentary habitat with no relief (Newman et al. 2008).

The following information was provided in consultation with a Principal Research Scientist at DPIRD in 2019 for the Polarcus Cygnus Phase 3 South EP, in regards to goldband snapper spawning:

- Goldband Snapper is widely distributed throughout northern Australia and the tropical Indo–West Pacific.
- Goldband snapper is more typically found between approximately 50 m and 200 m water depths, with evidence of a greater concentrations associated with the submerged ancient coastline between 80 m and 140 m depths.
- The species are serial/multiple batch spawners, releasing multiple batches of eggs into the water column over a wide area during the spawning period, and likely spawn every few days throughout the spawning period, or in response to environmental cues such as water temperature. Goldband snapper spawn throughout their range.

- Gaughan and Santoro (2018) assessed the stock to be adequate and sustainable. The status of goldband snapper was considered acceptable and the current risk control measures in place were adequate (i.e. no new management required). However, the forward projections in model derived outputs indicate a decreasing trend in biomass under current management settings. As such, careful ongoing monitoring of the stock is required.

Updated advice from DPIRD Fisheries suggests that goldband snapper spawn between November and May in the Kimberley region. This period is also broadly consistent with other goldband snapper spawning in northern Australia, as reported for the Timor Sea and Arafura Sea stocks, where spawning was found to occur for an extended period from September/October, peaking in December, and remaining elevated with some fluctuations until March/April, and with minimum activity occurring during the winter months (June - August) (Lloyd 2006). Although goldband snapper are understood to be broadcast spawners, it is also understood that eggs and larvae do not travel long distances between regions and there is limited genetic connectivity between the Kimberley stock and stocks in the Timor and Arafura Seas, Broome, and the Pilbara and Exmouth stocks (Lloyd et al. 2000; Newman et al. 2000; Ovenden et al. 2002; Newman et al. 2008).

The Kimberley stock and its spawning biomass are assumed to be separate, as both larval dispersal and movement of adults between the stocks is understood to be negligible (Newman et al. 2008; Lloyd et al. 2000; Newman et al. 2000; Ovenden et al. 2002).

While adults are understood to be a relatively vagile (free to move) species, the genetic subdivision indicates constrained home ranges and limited migration of adults over long distances, potentially where significant changes in water depth or other factors may influence adult movements (Ovenden et al. 2004). The range of the Kimberley stock is, therefore, considered separate from the adjacent Timor and Arafura Seas stocks to the east, Indonesian stocks to the north, and the Broome stock. The geographical extent of the Kimberley stock appears to encompass genetically similar sub-stocks (Lloyd et al. 2000; Newman et al. 2000; Ovenden et al. 2002).

Red emperor may also spawn in offshore waters in the region. They are widely distributed across the continental shelf in up to 180 m water depths and are associated with reefs, lagoons, epibenthic communities, limestone sand flats and gravel patches (Newman et al. 2008). The species spawns between August and May, with a peak in October and March. The species is also a serial batch spawners, releasing multiple batches of eggs into the water column over a wide area during the spawning period. While movement of adults between the Gascoyne, Pilbara, Kimberley and NT stocks is understood to be limited, the stocks across northern Australia (from north Queensland to the mid-west coast of WA) are understood to be biologically connected, with genetic homogeneity maintained by the wide dispersal of pelagic eggs and larvae between these regions (Newman et al. 2008).

Given the vagile and highly mobile nature of lutjanid and lethrinid species, such as goldband snapper and red emperor, no mortality or reduction in spawning biomass is expected, given that the available research indicates that the stimuli to move and avoid the approaching sound source will occur before sound reaches levels that could result in injury or mortality.

To provide an indication of natural variation, red emperor and goldband snapper spawning biomass and recruitment rates fluctuate annually, with years of elevated of reduced recruitment influencing the overall stock population (Marriott et al. 2014). Newman et al. (2003) and Marriott et al. (2014) suggest that both spawning and recruitment success can vary depending upon both environmental (e.g. water temperature, cyclones, El Nino-La Nina cycles) and anthropogenic influences (e.g. fisheries catch levels over and above natural mortality rates). Extended periods of high exploitation by fisheries can result in decreases in the spawning stock biomass and number of effective spawning’s (Newman et al. 2003).

Between 1980 and 2013, the red emperor spawning biomass in the NDSMF generally decreased to approximately 35% of unfished levels while recruitment success fluctuated inter-annually between a minimum of approximately 150 million fish and 400 million fish (Figure 7-2). Similarly, goldband snapper spawning biomass has declined steadily while recruitment success fluctuated inter-annually between a minimum of approximately 250 thousand fish and 900 thousand fish (Figure 7-3).

This provides an indication of natural inter-annual variability in the spawning and recruitment of both red emperor and goldband snapper. Very large or very low recruitment success may reflect in the available spawning mass several years later, and fisheries catch rates/natural mortality also influence the available biomass. However, trends in spawning biomass and recruitment do not clearly reflect one another, indicating that there may also be significant variation in spawning biomass and stock recruitment success as a result of other natural factors.

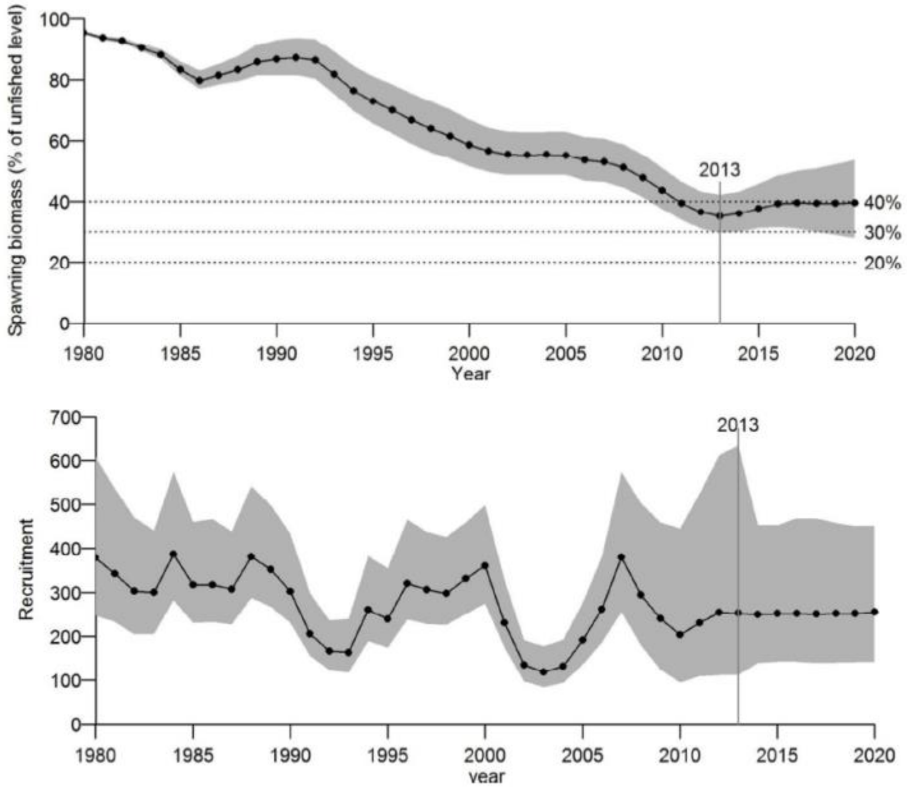


Figure 7-2 Red Emperor Spawning Biomass as a Percentage of Unfished Levels (top) and Recruitment (Millions of Fish) (bottom) (DoF 2015)

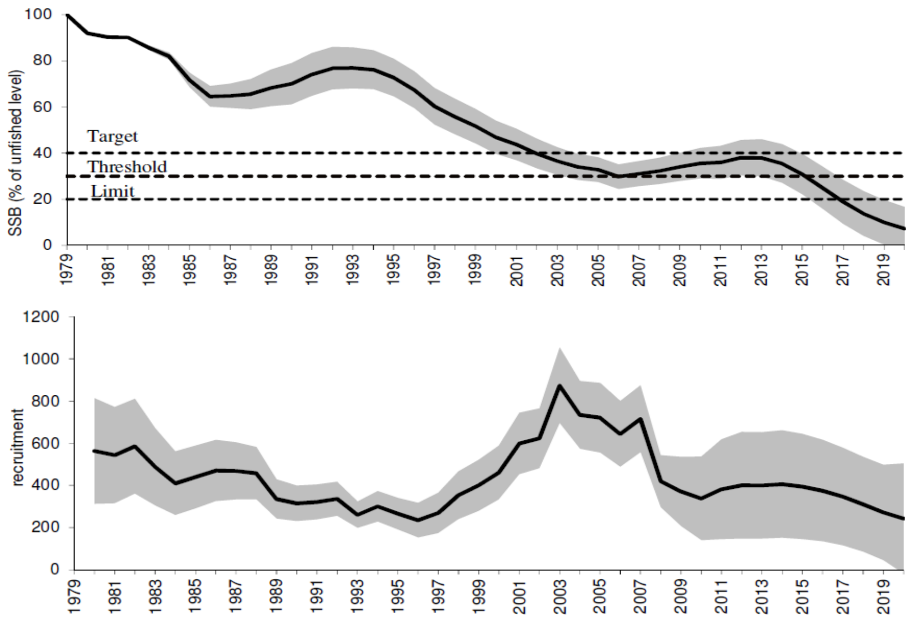


Figure 7-3 Goldband Snapper Spawning Biomass as a Percentage of Unfished Levels (top) and Recruitment (Thousands of Fish) (bottom) (DoF 2015)

To understand the potential area where spawning behaviour may be influenced by seismic sound, the available research into behavioural impacts to fish has been considered. Behavioural effects of noise on fish may vary depending on the particular circumstances of the fish, hearing sensitivity, the activities in which it is engaged, its motivation, and the context in which it is exposed to sounds (Popper et al. 2014; Hawkins and Popper 2017). For example, fish may respond differently, depending on whether they are foraging, migrating, resting or spawning. Changes in behaviour are generally temporary and localised (McCauley 1994; Simmonds and MacLennan 2005; McCauley et al. 2000a; Fewtrell and McCauley 2012; Popper et al. 2014; Carroll et al. 2017).

The majority of studies reviewed on the potential effects of seismic surveys on fish behaviour suggest that behavioural responses are typically observed within several hundred metres (strong avoidance responses) to several kilometres (minor responses such as changes in direction or position in the water column) from the seismic source and quickly return to normal (within an hour) after the seismic source has passed or ceased. These behaviours have been recorded in response to SPLs of 156 dB re 1 µPa or greater and peak pressures greater than 160 dB re 1 µPa, returning to normal behaviour within as little as an hour of the seismic source passing or ceasing (Wardle et al. 2001; Pearson et al. 1992; Santulli et al. 1999; McCauley et al. 2000a; Fewtrell and McCauley 2012; Miller and Cripps 2013). Based on the acoustic modelling completed for the Petrelex 3D MSS (Quijano et al. 2019), these SPL levels correspond with ranges of approximately 8 – 12 km from the active source, depending on tow direction.

However, some potentially more extensive and longer duration changes in distribution and local abundance in demersal and pelagic species have been reported by Slotte et al. (2004), Engås et al. (1996) and Engås and Lokkeborg (2002). Schools of fish were observed to be present within the survey area in response to a 3,090 cui seismic array, although the density and local abundance of fish increased gradually with distance from the survey lines, between ranges of a few kilometres and potential subtle differences evident out to a maximum of 37 km. The differences in local abundance were not clearly pronounced in all instances and results were inconsistent (trends were not observed in all cases). It could also not be confirmed from these studies how much the changes in local abundance and distribution could be attributed to the seismic survey or if normal migratory movements or other natural factors also contributed to some degree. Changes in local abundance and distribution were no longer detectable within three to five days following completion of the survey (Slotte et al. 2004; Engås et al.; 1996 and Engås and Lokkeborg 2002).

Therefore, despite changes in behaviour typically reported as occurring within several hundred metres to several kilometres of a seismic source, the assessment of potential impacts to spawning considers the maximum reported distance (37 km; from the findings of Slotte et al. 2004) as indicative of the ranges to where the density, local abundance and behaviours of schooling fish may still continue to be influenced by seismic sound levels to some small degree. Using this as a proxy is considered to be a conservative approach, given that the 37 km maximum range reported in Slotte et al. (2004) was reported for a 3,090 cui array volume, which is larger than the array proposed for the Petrelex 3D MSS (2,495 cui). However, the reported changes in distribution and local abundance were minor and so the behavioural effects at these further ranges are expected to be minimal and the method of assessment adopted in this EP is considered to be worst case.

Popper et al. (2014) also suggests that the risk of any significant masking effects or changes in behaviour for a large proportion of the fish exposed to a sound is of low to moderate risk in the far-field (thousands of metres). Popper et al. (2014) and Hawkins and Popper (2017) indicate that potential masking impacts to a significant proportion of a fish population are likely to be limited to shorter distances from the source than behavioural changes.

To assess the potential spatial and temporal overlap with spawning goldband snapper and red emperor, the assessment conservatively assumes the maximum spatial and temporal behavioural changes reported by Slotte et al. (2004) and Engås et al. (1996); that the potential extent of impacts to spawning may extend between a few kilometres and to approximately 37 km with some effects lasting up to 5 days following exposure. These ranges and timeframes have therefore been considered to provide an indication of the maximum area and durations over which spawning behaviours may be affected by the Petrelex 3D MSS.

Localised and short-term disturbances resulting from the transient seismic source is unlikely to result in a discernible impact to demersal fish populations given that spawning and stock connectivity occurs over significantly larger geographic areas, over several months, involves the production of millions of eggs over multiple spawning events, and shows extremely high natural variation. If disturbance from the passing seismic source temporarily diverts effort away from egg production or happens to coincide with a spawning aggregation, it is acknowledged that spawning within that particular aggregation may be disrupted at that particular time. Spawning at that particular site may simply be delayed for a short period (minutes or hours) with fishes' motivation to spawn resuming once normal behaviours resume, although this may result in spawning during less favourable conditions (e.g. stage of tide). Fishes may delay spawning further until conditions are favourable again. This strategy of reallocating energy and adapting is common in demersal fishes where there may be a predation risk or environmental conditions naturally fluctuate (e.g. Sancho et al. 2000; Claydon 2004; Pavlov et al. 2009), so this is not necessarily unusual or indicative of a reduction in reproductive success.

For the purpose of this assessment, if it is conservatively assumed that an entire spawning event at an affected aggregation site is compromised by disturbance from the passing seismic source, impacts may still not be discernible from natural variation given that only that particular site is affected at that point in time; spawning will continue undisturbed elsewhere throughout the fishes' ranges and the majority of spawning aggregations in the region will be undisturbed. The affected fishes will also spawn again at multiple other times during the spawning season and so discernible impacts to recruitment and populations are not expected. Given the transient nature of the survey and broad line spacing there is limited potential for significant exposure and disturbance to be repeated at the same site. While there may be multiple occasions during the survey when the activity coincides with and disturbs an individual spawning event somewhere within the Acquisition Area, the acute nature of these disturbances is not expected to have a detrimental population level impact.

It is also important to note that the seismic source will be constantly moving along predetermined lines within the Acquisition Area, made up of "racetrack" line formations with sound levels received at any given location rising and falling periodically as the seismic source approaches and then moves away. A line and reciprocal line would be completed within approximately 24 hours and then the survey vessel and seismic source would be continuously moving across the racetrack, repeating the same pattern, until the required coverage is completed. Based on the potential for fish distribution and local abundance to take up to five days to return to normal levels, fish will likely begin to return to areas as the vessel and seismic source moves laterally across the racetrack and become more distant.

To provide a 'potential area of influence', the Petrelex 3D MSS Acquisition Area, buffered by 37 km, has been selected to provide a conservative estimate of the potential area that may be influenced by sound emissions over the duration of the survey (up to 64 days). While this approach is not exact, the precautionary assumptions described previously provide a conservative indication of the maximum potential spatial and temporal overlap with available spawning habitat from seismic data being acquired at any one time.

The 'potential area of influence' and spatial overlap, expressed as a percentage of the potential goldband snapper stocks (Kimberley and NT), is presented in Table 7-12 for the selected 37 km range from the Petrelex Acquisition Area. This spatial analysis indicates that the 'potential area of influence' (spatial overlap) may be between approximately 2-4% of the total area available to the Kimberley and NT goldband snapper stocks (within the 50-200 m depth range).

It is important to note that this is simply an indication of the area that may be ensonified and where potential spawning aggregations may be influenced. It is also important to note that there is no actual reduction in the total spawning biomass, as the effects are expected to be behavioural and no fish will be lost from the stock. Instead, while some temporary cessation of aggregation and spawning could occur within this potential area of influence, it is possible that adult fish may continue to be motivated to spawn or may simply aggregate and spawn further from the seismic source. In addition, goldband snapper are serial/multiple batch broadcast spawners, releasing multiple batches of eggs into the water column over a wide area, and spawn multiple times throughout the spawning period. They do not spawn continuously. Therefore, the temporal overlap may also over-represent what may, in reality, be a disturbance to one or two out of many spawning events for such a small proportion of fish effected during the spawning season.

Table 7-12 Percentage of Temporal and Spatial Overlap with Goldband Snapper Stock Range and Period

Parameter	Kimberley Stock	Northern Territory Stock
Spatial overlap (%) (including 37 km buffer zone)	2.5%	3.5%
Temporal overlap (%) (including 5 days of behavioural impacts)	22.5%	20.5%
Temporal and spatial overlap (%) (including 37 km buffer zone and 5 days of behavioural impacts)	0.5%	0.7%

*The % of spatial overlap is based on the depth ranges at which each species spawns within the Kimberley and Northern Territory management boundaries.

The Petrelex 3D MSS is estimated to take a maximum of 64 acquisition days to complete. Allowing in the assessment for 64 days' acquisition and up to five days for fish abundance and behaviour to return to normal after the area is acquired – Petrelex 3D MSS accounts for approximately 69 days of potential effects, which is approximately between 20-23% temporal overlap (with the Kimberley and NT stocks, respectively) (Table 7-12).

Accounting for both the spatial overlap and temporal overlap with the spawning period therefore equates to less than 1% with the goldband snapper range (Kimberley and NT stocks, respectively) (Table 7-12).

The temporal and spatial overlap has been assessed as an acceptable level, given no discernible population level impacts are expected to occur.

In the context of existing variations in spawning biomass and recruitment, the predicted impacts are unlikely to be biologically significant over and above the current fished levels; recruitment success has fluctuated between a minimum of approximately 250 thousand fish and 900 thousand fish, including a peak in recruitment even when exploitation by fishing had reduced the spawning biomass to 35% of unfished levels (Figure 7-3). The potential for some small cumulative impact to occur cannot be fully discounted should the maximum predicted 1% combined spatial and temporal overlap from the Petrelex 3D MSS have an additive effect at the time when the spawning biomass is at a significantly reduced level due to fishing activity. However, the impacts from the Petrelex 3D MSS are small and, as highlighted above, the method of assessment is conservative given that it assumes that all spawning associated with the 'potential area of influence' ceases, when in fact there will be no reduction in the total spawning biomass and it is possible that adult fish may continue to spawn, particularly away from the seismic source.

The most recent FRDC Status of Australian Fish Stocks Report (Saunders et al. 2018), indicates that the biomass of the Kimberley and NT goldband snapper biological stocks are at a level that is unlikely to be recruitment overfished and is currently classified as a sustainable stock. Therefore, in the context of natural variability and the latest stock assessment, the effects of the survey are not expected to result in a significant impact to the goldband snapper spawning biomass or recruitment.

In addition, the biomass of the Kimberley red emperor biological stock is classified as a sustainable stock, however the NT stock is currently classified as undefined (Saunders et al. 2018). Given the biological connectivity of the northern Australia red emperor stocks, the spatial overlap with the red emperor spawning range is expected to be significantly less than predicted for goldband snapper and potential impacts are expected to be negligible. Other species in the region are also understood to spawn over wide areas and/or in coastal waters and, therefore, impacts to spawning are expected to be very limited.

Summary

Based on the timing and duration (up to 64 days) of seismic acquisition, the potential impacts of noise emissions from the seismic source on spawning of key indicator commercial fish species during the Petrelex 3D MSS are considered to be slight and short-term, as the activity is not likely to result in any ecologically significant impacts at a population level for any key indicator species that may be spawning within or adjacent to the Acquisition Area during acquisition activities.

Taking into account the adopted controls, the consequence of occasional short-term and localised disturbance to fish spawning is Minor (2). The likelihood of this consequence occurring is Rare (B) and the residual risk is considered to be Low.

Commercial Fisheries

Increased sound levels associated with seismic acquisition may modify the behaviour, local abundance and distribution of fish species, and therefore affect commercial fisheries catch rates within the Petrelex 3D MSS Operational Area and in adjacent waters. Additionally, seismic acquisition has the potential to affect commercial fisheries via displacement or exclusion of fishers from areas where they normally operate for all or part of the period during which the survey is being acquired. This potential impact is assessed in Section 7.4.

As described in Section 4.6.6, there are a number of Commonwealth, State (WA) and Territory (NT) commercial fisheries that operate in waters overlapping the Operational Area, or in adjacent waters of the central JBG, as follows:

- Northern Prawn Fishery (NPF);
- Northern Demersal Scalefish Managed Fishery (NDSMF);

- Mackerel Managed Fishery (MMF);
- Demersal Fishery;
- Spanish Mackerel Fishery; and
- Offshore Net and Line Fishery (ONLF).

Scientific evidence of acoustic impacts on fish catches are somewhat equivocal because of the lack of determination between natural movements and changes in fish abundance. Based on studies presented in Engås et al. (1996) and Slotte et al. (2004) where fish were observed to return to the survey areas within 3-5 days following completion of the seismic surveys, any disruptions would likely be short-term and limited to the period of the survey itself, with conditions returning to 'normal' levels soon (days to weeks after).

Not all studies have resulted in behavioural alteration. Feeding Atlantic herring (Clupea harengus) schools off northern Norway showed no changes in swimming speed, direction or school size in response to a transmitting seismic vessel as it approached from a distance of 27 km to 2 km, over a 6-hour period (Peña et al. 2013). As fishing areas are large and commercial fish species are free-swimming, if fish are 'scared' temporarily from an area, based on evidence presented, it is likely they will be displaced temporarily to another area still within the fishing zone and so able to be caught.

There is little research undertaken on what effect seismic surveys have on fish catchability. Salgado Kent et al. (2016) acknowledge that there has been some effort to relate fisheries catch data to seismic survey effort, but to date none of the Australian efforts to relate fin-fish catch rates with seismic surveys have yielded results of any meaning. The Gippsland Marine Environmental Monitoring (GMEM) project provided no clear evidence of adverse effects on scallops, fish, or commercial catch rates due to the 2015 seismic survey (Przeslawski et al. 2016a): *"Catch rates in the six months following the seismic survey were different than predicted in nine out of the 15 species examined across both Danish Seine and Demersal Gillnet sectors. Across both fishing gear types, six species (tiger flathead, goatfish, elephantfish, boarfish, broadnose shark and school shark) indicated increases in catch subsequent to the seismic survey, and three species (gummy shark, red gurnard, sawshark) indicated decreases in catch. These results support previous work in which the effects of seismic surveys on catch seem transitory and vary among studies, species, and gear types.*"

Research to date has identified effects and no effects from seismic surveys on catch rates and abundance. This is likely due to the importance of the context of exposure. In many instances, fish may move away from an area when a seismic survey is being undertaken. This could impact on the catchability and catch rates for the target species of any commercial fisheries occurring in the same area at the same time.

Bruce et al. (2018) used a 2D seismic survey in the Gippsland Basin in April 2015 as an opportunity to quantify fish behaviour (field-based) and commercial fisheries catch desktop study) across the region before and after airgun operations. The catch rates in the six months following the survey indicated that six species (tiger flathead, goatfish, elephantfish, boarfish, broadnose shark and school shark) showing increases in catch following the seismic survey, and three species (gummy shark, red gurnard, and sawshark) showing reductions.

A critical review of the potential impacts of marine seismic surveys on fish and invertebrates (Carroll et al. 2017) found that other studies on fish have positive, inconsistent, or no effects from seismic surveys on catch rates or abundance. A desktop study of four species (gummy shark, tiger flathead, silver warehou, school whiting) in the Bass Strait found no consistent relationships between catch rates and seismic survey activity in the area, although the large historical window of the seismic data may have masked immediate or short-term effects which cannot therefore be excluded (Przeslawki et al. 2016b). Przeslawki et al. (2016b) concluded that "These results support previous work in which the effects of seismic surveys on catch seem transitory and vary among studies, species, and gear types". The body of peer-reviewed literature does not indicate any long-term abandonment of fishing grounds by commercial species, with several studies indicating that catch levels returned to pre-survey levels after seismic activity had ceased (Carroll et al. 2017). As noted by Przeslawski et al. (2016b), it is possible that fish may be displaced from a survey footprint to adjacent areas, however the total number of fish within the fishery stock remains unchanged.

Effects will be temporary as the seismic vessel traverses each survey line, and fish are expected to move away as the airgun array approaches. As described above, behavioural responses in the key indicator demersal and pelagic fish species (e.g. red emperor, goldband snapper and Spanish mackerel) will be limited to distances of a few tens or at most hundreds of metres from the operating seismic source.

Northern Prawn Fishery

Based on NPF fishing intensity data from 2013 to 2017 (sourced from the ABARES Fishery Status Reports), the main area of fishing activity in the NPF in the southern JBG is located to the south of the Petrelex 3D MSS Acquisition and Operational Areas (Figure 4-15). At the closest point, the boundary of the Acquisition Area is located approximately 26 km from the main area of fishing activity in the south-western part of the JBG, and approximately 110 km from main area of fishing activity in the north-eastern part of the gulf, offshore from Fog Bay (see Figure 4-15). Acquisition of the survey could overlap either the first or second fishing season in the NPF in 2020.

Based on catch and effort data presented in the NPF Data Summary 2016 (Laird 2017) the Bonaparte statistical area, within which the Acquisition and Operational areas are located, had the second lowest catch of banana prawns in 2016 (35 mt out of a total of 2,882 mt – 1.21%). Similarly, the Bonaparte area had the second lowest catch of tiger prawns in 2016 (0.1 mt out of a total of 2,136 mt – 0.005%). In 2015, the Bonaparte area had the lowest catch of banana prawns (26 mt out of a total of 3,916 mt – 0.66%), and there was no catch of tiger prawns recorded for this statistical area (Laird 2016).

As described above, the maximum predicted R_{max} distance for impacts to crustaceans (including prawns) is limited to 293 m from the nearest survey line. Prawns on the seafloor would have to be within approximately 300 m of the active source to be exposed to potential sub-lethal effects. The Acquisition and Operational Areas do not overlap the probable advection envelope for post-larval banana prawns in the southern JBG, and therefore acquisition of the survey will not impact on any juvenile prawns as they migrate offshore to deeper waters, where the adults are targeted by trawlers operating in the NPF.

Northern Demersal Scalefish Managed Fishery

Fish catch and effort data has been obtained from the WA DPIRD (Fisheries) for the NDSMF and MMF and for the years 2012 to 2017 (FishCube). The data is summarised for coarse 60 nm x 60 nm Catch and Effort System (CAES) blocks, with the Acquisition Area centred on the boundary between CAES blocks 13280 and 12280.

A review of the FishCube catch and effort data indicated that between 2012 to 2017, in total 5 vessels in the NDSMF reported catch for up to 18 days within the Operational Area. The total catch was 7,810 kg. Less than three vessels reported catch within the Operational Area each year between 2012 to 2017. Due to confidentiality reasons catch and effort data was not available as there where less than three vessels reporting catch each year. Based on available data, catch and effort within the Operational Area is expected to be low.

Demersal Fishery

Similar catch and effort data is currently not available from the NT DPIR (Fisheries). During consultation, the NT DPIR advised that the Operational Area overlaps with approximately 10% (and the Acquisition Area overlaps with approximately 1%) of the total area of which catch has been reported by the fishery for the last 10 years.

A review of publically available AIS data for commercial fishing vessels via Global Fishing Watch (GFW) revealed that three fishing vessels were present within the Operational Area and EMBA in 2018. These fishing vessels were identified as being vessels within the Demersal Fishery. The majority of the vessel activity occurred north of the Operational Area, within the line, fish-trap and trawl permitted area (GFW 2019). It is expected that most of the activity in the Demersal Fishery in the central JBG is concentrated on and around Flat Top Bank (north of the Operational Area), which coincides with the AIS data.

Mackerel Managed Fishery, Spanish Mackerel Fishery and Offshore Net and Line Fishery

A review of FishCube data for 2012 to 2017 indicated that no catch by the MMF has been reported within the Operational Area since 2013. Less than 3 vessels from the MMF fished within the Operational Area in 2012 and 2013. However, due to confidentiality reasons catch and effort data was not available, as there were less than three vessels reporting catch each year. Based on available data, catch and effort within the Operational Area is expected to be low.

Similar catch and effort data is currently not available from the NT DPIR (Fisheries) for the Spanish Mackerel and Offshore Net and Line Fisheries. During consultation, the NT DPIR advised that the Operational Area overlaps with less than 1% of the area in which catch has been reported by both fisheries for the last 10 years.

The MMF, Spanish Mackerel Fishery and ONLF target fast swimming pelagic species, such as Spanish and grey mackerel, and blacktip and spot-tail sharks. As described above, the maximum predicted R_{max} distance to the injury threshold in the water column for the hearing groups of fishes with swim bladders (Groups II and III), is 160 m (refer to Table 7-7), and the maximum predicted R_{max} distance to the injury threshold in the water column for the hearing group of fishes without swim bladders (Group I, incl. sharks), is 70 m. The maximum predicted R_{max} distance to the TTS threshold in the water column for all fish hearing groups is ~3.1 km.

Large, pelagic, fast-swimming fish species such as mackerel and sharks are highly unlikely to experience TTS effects as they can swim away from a seismic source. Individuals would have to remain within ranges of approximately 3.1 km of the operating seismic 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 an operating seismic source that approaches within a few tens of metres of them.

Potential impacts to commercial catch rates in the NDSMF, Demersal Fishery, MMF, Spanish Mackerel Fishery and ONLF are not likely to be significant based on the following reasons:

- Mortality of fish (both immediate and delayed) is considered highly unlikely based on no documented cases of fish mortality upon exposure to seismic airgun sound under experimental or field operating conditions (ERM 2017).
- In the DPIRD Fisheries risk assessment of impacts from seismic surveys (Webster et al. 2018), it is emphasised that consequence for individual fish only considers mortality and that the risk assessment is not for application to larger scale impacts such as regional aggregations, fisheries, management units and populations.
- The stock assessment for key indicator commercial fish species (e.g. mackerel, red emperor) indicates adequate stock status, breeding stock and fishery catch levels (Gaughan and Santoro 2018).
- Fish recovery from TTS or behavioural effects is expected in days to weeks. No population level effects are predicted to target fish species hence no lasting effects on their catchability, and consequently to commercial catch rates are expected.
- There are no effects predicted to the ecosystems or habitats of the North Coast fishing bioregion, therefore the proposed seismic activities do not threaten the sustainability of the fisheries that cover significantly smaller areas than the overall distribution of fish in the North Coast fishing bioregion.

- The sound exposure thresholds applied are highly conservative and the criteria predicting the largest impact ranges (across all of the modelled sites and scenarios) have been utilised, providing further conservatism in the impact assessment.
- The area of potential impact assumes that the area will receive the same sound levels at the same time for the entire period of a survey, which is not the case. The received sound levels at a location will reduce and increase as the seismic vessel moves through the area during a survey.
- The area of potential impact for the assessed species is a low proportion of the area they are likely to inhabit. Thus, population effects are not likely as there is a significant proportion of the population that remains unaffected.

Summary

Based on the timing and duration (up to 64 days) of seismic acquisition, the potential impacts of underwater noise emissions from the seismic source on commercial fisheries catch rates during the Petrelex 3D MSS are considered to be slight and short-term, as the activity is not likely to result in any ecologically significant impacts at a population level for any key indicator commercial crustacean or fish species targeted by commercial fisheries within or adjacent to the Operational Area.

Taking into account the adopted controls, the consequence of occasional short-term and localised disturbance to commercial fisheries is Minor (2). The likelihood of this consequence occurring is Rare (B) and the residual risk is considered to be Low.

Marine Protected Areas

As shown in Figure 4-13, the north-western boundary of the Operational Area is located approximately 2 km from the south-east corner of the Multiple Use Zone (MUZ) of the Ocean Shoals Marine Park (OSMP) (17 km from the Acquisition Area). The south-east corner of the Operational Area is located approximately 35 km from the boundary of the Special Purpose Zone (SPZ) of the Joseph Bonaparte Gulf Marine Park (JBGMP).

Oceanic Shoals Marine Park

As described in Section 4.6.1.1, the OSMP was established to protect a range of natural, cultural and heritage values, including the Carbonate bank and terrace system of the Sahul Shelf KEF and the Pinnacles of the Bonaparte Basin KEF, and foraging BIAs for loggerhead, flatback and olive ridley turtles. All of these KEFs and BIAs overlap the MUZ of the OSMP. The characteristics of these KEFs and BIAs are described in Sections 4.3 and Section 4.5.7.

Based on the sound level isopleths for modelling Site 1, and a tow direction of NE-SW, maximum predicted received sound levels in the water column at the boundaries of MUZ are approximately 155-160 dB re 1 µPa (SPL). The potential impacts to turtles, fishes/elasmobranchs, benthic invertebrates or zooplankton associated with the KEFs and BIAs overlapped by the MUZ of the OSMP are assessed in the sub-sections above. Given the distance from the Acquisition Area (17 km) and Operational Area (2 km), received sound levels in the water column or at the seafloor within the MUZ of the OSMP is not predicted to exceed any of the sound exposure thresholds for injury in turtles, fishes/elasmobranchs, benthic invertebrates or zooplankton that may be present within the MUZ during acquisition of the Petrelex 3D MSS.

Joseph Bonaparte Gulf Marine Park

As described in Section 4.6.1.1, the JBGMP was established to protect a range of natural, cultural and heritage values, including the Carbonate bank and terrace system of the Sahul Shelf KEF, 'Habitat Critical' for flatback turtles—internesting buffer around Cape Domett, and foraging BIAs for green and olive ridley turtles. Part of the Carbonate bank and terrace system of the Sahul Shelf KEF and the 'Habitat Critical' for flatback turtles overlaps the MUZ of the JBGMP. The foraging BIAs for green and olive ridley turtles overlaps both the MUZ and the SPZ of the JBGMP. The characteristics of this KEF, 'Habitat Critical' and BIAs are described in Sections 4.3 and Section 4.5.7.

Based on the sound level isopleths for modelling Site 2, and a tow direction of NE-SW, maximum predicted received sound levels in the water column at the boundaries of SPZ and MUZ are within the range of 130 – 140 dB re 1 µPa (SPL). The potential impacts to turtles, fishes/elasmobranchs, benthic invertebrates or zooplankton associated with the KEF and BIAs overlapped by the SPZ and MUZ are assessed in the sub-sections above. Received sound levels in the water column or at the seafloor within the SPZ or MUZ of the JBGMP will not exceed any of the sound exposure thresholds for injury, TTS or behavioural disturbance in turtles, fishes/elasmobranchs, benthic invertebrates or zooplankton that may be present within either zone of the marine park during acquisition of the Petrelex 3D MSS.

Summary

Based on the timing and duration (64 days) of the Petrelex 3D MSS, spatial separation from the Oceanic Shoals and Joseph Bonaparte Gulf Marine Parks, and the control measures that will be implemented, predicted noise levels from seismic acquisition are not considered expected to cause any impacts to the natural and cultural heritage values of any AMP in the region.

Taking into account the adopted controls, the consequence of occasional short-term and localised disturbance to marine protected areas is Slight (1). The likelihood of this consequence occurring is Rare (B) and the residual risk is considered to be Low.

7.1.3 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Justification
Inherent Design and Legislative Requirements		
Minimum source size selected (2,495 cui) to acquire survey data and meet the geophysical objectives of the survey.	Yes	The Polarcus 2,495 cui source was intentionally selected during the pre-planning phase of the Petrelex 3D MSS as it is the minimum source size identified to meet the geophysical objectives of the survey, taking into account the depth of the seismic targets and the characteristics of the underlying geology.
Part A of EPBC Policy Statement 2.1 will be applied in full to mitigate potential impacts to whales , including: ■ Observation zone: 3+ km horizontal radius from the seismic source. ■ Low power zone: 2 km horizontal radius from the seismic source. ■ Shut-down zone: 500 m horizontal radius from the seismic source. ■ Pre-Start-up Visual Observations ■ Soft-start Procedures ■ Start-up Delay Procedures ■ Operational Shut-down and Low-power Procedures ■ Night-time and Low Visibility Procedures ■ Sighting Reports	Yes	Part A of EPBC Policy Statement 2.1 are standard management procedures and will be implemented during the Petrelex 3D MSS.
Alternatives/Substitutes Considered		
No practicable alternatives or substitutes were identified.	N/A	N/A

Control Measure	Control Adopted	Justification
Additional Controls Considered		
An MFO will be on board the seismic vessel and on duty during daylight hours during the survey.	Yes	Consistent with Part B of EPBC Policy Statement 2.1, an MFO will be on board the seismic vessel and on duty during daylight hours during the survey.
Crew, survey personnel and MFOs will be briefed in the marine fauna observation, separation distance estimation, controls and reporting requirements relevant to this EP.	Yes	Crew survey personnel and MFOs will be briefed in marine fauna observations (i.e. identification), separation distance estimation, EP controls and EP reporting requirements.
EPBC Act Policy Statement 2.1 Part B.2 – Night-time/ Poor Visibility	No	These control measures will not be implemented given the relatively low densities of whales expected in the Operational Area during survey acquisition, and the absence of any overlap with critical habitats (i.e. feeding, breeding, calving areas) or a constricted migratory pathway. The costs are grossly disproportionate to any potential environmental benefit gained.
EPBC Act Policy Statement 2.1 Part B.3 - Use of spotter aircraft and vessels to detect presence of cetaceans	No	These control measures will not be implemented given the relatively low densities of whales expected in the Operational Area during survey acquisition, and the absence of any overlap between critical habitats (i.e. feeding, breeding, calving areas) or a constricted migratory pathway and the Acquisition Area. Additionally, survey acquisition is timed to avoid the humpback whale migration season. The costs are grossly disproportionate to any potential environmental benefit gained.
EPBC Act Policy Statement 2.1 Part B.5 - Passive Acoustic Monitoring (PAM) to detect presence of vocalising cetaceans	No	Consideration was given to the other controls provided for in Part B of the EPBC Policy Statement 2.1, including the use of PAM. The additional management measures described in Part B are designed to ensure that impacts and interference to whales are avoided/and or minimised for seismic surveys operating in areas where the likelihood of encountering whales is moderate to high. There are no known aggregation areas for foraging, breeding, calving or resting habitat for cetaceans within or in close proximity to the Operational Area. Although PAM can be used to supplement visual observations made by the MFO, the method is dependent upon animals vocalizing. Costs for engaging a trained PAM operator for the survey are approximately US$40,000. The significant additional cost of having a qualified PAM operator on board for the duration of the survey when few or no detections are expected was determined to outweigh any limited additional benefit

Control Measure	Control Adopted	Justification
		that PAM might provide, particularly given the proposed soft-start, night time and low visibility procedures. MFOs may be trained in the operation of the PAM system on board the vessel, however, MFOs on board the vessel will be present to undertake observational duties on deck and therefore additional MFOs would need to be engaged at a similar cost. Given that the Operational Area is not significant for cetaceans, and the limited detections expected from the use of PAM, the cost of this option is considered to outweigh the limited potential for any further reduction to an already low level of risk.
EPBC Act Policy Statement 2.1 Part B.6 - Adaptive Management Measures	No	These control measures will not be implemented given the relatively low densities of whales expected in the Operational Area during survey acquisition, and the absence of any overlap with critical habitats (i.e. feeding, breeding, calving areas) or a constricted migratory pathway. The costs are grossly disproportionate to any potential environmental benefit gained.
Phasing of the survey to avoid the flatback turtle (Kimberley stock) internesting period (May-July).	No	The Petrelex 3D MSS will be conducted outside of flatback internesting turtle habitat, which is considered to be up to 60 km from nesting beaches (Commonwealth of Australia 2017). The Acquisition Area is approximately 44 km from the nearest 'Habitat Critical' for flatback turtles and so no impacts on behaviours in these habitats are expected. Phasing of the survey to avoid the nesting period was considered as a further risk reduction measure, however, given that internesting females are expected to occur beyond the predicted range of behavioural impacts and the other proposed control measures, the survey scheduling limitations that would be created avoiding this period were considered to provide little additional benefit and are therefore disproportionate to the potential benefit gained. Adult turtles within central JBG are more likely to occur in association with the year-round foraging BIA that overlaps the Operational Area and, therefore, seasonal avoidance is not expected to effectively reduce the risks. Flatback turtle hatchlings do not have an offshore pelagic phase and are expected to remain close to nesting beaches (Commonwealth of Australia 2012) and therefore, the significant numbers of turtle hatchlings are not expected. In the event that the DoEE delineate new internesting BIAs during the life of the EP, Polarcus will address this through the Management of Change and New Information process outlined in Section 10.2.3, and controls will be considered to avoid peak nesting periods as required by the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017).

Control Measure	Control Adopted	Justification
Exclude seismic acquisition within turtle foraging BIAs.	No	The combined foraging BIAs for flatback, loggerhead, green and olive ridley turtles in the JBG overlap approximately 75% of the Acquisition and Operational Areas. Complete exclusion of the BIAs from the Acquisition Area is not considered feasible as the loss in data would be too significant and the survey would not be able to acquire the clients' (block titleholders) required line kilometre commitments under their permit to NOPTA. The waters of the Operational Area are unlikely to represent significant foraging habitat for any turtle species. Given that only short-term and localised behavioural impacts are predicted, displacement from critical foraging habitat or population level impacts is not likely to occur and the risk to turtles is already low. Therefore, the cost of excluding the BIAs far outweighs the small environmental benefit that would be gained from doing so.
Increased line spacing within the foraging BIA to reduce cumulative sound exposures.	No	Line spacing has been designed to meet the requirement for 100% data coverage. Widening these lines would result in gaps in the dataset that cannot be reconciled with other data and therefore the survey objectives cannot be met. Cumulative SEL exposures that may result in potential injury will not be exceeded (Quijano et al. 2019), therefore, widening the line spacing serves no purpose with respect to cumulative exposures. Given the mobile nature of the source and other controls in place, impacts are predicted to be behavioural, resulting from avoidance of single shot SPLs. Widening line spacing is not expected to make any difference to the potential footprint where behavioural impacts could occur along an acquisition line.
Conducting the survey during daylight hours only.	No	As identified in the Richardson et al. (2017) report, conducting survey activities during the day rather than the night might minimize impact on zooplankton, as fewer zooplankton may occur near the surface during the day because zooplankton vertically migrate in the water column to balance food intake and predation risks, and are generally deeper during the day. However, such a control would put major scheduling constraints on the Petrelex 3D MSS resulting in a longer overall survey duration and additional time on the water with the potential for other impacts and risks.
Complete avoidance of spawning times for commercially targeted key indicator species.	No	Not justified. Combined spawning periods for the key indicator species covers all 12 months of the year, and therefore the survey could not be acquired. The costs are grossly disproportionate to any potential environmental benefit gained.

Control Measure	Control Adopted	Justification
Complete avoidance of the goldband snapper spawning period.	No	Complete avoidance of the goldband snapper spawning period was given careful consideration, but was not considered practicable and as being disproportionate to the already low level of risk. Goldband snapper potentially could spawn for nine months over the 2019-2020 period, it is not operationally practicable for Polarcus to completely avoid acquisition during this period. Polarcus is a multi-client company and cannot guarantee that the survey will be undertaken outside of the spawning period, as acquisition is based on client requirements and operational considerations (i.e. vessel availability in the region). The earliest Polarcus is operationally able to acquire Petrelex 3D MSS is September 2019 (subject to EP acceptance). If Polarcus was able to acquire Petrelex 3D MSS from September 2019 – December 2020 (a 488-day period), the goldband snapper spawning season would represent approximately 50% of this period. It is not practicable for Polarcus to limit seismic acquisition to a 243-day window for a two-year EP. Scheduling seismic acquisition is complex in nature, as numerous factors need to be considered during the process. For example, if Polarcus had a seismic vessel available within Commonwealth waters and the vessel was unable to acquire Petrelex 3D MSS due to the spawning period (and the vessel was unable to acquire any other surveys within Commonwealth waters), the cost to Polarcus would be in the order of several million dollars, which would be detrimental to the commerciality of the survey. The duration and overlap with the goldband snapper spawning period has been assessed to be low risk and acceptable based on the potential spatial and temporal overlap with spawning. Further reduction of the temporal overlap is also not considered practicable due to potential flexibility required for potential operational and weather downtime, which could jeopardise the survey objectives, Polarcus obligations and client requirements (see below).
Restricting acquisition to a limited number of days during the goldband snapper spawning period.	No	Polarcus considered restricting the number of days of acquisition during the goldband snapper spawning period, however it was not considered practicable or feasible. It is not feasible for Polarcus to restrict acquisition during this period, as the cost to return to acquire the remainder of the survey (outside of the spawning period) to Polarcus is in the order of several million dollars, which would be detrimental to the commerciality of the survey. The duration and overlap with the goldband snapper spawning period has been assessed to be low risk and acceptable based on the potential spatial and temporal overlap with spawning.

Control Measure	Control Adopted	Justification
		Further reduction of the temporal overlap is also not considered practicable due to potential flexibility required for potential operational and weather downtime, which could jeopardise the survey objectives, Polarcus obligations and client requirements (see below).
Reduce survey area to decrease area of overlap with commercial fisheries.	No	Not justified. Polarcus would not be able to obtain the data for the identified hydrocarbon prospects being targeted. There is minimal overlap (less than 2%) between the Acquisition Area and key fishing areas for the Northern Demersal Scalefish Managed Fishery, Mackerel Managed Fishery, Spanish Mackerel Fishery, Offshore Net and Line Fishery and Demersal Fishery.
Payment of compensation to commercial fishers for loss of catch due to displacement or via seismic noise reducing the 'catchability' of fish.	No	Not justified. Whilst a compensation or 'make-good' process can be an appropriate mechanism for compensating fishers who are impacted by a seismic survey, either by displacement or from a loss of catch, compensation has to be assessed on a case-by-case basis. If compensation is appropriate for the activity, an appropriate process should be developed in collaboration with stakeholders. Polarcus has determined that compensation for commercial fishers is not an appropriate control or mitigation measure for the Petrelex 3D MSS, given the nature and scale of the activity, and the minimal impacts expected to the commercial fishing industry.
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)		
A 500 m shut-down zone from the operating source, as per the shut-down zone for whales in EPBC Act Policy Statement 2.1, will also be applied to turtles.	Yes	In order to reduce the potential risks to turtles, the 500 m shut-down zone is considered to be a practicable measure to implement given that precaution zones will already be established for whales.
A 500 m shut-down zone from the operating source, as per the shut-down zone for whales in EPBC Act Policy Statement 2.1, will also be applied to whale sharks.	Yes	In order to reduce the potential risks to whale sharks, the 500 m shut-down one is considered to be a practicable measure to implement given that precaution zones will already be established for whales.

Control Measure	Control Adopted	Justification
Two MFOs will be available on board the seismic vessel to manage shift duties during daylight hours during the survey.	Yes	In order to share shifts and manage fatigue, Polarcus ensures that two MFOs are available on board the seismic survey vessel. This has proven to be effective in previous surveys. Polarcus engages reputable MFO suppliers for seismic survey operations. In addition, when selecting MFOs, Polarcus gives preference to those with previous experience on board a Polarcus vessel, familiarity with the Polarcus Management System and those who have previously received positive feedback from Polarcus vessel party managers.
Increased shut-down / lower power zone implemented for turtles.	No	The likelihood of being able to spot a turtle at ranges further than 500 m is unlikely, therefore, no further precaution zone is proposed and is not considered necessary given the already low level of risk.
Increased shut-down / lower power zone implemented for whale sharks.	No	The likelihood of being able to effectively spot a whale shark at ranges further than 500 m is unlikely, therefore, no further precaution zone is proposed and is not considered necessary given the already low level of risk.

ALARP Statement

The residual risk has been determined to be Low. Polarcus considers the adopted control measures appropriate to manage the impacts of seismic sound on sensitive receptors. As no reasonable additional or alternative controls were identified that would further reduce the impacts and risks, without jeopardising the objectives of the survey, the impacts and risks are considered to be ALARP.

7.1.4 *Demonstration of Acceptable Levels*

Context	Demonstration
Risk Level	The residual risk to all sensitive receptors associated with underwater noise emissions from the seismic source has been assessed as Low, and will not have a significant impact upon Protected Matters in accordance with EPBC Policy Statement 1.1. – Significant Impact Guidelines.
Legislative Requirements	The proposed control measures exceed the required standards and control measures set out in Part A of EPBC Policy Statement 2.1.
Conservation Advice, Recovery Plans, and Other Guidelines	The activity will be undertaken in a manner consistent with the applicable objectives and actions of the following species conservation or recovery plans, threat abatement plans, and conservation advice: ■ Conservation Management Plan for the Blue Whale; ■ Approved Conservation Advice for Megaptera novaeangliae (humpback whale); ■ Conservation advice for sei and fin whales; ■ Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017); and ■ Whale shark – wildlife management program no. 57 (DPaW 2013).
AMP Values, Management Prescriptions and IUCN Reserve Management Principles	The activity will be undertaken in a manner consistent with the applicable objectives and actions of the North Marine Parks Network Management Plan. No population-level impacts or serious or irreversible ecological implications are predicted to the values of the Oceanic Shoals Marine Park or Joseph Bonaparte Gulf Marine Park. The biological diversity and natural values of these AMPs will not be impacted in the long term, and therefore, management measures are consistent with IUCN management prescriptions and the ecological use of the marine parks.
Principles of Ecologically Sustainable Development	Polarcus has reduced the impact/risk of noise emissions from the seismic source to prevent serious or irreversible ecological damage. The aspect and potential interactions are well understood and managed in accordance with EPBC Policy Statement 2.1 and applicable industry standards and best practice guidance.
Stakeholder Objections, Claims, Concerns or Advice	WAFIC, DPIRD and DPIR raised concerns regarding seismic acquisition during key spawning times for commercially targeted fish species (i.e. key indicator species). DPIRD and DPIR provided updated advice regarding the spawning behaviours (depth ranges and timings) of relevant species. The concerns raised by stakeholders have been assessed, responded to and controls adopted (where applicable).

Acceptability Statement
Based on the criteria above, Polarcus considers the adopted control measures appropriate to manage the impacts of seismic sound on sensitive receptors to be of an acceptable level.

7.2 Noise Emissions: Cumulative Seismic Sound

7.2.1 *Assessment Summary*

Source of Impact / Risk			
Cumulative impacts from seismic sound can potentially occur when: ■ Multiple seismic surveys occur in a region at the same time, leading to an increase in sound exposure to the same receptors; or ■ Seismic surveys occur one after the other in the same area over time.			
Receptors			
■ Marine fauna; ■ Fish; ■ Fish spawning; ■ Plankton, fish eggs and larvae; ■ Benthic invertebrates; and ■ Commercial fisheries.			
Adopted Control Measures			**EPS #**
Polarcus will engage with proponents identified as having potential concurrent seismic activities within 40 km of the Petrelex 3D MSS.			2.1
A minimum separation distance of 40 km shall be maintained between the Petrelex 3D MSS seismic sources and other operating seismic sources.			2.2
Details of Residual Impacts and Risks			
No cumulative impacts are expected to occur as a result of the Petrelex 3D MSS. Impacts to receptors from previous seismic surveys (completed in the last five years) are expected to have recovered, well in advance of the Petrelex 3D MSS commencing. No other proposed seismic surveys have been identified to occur within the time period of the Petrelex 3D MSS. Therefore the consequence of cumulative impacts to receptors is considered Slight and the likelihood is Rare. The residual risk associated with cumulative impacts from seismic sound has been determined to be Low. Further detail is provided in the evaluation of impacts and risks below.			
Risk Ranking	**Consequence**	**Likelihood**	**Risk**
Inherent Risk	Slight (1)	Rare (B)	**Low**
Residual Risk	Slight (1)	Rare (B)	**Low**

7.2.2 *Detailed Evaluation of Impacts and Risks*

A review of seismic survey activities published on the NOPSEMA website has been undertaken to identify other marine seismic surveys that have been completed or are planned in the same region as the Petrelex 3D MSS.

This section assesses the potential for cumulative impacts associated with:

- Petrelex 3D MSS being undertaken in an area where other seismic surveys have occurred previously; and
- Petrelex 3D MSS being undertaken concurrently (as the same time) as other marine seismic surveys in the areas.

7.2.2.1 Previous Seismic Surveys

Cumulative impacts from successive surveys in the same areas can occur when the timing between surveys is less than the recovery rate of any potential impacts to receptors.

Table 7-13 presents a summary of the marine seismic surveys that have been undertaken in the last five years within approximately 150 km of the Petrelex 3D MSS Operational Area. The footprint of impacts resulting from the Petrelex 3D MSS has been assessed as being localised, however a 150 km buffer has been selected as a conservative search criterion.

In some instances, it has not been possible to confirm whether surveys have been undertaken or not, the dates surveys were acquired or the final areas that were acquired. Therefore, for the purposes of the assessment, it has been conservatively assumed that surveys have gone ahead within the area and timescale proposed in their respective EPs.

Table 7-13 Seismic Surveys Completed within 150 km of the Petrelex 3D MSS in the Last 5 Years

Year	Company	Survey Title	Survey Location	Survey Status and Timing	Evaluation
2014	GX Technology Australia Pty Ltd	Westralia 2D SPAN Marine Seismic Survey	Large multi-basin SPAN survey.	Completed prior to the end of Q2 2014.	It could not be confirmed if or when the proposed lines were acquired. However, the survey was completed >4 years ago and recovery of all impacts are expected to have occurred well before commencement of the Petrelex 3D MSS. No cumulative impacts are expected.
2017	Origin	Gulpener 2D Seismic Survey	Located ~30 km from the Petrelex 3D MSS Acquisition Area. Maximum of 2,850 km^2 of 3D seismic acquisition in NT/P84 permit.	Completed between June – July 2017. Maximum of 21 days of acquisition.	There is no spatial overlap with the Petrelex 3D MSS. The survey was completed >2 years prior and recovery of all impacts are expected to have occurred well before commencement of the Petrelex 3D MSS. No cumulative impacts are expected.
2017	Santos Limited	Fishburn WA-459-P Seismic Survey	Located ~60 km from the Petrelex 3D MSS Acquisition Area. Maximum of 3,150 km^2 of 3D seismic acquisition in exploration permit WA-459-P.	Completed between June – July 2017. Maximum of 21 days of acquisition.	There is no spatial overlap with the Petrelex 3D MSS. The survey was completed >2 years prior and recovery of all impacts are expected to have occurred well before commencement of the Petrelex 3D MSS. No cumulative impacts are expected.
2018	Polarcus	Zénaïde 3D MSS	Located ~94 km from the Petrelex 3D MSS Acquisition Area. Maximum of 2,850 km^2 of 3D seismic acquisition in exploration permit WA-552-P.	Completed between January – May 2018. Maximum of 60 days of acquisition.	There is no spatial overlap with the Petrelex 3D MSS. The survey was completed >1 year prior and recovery of all impacts are expected to have occurred well before commencement of the Petrelex 3D MSS. No cumulative impacts are expected.

Year	Company	Survey Title	Survey Location	Survey Status and Timing	Evaluation
2018	Santos Limited	Bethany 3D Marine Seismic Survey	Located ~160 km from the Petrelex 3D MSS Acquisition Area. Maximum of 12,610 km^2 of 3D seismic acquisition in NT/P85 and NT/P82 permits.	Completed between May – July 2018. Maximum of 75 days of acquisition.	There is no spatial overlap with the Petrelex 3D MSS. The survey was completed >1 year prior and recovery of all impacts are expected to have occurred well before commencement of the Petrelex 3D MSS. No cumulative impacts are expected.
2018	Santos Limited	Beehive 3D Marine Seismic Survey	Located ~62 km from the Petrelex 3D MSS Acquisition Area. Maximum of 975 km^2 of 3D seismic acquisition in exploration permit WA-488-P.	Completed between July – August 2018. Maximum of 30 days.	There is no spatial overlap with the Petrelex 3D MSS. The survey was completed >1 year prior and recovery of all impacts are expected to have occurred well before commencement of the Petrelex 3D MSS. No cumulative impacts are expected.

7.2.2.2 Concurrent Seismic Surveys

Over the scheduled period of the Petrelex 3D MSS, no other concurrent seismic surveys are planned to occur in the region (at the time of EP submission to NOPSEMA).

Polarcus will engage with any proponents that are identified as having potential concurrent seismic activities prior to commencing the Petrelex 3D MSS and will develop a concurrent operations plan for any concurrent surveys identified within 40 km of the Acquisition Area.

For operational reasons (to prevent acoustic interference and preserve seismic data integrity) a minimum separation distance of at least 40 km will be maintained between the Petrelex 3D MSS seismic source and any other concurrently operating seismic sources during data acquisition activities. Given this separation distance, underwater sound from the seismic sources is not anticipated to combine to significantly raise the sound pressure levels to which receptors may be exposed. This is because, for example, where sound levels from two sources combine through constructive interference, a doubling of sound pressure corresponds with an increase in SPL of 6 dB (e.g. Hass 2013). Modelling of the seismic source for the Petrelex 3D MSS (Quijano and McPherson 2019) demonstrates that sound levels will be below 145-155 dB re 1μPa SPL at 20 km from the source (half way between two seismic sources at their minimum separation distance of 40 km). A combination of seismic sound from two similar seismic sources at this distance would therefore be expected to result in an SPL of no greater than 161 dB re 1μPa, which is below known behavioural response thresholds for marine fauna (e.g. cetaceans and turtles).

While overall sound levels are not expected to be significantly elevated, it is acknowledged that the result of multiple seismic vessels operating concurrently would represent a wider spatial area of potential exposure to seismic sound for receptors.

Given, there are no other seismic surveys are currently planned to occur within the same region as the Petrelex 3D MSS, and the control measures that would be in place should a concurrent survey occur, the cumulative risk to receptors is considered Low.

7.2.3 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Justification
Inherent Design and Legislative Requirements		
No relevant legislation has been identified.	N/A	N/A
Alternatives/Substitutes Considered		
No practicable alternative or substitutes to the above controls have been identified.	N/A	N/A
Additional Controls Considered		
Polarcus will engage with proponents identified as having potential concurrent seismic activities within 40 km of the Petrelex 3D MSS.	Yes	Engagement with titleholders for potential concurrent seismic activities prior to acquisition commencing, and development of a concurrent operations plan (if required). Good industry practice, environmental benefit outweighs additional cost
A minimum separation distance of 40 km shall be maintained between the Petrelex 3D MSS seismic sources and other operating seismic sources.	Yes	This measure will reduce the risk of cumulative impacts occurring and also preserves seismic data quality.
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)		
No practicable improvements have been identified.	N/A	N/A
ALARP Statement		
The residual risk has been determined to be Low. Polarcus considers the adopted control measures appropriate to manage the risk of cumulative seismic sound impacts. As no reasonable additional or alternative controls were identified that would further reduce the impacts and risks, without jeopardising the objectives of the survey, the impacts and risks are considered to be ALARP.		

7.2.4 *Demonstration of Acceptable Levels*

Context	Demonstration
Risk Level	The residual risk is assessed to be Low.
Legislative Requirements	N/A - No legislative requirements has been identified that specifically address cumulative seismic sound impacts.
Conservation Advice, Recovery Plans, and Other Guidelines	N/A – No specific Conservation Advice, Recovery Plans or Guidelines have been identified for managing cumulative risks.
AMP Values, Management Prescriptions and IUCN Reserve Management Principles	No population-level impacts or serious or irreversible ecological implications are predicted to the values of the Joseph Bonaparte Gulf Marine Park or Oceanic Shoals Marine Park. The biological diversity and natural values of these AMPs will not be impacted in the long term, and therefore, management measures are consistent with IUCN management prescriptions and the ecological use of the Marine Parks.
Principles of Ecologically Sustainable Development	Polarcus has reduced the impact/risk of cumulative underwater noise emissions from the seismic source to prevent serious or irreversible ecological damage. The aspect and potential interactions are well understood and managed in accordance with EPBC Policy Statement 2.1 and applicable industry standards and best practice guidance.
Stakeholder Objections, Claims, Concerns or Advice	N/A – Stakeholders have not raised any specific concerns relating to cumulative seismic sound impacts. Information on cumulative impacts associated with the Petrelex 3D MSS was provided to WAFIC and DPIRD Fisheries.
Acceptability Statement	
Based on the criteria above, Polarcus considers the adopted control measures appropriate to manage the risk of cumulative seismic sound to be of an acceptable level.	

7.3 Noise Emissions: Vessels and Helicopter

7.3.1 *Assessment Summary*

Source of Impact / Risk	
Generation of noise emissions from vessels, helicopters and mechanical equipment during routine operations has the potential to cause behavioural disturbance to marine fauna and seabirds.	
Receptors	
■ Cetaceans; ■ Marine turtles; ■ Whale sharks; ■ Dugongs; and ■ Seabirds.	
Adopted Control Measures	**EPS #**
Vessel activities will be undertaken in accordance with EPBC Regulations 2000 – Part 8 Division 8.1, including: ■ taking action to avoid approaching or drifting closer than 50 m to a dolphin or 100 m to a whale; and ■ not exceeding a speed of 6 knots within the caution zone of a cetacean (300 m).	3.1
In addition to the requirements of the EPBC Regulations 2000 - Part 8 Division 8.1 for cetaceans, vessels, when safe to do so, will also: ■ take action to avoid approaching or drifting closer than 50 m to a turtle; and ■ not exceeding a speed of 6 knots within 300 m of a turtle.	3.2
Seismic vessel and support vessels (taking into account the limited manoeuvrability of the former) will also adopt measures consistent with the DPaW Whale Shark Management Program (2013), including: ■ taking action to avoid approaching or drifting closer than 30 m of a whale shark; and ■ not exceeding 8 knots within 250 m of a whale shark.	3.3
Helicopter movements will be undertaken in accordance with EPBC Regulations 2000 – Part 8 Division 8.1, including: ■ helicopters not to operate at a height lower than 1,650 feet within a horizontal radius of 500 metres of a cetacean; and ■ helicopters not to approach a cetacean from head on.	3.4
Details of Residual Impacts and Risks	
Given there are no high energy impulsive sound sources associated with the routine operation of helicopters and vessels, there may be some localised behavioural disturbance of marine fauna in the immediate vicinity of vessels during operations, but physiological effects on fauna are not anticipated. Some transient marine fauna individuals may choose to avoid the immediate proximity of the vessel, but this is not expected to have any widespread or longer-term impacts on their behaviour or populations. Seabirds are generally understood to be undeterred by vessel noise. Some minor behavioural disturbance may occur for short periods if marine fauna are present near the surface in the vicinity of helicopters landing on the seismic vessel. This would be limited to a temporary change in behaviour due to avoidance of the area, but is not expected to have any longer term impacts. Seabirds are expected to avoid the immediate vicinity of a helicopter, but again no long-term impacts are anticipated.	

The residual impacts and risks, with the control measures in place, have therefore been assessed as Low. Further detail is provided in the evaluation of impacts and risks below.			
Risk Ranking	**Consequence**	**Likelihood**	**Risk**
Inherent Risk	Slight (1)	Occasional (C)	**Low**
Residual Risk	Slight (1)	Occasional (C)	**Low**

7.3.2 *Detailed Evaluation of Impacts and Risks*

A seismic vessel and two support vessels (one supply and one chase) will be employed for the Petrelex 3D MSS. Vessel noise comprises a combination of continuous noise generated by engine and machinery noise, and modulated, broadband noise produced by propeller rotation and cavitations (Richardson et al. 1995; Southall 2009; Jensen et al. 2009; Wales & Heitmeyer, 2002; Hildebrand, 2009). Vessel noise emissions varies with the size, speed, and engine type and the activity being undertaken. Noise levels for a range of vessels have been measured at 164-182 dB re µPa at 1 m (SPL) at dominant frequencies between 50 Hz and 7 kHz (Wyatt 2008; Simmonds et al. 2004).

A helicopter may be employed for the Petrelex 3D MSS for the purpose of crew changes. Crew changes are expected to occur every 35 days. The main source of noise from a helicopter is the main rotor. Dominant tones from helicopters are generally below 500 Hz (Richardson et al. 1995). The penetration of noise into the ocean is dependent on the angle of the aircraft and its distance from the sea surface. Typically, noise does not transmit well from air into water due to impedence at the air-water interface. Noise levels from a Bell 212 helicopter flying at altitudes of 610 to 152 m respectively were measured at 101 – 109 decibels (dB) at 3 m water depth (Richardson et al. 1995). This provides an indication of the low received level noise that may be expected from a helicopter.

The Operational Area is located in water depths ranging from approximately 65 m to 111 m. The marine fauna associated with these areas will be predominantly pelagic species of fish with the potential for the transient presence of other megafauna species encounters such as turtles, whale sharks and large whales passing through the Operational Area. The Operational Area does overlap with foraging BIAs for flatback, loggerhead, green and olive ridley turtles in the JBG. It is expected that low numbers of transient marine fauna (including marine turtles) will be present in the Operational Area (refer to Section 4.5).

As described in Section 0, elevated underwater noise can affect marine fauna, including cetaceans, in three main ways (Richardson et al. 1995; Simmonds et al. 2004):

- By causing direct physical effects on hearing or other organs (injury);
- 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.

Given there are no high energy impulsive sound sources associated with the routine operation of vessels, physiological effects on fauna are not anticipated. Permanent injury would be expected to occur at 230 dB re 1 µPa (PK) (Southall et al. 2007) for cetaceans. Noise generated by vessels would not exceed that level so permanent or temporary injury to protected migratory whale species or other marine species is not anticipated.

There may be some localised behavioural disturbance of marine fauna in the immediate vicinity of vessels during operations. Gradual exposure to continuous noise, such as noise produced by an approaching vessel, is generally regarded as being unlikely to startle or stress marine fauna (Southall et al. 2007). Some transient marine fauna individuals may choose to avoid the immediate proximity of the vessel, but this is not expected to have any widespread or longer-term impacts on their behaviour or populations.

Hence, any avoidance or attraction behaviours displayed are expected to be localised and temporary, based on the limited duration of the survey. Predicted noise levels are not considered to be ecologically significant at a population level and the potential impacts are considered to be localised with no lasting effect.

In general, exposure to helicopter sound emissions is of short duration, peaking as the helicopter passes directly overhead. Received levels are expected to be low during transit when helicopter altitude is greatest and disturbance to marine fauna is not expected. The highest received levels will occur at lower altitudes on approach to landing. Some minor behavioural disturbance may occur for short periods if marine fauna are present near the surface in the vicinity of helicopters landing on the seismic vessel. This would be limited to a temporary change in behaviour due to avoidance of the area, but is not expected to have any longer term impacts. Seabirds are expected to avoid the immediate vicinity of a helicopter, but again no long-term impacts are anticipated.

Based on the assessment above and the implementation of the identified controls, the consequence of occasional short-term and localised disturbance to marine fauna is Slight (1). The likelihood of this consequence occurring is Occasional (C) and the risk is considered to be Low.

Further information about the selected control measures, the ALARP evaluation, and the demonstration of Acceptability is provided below.

7.3.3 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Justification
Inherent Design and Legislative Requirements		
Vessel activities will be undertaken in accordance with EPBC Regulations 2000 – Part 8 Division 8.1, including: ■ taking action to avoid approaching or drifting closer than 50 m to a dolphin or 100 m to a whale; and ■ not exceeding a speed of 6 knots within the caution zone of a cetacean (300 m).	Yes	The requirements of the EPBC regulations set out clear measures to reduce speed and avoid approaching cetaceans, which also reduce the risk of engine noise in close proximity to cetaceans. It is a legislative requirement for vessels to comply with the EPBC Regulations 2000.
Helicopter movements will be undertaken in accordance with EPBC Regulations 2000 – Part 8 Division 8.1, including: ■ helicopters not to operate at a height lower than 1650 feet within a horizontal radius of 500 metres of a cetacean; and ■ helicopters not to approach a cetacean from head on.	Yes	The requirements of the EPBC regulations set out clear measures on altitudes above cetaceans and on approaching cetaceans, which reduce the risk of noise in close proximity to cetaceans. It is a legislative requirement for helicopters to comply with the EPBC Regulations 2000.
Alternatives/Substitutes Considered		
No helicopter transfers.	No	The alternative option of eliminating helicopter transfers was considered but not selected. Helicopter transfers are necessary from time to time to make crew transfers. The alternative would require the vessel to return to port to change crew or the use of an additional transfer vessel which would be costly, time consuming and would increase vessel movements and potential interactions with receptors. Given the already low risk of potential short term, localised behavioural responses from up to a few individuals, the control is disproportionate to the level of risk and is not expected to provide any benefit.

Control Measure	Control Adopted	Justification
Additional Controls Considered		
In addition to the requirements of the EPBC Regulations 2000 - Part 8 Division 8.1 for cetaceans, vessels, when safe to do so, will also: ▪ take action to avoid approaching or drifting closer than 50 m to a turtle; and ▪ not exceeding a speed of 6 knots within 300 m of a turtle.	Yes	In addition to implementing avoidance measures for cetaceans, Polarcus has considered extending the prescribed avoidance measures to turtles. Good industry practice, environmental benefit outweighs additional cost.
Seismic vessel and support vessels (taking into account the limited manoeuvrability of the former) will also adopt measures consistent with the DPaW Whale Shark Management Program (2013), including: ▪ taking action to avoid approaching or drifting closer than 30 m of a whale shark; and ▪ not exceeding 8 knots within 250 m of a whale shark.	Yes	In addition to implementing the EPBC Regulations 2000 for cetaceans, Polarcus has extended the avoidance measures to whale sharks. Good industry practice, environmental benefit outweighs additional cost.
Extend the requirements of the EPBC Regulations 2000 - Part 8 Division 8.1 for helicopters to turtles, whale sharks and dugongs.	No	Helicopter transfers will be infrequent. Extending the legislative requirements of the regulations for cetaceans to other fauna could prevent the helicopter from landing, should fauna be observed. When making a descent towards the helideck of the vessel, the pilot's attention is on landing the helicopter and the relative position of the craft with the vessel. For safety and practicality reasons, the helicopter needs to land safely and the pilot or others on board should not need to observe for additional fauna. The potential impacts and risks associated with occasional helicopter landings are low given the short-term and localised behavioural response that may occur to individual or small numbers of animals. No significant impacts are expected and the risk is deemed acceptable. Therefore, applying measures to other marine fauna is impractical, unnecessary and disproportionate to the limited additional benefit it may provide to reducing the already low level of risk.

Control Measure	Control Adopted	Justification
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)		
No practicable improvements have been identified.	N/A	N/A
ALARP Statement		
The residual risk has been determined to be Low. Polarcus considers the adopted control measures appropriate to manage the impacts of vessel and helicopter noise emissions on marine fauna. As no reasonable additional or alternative controls were identified that would further reduce the impacts and risks, without jeopardising the objectives of the survey, the impacts and risks are considered to be ALARP.		

7.3.4 *Demonstration of Acceptable Levels*

Context	Demonstration
Risk Level	The residual risk is assessed to be Low.
Legislative Requirements	The requirements of the EPBC Regulations 2000 (Part 8 Division 8.1 'Interacting with cetaceans') will be implemented.
Conservation Advice, Recovery Plans, and Other Guidelines	Proposed control measures and the low residual risk of vessel noise are consistent with the various Conservation Advice, Conservation Management Plans and Recovery Plans for whales, sharks and turtles. Proposed control measures for whale sharks are also consistent with the DPaW (2013) Whale Shark Management Program.
AMP Values, Management Prescriptions and IUCN Reserve Management Principles	No population-level impacts or serious or irreversible ecological implications are predicted to the values of the Joseph Bonaparte Gulf Marine Park or Oceanic Shoals Marine Park. The biological diversity and natural values of these AMPs will not be impacted in the long term, and therefore, management measures are consistent with IUCN management prescriptions and the ecological use of the Marine Parks.
Principles of Ecologically Sustainable Development	There is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecological integrity associated with the generation of noise emissions from the seismic vessel, support vessels and operation of mechanical equipment operation during the Petrelex 3D MSS. The aspect and potential interactions are well understood and managed in accordance with EPBC Policy Statement 2.1 and applicable industry standards and best practice guidance.
Stakeholder Objections, Claims, Concerns or Advice	N/A – Stakeholders have not raised any specific concerns relating to noise emissions from vessels and/or helicopters.
Acceptability Statement	
Based on the criteria above, Polarcus considers the adopted control measures appropriate to manage the impacts of noise emission from vessels and helicopters to be of an acceptable level.	

7.4 Physical Presence: Interference with Other Marine Users

7.4.1 *Assessment Summary*

Source of Impact/Risk	
Potential disruption/interference with other marine users associated with the physical presence of the seismic vessel, in-water equipment and support vessels in the Operational Area. The seismic vessel and towed array will be comprised of the airgun array and streamer array, which includes header buoys, starboard and port spreaders or vanes, streamers and tail buoys.	
Receptors	
■ Commercial fishing; ■ Tourism and recreation; ■ Commercial shipping; ■ Defence activities; and ■ Petroleum exploration and production operations.	
Adopted Control Measures	**EPS #**
Notice to Mariners issued prior to commencement of survey activities.	4.1
Daily reporting to AMSA JRCC for promulgation of radio-navigation warnings.	4.2
Notification will be provided to fisheries stakeholders, four weeks prior to commencement, indicating location and expected timing. Notification will also be provided to fisheries stakeholders within two weeks of cessation of activities.	4.3
Notification to the Department of Defence (DoD) five weeks prior to survey commencement and following cessation of activities.	4.4
Daily look-ahead reports detailing the upcoming 48 hours survey events will be provided via email to stakeholders who register for the service.	4.5
Adherence with requirements of the International Regulations for Preventing Collisions as Sea 1972 (COLREGS) and Chapter 5 of Safety of Life at Sea Convention (SOLAS) as implemented in Commonwealth waters through the *Navigation Act 2012* and associated Marine Orders Parts 21, 27, 30, 58 - safety and emergency arrangements, prevention of collisions, safe management of vessels, including: ■ Appropriate lighting, navigation and communication to inform other users. ■ Use of radar and 24/7 watch.	4.6
At least one support vessel (supply or chase vessel) will accompany the seismic vessel when the seismic vessel is in operation and when safe to do so (e.g. outside of inclement weather periods). The support vessel will conduct advanced scouting to ensure that fishing vessels or other activities in the area are provided with advance notice to move away from the path of the seismic vessel.	4.7
Streamers marked with tail buoys.	4.8
No seismic acquisition during scheduled military exercises within the NAXA.	4.9
Details of Residual Impacts and Risks	
The seismic vessel will typically move along pre-determined seismic lines at a constant speed of approximately 4-5 knots and will proactively and collaboratively manage operational information between Polarcus, other marine users (including commercial fishing operators) in the Operational Area.	

The limited manoeuvrability of the seismic vessel means that vessels associated with shipping and commercial fisheries may be asked to take measures to avoid the immediate vicinity of the seismic vessel and associated equipment. Skippers of commercial fishing vessels may be asked to remove fishing gear such as traps and lines to avoid interaction with the seismic vessel and in-water equipment. A chase vessel will be employed for the survey to ensure that third party vessels are informed and aware of the Petrelex 3D MSS. Some commercial shipping may also be asked to deviate from their intended routes to avoid the seismic vessel and towed array, but given the controls identified above, no significant navigational implications or changes in shipping traffic patterns are expected. No seismic acquisition will occur during scheduled military exercises within the NAXA. The residual impacts and risks have therefore been assessed as Low. Further detail is provided in the evaluation of impacts and risks below.			
Risk Ranking	**Consequence**	**Likelihood**	**Risk Ranking**
Inherent Risk	Minor (2)	Regular (D)	**Medium**
Residual Risk	Minor (2)	Occasional (C)	**Low**

7.4.2 *Detailed Evaluation of Impacts and Risks*

The seismic vessel will typically move along planned seismic lines at a constant speed of approximately 4-5 knots and will proactively and collaboratively manage operational information between Polarcus, and other marine users (including commercial fishers). The survey will adhere to the requirements of the International Regulations for Preventing Collisions as Sea 1972 (COLREGS) and Chapter 5 of Safety of Life at Sea Convention (SOLAS) as implemented in Commonwealth waters through the *Navigation Act 2012* and associated Marine Orders Parts 21, 27, 30, 58 - safety and emergency arrangements, prevention of collisions, safe management of vessels.

The likelihood of direct interactions between the seismic vessel and other vessels in the Operational Area will be reduced through the required use of appropriate navigational lighting and shapes, communication channels and procedures, use of radar and implementation of 24/7 watch on board to keep other users of the area aware of the vessel's position.

Relevant stakeholders have been and will continue to be consulted regarding the proposed survey activities. A Notice to Mariners will be issued prior to commencement of survey activities and daily reporting to AMSA JRCC (for promulgation of AUSCOAST warnings) will also be undertaken.

A range of activities associated with other marine users may occur within or near to the Operational Area, including:

- Commercial fishing – Commonwealth, WA and NT commercial fishing licence holders may be encountered during the Petrelex 3D MSS (refer to Section 4.6.6).
- Tourism and recreational – tourism operators may transverse through the Operational Area from Darwin to the Kimberley coastline (refer to Section 4.6.7).
- Defence activities – the Acquisition and Operational areas overlap with the NAXA, an area within which Defence operates a biennial major military training exercise. No seismic acquisition will occur within the NAXA during scheduled military exercises (refer to Section 4.6.8).
- Commercial shipping - vessels may pass through on occasion; however a high density of shipping traffic is expected in the northern section of the Operational Area (refer to Section 4.6.9).
- Petroleum exploration and production operations, including associated vessel activities (refer to Section 4.6.10).

7.4.2.1 Commercial Fishing

There are a number of Commonwealth, WA and NT managed fisheries that have historically had catch effort within the Operational Area (refer to Section 4.6.6). The physical presence of the seismic vessel, in-water equipment and the support vessels have the potential to interfere with the movements and operations of commercial fishing vessels.

The limited manoeuvrability of the seismic vessel means that commercial fishers may be asked to take measures to avoid the seismic vessel and towed equipment or remove fishing gear such as traps and lines to avoid any interaction. Typically, other users are requested to provide a wide berth of 3.0 nm (5.5 km) ahead and on either side of the seismic vessel, and 6.0 nm (11 km) astern of the vessel.

There is a possibility that commercial fishing vessels will be displaced from the areas, whilst the seismic vessel is conducting seismic acquisition. Disruptions to fishing operations are anticipated to be temporary and not significant for the following reasons:

- The fisheries cover wide spatial areas with only a small portion (less than 2%) of each fishery overlapping within the Operational Area.
- The transient nature of both the fishing vessels and the seismic survey vessel means that an area is only temporarily unavailable to fishing.
- Notifications to fisheries licence holders via Notice to Mariners prior to survey commencement will enable pre-planning of fishing activities to avoid disruption.
- Radar detection systems and ongoing radio communications with licence holders will provide advanced and timely notice to fishers during operations.

It should be noted that the inherently broad nature of multi-client seismic acquisition programmes reduces the potential for future seismic acquisition to be required in areas actively targeted by commercial fisheries. This is because such multi-client surveys generate large, uniform datasets of geological information for access by oil and gas operators to further their understanding of the regional geology and support future petroleum exploration and production activity in the region over the medium to long term. Therefore, a multi-client survey approach reduces the long-term additional seismic activity in a given area by replacing the need for several seismic surveys to be conducted by individual petroleum titleholders.

7.4.2.2 Tourism and Recreation

Tourism and recreational activities are known to take place along the northern Kimberly coastline, however interactions with the Petrelex 3D MSS are considered unlikely due to the remoteness and predominantly deep waters of the Operational Area (refer to Section 4.6.7). In the event that tourism/recreational activities are present within the Operational Area, displacement would be minimal given the transient nature of the seismic activities. Therefore, no significant implications are expected.

7.4.2.3 Defence Activities

The Acquisition Area and Operational Area overlap with the NAXA. The Department of Defence will be conducting a major military exercise within the NAXA during the period of between 1 August – 30 September 2020 (subject to rescheduling). The DoD advised during consultation that activities conducted within the NAXA and surrounding areas during this period are likely to be disrupted. Polarcus will not undertake any seismic survey activities associated with the Petrelex 3D MSS during any major military exercise conducted within the NAXA. Therefore, no implications to Defence activities are expected.

7.4.2.4 Commercial Shipping

Heavy vessel traffic in the northern section of the Operational Area is expected, due to vessels heading in and out of Darwin (refer to Section 4.6.9). Some commercial shipping may be asked to deviate from their intended routes to avoid the seismic vessel, in-water equipment and support vessels. Based on the controls identified below, no significant navigational implications to shipping traffic patterns are expected.

7.4.2.5 Petroleum Exploration and Production Operations

The Bonaparte Basin is an established hydrocarbon province with a number of commercial operations such as the Blacktip Field operated by Eni Australia B.V (refer to Section 4.6.10). Vessels associated with nearby petroleum operations may be asked to deviated from intended routes to avoid the seismic vessel, in-water equipment and support vessels. Based on the controls identified below, no significant implications are expected.

Based on the assessment above and the implementation of the identified controls, it is expected that localised and temporary disruptions to other marine users will be Minor (2), with fishers and other users able to return to a particular area once the seismic vessel has passed. The likelihood of interaction is considered to be Occasional (C), resulting in a Low inherent risk to other users in the Operational Area.

Further information about the selected control measures, the ALARP evaluation, and the evaluation of Acceptability are provided below.

7.4.3 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Comment / Justification
Inherent Design and Legislative Requirements		
Adherence with requirements of the International Regulations for Preventing Collisions as Sea 1972 (COLREGS) and Chapter 5 of Safety of Life at Sea Convention (SOLAS) as implemented in Commonwealth waters through the Navigation Act 2012 and associated Marine Orders Parts 21, 27, 30, 58 - safety and emergency arrangements, prevention of collisions, safe management of vessels, including: ■ Appropriate lighting, navigation and communication to inform other users. ■ Use of radar and 24/7 watch.	Yes	These are a legislative requirement for vessels operating in Australian Commonwealth waters and will be implemented by all vessel employed for the Petrelex 3D MSS.
Alternatives/Substitutes Considered		
No practicable alternative or substitutes to the acquisition or the inherent controls have been identified.	N/A	N/A
Additional Controls Considered		
Notice to Mariners issued prior to commencement of survey activities.	Yes	AHS will be contacted four weeks prior to the commencement of the survey for the publication of a Notice to Mariners. This will ensure other users that may potentially be present in the Operational Area are aware of the survey. Implementation will reduce the likelihood of interactions with other marine users. Good industry practice.

Control Measure	Control Adopted	Comment / Justification
Daily reporting to AMSA JRCC for promulgation of radio-navigation warnings.	Yes	The AMSA JRCC will be contacted 24-48 hours before operations commence for the promulgation of radio-navigation warnings (i.e. AUSCOAST warnings). Good industry practice.
Notification will be provided to fisheries stakeholders, four weeks prior to commencement, indicating location and expected timing. Notification will also be provided to fisheries stakeholders within two weeks of cessation of activities.	Yes	Notification will be provided to fisheries stakeholders, four weeks prior to commencement of the survey, indicating location and expected timing. Notification will also be provided to fisheries stakeholders within two weeks of completion of the survey. Good industry practice.
Notification to Department of Defence five weeks prior to the commencement of the survey and following cessation of activities.	Yes	The DoD will be contacted five weeks prior to the commencement of the survey, and following cessation of activities. Good industry practice.
At least one support vessel (supply or chase) will accompany the seismic vessel when the vessel is in operation and when safe to do so (e.g. outside of inclement weather periods). A support vessel will conduct advanced scouting to ensure that other marine users in the area are provided with advance notice to move away from the path of the seismic vessel.	Yes	A support vessel will provide effective look-aheads and communications with other activities and users. Good industry practice, environmental benefit outweighs additional cost.
Streamers marked with tail buoys.	Yes	Tail buoys will be used to mark ends of the streamers so that they are visible to other vessels. Good industry practice, environmental benefit outweighs additional cost.
No seismic acquisition during scheduled military exercises within the NAXA.	Yes	In consultation with the DoD, Polarcus and the DoD agreed that no seismic acquisition will occur during the major military exercise being held within the NAXA in 2020. The military exercise is scheduled to be undertaken between 1 August – 30 September 2020 (subject to rescheduling).

Control Measure	Control Adopted	Comment / Justification
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)		
Daily look-ahead reports detailing the upcoming 48 hours survey events will be provided via email to stakeholders who register for the service.	Yes	Daily look-ahead reports detailing the upcoming 48 hours survey events will be provided via email to stakeholders who register for the service. This will ensure other marine users that may present (or are present) in the Operational Area are aware of the upcoming survey activities. Implementation will reduce the likelihood of interactions with other marine users. Good industry practice.
ALARP Statement		
The residual risk has been determined to be Low. Polarcus considers the adopted control measures appropriate to manage the impacts associated with the physical presence of vessels and in-water equipment. As no reasonable additional or alternative controls were identified that would further reduce the impacts and risks, without jeopardising the objectives of the survey, the impacts and risks are considered to be ALARP.		

7.4.4 *Demonstration of Acceptable Levels*

Context	Demonstration
Risk Level	The residual risk is assessed to be Low.
Legislative Requirements	All requirements under the *Navigation Act 2012* and associated Marine Orders for safety and emergency arrangements, prevention of collisions and safe management of vessels are identified as control measures.
Conservation Advice, Recovery Plans, and Other Guidelines	N/A: No advice or guidelines have been identified that specifically address potential impacts to fisheries.
AMP Values, Management Prescriptions and IUCN Reserve Management Principles	The socio-economic values of the Joseph Bonaparte Gulf Marine Park and Oceanic Shoals Marine Park will not be impacted, and therefore, management measures are consistent with IUCN management prescriptions and the socio-economic use of the AMPs.
Principles of Ecologically Sustainable Development	The seismic vessel will be moving at 4-5 knots during the activity and all vessels (including support vessels) will comply with the requirements of the *Navigation Act 2012* and associated Marine Orders. The potential interactions between vessels and other marine users are well understood. Ongoing consultation will be undertaken to communicate key updates on the survey to stakeholders. In addition, there is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecological integrity associated with the disruption/interference with other users during the Petrelex 3D MSS.
Stakeholder Objections, Claims, Concerns or Advice	Stakeholder concerns have been assessed, responded to and controls adopted for objections and claims which hold merit. The proposed control measures have been developed based on the advice of DoD, WAFIC, DPIRD and NPFI.
Acceptability Statement	
Based on the criteria above, Polarcus considers the adopted control measures appropriate to manage the impacts associated with the physical presence of vessels and in-water equipment to be of an acceptable level.	

7.5 Discharge: Liquid Waste Management

7.5.1 *Assessment Summary*

Source of Impact/Risk	
The seismic vessel and support vessels used during the survey will generate liquid wastes associated with routine activities, including: ■ Domestic waste discharges (treated sewage, grey water and putrescible food waste); and ■ Deck drainage and bilge water.	
Receptors	
■ Water quality; and ■ Marine biota.	
Adopted Control Measures	**EPS #**
Sewage will be managed in accordance with MARPOL Annex IV and AMSA Marine Order 96, using an IMO-approved sewage treatment plant, a sewage comminuting and disinfecting system or a sewage holding tank as applicable depending on vessel gross tonnage or people capacity (as evidenced by a current International Sewage Pollution Prevention (ISPP) Certificate).	5.1
In accordance with MARPOL Annex IV and AMSA Marine Order 96: ■ Sewage will only be discharged via an IMO-approved sewage treatment plant; or ■ Comminuted/disinfected sewage via an IMO-approved system will only be discharged when ≥3 nm from land and when the vessel is moving at ≥4 knots; or ■ Sewage that has not been comminuted/ disinfected via an IMO-approved system will only be discharged when ≥12 nm from land and when the vessel is moving at ≥4 knots.	5.2
Vessels will have facilities on board of a standard capable of macerating or grinding putrescible wastes and screening to less than 25 mm in diameter, prior to discharge while the vessel is moving and ≥3 nm from land.	5.3
Vessels > 400 GRT will have an oil discharge monitoring and control system and oil filtering equipment on board, hold a current IOPP Certificate and maintain an oil usage management log book, in accordance with MARPOL 73/78.	5.4
Treated bilge water will be discharged only when the vessel is moving and the oil discharge monitoring and control system and oil filtering equipment is operating. If oil discharge monitoring and control system and oil filtering equipment are unavailable, bilge water mixtures will be retained on board for on shore disposal.	5.5
Oil discharge monitoring and control systems on board the vessels will be maintained and calibrated to ensure monitoring readings are accurate.	5.6
Details of Residual Impacts and Risks	
Impacts resulting from the discharge of liquid wastes are expected to be negligible, as treated discharges would rapidly disperse in close proximity to the release location given surface currents and the assimilative capacity of the open ocean environment. Routine discharge of liquid wastes has the potential to temporarily create a localised increase in nutrient levels resulting in minor and temporary ecological impacts (e.g. changes in the availability of light, certain nutrients and/or dissolved oxygen).	

With the proposed management and discharge controls in place, discernible impacts to water quality and marine biota are not expected in the open water location of the Petrelex 3D MSS. The consequence of reduction in water quality and impacts to marine biota is therefore slight given the nature and scale of the impact, though any changes would rarely be discernible.

The residual risk associated with the management and disposal of liquid waste discharges has been determined to be low. Further detail is provided in the evaluation of impacts and risks below.

Risk Ranking	Consequence	Likelihood	Risk
Inherent Risk	Slight (1)	Rare (B)	**Low**
Residual Risk	Slight (1)	Rare (B)	**Low**

7.5.2 *Detailed Evaluation of Impacts and Risks*

The waters within and adjacent to the Operational Area are generally oligotrophic (i.e. low nutrient levels) except where localised and sporadic and short-lived upwellings occur in the region (e.g. at the shelf break, where deeper, cooler nutrient rich water is brought to the surface). Section 4.5 provides a detailed description of the ecological communities and marine fauna that may occur in the Operational Area, which could potentially be impacted.

7.5.2.1 Discharge of Domestic Wastes

The seismic vessel will have up to 60 persons on board, resulting in up to approximately 9 m^3 of sewage and grey water discharges per day from domestic processes such as ablution, laundry and galley activities, and putrescible wastes primarily from food wastes. Discharges from the support vessels will be significantly less than that of the seismic vessel.

Routine discharges of domestic wastes has the potential outcome of temporary and localised increased nutrient levels resulting in localised, minor and temporary ecological impacts (e.g. changes in certain nutrients and/or dissolved oxygen).

All domestic waste discharge streams will be managed in accordance with the requirements of MARPOL 73/78 and the AMSA Marine Orders made under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*, as follows:

- All vessels over 400 GRT to be used for the survey will hold a current International Sewage Pollution Prevention Certificate (ISPP Certificate);
- Sewage will be treated and discharged in accordance with MARPOL; using an International Maritime Organisation (IMO) approved sewage treatment plant, a sewage comminuting and disinfecting system or a sewage holding tank prior to discharge, as applicable depending on vessel gross tonnage or people capacity;
- Comminuted/disinfected sewage via an IMO-approved system will only be discharged when ≥3 nm from land and when the vessel is moving at ≥4 knots. Sewage that has not been comminuted/ disinfected via an IMO-approved system will only be discharged when ≥12 nm from land and when the vessel is moving at ≥4 knots; and
- For vessels greater than 100 GRT (or certified for >15 persons on board), a Waste Management Plan will be developed, and vessels greater than 400 GRT will have a waste management log book, in accordance with MARPOL 73/78.

Discharges will therefore be conducted when vessels are transient, resulting in those discharges dispersing rapidly in the predominantly open oceanic location of the Operational Area. The resulting change in water quality in the water column will be highly localised and short term, with nutrient concentrations returning to background levels shortly after discharge. Thus, significant impacts to marine biota are not expected. The extent of impacts is expected to be localised to surface waters and in the immediate vicinity of the discharge location. Benthic communities are therefore not expected to be impacted.

7.5.2.2 Drains and Bilge Discharge

Liquids collected in the bilge consist of a mixture of water, oily residue, lubricants and cleaning fluids from various sources, including engines and machinery areas on board the vessel. The amount of bilge wastes accumulated on board is dependent on vessel characteristics, such as size, engine room design, and preventative maintenance schedule.

Rainwater and wash-down water from deck areas and other open drainage areas on-board the vessel may contain low concentration residues (e.g. oil, grease, detergent), and will require discharge. The volume of drain discharge required during the survey is dependent on the amount of rainfall received and the frequency of the deck washing activities. Discharges from open drain areas will be conducted directly overboard.

Routine discharge of deck drainage and bilge water, if not managed or treated, has the potential outcome of a temporary and localised reduction in water quality resulting in localised, minor and temporary toxicity impacts on marine biota. The discharge from drains and bilge from each vessel also has the potential to result in a reduction in water quality (through an increase in nutrient levels or contaminants such as hydrocarbons), which has the potential to affect marine biota. However, areas of potential contamination on vessels such as machinery and bulk liquid storage areas are contained or bunded to capture any spilled chemicals or oil residues. Drainage from these areas will be directed to holding tanks for treatment through an oil-in-water separator prior to discharge.

Deck drainage and bilge water discharges will be managed in accordance with the requirements of MARPOL 73/78 and the AMSA Marine Orders made under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*.

All vessels >400 GRT to be used for the survey will hold a current International Oil Pollution Prevention (IOPP) Certificate demonstrating that vessels are fitted with an oil discharge monitoring and control system and oil filtering equipment, which will be maintained and operated to 15 ppm standard so that the bilge stream is treated to reduce hydrocarbon concentrations below 15 ppm in accordance with MARPOL 73/78 prior to discharge overboard.

In addition, oil discharge monitoring and control systems on board the vessels will be regularly calibrated to ensure monitoring readings are accurate.

Given the minor quantities of contaminants expected from the open drains, the expected rapid dispersal of both open drain and treated bilge discharges, the assimilative capacity of the open ocean environment, and the management measures to be implemented for the bilge waste stream, no discernible impacts are expected. The risk of toxicity impacts to marine biota from drains and bilge discharge is considered to be Low.

Further information about the selected control measures, the ALARP evaluation, and the evaluation of Acceptability are provided below.

7.5.3 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Comment / Justification
Inherent Design and Legislative Requirements		
Sewage will be managed in accordance with MARPOL Annex IV and AMSA Marine Order 96, using an IMO-approved sewage treatment plant, a sewage comminuting and disinfecting system or a sewage holding tank as applicable depending on vessel gross tonnage or people capacity (as evidenced by a current International Sewage Pollution Prevention (ISPP) Certificate).	Yes	Vessels used for the survey that are of 400 GRT or certified to carry more than 15 persons, will have an appropriate sewage treatment plant, sewage comminuting and disinfecting system or sewage holding tank on board (with related ISPP Certificate).
In accordance with MARPOL Annex IV and AMSA Marine Order 96: ■ Sewage will only be discharged via an IMO-approved sewage treatment plant; or ■ Comminuted/disinfected sewage via an IMO-approved system will only be discharged when ≥3 nm from land and when the vessel is moving at ≥4 knots; or ■ Sewage that has not been comminuted/ disinfected via an IMO-approved system will only be discharged when ≥12 nm from land and when the vessel is moving at ≥4 knots.	Yes	Sewage discharges to the marine environment during the survey will be undertaken in accordance with the requirements of MARPOL Annex IV and AMSA Marine Order 96, including via approved systems and the required discharge rates to ensure adequate dispersion of discharges to reduce the potential for impacts.
Vessels will have facilities on board of a standard capable of macerating or grinding putrescible wastes and screening to less than 25 mm in diameter, prior to discharge while the vessel is moving and ≥3 nm from land.	Yes	Discharges of putrescible waste (e.g. food waste) will be undertaken in accordance with the requirements of MARPOL Annex V and AMSA Marine Order 95.

Control Measure	Control Adopted	Comment / Justification
Vessels >400 GRT will have an oil discharge monitoring and control system and oil filtering equipment on board, hold a current IOPP Certificate and maintain an oil usage management log book, in accordance with MARPOL 73/78.	Yes	Vessels used for the survey that are of 400 GRT will have an oil discharge monitoring and control system and oil filtering equipment on board (with related IOPP Certificate) in accordance with the requirements of MARPOL Annex I and AMSA Marine Order 91.
Treated bilge water will be discharged only when the vessel is moving and the oil discharge monitoring and control system and oil filtering equipment is operating. If oil discharge monitoring and control system and oil filtering equipment is unavailable, bilge water mixtures will be retained on board for onshore disposal.	Yes	Bilge water discharges will be undertaken in accordance with the requirements of MARPOL Annex I and AMSA Marine Order 91 to ensure discharges to the marine environment are acceptable or otherwise retained on board for disposal.
Alternatives/Substitutes Considered		
Alternative to the discharge of liquid waters to the marine environment is the retention of all liquid wastes on board and transfer to a licensed onshore disposal site.	No	The alternative was discounted as being impractical for the following reasons: ■ Environmental risks associated with offshore discharge are low given the use of IMO-standard sewage systems and macerator, IMO-standard oil discharge monitoring and control systems and the commitment to discharge offshore in accordance with MARPOL and associated Marine Orders. ■ Retaining wastes on board for transfer to shore would require additional supply vessel journeys to be made during the survey, resulting in additional vessel movements and associated increased risks of physical presence, noise, atmospheric emissions etc. ■ Transfer and disposal of liquid wastes to sure would have significant additional cost and time implications. Given the already low environmental risk associated with proposed discharges, the planning, time and cost implications are grossly disproportionate to the negligible reduction in risk that would be achieved and the already low level of risk.

Control Measure	Control Adopted	Comment / Justification
Additional Controls Considered		
Oil discharge monitoring and control systems on board the vessels will be maintained and calibrated to ensure monitoring readings are accurate.	Yes	Records of equipment calibration can be retained and checked to confirm that equipment is operating as per the requirements of MARPOL and associated Marine Orders.
In addition to vessels complying with the requirement to be fitted with an IMO-approved sewage treatment plant or sewage holding tank (where applicable), vessels may be required to have an IMO-approved sewage treatment plant regardless of vessel size and people capacity.	No	This additional control would add to the cost of the survey, making it impractical to the nature and scale of the risk associated with sewage discharge on small vessels; as a result this additional control was determined to be impractical from an operational perspective.
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)		
No further practicable improvements to the above controls have been identified.	N/A	N/A
ALARP Statement		
The residual risk has been determined to be Low. Polarcus considers the adopted control measures appropriate to manage the impacts of liquid waste discharge during the survey. As no reasonable additional or alternative controls were identified that would further reduce the impacts and risks, without jeopardising the objectives of the survey, the impacts and risks are considered to be ALARP.		

7.5.4 *Demonstration of Acceptable Levels*

Context	Demonstration
Risk Level	The residual risk is assessed to be Low.
Legislative Requirements	The proposed controls meet or exceed the requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) and associated AMSA Marine Orders made under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* for the management of discharges at sea.
Conservation Advice, Recovery Plans, and Other Guidelines	No species Recovery Plans or Conservation Advice set requirements relating to the management of liquid waste discharges.
AMP Values, Management Prescriptions and IUCN Reserve Management Principles	No population-level impacts or serious or irreversible ecological implications are predicted to the values of the Joseph Bonaparte Gulf Marine Park or Oceanic Shoals Marine Park. Although the Operational Area is not located within any AMPs, management of discharges in accordance with the requirements of MARPOL meets the management prescriptions for Multiple Use Zones in the North Marine Park Network Management Plan. The biological diversity and natural values of these AMPs will not be impacted in the long term, and therefore, management measures are consistent with IUCN management prescriptions and the ecological use of the marine parks.
Principles of Ecologically Sustainable Development	The residual risks to water quality and marine biota are low given the proposed controls meet the requirements of MARPOL 73/78. Impacts are expected to be negligible with no lasting, serious or irreversible ecological damage. The aspect and potential interactions are well understood and managed according to internationally adopted standards.
Stakeholder Objections, Claims, Concerns or Advice	N/A – Stakeholders have not raised any specific concerns relating to liquid waste management and discharge from vessels.
Acceptability Statement	
Based on the criteria above, Polarcus considers the adopted control measures appropriate to manage the impacts of liquid waste discharge during the survey to be of an acceptable level.	

7.6 Atmospheric Emissions: Vessels and Equipment

7.6.1 *Assessment Summary*

Source of Impact / Risk

Atmospheric emissions have the potential to result in a localised reduction in air quality in the immediate vicinity of the vessel exhaust and to contribute to greenhouse gases (GHG) in the atmosphere.

The seismic vessel and support vessels will generate atmospheric emissions from power generation equipment, engine exhaust and waste incinerators during the Petrelex 3D MSS. Atmospheric emissions generated from internal combustion engines of seismic vessel and support vessels and machinery used during the survey will include SO_2, NOX, ozone depleting substances, CO_2, particulates and Volatile Organic Compounds (VOCs).

Receptors

- Air quality in the immediate vicinity of the vessel exhaust; and
- Contribute to global levels of GHG in the atmosphere.

Adopted Control Measures	EPS #
In accordance with MARPOL 73/78 Annex VI (Prevention of Air Pollution) and Marine Order 97: ■ Vessels to have a valid IAPP Certificate. ■ Incinerator will be certified to meet prescribed emissions standards. ■ Diesel engines >130 kW certified to meet prescribed emission standards.	6.1
Vessels will use MGO grade fuel during the survey, which will have low sulphur content.	6.2
Vessel engines and incinerators maintained according to manufacturer's specification.	6.3

Details of Residual Impacts and Risks

Atmospheric emissions have the potential to result in a localised reduction in air quality in the immediate vicinity of the vessel exhaust and to contribute to Australian and global levels of greenhouse gases in the atmosphere. Due to the low emission levels and very low background levels of pollutants, it is anticipated that emissions resulting from the survey will only result in a short term and localised reduction in air quality, with emissions quickly dispersing back to within background levels. Given the low level of emissions anticipated, survey emissions only represent a very small contribution to overall Australian and global GHG emissions to the atmosphere.

With the proposed management and controls in place, discernible impacts to air quality are not expected in the vicinity of the Petrelex 3D MSS. No lasting effect on sensitive receptors is likely. The consequence of reduction in air quality is therefore low given the nature and scale of the impact, though any changes would rarely be discernible.

The residual impacts and risks have therefore been assessed as low. Further detail is provided in the evaluation of impacts and risks below.

Risk Ranking	Consequence	Likelihood	Risk
Inherent Risk	Slight (1)	Rare (B)	**Low**
Residual Risk	Slight (1)	Rare (B)	**Low**

7.6.2 *Detailed Evaluation of Impacts and Risk*

The vessels present in the Operational Area will generate atmospheric emissions from power generation and waste incineration. Atmospheric emissions have the potential to result in a localised reduction in air quality in the immediate vicinity of the vessel exhaust and to contribute to Australian and global levels of greenhouse gases in the atmosphere.

Overall emissions from the seismic vessel are expected to be low given the class of vessels to be used and the duration of the survey. To further reduce emissions, vessels will also comply with MARPOL 73/78 Annex VI (Prevention of Air Pollution from Ships) requirements, whereby they will:

- Hold a valid International Air Pollution Prevention (IAPP) Certificate;
- Implement a preventative maintenance system to maintain diesel-powered equipment and incinerator for efficient operation; and
- Use low sulphur MGO.

Given the location of survey activities offshore, any emissions are expected to disperse rapidly in the open oceanic conditions. Given the distance of the Operational Area offshore, background levels of atmospheric pollutants are expected to be low. Due to the low emissions levels and very low background levels of pollutants, it is anticipated that emissions resulting from the survey will only result in a short-term and localised reduction in air quality, with emissions quickly dispersing back to within background levels. No lasting effect on sensitive receptors is likely. Given the low level of emissions anticipated, survey emissions only represent a very small contribution to overall Australian and global GHG emissions to the atmosphere.

Further information about the selected control measure, the ALARP evaluation, and the evaluation of Acceptability are provided below.

7.6.3 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Comment / Justification
Inherent Design and Legislative Requirements		
In accordance with MARPOL 73/78 Annex VI (Prevention of Air Pollution) and Marine Orders 97: ■ Vessels to have a valid IAPP Certificate (International air pollution prevention certificate) ■ Incinerator will be certified to meet prescribed emissions standards ■ Diesel engines >130 kW certified to meet prescribed emission standards	Yes	MARPOL is a legislative requirement for vessels operating in Australian Commonwealth waters and will be implemented by all vessels. Implementation of the regulations will reduce the atmospheric emissions released into the environment. It is a legislative requirement for vessels to comply with MARPOL and AMSA Marine Orders.
Vessels will use MGO grade fuel during the survey, which will have low sulphur content.	Yes	Vessels will use low sulphur MGO during the survey. The current requirement of MARPOL Annex VI is that sulphur content of fuel oil is to not exceed 3.5% by mass (m/m). From 1 January 2020, the new limit for sulphur in fuel oil used on board vessels will be <0.50% m/m. It is a legislative requirement for vessels to comply with MARPOL and AMSA Marine Orders.
Alternatives/Substitutes Considered		
No practical alternative or substitute to the above controls have been identified.	N/A	N/A
Additional Controls Considered		
Vessel engines and incinerators maintained according to manufacturer's specification.	Yes	Vessel engines will be maintained to manufacturer's specification and in accordance with MARPOL 73/78 Annex VI to reduce the atmospheric emissions released into the environment. Good industry practice, environmental benefit outweighs additional cost.
Use of renewable fuels to provide vessel power and no incineration of waste offshore.	No	Adopting renewable energy sources would incur considerable cost associated with vessel modifications. Given the low-level of risk identified, this option is not considered commercially viable. Non-fuel powered engines are not considered technically efficient to execute.

Control Measure	Control Adopted	Comment / Justification
Transferring non-hazardous combustible waste to shore for disposal.	No	If waste were not incinerated offshore, additional cost, safety and environmental implications would be incurred associated with transferring non-hazardous combustible waste to shore for disposal. This would also be unlikely to reduce overall emissions as additional supply vessel visit would be required to collect and transfer the waste to shore, where it would then need to be dealt with.
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)		
No further practicable improvements to the above controls have been identified.	N/A	N/A
ALARP Statement		
The residual risk has been determined to be Low. Polarcus considers the adopted control measures appropriate to manage the impacts of atmospheric emissions during the survey. As no reasonable additional or alternative controls were identified that would further reduce the impacts and risks, without jeopardising the objectives of the survey, the impacts and risks are considered to be ALARP.		

7.6.4 *Demonstration of Acceptable Levels*

Context	Demonstration
Risk Level	The residual risk is assessed to be Low.
Legislative Requirements	The proposed controls meet or exceed the requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) and associated AMSA Marine Orders under the *Protection of the Sea (Prevention of Air Pollution) Act 1983* for the management of emissions at sea.
Conservation Advice, Recovery Plans, and Other Guidelines	No species Recovery Plans or Conservation Advice set requirements relating to the management of atmospheric emissions.
AMP Values, Management Prescriptions and IUCN Reserve Management Principles	No population-level impacts or serious or irreversible ecological implications are predicted to the values of the Joseph Bonaparte Gulf Marine Park or Oceanic Shoals Marine Park. The Operational Area is not located within any AMPs. The management prescriptions for AMPs does not include information on atmospheric emissions from commercial vessels/operations. The biological diversity and natural values of these AMPs will not be impacted in the long term, and therefore, management measures are consistent with IUCN management prescriptions and the ecological use of the marine parks.
Principles of Ecologically Sustainable Development	Atmospheric emissions (air pollution) will be managed in accordance with the requirements of MARPOL 73/78. The residual risks to air quality are low given the proposed controls. Impacts are expected to be negligible with no lasting, serious or irreversible ecological damage. The aspect and potential interactions are well understood and managed accordingly to internationally adopted standards.
Stakeholder Objections, Claims, Concerns or Advice	N/A – Stakeholders have not raised any specific concerns relating to the atmospheric emissions.
Acceptability Statement	
Based on the criteria above, Polarcus considers the adopted control measures appropriate to manage the impacts of atmospheric emissions to be of an acceptable level.	

7.7 Artificial Light Emissions: Vessels

7.7.1 *Assessment Summary*

Source of Impact / Risk

The seismic survey vessel, support vessels and in-water equipment present in the Operational Area will display artificial lighting to meet navigational and safety requirements under the COLREGS Convention (Marine Order 30).

Receptors

Marine fauna sensitive to artificial lighting:

- Marine turtles;
- Fish assemblages; and
- Seabirds.

Adopted Control Measures	EPS #
Lighting reduced to levels required for navigational and safety purposes (where practicable), so as to not cause significant disruption to the behavioural patterns of marine fauna. Vessels will adhered to the requirements of the International Regulations for Preventing Collisions as Sea 1972 (COLREGS) and Chapter 5 of Safety of Life at Sea Convention (SOLAS) as implemented in Commonwealth waters through the *Navigation Act 2012* and associated Marine Orders 21, 27, 30, 58 – safety and emergency arrangements, prevention of collisions, safe management of vessels, including: ■ Appropriate lighting, navigation and communication to inform other users. Use of radar and 24/7 watch.	7.1
Opportunities to further reduce lighting on vessels used for the survey shall be reviewed prior to the survey commencing.	7.2

Details of Residual Impacts and Risks

Impacts resulting from artificial lighting during the survey are expected to be negligible. Due to the size of the vessel and the height above sea level where lights will be positioned, it is expected that light emissions will be limited to localised offshore attraction/repulsion of marine fauna species, including marine turtles, fish and seabirds.

Artificial lighting has the potential to temporarily create an attraction/repulsion of marine fauna species, including marine turtles, fish and seabirds. The transient nature of the survey, the predominantly open oceanic location of the Operational Area, and the minimum distance to known turtle nesting and bird breeding colonies (> 150 km) means that these are unlikely to be impacted. In addition, sound emissions from the seismic source is expected to act as a localised and temporary deterrent to approaching marine fauna. The survey will not generate light levels sufficient to disrupt natural behavioural patterns on a long-term basis that could result in significant effects to the marine fauna populations in the region.

With the proposed management controls in place, discernible impacts to marine fauna are not expected in the location of the Petrelex 3D MSS from artificial light. The consequence of disrupting some marine fauna behaviours is slight given the nature and scale of the impact, though any changes would rarely be discernible.

The residual impacts and risks have therefore been assessed as low. Further detail is provided in the evaluation of impacts and risks below.

Risk Ranking:	Consequence	Likelihood	Risk
Inherent Risk	Slight (1)	Rare (B)	Low
Residual Risk	Slight (1)	Rare (B)	Low

7.7.2 *Detailed Evaluation of Impacts and Risks*

Essential lighting from work related areas and navigational beacons, mainly during night-time operations, has the potential to result in the disruption of marine fauna behaviours. The extent of impacts to marine fauna from artificial light emissions is dependent on the:

- density and wavelength of the light source;
- extent to which the light spills into areas that are significant for breeding and foraging;
- timing of the light spill relative to breeding and foraging activity; and
- ability of the fauna populations to return to their original state following the survey.

It is important to note, that the northern section of the Operational Area overlaps with a heavy vessel traffic path. Vessels associated with the survey will only result in a very small incremental increase in vessel lighting in the region.

Due to the size of the vessel and the height above sea level where lights will be positioned, it is expected that light emissions, particularly the area that is directly lit by lights on the vessel, will be localised and limited to the immediate vicinity of the vessel. As a result of the transient nature of the survey, the predominantly open oceanic location of the Operational Area, shipping/vessel activity in the region and the minimum distance to known turtle nesting (flatback turtle nesting at Cape Domett, 150 km south) and bird breeding colonies (various colonies a the head of the JBG, 150 km south) means that these are unlikely to be impacted. The survey will not generate light levels sufficient enough to disrupt natural behavioural patterns on a long-term basis that could result in significant effects to the marine fauna populations in the region.

7.7.2.1 Marine Turtles

Artificial light has the potential to disrupt critical behaviours in turtles, particularly in relation to nesting at the shoreline. However, the Operational Area is approximately 150 km north from the closest known turtle nesting beach (flatback turtle nesting at Cape Domett), and impacts to nesting turtles are therefore not credible.

Limited information is available on the extent to which hatchlings use vision over wave direction and the earth’s magnetic field for orientation once they enter the ocean (Lohmann 1992). However, Lohmann and Lohmann (1992) and Amos (2014) suggest that the vision of hatchlings is limited in the water and that other, more dominant navigational cues take over. Numerous studies have shown that hatchling dispersal offshore is heavily influenced by sea surface currents, particularly following the initial 24-hour swimming frenzy as swimming activity declines in duration and vigour (Frick 1976; Salmon and Wykenen 1987; Liew and Chan 1995; Witherington 1995; Okuyama et al. 2009). At 150 km from the nearest nesting beach, hatchlings in the vicinity of the Operational Area would be widely dispersed. It is also unlikely that metocean conditions in the open oceanic location of the Operational Area would be conducive for hatchlings to actively swim towards and remain in the vicinity of moving vessels should they be attracted by lighting.

Adult turtles that may be present within the Operational Area may be attracted to the seismic vessel lighting. However, attraction of turtles to the vessels would be localised, short-term and affect a small proportion of the population due to:

- the transient nature of the survey (moving at 4-5 knots); and
- the limited distance of visible light from the seismic and support vessels.

In addition, during acquisition, sound emissions from the seismic vessels are expected to act as a localised and temporary deterrent to approaching adult turtles (refer to Section 0).

7.7.2.2 Fish Assemblages

Light emissions from the vessels in the Operational Area may result in localised aggregation of fish in the immediate vicinity of the vessels at night. This may result in an increase in predation on prey species aggregating in the area, or exclusion of nocturnal foragers/predators (Marchesan et al. 2006).

Light emission impact to fish within the Operational Area would be highly localised and short-term due to the transient nature of the survey, the limited distance of visible light from the seismic vessel and light use being limited to night-time operations. In addition, sound emissions from the seismic vessel during acquisition are also expected to act as a localised and temporary deterrent to fish (refer to Section 0).

7.7.2.3 Birds

Studies conducted in the North Sea indicate that migratory birds may be attracted to offshore lights when travelling within a radius of 3-5 km from the light source. Outside this area their migratory paths are likely to be unaffected (Marquenie et al. 2008). Light emission effects to birds within the Operational Area (including those migrating) are expected to be localised and temporary based on the transient nature of the survey and the limited distance of visible light from the seismic vessel. In addition, the Operational Area is located approximately 150 km away from recognised important roosting sites for migratory birds (i.e. the Keep, Victoria and Fitzmaurice rivers at the head of the JPG). The minor radius of potential disorientation/attraction compared to the wide extent of known migratory routes further reduces the risk of impacts from light emissions on migratory birds present during the survey.

Any behavioural effects to migratory and foraging birds while on transit to/from these locations, such as attraction to the light source are expected to be highly localised and short term and therefore are not expected to have any discernible impacts on emigrational or behavioural patterns.

Based on the assessment above and the controls identified below, the potential impacts are expected to be localised with no lasting effect, with light spill limited to the immediate vicinity of vessels. The consequence of occasional short-term and localised disturbance to marine fauna sensitive to artificial lighting is Slight (1). The likelihood of this consequence occurring is Rare (B) and the risk is considered to be Low.

Further information about the selected control measure, the ALARP evaluation, and the evaluation of Acceptability are provided below.

7.7.3 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Comment / Justification
Inherent Design and Legislative Requirements		
No relevant legislation has been identified.	N/A	N/A
Alternatives/Substitutes Considered		
No practicable alternative or substitutes to the above controls have been identified.	N/A	N/A
Additional Controls Considered		
Lighting reduced to levels required for navigational and safety purposes, so as to not cause significant disruption to the behavioural patterns of marine fauna. Vessels will adhere to the requirements of the International Regulations for Preventing Collisions as Sea 1972 (COLREGS) and Chapter 5 of Safety of Life at Sea (SOLAS) as implemented in Commonwealth Waters through the *Navigation Act 2012* and associated Marine Orders 21, 27, 30, 58 – safety and emergency arrangements, prevention of collisions, safe management of vessels, including: ▪ Appropriate lighting, navigation and communication to inform other users. ▪ Use of radar and 24/7 watch.	Yes	Non-essential lighting will be reduced as far as practicable, whilst not jeopardising safety. Regulatory requirements necessitate vessels to maintain lighting to avoid jeopardising safety (Marine Order 30). Survey crews will be instructed to minimise unnecessary external lighting where practicable during the activity. Lighting for the purpose of safety or navigation purposes is necessary. All vessels associated with the Petrelex 3D MSS are required to comply with the *Navigation Act 2012*. The environmental benefit outweighs the additional cost.
Restriction on night-time activities or activities in low light conditions.	No	Significant light impacts to birds and turtles are not expected due to the transient nature of the survey and support vessels and the offshore location of the survey. Given the resulting increase in survey time and cost, this option was considered impractical and disproportionate to the limited benefit that would be gained.

Control Measure	Control Adopted	Comment / Justification
Opportunities to further reduce lighting on vessels used for the survey shall be reviewed prior to the survey commencing.	Yes	A pre-survey environmental checklist will be conducted prior to acquisition to identify opportunities for further light reduction, without jeopardising safety. The environmental benefit outweighs the additional cost.
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)		
No further practicable improvements to the above controls have been identified.	N/A	N/A
ALARP Statement		
The residual risk has been determined to be Low. Polarcus considers the adopted control measures appropriate to manage the impacts of artificial light emissions from vessels during the survey. As no reasonable additional or alternative controls were identified that would further reduce the impacts and risks, without jeopardising the objectives of the survey, the impacts and risks are considered to be ALARP.		

7.7.4 *Demonstration of Acceptable Levels*

Context	Demonstration
Risk Level	The residual risk is assessed to be Low.
Legislative Requirements	N/A: No legislative requirements have been identified that specifically address potential artificial lighting impact on marine fauna (seabirds, turtles, fish etc.) Artificial lighting will be managed in accordance with the requirements of the International Regulations for Preventing Collisions at Sea, 1972 (COLREGS) and associated AMSA Marine Orders under the *Protection of Sea (Prevention of Collisions) Act 1983*. All navigational/safety lighting is essential.
Conservation Advice, Recovery Plans, and Other Guidelines	Polarcus has reduced and, where possible, eliminated any adverse impacts of artificial lighting from the activities on Australian turtle species, noting the linkages with the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017).
AMP Values, Management Prescriptions and IUCN Reserve Management Prescriptions	No population-level impacts or serious or irreversible ecological implications are predicted to the values of the Joseph Bonaparte Gulf Marine Park or Oceanic Shoals Marine Park. The Operational Area is not located within any AMPs. The management prescriptions for AMPs do not include information on artificial light emissions from commercial vessels. The biological diversity and natural values of these AMPs will not be impacted in the long term, and therefore, management measures are consistent with IUCN management prescriptions and the ecological use of the marine parks.
Principles of Ecologically Sustainable Development	Navigational/Safety lighting will be managed in accordance with the requirements of COLREGS and AMSA Marine Orders Polarcus has reduced the impact of artificial light emissions on marine fauna to prevent serious or irreversible ecological damage. There are no legislative requirements that address the potential impact of artificial lighting on marine fauna. Impacts are expected to be negligible with no lasting, serious or irreversible ecological damage. The aspect and potential interactions are well understood and managed according to internationally adopted standards.
Stakeholder Objections, Claims, Concerns or Advice	N/A – Stakeholder have not raised any specific concerns relating to the artificial light impacts on marine biota.
Acceptability Statement	
Based on the criteria above, Polarcus considers the adopted control measures appropriate to manage the impacts of artificial lighting to be of an acceptable level.	

8. ENVIRONMENTAL RISKS AND MANAGEMENT – UNPLANNED

This section presents the evaluation of environmental impacts and risks completed for unplanned events associated with the Petrelex 3D MSS using the methodology described in Section 6, as required by OPGGS (E) Regulations 13(5) and 13(6).

A summary of the residual rankings for all impacts and risks identified and assessed in this Section are summarised in Table 8-1.

Table 8-1 Environmental Impact and Risk Ranking Summary

Impact/Risk	EP Section No.	Residual Risk		
		Consequence	Likelihood	Risk Ranking
Hydrocarbon Spill: Vessel Tank Failure	8.2	Extensive (3)	Rare (B)	Low
Hydrocarbon Spill: Vessel Refuelling Failure	8.3	Minor (2)	Rare (B)	Low
Chemical Spill: Single Point Failure	8.4	Slight (1)	Rare (B)	Low
Physical Presence: Collision / Entanglement with Marine Fauna	8.5	Extensive (3)	Rare (B)	Low
Physical Presence: Loss of Equipment	8.6	Slight (1)	Rare (B)	Low
Discharge: Loss of Hazardous or Non-Hazardous Solid Waste	8.7	Slight (1)	Rare (B)	Low
Introduction of Invasive Marine Species: Biofouling and Ballast	8.8	Extensive (3)	Rare (B)	Low

* The residual risk ranking is based on the ranking of the most sensitive receptor.

8.1 Hydrocarbon and Chemical Spills Background

8.1.1 *Properties*

The following types of hydrocarbons and chemicals are likely to be present on the vessels in varying quantities during the survey:

- MGO used to fuel the vessels;
- hydraulic fluids such as engine and synthetic oils required for equipment and engine use; and
- chemicals, such as for cleaning and maintenance purposes.

The characteristics and general behaviour of these hydrocarbons and chemicals in the event of a spill to the marine environment are provided below.

8.1.1.1 MGO

MGO is classified as a Group II non-persistent oil according to the International Tanker Owners Pollution Federation (ITOPF) classifications. It is characterised by light hydrocarbon fractions that are 97.3% volatile to semi- and low-volatile and 2.7% persistent, resulting in rapid weathering and evaporation in the event MGO is spilled to the marine environment.

In the event of a surface release of MGO to the marine environment, the release is expected to spread rapidly and form a very thin slick, with the more volatile components readily evaporating when on the water surface.

8.1.1.2 Hydraulic Fluid

Hydraulic fluid is likely to be present in small quantities on board the seismic vessel. A spill of hydraulic fluid resulting in less than 1 m^3 released to the marine environment is considered likely to disperse and weather very rapidly in the open ocean environment of the Operational Area. The Polarcus Hazardous Substances Handling, Storage and Use Procedure guides the selection, and management, of hazardous substances (including hydraulic fluid) on board the seismic vessel. The procedure explains that environmentally-friendly solutions will be sought out and considered as a replacement for hazardous substances that have been previously used in the industry.

Where no environmentally-friendly solutions are available it must be decided whether or not the hazardous substance is considered necessary for operations.

8.1.1.3 Chemicals

Small quantities of chemicals may be used and stored on board (e.g. for cleaning and maintenance purposes).

If spilled to the marine environment, the small volume (less than 1 m^3) is expected to rapidly disperse naturally and weather in the open ocean environment. The Polarcus Chemical Control Procedure requires chemicals to be selected taking into account their environmental characteristics. Only chemicals approved using this procedure may be used or stored on board the seismic vessel.

8.1.2 ***Credible Spill Scenarios***

Credible hydrocarbon and chemical spill scenarios were identified during the environmental risk assessment undertaken for this EP (Section 6), taking into account:

- survey activities;
- known volumes of hydrocarbons and chemicals stored on the vessels, as well as material transfer rates and reaction times for spill detection and mitigation;
- design features inherent to the vessel and storage areas (e.g. bunds); and
- proximity to sensitive receptors and features of conservation significance.

The resulting credible spill scenarios selected for assessment are summarised in Table 8-2.

Table 8-2 Hydrocarbon and Chemical Spill Scenarios

Scenario	Spilt Material and Volume	Description
Single point failure (overboard)	< 1 m^3 of hydraulic fluids or chemicals	A single point failure may occur as a result of mechanical/ structural failure, human error or poor housekeeping. Should a spill occur on deck, controls such as equipment bunds, scupper plugs and on-board clean up should prevent the spilt material reaching the marine environment. However, in the event these controls fail, or are not implemented, spill volumes released to the environment are likely to be less than 1 m^3 based on the inventory used on deck. Due to the low volumes involved, and the anticipated rapid dispersal in the marine environment, no modelling was undertaken.
Vessel refuelling failure	1.2 m^3 to 25 m^3 MGO	Vessel refuelling failure may result in the release of MGO to the marine environment. The Polarcus Bunkering Procedure guides refuelling activities. Through the use of dry break couplings (which provide an automatic mechanism to seal off both the hose and the fixed pipe end when the hose is disconnected), the maximum credible spill volume from a refuelling failure is considered to be the maximum typical volume of a transfer hose (1.2 m^3). In the event dry break couplings fail, guidelines indicate the maximum credible spill volume from a refuelling incident with continuous supervision is equivalent to the volume of MGO transferred within a 15 minute period (AMSA 2013a), which represents the estimated time required to shut down refuelling operations following discovery of a spill. Based on the known transfer volume of 100 m^3/hr, this may result in a spill volume of 25 m^3. Due to the low volumes involved, and the anticipated rapid dispersal in the marine environment, no modelling of this spill scenario was undertaken.
Vessel fuel tank rupture	280 m^3 of MGO	The grounding of the seismic vessel or a collision between the seismic vessel, support vessel or a third party vessel has the potential to result in the breach of the hull and subsequent rupture of a fuel tank. A major spill to sea as a result of vessel collision/grounding is only likely to occur under exceptional circumstances where these conditions resulted in significant damage to one or more of the fuel tanks in the hull of the vessel. These may include: ■ navigational error; ■ vessel loss of power; and ■ floundering due to weather. If a collision/grounding involving the seismic vessel occurred, the worst case credible scenario would be the loss of the largest single fuel tank volume (consistent with AMSA (2013a) guidelines), which is 280 m^3 of MGO.

The identified credible spill scenarios shown in Table 8-2 provide a representative range of spill sizes and locations. Other scenarios were either deemed non-credible, or else the risk of environmental impacts associated with spill scenarios involving less sensitive locations, shorter durations or smaller spill volumes were already captured through the assessment of the selected scenarios for consideration in this EP.

To understand the fate and trajectory of a potential spill associated with the Petrelex 3D MSS, existing hydrocarbon spill modelling available for the Petrelex field was assessed (refer to Section 8.1.3). Given the volumes involved, impacts and risks associated with a single point failure or a vessel refuelling spill would be expected to be considerable less than those described for a vessel collision/grounding scenario.

8.1.3 *Spill Modelling Methodology*

Modelling of a 1,014 m^3 surface release of Shell Diesoline (equivalent to Marine Diesel Oil, MDO) was available for the Petrelex field from Santos Limited for the drilling of the Petrelex-8 appraisal well in 2012. The release location used for the spill modelling is located within the Acquisition Area, approximately 34 km from the Operational Area boundary (see coordinates in Table 8-3). The modelling was conducted by Asia-Pacific ASA (APASA) using a three-dimensional hydrocarbon spill trajectory and weathering model (SIMAP, Spill Impact Mapping and Analysis Program) (APASA 2012) (refer to Appendix F).

The modelled spill volume of 1,014 m^3 is considerably greater than the worst-case credible release volume of 280 m^3 for this EP. However, the results of the modelling were able to be used to demonstrate that a much larger spill in the Operational Area has an EMBA that is not predicted to include any surface slicks above threshold volumes entering WA or NT waters, or any shoreline contact or accumulation within the JBG. Basing the impact assessment for a vessel collision scenario on this modelling is considered highly conservative and consequently, the EMBA for a 280 m^3 surface release of marine diesel/MGO within the Operational Area would be considerably smaller than the EMBA described in this EP.

SIMAP is designed to simulate the fate and effects of spilled hydrocarbons for both the surface and subsurface releases (Spaulding et al. 1994; French et al. 1999; French-McCay 2003; French-McCay 2004; French-McCay et al. 2004; Spaulding et al. 2015). The SIMAP model calculates two components: (i) the transport, spreading, entrainment, evaporation and decay of surface oil slicks and, (ii) the entrained and dissolved hydrocarbons released from the slicks into the water column. Input specifications for oil types include the density, viscosity, pour point, distillation curve (volume lost versus temperature) and the aromatic/aliphatic component ratios within given boiling point ranges.

The SIMAP trajectory model separately calculates the movement of the material that: (i) is on the water surface (as surface slicks), (ii) in the water column (as either entrained whole oil droplets or dissolved hydrocarbons), (iii) has stranded on shorelines, or (iv) that has precipitated out of the water column onto the seabed. The model calculates the transport of surface slicks from the combined forces exerted by surface currents and wind acting on the oil. Transport of entrained oil (oil that is below the water surface) is calculated using the currents only.

SIMAP's stochastic model was used to quantify the probability of exposure to the sea surface and in-water and probability of shoreline contact from the hypothetical spill scenario. 150 simulations were modelled in total. Each simulation was configured with the same spill information (i.e. spill volume, duration and oil type) except for start the time and date. This approach ensures that the predicted transport and weathering of an oil slick is subject to a wide range of current and wind conditions.

During each spill trajectory, the model records the grid cells exposed to hydrocarbons, as well as the time elapsed. Once all the spill trajectories have been run, the model then combines the results from the individual simulations to determine the following:

- Maximum exposure (or load) observed on the sea surface;
- Minimum time before sea surface exposure;
- Probability of contact to any shorelines;
- Probability of contact to individual sections of shorelines;
- Maximum volume of oil that may contact shorelines from a single simulation;
- Maximum load that an individual shoreline may experience;
- Maximum exposure from entrained hydrocarbons observed in the water column; and
- Maximum exposure from dissolved aromatic hydrocarbons observed in the water column.

The stochastic model output does not represent the extent of any one spill trajectory (which would be significantly smaller) but rather provides a combined summary of all 150 trajectories run for the scenario.

Inputs for the modelling are summarised in Table 8-3.

Table 8-3 Spill Modelling Inputs

Parameters	Modelling Inputs
Spill release location	12°50'31.41625"S; 128°29'50.85638"E (98 m water depth)
Spill volume	1,014 m^3
Hydrocarbon type	Shell Diesoline (MDO)
Release type	Surface
Spill duration	6 hours
Simulation duration	20 days
No. of simulations	50 randomly selected trajectories modelled per season (3) using a range of wind and current conditions. 150 simulations in total
Modelled seasons	Summer (September to March) Transitional (April and August) Winter (May to July)

8.1.3.1 Seasonality

To ensure that modelling results are representative of the range of metocean conditions experienced during the survey period, random conditions were selected to represent different wind and current conditions. A total of 50 spill trajectories per season were modelled, resulting in a total of 150 possible spill trajectories.

8.1.4 *Hydrocarbon Exposure Thresholds*

Based on the modelling outcomes, nearby sensitive locations may be contacted by hydrocarbons either at the surface or in the water column. In order to determine the ecological effects of a spill, different thresholds were considered for the risk assessment as follows:

- Surface hydrocarbon thresholds, to assess physical effects on sensitive receptors offshore;

- Shoreline accumulation thresholds, to assess physical effects on sensitive receptors onshore; and
- Water column exposure thresholds, to assess toxicity effects to sensitive receptors offshore from entrained and dissolved aromatic hydrocarbons.

The hydrocarbon exposure thresholds are summarised in Table 8-4.

Table 8-4 Hydrocarbon Exposure Thresholds

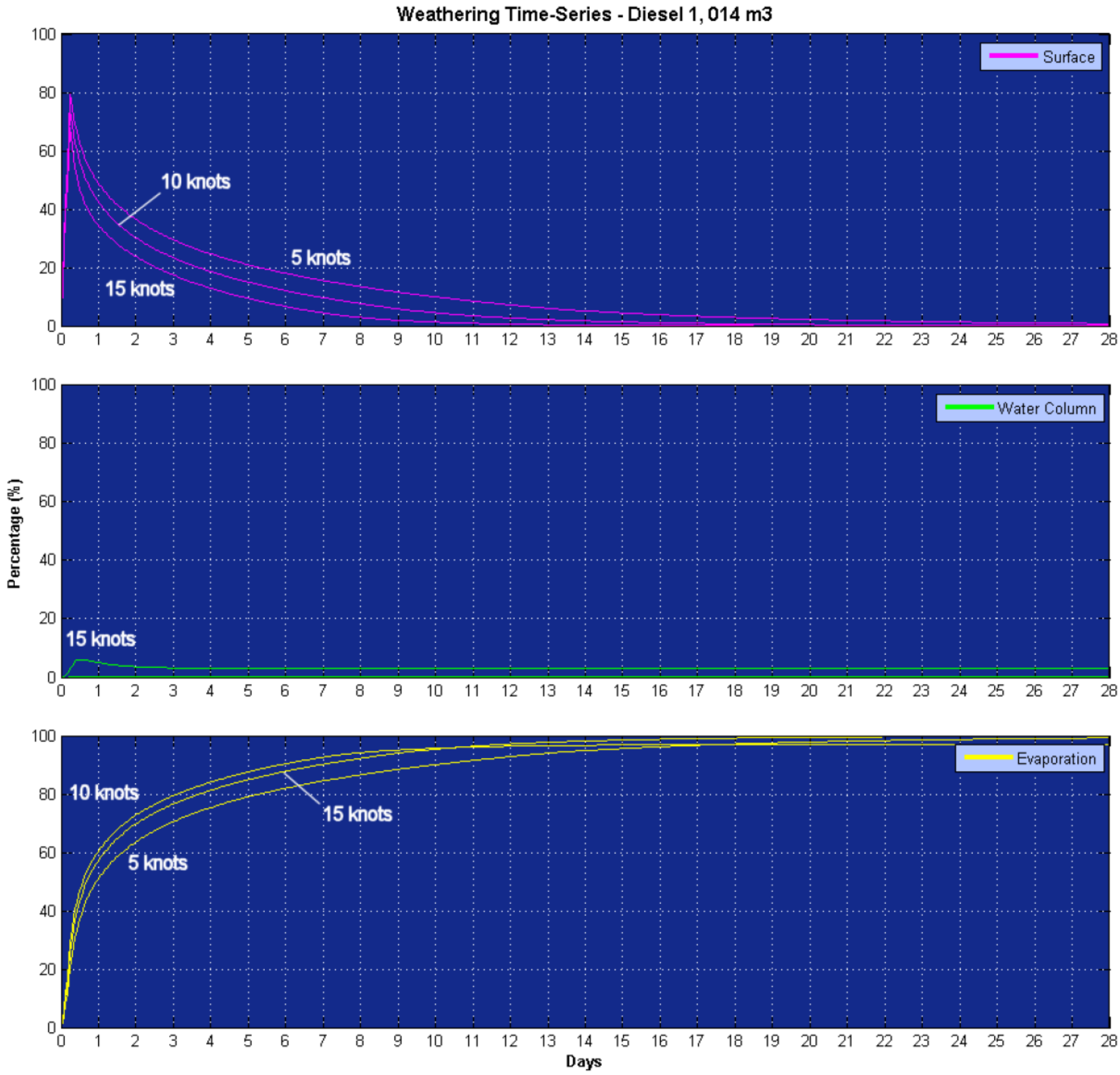
Exposure Type	Hydrocarbon Concentrations	Equivalent Dosage of Entrained Oil or Dissolved Aromatics (ppb.hrs)	Potential Level of Exposure
Sea Surface and Shoreline Exposure (g/m^2)	1	-	Low
	10	-	Moderate
	25	-	High
Dissolved Hydrocarbon Concentration (ppb)	6	576	Low
	50	4,800	Moderate
	400	38,400	High
Entrained Concentration (ppb)	10	960	Low
	100	9,600	Moderate
	500	48,000	High

These thresholds are consistent with, and in some cases more conservative than, the exposure thresholds for floating, shoreline, dissolved and entrained hydrocarbons recommended by NOPSEMA in the Bulletin #1 "Oil spill modelling" April 2019 (NOPSEMA 2019a).

8.1.4.1 Hydrocarbon Characteristics

Shell Diesoline has variable density typically of 830 kg/m^3 and a dynamic viscosity of 10 cP. Figure 8-1 illustrates a sample weathering and fates graphs for a 1,014 m^3 surface release of diesel over six hours, under three constant winds of different magnitudes (5, 10 and 15 knots).

It is important to note that diesel typically contains some heavy components (or low volatile components) that have a strong tendency to physically entrain into the upper water column in the presence of moderate winds (i.e. >12 knots) and breaking waves, but can re-float to the surface if these energies abate. In the event of a substantial diesel spill, the heavier components of diesel can remain on the sea surface for an extended period. As brightly coloured and silvery reflective sheens, which are highly visible, but below levels, which could be responded to effectively and could cause any potential environmental harm.



Data expressed as a percentage of total spill volume, under three constant wind conditions

Figure 8-1 Predicted Weather and Fate of a 1,014 m³ Surface Release of Shell Diesoline over 6 Hours

8.1.5 *Spill Modelling Results*

The SIMAP stochastic module was used to simulate multiple (50 per season) worst-case (1,014 m³) surface diesel spills to quantify the: (i) probability of exposure to the sea surface and shorelines and (ii) minimum time to sea surface contact for the 1 g/m² threshold. This threshold is above the extent of visible oil, but is one order of magnitude below the 10 g/m² potential impact threshold and defines the extent that spill response measures can be useful in reducing surface oil (such as mechanical dispersion using water jetting or prop wash to disperse any surface diesel slicks whilst they remain in deep water). The modelling also quantified the potential extents of dissolved aromatics and entrained diesel oil for the hypothetical spill to define the in water zone of potential impact.

When interpreting the stochastic results, it should be noted that the estimators (probability and surface load/thickness) are calculated independently for each surface location in the model domain. Hence, the plots do not show the extent of effect that would be expected from any single release. Rather, the contours show likelihood of contact, given the predicted weathering rates, wind and current patterns for randomly selected time-periods.

The modelling indicated that a 1,014 m^3 surface spill of diesel at the Petrelex-8 well location within the Acquisition Area, across all seasons, would typically evaporate significantly and reduce its surface thickness overtime (<25 microns by 24 km and <10 microns by 40 km). The direction of drift will be typically with the currents when winds are light, but typically with the winds during moderate winds. Under strong winds, diesel slicks will entrain into the water column as droplets. If the spill were to occur during strong winds, spilt oil, still very fresh, will entrain and some exposure to aromatic compounds dissolving from the diesel droplets is predicted to occur, but limited to within 20 km of the spill site and at low levels only. Beyond this extent, the modelling quantified that diesel slicks up to this size may entrain but would have significantly lost its aromatic content to evaporative processes by that time, as to remove the risk significantly for any potential in-water impact.

8.1.5.1 Sea Surface Exposure and Shoreline Contact

During the summer conditions, the majority of slicks were shown to migrate in an east-southeast direction from the release site. The furthest distance surface slicks above 1 µm (or very light oiling) were observed, during the summer conditions, was 113 km. During the transitional periods, the majority of slicks also moved in a south-east direction however a small number of slicks were shown to travel towards the west. The furthest distance surface slicks above 1 g/m^2 (or very light oiling) were observed, during the transitional period conditions, was 450 km.

During the winter season, waters to the northwest of the release site were shown to have the greatest probability of being exposed to diesel slicks, with a small number of slicks migrating to the south-west The furthest distance surface slicks above 1 g/m^2 (or very light oiling) were observed, during the summer conditions, was 215 km.

Figure 8-2, Figure 8-3 and Figure 8-4 show the zones of potential sea surface exposure for low exposure (1 g/m^2), moderate exposure (10 g/m^2) and high exposure (>25 g/m^2), for each season.

The maximum extents of the zones of potential moderate and high exposure for the summer season were within a radius of 40 km and 24 km from the release site, respectively. The maximum extents of the zones of potential moderate and high exposure for the transitional period were within a radius of 38 km and 18 km from the release site, respectively. The maximum extents of the zones of potential moderate and high exposure for the summer season were within a radius of 30 km and 19 km from the release site, respectively.

In terms of shoreline contact, modelling for all seasons did not identify any shoreline impacts above the lowest threshold specified (1 g/m^2).

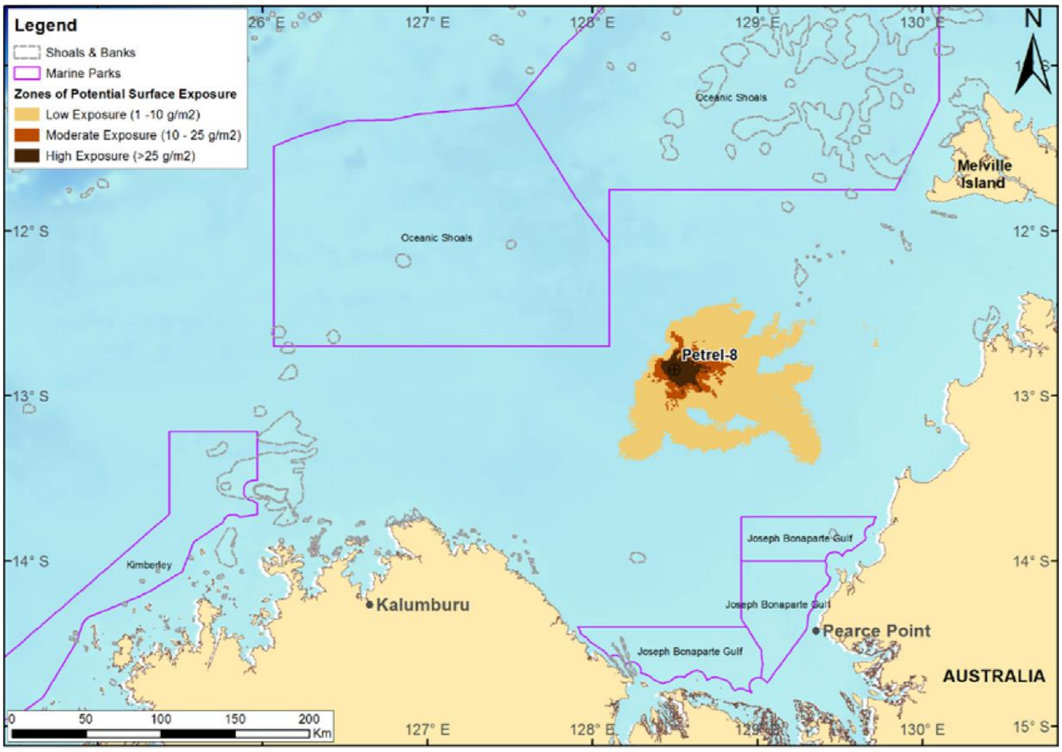


Figure 8-2 Zones of Potential Surface Exposure, in the Event of a 1,014 m^3 Surface Release of Diesel within the Operational Area during Summer

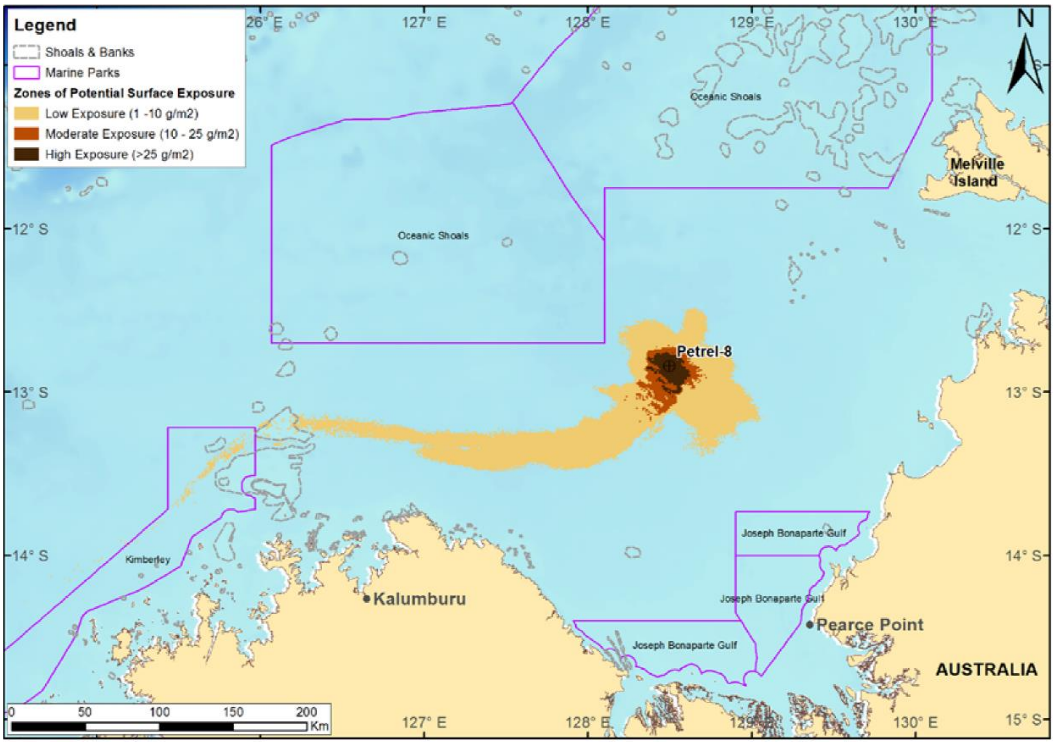


Figure 8-3 Zone of Potential Surface Exposure in the Event of a 1,014 m^3 Surface Release of Diesel within the Operational Area during Transitional Season

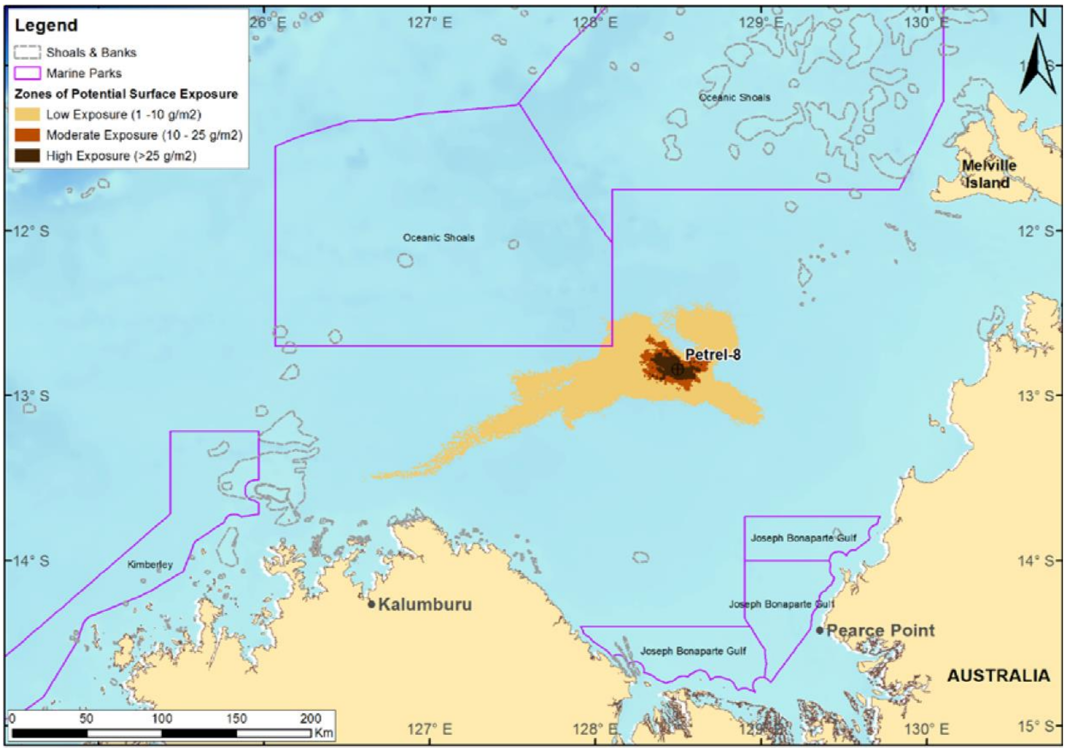


Figure 8-4 Zones of Potential Surface Exposure, in the Event of a 1,014 m^3 Surface Release of Diesel within the Operational Area during Winter

8.1.5.2 Aromatic and Entrained Concentrations

In addition to quantifying the exposure to the sea surface, the modelling also explored the potential zones of exposure from dissolved aromatics and entrained hydrocarbon concentrations for each season. These occur when diesel slicks were entrained into the water column by high wind events for prolonged periods. Diesel droplets, when entrained into the water column, leached their aromatic content via dissolution rather than evaporation processes, which the modelling took into account and quantified based on the wind conditions and oil chemistry at the time of the high wind event.

For all seasons, waters bounded within 20 km of the spill location were quantified to be at some potential risk of low level exposure to dissolved aromatic concentrations above the lowest dosage threshold of 576 ppb hrs (that is, exposures were higher than 6 ppb dissolved aromatics for 96 hours outside of this zone). No zones of potential moderate or high impact from dissolved aromatics were found from any of the 50 simulations for any season.

Figure 8-5, Figure 8-6 and Figure 8-7 illustrate the zones of potential low, moderate and high exposure from entrained hydrocarbon droplets in the upper water column (0-5 m below the sea surface), for each season that resulted from simulated high wind events.

During summer, the zones of potential low exposure to entrained hydrocarbon droplets extended mostly towards the north-east and almost as far as Melville Island and essentially coincided with path of the surface slicks. Note that these extents do not map the subsurface drift of entrained diesel droplets just that surface slicks, when entrained, will produce droplets within the water column at these distances. The extent of subsurface plumes simply follow the extent that surface slicks of diesel travelled in a high wind event. The results are also indicative of the outcomes of mechanical dispersion in terms of in water concentrations when the wind event occurs. For summer, zones of moderate exposure were shown to be limited to 18 km.

During the transitional period, the zones of potential low exposure to entrained hydrocarbons extended mostly towards the south-west and as far as the Kimberly coastline. Zones of moderate exposure were shown up to 13 km from the release site. During winter, the zones of potential low exposure to entrained hydrocarbons extended mostly towards the south-west and as far as the Kimberly coastline. Zones of moderate exposure were shown up to 38 km from the release site.

There were no zones of potential high exposure from entrained oil concentrations for all three seasons.

No exposure of entrained hydrocarbons doses of meaningful levels to any reef or island was registered for any season. Additionally, no moderate or high exposure zones were predicted in nearby waters to the surrounding sensitive marine environment and shorelines.

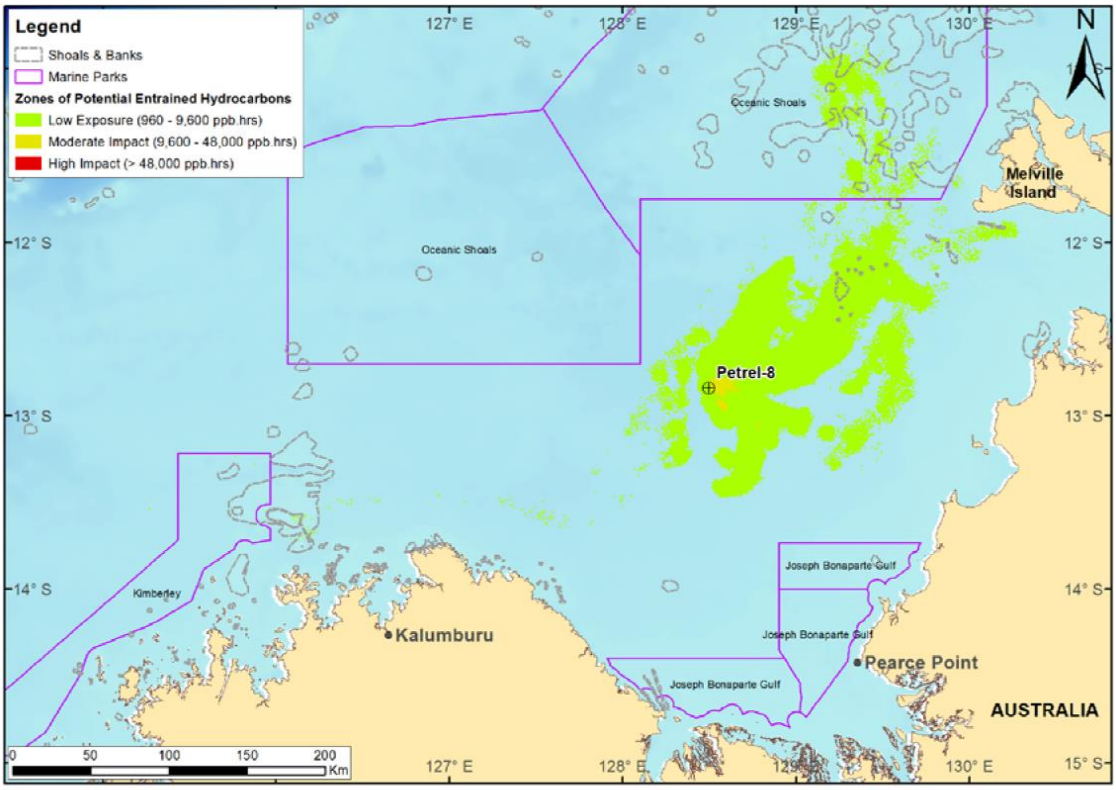


Figure 8-5 Zone of Potential Exposure from Entrained Hydrocarbons, in the Event of a 1,014 m^3 Surface Release of Diesel within the Operational Area during Summer

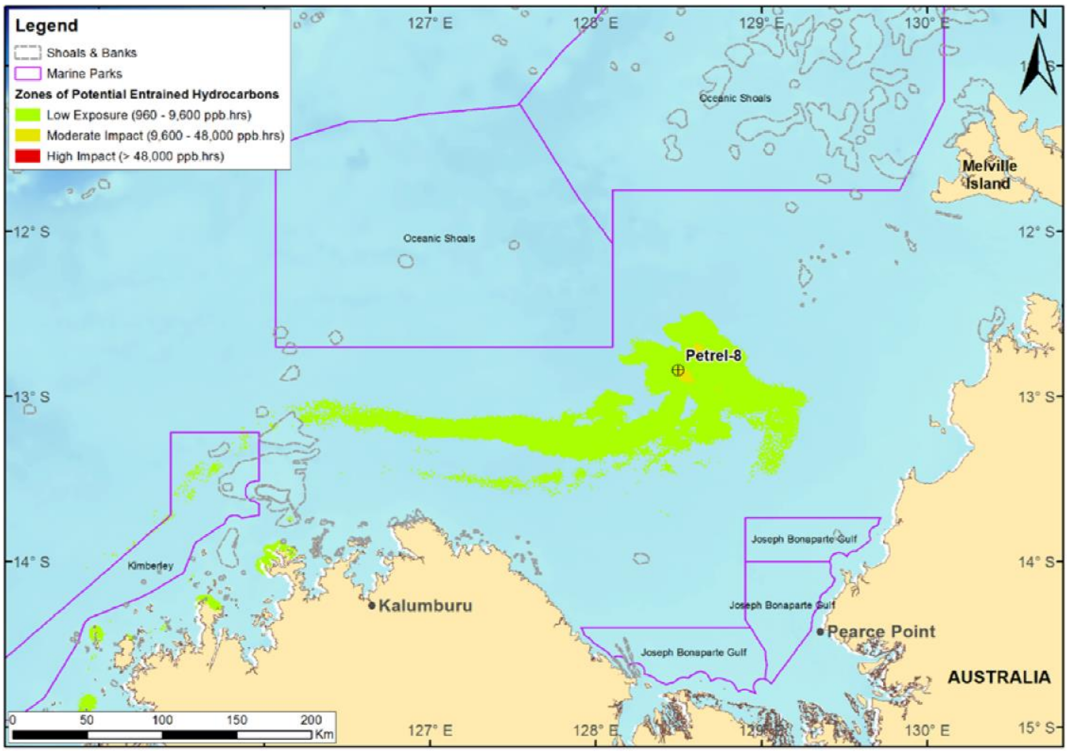


Figure 8-6 Zones of Potential Exposure from Entrained Hydrocarbons in the Event of a 1,014 m³ Surface Release of Diesel within the Operational Area during the Transitional Season

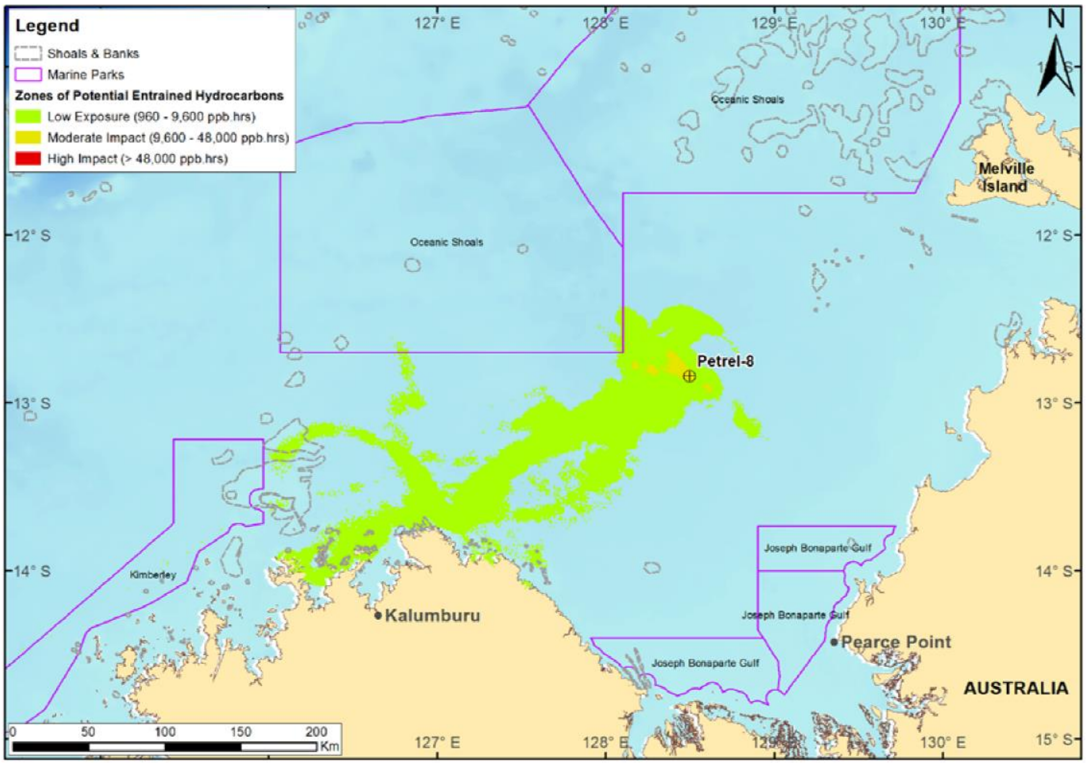


Figure 8-7 Zones of Potential Exposure from Entrained Hydrocarbons, in the Event of a 1,014 m³ Surface Release of Diesel within the Operational Area during Winter

8.1.5.3 EMBA Definition

For the purposes of this EP, and for the assessment of the potential impacts and risks associated with worst-case credible hydrocarbon spill of 280 m^3 within the Operational Area during the activity, the environment that may be affected (EMBA) has been conservatively defined as a 40 km buffer around the boundary of the Operational Area (see Figure 4-1). This is based on the maximum extent of sea surface exposure above the moderate threshold (>10 g/m^2) across all three seasons (see Figure 8-2, Figure 8-3 and Figure 8-4) for the 1,014 m^3 spill scenario modelled. Note that the zone of potential exposure to entrained hydrocarbons above the moderate exposure threshold (100 ppb or 9,600 ppb.hrs) falls well within this surface exposure EMBA (see Figure 8-5, Figure 8-6 and Figure 8-7).

8.2 Hydrocarbon Spill: Vessel Tank Failure

8.2.1 *Assessment Summary*

Source of Impact / Risk	
An accidental hydrocarbon release to the marine environment could result from a vessel fuel tank failure, following a vessel collision. The potential hazards associated with the release of large volumes of marine diesel on to the sea surface within the Operational Area are temporary and localised reduction in water quality and temporary toxicity effects to marine biota. A seismic survey vessel can have a fuel capacity in excess of 1,000 m^3 that is distributed through multiple isolated tanks typically located mid-ships, and typically ranging in capacity from 22-280 m^3. There will be at least one support vessel utilised throughout the Petrelex 3D MSS. The marine diesel storage capacity of a support vessel can also be in the order of 1,000 m^3 in total, which is distributed through multiple isolated tanks typically located mid-ship and ranging in capacity from 22-105 m^3. If a collision/grounding involving the seismic vessel occurred, the worst case credible scenario would be the loss of the largest single fuel tank volume (consistent with AMSA (2013a) guidelines), which is 280 m^3 of MGO.	
Receptors	
■ Marine fauna - Cetaceans, marine reptiles, seabirds, fishes/elasmobranchs, planktonic communities. ■ Water quality; ■ Marine protected areas; and ■ Commercial fisheries.	
Adopted Control Measures	**EPS #**
Seismic vessel will utilise MGO, which is stored in multiple fuel tanks on board. Fuel tanks can be isolated and contents transferred between them.	8.1
Seismic vessel has a double hull design making a rupture highly unlikely, even in a collision situation.	8.2
Radar on board the seismic vessel is fitted with a collision alarm, and the seismic vessel has DNVGL NAUT-AW class notation for enhanced nautical safety, incorporating a grounding avoidance system.	8.3
Seismic vessel and support vessels will maintain appropriate lighting, shapes, navigation and communication at all times to inform other users of the position and intentions of the vessel, in compliance with the *Navigation Act 2012* and associated Marine Orders.	8.4

A 24 hour visual, radio and radar watch will be maintained for vessels in the vicinity of the Operational Area.	8.5
All vessels over 400 GRT (MARPOL 73/78 Annex I) hold approved and tested SOPEPs and crew are trained in its implementation.	8.6
Notice to Mariners issued prior to commencement of survey activities.	8.7
Daily reporting to AMSA JRCC for promulgation of radio-navigation warnings.	8.8
Notification will be provided to fisheries stakeholders, four weeks prior to commencement, indicating location and expected timing. Notification will also be provided to fisheries stakeholders within two weeks of cessation of activities.	8.9
In the event of a spill to the marine environment, the OPEP presented in Section 10.3 will be followed.	8.10

Details of Residual Impacts and Risks

A vessel fuel tank failure spill of up to 280 m^3 of MGO may result in localised exposure of receptors to surface and entrained hydrocarbons. Potential exposures to spilt surface oil >10 g/m^2, considered representative of potential lethal and sub-lethal impacts to marine fauna such as turtles, cetaceans and marine birds are expected to be limited to a localised area for a few days at most. Therefore, worst case impacts are expected to be limited to sub-lethal impacts or potential mortality to a small number of individuals. Entrained exposures are also expected to be low, resulting in limited interactions with small numbers of fish, eggs and larvae in the upper water column that are largely incidental in nature.

The localised and short-term impacts that are predicted to occur to marina fauna and fish following weathering, dispersion and degradation in the open water environment of the Operational Area are therefore assessed to be Low. Further detail is provided in the evaluation of impacts and risks below.

Risk Ranking	Consequence	Likelihood	Risk
Inherent Risk	Extensive (3)	Rare (B)	**Low**
Residual Risk	Extensive (3)	Rare (B)	**Low**

8.2.2 *Detailed Evaluation of Impacts and Risks*

An accidental hydrocarbon release to the marine environment could result from a vessel fuel tank failure, following a vessel collision. As identified in Section 4.5, a range of protected species may be encountered within and adjacent to the Operational Area and therefore could be impacted by a marine diesel spill.

8.2.2.1 Cetaceans

No critical habitats or aggregation areas (feeding, breeding, resting) for cetaceans have been identified within the EMBA or adjacent waters, and it is therefore considered that any cetacean species that are present will be in low numbers and transient, as they traverse the area. There is no overlap between BIAs for any cetacean species and the EMBA. The closest cetacean BIAs to the EMBA are the breeding and foraging BIAs for the Indo-Pacific humpback dolphin in Darwin Harbour, and a breeding/calving BIA for Australian snubfin dolphins, which is located in the Cambridge Gulf (see Figure 4-11). These BIAs are located at least 95 km from the boundary of the EMBA.

Marine mammals are highly mobile and a number of field and experimental observations indicate whales and dolphins may be able to detect and avoid surface slicks. However, instances have been observed where animals have swum directly into oiled areas without seeming to detect the slicks or because the slicks could not be avoided. Cetaceans may exhibit avoidance behaviour and move away from the spill-affected area.

Marine mammals that have direct physical contact with surface slicks and entrained hydrocarbons may suffer surface fouling or ingestion of hydrocarbons and inhalation of 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 (Etkins 1997). For example, fouling of baleen whales (e.g. humpback and pygmy blue whales) may disrupt feeding by decreasing the ability to intake prey. If prey (fish and plankton) is also contaminated, this can result in the absorption of toxic components of the hydrocarbons (polycyclic aromatic hydrocarbons - PAHs). Toothed whales (including dolphins), are 'gulp-feeders' targeting specific prey at depth in the water column away from any potential surface slick and are likely to be less susceptible to the ingestion of hydrocarbons. Furthermore, given cetaceans are smooth skinned and hydrocarbons would not tend to adhere to body surfaces, the likely biological consequences of physical contact with surface hydrocarbons is likely to be in the form of irritation and sub-lethal stress.

In the unlikely event of a hydrocarbon release, it is considered that contact will be low and temporary in nature due to the relatively small EMBA, the rapid dispersion of marine diesel, and the fact that only isolated individuals transiting the area could potentially come into contact with surface slicks.

8.2.2.2 Marine Reptiles

The EMBA overlaps foraging BIAs for green, loggerhead, flatback and olive ridley turtles (see Figure 4-8). The EMBA also overlaps with the Pinnacles of the Bonaparte Basin KEF, and there are seven individual pinnacles in the KEF that are located within the EMBA. However, water depths on the tops of these pinnacles are in the range of approximately 80 – 92 m, and hence they are highly unlikely to represent foraging habitats for any marine turtle species. Minimum water depths within the EMBA are approximately 46 m, and as described in Section 4.5.7, it is unlikely that any areas in the JBG with water depths greater than 40 m represent important foraging areas for marine turtles.

At the closest point, the EMBA is located at least 14 km from the nearest nesting or interesting BIA for turtles (flatback turtle internesting BIA adjacent to Melville Island and Cobourg Peninsula). At the closest point, the EMBA is located approximately 5 km from the nearest 'Habitat Critical' for flatback turtles in the JBG (60 km internesting buffer around Waigait Beach to south of Point Blaze, including all offshore islands – refer Figure 4-10). The EMBA is located at least 44 km from the 'Habitat Critical' for flatback turtles around Cape Domett.

Adult sea turtles exhibit no avoidance behaviour when they encounter hydrocarbon slicks (Odell and MacMurray 1986). Contact with surface slicks, or entrained hydrocarbons, can therefore result in hydrocarbon adherence to body surfaces (Gagnon and Rawson 2010) causing irritation of mucous membranes in the nose, throat and eyes leading to inflammation and infection (NOAA 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, such as crude oil, may affect the functioning of their salt gland (Lutcavage et al. 1995).

Hydrocarbons in surface waters may also 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 2002). This can lead to lung damage and congestion, interstitial emphysema, inhalant pneumonia and neurological impairment (Etkins 1997; IPIECA 1995).

Due to the absence of potential nesting habitat (i.e. no emergent islands) and the water depths (65 – 111 m), the Operational Area is highly unlikely to represent important foraging habitat for marine turtles. The worst case diesel release scenario indicates a relatively small EMBA and a rapid dispersion and evaporation of marine diesel that will be confined to offshore waters, with no contact between surface, dissolved or entrained hydrocarbons and any turtle nesting beaches in the region.

Impacts to sea snakes from direct contact with surface hydrocarbons are likely to result in similar physical effects to those recorded for marine turtles and may include potential damage to the dermis and irritation to mucous membranes of the eyes, nose and throat (ITOPF 2011). They may also be impacted when they return to the surface to breathe and inhale the toxic vapours associated with the hydrocarbons, resulting in damage to their respiratory system.

In general, sea snakes frequent the waters of the continental shelf area, around offshore islands and potentially submerged shoals (water depths <100 m) and while individuals may be present in the Operational Area, their abundance is not expected to be high, given the deep water and offshore location of the activity. Therefore, a hydrocarbon spill may have a minor disruption to a portion of the population however there is no threat to overall population viability.

8.2.2.3 Seabirds

There is no overlap between the EMBA and any breeding and foraging BIAs for marine birds in the JBG. At the closest point, the south-west boundary of the EMBA is located approximately 58 km from the nearest seabird BIA, which is the foraging and breeding BIA for lesser crested terns along the north Kimberley coastline (refer to Figure 4-7).

In the unlikely event of a large diesel spill, there is the potential for seabirds to be exposed to surface, entrained and dissolved hydrocarbons. This could result in lethal or sub-lethal effects. Although breeding oceanic seabird species can travel long distances to forage in offshore waters, most breeding seabirds tend to forage in nearshore waters near their breeding colony, resulting in intensive feeding by higher marine bird densities in these areas during the breeding season and making these areas particularly sensitive in the event of a spill. Surface, entrained or dissolved hydrocarbons are unlikely to impact nesting or egg-laying individuals in colonies, however, it is possible that breeding individuals could come into contact with surface or entrained hydrocarbons while foraging (dive and skim feeding).

Seabirds are vulnerable to contacting surface slicks during feeding or resting on the sea surface, particularly as they do not generally exhibit avoidance behaviour to floating hydrocarbons. Physical contact of seabirds with surface slicks is by several exposure pathways, primarily, immersion, ingestion and inhalation. Such contact with hydrocarbons may result in plumage fouling and hypothermia (loss of thermoregulation), decreased buoyancy and potential to drown, inability to fly or feed, anaemia, pneumonia and irritation of eyes, skin, nasal cavities and mouths (AMSA 2012; IPIECA 2004) and result in mortality due to oiling of feathers or the ingestion of hydrocarbons. Longer term exposure effects that may potentially impact seabird populations include a loss of reproductive success (loss of breeding adults) and malformation of eggs or chicks (AMSA 2012).

A diesel spill within the Operational Area is not likely to result in any significant impacts on any seabird populations within the JBG, due to the relatively small EMBA and the rapid dispersion of marine diesel.

8.2.2.4 Fish, Sharks and Rays

Hydrocarbon droplets can physically affect fishes and elasmobranchs (sharks and rays) exposed for an extended duration (weeks to months). Smothering through coating of gills can lead to the lethal and sub-lethal effects of reduced oxygen exchange, and coating of body surfaces may lead to increased incidence of irritation and infection. Fish may also ingest hydrocarbon droplets or contaminated food leading to reduced growth.

Near the sea surface, fishes are able to detect and avoid contact with surface slicks and as a result, fish mortalities rarely occur in open waters from surface spills (Kennish 1997; Scholz et al.1992). Pelagic fish species are therefore generally not highly susceptible to impacts from hydrocarbon spills. In offshore waters near to the release point, pelagic fish are potentially at risk of exposure to the more toxic aromatic components of marine diesel.

Pelagic fish in offshore waters are highly mobile and comprise species such as tunas, sharks and mackerel. Due to their mobility, it is unlikely that pelagic fish would be exposed to toxic components for long periods of time. The more toxic components would also rapidly evaporate and concentrations would significantly diminish with distance from the spill site, limiting the potential area of impact.

Any whale sharks located in open offshore waters in the JBG are most likely transiting the region. The EMBA is located at least 200 km from the whale shark foraging BIA that extends north from North West Cape across the North West Shelf (NWS) and north-east across the Browse Basin (refer to Figure 4-12).

Hydrocarbon contact may affect whale sharks through direct physical coating (surface slicks) and ingestion (surface slicks and entrained/dissolved hydrocarbons), particularly if feeding. Whale sharks are vulnerable to surface, entrained and dissolved aromatic hydrocarbon spill impacts, as they filter large amounts of water over their gills, catching planktonic and nektonic organisms (Jarman and Wilson 2004). Whale sharks at Ningaloo Reef have been observed using two different feeding strategies, including passive sub-surface ram-feeding and active surface feeding (Taylor 2007). Passive feeding consists of swimming slowly at the surface with the mouth wide open. During active feeding sharks swim high in the water with the upper part of the body above the surface with the mouth partially open (Taylor 2007). These feeding methods would result in the potential for individuals that are present in worse affected spill areas to ingest potentially toxic amounts of surface, entrained or dissolved aromatic hydrocarbons. Large amounts of ingested hydrocarbons may affect their endocrine and immune system in the longer term. The presence of hydrocarbons may cause displacement of whale sharks from the area where they normally feed and rest, and potentially disrupt migration and aggregations to these areas in subsequent seasons. Whale sharks may also be affected indirectly by surface, entrained or dissolved aromatic hydrocarbons through the contamination of their prey. The contamination of their food supply and the subsequent ingestion of prey by whale sharks may also result in long-term impacts as a result of bioaccumulation.

The offshore waters of the Operational Area are unlikely to represent important or significant foraging habitat for whale sharks, and it is most likely that their presence will be limited to isolated individuals transiting the Operational Area and surrounding waters. Individuals that have direct contact with hydrocarbons within the spill affected area may be impacted, but the consequences to migratory whale shark populations will be minor.

Fish populations in the open water, offshore environment of the Operational Area and EMBA are highly mobile and have the ability to move away from a marine diesel spill. The spill affected area will likely be confined to the upper surface layers (0-10 m). It is therefore unlikely that fish populations would be exposed to hydrocarbon contamination. Fish populations are likely to be distributed over a wide geographical area so impacts on populations or species level are considered to be negligible. Combined with these factors and the relatively small EMBA and the rapid dispersion of marine diesel, it is considered that any potential impacts will be negligible.

8.2.2.5 Plankton, Fish Eggs and Larvae

Planktonic communities within the EMBA for a worst case marine diesel spill within the Operational Area will include zooplankton, fish eggs and larvae, and potentially coral spawn and larvae. Spatially, the EMBA has the potential to overlap with spawning aggregations of some fishes. Given the year-round spawning of some species, the Petrelex 3D MSS has the potential to overlap spawning periods for some fish species.

There is potential for localised mortality of plankton due to reduced water quality and toxicity from entrained hydrocarbons. Effects will be greatest in the upper 10 m of the water column and areas close to the spill source where hydrocarbon concentrations are likely to be highest.

In the unlikely event of a spill occurring, fish and coral eggs and larvae may be impacted by hydrocarbons entrained in the water column. However, following release, the marine diesel will rapidly evaporate and disperse in the offshore environment, reducing the concentration and toxicity of the spill. Given the quick evaporation and dispersion of marine diesel, impacts to fish eggs and larvae are not expected to be significant.

Any planktonic communities impacts by entrained hydrocarbons are expected to recover quickly (weeks/months) due to fast population turnover (ITOPF 2011), and high rates of natural mortality. Given the relatively small EMBA and the fast population turnover of open water planktonic populations it is considered that any potential impacts will be low and temporary in nature.

8.2.2.6 Water Quality

It is likely water quality will be reduced within a localised area around the marine diesel spill, with contamination levels above background levels and/or national/international water quality standards. However, such impacts to water quality would be temporary and highly localised in nature due to the relatively small EMBA and the rapid dispersion of marine diesel. The potential impact is therefore considered low.

8.2.2.7 Marine Protected Areas

Joseph Bonaparte Gulf Marine Park

There is a small overlap (approximately 40 km^2) between the EMBA and the north-west corner of the Special Purpose Zone (IUCN VI) of the Joseph Bonaparte Gulf Marine Park (JBGMP).

The designated natural values of the JBGMP include a range of species (including species listed as threatened, migratory, marine or cetacean under the EPBC Act), and foraging habitat for marine turtles and the Australian snubfin dolphin. Potential impacts to these values from a worst case marine diesel spill within the Operational Area are assessed in the sub-sections above.

Oceanic Shoals Marine Park

There is an overlap of approximately 1,500 km^2 between the EMBA and the south-east corner of the Multiple Use Zone (IUCN VI) of the Oceanic Shoals Marine Park (OSMP).

The designated natural values of the OSMP include a range of species (including species listed as threatened, migratory, marine or cetacean under the EPBC Act), and foraging and internesting habitat for marine turtles. Potential impacts to these values from a worst case marine diesel spill within the Operational Area are assessed in the sub-sections above.

Potential impacts to commercial fisheries occurring within the Multiple Use Zone of the OSMP are assessed below.

8.2.2.8 Commercial Fisheries

A worst case marine diesel spill in the Operational Area is considered unlikely to cause significant direct impacts on the target species fished by the Northern Prawn Fishery, Northern Demersal Scalefish Managed Fishery (NDSMF), the NT Demersal Fishery and the NF Offshore Net and Line Fishery (ONLF). The target species for these fisheries (demersal finfish and crustaceans) inhabit water depths in the range of >30-200 m and any in-water hydrocarbons are likely to be confined to the upper layers of the water column (0-10 m).

The Mackerel Managed Fishery (MMF) and NT Spanish Mackerel Fishery targets pelagic fish species. As described above, adult pelagic fish species are highly mobile and have the ability to move away from the spill affected area or avoid surface waters. The relatively small spill affected area and temporary nature of the predicted marine diesel spill would infer that it is unlikely the hydrocarbon concentrations in the upper layers of the water column would lead to potential exposure of pelagic fish to contamination. Given these pelagic species are distributed over a wide geographical area, the impacts at the population or species level are considered very minor in the unlikely event of a marine diesel spill.

However, there is potential that a fishing exclusion zone would be applied in the area of the spill, which would put a temporary ban on fishing activities and therefore potentially lead to subsequent economic impacts on commercial fishing operators if they were planning on undertaking fishing within the area of the spill.

8.2.3 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Justification
Inherent Design and Legislative Requirements		
Seismic vessel will utilise MGO, which is stored in multiple fuel tanks on board. Fuel tanks can be isolated and contents transferred between them.	Yes	The risk profile of a vessel fuel tank rupture is based on a release of MGO. Use of another fuel type, such as heavy fuel oil, would result in different impacts and risk due to the different oil characteristics. Polarcus will ensure the seismic vessel uses MGO. Polarcus seismic vessels, by design, have fuel tanks that can be isolated and the contents transferred between tanks.
Seismic vessel has a double hull design making a rupture highly unlikely, even in a collision situation.	Yes	Polarcus seismic vessels, by design, have a double hull design which provides additional structural integrity to prevent a fuel tank rupture form occurring.
Radar on board the seismic vessel is fitted with a collision alarm, and the seismic vessel has DNVGL NAUT-AW class notation for enhanced nautical safety, incorporating a grounding avoidance system.	Yes	Polarcus seismic vessels, by design, have DNVGL NAUT-AW class notation, and collision alarms fitted to the radar systems to alert the Vessel Master and crew to a potential collision, and grounding avoidance systems. These systems significantly reduce the potential for a vessel collision or grounding event from occurring, thus, preventing a spill.
Seismic vessel and support vessels will maintain appropriate lighting, shapes, navigation and communication at all times to inform other users of the position and intentions of the vessel, in compliance with the *Navigation Act 2012* and associated Marine Orders.	Yes	Survey and support vessels will maintain appropriate lighting, shapes, navigation and communication in accordance with the requirements of the *Navigation Act 2012* and associated AMSA Marine Orders.
A 24 hour visual, radio and radar watch will be maintained for vessels in the vicinity of the Operational Area.	Yes	Vessels will maintain a 24-hour visual, radio and radar watch in accordance with the requirements of AMSA Marine Orders.
All vessels over 400 GRT (MARPOL 73/78 Annex I) hold approved and tested SOPEPs and crew are trained in its implementation.	Yes	In accordance with the requirements of Annex I of MARPOL 73/78, vessels will have a SOPEP.

Control Measure	Control Adopted	Justification
In the event of a spill to the marine environment, the OPEP presented in Section 10.3 will be followed.	Yes	In accordance with the requirements of the OPGGS (E) Regulations 2009, an OPEP accompanies this EP, which details the spill preparedness and response arrangements that will be implemented in the event of a spill. The OPEP includes arrangements for notifying AMSA and engaging the National Plan resources.
Alternatives/Substitutes Considered		
No practicable alternative	N/A	N/A
Additional Controls Considered		
Notice to Mariners issued prior to commencement of survey activities.	Yes	AHS will be contacted four weeks prior to the commencement of the survey for the publication of a Notice to Mariners. This will ensure other users that may potentially be present in the Operational Area are aware of the survey. Implementation will reduce the likelihood of interactions with other marine users. Good industry practice.
Daily reporting to AMSA JRCC for promulgation of radio-navigation warnings.	Yes	The AMSA JRCC will be contacted 24-48 hours before operations commence for the promulgation of radio-navigation warnings (i.e. AUSCOAST warnings). Good industry practice.
Notification will be provided to fisheries stakeholders, prior to the commencement of the survey, indicating location and expected timing. Notification will also be provided to fisheries stakeholders upon completion of the survey.	Yes	Notification will be provided to fisheries stakeholders, four weeks prior to commencement of the survey, indicating location and expected timing. Notification will also be provided to fisheries stakeholders within two weeks of completion of the survey. Good industry practice.
Dedicated spill response vessel and resources on standby.	No	The option of having a dedicated spill response vessel on standby for the survey was discounted on the basis that the cost would be grossly disproportionate to any reduction in risk (which is already determined to be Low), particularly as the expected behaviour of an MGO spill would limit the effectiveness of on-water response options. Additional vessels could also increase the risk of interference and potential for collisions.

Control Measure	Control Adopted	Justification
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)		
No further practicable improvements to the above controls have been identified.	N/A	N/A
ALARP Statement		
The residual risk has been determined to be Low. Polarcus considers the adopted control measures appropriate to manage the risk of a hydrocarbon spill from a vessel fuel tank failure. As no reasonable additional or alternative controls were identified that would further reduce the impacts and risks, without jeopardising the objectives of the survey, the impacts and risks are considered to be ALARP.		

8.2.4 *Demonstration of Acceptable Levels*

Context	Demonstration
Risk Level	Given the very low likelihood of a vessel fuel tank rupture and subsequent worst-case impacts occurring, the residual risk is assessed to be Low.
Legislative Requirements	Preventative controls are consistent with COLREGS; SOLAS; the *Navigation Act 2012* and associated AMSA Marine Orders. The SOPEP and OPEP controls are consistent with the requirements of AMSA Marine Orders made under the Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and also fulfil Polarcus' obligations under the OPGGS (E) Regulations and the National Plan for Maritime Environmental Emergencies which in turn provides for Australia's obligations under the International Convention on Oil Pollution Preparedness, Response and Co-operation 1990.
Conservation Advice, Recovery Plans, and Other Guidelines	The spill risk has been assessed based on the maximum case spill scenario identified in accordance with AMSA guidance on oil spill risk assessment (AMSA 2013a). Proposed controls are consistent with the National Plan and the NOPSEMA (2017) Information Paper on Oil pollution risk management
AMP Values, Management Prescriptions and IUCN Reserve Management Principles	The activity remains consistent with AMP management prescriptions. While there is a risk to the values of the Joseph Bonaparte Gulf Marine Park and Oceanic Shoals Marine Park, the risk is manageable to ALARP and acceptable levels through control measures to prevent a spill from occurring, as well as mitigation. The likelihood of a spill occurring and the risk to these values is low.
Principles of Ecologically Sustainable Development	The potential consequences of a spill of MGO include potential lethal and sub-lethal impacts to a relatively small number of marine fauna individuals; disruption to marine users; negligible impacts to fish, eggs and larvae that may receive low but chronic exposures of entrained hydrocarbons. It is highly unlikely that any population and stock level impacts would occur given the main window for exposure is within the first 24 hours of the spill and limited to several kilometres. With the proposed preventative and mitigative controls in place, the likelihood of a vessel incident occurring, and resulting in a fuel tank rupture and the loss of a full 280 m^3 tank volume, and resulting in the impacts described above is considered highly unlikely. Therefore, the impacts and risks are not expected to result in lasting, serious or irreversible ecological damage.
Stakeholder Objections, Claims, Concerns or Advice	N/A – Stakeholders have not raised any specific concerns relating to spills from vessels.

Acceptability Statement
Based on the criteria above, Polarcus considers the adopted control measures appropriate to manage the risk of hydrocarbon spill from a vessel fuel tank failure to be of an acceptable level.

8.3 Hydrocarbon Spill: Vessel Refuelling Failure

8.3.1 *Assessment Summary*

Source of Impact / Risk

An accidental MGO spill during vessel refuelling (up to 25 m^3) has the potential to result in the following adverse effects on the environment:

- Toxic effects on marine fauna that come into contact with surface hydrocarbons; and
- Toxic effects to juvenile fish, eggs and larvae from entrained hydrocarbon droplets.

Receptors

- Marine fauna (i.e. turtles, cetaceans, whales sharks and seabirds); and
- Pelagic fish, eggs and larvae.

Adopted Control Measures	EPS #
All vessels over 400 GRT (MARPOL 73/78 Annex I) hold approved and tested SOPEPs and crew are trained in its implementation.	8.6
In the event of a spill to the marine environment, the OPEP presented in Section 10.3 will be followed.	8.10
Bunkering contractor selection is made in accordance with the contractor selection procedure to ensure the contractor will use dry-break couplings.	8.11
Refuelling undertaken in accordance with Polarcus Bunkering Procedure including: ■ Refuelling will only be undertaken during daylight hours and in suitable weather conditions. ■ Completion of the Permit to Work Refuelling At Sea Checklist and Bunkering Checklist ensuring that anti-pollution equipment is ready and scuppers plugged before bunkering commences. ■ Spill kits are available on board the seismic vessel and crew are trained in their use.	8.12

Details of Residual Impacts and Risks

A refuelling spill of up to 25 m^3 of MGO may result in localised exposure of receptors to localised surface and entrained hydrocarbons. Potential exposures to spilt surface oil >10 g/m^2, considered representative of potential lethal and sub-lethal impacts to marine fauna such as turtles, cetaceans and birds are expected to be limited to a localised area for a few hours or less than a day. Therefore, worst case impacts are expected to be limited to sub-lethal impacts or potential mortality to a small number of individuals Entrained exposures are also expected to be low, resulting in limited interactions with small numbers of fish, eggs and larvae in the upper water column that are largely incidental in nature.

The localised and short-term impacts that are predicted to occur to marina fauna and fish following weathering, dispersion and degradation in the open water environment of the Operational Area are therefore assessed to be Low. Further detail is provided in the evaluation of impacts and risks below.

Risk Ranking	Consequence	Likelihood	Risk
Inherent Risk	Minor (2)	Occasional (C)	**Low**
Residual Risk	Minor (2)	Rare (B)	**Low**

8.3.2 *Detailed Evaluation of Impacts and Risks*

The accidental release of up to 25 m^3 of MGO to the marine environment may result in the temporary and localised reduction in water quality. The behaviour, weathering and fates of the spilt MGO are expected to be the similar to those described for a vessel fuel tank rupture, with the majority of the MGO forming a film on the surface and rapidly evaporating and dispersing following release, with a proportion becoming entrained in the upper water column by wind and wave action. Potential impacts are expected to be limited both temporally and spatially due to the expected small volumes spilt and rapid evaporation and dilution of the spill in the offshore marine environment.

Surface exposures are expected to rapidly fall below the 10 g/m^2 threshold considered representative of potential lethal and sub-lethal impacts to marine fauna, with the greatest concentrations occurring for a brief period in the immediate vicinity of the spill in the Operational Area (e.g. a few hours or less than a day). Entrained exposures are also expected to be low, resulting in limited interactions with small numbers of fish, eggs and larvae in the upper water column that are largely incidental in nature.

The localised and short-term impacts that are predicted to occur to marina fauna and fish assemblages following weathering, dispersion and degradation in the open water environment of the Operational Area are therefore considered to result in a Minor consequence (2). Although not expected, spills during vessel refuelling at sea can occur and the likelihood of the described consequence occurring has been ranked as Occasional (C).

Polarcus will implement fuel bunkering procedures and use dry-break couplings when refuelling. In the unlikely event that a spill occurs during refuelling, the vessel SOPEP and the OPEP included with this EP (Section 0) will be implemented to limit exposures where practicable.

Through implementation of the above controls, the consequence of a MGO refuelling spill resulting in a reduction in water quality and toxicity to marine fauna and fish assemblages remains as Minor (2). However, the likelihood of occurrence is considered to be Rare (B) due to the controls in place, and the overall risk is assessed to be Low.

Further information about the selected control measures, the ALARP evaluation, and the evaluation of Acceptability are provided below.

8.3.3 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Justification
Inherent Design and Legislative Requirements		
All vessels over 400 GRT (MARPOL 73/78 Annex I) hold approved and tested SOPEPs and crew are trained in its implementation.	Yes	In accordance with the requirements of Annex I of MARPOL 73/78, vessels will have a SOPEP.
In the event of a spill to the marine environment, the OPEP presented in Section 0 will be followed.	Yes	In accordance with the requirements of the OPGGS (E) Regulations 2009, an OPEP accompanies this EP which details the spill preparedness and response arrangement s that will be implemented in the event of a spill.
Alternatives/Substitutes Considered		
No offshore refuelling. Refuelling in port only.	No	To reduce the potential for refuelling spills, consideration was given to refuelling only in port. Refuelling in port will be considered during the survey based on location of the vessel and any other requirements to go into port; however the requirement to return to port for all refuelling operations would increase survey duration, fuel use and associated vessel movements and emissions. The potential for near-shore interactions with other users of the area would also increase. As such, the option of requiring all refuelling to occur in port was not considered operationally viable and would not necessarily deliver a net reduction in environmental risk. Controls listed were deemed sufficient based on the nature and scale of the potential impacts and risk. No additional controls were identified to further reduce the likelihood or consequence.
Additional Controls Considered		
Bunkering contractor selection is made in accordance with the contractor selection procedure to ensure the contractor will use dry-break couplings.	Yes	Dry-break couplings will be used to reduce the risk of a refuelling incident from occurring.
Refuelling undertaken in accordance with Polarcus Bunkering Procedure including:	Yes	Refuelling will only be undertaken during daylight and during appropriate weather and sea conditions. Polarcus' Bunkering Procedure, Permit to Work Refuelling At Sea Checklist and Bunkering Checklist require this to be checked along with scupper plugs and the availability of spill kits to clean up deck spills, should one occur.

Control Measure	Control Adopted	Justification
■ Refuelling will only be undertaken during daylight hours and in suitable weather conditions. ■ Completion of the Permit to Work Refuelling At Sea Checklist and Bunkering Checklist ensuring that anti-pollution equipment is ready and scuppers plugged before bunkering commences. ■ Spill kits are available on board the vessel and crew are trained in their use.		
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)		
No further practicable improvements to the above controls have been identified.	N/A	N/A
ALARP Statement		
The residual risk has been determined to be Low. Polarcus considers the adopted control measures appropriate to manage the and risks of a hydrocarbon spill resulting from bunkering at sea. As no reasonable additional or alternative controls were identified that would further reduce the impacts and risks, without jeopardising the objectives of the survey, the impacts and risks are considered to be ALARP.		

8.3.4 *Demonstration of Acceptable Levels*

Context	Demonstration
Risk Level	The residual risk is assessed to be Low.
Legislative Requirements	The SOPEP and OPEP controls are consistent with the requirements of AMSA Marine Orders made under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and also fulfil Polarcus' obligations under the OPGGS (E) Regulations and the National Plan for Maritime Environmental Emergencies, which in turn provides for Australia's obligations under the International Convention on Oil Pollution Preparedness, Response and Co-operation 1990.
Conservation Advice, Recovery Plans, and Other Guidelines	N/A – No specific plans, advice or guidelines have been identified. Refuelling will be undertaken in accordance with Polarcus' Bunkering Procedures to ensure refuelling is done correctly and safely, with minimal possibility of a spill occurring.
AMP Values, Management Prescriptions and IUCN Reserve Management Principles	The activity remains consistent with AMP management prescriptions. While there is a risk to the values of the Joseph Bonaparte Gulf Marine Park or Oceanic Shoals Marine Park, the risk is manageable to ALARP and acceptable levels through control measures to prevent a spill from occurring, as well as mitigation. The likelihood of a spill occurring and the risk to these values is low.
Principles of Ecologically Sustainable Development	The potential consequences of a refuelling spill include potential lethal and sub-lethal impacts to a few individuals, and negligible impacts to fish, eggs and larvae. No population level impacts would occur. With the proposed preventative and mitigative controls in place, the likelihood of a refuelling incident occurring, and resulting in the impacts described above is considered highly unlikely. Therefore, the impacts and risks are not expected to result in lasting, serious or irreversible ecological damage.
Stakeholder Objections, Claims, Concerns or Advice	N/A – Stakeholders have not raised any specific concerns relating to spills from vessels.
Acceptability Statement	
Based on the criteria above, Polarcus considers the adopted control measures appropriate to manage the risk of a hydrocarbon spill during bunkering at sea to be of an acceptable level.	

8.4 Chemical Spill: Single Point Failure

8.4.1 *Assessment Summary*

Source of Impact / Risk	
Accidental spills of up to 1 m^3 of hydraulic fluids or chemicals are expected to result in a localised and short-term reduction in water quality with the potential to result in toxic effects on marine fauna.	
Receptors	
■ Water quality; ■ Marine fauna (i.e. turtles, cetaceans, whale sharks and seabirds); and ■ Pelagic fish, eggs and larvae.	
Adopted Control Measures	**EPS #**
All vessels over 400 GRT (MARPOL 73/78 Annex I) hold approved and tested SOPEPs and crew are trained in its implementation.	8.6
In the event of a spill to the marine environment, the OPEP presented in Section 10.3 will be followed.	8.10
Hydraulic fluids and chemicals will be selected in accordance with the Polarcus Chemical Control Procedure and will be selected to have the lowest environmental toxicity possible whilst meeting operational performance requirements.	8.13
Storage, handling and use of hazardous substances (including hydraulic fluids and chemicals) shall be in accordance with the product's Safety Data Sheet (SDS)	8.14
Spill kits and scupper plugs are available on board the seismic vessel and crew are trained in their use.	8.15
Spills will be reported through the Polarcus Incident Reporting Procedure and waste materials managed in accordance with the vessel Waste/Garbage Management Plan	8.16
Details of Residual Impacts and Risks	
The accidental release of up to 1 m^3 of hydraulic fluids or chemicals to the marine environment may result in a localised reduction in water quality. Hydraulic fluids spilt overboard have the potential to result in toxicity effects to marine fauna and fish in the immediate vicinity of the spill release location, through direct contact or accidental ingestion. Given the open water dispersive location of the Operational Area, the extent and duration of potential exposures, impacts to marine fauna and fish is expected to be highly localised and short term, and limited to the vicinity of point of discharge. Therefore, impacts are considered to result in a minor consequence and the residual risk has been determined to be Low with the proposed preventative controls in place. Further detail is provided in the evaluation of impacts and risks below.	

Risk Ranking	Consequence	Likelihood	Risk
Inherent Risk	Slight (1)	Occasional (C)	**Low**
Residual Risk	Slight (1)	Rare (B)	**Low**

8.4.2 *Detailed Evaluation of Impacts and Risks*

The accidental release of up to 1 m^3 of hydraulic fluids or chemicals to the marine environment may result in a localised reduction in water quality. Hydraulic fluids spilt overboard have the potential to result in toxicity effects to marine fauna and fish in the immediate vicinity of the spill release location, through direct contact or accidental ingestion. Given the open water dispersive location of the Operational Area, the extent and duration of potential exposures and impacts to marine fauna and fish is expected to be highly localised and short term, and limited to the vicinity of point of discharge.

Therefore, impacts are considered to result in a Minor consequence (2). The likelihood of an accidental single point failure occurring without preventative controls in place, and resulting in the described consequence is considered to be Occasional (C).

Through implementation of the proposed controls the consequence of a single point failure resulting in a reduction in water quality and toxicity to marine fauna and fish remains as Minor (2). However, the likelihood of occurrence is considered to be Rare (B) due to the controls in place. The residual risk has been determined to be Low. Further detail is provided in the evaluation of impacts and risks below.

Further information about the selected control measures, the ALARP evaluation, and the evaluation of Acceptability are provided below.

8.4.3 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Justification
Inherent Design and Legislative Requirements		
All vessels over 400 GRT (MARPOL 73/78 Annex I) hold approved and tested SOPEPs and crew are trained in its implementation.	Yes	In accordance with the requirements of Annex I of MARPOL 73/78, vessels will have a SOPEP.
In the event of a spill to the marine environment, the OPEP presented in Section 10.3 will be followed.	Yes	In accordance with the requirements of the OPGGS (E) Regulations 2009, an OPEP accompanies this EP, which details the spill preparedness and response arrangements that will be implemented in the event of a spill.
Alternatives/Substitutes Considered		
No hydraulic fluids or chemicals to be used during the seismic survey activity.	No	During the survey, the use of hydraulic oils cannot be eliminated as they are required for the safe operation of equipment. Chemical use is controlled through implementation of the Polarcus Chemical Control Procedure ensuring the use of chemicals with the lowest environmental toxicity possible meeting technical specifications.
Additional Controls Considered		
Hydraulic fluids and chemicals will be selected in accordance with the Polarcus Chemical Control Procedure and will be selected to have the lowest environmental toxicity possible whilst meeting operational performance requirements.	Yes	Chemical use is controlled through the implementation of the Polarcus Chemical Control Procedure ensuring the use of chemicals with the lowest environmental toxicity possible meeting technical specifications. Good industry practice.
Storage, handling and use of hazardous substances (including hydraulic fluids and chemicals) shall be in accordance with the product's Safety Data Sheet (SDS).	Yes	Storage and handling in accordance with SDS, reduces the potential for deck spills. Good industry practice.

Control Measure	Control Adopted	Justification
Spill kits and scupper plugs are available on board the seismic vessel and crew are trained in their use.	Yes	Should a spill occur on deck, spill kits and scupper plugs can prevent the spill from entering the marine environment. Good industry practice.
Spills will be reported through the Polarcus Incident Reporting Procedure and waste materials managed in accordance with the vessel Waste/Garbage Management Plan.	Yes	All spills during the Petrelex 3D MSS will be reported through the Polarcus Incident Reporting Procedure. Waste materials will be managed in accordance with the vessel Waste/Garbage Management Plan. Good industry practice.
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)		
No further practicable improvements to the above controls have been identified.	N/A	N/A
ALARP Statement		
The residual risk has been determined to be Low. Polarcus considers the adopted control measures appropriate to manage the impacts and risks of a hydraulic fluid or chemical spill resulting from a single point failure. As no reasonable additional or alternative controls were identified that would further reduce the impacts and risks, without jeopardising the objectives of the survey, the impacts and risks are considered to be ALARP.		

8.4.4 *Demonstration of Acceptable Levels*

Context	Demonstration
Risk Level	The residual risk is assessed to be Low.
Legislative Requirements	The SOPEP and OPEP controls are consistent with the requirements of AMSA Marine Orders made under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and also fulfil Polarcus' obligations under the OPGGS (E) Regulations and the National Plan for Maritime Environmental Emergencies, which in turn provides for Australia's obligations under the International Convention on Oil Pollution Preparedness, Response and Co-operation 1990.
Conservation Advice, Recovery Plans, and Other Guidelines	N/A – No specific plans, advice or guidelines have been identified. Refuelling will be undertaken in accordance with Polarcus' Bunkering Procedures to ensure refuelling is done correctly and safely, with minimal possibility of a spill occurring.
AMP Values, Management Prescriptions and IUCN Reserve Management Principles	The activity remains consistent with AMP management prescriptions. While there is a risk to the values of the Joseph Bonaparte Gulf Marine Park or Oceanic Shoals Marine Park, the risk is manageable to ALARP and acceptable levels through control measures to prevent a spill from occurring, as well as mitigation. The likelihood of a spill occurring and the risk to these values is low.
Principles of Ecologically Sustainable Development	The potential consequences of a single point failure resulting in <1 m^3 spill of hydraulic fluid or other general-purpose chemicals are not expected to result in any serious or irreversible environmental damage. With the proposed preventative and mitigative controls in place, the likelihood of such a spill occurring, and resulting in the impacts described above is considered unlikely.
Stakeholder Objections, Claims, Concerns or Advice	N/A – Stakeholders have not raised any specific concerns relating to spills from vessels.
Acceptability Statement	
Based on the criteria above, Polarcus considers the adopted control measures appropriate to manage the risk of a hydraulic fluid or chemical spill to be of an acceptable level.	

8.5 Physical Presence: Collision / Entanglement with Marine Fauna

8.5.1 *Assessment Summary*

Source of Impact / Risk	
The seismic vessel and support vessels operating in the Operational Area, and the towed seismic equipment, may represent a potential entanglement / collision risk to marine fauna.	
Receptors	
EPBC listed species, including threatened and migratory cetaceans, marine turtles.	
Adopted Control Measures	**EPS #**
Seismic vessel and support vessels (taking into account the limited manoeuvrability of the former) will comply with relevant requirements of EPBC Regulations 2000 - Part 8 Division 8.1, including: ■ taking action to avoid approaching or drifting closer than 50 m to a dolphin or 100 m to a whale; and ■ not exceeding a speed of 6 knots within the caution zone of a cetacean (300 m).	9.1
In addition to the requirements of the EPBC Regulations 2000 - Part 8 Division 8.1 for cetaceans, seismic vessels and support vessels (taking into account the limited manoeuvrability of the former) will also take action to avoid approaching or drifting closer than 50 m to a turtle or dugong.	9.2
Seismic vessel and support vessels (taking into account the limited manoeuvrability of the former) will also adopt measures consistent with the DPaW Whale Shark Management Programme (2013), including: ■ taking action to avoid approaching or drifting closer than 30 m of a whale shark; and ■ not exceeding 8 knots within 250 m of a whale shark.	9.3
Two MFOs will be available on board the seismic vessel to manage shift duties during daylight hours during the survey.	9.4
Crew, survey personnel and MFOs will be briefed in the marine fauna observation, separation distance estimation, controls and reporting requirements relevant to this EP.	9.5
If safe and practicable to do so, fauna found to be entangled in towed equipment shall be returned to the ocean.	9.6
Turtle guards will be fitted on tail buoys, or tail buoys will be of a design that does not represent an entanglement risk to turtles.	9.7
All collisions with cetaceans in Commonwealth waters will be reported to the National Ship Strike Database.	9.8
Details of Residual Impacts and Risks	
The potential impact associated with the physical presence of vessels and towed equipment is the risk of collision or entanglement with marine fauna resulting in injury or mortality, including various whale and marine turtle species. There are no known important habitats for cetaceans within or nearby the Operational Area. Marine turtle foraging BIAs partially overlap the Operational Area, however bycatch records indicate turtles occur infrequently in depths exceeding 40 m and therefore occurrence within the Operational Area is expected to be limited to isolated individuals.	

Research shows that faster vessels have a greater risk of collision with marine fauna than slower-moving vessels. There have been no reported cases of marine fauna becoming entangled in seismic equipment in Australian waters. Given the proposed controls and the fact that the seismic survey vessel will be moving at 4-5 knots during seismic data acquisition, the risk is limited. Close-range encounters with marine fauna are expected to be infrequent and limited to isolated individuals in the immediate vicinity of the operating vessels and survey array. As a result, marine fauna injury or mortality as a result of collision or entanglement is highly unlikely and there is no risk of population-level impacts or threats of serious / irreversible environmental damage. The residual impacts and risks have therefore been assessed as Low. Further detail is provided in the evaluation of impacts and risks below.			
Risk Ranking	**Consequence**	**Likelihood**	**Risk Ranking**
Inherent Risk	Extensive (3)	Occasional (C)	**Moderate**
Residual Risk	Extensive (3)	Rare (B)	**Low**

8.5.2 *Detailed Evaluation of Impacts and Risks*

Vessel movements can result in collisions between the vessel (hull, propellers and streamer array) and marine fauna, potentially resulting in serious injury that may affect life functions (e.g. movement and reproduction) or cause mortality. The factors that contribute to the frequency and severity of impacts due to collisions vary greatly due to the vessel type, vessel operation (specific activity, speed), physical environment (e.g. water depth) and the type of fauna potentially present and their behaviours.

The survey will be undertaken by a purpose-built seismic survey vessel towing an underwater seismic source (at a depth of 5-10 m) and a series of hydrophone streamers (up to 10). These streamers will be towed at a depth of approximately 15 m below the surface. The seismic vessel, when acquiring data will travel along a series of pre-determined lines within the Acquisition Area at approximately 4-5 knots, until the required coverage is completed. The seismic vessel will be accompanied by two support vessels.

While the seismic source is in operation it is unlikely that marine fauna would become entangled in the array or collide with the seismic equipment, as the sound generated during operations would act as a deterrent. During line turns, when typically the seismic source is not in full operation, the source is activated at low power in accordance with industry standards as a precautionary measure to reduce the likelihood of entanglement or contact during line turns. It should also be noted, that during the survey, the seismic vessel will already be moving at low speed (4-5 knots), and approaching seismic and/or vessel noise will provide some level of warning to marine fauna at the surface.

To date, there have been no reported cases of marine fauna becoming entangled in seismic equipment in Australian waters.

8.5.2.1 Marine Turtles

Marine turtles are at potential risk from vessel strike and entanglement with the in-water seismic equipment. Peel et al. (2016) reviewed vessel strike data (2000-2015) for marine turtle species in Australian waters and identified that all turtle species present in Australian waters had had an interaction with vessels. Green and loggerhead turtles exhibited the highest incident of interaction. The effect of vessel speed and turtle flee response can be significant. A study by Hazel et al. (2007) recorded 60% of green turtles fleeing from vessels travelling at 4 km/h, while only 4% fled from vessels travelling at 19 km/h. When fleeing, 75% of turtles moved away from the vessel's track, 8% swam along the vessel track and 18% crossed in front of the vessel. The study concluded that most turtles would be unlikely to avoid vessels travelling at speeds greater than 4 km/h (DoEE 2017).

The NWMR and NMR are considered to be significant for supporting large feeding and nesting turtle populations. The Operational Area partially overlaps with BIAs for foraging marine turtles (loggerhead, flatback, green and olive ridley). A portion of the Carbonate bank and terrace system of the Sahul Shelf KEF and Pinnacles of the Bonaparte Basin KEF partially overlap with the Operational Area and have been identified as foraging areas for loggerhead, olive ridley and flatback turtles. Bycatch records from the NPF within the southern portion of the EMBA identified that turtle catches varied with water depth: the highest catch rates were from trawls in water between 20 and 30 m deep, relatively few turtles (10%) were captured in water deeper than 40 m (Poiner and Harris 1996). It is unlikely that the marine environment within the Operational Area is a predominant foraging area for turtles.

No internesting, or nesting BIAs overlap with the Operational Area, however these occur within the wider region (Figure 4-9). The closest nesting and internesting site for marine turtles is located at Cape Domett, which is utilised by flatback turtles and is located approximately 150 km south of the Operational Area. The occurrence of marine turtles within the Operational Area is expected to be low and limited to transitory individuals.

8.5.2.2 Cetaceans

Cetaceans are naturally inquisitive marine mammals that are often attracted to offshore vessels, and dolphins commonly 'bow ride' with offshore vessels. The reaction of whales to the approach of a vessel is quite variable. Some species remain motionless when close to a vessel while others are known to be curious and often approach ships that have stopped or are slow moving, although they generally do not approach, and sometimes avoid, faster moving ships (Richardson et al. 1995).

Collisions between vessels and cetaceans occur more frequently where high vessel traffic and cetacean habitat coincide (Whale and Dolphin Conservation Society (WDCS) 2006). There have been occasional recorded instances of cetacean deaths in Australian waters (WDCS 2006), though the data indicates this is more likely to be associated with container ships and fast ferries. The Whale and Dolphin Conservation Society (WDCS 2006) also indicates that some cetacean species, such as humpback whales, can detect and change course to avoid a vessel.

Laist et al. (2001) identified larger vessels (container vessel and fast ferries), moving faster than 10 knots may cause fatal or severe injuries to cetaceans, with the most severe injuries caused by vessels travelling at speeds greater than 14 knots. Individual cetaceans engaged in behaviours such as feeding, mating or nursing may also be more vulnerable to vessel collisions when distracted by these activities (DoEE 2017).

Several species of cetaceans are known to occur in the NWMR and have wide distributions that are associated with feeding and migration patterns linked to reproductive cycles. There are no known important cetacean habitats within or adjacent to the Operational Area (Section 4.5.8). The closest marine mammal BIAs are located 125 km east of the Operational Area near Darwin Harbour, and include foraging habitats for the Indo-Pacific humpback dolphin and breeding and foraging habitats for the spotted bottlenose dolphin. Due to the absence of important habitat and infrequent sightings, the occurrence of marine mammals within the Operational Area is expected to be infrequent and limited to transitory individuals.

8.5.2.3 Whale Sharks

Whale sharks are at risk from vessel strikes when feeding at the surface or in shallow waters (where there is limited option to dive). Whale sharks may traverse the offshore waters in the wider EMBA during their migrations to and from Ningaloo Reef. Migration is expected to occur between January and March. The closest BIA for the species is the foraging BIA, located along the 200 m isobath of the northern WA coastline (approximately 252 km from the Operational Area) (refer to Figure 4-12). It is expected that whale shark presence in the Operational Area would not comprise significant numbers, given the main aggregations are recorded in coastal waters, (MPRA 2005; Sleeman et al. 2010) and their presence would be transitory and of a short duration. The risk of entanglement or collision is considered Low.

Based on the assessment above and implementation of the identified controls, the risk of collision or entanglement is limited, with the potential to affect isolated individuals in the immediate vicinity of the operating vessels and survey array. Through implementation of the proposed controls the consequence of a collision or entanglement with marine fauna resulting in injury or death remains Extensive (3). However, the identified additional controls are considered practicable methods of further reducing the likelihood of occurrence, despite the assessed likelihood remaining in the Rare (B) category. This results in a Low residual risk to marine fauna.

Further information about the selected control measures, the ALARP evaluation, and the evaluation of Acceptability are provided below.

8.5.3 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Comment / Justification
Inherent Design and Legislative Requirements		
Survey and support vessels (taking into account the limited manoeuvrability of the former) will comply with relevant requirements of EPBC Regulations 2000 - Part 8 Division 8.1, including: ▪ taking action to avoid approaching or drifting closer than 50 m to a dolphin or 100 m to a whale; and ▪ not exceeding a speed of 6 knots within the caution zone of a cetacean (300 m).	Yes	The requirements of the EPBC regulations set out clear measures to reduce speed and avoid approaching cetaceans, which reduces the risk of collision or entanglement. Therefore, these measures will be applied during the Petrelex 3D MSS.
Turtle guards will be fitted on tail buoys, or tail buoys will be of a design that does not represent an entanglement risk to turtles.	Yes	A tail buoy will be fitted to the end of each streamer, which controls the depth at which the streamers are towed. Tail buoys are brightly coloured and contain a radar reflector and strobe light to be visible to other marine users. If the tail buoys have not been designed to avoid entrapment, they will be fitted with guards to prevent accidental entrapment of turtles. Turtle guards are designed to prevent entanglement with tail buoys and are used as standard during Polarcus surveys.
Alternatives/Substitutes Considered		
Use OBN instead of towed hydrophone streamers	No	To further reduce the potential for entanglement, an alternative to the use of towed streamers is the use of ocean bottom receivers or nodes (OBN). However, this was considered impractical for the following reasons: ▪ Environmentally, ocean bottom receivers placed on the seabed may reduce the risk of marine fauna becoming entangled in towed streamers. However, this alternative would not alter the risks associated with potential vessel interactions. Also, OBN can result in unnecessary seabed disturbance particularly in areas of shallow benthic habitat. ▪ OBN would result in a significant increase in vessel activity to manage deployments and recoveries throughout the Operational Area, which would increase the potential for vessel collision and may disrupt other marine users.

Control Measure	Control Adopted	Comment / Justification
		■ Operationally, this alternative would not meet survey requirements for coverage and would also add significantly to the cost and timeframe for the survey, making it impractical. ■ Given that there have been no reported cases of marine fauna becoming entangled in seismic equipment, the risk is already very low and so little additional benefit would be gained.
Additional Controls Considered		
All collisions with cetaceans in Commonwealth waters will be reported to the National Ship Strike Database.	Yes	Reporting ship strikes with cetaceans is requested by the DoEE's Australian Antarctic Division and allows the Australian Government and International Whaling Commission (IWC) to collate scientific data on vessel strike locations, frequencies and timings so that further research and mitigation can be considered.
If safe and practicable to do so, any fauna found to be entangled in towed equipment shall be returned to the ocean.	Yes	If safe and practicable to do so, fauna found to be entangled in towed equipment shall be recovered to reduce the risk of mortality.
Retrieve towed equipment when not in use.	No	Consideration was given to the option of retrieving towed equipment when not in use. However, given the other controls in place to reduce the risk of interaction with marine fauna, this additional control was determined as providing limited benefit and as being disproportionate to the significantly increased time, cost and complexity associated with implementing it, as well as increased health and safety risks from repeatedly retrieving and deploying equipment from the seismic vessel.
Crew, survey personnel and MFOs will be briefed in the marine fauna observation, separation distance estimation, controls and reporting requirements relevant to this EP.	Yes	Crew survey personnel and MFOs will be briefed in marine fauna observations (i.e. identification), separation distance estimation, EP controls and EP reporting requirements. Good industry practice.

Control Measure	Control Adopted	Comment / Justification
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)		
In addition to the requirements of the EPBC Regulations 2000 - Part 8 Division 8.1 for cetaceans, vessels will also take action to avoid approaching or drifting closer than 50 m to a turtle.	Yes	In addition to implementing avoidance measures for cetaceans, Polarcus has considered extending the prescribed avoidance measures to turtles and dugongs.
Seismic vessel and support vessels (taking into account the limited manoeuvrability of the former) will also adopt measures consistent with the DPaW Whale Shark Management Program (2013), including: ■ taking action to avoid approaching or drifting closer than 30 m of a whale shark; and ■ not exceeding 8 knots within 250 m of a whale shark.	Yes	In addition to implementing the EPBC Regulations 2000 avoidance measures for cetaceans, Polarcus has extended avoidance measures to whale sharks.
Two MFOs will be available on board the seismic vessel to manage shift duties during daylight hours during the survey.	Yes	In order to share shifts and manage fatigue, Polarcus ensures that two MFOs are available on board the seismic survey vessel. This has proven to be effective in previous surveys. Polarcus engages reputable MFO suppliers for seismic survey operations. In addition, when selecting MFOs, Polarcus gives preference to those with previous experience on board a Polarcus vessel, familiarity with the Polarcus Management System and those who have previously received positive feedback from Polarcus vessel party managers.
ALARP Statement		
The residual risk has been determined to be Low. Polarcus considers the adopted control measures appropriate to manage the risks of collision or entanglement with marine fauna. As no reasonable additional or alternative controls were identified that would further reduce the impacts and risks, without jeopardising the objectives of the survey, the impacts and risks are considered to be ALARP.		

8.5.4 *Demonstration of Acceptable Levels*

Context	Demonstration
Risk Level	The residual risk is assessed to be Low.
Legislative Requirements	The requirements of the EPBC Regulations 2000 (Part 8 Division 8.1 'Interacting with cetaceans') will be implemented.
Conservation Advice, Recovery Plans, and Other Guidelines	Proposed control measures and the low residual risk of vessel collision or entanglement are consistent with the various Conservation Advice, Conservation Management Plans and Recovery Plans for whales, sharks and turtles. Proposed control measures for whale sharks are also consistent with the DPaW (2013) Whale Shark Management Program.
AMP Values, Management Prescriptions and IUCN Reserve Management Principles	No impacts are predicted to foraging turtles as a value of the Joseph Bonaparte Gulf Marine Park and Oceanic Shoals Marine Park.
Principles of Ecologically Sustainable Development	The seismic survey vessel will be moving at 4-5 knots during the activity and all vessels will comply with the requirements of the EPBC Regulations 2000 (Part 8 Division 8.1 'Interacting with cetaceans'). The potential interactions between vessels and towed equipment are well understood and the proposed controls meet or exceed well established industry management measures that are designed to reduce the risk of collisions with marine fauna. Therefore, marine fauna injury or mortality is not expected and there is no risk of population level impacts or threats of serious or irreversible environmental damage.
Stakeholder Objections, Claims, Concerns or Advice	No feedback relating specifically to collision or entanglement with marine fauna has been received during stakeholder consultation. This issue is considered to be addressed and will be managed to acceptable levels.
Acceptability Statement	
Based on the criteria above, Polarcus considers the adopted control measures appropriate to manage the impacts and risks of collision or entanglement with marine fauna to be of an acceptable level.	

8.6 Physical Presence: Loss of Equipment

8.6.1 *Assessment Summary*

Source of Impact

The loss of equipment overboard has the potential to:

- disrupt other users of the Operational Area; and
- result in disturbance to the seabed.

The seismic equipment (i.e. streamers and seismic array) has the potential to be lost during the survey as a result of breakage of cables or lifting equipment. While loss of equipment overboard is not a common occurrence, it has occurred in the Australian oil and gas industry. The design of this equipment means that rapid recovery by the seismic or support vessel is facilitated, reducing the risk of lost equipment becoming a long-term hazard to marine environments or other marine users.

Receptors

- Other marine users (i.e. commercial fisheries and shipping)
- Benthic habitats and communities

Adopted Control Measures	EPS #
Streamers will be deployed and retrieved in accordance with the Polarcus Deployment and Recovery of Streamers Procedure, of which key requirements include: ■ Ensuring weather conditions are appropriate for deployment and retrieval; ■ Ensuring tail buoy GPS is operational; ■ Monitoring deployment and retrieval closely; ■ Checking for physical damage; ■ Ensuring connection devices are in serviceable condition; and ■ Storing all birds, floats, streamer recovery devices (SRDs) and acoustic racks immediately following recovery.	10.1
Streamers will be fitted with redundant retainers, tail buoys and relative GPS.	10.2
Solid streamers will be used for the survey.	10.3
All lifting gear used for deployment and retrieval of equipment over the vessel shall be load rated for the working load.	10.4
AMSA JRCC, and other marine users in the Operational Area, will be notified in the event of equipment loss.	10.5
At least one support vessel will accompany the seismic vessel at all times and will, if necessary, assist in the recovery of lost equipment.	10.6

Details of Residual Impacts and Risks

In the event that equipment is lost, other users of the Operational Area may be required to make minor diversions to avoid the equipment, until it can be retrieved. The potential for such interactions will be limited to a short period of time while the equipment is retrieved. Should disruption occur it is only expected to affect individual users and cause temporary disruption through avoidance of a highly localised area. Given the nature and size of the equipment to be used during the survey, lost equipment is not expected to result in a navigational hazard.

Dropped equipment may also disturb benthic habitats. The majority of benthic habitats in the Operational Area comprise mostly soft sediment seabed, supporting sparse sessile filter-feeding organisms (e.g. gorgonians, sponges, ascidians and bryozoans) and mobile invertebrates (e.g. echinoderms, prawns and detritus-feeding crabs). Such habitats are well represented throughout the region. Given the size of equipment used for the survey, only a relatively small area of the seabed would be disturbed and lasting impacts are not expected. Therefore, impacts are considered to result in a minor consequence and the residual risk has been determined to be Low. Further detail is provided in the evaluation of impacts and risks below.			
Risk Ranking	**Consequence**	**Likelihood**	**Risk**
Inherent Risk	Slight (1)	Occasional (C)	**Low**
Residual Risk	Slight (1)	Rare (B)	**Low**

8.6.2 *Detailed Evaluation of Impacts and Risks*

8.6.2.1 Other Marine Users

In the unlikely event that equipment is lost, other marine users of the Operational Area may be required to make minor diversions to avoid the equipment, until it can be retrieved (if possible). The potential for such interactions will be limited to a short period of time while the equipment is retrieved (if possible). Should disruption occur it is only expected to affect individual users and cause temporary disruption through avoidance of a highly localised area. Given the nature and size of the equipment to be used during the survey, lost equipment is not expected to result in a navigational hazard. Therefore, anticipated impacts are expected to be low

8.6.2.2 Benthic Habitat and Communities

Loss of equipment has the potential to cause localised seabed disturbance and localised damage to benthic habitats, arising from the streamers and associated equipment potentially sinking and being dragged along the seabed. However, the tow depth of streamers (15 m), and the application of depth control in-built into the design and planning of the activity means that the likelihood of direct impact on benthic communities during normal operations is highly unlikely.

As described in Section 4.5.2, the majority of benthic habitats in the Operational Area comprise mostly soft sediment seabed with infrequent localised rocky outcrops, gravel deposits and sands banks. The muddy substrates that cover the majority of the Acquisition Area support relatively little seabed structure or sessile epibenthos. Seabed habitat is expected to be sparsely covered by sessile filter-feeding organisms (e.g. gorgonians, sponges, ascidians and bryozoans) and mobile invertebrates (e.g. echinoderms, prawns and detritus-feeding crabs). Such habitats are well represented throughout the region. Given the size of equipment used for the survey, only a relatively small area of the seabed would be disturbed and lasting impacts are not expected.

Any consequence is therefore anticipated to be Slight (1). Loss of equipment and dropped objects could Occasionally occur (C) without the appropriate checks and controls. Through implementation of the above controls, the likelihood of occurrence is reduced to Rare (B) and the risk is considered to be Low.

8.6.3 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Comment / Justification
Inherent Design and Legislative Requirements		
Solid streamers will be used for the survey.	Yes	Solid streamers are used as standard so as to prevent any possibility of discharges that could otherwise occur if fluid-filled streamers were used and became damaged. The environmental benefit outweighs the additional cost.
All lifting gear used for deployment and retrieval of equipment over the vessel shall be load rated for the working load.	Yes	All lifting gear used for deployment and retrieval of equipment over the vessel shall be load rated for the working load. The environmental benefit outweighs the additional cost.
Alternatives/Substitutes Considered		
No practicable alternative or substitutes to the above the controls have been identified	N/A	N/A
Additional Controls Considered		
Streamers will be deployed and retrieved in accordance with the Polarcus Deployment and Recovery of Streamers Procedure, of which key requirements include: ■ Ensuring weather conditions are appropriate for deployment and retrieval; ■ Ensuring tail buoy GPS is operational; ■ Monitoring deployment and retrieval closely; ■ Checking for physical damage; ■ Ensuring connection devices are in serviceable condition; ■ Storing all birds, floats, SRDs and acoustic racks immediately following recovery.	Yes	The procedures ensure the necessary checks are conducted and the integrity of equipment, retainers and fastenings is confirmed.
Streamers will be fitted with redundant retainers, tail buoys and relative GPS.	Yes	Tail buoys and GPS allow for the streamers to be easily located and recovered if lost. The environmental benefit outweighs the additional cost.

Control Measure	Control Adopted	Comment / Justification
AMSA JRCC, and other marine users in the Operational Area, will be notified in the event of equipment loss.	Yes	Notification to other marine users (i.e. commercial fishing and shipping) to alert them of the navigational hazard (if applicable). The environmental benefit outweighs the additional cost.
At least one support vessel will accompany the seismic vessel at all times and will, if necessary, assist in the recovery of lost equipment.	Yes	Two support vessels will accompany the survey vessel. Support vessels are able to assist in the search and recovery of lost equipment. The environmental benefit outweighs the additional cost.
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)		
No further practicable improvements to the above controls have been identified.	N/A	N/A
ALARP Statement		
The residual risk has been determined to be Low. Polarcus considers the adopted control measures appropriate to manage the risks of an accidental loss of equipment to the marine environment. As no reasonable additional or alternative controls were identified that would further reduce the impacts and risks, without jeopardising the objectives of the survey, the impacts and risks are considered to be ALARP.		

8.6.4 *Demonstration of Acceptable Levels*

Context	Demonstration
Risk Level	The residual risk is assessed to be Low.
Legislative Requirements	N/A – No legislative requirements were identified
Conservation Advice, Recovery Plans, and Other Guidelines	Marine debris causing entanglement and ingestion was recognised in 2003 as a key threatening process for marine vertebrates under the *EPBC Act*. Pollution generally is also identified as a threat in several conservation advices / recovery plans for EPBC-listed species potentially occurring within the Operational Area. Polarcus has reduced and, where possible, eliminated any adverse impacts of marine debris from the activities of the seismic survey on turtles, cetaceans, sharks and birds, noting the linkages with the Threat Abatement Plan for the Impact of Marine Debris on Vertebrate Marine Life (Commonwealth of Australia 2018
Amp Values, Management Prescriptions and IUCN Management Principles	The activity is consistent with the management prescriptions for Australian Marine Parks. No population-level impacts or serious or irreversible ecological implications are predicted for any values of the Joseph Bonaparte Gulf Marine Park and Oceanic Shoals Marine Park.
Principles of Ecologically Sustainable Development	The potential consequences of lost equipment do not have the potential to result in serious or irreversible environmental damage. Therefore, the activity and risk is considered to be consistent with the principles of ecologically sustainable development.
Stakeholder Objections, Claims, Concerns or Advice	N/A – Stakeholders have not raised any specific concerns relating to spills from vessels.
Acceptability Statement	
Based on the criteria above, Polarcus considers the adopted control measures appropriate to manage the risk of an accidental loss of equipment to be of an acceptable level.	

8.7 Discharge: Loss of Hazardous or Non-Hazardous Solid Waste

8.7.1 *Assessment Summary*

Source of Impact / Risk	
Vessels employed for the Petrelex 3D MSS will contribute to the generation of soil wastes. Solid wastes may include non-biodegradable, non-hazardous wastes such as plastics, waste metal, glass and timber, and/or non-biodegradable hazardous wastes such as batteries and oil filters. Some solid waste generated aboard the project vessels may have potential to be blown or knocked off the vessel, or otherwise be lost overboard to the marine environment.	
Receptors	
■ Water quality; ■ Marine biota; and ■ Marine fauna.	
Adopted Control Measures	**EPS #**
In accordance with MARPOL Annex V and Marine Order 95: ■ Vessels > 100 GRT (or certified for >15 persons on board) will have a Waste Management Plan ■ Vessels >400 GRT (or certified for >15 persons on board) will have a waste management log book	11.1
Bins available for the segregation of waste in accordance with the vessel Waste Management Plan, and bins are fitted with lids/cargo nets for waste with potential to be wind-blown (e.g. paper, cardboard).	11.2
Solid hazardous and non-hazardous wastes generated during the survey are segregated on board the vessels and are either incinerated (using an IMO-approved incinerator, on seismic vessel only) or appropriately disposed of at a licensed onshore facility in accordance with the Vessel Waste Management Plan.	11.3
Solid waste generated during the survey on board the vessel will be minimised where practical, as identified during the pre-survey environmental checklist.	11.4
Recycling or re-use of non-hazardous solid waste, where possible.	11.5
Details of Residual Impacts and Risks	
Impacts resulting from the routine management of sold hazardous and non-hazardous wastes are expected to be negligible, as there will be no planned discharge of solid wastes to the marine environment. Discharge of solid wastes has the potential to temporarily create a localised change in water quality and temporary ecological impacts. Solid wastes may also be blown off the vessel, which could have the potential to result in fauna mortality or injury through ingestion or entanglement. Windblown waste would be rare as wastes will be stored in closed containers. With the proposed management and discharge controls in place, discernible impacts to water quality and marine biota are not expected in the open water location of the Petrelex 3D MSS. The consequence of reduction in water quality and impacts to marine biota is therefore slight given the nature and scale of the impact, though any changes would rarely be discernible. The residual impacts and risks, with the control measures in place, have therefore been assessed as low. Further detail is provided in the evaluation of impacts and risks below.	

Risk Ranking	Consequence	Likelihood	Risk
Inherent Risk	Slight (1)	Rare (B)	**Low**
Residual Risk	Slight (1)	Rare (B)	**Low**

8.7.2 *Detailed Evaluation of Impacts and Risks*

The seismic and support vessels will generate a variety of solid waste including non-hazardous wastes (e.g. paper, plastics, waste metal and glass) and/or hazardous wastes (e.g. batteries and oil filters). Hence, there is the potential for solid wastes to be discharged to the marine environment.

Solid wastes will not be discharged to sea but rather will be stored on board the vessels prior to transfer to a supply vessel for onshore recycling or disposal. Where practical solid waste will be minimised and non-hazardous waste will be either re-used or recycled where practical. Solid waste generated will be segregated on board the vessel in specific bins in accordance with the vessel Waste Management Plan. Bins will be fitted with lids/cargo nets for any waste with the potential to be windblown.

If solid wastes on board vessels are not managed or disposed of appropriately, small quantities of solid waste (e.g. packaging and other domestic waste products) may be released with the potential to impact the environment. All domestic waste discharge will be managed in accordance with the requirements of MARPOL 73/78 and the AMSA Marine Orders made under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*.

Loss of solid wastes to the marine environment have the potential to:

- Temporarily create a localised change in water/sediment quality resulting in localised, minor and temporary ecological impacts; and
- Cause injury, ingestion or entanglement by marine fauna.

8.7.2.1 Water/Sediment Quality

Impacts to water quality resulting from the unplanned loss of solid wastes are expected to be minor, temporary and highly localised. The resulting change in water quality in the water column will be highly localised and short term. Impacts to sediment quality are also expected to be minor, temporary and highly localised. Therefore, significant impacts to marine biota are not expected.

8.7.2.2 Marine Fauna

Interaction may occur with marine fauna, including EPBC listed species such as cetaceans, marine turtles and whale sharks in the:

- pelagic zone (floating wastes / temporarily floating wastes); and/or
- benthic zone (wastes that descend the water column to the seabed).

Windblown waste is likely to be a rare event as wastes will be stored in closed/covered containers. In the event of waste being blown overboard attempts would be made to recover it. There is the potential for windblown wastes to not be recovered from the marine environment, which may impact fauna via ingestion or entanglement. Ingestion or entanglement by marine fauna has the potential to result in serious injury or mortality.

Lost heavy solid wastes descending the water column will settle on the seabed, potentially causing minor disturbance to sediment and sessile benthic organisms. Benthic habitats within the Operational Area are considered to generally comprise of relatively little seabed structure or sessile epibenthos (refer to Section 4.5.2). Any impact associated with this risk would be highly localised and proportional to the size of the solid waste.

Consequently, the potential impacts to marine fauna as a result of windblown waste or waste knocked overboard are unlikely and would be limited to individual occurrences.

Given there will be no planned discharge of solid wastes to the marine environment. Polarcus does not consider there to be any practical alternatives or substitutes to current waste management practices that could further reduce the low environmental risk associated with the generation of solid wastes during the survey. Polarcus is proposing to adopt industry-standard solid waste management methods that meet or exceed the requirements of MARPOL (73/78).

With the implementation of the identified controls, the residual risk associated with the management and disposal of soil wastes has been determined to be low. As such, no further controls are considered warranted.

Further information about the selected control measure, the ALARP evaluation, and the evaluation of Acceptability are provided below.

8.7.3 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Comment / Justification
Inherent Design and Legislative Requirements		
In accordance with MARPOL Annex V and Marine Order 95: ■ Vessels > 100 GRT (or certified for >15 persons on board) will have a Waste Management Plan Vessels >400 GRT (or certified for >15 persons on board) will have a waste management log book.	Yes	Vessels used for the survey that are of 100 GRT or certified to carry more than 15 people will have a Waste Management Plan and vessels over 400 GRT or certified to carry more than 15 persons, will hold a Waste Management Log Book. It is a legislative requirement for vessels to comply with MARPOL and AMSA Marine Orders.
Alternatives/Substitutes Considered		
No practicable alternative or substitutes to the above the controls have been identified.	N/A	N/A
Additional Controls Considered		
Bins available for the segregation of waste in accordance with the vessel Waste Management Plan, and bins are fitted with lids/cargo nets for waste with potential to be wind-blown (e.g. paper, cardboard).	Yes	Bins will be used to segregate wastes on vessels in accordance with the vessel Waste Management Plan and covered bins will be used to prevent windblown waste. The control is considered good practice, is well defined and established standard practice by the offshore petroleum sector. While adoption of the control does not reduce the likelihood or consequence of the risk, implementation is considered to provide overall benefit to the risk.
Solid and hazardous wastes generated during the survey will not be discharged overboard and will be segregated on board the vessel for either incineration (using an IMO-approved incinerator, on seismic vessel only) or appropriately disposed of at a licensed onshore facility in accordance with the Vessel Waste Management Plan.	Yes	Solid wastes will not be disposed of at sea. Wastes will be segregated on board the vessel into bins as stated above or will be incinerated (ash disposed of at licensed onshore facility) and appropriately disposed of at a licensed onshore facility, in accordance with the Vessel Waste Management Plan. Good industry practice, environmental benefit outweighs additional cost.

Control Measure	Control Adopted	Comment / Justification
Solid waste generated during the survey on board the vessel will be minimised where practical, as identified during the pre-survey environmental checklist.	Yes	Solid waste generated on board the vessels will be minimised wherever possible and practical. Good industry practice, environmental benefit outweighs additional cost.
Recycling or re-use of non-hazardous solid waste, where possible.	Yes	Non-hazardous solid waste generated on board the vessel will either be recycled where practical or re-used. Good industry practice, environmental benefit outweighs additional cost.
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)		
No further practicable improvements to the above controls have been identified.	N/A	N/A
ALARP Statement		
The residual risk has been determined to be Low. Polarcus considers the adopted control measures appropriate to manage the risks of an accidental loss of hazardous or non-hazardous solid waste to the marine environment. As no reasonable additional or alternative controls were identified that would further reduce the impacts and risks, without jeopardising the objectives of the survey, the impacts and risks are considered to be ALARP.		

8.7.4 *Demonstration of Acceptable Levels*

Context	Demonstration
Risk Level	The residual risk is assessed to be Low.
Legislative Requirements	The proposed controls meet or exceed the requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) and associated AMSA Marine Orders made under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* for the management of discharges at sea.
Conservation Advice, Recovery Plans, and Other Guidelines	Marine debris causing entanglement and ingestion was recognised in 2003 as a key threatening process for marine vertebrates under the EPBC Act. Pollution generally is also identified as a threat in several conservation advices / recovery plans for EPBC-listed species potentially occurring within the Operational Area. Polarcus has reduced and, where possible, eliminated any adverse impacts of marine debris from the activities of the seismic survey on turtles, cetaceans, sharks and birds, noting the linkages with the *Threat Abatement Plan for the Impact of Marine Debris on Vertebrate Marine Life* (Commonwealth of Australia 2018). (Commonwealth of Australia 2018).
AMP Values, Management Prescriptions and IUCN Reserve Management Principles	Although the Operational Area is not located within any AMPs, management of discharges in accordance with the requirements of MARPOL meets the management prescriptions outlined in the North Marine Parks Network Management Plan.
Principles of Ecologically Sustainable Development	Solid waste discharge will be managed in accordance with the requirements of MARPOL 73/78, to prevent serious or irreversible ecological damage in the marine environment. The residual risks to water quality and marine biota are low given the proposed controls meet the requirements of MARPOL 73/78. Impacts are expected to be negligible with no lasting, serious or irreversible ecological damage. The aspect and potential interactions are well understood and managed according to internationally adopted standards.
Stakeholder Objections, Claims, Concerns or Advice	N/A – Stakeholders have not raised any specific concerns relating to solid waste management and discharge from vessels.
Acceptability Statement	
Based on the criteria above, Polarcus considers the adopted control measures appropriate to manage the risks of an accidental loss of hazardous or non-hazardous solid waste to be of an acceptable level.	

8.8 Introduction of Invasive Marine Species: Biofouling and Ballast Water

8.8.1 *Assessment Summary*

Source of Impact / Risk

Introduction of invasive marine species (IMS) to the Operational Area has the potential to occur through:

- Biofouling of vessel hull and/or in-water survey equipment; and
- Exchange of ballast waters.

If successfully established, IMS may result in:

- Competition, predation or displacement of native species;
- Alteration of natural ecological processes; and/or
- Introduction of pathogens with the potential to impact on ecological health.

Receptors

- Marine ecological communities (alterations to local ecosystems).

Adopted Control Measures	EPS #
Vessel hull and niches confirmed to be free of IMS prior to mobilisation into Australian waters.	12.1
Seismic vessel and support vessels will have all necessary Department of Agriculture and Water Resources biosecurity approvals prior to mobilisation, including Pre-Arrival Report clearance for vessels entering Australian territorial waters.	12.2
All vessels will comply with the requirements of the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Commonwealth of Australia, 2009) of which key requirements are: ■ Maintenance of biofouling electronic records outlining marine fouling management actions. ■ Completion of an IMS risk assessment prior to vessel entry into Australian waters which concludes a low risk of IMS presence. ■ In-water equipment free of marine fouling prior to the commencement of the survey.	12.3
All vessels will maintain a current anti-fouling coating that complies with the requirements of Annex 1 of the International Convention on the Control of Harmful Anti-Fouling Systems on Ships and the requirements of the *Protection of the Sea (Harmful Antifouling Systems) Act 2006*.	12.4
Streamers and associated equipment will be inspected, maintained and cleaned during retrieval (e.g. due to transit, crew change, inclement weather) to reduce biofouling.	12.5
Exchange of ballast water will only occur >12 nm from land and in water depths of >50 m in accordance with the Australian Ballast Water Management Requirements (Department of Agriculture and Water Resources 2017).	12.6
BWM-T class (IMO approved) ballast water management system on board the seismic vessel treats water to reduce the risk of any living organisms being present prior to discharge.	12.7
Seismic vessel and support vessels will have a Ballast Water Management Plan and a ballast water record system/book, consistent with the Australian Ballast Water Management Requirements (Department of Agriculture and Water Resources 2017).	12.8

Seismic vessel and support vessels will have a Ballast Water Management Plan and a ballast water record system/book, consistent with the Australian Ballast Water Management Requirements (Department of Agriculture and Water Resources 2017).	12.9

Details of Residual Impacts and Risks

IMS once introduced are irreversible and can have significant impacts on the marine ecosystem as they are likely to have little or no natural competition or predation, resulting in IMS outcompeting native species for food or space, preying on native species or changing the nature of the environment. This will result in an alteration of natural ecological processes and the potential to introduce pathogens.

Vessels operating in offshore environments are less likely to accumulate or translocate marine pests than vessels that spend prolonged periods in shallow port or coastal waters (Commonwealth of Australia 2009; Wells et al. 2009). Therefore, highly disturbed, shallow water environments such as ports and marinas are more susceptible to colonisation than open-water environments, such as the Operational Area, where the rate of dilution and the degree of dispersal are high (Williamson and Fitter 1996; Paulay et al. 2002).

With the proposed management controls in place, discernible impacts to ecological marine communities are not expected in the open water location of the Petrelex 3D MSS. The consequence to marine biota is ranked as extensive given the potential nature and scale of the impact, although the likelihood is rare.

The likelihood of IMS establishment in the Operational Area is further reduced with the controls in place, but remains Rare (B). The residual impacts and risks have therefore been assessed as low. Further detail is provided in the evaluation of impacts and risks below.

Risk Ranking	Consequence	Likelihood	Risk
Inherent Risk	Extensive (3)	Rare (B)	**Low**
Residual Risk	Extensive (3)	Rare (B)	**Low**

8.8.2 *Detailed Evaluation of Impacts and Risks*

IMS are non-indigenous marine plants or animals that have been introduced into a region beyond their natural range and have the ability to survive, reproduce and establish invasive populations. The survey and support vessels operating in the Operational Area have the potential to introduce IMS via the following mechanisms:

- Discharge of ballast water containing IMS; and
- Translocation of IMS through biofouling of the vessel hull, internal seawater systems (e.g. sea chests, bilges) or immersible equipment (e.g. towed seismic source and streamers).

The most common transfer mechanisms for IMS are via uptake and discharge of ballast water or due to marine fouling on the hulls and internal niches (e.g. seawater intakes) on vessels. However, not all species that are introduced to an area outside of their natural range survive to become an IMS, with the majority of introduced species failing to establish (Williamson and Fitter 1996). The successful establishment of an IMS is dependent on a number of factors, including:

- presence of IMS at 'source', such as a port, harbour or within coastal waters;
- activities undertaken by the vessel favouring successful establishment of the IMS; and
- environmental conditions during transit and at destination, such as water temperatures, salinities and habitats, favouring IMS's survival, establishment, growth and reproduction.

Once introduced, IMS may be irreversible and can have significant impacts on the marine ecosystem as they are likely to have little or no natural competition or predation, resulting in IMS outcompeting native species for food or space, preying on native species or changing the nature of the environment. This will result in an alteration of natural ecological processes and the potential to introduce pathogens.

Section 4.5, provides a detailed description of the biological communities in the Operational Area, the majority of which are located in waters deeper than 65 m, therefore providing unfavourable environmental conditions for IMS to become established (survival, settlement and reproduction).

Vessels operating in offshore environments are less likely to accumulate or translocate marine pests than vessels that spend prolonged periods in shallow port or coastal waters (Commonwealth of Australia 2009; Wells et al. 2009). Highly disturbed, shallow water environments such as ports and marinas are more susceptible to colonisation than open-water environments, such as the Operational Area, where the rate of dilution and the degree of dispersal are high (Williamson and Fitter 1996; Paulay et al. 2002).

Prior to entering Australian waters, all vessels are required to obtain Department of Agriculture and Water Resources (DAWR) biosecurity clearance (via submission of a Pre-Arrival Report at least 12 hours prior to arrival, to confirm that the vessel is meeting requirements of the *Biosecurity Act 2015* for entry into Australian waters. Survey mobilisation will only occur after clearance is received and a valid anti-fouling certificate is confirmed. Valid hull anti-fouling certificates will meet the requirements of Annex 1 of the International Convention on the Control of Harmful Anti-Fouling Systems on Ships and the requirements of the *Protection of the Sea (Harmful Antifouling Systems) Act 2006*.

Submersible equipment used as part of survey activities may be retrieved out of the water from time to time, for maintenance purposes and during transit. The time this equipment spends outside of the water will facilitate the desiccation and death of any biofouling present. Seismic streamers are also routinely cleaned to prevent excessive biofouling that could lead to interference of the received signal, and consequently, the quality of the seismic data. Inspection, cleaning and maintenance of survey equipment during retrieval (e.g. due to transit, crew change, inclement weather) will be implemented as a management measure throughout the survey.

Before arriving in Australian waters, survey and support vessels will also be required to adhere to the Australian Ballast Water Management requirements (Department of Agriculture and Water Resources 2017), including deep water exchange of ballast water in the open ocean. Once in the Operational Area vessels are not anticipated to discharge ballast water or will comply with the ballast water management requirements which includes no exchange of ballast water within 12 nm of the Australian coastal baseline or in water depths of less than 50 m. In addition, the Polarcus vessels will be fitted with BWM-T class (IMO approved) advanced ultraviolet (UV) ballast water treatment systems.

Given the potential for changes to ecological communities, the consequence of introducing IMS is considered to be Extensive (3). However, based on the controls listed above, the likelihood of introducing IMS from biofouling of vessel hulls and equipment or from ballast water exchange is considered to be Rare (B).

Further information about the selected control measure, the ALARP evaluation, and the evaluation of Acceptability are provided below.

8.8.3 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Comment / Justification
Inherent Design and Legislative Requirements		
Seismic vessel and support vessels will have all necessary Department of Agriculture and Water Resources biosecurity approvals prior to mobilisation, including pre-arrival report (for vessels entering Australian territorial waters.	Yes	Vessels are required to submit a pre-arrival report prior to entering Australian territorial waters, and obtain DWAR biosecurity clearance. Clearance confirms that the vessel meets the requirements of the *Biosecurity Act 2015* for entry into Australian waters, including review of a ballast water report by a biosecurity officer. Mobilisation of the vessels to the Operational Area will only occur after clearance is confirmed. Clearance confirms that the vessel does not present a high risk to the marine environment in Australian waters and therefore reduces the likelihood of IMS being translocated to the Operational Area. The Ballast Water Report provided during reporting identifies if the vessel has or intends to discharge internationally sourced ballast water, and management will be conducted as determined by DWAR.
All vessels will maintain a current anti-fouling coating that complies with the requirements of Annex 1 of the International Convention on the Control of Harmful Anti-Fouling Systems on Ships and the requirements of the *Protection of the Sea (Harmful Antifouling Systems) Act 2006*.	Yes	Vessels will have an anti-fouling system that is compliant with the International Convention on the Control of Harmful Anti-fouling systems on ships 2001, the requirements of the *Protection of the Sea (Harmful Antifouling Systems) Act 2006* and Marine Order 98 (Marine pollution - anti-fouling systems) 2013. An anti-fouling coating provides a level of protection to reduce the establishment of marine organisms on hulls and in niches, and therefore reduces the likelihood of IMS being introduced through biofouling.
BWM-T class (IMO approved) ballast water management system on board the seismic vessel treats water to reduce the risk of any living organisms being present prior to discharge	Yes	Regulation D-2 of the Ballast Water Management Convention as implemented through the Australian Ballast Water Management Requirements (DAWR 2017) requires vessels to have an IMO approved Ballast Water Management System or use one of the other approved methods of management. The Polarcus seismic vessels have the BWM-T class notation for advanced UV ballast water treatment systems, which meet the required IMO performance standard in Regulation D-2 of the Ballast Water Management Convention. Ballast water will therefore be treated with an ultraviolet ballast water system to reduce the risk of living organisms being present prior to discharge.

Control Measure	Control Adopted	Comment / Justification
Exchange of ballast water will occur > 12 nm from land and in water depths of > 50 m in accordance with the Australian Ballast Water Management Requirements (Department of Agriculture and Water Resources 2017).	Yes	Regulation D-2 of the Ballast Water Management Convention as implemented through the Australian Ballast Water Management Requirements (Department of Agriculture and Water Resources 2017) requires vessels to have an IMO approved Ballast Water Management System or use one of the other approved methods of management, which includes the requirement for ballast water exchange to occur areas at least 12 nm from the nearest land and in water at least 50 m deep. Polarcus seismic vessels have the BWM-T class notation for an IMO approved Ballast Water Management System. The Polarcus seismic vessel and the support vessels will also not exchange ballast water within 12 nm from the nearest land or in water <50 m deep during the Petrelex 3D MSS.
Seismic vessel and support vessels will have a Ballast Water Management Plan and a ballast water record system/book, consistent with the Australian Ballast Water Management Requirements (Department of Agriculture and Water Resources 2017).	Yes	In accordance with the Australian Ballast Water Management Requirements (DAWR 2017), vessels will have Ballast Water Management Plans (BWMP) and maintain complete and accurate records of ballast water exchange.
Alternatives/Substitutes Considered		
No exchange of ballast water	No	This control would potentially reduce the risk of introduction of marine species via ballast water exchange, however could potentially have a significant impact on the vessels stability. It is impractical to have no exchange of ballast water, introducing additional health and safety risks to personnel.
Solid Ballast	No	Given the design of the vessels to use ballast water this was not considered to be a practicable alternative. If used, solid ballast also would add to the waste burden for the survey. Additionally, under normal operational conditions there is not expected to be any requirement for ballast water discharge or exchange within the Operational Area.
Additional Controls Considered		
Vessel hull and niches confirmed to be free of IMS prior to mobilisation into Australian waters.	Yes	Vessels entering Australia waters will need to confirm free of IMS and will need to conduct an IMS risk assessment. Vessel will be required to meet these requirements for entry into Australian waters.

Control Measure	Control Adopted	Comment / Justification
All vessels will comply with the following key requirements of the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Commonwealth of Australia, 2009) of which key requirements are: ▪ Maintenance of a biofouling electronic records outlining marine fouling management actions ▪ Completion of an IMS risk assessment prior to vessel entry into Australian waters which concludes a low risk of IMS presence ▪ In-water equipment free of marine fouling prior to the commencement of the survey	Yes	Vessels will comply with the key requirements of National Biofouling Management Guidance for the Petroleum Production and Exploration Industry, including risk assessment.
Streamers and associated equipment will be inspected, maintained and cleaned during retrieval (e.g. due to transit, crew change, inclement weather) to reduce biofouling.	Yes	Streamers will be inspected, maintained and cleaned during retrieval when there is a crew change or inclement weather in an effort to reduce biofouling. It is not practical to conduct routine inspections of submersible equipment.
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)		
Regular scheduled cleaning of streamers	No	This control would add to the cost and timeframe of the survey, due to requirements for retrieval of the survey equipment for inspection and cleaning on board the vessel. At this time, the vessel cannot acquire data, making this measure impractical. Additionally, this measure would only remove fouling accumulated in the Operational Area that is unlikely to present a risk of IMS (noting that the equipment would have been confirmed free of IMS prior to use in the Operational Area).
ALARP Statement		
The residual risk has been determined to be Low. Polarcus considers the adopted control measures appropriate to manage the risks of introducing IMS to the marine environment of the Operational Area. As no reasonable additional or alternative controls were identified that would further reduce the impacts and risks, without jeopardising the objectives of the survey, the impacts and risks are considered to be ALARP.		

8.8.4 *Demonstration of Acceptable Levels*

Context	Demonstration
Risk Level	The residual risk is assessed to be Low.
Legislative Requirements	The proposed controls meet the requirements of the *Biosecurity Act 2015* and the Australian Ballast Water Management Requirements.
Conservation Advice, Recovery Plans, and Other Guidelines	IMS is identified as a key threat in several conservation management plans, with actions focusing on the prevention of their introduction. The proposed control measures are consistent with these actions.
AMP Values, Management Prescriptions and IUCN Reserve Management Principles	The Operational Area is not located within any AMPs. However, the management of the introduction of invasive marine species is in accordance with the requirements of MARPOL, which meets the management prescriptions for AMPs under the North Marine Parks Network Management Plan.
Principles of Ecological Sustainable Development	Prevention of IMS within the Operational Area will ensure there is no threat of series or irreversible environmental damage or significant impact to biological diversity and ecology integrity as a result of the Petrelex 3D MSS.
Stakeholder Objections, Claims, Concerns or Advice	N/A – Stakeholders have not raised any specific concerns relating to the introduction of invasive marine species.
Acceptability Statement	
Based on the criteria above, Polarcus considers the adopted control measures appropriate to manage the risk of introducing invasive marine species to be of an acceptable level.	

9. SUMMARY OF EPO, EPS AND MC

This section presents the environmental performance outcomes, performance standards and measurement criteria for each of the identified environmental impacts and risks.

Table 9-1 provides a summary of the EPO, EPS and MC relevant to the Petrelex 3D MSS.

Table 9-1 Environmental Commitments Register

EPO #	EPO	EPS #	EPS	MC	Responsibility
Noise Emissions: Seismic Source					
1	Undertake seismic acquisition in a manner that prevents injury and population/stock level impacts from seismic sound emissions.	1.1	Minimum source size selected (2,495 cui) to acquire survey data and meet the geophysical objectives of the survey.	Record of pre-survey environmental checklist (Section 10.2.6.6) confirms seismic source volume to be used is 2,495 cui or less. Audit during activity to confirm the operating array size is 2,495 cui.	Polarcus Vessel Manager
		1.2	Part A of EPBC Policy Statement 2.1 is applied in full to mitigate potential impacts to whales, including: ■ Observation zone: 3+ km horizontal radius from the seismic source. ■ Low power zone: 2 km horizontal radius from the seismic source. ■ Shut-down zone: 500 m horizontal radius from the seismic source. ■ Pre-Start-up Visual Observations ■ Soft-start Procedures ■ Start-up Delay Procedures ■ Operational Shut-down and Low-power Procedures ■ Night-time and Low Visibility Procedures ■ Sighting Reports	MFO report confirms that precaution zones and procedures are implemented in accordance with Part A of EPBC Policy Statement 2.1.	Vessel Master MFO
		1.3	Two MFOs are available on board the seismic vessel to manage shift duties during daylight hours during the survey.	Curriculum Vitae of the MFOs engaged for the Petrelex 3D MSS confirms: ■ UK Joint Nature Conservation Committee (JNCC) accreditation (or equivalent); and	Polarcus Vessel Manager

EPO #	EPO	EPS #	EPS	MC	Responsibility
				■ at least one year (minimum four surveys) previous MFO experience. MFO report confirms two MFOs were on board the seismic vessel to manage shift duties for daylight visual observations during the survey.	
		1.4	A 500 m shut-down zone from the operating source, as per the shut-down zone for whales in EPBC Act Policy Statement 2.1, is applied to turtles.	MFO report confirms that the seismic source is shut down if a turtle is sighted within the 500 m shut down zone implemented under EPBC Act Policy Statement 2.1.	Vessel Master MFO
		1.5	A 500 m shut-down zone from the operating source, as per the shut-down zone for whales in EPBC Act Policy Statement 2.1, is applied to whale sharks.	MFO report confirms that the seismic source is shut down if a whale shark is sighted within the 500 m shut down zone implemented under EPBC Act Policy Statement 2.1.	Vessel Master MFO
		1.6	Crew, survey personnel and MFOs are briefed in the marine fauna observation, separation distance estimation, controls and reporting requirements relevant to this EP.	Induction slide pack includes briefing on Part A of EPBC Policy Statement 2.1 and additional controls. Training, induction and competency matrix to confirm that the crew, survey personnel and MFO's are briefed in whale observation, separation distance estimation and reporting.	Polarcus Vessel Manager
Noise Emissions: Cumulative Seismic Sound					
2	Prevent multiple seismic surveys from occurring concurrently in the same location.	2.1	Polarcus have engaged with proponents identified as having potential concurrent seismic activities within 40 km of the Petrelex 3D MSS.	Consultation log demonstrates that Polarcus has engaged with proponents identified as having potential concurrent seismic activities within 40km of the Petrelex 3D MSS. SIMOPs Plan for the survey documents requirement to maintain at least 40 km	Vessel Party Manager

EPO #	EPO	EPS #	EPS	MC	Responsibility
				separation distance between operating survey vessels.	
		2.2	A minimum separation distance of 40 km is maintained between the Petrelex 3D MSS seismic sources and other operating seismic sources.	SIMOPs Plan for the survey documents requirement to maintain at least 40 km separation distance between operating survey vessels. Survey crew induction materials include separation distance requirement and induction records demonstrate relevant survey crew have attended this induction. Survey log shows no operation of the seismic source has occurred within 40 km of other operating seismic vessels. In the case of an audit the following can also be provided: ■ Navigation data files (P190 files) demonstrate location and status (active or non-active) of the source; ■ Joined Survey Outputs provide the relative positions of two Polarcus vessels (or if the other contractor will agree to supply this information); and ■ MultiSeis (online tracking system) demonstrates the relative locations of the survey vessels.	Vessel Part Manager
Noise Emissions: Vessels and Helicopters					
3	Undertake vessel and helicopter activities in accordance with Part 8	3.1	Vessel activities are undertaken in accordance with EPBC Regulations 2000 – Part 8 Division 8.1, including:	Survey crew induction materials include vessel/fauna separation distance and speed requirements and requirement to report sightings.	Vessel Master MFO

EPO #	EPO	EPS #	EPS	MC	Responsibility
	of the EPBC Regulations 2000.		■ taking action to avoid approaching or drifting closer than 50 m to a dolphin or 100 m to a whale; and ■ not exceeding a speed of 6 knots within the caution zone of a cetacean (300 m).	Induction records confirm that survey induction attended by all crew. Sightings and details of fauna interactions documented in daily operational logs. Daily operational log and MFO reports confirm that interactions between the seismic/support vessels and cetaceans were managed in accordance with Part 8 of the EPBC Regulations.	
		3.2	In addition to the requirements of the EPBC Regulations 2000 - Part 8 Division 8.1 for cetaceans, vessels, when safe to do so, also: ■ take action to avoid approaching or drifting closer than 50 m to a turtle; and ■ not exceeding a speed of 6 knots within 300 m of a turtle.	Survey crew induction materials include vessel/fauna separation distance and speed requirements and requirement to report sightings. Induction records confirm that survey induction attended by all crew. Sightings and details of fauna interactions documented in daily operational logs. MFO reports confirm that interactions between the survey vessel and/or equipment and turtles were managed in accordance with Part 8 of the EPBC Regulations	Vessel Master MFO
		3.3	Seismic vessel and support vessels (taking into account the limited manoeuvrability of the former) also adopt measures consistent with the DPaW Whale Shark Management Program (2013), including: ■ taking action to avoid approaching or drifting closer than 30 m of a whale shark; and ■ not exceeding 8 knots within 250 m of a whale shark.	Survey crew induction materials include vessel/fauna separation distance and speed requirements and requirement to report sightings. Induction records confirm that survey induction attended by all crew. Sightings and details of fauna interactions documented in daily operational logs. MFO reports confirm that interactions between the survey vessel and/or	Vessel Master MFO

EPO #	EPO	EPS #	EPS	MC	Responsibility
				equipment and whale sharks were managed in accordance with DPaW Whale Shark Management Programme (2013).	
		3.4	Helicopter movements are undertaken in accordance with EPBC Regulations 2000 – Part 8 Division 8.1, including: ■ helicopters not to operate at a height lower than 1,650 feet within a horizontal radius of 500 metres of a cetacean; and ■ helicopters not to approach a cetacean from head on.	Records show helicopter transfers were compliant with Part 8 of the EPBC Regulations.	Polarcus Vessel Manager Helicopter Pilot
Physical Presence: Interference with Other Marine Users					
4	No significant disruption or interference with other marine users in the Operational Area during the survey.	4.1	Notice to Mariners issued prior to commencement of survey activities.	Consultation records confirms that AHS was notified three week prior to survey commencement and within two weeks of survey cessation.	Polarcus Vessel Manager
		4.2	Daily reporting issued to AMSA JRCC for promulgation of radio-navigation warnings	Consultation records confirm that AMSA JRCC received notification of survey commencement at least 24-48 hours prior to survey commencement.	Polarcus Vessel Manager
		4.3	Notification is provided to fisheries stakeholders, four weeks prior to commencement, indicating location and expected timing. Notification is also provided to fisheries stakeholders within two weeks of cessation of activities.	Consultation records confirm that fisheries stakeholders were notified four weeks prior to survey commencement and within two weeks of cessation of activities.	Polarcus Vessel Manager
		4.4	Notification to the Department of Defence is issued five weeks prior to survey commencement and following cessation of activities.	Consultation records confirm that the Department of Defence was notified five weeks prior to survey commencement and following cessation of activities.	Polarcus Vessel Manager

EPO #	EPO	EPS #	EPS	MC	Responsibility
		4.5	Daily look-ahead reports detailing the upcoming 48 hours survey events are provided via email to stakeholders who register for the service.	Consultation records confirm that stakeholder wo registered for the service received daily look-ahead notifications.	Polarcus Vessel Manager
		4.6	Vessels are compliant with requirements of the International Regulations for Preventing Collisions as Sea 1972 (COLREGS) and Chapter 5 of Safety of Life at Sea Convention (SOLAS) as implemented in Commonwealth waters through the Navigation Act 2012 and associated Marine Orders Parts 21, 27, 30, 58 - safety and emergency arrangements, prevention of collisions, safe management of vessels, including: ▪ Appropriate lighting, navigation and communication to inform other users. ▪ Use of radar and 24/7 watch.	Vessel crew training and competency records demonstrate that all relevant marine crew are competent to STCW95 / Elements of Shipboard Safety Standards. No records of survey or support vessels failing to comply with appropriate navigation, lighting and communication requirements under the Navigation Act 2012 or its associated Marine Orders.	Polarcus Vessel Manager
		4.7	At least one support vessel (supply or chase vessel) accompanies the seismic vessel when the seismic vessel is in operation and when safe to do so (e.g. outside of inclement weather periods). The support vessel conducts advanced scouting to ensure that fishing vessels or other activities in the area are provided with advance notice to move away from the path of the seismic vessel.	Survey logs confirm a support vessel is present within 10 nautical miles of the seismic vessel when the seismic vessel is in operation. MultiSeis (online tracking system) demonstrates the relative location of the survey and supply vessel.	Polarcus Vessel Manager
		4.8	Streamers are marked with tail buoys.	Record of pre-survey environmental checklist (Section 10.2.6.6) confirms tail buoys are available for each streamer. Record of compliance audit during the survey (Section 10.2.6.6) confirms tail buoys are fitted to each streamer.	Polarcus Vessel Manager

EPO #	EPO	EPS #	EPS	MC	Responsibility
		4.9	No seismic acquisition occurs during scheduled military exercises within the NAXA	Daily operations log confirms that no seismic acquisition occurred during any scheduled military exercises within the NAXA (unless agreed with Defence). Navigation data files (P190 files) demonstrate location and status of vessels.	Polarcus Vessel Manager Vessel Master
Discharge: Liquid Waste Management					
5	Liquid waste discharges to meet or exceed the requirements of MARPOL Annex I, IV, V and Marine Orders 91, 95, 96.	5.1	Sewage is managed in accordance with MARPOL Annex IV and AMSA Marine Order 96, using an IMO-approved sewage treatment plant, a sewage comminuting and disinfecting system or a sewage holding tank as applicable depending on vessel gross tonnage or people capacity (as evidenced by a current International Sewage Pollution Prevention (ISPP) Certificate).	Records show that vessels used for the survey that are engaged in international voyages of 400 gross tonnes or certified to carry more than 15 persons, have an appropriate sewage treatment plant, sewage comminuting and disinfecting system or sewage holding tank on board (with related IMO certificate). Record of pre-survey environmental checklist (Section 10.2.6.6) confirms an IMO-approved sewage treatment plant, sewage comminuting and disinfecting system or sewage holding tank on board (as required per above) is operational, where applicable depending on vessel class. Evidence of a current ISPP certificate.	Vessel Master
		5.2	In accordance with MARPOL Annex IV and AMSA Marine Order 96: ■ Sewage is only discharged via an IMO-approved sewage treatment plant; or ■ Comminuted/disinfected sewage via an IMO-approved system is only discharged	Vessel logs show that all sewage discharges during the survey have been treated by an appropriate on-board sewage treatment system such as a sewage treatment plant or sewage comminuting and disinfecting system prior to discharge, where applicable depending on vessel class.	Vessel Master

EPO #	EPO	EPS #	EPS	MC	Responsibility
			when ⩾3 nm from land and when the vessel is moving at ⩾4 knots; or ■ Sewage that has not been comminuted/ disinfected via an IMO-approved system is only discharged when ⩾12 nm from land and when the vessel is moving at ⩾4 knots.	MultiSeis (online tracking system) demonstrates the time and location of vessel during the activity.	
		5.3	Vessels have facilities on board of a standard capable of macerating or grinding putrescible wastes and screening to less than 25 mm in diameter, prior to discharge while the vessel is moving and ⩾3 nm from land.	Record of pre-survey environmental checklist (Section 10.2.6.6) confirms a macerator is available on board each vessel and is operational. Vessel logs confirm details of discharges (treatment, location) are achieved. MultiSeis (online tracking system) demonstrates the time and location of vessel during the activity.	Vessel Master
		5.4	Vessels > 400 GRT have an oil discharge monitoring and control system and oil filtering equipment on board, hold a current IOPP Certificate and maintain an oil usage management log book, in accordance with MARPOL 73/78.	Records of pre-survey environmental checklist (Section 10.2.6.6) confirm that vessel holds a current IOPP Certificate and an oil usage management log book, and oil discharge monitoring and control system and oil filtering equipment are on board and functioning.	Vessel Master
		5.5	Treated bilge water is discharged only when the vessel is moving and the oil discharge monitoring and control system and oil filtering equipment is operating. If oil discharge monitoring and control system and oil filtering equipment are unavailable, bilge water mixtures is retained on board for on shore disposal.	Vessel logs confirm all discharges of bilge water during the survey occurred while the vessel was moving and via oil discharge monitoring and control system and oil filtering equipment (or otherwise retained on board). MultiSeis (online tracking system) demonstrates the time and location of vessel during the activity.	Vessel Part Manager Vessel Master

EPO #	EPO	EPS #	EPS	MC	Responsibility
		5.6	Oil discharge monitoring and control systems on board the vessels is maintained and calibrated to ensure monitoring readings are accurate.	Records of pre-survey environmental checklist (Section 10.2.6.6) confirm that oil-in-water separator has undergone regular maintenance. Discharge records and oil usage management electronic records confirm discharges meet the oil concentration of <15 ppm prior to discharge.	Vessel Master
Atmospheric Emissions: Vessels and Equipment					
6	Atmospheric emissions to meet or exceed the requirements of MARPOL Annex VI and AMSA Marine Order 97.	6.1	In accordance with MARPOL 73/78 Annex VI (Prevention of Air Pollution) and Marine Order 97: ■ Vessels have a valid IAPP Certificate. ■ Incinerator is certified to meet prescribed emissions standards. ■ Diesel engines >130 kW are certified to meet prescribed emission standards.	Records of the pre-survey environmental checklist (Section 10.2.6.6) confirm that current IAPP certificate is sighted on board vessel.	Vessel Party Manager
		6.2	Vessels use MGO grade fuel during the survey, which will have low sulphur content.	Records / oil log book confirm MGO grade fuel is used and fuel data sheet confirms low sulphur content.	Vessel Master
		6.3	Vessel engines and incinerators are maintained according to manufacturer's specification.	Records confirm that the incinerator's MARPOL 73/78 certification is current and sighted, and maintained as per maintenance records.	Vessel Master
Artificial Light Emissions: Vessels					
7	Lighting reduced to levels required for navigational and safety purposes, so as to not disrupt behaviour	7.1	Lighting reduced to levels required for navigational and safety purposes (where practicable), so as to not cause significant disruption to the behavioural patterns of marine fauna. Vessels are compliant with the requirements of the International Regulations for	No records of the seismic or support vessels failing to comply with *Navigation Act 2012* or its associated Marine Orders. Survey crew induction materials include a summary of the requirements to minimise	Vessel Master Vessel Party Manager

EPO #	EPO	EPS #	EPS	MC	Responsibility
	patterns of marine fauna.		Preventing Collisions as Sea 1972 (COLREGS) and Chapter 5 of Safety of Life at Sea Convention (SOLAS) as implemented in Commonwealth waters through the Navigation Act 2012 and associated Marine Orders 21, 27, 30, 58 – safety and emergency arrangements, prevention of collisions, safe management of vessels, including: ■ Appropriate lighting, navigation and communication to inform other users. ■ Use of radar and 24/7 watch.	artificial lighting. Survey induction attended by all crew as demonstrated by induction records. Record of the compliance audit during the survey (Section 10.2.6.6) confirms that light reduction measures have been adopted, where appropriate.	
		7.2	Identified opportunities to further reduce lighting during pre-survey environmental checklist.	Records of the pre-survey environmental checklist (Section 10.2.6.6) confirm that relevant personnel responsible for the vessel (e.g. Vessel Master / Senior Engineer) have been interviewed to identify any opportunities for further light reduction. Where further light reductions are identified, the record of the compliance audit during the survey (Section 10.2.6.6) confirms that these measures have been adopted, where appropriate.	Vessel Party Manager
Hydrocarbon and Chemical Spills: Vessel Tank Failure, Vessel Refuelling Failure and Single Point Failure					
8	No hydrocarbon or chemical spills to the marine environment. Reduce impacts to the marine environment through appropriate spill preparedness and response.	8.1	Seismic vessel utilised MGO, which is stored in multiple fuel tanks on board. Fuel tanks can be isolated and contents transferred between them.	Bunkering records confirm MGO-grade fuel is used on the vessel for the survey. Record of pre-survey environmental checklist (Section 10.2.6.6) confirms tanks can be isolated and contents transferred. Record of compliance audit during the survey (Section 10.2.6.6) confirms tanks can be isolated and contents transferred.	Vessel Master

EPO #	EPO	EPS #	EPS	MC	Responsibility
		8.2	Seismic vessel has a double hull design making a rupture highly unlikely, even in a collision situation.	Vessel specifications confirm double hull design.	Polarcus Vessel Manager
		8.3	Radar on board the seismic vessel is fitted with a collision alarm, and the seismic vessel has DNVGL NAUT-AW class notation for enhanced nautical safety, incorporating a grounding avoidance system.	Vessel audit records confirm that radar and collision alarms are fitted, operational and that relevant crew are experienced in use of the radar.	Vessel Master
		8.4	Seismic vessel and support vessels maintained appropriate lighting, shapes, navigation and communication at all times to inform other users of the position and intentions of the vessel, in compliance with the Navigation Act 2012 and associated Marine Orders.	Vessel crew training and competency records demonstrate that all relevant marine crew are competent to STCW95 / Elements of Shipboard Safety Standards. No records of the survey or support vessels failing to comply with appropriate navigation, lighting and communication requirements under the Navigation Act 2012 or its associated Marine Orders.	Vessel Master
		8.5	A 24 hour visual, radio and radar watch was maintained for vessels in the vicinity of the Operational Area.	Vessel crew training and competency records demonstrate that all relevant marine crew are competent to STCW95 / Elements of Shipboard Safety Standards. Vessel records show communications with, and actions taken when other third party vessels are in the vicinity of the Operational Area.	Vessel Master
		8.6	All vessels over 400 GRT (MARPOL 73/78 Annex I) hold approved and tested SOPEPs and crew are trained in its implementation.	Records confirm that each vessel over 400 GRT holds an approved SOPEP and the SOPEP has been tested in the last 12 months. Training and competency records confirm that relevant crew have been trained on	Vessel Master Vessel Party Manager

EPO #	EPO	EPS #	EPS	MC	Responsibility
				implementation of the SOPEP prior to the survey commencing.	
		8.7	Notice to Mariners issued prior to commencement of survey activities.	Consultation records confirms that AHS has been notified of survey commencement at least three weeks prior to survey commencement and within two weeks of survey demobilisation.	Polarcus Vessel Manager Vessel Master
		8.8	Daily reporting to AMSA JRCC for promulgation of radio-navigation warnings.	Consultation records confirm that AMSA JRCC have received notification of survey commencement at least 24-48 hours prior to survey commencement. Vessel communication log/daily operational log confirm AMSA JRCC provided with daily report of vessel position and activities.	Polarcus Vessel Manager Vessel Master
		8.9	Notifications provided to fisheries stakeholders, four weeks prior to commencement, indicating location and expected timing. Notification was also provided to fisheries stakeholders within two weeks of cessation of activities.	Consultation records confirm that fisheries stakeholders were notified four weeks prior to survey commencement and within two weeks of cessation of activities.	Polarcus Vessel Manager
		8.10	In the event of a spill to the marine environment, the OPEP presented in Section 10.3 is followed.	Survey induction materials include an overview of the OPEP providing roles and responsibilities in the event of a hydrocarbon spill. Induction records confirm that survey induction attended by all crew. Records confirm that the provisions in the OPEP have been tested prior to the survey commencing. Record of compliance audit during the survey (Section 10.2.6.6) confirms a copy of the OPEP is held on board the vessel.	Vessel Party Manager

EPO #	EPO	EPS #	EPS	MC	Responsibility
		8.11	Bunkering contractor selection was made in accordance with the contractor selection procedure to ensure the contractor will use dry-break couplings.	Records demonstrate bunkering contractor selection undertaken in accordance with contractor selection procedure.	Vessel Master Vessel Technicians and Crew
		8.12	Refuelling was undertaken in accordance with Polarcus Bunkering Procedure including: ■ Refuelling will only be undertaken during daylight hours and in suitable weather conditions. ■ Completion of the Permit to Work Refuelling At Sea Checklist and Bunkering Checklist ensuring that anti-pollution equipment is ready and scuppers plugged before bunkering commences. ■ Spill kits are available on board the seismic vessel and crew are trained in their use.	Permit to Work Refuelling At Sea Checklist and Bunkering Checklist confirm refuelling undertaken in accordance with Polarcus Bunkering Procedure including: ■ Refuelling will only be undertaken during daylight hours and in suitable weather conditions; ■ Completion of the Permit to Work Refuelling At Sea Checklist and Bunkering Checklist ensuring that anti-pollution equipment is ready and scuppers plugged before bunkering commences; and ■ Spill kits are available on board the seismic vessel and crew are trained in their use.	Vessel Master
		8.13	Hydraulic fluids and chemicals are selected in accordance with the Polarcus Chemical Control Procedure and will be selected to have the lowest environmental toxicity possible whilst meeting operational performance requirements.	Records of pre-survey environmental checklist and compliance audit during the survey (Section 10.2.6.6) confirm that only chemicals approved via the Polarcus Chemical Control Procedure are carried on the vessel.	Polarcus Vessel Manager Vessel Party Manager
		8.14	Storage, handling and use of hazardous substances (including hydraulic fluids and chemicals) are in accordance with the product's Safety Data Sheet (SDS)	Survey induction records included the requirement to follow SDS when storing, handling and using hazardous substances (including hydraulic fluids and chemicals). Record of audit during the survey confirms that SDS for hydraulic fluids are	Vessel Master Vessel Technicians and Crew

EPO #	EPO	EPS #	EPS	MC	Responsibility
				available on board and storage, handling and/or use is in accordance with the SDS.	
		8.15	Spill kits and scupper plugs are available onboard the seismic vessel and crew are trained in their use.	Record of pre-survey environmental checklist (Section 10.2.6.6) confirms spill kits and scupper plugs are available on board. Training and competency records confirm that relevant crew have been trained on the use of spill kits and scupper plugs.	Vessel Master Vessel Party Manager
		8.16	Spills are reported through the Polarcus Incident Reporting Procedure and waste materials managed in accordance with the vessel Waste/Garbage Management Plan	If a spill has occurred during the survey, Polarcus Incident Reporting records demonstrate that immediate action was taken to clean up the spill and waste was managed in accordance with the vessel Waste/Garbage Management Plan.	Vessel Master
Physical Presence: Collision / Entanglement with Marine Fauna					
9	No injury or death of large marine fauna due to collision or entanglement with vessels or seismic equipment.	9.1	Seismic vessel and support vessels (taking into account the limited manoeuvrability of the former) comply with relevant requirements of EPBC Regulations 2000 - Part 8 Division 8.1, including: ■ taking action to avoid approaching or drifting closer than 50 m to a dolphin or 100 m to a whale; and ■ not exceeding a speed of 6 knots within the caution zone of a cetacean (300 m).	Survey crew induction materials include vessel/fauna separation distance and speed requirements and requirement to report sightings. Induction records confirm that survey induction attended by all crew. Sightings and details of fauna interactions documented in daily operational logs. MFO reports confirm that interactions between the survey vessel and/or equipment and cetaceans were managed in accordance with Part 8 of the EPBC Regulations.	Vessel Master MFO
		9.2	In addition to the requirements of the EPBC Regulations 2000 - Part 8 Division 8.1 for	Survey crew induction materials include vessel/fauna separation distance and	Vessel Master

EPO #	EPO	EPS #	EPS	MC	Responsibility
			cetaceans, seismic vessels and support vessels (taking into account the limited manoeuvrability of the former) took action to avoid approaching or drifting closer than 50 m to a turtle.	speed requirements and requirement to report sightings. Induction records confirm that survey induction attended by all crew. Sightings and details of fauna interactions documented in daily operational logs. MFO reports confirm that interactions between the survey vessel and/or equipment and turtles were managed in accordance with Part 8 of the EPBC Regulations.	MFO
		9.3	Seismic vessel and support vessels (taking into account the limited manoeuvrability of the former) adopted measures consistent with the DPaW Whale Shark Management Programme (2013), including: ■ taking action to avoid approaching or drifting closer than 30 m of a whale shark; and ■ not exceeding 8 knots within 250 m of a whale shark.	Survey crew induction materials include vessel/fauna separation distance and speed requirements and requirement to report sightings. Induction records confirm that survey induction attended by all crew. Sightings and details of fauna interactions documented in daily operational logs. MFO reports confirm that interactions between the survey vessel and/or equipment and whale sharks were managed in accordance with DPaW Whale Shark Management Programme (2013).	Vessel Master MFO
		9.4	Two MFOs will be available on board the seismic vessel to manage shift duties during daylight hours during the survey.	Curriculum Vitae of the MFOs engaged for the Cygnus 3D MSS confirms: ■ UK Joint Nature Conservation Committee (JNCC) accreditation (or equivalent); and ■ at least one year (minimum four surveys) previous MFO experience.	Polarcus Vessel Manager

EPO #	EPO	EPS #	EPS	MC	Responsibility
				MFO report confirms two MFOs were on board the seismic vessel for daylight visual observations during the survey.	
		9.5	Crew, survey personnel and MFOs are briefed in the marine fauna observation, separation distance estimation, controls and reporting requirements relevant to this EP.	Induction slide pack includes briefing on Part A of EPBC Policy Statement 2.1, additional controls and adaptive management measures. Training, induction and competency matrix to confirm that the crew, survey personnel and MFO's are briefed in whale observation, separation distance estimation, adaptive management measures, and reporting.	Polarcus Vessel Manger
		9.6	If safe and practicable to do so, fauna found to be entangled in towed equipment were returned to the ocean.	Survey crew induction materials include reporting arrangements with respect to interactions/entanglement and returning entangled fauna to the ocean. Induction records confirm that survey induction attended by all crew. MFO report documents any instances of fauna entanglement and confirms that fauna were quickly returned to the ocean.	Vessel Master MFO
		9.7	Turtle guards are fitted on tail buoys, or tail buoys are of a design that does not represent an entanglement risk to turtles.	Record of pre-survey environmental checklist (Section 10.2.6.6) confirms turtle guards available on board the survey vessel or tail buoys designed to prevent turtles becoming trapped. Record of compliance audit during the survey (Section 10.2.6.6) confirms turtle guards are fitted to tail buoys unless tail buoys designed to prevent turtles becoming trapped.	Polarcus Vessel Manager

EPO #	EPO	EPS #	EPS	MC	Responsibility
		9.8	All collisions with cetaceans in Commonwealth waters are reported to the National Ship Strike Database.	Communication records confirming ship strikes with cetaceans referenced in MFO reports have been reported to the National Ship Strike Database. Reports to include vessel strike locations, frequencies and timings.	MFO
Physical Presence: Loss of Equipment					
10	No loss of equipment to the marine environment, during the survey.	10.1	Streamers will be deployed and retrieved in accordance with the Polarcus Deployment and Recovery of Streamers Procedure, of which key requirements include: ■ Ensuring weather conditions are appropriate for deployment and retrieval; ■ Ensuring tail buoy GPS is operational; ■ Monitoring deployment and retrieval closely; ■ Checking for physical damage; ■ Ensuring connection devices are in serviceable condition; and ■ Storing all birds, floats, streamer recovery devices (SRDs) and acoustic racks immediately following recovery.	Training and competency matrix of vessel crew involved in the deployment and retrieval of streamers demonstrates that they have received training on the deployment and retrieval of equipment. Record of compliance audit during the survey (Section 10.2.6.6) confirms streamer deployment and/or retrieval activities have been undertaken in accordance with the stated procedure. Daily survey log confirms that weather conditions during deployment and recovery of streamers are suitable.	Vessel Part Manager
		10.2	Streamers are fitted with redundant retainers, tail buoys and relative GPS.	Record of pre-survey environmental checklist (Section 10.2.6.6) confirms streamers are fitted with redundant retainers, tail buoys and relative GPS. Record of compliance audit during the survey (Section 10.2.6.6) confirms stated equipment is fitted, redundant retainers are secured and GPS is operational.	Polarcus Vessel Manager
		10.3	Solid streamers are used for the survey.	Survey equipment list and record of pre-survey environmental checklist (Section	Vessel Party Manager

EPO #	EPO	EPS #	EPS	MC	Responsibility
				10.3.12) confirms solid streamers are used.	
		10.4	All lifting gear used for deployment and retrieval of equipment over the vessel shall be load rated for the working load.	Load ratings or load test certificates (as per Polarcus lifting equipment requirements) to be confirmed by Chief Engineer during pre-survey environmental checklist (Section 10.2.6.6).	Vessel Party Manager
		10.5	AMSA JRCC, and other marine users in the Operational Area, are notified in the event of equipment loss.	Consultation records confirm AMSA JRCC and other marine users in the Operational Area have been notified of any events of equipment loss.	Vessel Master
		10.6	At least one support vessel will accompany the seismic vessel at all times and, if necessary, assisted in the recovery of lost equipment.	Survey logs confirm a support vessel is present within 10 nautical miles of the seismic vessel when the seismic vessel is in operation. MultiSeis (online tracking system) demonstrates the relative location of the survey and supply vessel.	Polarcus Vessel Manager
Discharge: Loss of Hazardous and Non-Hazardous Solid Waste					
11	Management of solid waste (hazardous and non-hazardous) to meet or exceed the requirements of MARPOL Annex V and AMSA Marine Order 95.	11.1	In accordance with MARPOL Annex V and Marine Order 95: ■ Vessels > 100 GRT (or certified for >15 persons on board) will have a Waste Management Plan ■ Vessels >400 GRT (or certified for >15 persons on board) will have a waste management log book	Records of the pre-survey environmental checklist (Section 10.2.6.6) confirm vessels > 100 T (or certified for >15 persons on board) have a Waste Management Plan, and vessels >400 T (or certified for >15 persons on board) will have waste management log book.	Vessel Master
		11.2	Bins are available for the segregation of waste in accordance with the vessel Waste Management Plan, and bins are fitted with lids/cargo nets for	Survey induction materials include waste management and housekeeping requirements.	Vessel Master

EPO #	EPO	EPS #	EPS	MC	Responsibility
			waste with potential to be wind-blown (e.g. paper, cardboard).	Survey induction attended by all crew, demonstrated by induction records. Record of compliance audit during the survey (Section 10.2.6.6) confirms bins are available and labelled appropriately, and bins for potentially wind-blown wastes are suitably covered.	
		11.3	Solid hazardous and non-hazardous wastes generated during the survey are segregated onboard the vessels and are either incinerated (using an IMO-approved incinerator, on seismic vessel only) or appropriately disposed of at a licensed onshore facility in accordance with the Vessel Waste Management Plan.	Survey induction materials include waste management and housekeeping requirements. Survey induction attended by all crew, demonstrated by induction records. Records confirm incinerator on board seismic vessel is IMO-approved (certificate current and sighted). Details of solid wastes incinerated or transferred to shore are maintained in the vessel's waste management log book, including records of the receiving company for transferred wastes.	Vessel Master
		11.4	Solid waste generated during the survey on board the vessel are minimised where practical, as identified during the pre-survey environmental checklist.	Survey crew induction materials include a summary of the waste management and housekeeping requirements, including waste minimisation where practicable. Induction attendance records demonstrate survey crew have received this induction.	Vessel Master
		11.5	Recycling or re-use of non-hazardous solid waste, where possible.	Survey crew induction materials include a summary of the waste management and housekeeping requirements, including recycling or re-use where practicable.	Vessel Master

EPO #	EPO	EPS #	EPS	MC	Responsibility
				Induction attendance records demonstrate survey crew have received this induction.	
Introduction of Invasive Marine Species: Biofouling and Ballast Water					
12	Implement controls to prevent the introduction and establishment of IMS in the marine environment from the survey.	12.1	Vessel hull and niches confirmed to be free of IMS prior to mobilisation into Australian waters.	Record of pre-survey environmental checklist (Section 10.2.6.6) confirms that the risk assessment for the seismic vessel has been accepted by a Department of Agriculture compliance officer confirming that the vessel meets the requirements for entry into Australian waters.	Vessel Party Manager
		12.2	Seismic vessel and support vessels have all necessary Department of Agriculture and Water Resources biosecurity approvals prior to mobilisation, including Pre-Arrival Report clearance for vessels entering Australian territorial waters.	Record of pre-survey environmental checklist (Section 10.2.6.6) confirms all seismic and support vessels have Department of Agriculture and Water Resources biosecurity clearance. Record of compliance audit during the survey (Section 10.2.6.6) confirms that any conditions imposed by the Department of Agriculture and Water Resources clearance are being complied with.	Vessel Party Manager
		12.3	All vessels comply with the requirements of the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Commonwealth of Australia, 2009) of which key requirements are: ■ Maintenance of biofouling electronic records outlining marine fouling management actions.	Record of pre-survey environmental checklist (Section 10.3.12) confirms: ■ Biofouling Record Book is current and management actions are up to date; ■ IMS risk assessment has been completed prior to the vessel's entry into Australia and the risk has been determined as low; and	Vessel Party Manager Polarcus Vessel Manager

EPO #	EPO	EPS #	EPS	MC	Responsibility
			■ Completion of an IMS risk assessment prior to vessel entry into Australian waters which concludes a low risk of IMS presence. ■ In-water equipment free of marine fouling prior to the commencement of the survey.	■ Equipment maintenance records confirm that in-water equipment is free of marine fouling prior to survey commencement.	
		12.4	All vessels maintain a current anti-fouling coating that complies with the requirements of Annex 1 of the International Convention on the Control of Harmful Anti-Fouling Systems on Ships and the requirements of the Protection of the Sea (Harmful Antifouling Systems) Act 2006.	Record of pre-survey environmental checklist (Section 10.2.6.6) confirms vessels have current anti-fouling certification that complies with the stated convention and Act.	Vessel Party Manager
		12.5	Streamers and associated equipment are be inspected, maintained and cleaned during retrieval (e.g. due to transit, crew change, inclement weather) to reduce biofouling.	Operational log (containing photographs where feasible) confirms streamers have been inspected and cleaned (if required) prior to deployment in the Operational Area and when retrieved within the Operational Area.	Vessel Party Manager
		12.6	Exchange of ballast water will only occur >12 nm from land and in water depths of >50 m in accordance with the Australian Ballast Water Management Requirements (Department of Agriculture and Water Resources 2017).	In the event that a ballast water exchange is required, daily operational log and ballast water management log confirm the position of the vessel is >12 nm from nearest land and in water depths > 50 m when exchanging water taken up in a foreign port or coastal waters. Survey induction materials include a summary of IMS and ballast water management. Survey induction attended by all crew, demonstrated by induction records.	Vessel Master
		12.7	BWM-T class (IMO approved) ballast water management system on board the seismic vessel treats water to reduce the risk of any living organisms being present prior to discharge.	IMO type approval certificate or BWM-T class vessel specification sheet for the ballast water treatment system.	Vessel Master

EPO #	EPO	EPS #	EPS	MC	Responsibility
		12.8	Seismic vessel and support vessels have a Ballast Water Management Plan and a ballast water record system/book, consistent with the Australian Ballast Water Management Requirements (Department of Agriculture and Water Resources 2017).	Record of pre-survey environmental checklist (Section 10.2.6.6) confirms all survey and support vessels have a Ballast Water Management Plan and ballast water record system/book, consistent with the Australian Ballast Water Management Requirements. Record of compliance audit during the survey (Section 10.2.6.6) confirms that all survey and support vessels have a Ballast Water Management Plan and ballast water record system/book, consistent with the Australian Ballast Water Management Requirements.	Vessel Party Manager

10. IMPLEMENTATION STRATEGY

In accordance with Regulation 14 of the OPGGS (E) Regulations, this section describes:

- The Polarcus Environmental Management System (EMS);
- Compliance assurance arrangements, including arrangements for monitoring, review and reporting of environmental performances;
- Preparedness for responding to oil pollution emergencies through an OPEP and appropriate arrangements for environmental monitoring; and
- Arrangements for ongoing stakeholder consultation and notifications.

10.1 Environmental Management System

The environmental performance outcomes, performance standards and measurement criteria defined in Section 8.7 will be implemented via the Polarcus Management System. The Management System is introduced in Section 2.3 and incorporates a number of documented manuals, plans and procedures, registers and work instructions, of which key ones relevant to the implementation of this EP are described in Table 2-6.

The Polarcus Environmental Management Procedure, amongst other procedures, provides for the implementation of the commitments in this EP, through implementation of actions including the following (note these are provided as examples):

- A pre-survey environmental checklist (input required from the Vessel Manager);
- Project kick-off meeting: this type of meeting is held at the start the survey to review the contractual and HSE specifications, scope of work, the Project Specific EHSQ Plan (incorporating this EP, Survey Hazards and Risk Assessment). It is attended by the Polarcus Vessel Manager, Polarcus Party Manager, Vessel Master and marine/survey crews;
- On-board daily meeting: this type of meeting has the objective to review seismic survey operations and any incidents of the previous day. They are attended by the Polarcus Party Manager, Vessel Master and relevant marine/survey crews;
- On-board HSE committee meetings: these types of meeting aim to review HSE issues against plan requirements, review actions arising from incidents and inspections and prepare, in close liaison with relevant parties, an action plan to facilitate continuous improvement in performance; and immediately address interim issues that arise by direct communication between the concerned parties, the Party Manager and the Vessel Master. These meetings are attended by on-board management positions and held at the start of operations (after induction activity) and after two weeks; and
- Toolbox Meetings: these types of meeting are undertaken before every critical or unfamiliar job with the aim of reviewing and managing the specific environmental and safety hazards associated with the job. Where relevant, they also address aspects such as spill prevention. They are attended by relevant personnel involved in a specific job.

Records are produced for each of these activities and meetings.

10.1.1 *Chain of Command*

The Polarcus Chain of Command and Project Management/Support Team structure is provided in Figure 10-1. Definition of the key roles and responsibilities of the relevant personnel of this EP are summarised in Section 10.1.2. Responsibilities for the implementation of specific environmental performance standards are detailed in Section 10.1.2.

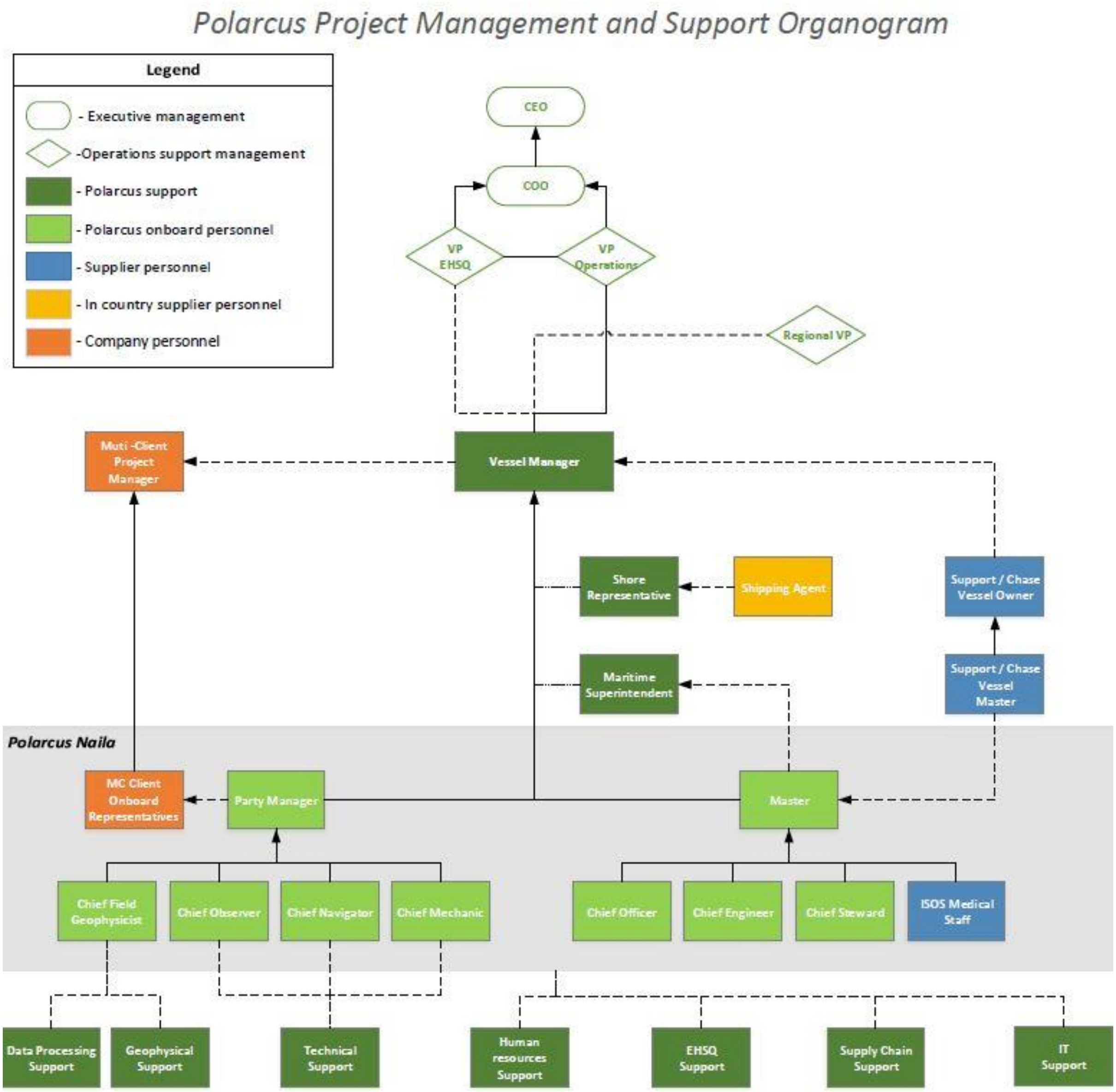


Figure 10-1 Petrelex 3D MSS Chain of Command

10.1.2 *Roles and Responsibilities*

The roles and responsibilities relevant to this EP are detailed in Table 10-1.

Table 10-1 Relevant Responsibilities

Role	Responsibilities Relevant to this EP
Chief Executive Officer (CEO)	Overall responsibility for delivering Company's Vision and Goals.
Chief Operations Officer (COO)	Ensures company activities comply with appropriate legislation and company policies.
Environment, Health, Safety and Quality (EHSQ) Vice President	Supports the company requirements for management system certification and maintenance of such.
EHSQ Supervisor	■ Provides day to day support for EHSQ issues arising within the Marine Acquisition Department; ■ Ensures incidents, non-conformances and system failures are properly investigated, root causes identified and recommendations communicated to prevent reoccurrence; ■ Provides guidance, support and training in order to promote the effective implementation of EHSQ programs; and ■ Supports Emergency Response and Contingency Planning and ensure adequate training for a company Emergency Response Team and the periodic testing of the Emergency Response Plan.
Vessel Manager	sponsible for the overall management and review of the EP and compliance with EP requirements. sures that: ■ Company management system is implemented, adhered to, measured and improved by those involved; ■ Compliance with local regulations in areas of operation; ■ Company policies/procedures and the environmental performance standards stated in this EP are implemented and the scope of the survey is completed in accordance with this EP; ■ Ensures the vessel management team is fully conversant with the contractual and legal requirements, including the requirements of this EP; ■ The survey fully complies with the commitments detailed in this EP and the requirements of the OPGGS Act; ■ The requirements of this EP are distributed to appropriate project personnel and relevant personnel are fully advised of the environmental performance outcomes, environmental performance standards and other commitments set out in this EP; ■ Changes in the survey that may trigger an EP revision are monitored and risks of any changing circumstances are re-evaluated; ■ Activity start/finish and incident notification(s) and associated reports to NOPSEMA, NOPTA and other relevant government agencies (including reportable environmental incidents and environmental performance close-out report) are fulfilled;

Role	Responsibilities Relevant to this EP
	■ A full briefing and induction of project personnel is undertaken so that they understand and are aware of the environmental sensitivities of the Operational Area, the environmental performance standards and commitments detailed in this EP and individual responsibilities; ■ Appropriately experienced MFOs are engaged to undertake fauna observation activities; ■ Appropriate organisation and response is in place in the event of a serious incident or emergency; ■ Communication with company personnel, government agencies and the media in the event of a serious incident is maintained; ■ Self or a similarly experienced delegate is available 24 hours for communication with the seismic vessel in the event of a serious incident or emergency, or an act of non-compliance by the vessel; ■ Consultation activities associated with the survey are conducted with relevant government agencies and marine stakeholders in advance of, during and after the completion of the survey; ■ Necessary seismic survey-specific procedures are developed and implemented prior to and during the survey, as relevant; ■ A pre-mobilisation vessel audit, oil spill response exercise and oil spill response capability audit is undertaken prior to seismic survey commencement; ■ An HSE review is undertaken at the completion of the survey and a "lessons-learnt" listing is developed; and ■ Whale Interaction Survey Conduct Report and Whale and Dolphin Sighting Forms and Survey Conduct Report Forms are forwarded to DOE on completion of the survey.
Vessel Party Manager	■ Oversight and reporting on the day-to-day conduct of the survey; ■ Verify that operations are undertaken in a manner consistent with the environmental performance outcomes and standards detailed in this EP; ■ Ensures the following: - day-to-day activities are monitored for compliance against this EP and the outcomes reported to the Polarcus Vessel Manager; - the Polarcus Vessel Manager is immediately alerted to changes in operations that could impact negatively on environmental performance or for changes in operations that alter the environmental risk profile of the survey; - vessel inspections are undertaken in accordance with Polarcus vessel procedures; - full awareness of ongoing operations is maintained, providing reports to the Polarcus Vessel Manager; - the procedures and work instructions required for seismic survey operations are known, understood and followed; - data and records are collected for the Environmental Performance Close-out Report;

Role	Responsibilities Relevant to this EP
	- relevant personnel have received a seismic survey environmental induction which includes a summary of environmental sensitivities, control measures, specific roles and responsibilities of vessels crew; - reportable incidents are reported to the Polarcus Vessel Manager and appropriate levels of incident investigation are undertaken and corrective actions from incidents are tracked to completion on behalf of Polarcus; - incidents are fully investigated and corrective actions monitored to close-out in accordance with the Incident Reporting Procedure; - implementation of environmental performance standards is monitored and measurement criteria records are maintained for compliance; - information is collated for monthly recordable incident report and information provided to the Polarcus Vessel Manager; and - an environmental audit is conducted during the survey.
Vessel Master	■ Has ultimate responsibility for the safe execution of vessel operations; ■ Ensures the following: - the vessel complies with regulatory requirements (both international and local); - vessel movements are notified to the AMSA JRCC; - initial action is executed to render the situation safe with respect to vessel incidents and near-misses, including the implementation of the vessel's SOPEP, if required. Incidents are recorded and investigated in accordance with the Incident Reporting Procedure; - notifications associated with vessel or equipment loss (hazard) incidents are made to AMSA; - notifications are made to other marine users associated with incidents; - notification to the Polarcus Emergency Core Team Leader and Vessel Manager in an emergency; - vessel inspections are undertaken; - SOPEP and emergency drills and training are undertaken; - incidents are investigated together with the Vessel Party Manager and corrective actions closed (as appropriate); - auditing is undertaken as required by vessel procedures; - equipment is maintained to statutory requirements or better; - statutory records (oil usage management electronic records, waste management electronic records, etc.) are maintained; - HSE related procedures and work instructions are known, understood and followed (e.g. toolbox meetings, HSE meetings); - new vessel crew are provided with induction, job familiarisation and specific obligations with respect to HSE participation; - marine crew have attended the HSE induction and are competent relevant to their specific roles and responsibilities; and

Role	Responsibilities Relevant to this EP
	- safe working codes and practices are implemented for vessel operations in accordance with recognised standards and policies.
Vessel Technicians and Crew	■ Applying operating procedures in letter and in spirit; ■ Following good housekeeping procedures and work practices; ■ Encouraging improvement wherever possible; and ■ Immediately reporting incidents to the Vessel Master.
Marine Fauna Observers (MFOs)	■ Supporting compliance with this EP with respect to marine fauna observations and interactions; ■ Ensuring compliance with the relevant management procedures in place for the survey, including EPBC Act Policy Statement 2.1 - Interaction between offshore seismic exploration and whales (DEWHA 2008a), adequate fauna watch and operational response; ■ Maintaining records of daily logs, environmental incidents, waste inventory, whale and dolphin sightings and operational response; and ■ Submitting daily reports to the Polarcus Vessel Manager.
Emergency Core Team Leader	■ Providing direct support to the Incident Site (Onshore and Offshore); ■ Determining the incident response level required; ■ Determining the incident response primacy during multiple party incidents; ■ Providing situational updates to the Executive Team Leader (CEO); ■ Coordinating support from external agencies; ■ Notifying the Environmental Service Provider ERM within 24 hours of the spill; ■ Liaising directly with all members of the Core Emergency Team; ■ Providing a focal point for decision making process; and ■ Allocating sufficient resources to support the incident. N.B. The project specific 'Emergency Response Plan' for the Petrelex 3D MSS, will provide further descriptions on the roles and responsibilities of key personnel involved in responding to an emergency, including the Polarcus Emergency Core Team Leader.

10.1.3 *Competency and Training*

The Polarcus Environmental Management Procedure provides a basis for ensuring personnel engaged in the survey understand and have the necessary competencies to undertake their responsibilities as defined in Section 10.1.2.

Relevant environmental responsibilities are detailed in position job descriptions and/or contractual documents. Polarcus will provide marine crew who are trained and competent to undertake their respective activities on-board the vessel. All relevant marine personnel will be qualified in accordance with the International Convention on Standards of Training Certification and Watch Keeping for Seafarers (STCW95) or Elements of Shipboard Safety. Marine Fauna Observers with demonstrable and relevant experience will be engaged for the duration of the survey.

The Polarcus Environmental Management Procedure provides for managers and personnel to receive training relevant to their roles and responsibilities. Training is delivered through on-the-job training, awareness briefings, through pre-start and tool-box meetings, emergency drills, posters and video presentations. Training and activities relevant to the implementation of this EP are described below.

10.1.4 *Inductions*

Prior to each survey phase commencing relevant personnel, including contractors, will be made aware of environmental information relevant to their role. Induction material will include:

- Importance of conforming with the accepted EP for the survey and associated regulatory requirements;
- Summary of the environmental setting of the survey (sensitivities such as shipping traffic, fishing, cetaceans, etc.);
- Summary of potential seismic survey environmental hazards and required controls to minimise impacts associated with these;
- Awareness of the environmental performance outcomes, standards and measurement criteria contained within this EP;
- Reportable and recordable environmental incidents associated with the survey;
- Personnel roles and responsibilities as detailed in this EP; and
- Summary of the emergency and oil spill response arrangements for the survey.

A record of induction will be maintained with endorsement of personnel who attended. These records shall be retained by Polarcus and made available upon request.

10.1.5 *Employee Communication and Participation*

Polarcus is responsible for keeping its vessel workforce informed of environmental issues. The Polarcus Party Manager keeps the survey crews advised of environmental issues. The Polarcus Party Manager acts as a focal point for personnel to raise environmental issues, and consults/involves relevant personnel in the following:

- Issues associated with the implementation of the EP;
- Proposed changes to equipment, systems, or methods of plant operation, where these may have environmental implications; and
- Proposals associated with continuous improvement of environmental protection, including the setting of environmental objectives and training schemes.

A daily review of HSE management is conducted on the seismic vessel as part of the on-board Daily Meeting. The issues discussed and actions taken are recorded. The minutes of each meeting, including action items from the meetings, are made available to relevant personnel. Other forms of internal communication include Toolbox Meetings.

10.2 Compliance Assurance

Compliance with this EP will be assured and reviewed via the daily on-board meetings and on-board HSE committee meetings described in Section 10.1, and via internal audit and monitoring programs described below.

10.2.1 *Monitoring*

Monitoring will be undertaken for the survey, and records kept as detailed in Table 10-2.

Table 10-2 Monitoring Summary

Discharge/Incident	Parameters	Record	Responsibility
Atmospheric Emissions			
Engine emissions	Quantity of marine diesel used by the seismic vessel	Engineers log	Vessel Master
Discharges to Sea			
Oily water discharges	The volume of oily water discharge from the seismic vessel.	Oil usage management electronic records	Vessel Master
Food waste	The volume of food-scraps discharged from the seismic vessel	Waste management electronic records	Vessel Master
Sewage/grey water discharge	The volume of sewage and grey water discharged from the seismic vessel	Engineers log	Vessel Master
Disposal of Wastes			
Hazardous wastes	Volume of hazardous wastes transferred onshore.	Waste management electronic records/oil usage management electronic records	Vessel Master
Non-hazardous wastes	Volume of non-hazardous wastes transferred onshore	Waste management electronic records	Vessel Master
Marine Fauna Interaction			
Cetacean, whale shark, dugong and turtle sightings	Details required on the Whale and Dolphin Sighting reports (DoEE)	Sighting records	MFOs
Collisions with cetaceans in Commonwealth waters will be reported to the National Ship Strike Database.	Location, timing, species, vessel speed, what happened	National Ship Strike Database https://data.marine mammals.gov.au/report/ shipstrike/new	MFOs
Marine User Interaction			
Vessel Interaction/ Complaints	Communications with other vessels	Ships log	Vessel Master

10.2.2 *Review of Environmental Performance*

Polarcus will undertake an internal review of the environmental performance of the survey on completion. The review will consider:

- An evaluation of conformance with the compliance register (based on the environmental performance outcomes, standards and measurement criteria outlined in Section 8.7);
- Improvements to the implementation strategy included within the EP;
- Compliance with Polarcus' Policies, Manuals and Procedures;
- The management of non-conformances identified during the survey, including reportable and recordable incidents; and

- Concerns identified by stakeholders during and after the completion of each survey phase, followed by appropriate liaison as required.

The outcomes of the review will be circulated to relevant persons in Polarcus and to other stakeholders as appropriate. The outcomes of the review will be incorporated into environmental management measures applied to future activities to further improve Polarcus' environmental performance, and will be included in the Environmental Performance Report.

10.2.3 *Management of Change and New Information*

In order to ensure that impacts and risks are continually reduced to ALARP and acceptable levels and the requirements of legislation will continue to be met, Polarcus will undertake periodic verification of environmental inputs used to inform the evaluation of impacts and risks in the EP, including identifying updates to legislative requirements and environmental information.

Review and verification of the information in the EP will be undertaken:

- Prior to mobilisation; or
- Annually from the date of acceptance of the EP (whichever occurs first).

This will include relevant legislation, guidance, species conservation management plans, protected area management plans, new and significant environmental information and research and new stakeholder information.

A record of each verification will document identified changes or new information and an evaluation will be conducted to confirm:

- Applicable changes to controls, environmental performance outcomes, standards and measurement criteria;
- Currency of certificates for insurance policies (and that the policies would apply in the event of a hydrocarbon spill; and
- If the information/change results in a new or increased residual risk ranking, as determined in the EP.

In addition, opportunities for improvement identified during reviews of environmental performance will be evaluated for any potential changes to control measures, environmental performance outcomes, standards and measurement criteria.

Any new or increased impacts or risks that may arise from the verifications will be managed through the Polarcus Management of Change Procedure (Polarcus 2014). This procedure ensures that temporary or permanent organisational, system or operational changes are considered for HSE and quality implications prior to those changes occurring.

The systematic process is a pre-defined four-step process:

- Step 1: Identify (Appraise and Select);
- Step 2: Risk Assessment (Define) – in accordance with the Polarcus Risk Assessment Procedure (Section 6);
- Step 3: Implement (Execute); and
- Step 4: Complete (Operate).

The requirements to develop a revision to the EP (in accordance with Regulation 17 of the OPGGS (E) Regulations) will be triggered should the following be identified through the implementation of the Polarcus Management of Change Procedure:

- Significant modification or new stage of activity;
- New or increased environmental impact or risk;

- Change in titleholder; or
- Changes to management of impacts and risks.

The above triggers (for a revision of the EP) will also trigger further consultation with relevant stakeholders to inform them of any changes to the proposed activity or associated risk profile.

10.2.4 *EP Review and Resubmission*

During review of environmental performance (Section 10.2.2), or during verification of information or following a change (Section 10.2.3), any new information, changes or updates will be considered against Regulation 17 of the OPGGS (E) Regulations, to determine if resubmission of the EP to NOPSEMA is required. Relevant sub regulations and triggers for EP resubmission under Regulation 17 including the following:

- **17(1) New activity**, defined as a change to the extent that the regulatory levy category applied to the Petrelex 3D MSS would change.
- **17(5) Significant modification** of the Petrelex 3D MSS activity or to how the activity is being managed and conducted. A modification to the activity or management system is considered by Polarcus to be significant if any of the following significance criteria are met:
  i. The number of vessels used during the survey increases from that described in Section 3; or
  ii. The seismic source volume is increased beyond that defined in Section 3; or
  iii. The vessel fuel type changes from that described in Section 3; or
  iv. The Polarcus Environmental Management System (Section 2.3) or Polarcus Management Documents (Section 2.3.3) are repealed; or
  v. The Polarcus Environmental Management System, or Polarcus Management Documents, or an Environmental Performance Outcome, or an Environmental Performance Standard is altered to the degree that it:
     - Materially affects the ability to achieve any environmental performance outcomes and performance standards; or
     - Materially alters the intent of a performance outcome or performance standard; or
     - If the overall activity or a potential impact or risk of the activity can no longer be managed to ALARP or acceptable levels.
- **17(5) New stage** of the activity, defined as either:
  i. A change to the spatial limits of the activity (an increase in the Acquisition Area or Operational Area boundary); or
  ii. A change to the temporal limits of the activity (an extension to the timeframe of this EP).
- **17(6) New or increased environmental impact or risk**. Only significant new or significant increased impacts or risks require resubmission of the EP to NOPSEMA.

  A new impact or risk is considered by Polarcus to be significant if any of the following significance criteria are met:

  i. The residual impact or risk, after determining controls and environmental performance standards, is categorised as ‘Medium’ or ‘High’; or
  ii. The impact or risk is not determined to be Acceptable;
  iii. The impact or risk is not determined to be ALARP.

  An increase in an impact or risk is considered by Polarcus to be significant if any of the following significance criteria are met:

i. The residual impact or risk ranking, after reviewing and identifying controls and environmental performance standards, increases by a category (e.g. from Low risk to Medium risk); or

ii. The impact or risk is no longer Acceptable;

iii. The impact or risk is no longer ALARP.

- **17(7) Change in Titleholder**

  A change in Titleholder requires a resubmission of the EP.

  A resubmission of the EP may also be required if requested by NOPSEMA (Regulation 18).

10.2.5 ***Records***

Record retention requirements relevant to the Petrelex 3D MSS are summarised in Table 10-3.

Table 10-3 Record Retention Requirements

Records
■ Environmental Induction Register; ■ Daily operational log; ■ Vessel communication log; ■ Maintenance records; ■ Measurement and recording of criteria that form the environmental performance outcomes (refer to Section 8.7); ■ Marine fauna sighting records and Activity Log, including records of action taken for managing interactions with marine fauna; ■ Waste management electronic records; ■ Oil usage management electronic records; ■ Marine User Consultation Logs (pre-mobilisation and during seismic survey); ■ Incident Register (including Marine User Complaints), incident investigation reports and corrective actions register; ■ Notice to Mariners and AUSCOAST warnings; ■ CVs of MFOs; ■ Emergency/Oil Spill Response Exercise Records; ■ Oil Pollution Reports (POLREPs), Situation Reports (SITREPs) and other incident documentation that would result from vessel oil spills; ■ Records of notifications to the DoEE (as required); ■ International Sewage Pollution Prevention (ISPP) certificate; ■ International Oil Pollution Prevention (IOPP) certificate; ■ International Air Pollution Prevention (IAPP) certificate; ■ Oil-water separator service records; ■ Engine service records; ■ Records of calibration and maintenance of monitoring devices; ■ Ballast water records and copies of required reports to the DAWR related to ballast water management; ■ Anti-fouling certificate; ■ Safety data sheets (SDS) for hazardous chemicals; and ■ End of Survey Closeout Report.

10.2.5.1 Storage of Records

Versions of the EP will be stored by Polarcus in such a way as to make retrieval of the EP reasonably practicable. Each version will be kept for at least five years after the date the version ceases to be in-force.

10.2.5.2 Making Records Available

In accordance with the provisions of Regulation 28(2), Polarcus will make available copies of records described in Section 10.2.5 to the following persons (or their agent), on request in writing by the person:

- NOPSEMA;
- A delegate of the responsible Commonwealth Minister; and
- A greenhouse gas project inspector or a petroleum project inspector;

The copies of the records will be made available:

- In the case of an emergency relating to an activity – as soon as possible at any time of the day or night during the emergency; and
- In any other case – during normal business hours in the place where the records are kept.

The copies of the records will be made available at the place where the records are kept, or if agreed between Polarcus and the person making the request (or the person's agent), at any other place (including by means of electronic transmission to the person or agent at that place). If the records are stored on a computer, the records will be made available in print-out form or, if Polarcus and the Regulator so agree, in electronic form.

10.2.6 *Reporting*

10.2.6.1 Environmental Performance Reporting

Polarcus will maintain a record of the environmental performance of the Petrelex 3D MSS in relation to the environmental performance outcomes, standards and measurement criteria detailed in Sections 7and 8. This record will be documented in the form of a compliance register.

A detailed report on the environmental performance ('Environmental Performance Report'), including the compliance register, will be submitted to NOPSEMA for assessment within two months of survey completion, or at least annually from the date of EP acceptance (whichever occurs first). The report and associated compliance register will be retained by Polarcus for a period of five years and will be made available as stated in Section 10.2.5.

10.2.6.2 Reportable Incidents

Polarcus will notify NOPSEMA of an incident relating to the survey that has caused, or has the potential to cause, moderate to significant environmental damage (reportable incident). Based on the risk assessment undertaken, the following residual consequences rated as 'Extensive' or higher (refer to Section 6.6) during the risk assessment for this EP, are considered consistent with the moderate to significant environmental damage defined in the Regulations:

- Collision or entanglement with large marine fauna resulting in injury/death of a listed species;
- Confirmed introduction of IMS resulting in alterations to local ecosystems; and
- A hydrocarbon or chemical spill categorised as a Tier 2 hydrocarbon (MGO) spill resulting in toxic effects and oiling of marine biota, and interruption to commercial and coastal fishing and shipping activities (for the purposes of this EP a Tier 2 hydrocarbon (MGO) spill is equivalent to a Level 2 incident under the National Plan for Maritime Environmental Emergencies (AMSA 2019)). A Tier 2 hydrocarbon spill, which is more complex in size, duration, resource management and risk, than a Level 1 incident (AMSA 2019), may require deployment of additional resources beyond the initial response, and which may require trans-jurisdictional involvement. This would be facilitated by AMSA.

As such, realisation of these consequences would be considered to constitute a reportable incident.

In the event of a reportable incident occurring during the survey that has an actual or potential reputational risk for Polarcus, NOPSEMA will also be notified. Reputational risks will be assessed as they apply to Polarcus' risk assessment and performance standards.

NOPSEMA will be notified of reportable incidents by Polarcus as soon as practicable, and not later than two hours after the first occurrence of the incident, and a written report submitted using NOPSEMA's FM0831 template (Report of an Accident, Dangerous Occurrence or Environmental Incident) within three days. Notification of reportable incidents will contain the following:

- Material facts and circumstances concerning the reportable incident that the operator knows or is able, by reasonable search or enquiry, to find out;
- Action taken to avoid or mitigate adverse environment impacts of the reportable incident;
- The corrective action that has been taken, or is proposed to be taken, to stop, control or remedy the reportable incident; and
- The corrective action that has been taken, or is proposed to be taken, to prevent a similar reportable incident.

When notifying NOPSEMA of a reportable incident, Polarcus will also notify NOPTA and the Department of the responsible State Minister in writing within seven days. Polarcus will submit a written report of a reportable incident in accordance with a notice given by the Regulator, if required to do so. Additional notifications and reporting relevant to oil spills are described in the OPEP (Section 0).

Although a Level 2 incident / Tier 2 hydrocarbon spill requires involvement from a third party Control and Combat agency, overall responsibility for reporting 'reportable incidents' under the OPGGS (E) Regulations remains with the titleholder (i.e. Polarcus).

It is therefore not expected that the required reporting of the incident to NOPSEMA by Polarcus would be delayed beyond the requirement of two hours after:

- The first occurrence of the reportable incident; or
- If the reportable incident was not detected by the titleholder at the time of the first occurrence—the time the titleholder becomes aware of the reportable incident.

10.2.6.3 Recordable Incidents

Polarcus will maintain a record via a compliance register of breaches of an environmental performance outcome or environmental performance standard that is not a reportable incident (recordable incident). Recordable incidents occurring during the survey that have actual or potential reputational risk to Polarcus will also be recorded in the compliance register. The reputational risk of recordable incidents will be assessed as they apply to Polarcus' risk assessment and performance standards. This written record will be provided as soon as practicable to NOPSEMA for each calendar month in which the Petrelex 3D MSS is undertaken, and will be provided no later than 15 days following the end of a calendar month.

This report will contain:

- A record of any recordable incidents that occurred during the calendar month;
- Material facts and circumstances concerning the recordable incident(s) that the titleholder knows or is able, by reasonable search or enquiry, to find out;
- Action taken to avoid or mitigate adverse environment impacts of the recordable incident(s);
- The corrective action that has been taken, or is proposed to be taken, to stop, control or remedy the recordable incident(s); and
- The action that has been taken, or is proposed to be taken, to prevent a similar incident occurring in the future.

The Environmental Performance Report (Section 10.2.6.1) will include a summary of recordable incidents, and will be submitted to NOPSEMA within two months of the conclusion of the Petrelex 3D

MSS. Lessons learnt from the environmental compliance audit (Section 10.2.6.6) will be included in the Environmental Performance Report.

10.2.6.4 Polarcus Incident Reporting

In accordance with Polarcus' risk assessment and management procedures, incidents involving people, environment, Polarcus property and Polarcus’ reputation (including reportable and recordable incidents or near misses) during the Petrelex 3D MSS will be recorded, reported and investigated in accordance with the Vessel Incident Reporting Procedure. The Vessel Master will be responsible for forwarding incidents to the Polarcus Vessel Manager. All corrective actions arising from incidents, audits and inspections are recorded in this system and monitored for closure by the Vessel Master and Vessel Manager. Corrective and preventative actions taken to eliminate the cause of potential incidents will be commensurate with the magnitude of the environmental risks.

In line with its commitment to continual improvement, environmental incidents and near misses will be shared amongst the vessels (seismic and support), and corrective actions will be applied to other vessels where relevant. In addition, Polarcus will carry forward the identified corrective/preventative actions from incidents for consideration in future seismic survey campaigns to ensure “lessons learnt” are captured and assist with continuous improvement in environmental management or to provide frequency data (i.e. likelihood determination) associated with seismic survey operations.

10.2.6.5 Cetacean Sighting Reports

In accordance with EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales, the interaction between the seismic vessel and cetaceans (and whale sharks) in the area will be documented using the Cetacean Sightings Application (v 3.0). A report detailing interactions will be provided to DoEE by Polarcus within two months of completion of the survey.

10.2.6.6 Compliance Audits

Polarcus will maintain a compliance register that will serve as an audit tool during the Petrelex 3D MSS. The register will be sufficiently detailed to enable auditors to determine whether the environmental performance outcomes and standards for the survey have been met. The register includes:

- The environmental performance outcomes and environmental performance standards relevant to the survey as set out in this EP;
- Measurement criteria to enable an auditor to determine if the survey has complied with the relevant performance standards; and
- The person/party responsible for implementing the performance standard to meet the environmental performance outcome.

Prior to mobilisation and in accordance with the Polarcus Environmental Management Procedure, Polarcus will complete:

- A pre-survey environmental checklist with input from the Vessel Manager, Vessel Master and the Party Manager addressing pre-survey planning, preparedness for compliance with regulatory requirements, including this EP, operational considerations and on board preparedness. The activity will be documented and corrective actions rectified prior to mobilisation; and
- An audit of the on-board spill response capability against the vessel SOPEP to verify spill preparedness.

Polarcus will then conduct a compliance audit against this EP. This will target confirmation that:

- Compliance with regulatory requirements detailed in this EP is being achieved;
- Environmental performance outcomes and standards have been monitored, measured and evaluated as required;

- Emissions and discharges are being monitored, measured and documented as required; and
- Management strategies and procedures to achieve the environmental performance outcomes are in place and being implemented effectively.

Any required remedial actions will be followed up. A copy of the environmental compliance audit will be forwarded to NOPSEMA upon request. Lessons learnt from the environmental compliance audit will be included in the Environmental Performance Report.

10.2.6.7 Management of Non-conformance

Non-conformances and opportunities for improvement will be identified and corrective actions will be tracked to completion in accordance with the Polarcus Incident Reporting Procedure and Risk Management Procedure, and results logged in the Risk Register. In accordance with Polarcus' Risk Management Procedure, the Risk Register is a snapshot that provides generic listings of:

- Potential hazards that can lead to an undesirable event;
- Controls in place to prevent or minimise the undesirable event;
- Potential consequences should the undesirable event occur; and
- The recovery measures should the undesirable event occur.

Polarcus will carry forward non-conformances identified during the Petrelex 3D MSS for consideration in future seismic surveys to assist with continuous improvement in environmental management controls and performance outcomes.

10.3 Emergency Management and Response

In accordance with the Polarcus Emergency Response Procedure, a project specific 'Emergency Response Plan' (ERP) will be drafted for the survey. The ERP contains key actions, responsibilities and contact details for responding to a vessel emergency.

In the event of an emergency, the Vessel Master will assume overall onsite command, will make the initial regulatory notifications to AMSA as defined in Section 10.4.5 and will act as onsite coordinator directed by AMSA. All persons aboard the vessel(s) will be required to act under the direction of the Vessel Master.

The seismic vessel and support vessels will have equipment on board for responding to emergencies, including but not limited to medical equipment, firefighting equipment and oil spill response equipment as defined in the SOPEP.

The Vessel Master will notify the Polarcus Emergency Core Team Leader in accordance with the ERP who will act as onshore liaison.

Polarcus has insurance policies in place that would cover the costs of any clean-up or remediation activities following a spill. These policies cover activities in Australian Commonwealth and State waters and are therefore applicable to the whole of the survey.

10.3.1 *Oil Pollution Emergency Plan*

In order to encompass the nature and scale of the survey and respond to the identified credible spill scenarios (Section 8.1.2), the overall Oil Pollution Emergency Plan (OPEP) for the survey encompasses multiple levels of planning and response capability.

The overall seismic survey OPEP is therefore represented by various levels of emergency plan, which comprise of:

- Vessel(s) SOPEP – for spills contained on the vessel or spills overboard which can be managed by the vessel;

- The National Plan for Maritime Environmental Emergencies (National Plan) (AMSA 2014) - AMSA is the jurisdictional authority and control agency for spills from vessels which affect Commonwealth waters; and
- The Western Australian State Hazard Plan for Maritime Environmental Emergencies (State Hazard Plan) (DoT 2019) – for spills from vessels, which affect WA State waters.

10.3.2 *Vessel SOPEP*

A vessel SOPEP has been prepared in accordance with the IMO guidelines for the development of shipboard oil pollution emergency plans (resolution MEPC.54(32) as amended by resolution MEPC.86(44)). An illustrative copy of a Polarcus seismic vessel SOPEP is provided in Appendix G.

Priority actions in the event of a hydrocarbon spill are to make the area safe, stop the leak and ensure that further spillage is avoided. All deck spills will be cleaned-up immediately, using appropriate equipment from the on board spill response kits (e.g. absorbent materials) to minimise any likelihood of discharge of hydrocarbons or chemicals to the sea.

The Vessel Master is responsible for activating and implementing the vessel SOPEP. In accordance with the Polarcus Oil Spill Management Procedure (Table 2-6), the shipboard Oil Pollution Prevention Team is responsible for both prevention and response activities with detailed instructions for the team being listed in the vessel specific SOPEP.

10.3.3 *Spill Response Options*

Spill response mitigation measures will be implemented as appropriate to reduce the likelihood of impacts to key marine environmental receptors (refer to Section 10.4.1 for preferred spill response strategy). The objectives of spill response include the protection of human health, environmental values, and the protection of assets. The selection of spill response techniques in any situation will include an assessment of the net environmental benefit of the technique, taking account of priorities for protection and restoration and the sensitivity of the receptors at risk.

Based upon the outcome of the predictive spill modelling and the properties of MGO, the following spill response options are considered applicable for potential MGO spills:

- Source control, which will include locating the source of the leakage and may also include isolating the tanks, transferring oil to slack or empty tanks, ceasing bunkering operations or using scupper plugs;
- Monitor and evaluate the trajectory and extent of the spill; and
- Assisted natural dispersion using propeller wash, if advised by the Control Agency, AMSA, and deemed safe.

Initial actions for source control are outlined in the vessel SOPEP (refer to Appendix G) and would be undertaken in consultation with the relevant statutory Combat Agency (initially AMSA, given the location of the Operational Area in Commonwealth waters).

Given the offshore location, very short window of exposure of receptors to MGO (days) and the transient nature of fauna, oiled wildlife response efforts are unlikely to be mobilised, but may be considered by AMSA, as the Combat Agency.

The above spill response options are not expected to introduce additional hazards to the marine environment or to result in significant additional potential impacts. The response options of source control, monitor and evaluate and assisted natural dispersion will use existing survey and/or support vessels, and the potential impacts associated with the use vessels is evaluated in Section 7.4 for planned activities.

10.3.4 *Preferred Response Strategy*

Given the offshore location of the Operational Area, the preferred strategy for MGO spills will be to allow small spills to disperse and evaporate naturally, and monitor the position and trajectory of any surface slicks. Physical break up (assisted natural dispersion) by repeated transits through the slick may be considered for larger slicks (following consultation with the Combat Agency – AMSA).

10.3.5 *Statutory Oil Spill Contingency Plans*

10.3.5.1 Australian Commonwealth Waters

The National Plan for Maritime Environmental Emergencies

The National Plan is an integrated government and industry framework that seeks to enable effective response to marine pollution incidents and maritime casualties. The framework, in accordance with the polluter pays principles of the OPRC 1990, provides for industry as the control agency for all spills which originate from offshore petroleum activities. NOPSEMA collaborates closely with the Australian Maritime Safety Authority (AMSA), as the manager of The National Plan, to ensure that arrangements under The National Plan, the OPGGS Act and associated regulations are aligned and understood.

In Commonwealth waters, initial actions will be undertaken by the vessel with subsequent actions determined in consultation with the regulatory authorities under the National Plan. AMSA is the responsible Combat Agency for hydrocarbon spills from vessels in waters under Commonwealth jurisdiction and will respond in accordance with its Marine Pollution Response Plan as approved by the AMSA Executive. Upon notification of an incident, AMSA will assume control of the incident.

Offshore Petroleum Incident Coordination Framework

The Australian Government established the Offshore Petroleum Incident Coordination (OPIC) framework for coordinating a whole of government response to a significant petroleum incident in Commonwealth waters. The framework interfaces with other emergency incident response/coordination arrangements, including The National Plan, titleholder oil pollution emergency plans and state/Northern Territory marine pollution contingency plans as appropriate.

10.3.5.2 Western Australian Waters

If surface slicks appear likely to enter WA State waters, then subsequent actions will be determined in consultation with the WA DoT under the State Hazard Plan for Maritime Environment Emergencies (State Hazard Plan). The WA DoT is the designated Combat Agency for oil spills from vessels in WA State jurisdiction.

Oil spill modelling

10.3.5.3 Northern Territory Waters

The Northern Territory (NT) Department of Environment and Natural Resources (DENR) is the designated Combat Agency for response to MOP incidents from vessels and coastal facilities into NT coastal waters. If surface slicks appears likely to enter NT waters, then subsequent actions will be determined in consultation with the NT DENR.

10.3.6 *Spill Notifications*

In the event of an MGO spill occurring during the survey, notification arrangements are shown in Table 10-4.

In addition to this, Polarcus will advise potentially affected stakeholders identified through stakeholder consultation, including stakeholders within the commercial fishing industry.

Table 10-4 Spill Notification Details

Agency	Contact Details	Notification Trigger	Reporting Requirement and Timing	Reporting Forms	Reference
AMSA	1800 641 792 (Emergency) (02) 6230 6811 (Office)	■ All slicks trailing from a vessel ■ All spills in Australian Commonwealth Waters (notwithstanding the size or amount of oil or sheen) ■ All spills where National Plan equipment is used in a response ■ All spills occurring within Perth Treaty Waters (notification to Indonesia also required – see below).	■ Immediate notification by the Vessel Master ■ Written Marine Pollution Report (POLREP) form submitted by the Vessel Master to AMSA; timing not specified	Incident Reporting Requirements: http://www.amsa.gov.au/forms-and-publications/AMSA1522.pdf AMSA POLREP: https://www.amsa.gov.au/environment/maritime-environmental-emergencies/national-plan/Contingency/Oil/documents/Appendix7.pdf	National Marine Oil Spill Contingency Plan
NOPSEMA	08 6461 7090	A Tier 2 or 3 hydrocarbon spill (i.e. a spill requiring third party support from AMSA) as per the reportable incidents in Section 10.2.6.2.	■ Notification within 2 hours. ■ Written report submitted within 3 days	http://www.nopsema.gov.au/assets/Guidance-notes/N-03000-GN0926-Notification-and-Reporting-of-Environmental-Incidents-Rev-4-February-2014.pdf	OPGSS (E) Regulations
WA Department of Transport (DoT)	(08) 9480 9924 1300 905 866 marine.pollution@transport.wa.gov.au	■ Spill to State waters (including ports and inland waters) from a vessel or unknown source.	■ Immediate notification by Vessel Master to the Oil Spill Response Coordination (OSRC) Unit. ■ Written POLREP submitted by Vessel	DoT POLREP: http://www.transport.wa.gov.au/mediafiles/marine/mac-f-pollutionreport.pdf SITREP:	State Emergency Management Plan for Marine Oil Pollution (WestPlan – MOP)

Agency	Contact Details	Notification Trigger	Reporting Requirement and Timing	Reporting Forms	Reference
		■ Spill that has the potential to drift into State waters.	Master, as soon as practicable. ■ Written Situation Report (SITREP) within 24 hours of being directed by DoT.	http://www.transport.wa.gov.au/mediafiles/marine/mac-f-situationreport.pdf	
Commonwealth Department of the Environment and Energy (DoEE)	-	■ Spill has potential to cause significant impacts to a matter of national environmental significance (NES) during the survey	■ Written notification submitted within 7 days.	N/A	Environment Protection and Biodiversity Conservation Act 1999
NOPTA and WA Department of Mines, Industry Regulation and Safety (DMIRS)	-	■ Spill to Commonwealth waters during an activity that is reportable to NOPSEMA.	■ Copy of the same report as provided to NOPSEMA within 7 days of the initial report being submitted to NOPSEMA.	Same report submitted to NOPSEMA.	Guidance Note (N-03000-GN0926) Notification and Reporting of Environmental Incidents.
Director of National Parks (DoNP)	Marine Compliance Duty Officer – 0419 293 465	■ Oil/gas pollution incidents within a marine park or likely to enter/impact on a marine park.	Notification to be made to the 24hr Marine Compliance Duty Officer by Vessel Master, as soon as practicable. The notification should include: ■ titleholder details ■ time and location of the incident (including name of marine park likely to be effected) ■ proposed response arrangements as per the Oil Pollution Emergency	N/A	Appendix D

Agency	Contact Details	Notification Trigger	Reporting Requirement and Timing	Reporting Forms	Reference
			Plan (e.g. dispersant, containment, etc.); and ■ contact details for the response coordinator.		
NT Department of Primary Industry and Resources (Mines)	(08) 8999 6350 Petroleum.operations@nt.gov.au	■ Spill to NT waters (including ports and inland waters) from a vessel or unknown source ■ Spill that has the potential to drift into NT waters	■ Notification immediately and no later than within 24 hours.	N/A	N/A
NT Environment Protection Authority (EPA)	1800 064 567 pollution@nt.gov.au	■ Spill to NT waters (including ports and inland waters) from a vessel or unknown source ■ Spill that has the potential to drift into NT waters	■ Notification immediately and no later than within 24 hours.	N/A	N/A

10.3.7 *Testing and Review of Response Arrangements*

The vessel SOPEP includes provision for testing the SOPEP (oil pollution emergency drills) as required under Regulations 14(8A) to 14(8C) of the OPGGS (E) Regulations. Furthermore, a test of the oil spill emergency response arrangements referred to in this EP will be conducted:

- When the response arrangements are introduced;
- If and when response arrangements are significantly amended;
- During the mobilisation phase prior to the survey commencing;
- Not later than 12 months after the most recent test;
- If a new location (new or revised Operational Area) is added to the EP; and
- If and when a new vessel is engaged for the activity.

The test will audit the on-board spill response capability against the SOPEP to verify spill preparedness (Section 10.3.2) and ensure vessel personnel are familiar with required actions.

Outcomes of this testing will be documented and any corrective actions/improvements implemented prior to mobilisation. If required as an outcome of this testing the emergency response arrangements in this EP will be reviewed. The vessel SOPEP is also reviewed at least annually by Polarcus to ensure it is current and up to date. The vessel SOPEP is subject to recertification every five years.

A planned maintenance system will be implemented on the seismic vessel, to ensure that all equipment used during operations is in full working order, and does not represent a hydrocarbon spill risk. Stocks of absorbent materials held aboard the vessel will be checked for their adequacy and replenished as necessary prior to the commencement of activities.

10.3.8 *Hydrocarbon Spill Monitoring*

AMSA (2003) recommends that monitoring programs reflect the scale and potential effects of the spill, and address key environmental issues relevant to the spill. This approach is considered best practice for oil spill monitoring in Australia and will be applied by Polarcus if spill monitoring is required. Monitoring appropriate to the nature and scale of the spill will be determined based on the hydrocarbon characteristics, the size and nature of the release (e.g. slow continuing release or instantaneous short-duration release), dispersion and dilution rates and the location of the spill that will determine the nature of the receiving environment.

10.3.8.1 Type I Operational Monitoring

In the event of an MGO spill to the waters surrounding the seismic vessel or support vessels, AMSA, as the Control Agency will be responsible for initiating an appropriate level of Type I "Operational Monitoring" using National Plan resources to monitor the spill and any response effort, if required. Operational monitoring may include spill surveillance and tracking to validate oil spill trajectory modelling. Polarcus may, at the direction of the Control Agency, support Type I "Operational Monitoring" with on-the-water surveillance to:

- Determine the extent and character of a spill;
- Track the movement and trajectory of surface MGO slicks;
- Identify areas/ resources potentially affected by surface slicks; and
- Determine sea conditions and potential constraints to spill response activities.

This monitoring will also enable the Vessel Master to provide information to the relevant Combat Agency (AMSA), via a POLREP/SITREP form, to allow for determination and planning of appropriate response actions under the National Plan (if required).

Operational Monitoring and observation in the event of a spill will inform an adaptive spill response and, if required, will support the identification of appropriate Scientific Monitoring of relevant key sensitive receptors (discussed further below).

Specific monitoring / data requirements for Type 1 Operational Monitoring may include:

- Estimation of sea state;
- Estimation of wind direction and speed;
- Locating and characterising any surface MGO slicks;
- GPS tracking;
- Manual or computer predictions of oil weathering (e.g. ADIOS) and trajectory; and
- GIS mapping.

Location and characterisation of slicks by Polarcus will likely be restricted to daylight hours only, when surface slicks will be visible from the seismic vessel or support vessels. However, evaluations of sea state and weather conditions from the vessel will continue until this function is taken over by the Combat Agency. The information gathered from this initial monitoring will be passed on to the relevant Combat Agency, via the POLREP form, but also via ongoing SITREP reports following the initial spill notification to AMSA RCC.

Polarcus will implement, assist with, or contribute to (including funding if required) any other Operational Monitoring (e.g. computer trajectory modelling) as directed by the Combat Agency.

10.3.8.2 Type II Scientific Monitoring

In the event of a spill of MGO in the marine environment, MGO is expected to undergo rapid evaporative weathering, with approximately 40% - 75% of the spill volume (comprising the most volatile and toxic fractions) expected to evaporate in the first 24 – 48 hours, and low exposures of entrained hydrocarbons subject to biodegradation and decay. Generally, negligible amounts of sea surface hydrocarbons persisted beyond 5 – 10 days.

Section 8.2 provides descriptions of the potentially affected environment and potential impacts of such a hydrocarbon spill on environmental and social receptors, including:

- Marine mammals;
- Marine reptiles;
- Fish and sharks;
- Seabirds and shorebirds; and
- Other marine users (e.g. commercial shipping, commercial fishing).

In the event of a vessel incident resulting in a major fuel release, Polarcus will work with AMSA and relevant stakeholders as described in Section 5, to develop and implement appropriate Type II Scientific Monitoring. The aim of the Scientific Monitoring is to understand the environmental impacts of the spill and response activities on the marine environment, with a focus on relevant environmental and social values and sensitive receptors.

The Scientific Monitoring program will be developed to ensure that it is sufficient to inform any remediation activities, and be consistent with monitoring guidelines and methodologies such as CSIRO (2016).

The Scientific Monitoring may comprise some or all of the monitoring studies described in Table 10-5. As described previously, in the event of a spill, Polarcus will engage with the relevant Combat Agency to coordinate and review Operational Monitoring data. Operational Monitoring may provide valuable surveillance and modelling data to confirm the predicted extent and degree of hydrocarbon exposure and impacts. These data will then be used to determine if Scientific Monitoring of relevant key sensitive receptors may be of value in the longer term to evaluate environmental impacts and recovery of affected receptors. The requirement for, and design of, Scientific Monitoring studies will be based on desktop/technical studies and/or field investigations, in order to ensure they are feasible and will obtain relevant information based on available monitoring data, the nature of the receiving environment and results of the consultation process.

For each Scientific Monitoring study triggered in Table 10-5, a detailed monitoring plan will be developed as per the template in Table 10-6. It is noted that where termination criteria for a study includes comparison to appropriate thresholds of concern, those thresholds will be confirmed and specified in the monitoring plan.

If deemed necessary, following consultation with the Combat Agency and relevant stakeholders (e.g. DoT, DoEE and/or DBCA), Polarcus will activate a contract with the company-approved environmental service provider Environmental Resources Management Australia Pty Ltd (ERM) to design and implement the appropriate Scientific Monitoring studies. ERM has previously developed Scientific Monitoring plans and undertaken a wide range of relevant marine environmental monitoring studies in northern Australia and internationally. ERM has the relevant skills, expertise and resources in place to provide scientific monitoring support.

Polarcus will keep ERM informed of the progress of the Petrelex 3D MSS and of any changes related to the risk assessments as documented in this EP. In addition to the required notifications described in Section 10.3.6, should a hydrocarbon spill occur, the Polarcus Emergency Core Team Leader will notify ERM within 24 hours of the spill occurring. Following that notification, ERM will make the necessary preparations for the potentially required monitoring studies.

Table 10-5 Polarcus Scientific Monitoring Studies

Scientific Monitoring Study	Objectives	Initiation Triggers	Termination Criteria
SM01: Hydrocarbon Exposures /Interactions and Marine Waters Study	■ Review and assess Operational Monitoring data and/or on-scene observations (e.g. aerial /vessel-based surveillance, shoreline assessment) to determine the extent, severity and persistence of hydrocarbon contamination; ■ Evaluate impacts to receptors (fauna, habitats) exposed to hydrocarbons based on observations, including surveillance and oiled wildlife records, if available; ■ Provide context on impact cause and effect relationships; and ■ Assess concentrations of hydrocarbons in marine waters.	■ A hydrocarbon spill results from the seismic survey; and ■ Agreement with relevant stakeholders that meaningful results can be provided by the study.	■ Operational Monitoring has ceased; ■ Operational Monitoring and other on-scene observational data has been reviewed and assessed; ■ Hydrocarbons are reported to be below thresholds of concern appropriate for the hydrocarbon / product; or ■ Elevated hydrocarbon concentrations are not detectable or statistically significant above background / reference concentrations (taking into account natural variability).
SM02: Shoreline Habitat Impact Study	■ Assess the range of shoreline habitats that were put at risk or exposed and collect information for the purposes of determining short-term and long-term impacts from hydrocarbon spill or the response activities.	■ Post-spill oil spill trajectory modelling predicts hydrocarbon contact or Operational Monitoring confirms that hydrocarbons have contacted shorelines; ■ SM01 identifies potential for longer-term impacts for the corresponding receptors that may be measurable above baseline conditions (taking into account natural variability); and ■ Agreement with relevant stakeholders that meaningful results can be provided by the study.	■ The extent, severity and persistence of impacts to the corresponding receptors has been assessed; or ■ The status and condition of the corresponding receptors cannot be statistically differentiated from background / reference conditions (taking into account natural variability).

Scientific Monitoring Study	Objectives	Initiation Triggers	Termination Criteria
SM03: Subtidal Habitat Impact Study	■ Assess the range of benthic primary producer habitats that were put at risk or exposed and collect information for the purposes of determining short-term and long-term impacts from hydrocarbon spill or the response activities.	■ Post-spill oil spill trajectory modelling predicts hydrocarbon contact or Operational Monitoring confirms that hydrocarbons have occurred at subtidal habitats; ■ SM01 identifies potential for longer-term impacts for the corresponding receptors that may be measurable above baseline conditions (taking into account natural variability); and ■ Agreement with relevant stakeholders that meaningful results can be provided by the study.	■ The extent, severity and persistence of impacts to the corresponding receptors has been assessed; or ■ The status and condition of the corresponding receptors cannot be statistically differentiated from background / reference conditions (taking into account natural variability).
SM04: Seabird and Shorebird Impact Study	■ Analyse records of oiled avifauna to evaluate potential impacts to seabird and shorebird populations; and ■ Evaluate the extent, severity and persistence of impacts of hydrocarbon exposure at targeted important bird areas (e.g. breeding colonies) if impacted by hydrocarbons.	■ Records of oiled avifauna made during Operational Monitoring or Operational Monitoring confirms that hydrocarbons have contacted important areas for seabirds or shorebirds (e.g. bird breeding colonies); ■ SM01 identifies potential for longer-term impacts for the corresponding receptors that may be measurable above baseline conditions (taking into account natural variability); and ■ Agreement with relevant stakeholders that meaningful results can be provided by the study.	■ The extent, severity and persistence of impacts to the corresponding receptors has been assessed; or ■ The status and condition of the corresponding receptors cannot be statistically differentiated from background / reference conditions (taking into account natural variability).

Scientific Monitoring Study	Objectives	Initiation Triggers	Termination Criteria
SM05: Marine Wildlife Impact Study	■ Analyse records of oiled wildlife to evaluate potential impacts to mobile marine megafauna (e.g. marine mammals, turtles, sharks and rays); and ■ Evaluate the extent, severity and persistence of impacts of hydrocarbon exposure at targeted important megafauna areas (e.g. turtle nesting beaches) if impacted by hydrocarbons.	■ Records of oiled megafauna made during Operational Monitoring or Operational Monitoring confirms that hydrocarbons have contacted important areas for marine megafauna (e.g. turtle nesting sites); ■ SM01 identifies potential for longer-term impacts for the corresponding receptors that may be measurable above baseline conditions (taking into account natural variability); and ■ Agreement with relevant stakeholders that meaningful results can be provided by the study.	■ The extent, severity and persistence of impacts to the corresponding receptors has been assessed; or ■ The status and condition of the corresponding receptors cannot be statistically differentiated from background / reference conditions (taking into account natural variability).
SM06: Fish Effects Study	■ Characterise the status and composition of fish assemblages (e.g. of representative functional trophic groups) exposed to hydrocarbons; and ■ Evaluate the extent, severity and persistence of impacts to fish assemblages, and their subsequent recovery	■ Post-spill oil spill trajectory modelling predicts hydrocarbon contact or Operational Monitoring confirms that hydrocarbons have occurred at important areas for fish; ■ SM01 identifies potential for longer-term impacts for the corresponding receptors that may be measurable above baseline conditions (taking into account natural variability); and ■ Agreement with relevant stakeholders that meaningful results can be provided by the study.	■ The extent, severity and persistence of impacts to the corresponding receptors has been assessed; or ■ The status and condition of the corresponding receptors cannot be statistically differentiated from background / reference conditions (taking into account natural variability).

Table 10-6 Scientific Monitoring Plan Template

Section	Content Description
Monitoring objectives and rationale	Study-specific objectives and critical success factors
Methodology	Approach, techniques and standards to be implemented
Termination criteria	Criteria for terminating the study
HSE Planning	HSE Risk Assessment and Management Plan (e.g. Job Hazard Analysis)
Survey / sampling plan (if applicable)	e.g. proposed sampling locations, numbers, frequencies, reference / control sites, statistical power analysis
Analysis plan	Analytical techniques to be implemented
Data and information requirements	Planning data and baseline / reference data
Field equipment and logistics (if applicable)	Required survey equipment, vessels, mobilisation and transport requirements
Personnel resources	Number of personnel required, qualifications and skill level
Subcontractor requirements	Required accreditations (e.g. NATA accredited laboratories) if applicable
Sample storage and transport requirements (if applicable)	Sample holding times, storage requirements and chain of custody procedures
Permits	Permit requirements/exemptions
Quality Control	QA/QC requirements for data and reporting
Reporting	Report format and communication of results to relevant stakeholders

10.3.9 *Cost Recovery*

Titleholders are required to maintain financial assurance sufficient to give the titleholder carrying out the petroleum activity, the capacity to meet the costs, expenses and liabilities that may result in connection with carrying out the petroleum activity; doing any other thing for the purpose of the petroleum activity; or complying (or failing to comply) with a requirement under the OPGGS Act in relation to the petroleum activity. This requirement is to be met by the titleholder before NOPSEMA can accept the EP.

Polarcus has insurance policies in place that would cover the costs of spill response, Type I Operational Monitoring and Type II Scientific Monitoring required in the event of a large hydrocarbon spill resulting from its activities. These policies cover activities in Australian Commonwealth and State waters.

Polarcus has determined the appropriate level of financial assurance required. A declaration and confirmation of financial assurance will be submitted to NOPSEMA prior to acceptance of this EP.

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APPENDIX A COMMITMENT TO ENVIRONMENT AND COMMUNITY

OUR COMMITMENT TO THE ENVIRONMENT AND THE COMMUNITY

Polarcus commits to protect and minimize the impact of our business on the environment and the communities where we work through established procedures and practices, both onshore and offshore. Polarcus continually seeks opportunities to be actively involved with local communities where we live and work.

Polarcus' goal is to never spill or discharge anything that could cause harm to the environment. In all activities, Polarcus complies with relevant legal regulations and strives to reduce, reuse or recycle wherever possible in order to help preserve our environment for future generations.

Polarcus establishes targets for minimizing waste and reducing emissions to ground, water and air. Measurement and monitoring of the progress of our environmental stewardship is continuously carried out and our findings reported in accordance with applicable regulatory requirements, internal Polarcus reporting requirements and in the annual Polarcus Sustainability Report.

Polarcus provides the latest technologies and initiatives available in the geophysical and maritime industries to minimize our environmental footprint, including:

- Use of low sulphur fuels
- Selective Catalytic Reduction (SCR) systems to reduce exhaust emissions
- Environmentally responsible hydraulic fluids
- Solid streamers
- Tail-buoys fitted with front guards to avoid harming turtles
- Using an oil-free seismic source with an optimized array, specifically designed to minimize noise impact to the surrounding environment

The Polarcus seismic fleet carries the stringent DNV GL Clean-Design notation. We are the first seismic company to hold the DNV GL BWM-T class notation. This means that our vessels operate a highly effective Ballast Water Management System (BWMS) that is 100% chemical free. These systems remove the threat of vessels introducing harmful foreign ballast waters to local ecosystems.

Polarcus is the first and only seismic company that has received the DNV GL Vessel Emissions Qualification Statement. This qualifies the methodology and accuracy of our emissions measurements. DNV GL has verified our ability to predict the exhaust emissions footprint for any project and accurately measure the actual emissions throughout the execution of a project.
In addition, Polarcus is the first company in the world to obtain the DNV GL Triple E™ Level 1 rating.

Duncan Eley, CEO

APPENDIX B COMMITMENT TO HEALTH AND SAFETY

OUR COMMITMENT TO HEALTH AND SAFETY

Polarcus continually evaluates the potential health and safety risks to anyone involved with Company operations. We comply with the Polarcus Management System, all applicable laws rules and regulations or administrative decisions of any government or regulatory body having jurisdiction in the countries where we operate.

Polarcus commits to not causing any harm to anyone. Everyone is encouraged and empowered to be a health and safety leader and to strive for the elimination of all incidents associated with company business. In addition, Polarcus urges everyone to share these beliefs with their family and friends outside of the workplace.

Anyone engaged in work on a Polarcus worksite or on behalf of Polarcus has the authority, the right and the obligation to intervene and stop any work that they feel is unsafe or inappropriate. Once any activity has been deemed unsafe or inappropriate, the work must cease and be reported to the immediate line manager or senior person on site for their review and action.

The activity may only resume once everyone involved is in agreement that it is safe and appropriate to continue.

Polarcus plans and monitors all activities that have any potential health and safety implications through a process of risk management and reduces any residual risk to As Low As Reasonably Practicable (ALARP).

Polarcus ensures that all employees and suppliers are trained and competent to plan and work safely.

Polarcus provides appropriate medical services for the treatment of occupational illnesses, injuries and medical emergencies that may occur at any of our worksites globally.

Polarcus is dedicated to maintaining a healthy, smoke free work environment. We shall eliminate the potential for exposure to all forms of second-hand smoke including smoke generated by electronic cigarettes, at all Polarcus worksites.

Polarcus endorses a safe driving culture and promotes the obligation of employees in helping to deliver a safe driving environment.

On an annual basis, Polarcus develops and shares with the organization strategies and goals for the continual improvement of our health and safety management system and ultimately the business.

Duncan Eley, CEO

APPENDIX C EPBC PROTECTED MATTERS SEARCH REPORTS

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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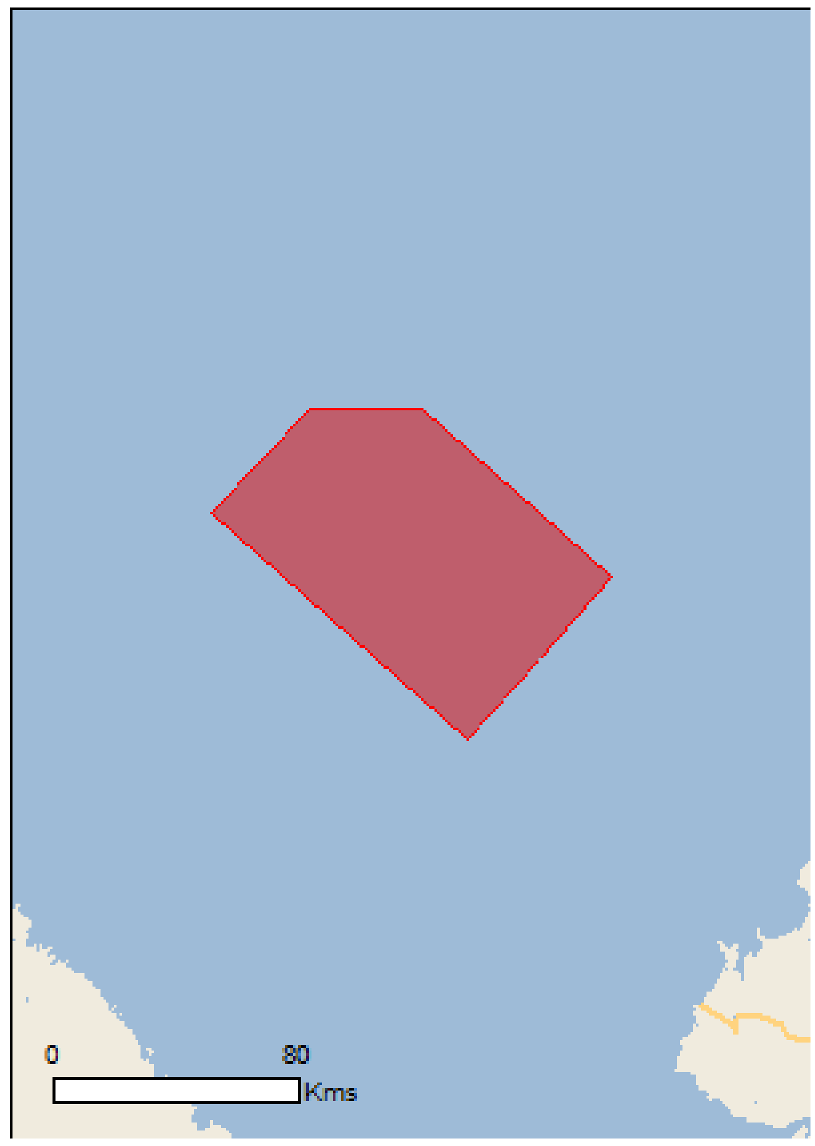

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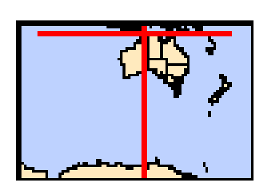

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	18
Listed Migratory Species:	33

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	66
Whales and Other Cetaceans:	13
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	1

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	None
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	1

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North
North-west

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Species or species habitat may occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Sharks		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Glyphis garricki Northern River Shark, New Guinea River Shark [82454]	Endangered	Species or species habitat may occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat may occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat likely to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat may occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Fish		
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis coggeri Slender-necked Seasnake [25925]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis inornatus Plain Seasnake [1107]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Hydrophis pacificus Large-headed Seasnake, Pacific Seasnake [1112]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Parahydrophis mertoni Northern Mangrove Seasnake [1090]		Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat may occur within area

Name	Status	Type of Presence
Tursiops aduncus (Arafura/Timor Sea populations)		
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat may occur within area
Tursiops truncatus s. str.		
Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Australian Marine Parks [Resource Information]

Name	Label
Oceanic Shoals	Multiple Use Zone (IUCN VI)

Extra Information

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Pinnacles of the Bonaparte Basin	North-west

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-12.82722 127.98944,-12.53 128.27528,-12.52639 128.61139,-13.01139 129.1638928,-13.47361 128.74111,-12.82722 127.98944

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

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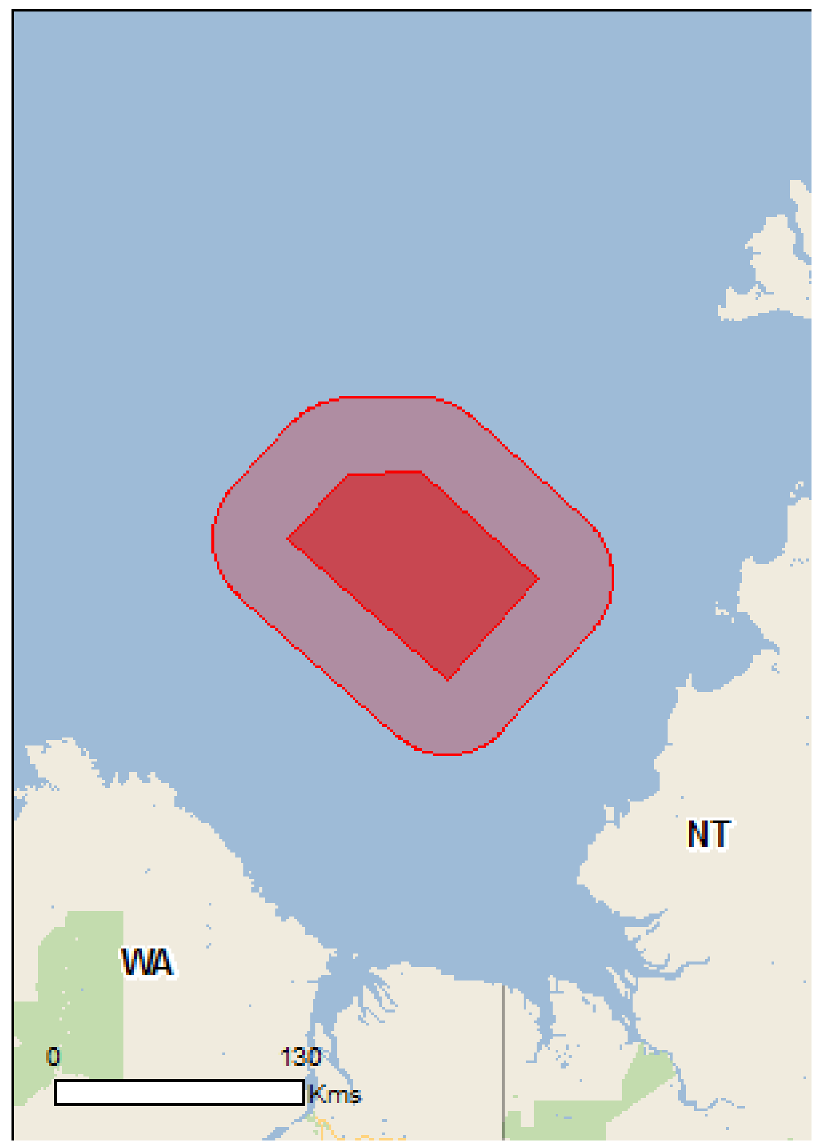
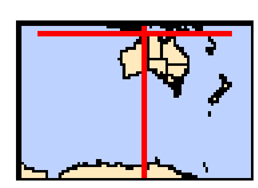


Coordinates
Buffer: 40.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	19
Listed Migratory Species:	37

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	68
Whales and Other Cetaceans:	14
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	2

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	None
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	3

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North
North-west

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Species or species habitat may occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Sharks		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Glyphis garricki Northern River Shark, New Guinea River Shark [82454]	Endangered	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Dugong dugon Dugong [28]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat likely to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat likely to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Fish		
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat may occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur

Name	Threatened	Type of Presence
		within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis coggeri Slender-necked Seasnake [25925]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis inornatus Plain Seasnake [1107]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Hydrophis pacificus Large-headed Seasnake, Pacific Seasnake [1112]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Parahydrophis mertoni Northern Mangrove Seasnake [1090]		Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		

Name	Status	Type of Presence
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat may occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Australian Marine Parks [Resource Information]

Name	Label
Joseph Bonaparte Gulf	Special Purpose Zone (IUCN VI)
Oceanic Shoals	Multiple Use Zone (IUCN VI)

Extra Information

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Pinnacles of the Bonaparte Basin	North
Carbonate bank and terrace system of the Sahul	North-west
Pinnacles of the Bonaparte Basin	North-west

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-12.82722 127.98944,-12.53 128.27528,-12.52639 128.61139,-13.01139 129.1638928,-13.47361 128.74111,-12.82722 127.98944

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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APPENDIX D STAKEHOLDER CONSULTATION LOG

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
Australian Fisheries Management Authority (AFMA)	2.1.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Australian Hydrographic Service (AHS)	2.2.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
	2.2.2	16/04/2019	Email/Letter from stakeholder	Automated response received.	No	N/A
Australian Marine Oil Spill Centre (AMOSC)	2.3.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Australian Maritime Safety Authority (AMSA)	2.4.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
	2.4.2	18/04/2019	Email/Letter to stakeholder	AMSA responded with a vessel traffic plot and further information on the use of the chartered shipping fairway. AMSA has requested that the survey vessel notify AMSA's Joint Rescue Coordination Centre before the survey commences. AMSA went on to state that the AHS will also need to be notified 4 working weeks before the survey comments for the promulgation of related notices to mariners.	Yes - Vessel Traffic Plot	Stakeholder has provided information and/or requested additional information. No objections or concerns were raised.

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
	2.4.3	29/04/2019	Email/Letter to stakeholder	Polarcus thanked AMSA for the vessel traffic plot. Polarcus provided AMSA with a list of controls that will be implemented. Polarcus advised AMSA that Polarcus will notify AMSA's Joint Rescue Coordination Centre (JRCC) 24-48 hours before operations commence for promulgation of radio-navigation warnings and the Australian Hydrographic Service will be contacted (4 weeks prior to survey commencement) for the promulgation of Notice to Mariners.	No	N/A
Beach Energy	2.5.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Commonwealth Fisheries Association (CFA)	2.6.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Department of Agriculture and Water Resources (DAWR) – Biosecurity (Marine Pests)	2.7.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Department of Communications and the Arts	2.8.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
Department of Defence	N/A	8/04/2019	Phone call to stakeholder	Phone call to Defence to inform Defence of the proposed Petrelex 3D MSS. Initial information was provided, ahead of the formal notification (as part of the consultation process). Polarcus requested information on the major military exercise scheduled for 2020. Defence was unable to provide details, and requested Polarcus to provide a formal notification.	N/A	N/A
	2.9.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes Information Sheet Polarcus Petrelex NAXA Figure	N/A
	2.9.2	13/05/2019	Email/Letter from stakeholder	Defence stated they have no objections to the survey; however, they advised Polarcus that the survey area is within the Northern Australia Exercise Area (NAXA) and partially within the Darwin Air Weapons Range (West). Polarcus was further advised that unexploded ordnance (UXO) may be present on and in the sea floor in the area of the proposed activities and Polarcus must, therefore, inform itself as to the risks associated with conducting activities in the area. Defence advised that they will be conducting a major military exercise within the NAXA during the period of between 1 August – 30 September 2020 (subject to rescheduling) and activities conducted within the NAXA and surrounding areas during this period are likely to be disrupted. Defence recommended that activities during this period should be rescheduled to avoid conflict with the exercise. Defence went on to advise that AHS is to be notified three weeks prior to the actual commencement of activities.	No	Stakeholder has provided information and/or requested additional information. No objections or concerns were raised.
	2.9.3	29/05/2019	Email/Letter to stakeholder	Polarcus thanked the Department of Defence for the email. Polarcus acknowledged that Defence will be undertaking a major military exercise within the NAXA during the period of between 1 August – 30 September 2020. Polarcus went on to state that it would endeavour to not acquire the Petrelex 3D MSS during this period to avoid any conflict with the exercise. Polarcus stated that notification to the Department will be provided a minimum of five weeks prior to the commencement of activities, via the email address provided below. In addition, the AHS will also be notified a minimum of three weeks prior to the commencement of activities. Defence stated that they require a minimum of five weeks notification prior to the commencement of activities.	No	N/A

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
Department of Industry, Innovation and Science (DoIIS)	2.10.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Director of National Parks	2.11.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
	2.11.2	30/04/2019	Email/Letter from stakeholder	Thanked Polarcus for the information provided. Requested information on the title(s) the proposed activity pertain to and who the holder of the title(s) is.	No	Stakeholder has provided information and/or requested additional information. No objections or concerns were raised.
	2.11.3	9/05/2019	Email/Letter to stakeholder	Polarcus advised Marine Parks that Petrelex 3D MSS will comprise acquisition of ~2,900 km2 over WA-6-R, NT/RL1 and open acreage and that Neptune Energy Bonaparte Pty Limited is the holder of both titles. Polarcus went on to mention that they would apply for an Access Authority (AA) title and Special Prospecting Authority (SPA) title from NOPTA prior to the submission of the EP to NOPSEMA.	No	N/A
	2.11.4	10/05/2019	Email/Letter from stakeholder	DNP thanked Polarcus for the information.	No	N/A
	2.11.5	10/05/2019	Email/Letter from stakeholder	DNP thanked Polarcus for the information. DNP went on to state that the planned activities do not overlap with any Australian Marine Parks. However, the Operational Area is immediately adjacent to Oceanic Shoals Marine Park and approximately 34 km from Joseph Bonaparte Gulf Marine Park. Therefore, there are no authorisation requirements from DNP. DNP confirmed they do not require any further information from Polarcus unless there are changes to the activity that may result in an overlap with a marine park, a new impact or for emergency responses. DNP stated that should there be oil/gas pollution within a marine park or impact to a marine park, DNP should be	No	Stakeholder has provided information and/or requested additional information. No objections or concerns were raised.

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
				notified immediately. DNP went on to state the information required in the notification.		
ENI Australia	2.12.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Environs Kimberley	2.13.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Kimberley Land Council (KLC)	2.14.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Melbana Energy	2.15.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
National Native Title Tribunal (NNTT)	2.16.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and	Yes - Information Sheet	N/A

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
				■ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.		
	2.16.2	15/04/2019	Email/Letter from stakeholder	Automated response received.	No	N/A
Northern Land Council	2.17.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Northern Prawn Fishing Industry Pty Ltd (NPFI)	N/A	8/04/2019	Phone call to stakeholder	Phone call to NPFI to inform the NPFI of the proposed Petrelex 3D MSS. Initial information was provided, ahead of the formal notification (as part of the consultation process). NPFI requested shapefiles for the proposed survey. No concerns were raised.	N/A	
	2.18.1	8/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached shapefiles for the acquisition and operational areas.	Yes - Petrel 3D Planned and Operational Area Shape files, Location Map	N/A
	2.18.2	16/04/2019	Email/Letter to stakeholder	Further email to the one dated 08.04.2019 advising of proposal to undertake the Petrelex 3D MSS. Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet, Relative Intensity for the NPF from 2013 - 2017	N/A
	2.18.3	17/04/2019	Email/Letter from stakeholder	Email thanking Polarcus for the information and we would get back to Polarcus.	No	N/A
	N/A	7/05/2019	Phone call to stakeholder	Phone call to NPFI, requesting any comments or queries on the proposed Petrelex 3D MSS. No answer received. Message left requesting call-back.	N/A	N/A
	N/A	21/05/2019	Phone call to stakeholder	Phone call to NPFI, requesting any comments or queries on the proposed Petrelex 3D MSS. No answer received. Message left requesting call-back.	N/A	N/A

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
	2.18.4	29/05/2019	Email/Letter to stakeholder	Follow up email sent, requesting any comments or queries on the proposed Petrelex 3D MSS. Polarcus advised NPFI that the Petrelex 3D MSS EP will be submitted to NOPSEMA mid-June 2019.	No	N/A
	2.18.5	30/05/2019	Email/Letter from stakeholder	Email received from NPFI. NPFI have no concerns; however will revert formally next week.	No	N/A
	N/A	19/06/2019	Phone call to stakeholder	Phone call to NPFI to seek feedback on the Petrelex 3D MSS. No answer received. Message left requesting a call-back.	N/A	N/A
	2.18.6	1/07/2019	Email/Letter from stakeholder	Follow up email sent, requesting any comments or queries on the proposed Petrelex 3D MSS. Polarcus advised NPFI that the Petrelex 3D MSS EP will be submitted to NOPSEMA mid-June 2019.	No	N/A
	N/A	2/07/2019	Phone call to stakeholder	Phone call to NPFI to seek feedback on the Petrelex 3D MSS. No answer received. Message left requesting a call-back.	N/A	N/A
	2.18.7	5/07/2019	Email/Letter from stakeholder	NPFI indicated that there is negligent historical fishing activity in the proposed Operational Area. However, fishing activity does take place near the operational area and has requested that all efforts need to be made to ensure there NPF commercial fishing operations are not disrupted. NPFI expressed concern about the immediate and future impacts of seismic activity on NPF prawn stocks given the lack of information. NPFI has urged Polarcus to take all measures to minimise and mitigate impacts on both NPF fishing operations and prawn stocks in the area. To minimise any potential impacts on NPF fishing operations, NPFI has requested that seismic exploration is undertaken outside of fishing seasons. The fishery is currently closed from 16th June to 31st July and from 1 December to 1 April each year. NPFI went on to state that they may seek compensation on behalf of the NPF Statutory Fishing Rights holders should there be any disruption to, or displacement of, NPF commercial fishing activities during the survey period. NPFI requested ongoing consultation on the Petrelex Survey.	No	Stakeholder has provided information and/or requested additional information. Stakeholder has raised concerns regarding impacts to commercial fisheries. Stakeholders concerns have been addressed in the EP
	2.18.8	10/07/2019	Email/Letter to stakeholder	Polarcus responded to NPFI and thanked NPFI on their comments. Polarcus noted NPFI's ongoing concern regarding the potential impacts of seismic survey activities on NPF prawn stocks and the lack of scientific information available on impacts to crustaceans. Information provided on historical fishing activity within the operational area and in proximity to the operational area has been incorporated into the EP. Polarcus went on to state that it has determined that compensation for commercial fishers is not an appropriate control or mitigation measure for the Petrelex 3D MSS, given the nature and scale of the activity, and the minimal impacts expected to the commercial fishing industry.	No	N/A No further response was received from the stakeholder at the time of EP submission.

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
				Polarcus acknowledges NPFI's request to schedule seismic acquisition outside of the NPF seasons. Currently, the Petrelex 3D MSS is scheduled to be acquired in Q1 2020; however, the precise timing is subject to NOPSEMA's acceptance of the EP, vessel availability, weather conditions and other operational considerations. Polarcus provided an update on the EP Timing / Acquisition. Polarcus will inform NPFI once the EP is open for public comment and review. Polarcus will provide a notification to the NPFI at least 4 weeks prior to survey commencement, indicating the survey timing and location. If NPFI is interested, a daily look-ahead report detailing the upcoming 48 hours survey events can be provided via email (or another preferred method).		
Northern Territory Seafood Council (NTSC)	2.19.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
NT Department of Environment and Natural Resources	2.20.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
NT Department of Primary Industries and Resources (Fisheries) (DPIR)	2.21.1	27/03/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Requested up to date information to assist with identifying relevant stakeholders. Also requested catch data.	No	N/A
	2.21.2	5/04/2019	Email/Letter to stakeholder	Follow up email sent based on the email dated 27/03/2019.	No	N/A
	2.21.3	5/04/2019	Email/Letter from stakeholder	Email received and acknowledged that DPIR will forward the information requested.	No	N/A
	2.21.4	5/04/2019	Email/Letter to stakeholder	Acknowledged email from DPIR.	No	N/A
	2.21.5	11/04/2019	Email/Letter from stakeholder	DPIR provided information on fisheries as well as catch-data.	No	Stakeholder has provided information and/or requested additional information. No objections or concerns were raised.

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
	2.21.6	11/04/2019	Email/Letter to stakeholder	Thanked DPIR for the information on fisheries and the catch-data. Provided DPIR with the map of the proposed survey location. Requested DPIR to confirm which fisheries have been active within the Operational Area over the last 5 Years.	Yes - Map of the Proposed Survey Location	N/A
	2.21.7	12/04/2019	Email/Letter from stakeholder	DPIR confirmed that fisheries with licenses in the Operational Area. Requested Polarcus also engage with Department of Environment and Natural Resources.	No	Stakeholder has provided information and/or requested additional information. No objections or concerns were raised.
	2.21.8	12/04/2019	Email/Letter to stakeholder	Thanked DPIR for the information provided and iterated that Department of Environment and Natural Resources has been engaged	No	N/A
	N/A	19/06/2019	Phone call to stakeholder	Phone call to DPIR to seek feedback on the proposed Petrelex 3D MSS. DPIR acknowledged receipt of initial email. DPIR to call-back once reviewed email.	N/A	N/A
	N/A	21/06/2019	Phone call from stakeholder	Phone call received from DPIR Scientist. The Department is in the process of preparing a response. DPIR would review fishing catch data and if possible relay this information back to Polarcus in the Departments response. Polarcus advised that the EP is planned to be submitted to NOPSEMA early-July. DPIR confirmed a response would be provided next week.	N/A	N/A
	2.21.9	25/06/2019	Email/Letter from stakeholder	DPIR provided information on catch fishery data and stated that only three fisheries have been active in the survey area for the last 10 years. DPIR also provided spawning information on the three fisheries.	No	Stakeholder has provided information and/or requested additional information. No objections or concerns were raised.
	2.21.10	26/06/2019	Email/Letter from stakeholder	DPIR provided Spawning information for key species	Yes - Lloyd 2006 Thesis Reproductive Dynamics of Saddletail and Crimson Snapper	Stakeholder has provided information and/or requested additional information. No objections or concerns were raised.
	2.21.11	25/06/2019	Email/Letter to stakeholder	Polarcus thanked DPIR for the information and requested species depth at which the species spawn, if available	No	N/A
	2.21.12	26/06/2019	Email/Letter from stakeholder	DPIR stated there is no specific information but provided a general depth at which species spawn.	No	Stakeholder has provided information and/or requested additional information. No objections or concerns were raised.
	2.21.13	26/06/2019	Email/Letter to stakeholder	Thanked DPIR for the information	No	N/A
	2.21.14	26/06/2019	Email/Letter from stakeholder	DPIR provided additional information on the catch percentage.	Yes - Map of stock areas	Stakeholder has provided information and/or requested additional information. No

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
					Stock structure report Jan 2018	objections or concerns were raised.
	2.21.15	27/06/2019	Email/Letter to stakeholder	Thanked DPIR for the information	No	N/A
NT Department of Primary Industries and Resources (Mines and Energy) (DPIR)	2.22.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
	N/A	19/06/2019	Phone call to stakeholder	Phone call to NT DPIR. No response received. Message left requesting call-back.	N/A	N/A
Pearl Producers Association of WA (PPA)	2.23.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Recfishwest	2.24.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Santos WA Northwest Pty Ltd	2.25.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ The location, schedule and description of activities to be undertaken; ▪ Types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Save the Kimberley	2.26.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on:	Yes - Information Sheet	N/A

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
				■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.		
Vocus	2.27.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
WA Department of Mines, Industry Regulation and Safety (DMIRS)	2.28.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
WA Department of Primary Industries and Regional Development (DPIRD) - Fisheries	N/A	8/04/2019	Phone call to stakeholder	Phone call to DPIRD Fisheries to inform the Department of the proposed Petrelex 3D MSS. Initial information was provided, ahead of the formal notification (as part of the consultation process).	N/A	N/A
	2.29.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet, Polarcus Petrel 3D MSS Presentation	N/A
	2.29.2	23/04/2019	Email/Letter from stakeholder	DPIRD requested clarification on what sound source will be used outside the acquisition area as the fact sheet stated "seismic source will not be operated at full power outside the acquisition area".	No	N/A

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
	2.29.3	9/05/2019	Email/Letter to stakeholder	Polarcus clarified that the seismic source of 2,495 cui will be used within the Acquisition Area and went on to state that the comment in the factsheet 'the seismic source will not be operated at full power outside the acquisition area' is incorrect. There is potential that the seismic source may be operated at full power outside the Acquisition Area during line run-ins and line run-outs. Polarcus also mentioned that draft impact assessments will be provided to DPIRD.	No	N/A
	2.29.4	7/06/2019	Email/Letter from stakeholder	DPIRD requested Polarcus provide the WA petroleum permit for the survey.	No	N/A
	2.29.5	17/06/2019	Email/Letter to stakeholder	Polarcus clarified the permit areas and the license holder. Polarcus also mentioned that an Access Authority (AA) title and Special Prospecting Authority (SPA) title from NOPTA will be applied for prior to the submission of the EP to NOPSEMA	No	N/A
	2.29.6	19/06/2019	Email/Letter from stakeholder	Email received from DPIRD WA. Department requested Polarcus consult with the following stakeholders: ▪ WAFIC ▪ PPA ▪ Recfishwest ▪ Relevant Traditional Owner groups. DPIRD would not support any proposed seismic survey where risk is severe or high, in-particular for immobile and mobile invertebrates and demersal finfish species. DPIRD requests a percent calculation of the overlap the Petrelex 3D MSS will have on key stocks in the Operational Area. DPIRD requests that no seismic survey acquisition occurs during spawning periods for key species. DPIRD attached updating spawning information on key indicator species in the North Coast Bioregion.	Yes - Updated Finfish Spawning Advice May 2019	Stakeholder has raised an objection, claim or concern. The objection or claim has merit and is addressed in the EP. Stakeholder has been advised of the outcome.
	N/A	20/06/2019	Phone call to stakeholder	Phone call to DPIRD to seek clarification on stock boundaries for the Kimberley region. No answer. Message left requesting call back.	N/A	N/A
	N/A	24/06/2019	Phone call to stakeholder	Phone call to DPIRD to seek clarification on stock boundaries for the Kimberley region. No answer. Message left requesting call back.	N/A	N/A
	2.29.7			Polarcus confirmed that WAFIC, PPA, Recfishwest and the relevant Traditional Owners groups have been consulted. In addition the relevant fishing license holders for WA and NT have also been consulted. Polarcus has obtained catch and effort data (i.e. Fishcube) from DPIRD Fisheries. Fishcube data has been used to assist	No	N/A

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
				Polarcus in the identification of relevant commercial fisheries, and to supplement existing scientific literature. Based on the FishCube data, disruptions to WA fishing operations are therefore, anticipated to be temporary and not significant. Based on the spawning information provided by DPIRD, the effects of the survey are not expected to result in a significant impact to the spawning biomass or recruitment of key indicator species. In addition, no discernible population level impacts are expected to occur, the risk to spawning is considered to be acceptable. Due to the small spatial and temporal overlap of the Petrelex 3D MSS, the lack of preferred habitats present in the Operational Area, and the multiple, broadcast spawning behaviours of commercially targeted fish species in the region, these species are not expected to be effected to a degree that would result in population level impacts. The impact has been assessed to be low risk and acceptable based on the potential spatial and temporal overlap.		
Western Australian Fishing Industry Council (WAFIC)	N/A	8/04/2019	Phone call to stakeholder	Phone call to WAFIC to inform WAFIC of the proposed Petrelex 3D MSS. Initial information was provided, ahead of the formal notification (as part of the consultation process). WAFIC requested consultation information to be provided as a package and not as separate documents.	N/A	N/A
	2.30.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ▪ the location, schedule and description of activities to be undertaken; ▪ types of vessels to be used and logistical arrangements, as known; and ▪ Potential impacts and control measures A presentation deck with the following information was also attached: ▪ Survey information and map ▪ Information on the commercial fisheries that overlap with the survey Timing of key biological and socio-economic sensitivities Key indicator species Cumulative assessment Potential control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet, Polarcus Petrel Information Presentation	N/A

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
	2.30.2	17/04/2019	Email/Letter from stakeholder	WAFIC thanked Polarcus for providing information in a consolidated format. WAFIC provided feedback and information on the following fisheries: ■ Northern Demersal Scalefish ■ Mackerel Managed Fishery ■ Joint Authority Shark Fishery ■ Southern Bluefin Tuna ■ Skipjack Tuna ■ Pearling WAFIC went on to provide information in regards to the key indicator species information Polarcus provided. WAFIC requested that no seismic survey activities are to be undertaken during peak spawning of the key indicator species of commercial fisheries overlapping the Operational Area.	No	Stakeholder has provided information and/or requested additional information. Stakeholder has raised concerns regarding impacts to commercial fisheries. Stakeholders concerns have been addressed in the EP.
	2.30.3	29/04/2019	Email/Letter to stakeholder	Polarcus thanked WAFIC for the feedback and responded to WAFIC's queries. In particular, Polarcus mentioned that engagement is underway with WA DPIRD (Fisheries) and NT DPIR (Fisheries) to better understand spawning patterns and distributions of the key indicator species in the Operational Area.	No	N/A
	2.30.4	29/04/2019	Email/Letter from stakeholder	WAFIC mentioned that the amount of stakeholder consultation received versus fair and equitable outcomes included in an environment plan do not encourage companies (who are extremely busy with their own businesses) to divert time to a process which always results in additional stress and operation costs, potential costs to the resource and impact costs regarding fishing catchability – with the expectation that commercial fishers meet all mitigation costs. WAFIC went on to state that where a proponent i.e. Polarcus cannot address potential impacts to commercial fishing activities and the commercial fishing resource to ALARP levels (and this is ALARP levels from a commercial fisher understanding/perspective) including cumulative impacts, and the commercial fishing sector is therefore negatively impacted by this proposed activity, then the expectation is that a “make good” process will be formally included in the Polarcus EP. It is completely unacceptable for commercial fishers to continue to wear all costs for survey mitigations.	No	Stakeholder has provided information and/or requested additional information. No objections or concerns were raised.

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
				It is WAFIC's expectation that a "make good" process be formally incorporated into the Polarcus Petrelex 3D MSS environment plan.		
	2.30.5	9/05/2019	Email/Letter to stakeholder	Polarcus thanked WAFIC for the response. In regards to the 'make-good' process – Polarcus agree it can be an appropriate mechanism for compensating fishers who are impacted by a seismic survey, either by displacement or from a loss of catch, however compensation has to be assessed on a case-by-case basis. If compensation is appropriate for the activity, an appropriate process should be developed in collaboration with stakeholders. Polarcus has determined that compensation for commercial fishers is not an appropriate control or mitigation measure for the Petrelex 3D MSS, given the nature and scale of the activity, and the minimal impacts expected to the commercial fishing industry.	No	N/A No further response was received from WAFIC at time of EP submission.
Wilderness Society	2.31.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Woodside Energy	2.32.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
World Wildlife Fund for Nature (WWF)	2.33.1	16/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the Petrelex 3D MSS. Attached Information Sheet provided information on: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
Mackerel Managed Fishery - All licence holders	N/A	15/04/2019	Email/Letter to stakeholder	Letter sent out by Polarcus. Factsheet provided details on the: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures. Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Northern Demersal Scalefish Managed Fishery - All licence holders	N/A	15/04/2019	Email/Letter to stakeholder	Letter sent out by Polarcus. Factsheet provided details on the: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures. Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Northern Shark Fishery - All licence holders	N/A	15/04/2019	Email/Letter to stakeholder	Letter sent out by Polarcus. Factsheet provided details on the: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures. Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
NT Demersal Fishery - All licence holders	N/A	15/04/2019	Email/Letter to stakeholder	Letter sent out by Polarcus. Factsheet provided details on the: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures. Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Offshore net and Line Fishery - All licence holders	N/A	15/04/2019	Email/Letter to stakeholder	Letter sent out by Polarcus. Factsheet provided details on the: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures. Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A

Stakeholder	Sensitive Matters Report Ref #	Date of Correspondence	Type of Correspondence	Summary of Correspondence	Attachments	Assessment of Merit (Objection or Claim)
Pearl Oyster Fishery - All licence holders	N/A	15/04/2019	Email/Letter to stakeholder	Letter sent out by Polarcus. Factsheet provided details on the: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures. Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A
Spanish Mackerel Fishery - All licence holders	N/A	15/04/2019	Email/Letter to stakeholder	Letter sent out by Polarcus. Factsheet provided details on the: ■ The location, schedule and description of activities to be undertaken; ■ Types of vessels to be used and logistical arrangements, as known; and ■ Potential impacts and control measures. Requested any feedback be provided prior to 20 May 2019.	Yes - Information Sheet	N/A

APPENDIX E ACOUSTIC MODELLING REPORT

Polarcus Petrel 3-D Marine Seismic Survey

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

Submitted to:

Jared Davidson
Environmental Resources Management
Contract Agreement Date: 6 March 2019

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Disclaimer:

The results presented herein are relevant within the specific context described in this report. They could be misinterpreted if not considered in the light of all the information contained in this report. Accordingly, if information from this report is used in documents released to the public or to regulatory bodies, such documents must clearly cite the original report, which shall be made readily available to the recipients in integral and unedited form.

Suggested citation:

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Executive Summary

JASCO Applied Sciences performed a numerical estimation study of underwater sound levels associated with the planned Polarcus Petrel 3-D Marine Seismic Survey (MSS) to assist in understanding the potential acoustic impact on key regional receptors including cetaceans, fish, turtles, benthic invertebrates, and plankton. Modelling considered two survey directions using a 2495 in^3 seismic source in a flip-flap-flop configuration, towed at a 6 m depth behind a single vessel.

A specialised airgun array source model was used to predict the acoustic signature of the seismic source, and complementary underwater acoustic propagation models were used in conjunction with the modelled array signature to estimate sound levels over a large area around the source. Single-impulse sound fields were predicted at two defined locations within the Acquisition Area, and accumulated sound exposure fields were predicted for two representative scenarios for likely survey operations over 24 hours.

The modelling methodology considered source directivity and range-dependent environmental properties in each of the areas assessed. Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p), zero-to-peak pressure levels (PK, L_{pk}), peak-to-peak pressure levels (PK-PK; $L_{pk\text{-}pk}$), and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria. A conservative sound speed profile that would be most supportive of sound propagation conditions for the period of the survey was defined and applied to all modelling.

The analysis considered the distances away from the seismic source at which several effects criteria or relevant sound levels were reached. The results are summarised below for the representative single-impulse sites and accumulated SEL scenarios.

Cetacean injury and behaviour

- The maximum distance where the NMFS (2014) cetacean behavioural response criterion of 160 dB re 1 µPa (SPL) could be exceeded was approximately 7.5 km.
- The results for the criteria applied for cetacean Permanent Threshold Shift (PTS), NMFS (2018), consider both metrics within the criteria (PK and SEL24h). The longest distance associated with either metric is required to be applied. The table below summarises the maximum distances for PTS, along with the relevant metric.
- The 24-h SEL is a cumulative metric that reflects the dosimetric impact of noise levels within 24 hours considering that an animal is consistently exposed to such noise levels at a fixed position. The corresponding 24-h SEL radii for low-frequency cetaceans were larger than those for peak pressure criteria, but they represent an unlikely worst-case scenario. More realistically, marine mammals (and fish) would not stay in the same location for 24 hours. Therefore, a reported radius for 24-h SEL criteria does not mean that marine fauna travelling within this radius of the source will be injured, but rather that an animal could be exposed to the sound level associated with injury (either PTS or TTS) if it remained in that location for 24 hours.

Table 1. Summary of maximum cetacean PTS onset distances for 24 h SEL modelled scenarios.

Relevant hearing group	Metric associated with longest distance to PTS onset	R_{max} (km)	
		Scenario 1	Scenario 2
Low-frequency cetaceans	SEL_{24h}†	1.19	2.43
Mid-frequency cetaceans	PK	<0.02	<0.02
High-frequency cetaceans	PK	0.37	0.39

† The model does not account for shutdowns.

Turtles

- The PK turtle injury criteria of 232 dB re 1 µPa for PTS and 226 dB re 1 µPa for TTS from Finneran et al. (2017) was not exceeded at a distance greater than 20 m from the centre of the array. Because the arrays are not a point source (approximately 14 × 8 m), the actual ranges from the edge of airgun arrays are small.

- The distances to where the NMFS criterion (NSF 2011a) for behavioural effects in turtles of turtles of 166 dB re 1 µPa (SPL) and the 175 dB re 1 µPa (SPL) Moein et al. (1995) could be exceeded are summarised in Table 2.

Table 2. Distances to turtle behavioural response criteria

SPL (L_p; dB re 1 µPa)	Distance (km)		
	Scenario 1*		Scenario 2
	Min	Max	Single Site
175†	1.49	1.59	1.53
166‡	4.38	4.51	4.53

* Minimum and maximum distances to criterion level - multiple modelling sites in scenario.
† Threshold for turtle behavioural response to impulsive noise (Moein et al. 1995).
‡ Threshold for turtle behavioural response to impulsive noise (NSF 2011b).

Fish, fish eggs, and fish larvae

- This modelling study assessed the ranges for quantitative criteria based on Popper et al. (2014) and considered both PK and SEL_{24h} metrics associated with mortality and potential mortal injury and impairment in the following groups:
  - Fish without a swim bladder (also appropriate for sharks in the absence of other information)
  - Fish with a swim bladder that do not use it for hearing
  - Fish that use their swim bladders for hearing
  - Fish eggs and fish larvae
- Table 3 summarises the distances to injury criteria for fish, fish eggs, and fish larvae along with the relevant metric and the location of the information within this report.

Table 3. Summary of maximum fish, fish eggs, and larvae injury and TTS onset distances for single impulse and SEL_{24h} modelled scenarios.

Relevant hearing group	Injury criteria	Water column			Seafloor		
		Metric associated with longest distance to injury criteria	R_{max} (km)		Metric associated with longest distance to injury criteria	R_{max} (km)	
			Scenario 1	Scenario 2		Scenario 1	Scenario 2
Fish: No swim bladder	Injury	PK	0.07	0.06	PK	0.07	0.06
	TTS	SEL_{24h}	3.08	5.06	SEL_{24h}	2.98	5.06
Fish: Swim bladder not involved in hearing Swim bladder involved in hearing	Injury	PK	0.16	0.14	PK	0.20	0.20
	TTS	SEL_{24h}	3.08	5.06	SEL_{24h}	2.98	5.06
Fish eggs, and larvae	Injury	PK	0.16	0.14	PK	0.20	0.20

Crustaceans, Sponges and Coral, and Plankton

To assist with assessing the potential effects on these receptors, the following have been determined:

- Crustaceans: The sound level of 202 dB re 1 µPa PK-PK from Payne et al. (2008) was considered; it was reached at ranges between 494 and 681 m depending on the modelled site.
- Sponges and coral: The PK sound level at the seafloor directly underneath the seismic source was estimated at both modelling sites considered for seafloor fish receptors and compared to the sound level of 226 dB re 1 µPa PK for sponges and corals (Heyward et al. 2018); it was found that the level was not reached at either site.
- Plankton: The distance to the sound level of 178 dB re 1 µPa PK-PK from McCauley et al. (2017) was estimated at both modelling sites through full-waveform modelling using FWRAM; the results ranged from 6.74 to 6.95 km.

1. Introduction

JASCO Applied Sciences (JASCO) performed a numerical estimation study of underwater sound levels associated with the planned Polarcus Petrel 3-D Marine Seismic Survey (MSS) to assist in understanding the potential acoustic impact on key regional receptors including fish, cetaceans, benthic invertebrates, plankton, and turtles. Modelling considered a 2495 in^3 seismic source in a flip-flap-flop configuration, towed at a 6 m depth behind a single vessel. Two survey tow directions were considered in this study.

JASCO's specialised Airgun Array Source Model (AASM) was used to predict the acoustic signature of the array. AASM accounts for individual airgun volumes and array geometry. Complementary underwater acoustic propagation models were used in conjunction with the modelled array signature to estimate sound levels over a large area around the source. Single-impulse sound fields were predicted at defined locations within the Acquisition Area, and accumulated sound exposure fields were predicted for two representative scenarios for likely survey operations over 24 h. A conservative sound speed profile that would be most supportive of sound propagation conditions for the period of the survey was defined and applied at each of the modelling locations.

The modelling methodology considered source directivity and range-dependent environmental properties. Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p), zero-to-peak pressure levels (PK, L_{pk}), peak-to-peak pressure levels (PK-PK; $L_{pk\text{-}pk}$), and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria.

2. Modelling Scenarios

Two standalone single impulse sites and two likely scenarios for survey operations over 24 hours to assess accumulated SEL were defined. The locations of the modelling sites are provided in Table 4, with all sites and the acquisition lines shown in Figure 1 along with the survey boundaries. The modelling assumed that the survey vessel sailed along the survey lines at ~4.4 knots, with an impulse interval of 12.5 m. For Scenario 1, the considered survey lines took ~10 h (each) to traverse with ~3.55 h of turn time required between the lines, which accounts for 13084 impulses. For Scenario 2, the considered survey lines took ~5.3 h (each) to traverse and ~7.1 h of turn time, which accounted for 10445 impulses.

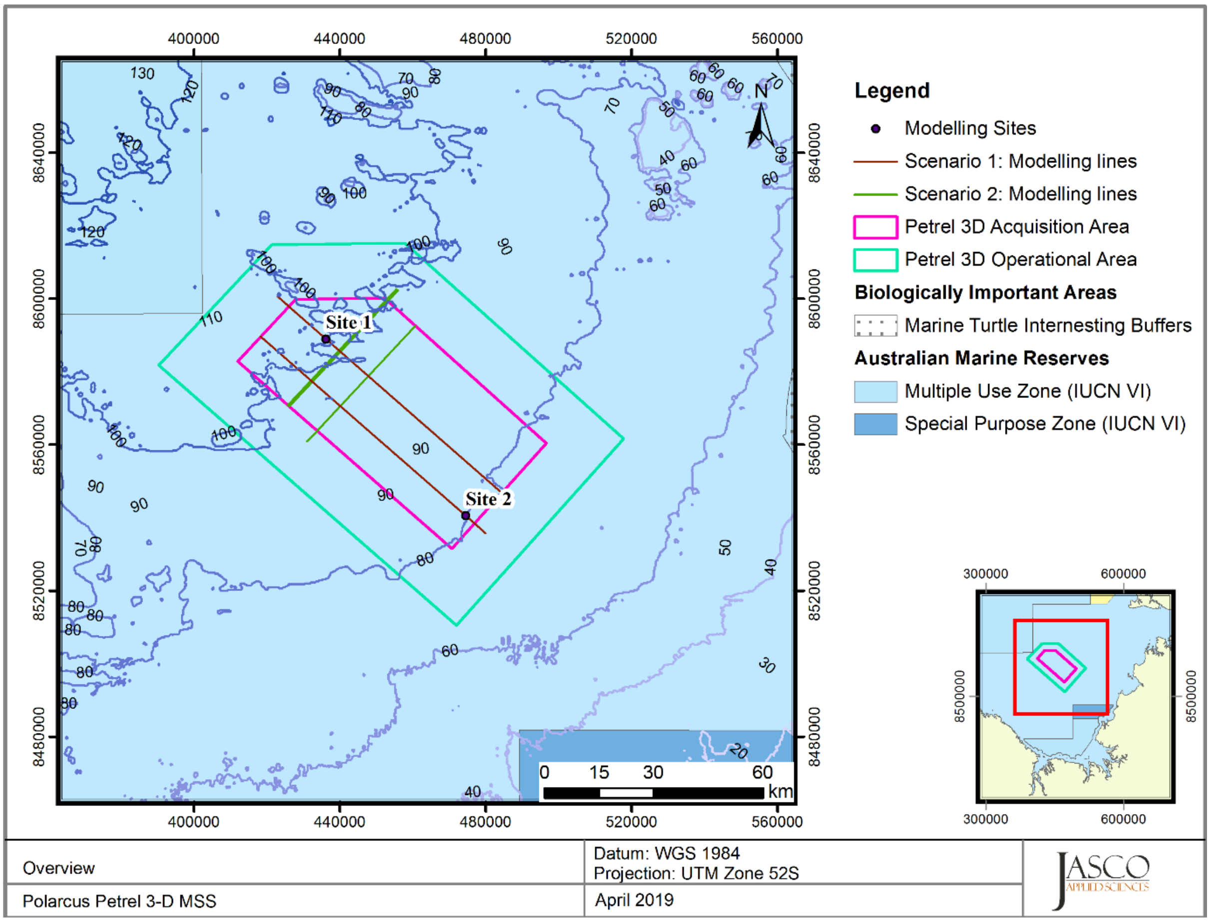

Figure 1. Overview of the modelling sites, acquisition lines, and features for the Polarcus Petrel 3-D marine seismic survey (MSS) modelling.

Table 4. Location details for the modelling sites.

Site	Latitude (S)	Longitude (E)	UTM (WGS1984), Zone 52S		Water depth (m)	Representative tow direction (°)
			X (m)	*Y* (m)		
1	12° 45' 50.7559"	128° 24' 44.1737"	436205	8588879	100	Scenario 1: 131 & 311 Scenario 2: 43 & 223
2	13° 12' 8.7160"	128° 45' 53.0384"	474508	8540467	81	Scenario 1: 131 & 311

3. Noise Effect Criteria

The perceived loudness of sound, especially impulsive noise such as from seismic airguns, is not generally proportional to the instantaneous acoustic pressure. Rather, perceived loudness depends on the pulse rise-time and duration, and the frequency content. Several sound level metrics, such as PK, SPL, and SEL, are commonly used to evaluate noise and its effects on marine life (Appendix A). The period of accumulation associated with SEL is defined, with this report referencing either a "per pulse" assessment or over 24 h. Appropriate subscripts indicate any applied frequency weighting; unweighted SEL is defined as required. The acoustic metrics in this report reflect the updated ISO standard for acoustic terminology, ISO/DIS 18405.2:2017 (2017).

Whether acoustic exposure levels might injure or disturb cetaceans is an active research topic. Since 2007, several expert groups have investigated an SEL-based assessment approach for injury, with a handful of key papers published on the topic. The number of studies that investigated the level of disturbance to marine animals by underwater noise has also increased substantially.

We chose the following noise criteria and sound levels for this study because they include standard thresholds, thresholds suggested by the best available science, and sound levels presented in literature for species with no suggested thresholds (Section 3 and Appendix A):

1. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,\text{24h}}$) from the U.S. National Oceanic and Atmospheric Administration (NOAA) Technical Guidance (NMFS 2018) for the onset of Permanent Threshold Shift (PTS) in cetaceans.
2. Cetacean behavioural threshold based on the current interim U.S. National Marine Fisheries Service (NMFS 2014) of 160 dB re 1 µPa SPL (L_{p}) for impulsive sound sources.
3. Sound exposure guidelines for fish, fish eggs and larvae, and turtles (Popper et al. 2014).
4. A threshold for turtle PTS of 232 dB re 1 µPa (PK) (Finneran et al. 2017), and a behavioural response of 166 dB re 1 µPa SPL (L_{p}) (NSF 2011b), as applied by the U. S. NMFS, along with a sound level associated with an increased level of response 175 dB re 1 µPa (SPL) (Moein et al. 1995, McCauley et al. 2000a, McCauley et al. 2000b, NSF 2011b).
5. A sound level 178 dB re 1 µPa PK-PK in the water column, reported for comparison to the results in McCauley et al. (2017) for plankton.
6. Peak-peak pressure levels (PK-PK; $L_{\text{pk-pk}}$) at the seafloor to help assess effects of noise on crustaceans and bivalves, for comparison to results in Payne et al. (2008), and Day et al. (2016).
7. A sound level of 226 dB re 1 µPa PK (L_{pk}) reported for comparing to Heyward et al. (2018) for sponges and corals.

Additionally, to assess the size of the low-power zone required under the Australian Environment Protection and Biodiversity Conservation (EPBC) Act Policy Statement 2.1, Department of the Environment, Water, Heritage and the Arts (DEWHA 2008), the distance to an unweighted per-pulse SEL of 160 dB re 1 µPa^2·s is reported.

The following section expands on the thresholds and sound levels for cetaceans, fish, turtles, fish eggs, and fish larvae and benthic invertebrates.

3.1. Cetaceans

The criteria applied in this study to assess possible effects of airgun noise on cetaceans are summarised in Table 5 and detailed in Sections 3.1.1 and 3.1.2, with frequency weighting explained in Appendix A.3.

Table 5. Unweighted SPL, SEL_{24h}, and PK thresholds for acoustic effects on cetaceans.

Hearing group	NMFS (2013)	NMFS (2018)			
	Behaviour	PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)	PK (L_{pk}; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)	PK (L_{pk}; dB re 1 µPa)
Low-frequency cetaceans	160	183	219	168	213
Mid-frequency cetaceans		185	230	170	224
High-frequency cetaceans		155	202	140	196

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.
L_p-denotes sound pressure level period and has a reference value of 1 µPa.
L_{pk}, flat–peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa.
L_E - denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa^{2}s.
Subscripts indicate the designated cetacean auditory weighting.

3.1.1. Behavioural response

Southall et al. (2007) extensively reviewed cetacean behavioural responses to sounds. Their review found that most cetaceans exhibited varying responses between 140 and 180 dB re 1 µPa SPL, but inconsistent results between studies makes choosing a single behavioural threshold difficult. Studies varied in their lack of control groups, imprecise measurements, inconsistent metrics, and that animal responses depended on study context, which included the animal's activity state. To create meaningful quantitative data from the collected information, Southall et al. (2007) proposed a severity scale that increased with increasing sound levels.

NMFS has historically used a relatively simple sound level criterion for potentially disturbing a cetacean. For impulsive sounds, this threshold is 160 dB re 1 µPa SPL for cetaceans (NMFS 2013). This threshold has been applied for this report.

3.1.2. Injury and hearing sensitivity changes

There are two categories of auditory threshold shifts or hearing loss: permanent threshold shift (PTS), a physical injury to an animal's hearing organs and Temporary Threshold Shift (TTS), a temporary reduction in an animal's hearing sensitivity as the result of receptor hair cells in the cochlea becoming fatigued.

To assist in assessing the potential for injuries to cetaceans, this report applies the criteria recommended by NMFS (2018), considering both PTS and TTS. Appendix A.2 provides more information about the NMFS (2018) criteria.

3.2. Fish, Turtles, Fish Eggs, and Fish Larvae

In 2006, the Working Group on the Effects of Sound on Fish and Turtles was formed to continue developing noise exposure criteria for fish and turtles, work begun by a panel convened by NOAA two years earlier. The resulting guidelines included specific thresholds for different levels of effects and for different groups of species (Popper et al. 2014). These guidelines defined quantitative thresholds for three types of immediate effects:

- Mortality, including injury leading to death.
- Recoverable injury, including injuries unlikely to result in mortality, such as hair cell damage and minor haematoma.
- TTS.

Masking and behavioural effects can be assessed qualitatively, by assessing relative risk rather than by specific sound level thresholds. These effects are not assessed in this report. Because the presence or absence of a swim bladder has a role in hearing, fish's susceptibility to injury from noise exposure varies depending on the species and the presence and possible role of a swim bladder in hearing. Thus, different thresholds were proposed for fish without a swim bladder (also appropriate for sharks and applied to whale sharks in the absence of other information), fish with a swim bladder not used for hearing, and fish that use their swim bladders for hearing. Turtles, fish eggs, and fish larvae are considered separately.

Table 6 lists relevant effects thresholds from Popper et al. (2014). In general, any adverse effects of seismic sound on fish behaviour depends on the species, the state of the individuals exposed, and other factors. We note that, despite mortality being a possibility for fish exposed to airgun sounds, Popper et al. (2014) do not reference an actual occurrence of this effect. Since the publication of that work, newer studies have further examined the question of possible mortality. Popper et al. (2016) adds further information to the possible levels of impulsive seismic airgun sound to which adult fish can be exposed without immediate mortality. They found that the two fish species in their study, with body masses in the range 200–400 g, exposed to a single-impulse of a maximum received level of either 231 dB re 1 μPa (PK) or 205 dB re 1 $\mu Pa^2 \cdot s$ (SEL), remained alive for 7 days after exposure and that the probability of mortal injury did not differ between exposed and control fish.

The SEL metric integrates noise intensity over some period of exposure. Because the period of integration for regulatory assessments is not well defined for sounds that do not have a clear start or end time, or for very long-lasting exposures, it is required to define a time. Popper et al. (2014) recommend a standard period should be applied, where this is either defined as a justified fixed period or the duration of the activity, however also include caveats about how long the fish will be exposed because they can move (or remain in location) and so can the source. Popper et al. (2014) summarises that in all TTS studies considered, fish that showed TTS recovered to normal hearing levels within 18–24 hours. Due to this, a period of accumulation of 24 hours has been applied in this study for SEL, which is similar to that applied for cetaceans in NMFS (2016, 2018).

In the discussion of the criteria, Popper et al. (2014) discuss the complications in determining a relevant period of mobile seismic surveys, as the received levels at the fish change between impulses due to the mobile source, and that in reality a revised guideline based on the closest PK or the per-pulse SEL might be more useful than one based on accumulated SEL. This is because exposures at the closest point of approach are the primary exposures contributing to a receiver's accumulated level (Gedamke et al. 2011). Additionally, several important factors determine the likelihood and duration a receiver is expected to be in close proximity to a sound source (i.e., overlap in space and time between the source and receiver). For example, accumulation time for fast moving (relative to the receiver) mobile sources is driven primarily by the characteristics of source (i.e., speed, duty cycle; NMFS 2016, 2018).

Table 6. Criteria for seismic noise exposure for fish and turtles, adapted from Popper et al. (2014).

Type of animal	Mortality and Potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	>219 dB SEL_{24h} or >213 dB PK	>216 dB SEL_{24h} or >213 dB PK	>>186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	210 dB SEL_{24h} or >207 dB PK	203 dB SEL_{24h} or >207 dB PK	>>186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{24h} or >207 dB PK	203 dB SEL_{24h} or >207 dB PK	186 dB SEL_{24h}	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate
Fish eggs and fish larvae	>210 dB SEL_{24h} or >207 dB PK	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Notes: Peak sound level (PK) dB re 1 µPa; SEL_{24h} dB re 1µPa²·s. All criteria are presented as sound pressure, even for fish without swim bladders, since no data for particle motion exist. Relative risk (high, moderate, or low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

3.2.1. Turtles

There is a paucity of data regarding responses of turtles to acoustic exposure, and no studies of hearing loss due to exposure to loud sounds. For turtle injury, a PTS of 232 dB re 1 µPa (PK), and TTS of 226 dB re 1 µPa (PK) from Finneran et al. (2017) has been applied as it represents updated information compared to the information in Popper et al. (2014).

There is a paucity of data regarding responses of turtles to acoustic exposure, and no studies of hearing loss due to exposure to loud sounds. McCauley et al. (2000a) observed the behavioural response of caged turtles—green (*Chelonia mydas*) and loggerhead (*Caretta caretta*)—to an approaching seismic airgun. For received levels above 166 dB re 1 µPa (SPL), the turtles increased their swimming activity and above 175 dB re 1 µPa they began to behave erratically, which was interpreted as an agitated state. The 166 dB re 1 µPa level has been used as the threshold level for a behavioural disturbance response by NMFS and applied in the Arctic Programmatic Environment Impact Statement (PEIS) (NSF 2011a). At that time, and in the absence of any data from which to determine the sound levels that could injure an animal, TTS or PTS onset were considered possible at an SPL of 180 dB re 1 µPa (NSF 2011a). Some additional data suggest that behavioural responses occur closer to an SPL of 175 dB re 1 µPa, and TTS or PTS at even higher levels (Moein et al. 1995), but the received levels were unknown and the NSF (2011a) PEIS maintained the earlier NMFS criteria levels of 166 and 180 dB re 1 µPa (SPL) for behavioural response and injury, respectively. Popper et al. (2014) suggested injury to turtles could occur for sound exposures above 207 dB re 1 µPa (PK) or above 210 dB re 1 µPa²·s (SEL_{24h}) (Table 6). Sound levels defined by Popper et al. (2014) show that animals are very likely to exhibit a behavioural response when they are near an airgun (tens of metres), a moderate response if they encounter the source at intermediate ranges (hundreds of metres), and a low response if they are far (thousands of meters) from the airgun. The NMFS criterion for behavioural disturbance (SPL of 166 dB re 1 µPa), and the Moein et al. (1995) criterion for behavioural disturbance (SPL of 175 dB re 1 µPa) have been included in this analysis.

3.3. Benthic Invertebrates (Crustaceans and Bivalves)

Research is ongoing into the relationship between sound and its effects on crustaceans, including the relevant metrics for both effect and impact. Available literature suggests particle motion, rather than sound pressure, is a more important factor for crustacean and bivalve hearing. Water depth and seismic source size are related to the particle motion levels at the seafloor, with larger arrays and shallower water being related to higher particle motion levels, more likely relevant to effects on crustaceans and bivalves.

At the seafloor interface, crustaceans and bivalves are subject to particle motion stimuli from several acoustic or acoustically-induced waves. These include the particle motion associated with an impinging sound pressure wave in the water column (the incident, reflected, and transmitted portions), substrate acoustic waves, and interface waves of the Scholte type. However, it is unclear which aspect(s) of these waves is/are most relevant to the animals, either when they normally sense the environment or their physiological responses to loud sounds so there is not enough information to establish similar criteria and thresholds as done for cetaceans and fish. Including recent research, such as Day et al. (2016), current literature does not clearly define an appropriate metric or identify relevant levels (pressure or particle motion) for an assessment. This includes the consideration of what particle motion levels lead to a behavioural response, or mortality. Therefore, at this stage, we cannot propose authoritative thresholds to inform the impact assessment. However, levels can be determined for pressure metrics presented in literature to assist the assessment.

For crustaceans, a PK-PK sound level of 202 dB re 1 µPa (Payne et al. 2008) is considered to be associated with no impact, and therefore applied in the assessment. Additionally for context, the PK-PK sound levels determined for crustaceans in Day et al. (2016), 209–212 dB re 1 µPa, are also included.

4. Methods

4.1. Acoustic Source Model

The pressure signature of the individual airguns and the composite 1/3-octave-band point-source equivalent directional levels (i.e., source levels) of the 2495 in^3 seismic source were modelled with JASCO's Airgun Array Source Model (AASM). Although AASM accounts for notional pressure signatures of each seismic source with respect to the effects of surface-reflected signals on bubble oscillations and inter-bubble interactions, the surface-reflected signal (known as surface ghost) is not included in the far-field source signatures. The acoustic propagation models account for those surface reflections, which are a property of the propagating medium rather than the source.

AASM considers:

- Array layout.
- Volume, tow depth, and firing pressure of each airgun.
- Interactions between different airguns in the array.

The array was modelled over AASM's full frequency range, up to 25 kHz. Appendix B details this model.

4.2. Sound Propagation Models

Three sound propagation models were used to predict the acoustic field around the seismic source:

- Combined range-dependent parabolic equation and Gaussian beam acoustic ray-trace model (MONM-BELLHOP, 10 Hz to 25 kHz).
- Full Waveform Range-dependent Acoustic Model (FWRAM, 0.5 Hz to 1024 Hz).
- Wavenumber integration model (VSTACK, 10 Hz to 2048 Hz).

The models were used in combination to characterise the acoustic fields at short and long ranges in terms of SEL, SPL, PK, and PK-PK. Appendix C details each model. MONM was used to calculate SEL of a 360° area around each source location. VSTACK was used to calculate close range PK, PK-PK, and SEL along transects at the seafloor from the broadside direction of the seismic source.

4.3. Parameter Overview

The specifications of the seismic source and the environmental parameters used in the propagation models are described in detail in Appendix D. Three 2495 in^3 seismic source arrays consisting of two strings each were modelled in a flip-flop-flap shooting configuration. The three arrays were towed at a depth of 6 m, and the lateral distance between the arrays was 25 m. A single sound speed profile for June was considered in the modelling; this was identified as the seasonal period that would provide the greatest propagation (Appendix D.3.2). Sediment in the area was modelled as muddy sand, assuming increasingly consolidated sediment as depth increases (Appendix D.3.3).

4.4. Accumulated SEL

During a seismic survey, new sound energy is introduced into the environment with each pulse from the seismic source. While some impact criteria are based on the per-pulse energy released, others, such as the cetacean and fish SEL criteria used in this report (Sections 3.1 and 3.2) account for the total acoustic energy marine fauna is subjected to over a specified period of time, defined in this report as 24 h. An accurate assessment of the accumulated sound energy depends not only on the parameters of each seismic pulse impulse, but also on the number of impulses delivered in a period and the relative positions of the impulses.

When there are many seismic pulses, it becomes computationally prohibitive to perform sound propagation modelling for every single event. The distance between the consecutive seismic impulses is small enough, however, that the environmental parameters that influence sound propagation are virtually the same for many impulse points. The acoustic fields can, therefore, be modelled for a subset of seismic pulses and estimated at several adjacent ones. After sound fields from representative impulse locations are calculated, they are adjusted to account for the source position for nearby impulses.

Although estimating the cumulative sound field with the described approach is not as precise as modelling sound propagation at every impulse location, small-scale, site-specific sound propagation features tend to blur and become less relevant when sound fields from adjacent impulses are summed. Larger scale sound propagation features, primarily dependent on water depth, dominate the cumulative field. The accuracy of the present method acceptably reflects those large-scale features, thus providing a meaningful estimate of a wide area SEL field in a computationally feasible framework.

To produce the map of accumulated received sound level distributions and calculate distances to specified sound level thresholds, the maximum-over-depth level was calculated at each sampling point within the modelled region. The radial grids of maximum-over-depth and seafloor sound levels for each impulse were then resampled (by linear triangulation) to produce a regular Cartesian grid. The sound field grids from all impulses were summed (Equation A-5) to produce the cumulative sound field grid with cell sizes of 20 m. The contours and threshold ranges were calculated from these flat Cartesian projections of the modelled acoustic fields. The single-impulse SEL fields were computed over model grids 200 × 200 km in range, which encompasses the full area of the cumulative grid (the entire survey area).

The unweighted (fish) and frequency-weighted SEL_{24h} results were rendered as contour maps, including contours that focus on the relevant criteria-based thresholds. Only contours at ranges larger than the nearfield of the seismic source were rendered.

4.5. Geometry and Modelled Regions

To assess sound levels with MONM-BELLHOP, the sound field modelling calculated propagation losses up to distances at least 100 km from the source, with a horizontal separation of 20 m between receiver points along the modelled radials. The sound fields were modelled with a horizontal angular resolution of $\Delta\theta$ = 2.5° for a total of N = 144 radial planes. Receiver depths were chosen to span the entire water column over the modelled areas, from 2 m to a maximum of 900 m, with step sizes that increased with depth. To supplement the MONM results, high-frequency results for propagation loss were modelled using Bellhop for frequencies from 1.25 to 25 kHz. The MONM and Bellhop results were combined to produce results for the full frequency range of interest.

FWRAM was run to 50 km, but along only four radials (fore and aft endfire, and port and starboard broadside) for computational efficiency, from 5 to 1024 Hz in 0.5 Hz steps. This was done to compute SEL-to-SPL conversions (Appendix D.2) but also to quantify water column PK and PK-PK. The horizontal range step is dependent on frequency and ranges from 50 m at lower frequencies to 10 m above 800 Hz.

The maximum modelled range for VSTACK was 1500 m and a variable receiver range increment that increased away from the source was used. The increment increased from 5 to 50 m. Received levels were computed for receivers at seafloor.

5. Results

5.1. Acoustic Source Levels and Directivity

AASM (Section 4.1) was used to predict the horizontal and vertical overpressure signatures and corresponding power spectrum levels for the seismic source, with results provided in Appendix B.2 along with the horizontal directivity plots.

Table 7 shows the PK and per-pulse SEL source levels in the horizontal-plane broadside (perpendicular to the tow direction), endfire (along the tow direction), and vertical directions. The vertical source level that accounts for the “surface ghost” (the out of phase reflected pulse from the water surface) is also presented to make it easier to compare the output of other seismic source models.

Figure B-1 shows the broadside, endfire, and vertical overpressure signature and corresponding power spectrum levels for the array. The signature consists of a strong primary peak, related to the initial release of high-pressure air, followed by a series of pulses associated with bubble oscillations. Most energy was produced at frequencies below 600 Hz. Frequency-dependent peaks and nulls in the spectrum result from interference among airguns in the array and correspond with the volumes and relative locations of the airguns to each other.

Table 7. Far-field source level specifications for the 2495 in^3 array, for a 6 m tow depth. Source levels are for a point-like acoustic source with equivalent far-field acoustic output in the specified direction. Sound level metrics are per-pulse and unweighted.

Direction	Peak source pressure level ($L_{S,pk}$) (dB re 1 µPa·m)	Per-pulse source SEL ($L_{S,E}$) (dB 1 µPa^{2}m^{2}s)	
		10–2000 Hz	2000–25000 Hz
Broadside	248.9	224.0	183.8
Endfire	244.7	222.4	187.1
Vertical	254.7	227.6	194.3
Vertical (surface affected source level)	254.7	230.0	197.3

5.2. Per-pulse Sound Fields

5.2.1. Tabulated results

Per-pulse results for the 2495 in³ seismic source towed at 6 m are presented for SPL, SEL, PK, and PK-PK, including seafloor PK and PK-PK. Tables 8–11 list the estimated ranges for the various applicable maximum-over-depth per-pulse effects criteria and isopleths of interest. Tables 12 and 13 list the estimated ranges for seafloor per-pulse effects criteria and isopleths of interest.

5.2.1.1. Entire water column

Table 8. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 2495 in³ array to modelled maximum-over-depth unweighted per-pulse SEL isopleths from the two modelled single impulse sites.

Per-pulse SEL (L_E; dB re 1 µPa²·s)	Scenario 1				Scenario 2	
	Site 1 (100 m)		Site 2 (81 m)		Site 1 (100 m)	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	0.03	0.03	0.03	0.03	0.03	0.03
180	0.17	0.15	0.23	0.18	0.17	0.15
170	0.84	0.71	0.81	0.72	0.87	0.73
160†	3.58	2.79	3.79	2.89	3.62	2.87
150	9.2	7.67	9.17	7.45	9.17	7.62
140	21.6	17.7	21.2	17	22	17.9
130	49.9	41	44.9	36.5	52.9	40.5

† Low power zone assessment criteria DEWHA (2008).

Table 9. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 2495 in³ array to modelled maximum-over-depth SPL isopleths from the two modelled single impulse sites.

SPL (L_p; dB re 1 µPa)	Scenario 1				Scenario 2	
	Site 1 (100 m)		Site 2 (81 m)		Site 1 (100 m)	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	0.03	0.03
190	0.14	0.13	0.17	0.14	0.14	0.13
180	0.6	0.49	0.75	0.65	0.6	0.5
175#	1.49	1.28	1.59	1.37	1.53	1.3
170	2.95	2.4	3.08	2.42	3.01	2.42
166†	4.51	3.51	4.38	3.5	4.53	3.61
160‡	7.47	6.31	7.48	6.16	7.48	6.27
150	18.4	15.4	18.2	14.8	18.8	15.3
140	44	35.9	39.6	32.4	45.1	35.5
130	99.3	78.5	88.3	70.6	*	*

* Radii extend beyond modelling boundary.
# Threshold for turtle behavioural response to impulsive noise (Moein et al. 1995).
† Threshold for turtle behavioural response to impulsive noise (NSF 2011b).
‡ Cetacean behavioural threshold for impulsive sound sources (NMFS 2014)

Table 10. Maximum (R_{max}) horizontal distances (km) from the 2495 in³ array to modelled maximum-over-depth peak pressure level (PK) thresholds based on the NOAA Technical Guidance (NMFS 2018) for cetaceans, and Popper et al. (2014) for fish and Finneran et al. (2017) for turtles, at the modelling sites (Table 4).

Hearing group	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (km)		
		Site 1, Scenario 1 (100 m)	Site 2, Scenario 1 (81 m)	Site 1, Scenario 2 (100 m)
Low-frequency cetaceans (PTS)	219	0.03	0.03	0.03
Low-frequency cetaceans (TTS)	213	0.06	0.07	0.06
Mid-frequency cetaceans (PTS)	230	<0.02	<0.02	<0.02
Mid-frequency cetaceans (TTS)	224	<0.02	<0.02	<0.02
High-frequency cetaceans (PTS)	202	0.37	0.36	0.39
High-frequency cetaceans (TTS)	196	0.77	0.84	0.87
Fish: No swim bladder (also applied to sharks)	213	0.06	0.07	0.06
Fish: Swim bladder not involved in hearing; Swim bladder involved in hearing Turtles, fish eggs, and larvae	207	0.14	0.16	0.14
Turtles (PTS)	232	<0.02	<0.02	<0.02
Turtles (TTS)	226	<0.02	<0.02	<0.02

Table 11. Maximum (R_{max}) horizontal distances (in km) from the 2495 in³ array to modelled maximum-over-depth peak-peak pressure level threshold (178 dB re 1µPa, PK-PK),, assessed along the four FWRAM modelling transects (maximum presented) at two of the modelling sites (Table 4).

PK-PK (L_{pk-pk}; dB re 1 µPa)	Distance R_{max} (km)		
	Site 1, Scenario 1 (100 m)	Site 2, Scenario 1 (81 m)	Site 1, Scenario 2 (100 m)
178	6.86	6.74	6.95

5.2.1.2. Seafloor

Table 12. Maximum (R_{max}) horizontal distances (in m) from the 2495 in³ array to modelled seafloor peak pressure level thresholds (PK) from four single-impulse modelling sites (Table 4).

Hearing group/animal type	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (m)	
		Site 1 (100 m)	Site 2 (81 m)
Sound levels for sponges and corals†	226	—	—
Fish: No swim bladder (also applied to sharks)	213	59	70
Fish: Swim bladder not involved in hearing; Swim bladder involved in hearing Turtles, fish eggs, and larvae	207	148	207

† Heyward et al. (2018)
A dash indicates the level is not reached.

Table 13. Maximum (R_{max}) horizontal distances (in m) from the 2495 in^3 array to modelled seafloor peak-peak pressure level thresholds (PK-PK) from four modelling sites (Table 4). Results included in relation to benthic invertebrates (Section 3.3).

PK-PK (L_{pk-pk}; dB re 1 µPa)	Distance R_{max} (m)	
	Site 1 (100 m)	Site 2 (81 m)
213	141	151
212	163	202
211	192	260
210	296	279
209	322	293
202	494	681

5.2.2. Sound field maps and graphs

5.2.2.1. Sound level contour maps

Maps of the estimated sound fields, threshold contours, and isopleths of interest for the per-pulse SEL and SPL sound fields have been presented at all modelling sites (Table 4), shown in Figures 2–7.

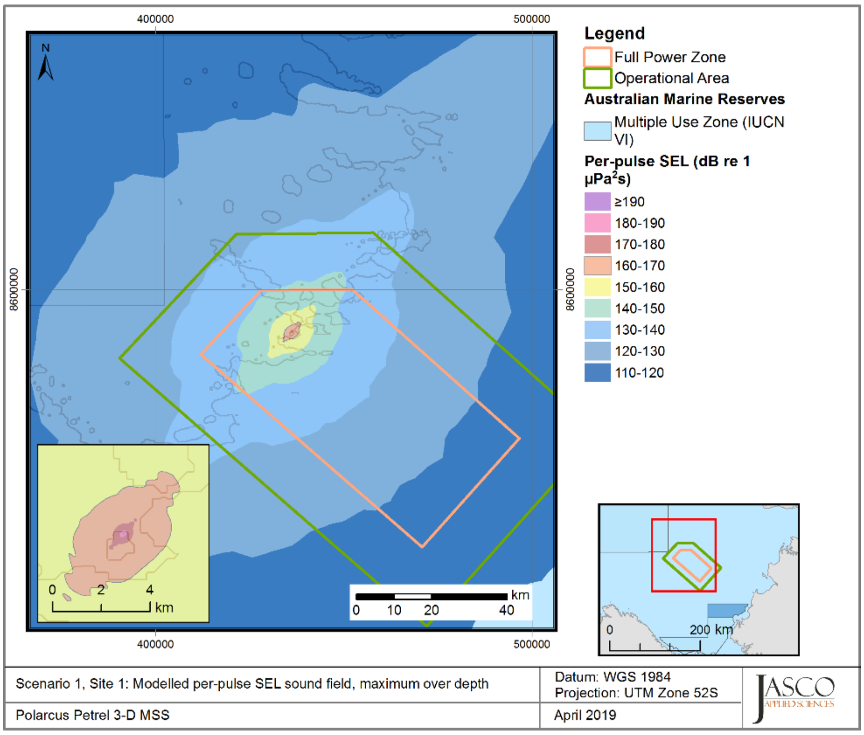

Figure 2. *Site 1, per-pulse SEL, tow direction 131°:* Sound level contour map showing unweighted maximum-over-depth results.

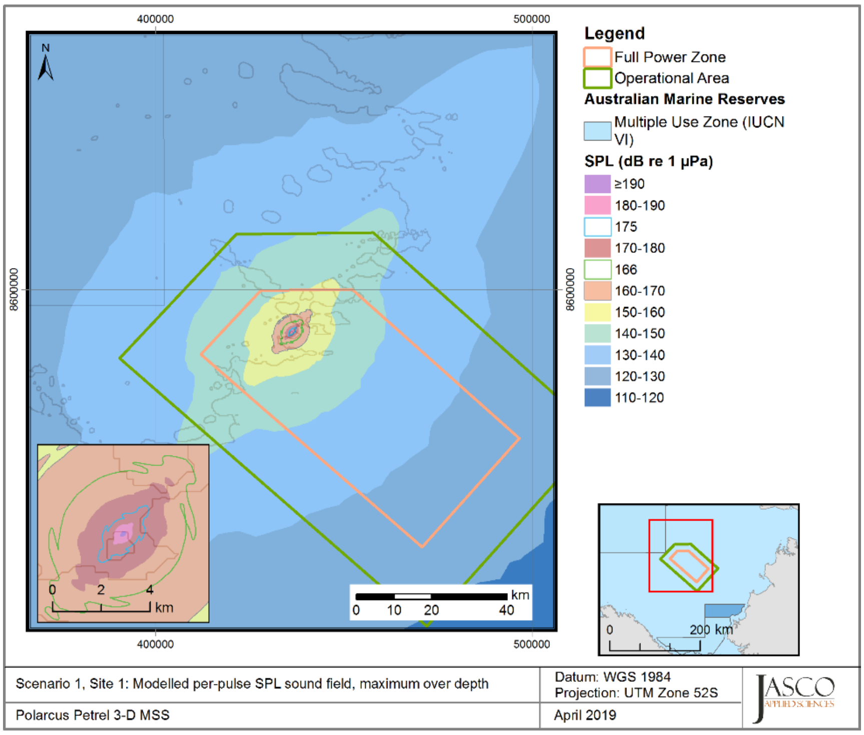

Figure 3. *Site 1, SPL tow direction 131°:* Sound level contour map showing unweighted maximum-over-depth results.

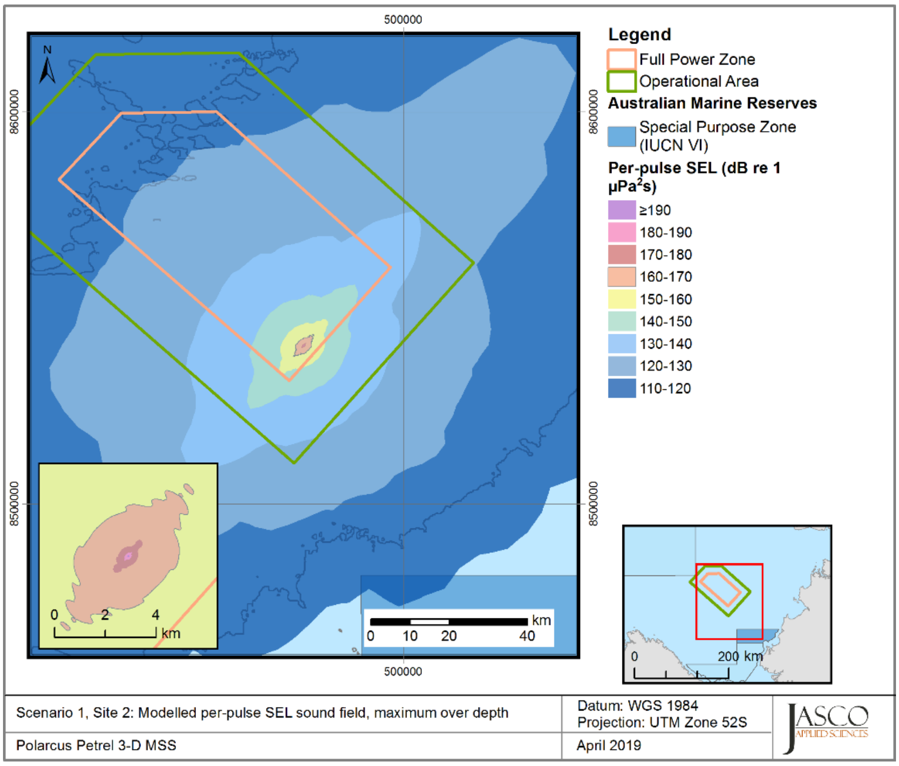

Figure 4. *Site 2, per-pulse SEL, tow direction 131°:* Sound level contour map showing unweighted maximum-over-depth results.

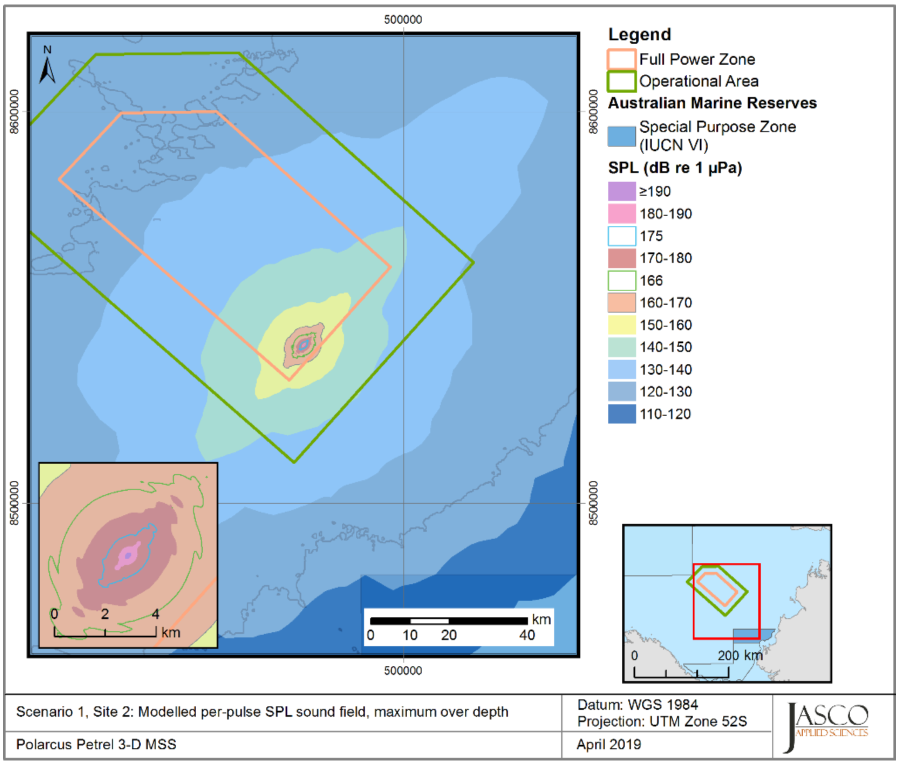

Figure 5. *Site 2, SPL tow direction 131°:* Sound level contour map showing unweighted maximum-over-depth results.

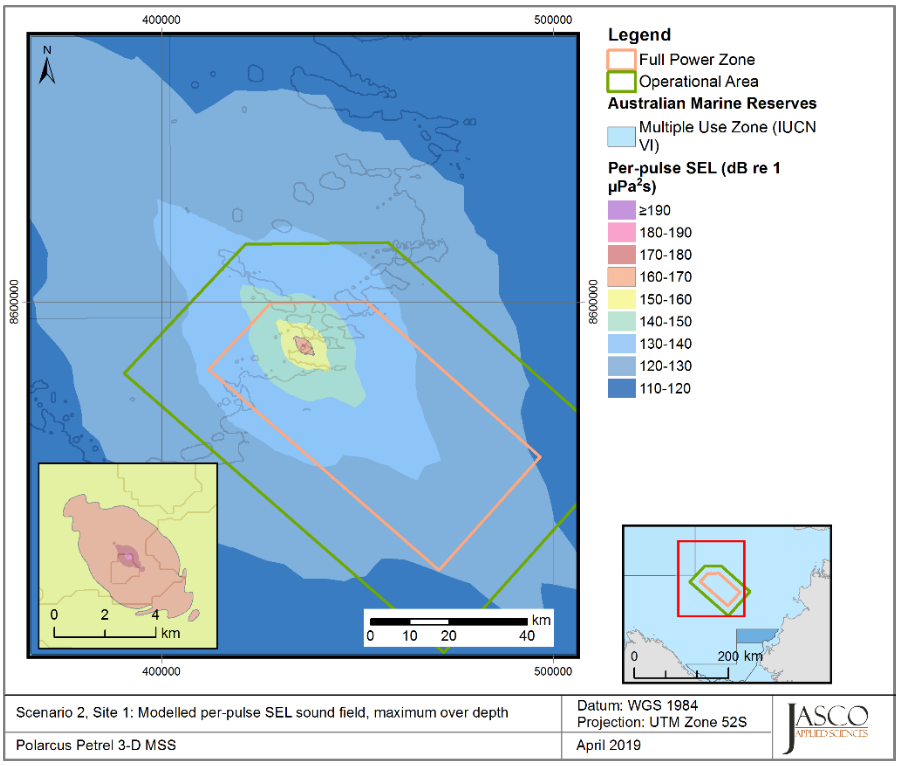

Figure 6. *Site 1, per-pulse SEL, tow direction 43°:* Sound level contour map showing unweighted maximum-over-depth results.

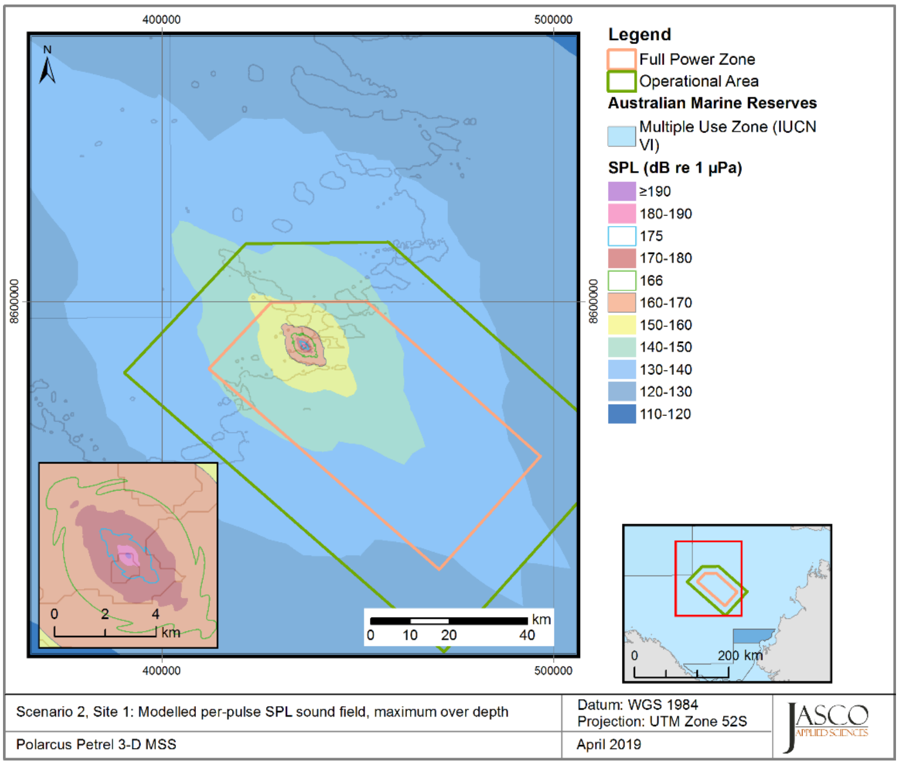

Figure 7. *Site 1, SPL tow direction 43°:* Sound level contour map showing unweighted maximum-over-depth results.

5.2.2.2. Vertical slices of modelled sound fields

Vertical slices of the SPL sound fields for the 2495 in^3 airgun array are shown in Figures 8 and 9.

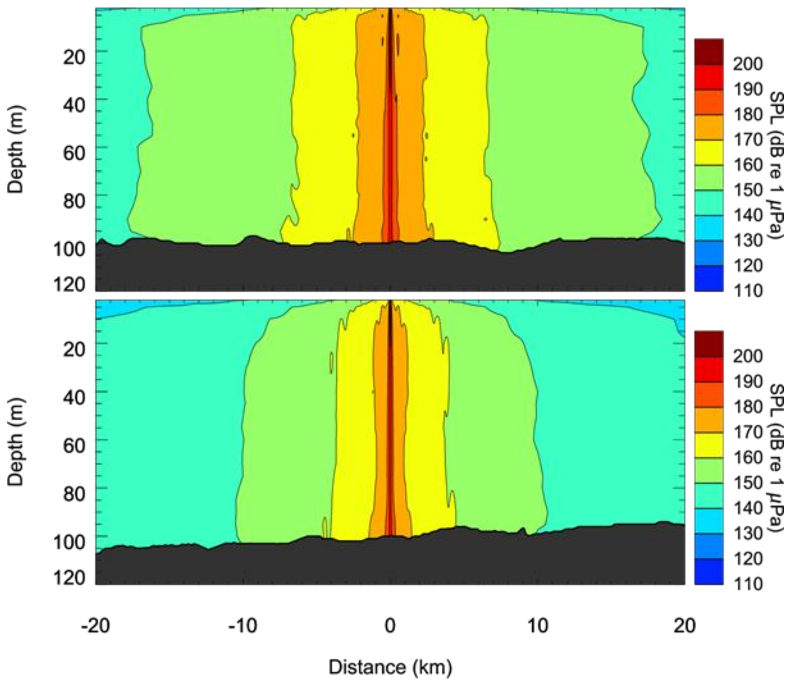

Figure 8. *Site 1, SPL, tow direction 131°*: Vertical slice of the predicted per-pulse SEL for the 2495 in^3 array. Levels are shown along the broadside (top) and endfire (bottom) directions.

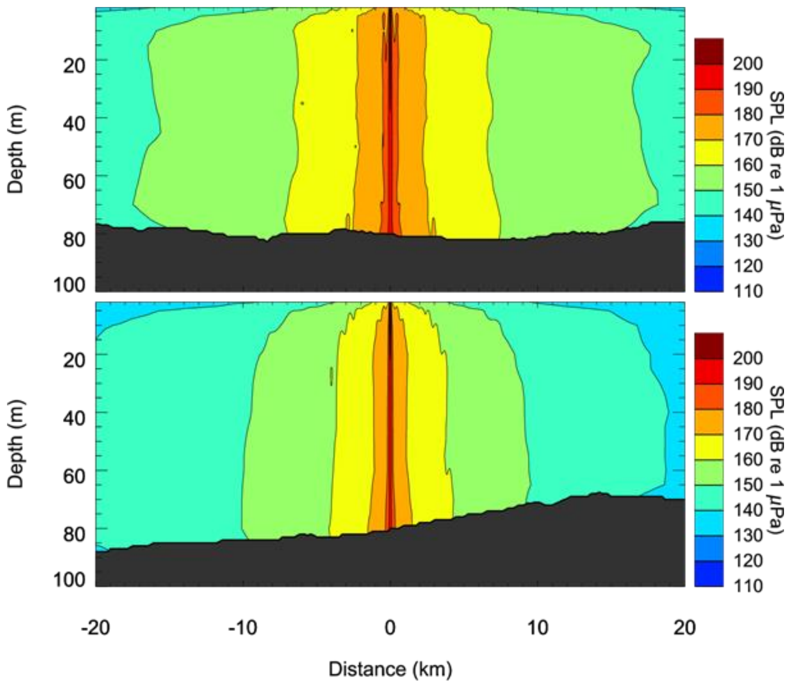

Figure 9. *Site 2, SPL, tow direction 131°*: Vertical slice of the predicted per-pulse SEL for the 2495 in^3 array. Levels are shown along the broadside (top) and endfire (bottom) directions.

5.3. Multiple Pulse Sound Fields

The SEL_{24h} results for the proposed survey are presented for one possible operational scenario within the Acquisition Area (Section 2). Tables 14,15 and 16 show the estimated ranges to the appropriate cumulative exposure criterion contour for the various marine fauna groups considered and the corresponding ensonified areas. The ranges in this section are the perpendicular distance from the survey line to the relevant isopleth. Estimates of the maximum-over-depth sound fields, including threshold contours relating to cetaceans and fish, are presented in Figures 10 and 12, while estimates of the sound field at the seafloor and threshold contours relevant to fish are presented in Figures 11 and 13.

Table 14. Maximum-over-depth distances to SEL_{24h} based cetacean PTS and TTS thresholds (NMFS 2018).

Hearing group	**PTS**				
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	**Scenario 1**		**Scenario 2**	
		R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)
Low-frequency cetaceans	183	1.19	302.8	2.43	304.1
Mid-frequency cetaceans	185	—	—	—	—
High-frequency cetaceans	155	—	—	—	—
Hearing group	**TTS**				
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	**Scenario 1**		**Scenario 2**	
		R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)
Low-frequency cetaceans	168	23.9	4788.7	30.1	3315.6
Mid-frequency cetaceans	170	—	—	—	—
High-frequency cetaceans	140	1.30	356.6	2.88	328.3

A dash indicates the threshold is not reached.

Table 15. Maximum-over-depth distances to SEL_{24h} based fish criteria.

Marine fauna group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	Scenario 1		Scenario 2	
		R_{max} (km)	Area (km²)	R_{max} (km)	Area (km²)
Mortality and potential mortal injury					
I	219	0.05	6.4	0.04	4.9
II, fish eggs and fish larvae	210	0.05	12.8	0.05	10.0
III	207	0.05	12.8	0.05	10.0
Fish recoverable injury					
I	216	0.05	11.7	0.05	7.2
II, III	203	0.05	12.8	0.05	10.0
Fish TTS					
I, II, III	186	3.08	945.3	5.06	755.1

A dash denotes a value below the minimum resolution of the modelling.
Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.

Table 16. Seafloor distances to SEL_{24h} based fish criteria.

Marine fauna group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	Scenario 1		Scenario 2	
		R_{max} (km)	Area (km²)	R_{max} (km)	Area (km²)
Mortality and potential mortal injury					
I	219	—	—	—	—
II, fish eggs and fish larvae	210	—	—	—	—
III	207	—	—	—	—
Fish recoverable injury					
I	216	—	—	—	—
II, III	203	—	—	—	—
Fish TTS					
I, II, III	186	2.98	888.6	5.06	735.7

A dash denotes a value below the minimum resolution of the modelling.
Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.

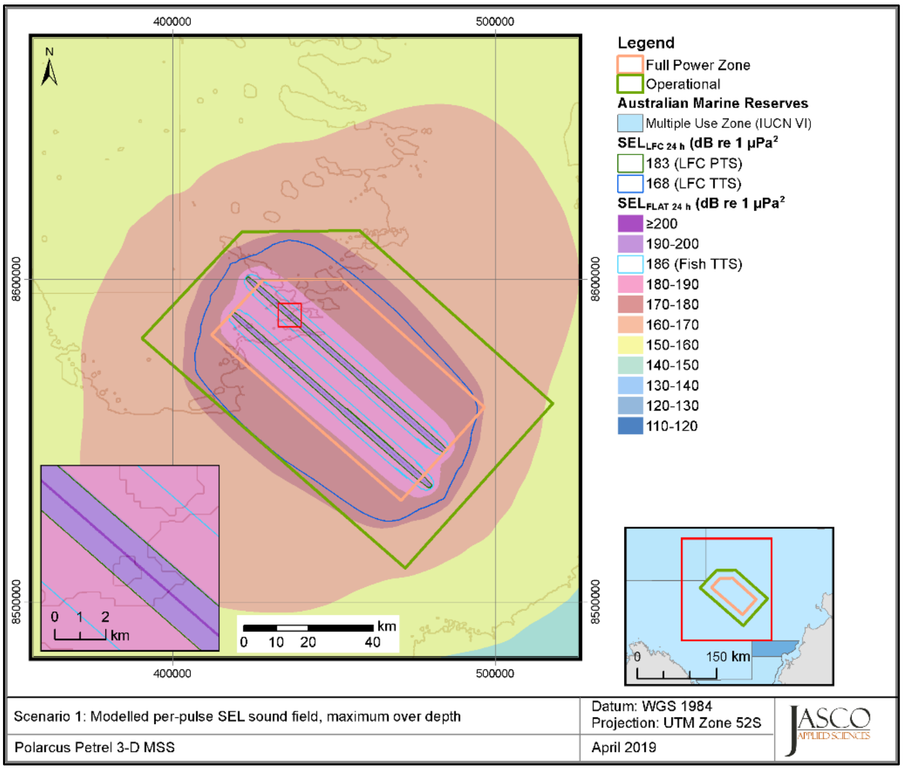

Figure 10. *Scenario 1*: Sound level contour map showing maximum-over-depth SEL_{24h} results.

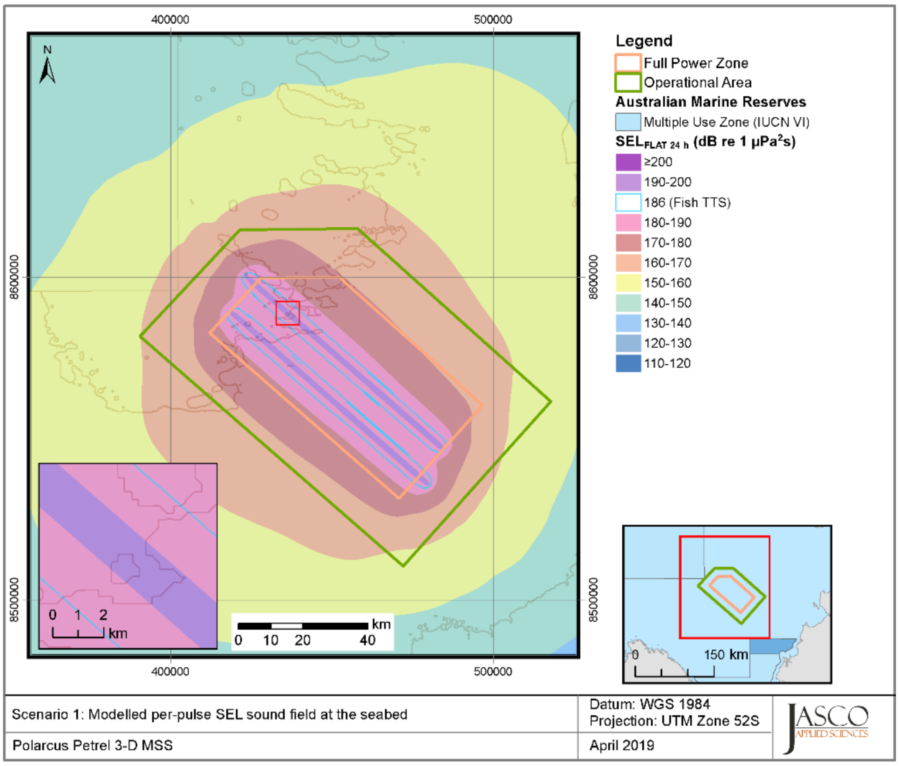

Figure 11. *Scenario 1*: Sound level contour map showing seafloor SEL_{24h} results.

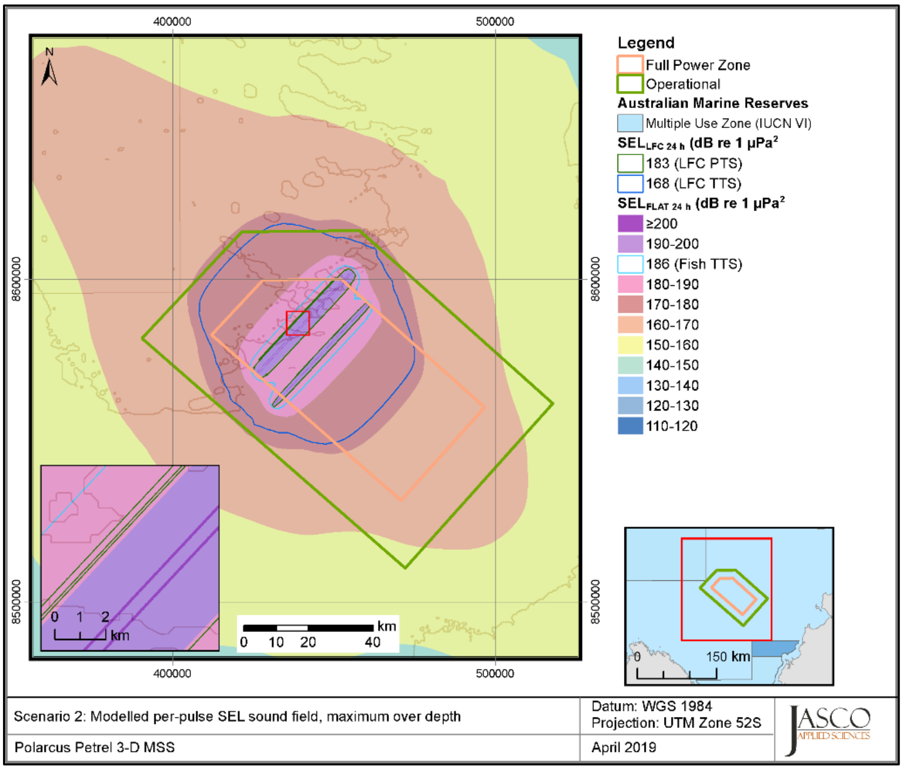

Figure 12. *Scenario 2*: Sound level contour map showing maximum-over-depth SEL_{24h} results.

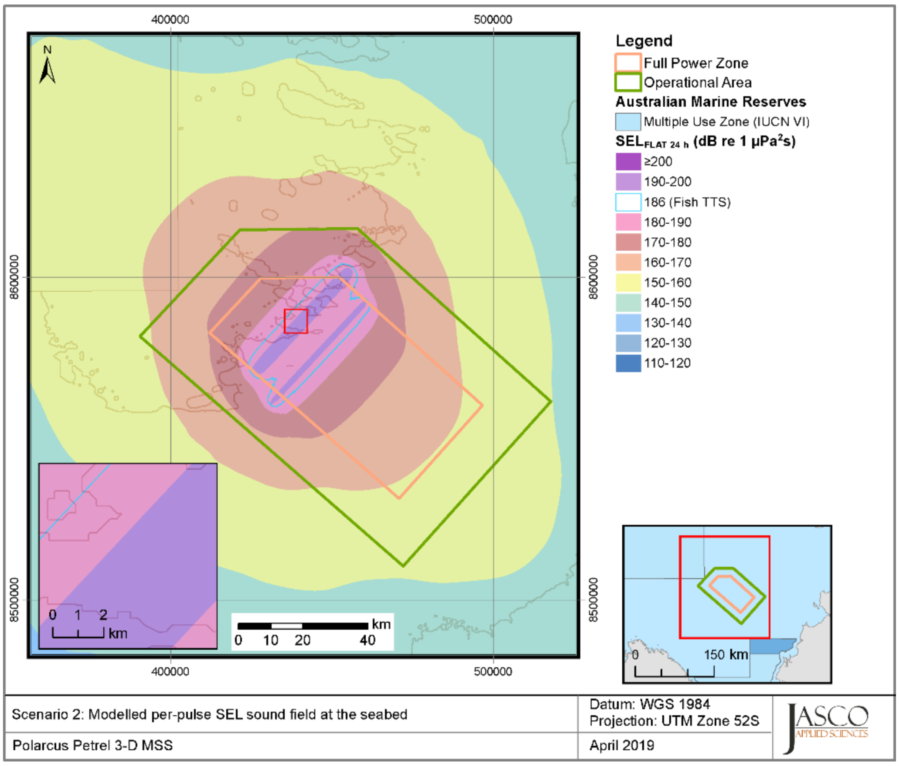

Figure 13. *Scenario 2*: Sound level contour map showing seafloor SEL_{24h} results.

6. Discussion

6.1. Overview and Source Levels

This modelling study predicted underwater sound levels associated with the planned Polarcus Petrel 3-D MSS. The underwater sound field was modelled for a 2495 in^3 seismic source (Appendix B) with a water column sound speed profile for July. An analysis of seasonal sound speed profiles (Appendix D.3.2) indicated that this month was the most conducive to sound propagation, and as such it was selected to ensure a conservative estimation of distances to received sound level thresholds over the entire survey period. The modelling also accounted for site-specific bathymetric variations (Appendix D.3.1) and local geoacoustic properties (Appendix D.3.3).

Most acoustic energy from the seismic sources is output at lower frequencies, in the tens to hundreds of hertz. The array had a pronounced broadside directivity for 1/3-octave-bands centred at 80 to 250 Hz (Appendix B.2), which caused a noticeable axial bulge in the modelled acoustic footprints.

The overall broadband (10–25000 Hz) unweighted per-pulse SEL source level of the 2495 in^3 array operating at 6 m depth was 224.0 dB 1 μPa^{2}m^{2}s in the broadside direction and 222.4 dB 1 μPa^{2}m^{2}s in the endfire direction. The peak pressure level in the same directions was 248.9 and 244.7 dB re 1 μPa·m , respectively. These results are presented in Table 7.

6.2. Per-Pulse Sound Fields

At all modelling sites, regardless of tow direction, the distances to identified isopleths were greater in the broadside direction than in the endfire direction, which is apparent in all footprint maps in Section 5.2.2. The array directionality coupled with the bathymetry affected propagation at longer distances. Bathymetry in the region (Figure D-3) is shallow (less than 80 m) in the southeast corner of the Operational Area. From the centre of the Operational Area, variations in the bathymetry are small; furthermore, the bathymetry is consistent in the northeast and southwest directions out to an approximate range of 40 km. Beyond this, there are local variations and changes in water depth. Deeper waters within the modelled area was located to the northwest of the Operational Area.

Modelling sites for Scenario 1 had tow directions of 131.3° and 311.3°, therefore the broadside lobes were in the northeast and southwest directions. The bathymetry profiles in the broadside directions were similar for most shot locations along the modelled survey lines. Single-shot sound levels were similar at Sites 1 and 2 to a distance of approximately 20 km from the source. Beyond this distance, the different bathymetry influenced propagation loss more, with the distances to sound levels below 140 dB re 1 μPa being less at Site 1 compared to Site 2. The tow directions for Scenario 2, 43.3° and 223.3°, aligned the broadside lobes with the direction of deeper water to the northwest and shallower water to the southeast. Sound footprints extended longer towards deeper water and were shorter towards shallower water (Figures 6 and 7). The distances to higher-level isopleths (>170 dB re 1 μPa) were farther at Site 2 than Site 1, regardless of tow direction. For lower sound levels, the distances were farther at Site 1, due to influence of the deeper water in the northwest direction. The vertical slice plots (Section 5.2.2.2) demonstrate the difference in the footprint directionality, but also the similarity at ranges less than 20 km from the source.

The distances to PK and PK-PK based potential injury criteria (Sections 3.2 and 3.3) for fish and benthic invertebrates at the seafloor were smaller at the deeper site, apart from the distance to the 202 dB re 1 μPa (PK-PK) threshold for crustaceans, which was larger at the deeper site. Since these threshold distances are relatively small, and the water depths at the two modelled sites span the water depths within the survey area, we expect the threshold distances to be representative of the range of distances for all source locations within the region.

6.3. Multiple Pulse Sound Fields

The accumulated SEL over 24 hours of seismic operation was modelled considering two potential acquisition patterns within the Acquisition Area. The model predicted the accumulation of sound energy, considering the change in location and the azimuth of the source at each pulse point, which were used to assess possible injury in cetaceans and the SEL_{24h} based fish criteria. The results were presented both as maps of the accumulated exposure levels and as tables of ranges to threshold levels and areas exposed above given effects criteria (Section 5.3). As discussed in Section 6.2, above the most prominent feature of the sound field footprints for both the SEL_{24h} scenarios were the broadside lobes. The footprint of the accumulated SEL for Scenario 1 (Figures 10 and 11) showed a minor change in shape at the shallower end of the survey lines due to the shallower water depths and the slightly different footprint for the sound fields at Site 2. The footprint of the accumulated SEL for Scenario 2 (Figures 12 and 13) accentuated the influence of the bathymetry on the sound fields, with the distances to isopleths being greater in the northwest direction towards deeper water. The distances to isopleths of interest are greater for Scenario 2 because the vessel traversed two adjacent survey lines within the 24 h scenario and the stronger broadside lobe was orientated towards deeper water which allowed for better long-distance sound propagation.

Note that ranges to thresholds were calculated based on maximum over depth levels, these ranges represent a worst-case threshold distance which implies that an animal would remain static throughout the 24-hour period. The actual dose an animal receives will be dependent on the path the animal takes relative to the operating survey; in the case of a fleeing animal, the received sound levels will be typically be much lower than if it remained stationary.

7. Summary

The findings of the study pertaining each of the metrics and criteria for various marine species of interest are summarised below with references to the result location.

Cetacean injury and behaviour

- The maximum distance where the NMFS (2014) cetacean behavioural response criterion of 160 dB re 1 µPa (SPL) could be exceeded was approximately 7.5 km, considering both tow directions assessed for Site 1 and the single direction for Site 2, Table 9 .
- The results for the criteria applied for cetacean Permanent Threshold Shift (PTS), NMFS (2018), consider both metrics within the criteria (PK and SEL_{24h}). The longest distance associated with either metric is required to be applied. The table below summarise the maximum distances for PTS, along with the relevant metric and the location of the results within this report.

The 24-h SEL is a cumulative metric that reflects the dosimetric impact of noise levels within 24 hours based on the assumption that an animal is consistently exposed to such noise levels at a fixed position. The corresponding SEL_{24h} radii for low-frequency cetaceans were larger than those for peak pressure criteria, but they represent an unlikely worst-case scenario. More realistically, cetaceans (and fish) would not stay in the same location or at the same range for 24 hours. Therefore, a reported radius for SEL_{24h} criteria does not mean that marine fauna travelling within this radius of the source will be injured, but rather that an animal could be exposed to the sound level associated with injury (either PTS or TTS) if it remained in that range for 24 hours.

Table 17. Summary of maximum cetacean PTS onset distances for SEL_{24h} modelled scenarios (PK values from Maximum (R_{max}) horizontal distances (km) from the 2495 in^3 array to modelled maximum-over-depth peak pressure level (PK) thresholds and SEL_{24h} values from Table 14)

Relevant hearing group	Metric associated with longest distance to PTS onset	R_{max} (km)	
		Scenario 1	Scenario 2
Low-frequency cetaceans†	SEL_{24h}	1.19	2.43
Mid-frequency cetaceans	PK	<0.02	<0.02
High-frequency cetaceans	PK	0.37	0.39

† The model does not account for shutdowns.

Turtles

- The PK turtle injury criteria of 232 dB re 1 µPa for PTS and 226 dB re 1 µPa for TTS from Finneran et al. (2017) was not exceeded at a distance greater than 20 m from the centre of the array. Because the arrays are not a point source (approximately 14 × 8 m), the actual ranges from the edge of airgun arrays are small.
- The distances to where the NMFS criterion (NSF 2011a) for behavioural effects in turtles of turtles of 166 dB re 1 µPa (SPL) and the 175 dB re 1 µPa (SPL) Moein et al. (1995) could be exceeded are summarised in Table 18.

Table 18. Distances to turtle behavioural response criteria, (from Table 9).

SPL (L_p; dB re 1 µPa)	Distance (km)		
	Scenario 1		Scenario 2
	Min	Max	Single site
175†	1.49	1.59	1.53
166‡	4.38	4.51	4.53

† Threshold for turtle behavioural response to impulsive noise (Moein et al. 1995).
‡ Threshold for turtle behavioural response to impulsive noise (NSF 2011b).

Fish, fish eggs, and fish larvae

- This modelling study assessed the ranges for quantitative criteria based on Popper et al. (2014) and considered both PK and SEL_{24h} metrics associated with mortality and potential mortal injury and impairment in the following groups:
  - Fish without a swim bladder (also appropriate for sharks in the absence of other information)
  - Fish with a swim bladder that do not use it for hearing
  - Fish that use their swim bladders for hearing
  - Fish eggs and fish larvae
- Table 19 summarises the distances to injury criteria for fish, fish eggs, and fish larvae along with the relevant metric and the location of the information within this report.

Table 19. Summary of maximum fish, fish eggs, and larvae injury and TTS onset distances for single impulse and SEL_{24h} modelled scenarios (PK values from Tables 10 and 12, SEL_{24h} values from Tables 15 and 16).

Relevant hearing group	Injury criteria	Water column			Seafloor		
		Metric associated with longest distance to injury criteria	R_{max} (km)		Metric associated with longest distance to injury criteria	R_{max} (km)	
			Scenario 1	Scenario 2		Scenario 1	Scenario 2
Fish: No swim bladder	Injury	PK	0.07	0.06	PK	0.07	0.06
	TTS	SEL_{24h}	3.08	5.06	SEL_{24h}	2.98	5.06
Fish: Swim bladder not involved in hearing Swim bladder involved in hearing	Injury	PK	0.16	0.14	PK	0.20	0.20
	TTS	SEL_{24h}	3.08	5.06	SEL_{24h}	2.98	5.06
Fish eggs, and larvae	Injury	PK	0.16	0.14	PK	0.20	0.20

Crustaceans Sponges and Coral, and Plankton

To assist with assessing the potential effects on these receptors, the following have been determined:

- Crustaceans: The sound level of 202 dB re 1 µPa PK-PK from Payne et al. (2008) was considered; it was reached at ranges between 494 and 681 m depending on the modelled site (Table 13).
- Sponges and coral: The PK sound level at the seafloor directly underneath the seismic source was estimated at all modelling sites considered for seafloor fish receptors, and compared to the sound level of 226 dB re 1 µPa PK for sponges and corals (Heyward et al. 2018); it was found that the level was not reached at any of the two considered sites (Table 12).
- Plankton: The distance to the sound level of 178 dB re 1 µPa PK-PK from McCauley et al. (2017) was estimated at two modelling sites through full-waveform modelling using FWRAM; the results ranged from 6.74 km to 6.95 km (Table 11).

Glossary

1/3-octave
One third of an octave. Note: A one-third octave is approximately equal to one decidecade (1/3 oct ≈ 1.003 ddec; ISO 2017).

1/3-octave-band
Frequency band whose bandwidth is one one-third octave. Note: The bandwidth of a one-third octave-band increases with increasing centre frequency.

90%-energy time window
The time interval over which the cumulative energy rises from 5 to 95% of the total pulse energy. This interval contains 90% of the total pulse energy. Symbol: T_{90}.

azimuth
A horizontal angle relative to a reference direction, which is often magnetic north or the direction of travel. In navigation it is also called bearing.

broadband sound level
The total sound pressure level measured over a specified frequency range. If the frequency range is unspecified, it refers to the entire measured frequency range.

broadside direction
Perpendicular to the travel direction of a source. Compare with endfire direction.

cavitation
A rapid formation and collapse of vapor cavities (i.e., bubbles or voids) in water, most often caused by a rapid change in pressure. Fast-spinning vessel propellers typically cause cavitation, which creates a lot of noise.

cetacean
Any animal in the order Cetacea. These are aquatic, mostly cetaceans and include whales, dolphins, and porpoises.

compressional wave
A mechanical vibration wave in which the direction of particle motion is parallel to the direction of propagation. Also called primary wave or P-wave.

decibel (dB)
One-tenth of a bel. Unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power (ANSI S1.1-1994 R2004).

endfire direction
Parallel to the travel direction of a source. See also broadside direction.

ensonified
Exposed to sound.

far-field
The zone where, to an observer, sound originating from an array of sources (or a spatially distributed source) appears to radiate from a single point. The distance to the acoustic far-field increases with frequency.

frequency
The rate of oscillation of a periodic function measured in cycles-per-unit-time. The reciprocal of the period. Unit: hertz (Hz). Symbol: *f*. 1 Hz is equal to 1 cycle per second.

hearing group
Groups of cetacean species with similar hearing ranges. Commonly defined functional hearing groups include low-, mid-, and high-frequency cetaceans, pinnipeds in water, and pinnipeds in air.

geoacoustic
Relating to the acoustic properties of the seabed.

hertz (Hz)
A unit of frequency defined as one cycle per second.

high-frequency (HF) cetacean
The functional cetacean hearing group that represents those odontocetes (toothed whales) specialized for hearing high frequencies.

impulsive sound
Sound that is typically brief and intermittent with rapid (within a few seconds) rise time and decay back to ambient levels (NOAA 2013, ANSI S12.7-1986 R2006). For example, seismic airguns and impact pile driving.

low-frequency (LF) cetacean
The functional cetacean hearing group that represents mysticetes (baleen whales) specialized for hearing low frequencies.

mean-square sound pressure spectral density
Distribution as a function of frequency of the mean-square sound pressure per unit bandwidth (usually 1 Hz) of a sound having a continuous spectrum (ANSI S1.1-1994 R2004). Unit: $\mu Pa^2/Hz$.

mid-frequency (MF) cetacean
The functional cetacean hearing group that represents those odontocetes (toothed whales) specialized for mid-frequency hearing.

octave
The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

parabolic equation method
A computationally efficient solution to the acoustic wave equation that is used to model transmission loss. The parabolic equation approximation omits effects of back-scattered sound, simplifying the computation of transmission loss. The effect of back-scattered sound is negligible for most ocean-acoustic propagation problems.

particle acceleration
The rate of change of particle velocity. Unit: meters per second squared (m/s^2). Symbol: *a*.

particle velocity
The physical speed of a particle in a material moving back and forth in the direction of the pressure wave. Unit: meters per second (m/s). Symbol: *v*.

peak pressure level (PK)
The maximum instantaneous sound pressure level, in a stated frequency band, within a stated period. Also called zero-to-peak pressure level. Unit: decibel (dB).

peak-to-peak pressure level (PK-PK)
The difference between the maximum and minimum instantaneous pressure levels. Unit: decibel (dB).

permanent threshold shift (PTS)
A permanent loss of hearing sensitivity caused by excessive noise exposure. PTS is considered auditory injury.

point source
A source that radiates sound as if from a single point (ANSI S1.1-1994 R2004).

pressure, acoustic
The deviation from the ambient hydrostatic pressure caused by a sound wave. Also called overpressure. Unit: pascal (Pa). Symbol: *p*.

received level (RL)
The sound level measured (or that would be measured) at a defined location.

rms
root-mean-square.

shear wave
A mechanical vibration wave in which the direction of particle motion is perpendicular to the direction of propagation. Also called secondary wave or S-wave. Shear waves propagate only in solid media, such as sediments or rock. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

signature
Pressure signal generated by a source.

sound
A time-varying pressure disturbance generated by mechanical vibration waves travelling through a fluid medium such as air or water.

sound exposure
Time integral of squared, instantaneous frequency-weighted sound pressure over a stated time interval or event. Unit: pascal-squared second ($Pa^2 \cdot s$) (ANSI S1.1-1994 R2004).

sound exposure level (SEL)
A cumulative measure related to the sound energy in one or more pulses. Unit: dB re 1 $\mu Pa^2 \cdot s$. SEL is expressed over the summation period (e.g., per-pulse SEL [for airguns], single-strike SEL [for pile drivers], 24-hour SEL).

sound exposure spectral density
Distribution as a function of frequency of the time-integrated squared sound pressure per unit bandwidth of a sound having a continuous spectrum (ANSI S1.1-1994 R2004). Unit: $\mu Pa^2 \cdot s/Hz$.

sound field
Region containing sound waves (ANSI S1.1-1994 R2004).

sound intensity
Sound energy flowing through a unit area perpendicular to the direction of propagation per unit time.

sound speed profile
The speed of sound in the water column as a function of depth below the water surface.

source level (SL)
The sound level measured in the far-field and scaled back to a standard reference distance of 1 metre from the acoustic centre of the source. Unit: dB re 1 μPa·m (pressure level) or dB re 1 $\mu Pa^2 \cdot s \cdot m$ (exposure level).

spectral density level
The decibel level ($10 \cdot \log_{10}$) of the spectral density of a given parameter such as SPL or SEL, for which the units are dB re 1 $\mu Pa^2/Hz$ and dB re 1 $\mu Pa^2 \cdot s/Hz$, respectively.

spectrum
An acoustic signal represented in terms of its power, energy, mean-square sound pressure, or sound exposure distribution with frequency.

surface duct
The upper portion of a water column within which the sound speed profile gradient causes sound to refract upward and therefore reflect off the surface resulting in relatively long-range sound propagation with little loss.

temporary threshold shift (TTS)
Temporary loss of hearing sensitivity caused by excessive noise exposure.

thermocline
The depth interval near the ocean surface that experiences temperature gradients due to warming or cooling by heat conduction from the atmosphere and by warming from solar heating.

transmission loss (TL)
The decibel reduction in sound level between two stated points that results from sound spreading away from an acoustic source subject to the influence of the surrounding environment. Also referred to as propagation loss.

wavelength
Distance over which a wave completes one cycle of oscillation. Unit: metre (m). Symbol: λ.

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Appendix A. Acoustic Metrics

A.1. Pressure Related Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 μPa. Because the perceived loudness of sound, especially impulsive noise such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate noise and its effects on marine life. We provide specific definitions of relevant metrics used in the accompanying report. Where possible we follow the ANSI and ISO standard definitions and symbols for sound metrics, but these standards are not always consistent.

The zero-to-peak sound pressure level (PK; L_{pk}; $L_{p,pk}$; dB re 1 µPa), is the maximum instantaneous sound pressure level in a stated frequency band attained by an acoustic pressure signal, $p(t)$:

$$L_{p,pk} = 20\log_{10}\left[\frac{\max(|p(t)|)}{p_0}\right] \tag{A-1}$$

PK is often included as a criterion for assessing whether a sound is potentially injurious; however, because it does not account for the duration of a noise event, it is generally a poor indicator of perceived loudness.

The peak-to-peak sound pressure level (PK-PK; $L_{pk\text{-}pk}$; $L_{p,pk\text{-}pk}$; dB re 1 µPa) is the difference between the maximum and minimum instantaneous sound pressure levels in a stated frequency band attained by an impulsive sound, $p(t)$:

$$L_{p,pk-pk} = 10\log_{10}\left\{\frac{[\max(p(t)) - \min(p(t))]^2}{p_0^2}\right\} \tag{A-2}$$

The sound pressure level (SPL; L_p; dB re 1 µPa) is the rms pressure level in a stated frequency band over a specified time window (T, s) containing the acoustic event of interest. It is important to note that SPL always refers to a rms pressure level and therefore not instantaneous pressure:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)dt \Big/ p_0^2\right) \tag{A-3}$$

The SPL represents a nominal effective continuous sound over the duration of an acoustic event, such as the emission of one acoustic pulse, a cetacean vocalization, the passage of a vessel, or over a fixed duration. Because the window length, T, is the divisor, events with similar sound exposure level (SEL) but more spread out in time have a lower SPL. A fixed window length of 0.125 s (critical duration defined by Tougaard et al. (2015)) is used in this study for impulsive sounds.

The sound exposure level (SEL; L_E; $L_{E,p}$; dB re 1 µPa²·s) is a measure related to the acoustic energy contained in one or more acoustic events (N). The SEL for a single event is computed from the time-integral of the squared pressure over the full event duration (T):

$$L_E = 10\log_{10}\left(\int_T p^2(t)dt \Big/ T_0 p_0^2\right) \tag{A-4}$$

where T_0 is a reference time interval of 1 s. The SEL continues to increase with time when non-zero pressure signals are present. It therefore can be construed as a dose-type measurement, so the integration time used must be carefully considered in terms of relevance for impact to the exposed recipients.

SEL can be calculated over periods with multiple acoustic events or over a fixed duration. For a fixed duration, the square pressure is integrated over the duration of interest. For multiple events, the SEL can be computed by summing (in linear units) the SEL of the *N* individual events:

$$L_{E,N} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}}\right). \tag{A-5}$$

If applied, the frequency weighting of an acoustic event should be specified, as in the case of weighted SEL (e.g., $L_{E,LFC,24h}$; Appendix A.3). The use of fast, slow, or impulse exponential-time-averaging or other time-related characteristics should else be specified.

A.2. Marine Mammal Impact Criteria

It has been long recognised that cetaceans can be adversely affected by underwater anthropogenic noise. For example, Payne and Webb (1971) suggested that communication distances of fin whales are reduced by shipping sounds. Subsequently, similar concerns arose regarding effects of other underwater noise sources and the possibility that impulsive sources—primarily airguns used in seismic surveys—could cause auditory injury. This led to a series of workshops held in the late 1990s, conducted to address acoustic mitigation requirements for seismic surveys and other underwater noise sources (NMFS 1998, ONR 1998, Nedwell and Turnpenny 1998, HESS 1999, Ellison and Stein 1999). In the years since these early workshops, a variety of thresholds have been proposed for both injury and disturbance. The following sections summarize the recent development of thresholds; however, this field remains an active research topic.

A.2.1. Injury

In recognition of shortcomings of the SPL-only based injury criteria, in 2005 NMFS sponsored the Noise Criteria Group to review literature on cetacean hearing to propose new noise exposure criteria. Some members of this expert group published a landmark paper (Southall et al. 2007) that suggested assessment methods similar to those applied for humans. The resulting recommendations introduced dual acoustic injury criteria for impulsive sounds that included peak pressure level thresholds and SEL_{24h} thresholds, where the subscripted 24h refers to the accumulation period for calculating SEL. The peak pressure level criterion is not frequency weighted whereas the SEL_{24h} is frequency weighted according to one of four cetacean species hearing groups: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively) and Pinnipeds in Water (PINN). These weighting functions are referred to as M-weighting filters (analogous to the A-weighting filter for human; Appendix A.3). The SEL_{24h} thresholds were obtained by extrapolating measurements of onset levels of Temporary Threshold Shift (TTS) in belugas by the amount of TTS required to produce Permanent Threshold Shift (PTS) in chinchillas. The Southall et al. (2007) recommendations do not specify an exchange rate, which suggests that the thresholds are the same regardless of the duration of exposure (i.e., it implies a 3 dB exchange rate).

Wood et al. (2012) refined Southall et al.'s (2007) thresholds, suggesting lower injury values for LF and HF cetaceans while retaining the filter shapes. Their revised thresholds were based on TTS-onset levels in harbour porpoises from Lucke et al. (2009), which led to a revised impulsive sound PTS threshold for HF cetaceans of 179 dB re 1 µPa^2·s. Because there were no data available for baleen whales, Wood et al. (2012) based their recommendations for LF cetaceans on results obtained from MF cetacean studies. In particular they referenced Finneran and Schlundt (2010) research, which found mid-frequency cetaceans are more sensitive to non-impulsive sound exposure than Southall et al. (2007) assumed. Wood et al. (2012) thus recommended a more conservative TTS-onset level for LF cetaceans of 192 dB re 1 µPa^2·s.

As of 2017, an optimal approach is not apparent. There is consensus in the research community that an SEL-based method is preferable either separately or in addition to an SPL-based approach to assess the potential for injuries. In August 2016, after substantial public and expert input into three draft versions and based largely on the above-mentioned literature (NOAA 2013, 2015, 2016), NMFS finalised technical guidance for assessing the effect of anthropogenic sound on cetacean hearing (NMFS 2016). The guidance describes injury criteria with new thresholds and frequency weighting functions for the five hearing groups described by Finneran and Jenkins (2012). The latest revision to this work was published in 2018; only the PK criteria defined in NMFS (2018) are applied in this report.

A.3. Marine Mammal Frequency Weighting

The potential for noise to affect animals depends on how well the animals can hear it. Noises are less likely to disturb or injure an animal if they are at frequencies that the animal cannot hear well. An exception occurs when the sound pressure is so high that it can physically injure an animal by non-auditory means (i.e., barotrauma). For sound levels below such extremes, the importance of sound components at particular frequencies can be scaled by frequency weighting relevant to an animal's sensitivity to those frequencies (Nedwell and Turnpenny 1998, Nedwell et al. 2007).

A.3.1. Cetacean frequency weighting functions

In 2015, a U.S. Navy technical report by Finneran (2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows the sensitivity of the human ear at low sound levels. The new frequency-weighting function is expressed as:

$$G(f) = K + 10\log_{10}\left[\left(\frac{(f/f_{lo})^{2a}}{\left[1+(f/f_{lo})^2\right]^a \left[1+(f/f_{hi})^2\right]^b}\right)\right] \quad \text{(A-6)}$$

Finneran (2015) proposed five functional hearing groups for cetaceans in water: low-, mid-, and high-frequency cetaceans, phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA's technical guidance that assesses noise impacts on cetaceans (NMFS 2016, NMFS 2018). Table A-1 lists the frequency-weighting parameters for each hearing group; Figure A-1 shows the resulting frequency-weighting curves.

Table A-1. Parameters for the auditory weighting functions used in this project as recommended by NMFS (2018).

Hearing group	a	b	f_{lo} (Hz)	f_{hi} (kHz)	K (dB)
Low-frequency cetaceans (baleen whales)	1.0	2	200	19,000	0.13
Mid-frequency cetaceans (dolphins, plus toothed, beaked, and bottlenose whales)	1.6	2	8,800	110,000	1.20
High-frequency cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* and *L. australis*)	1.8	2	12,000	140,000	1.36

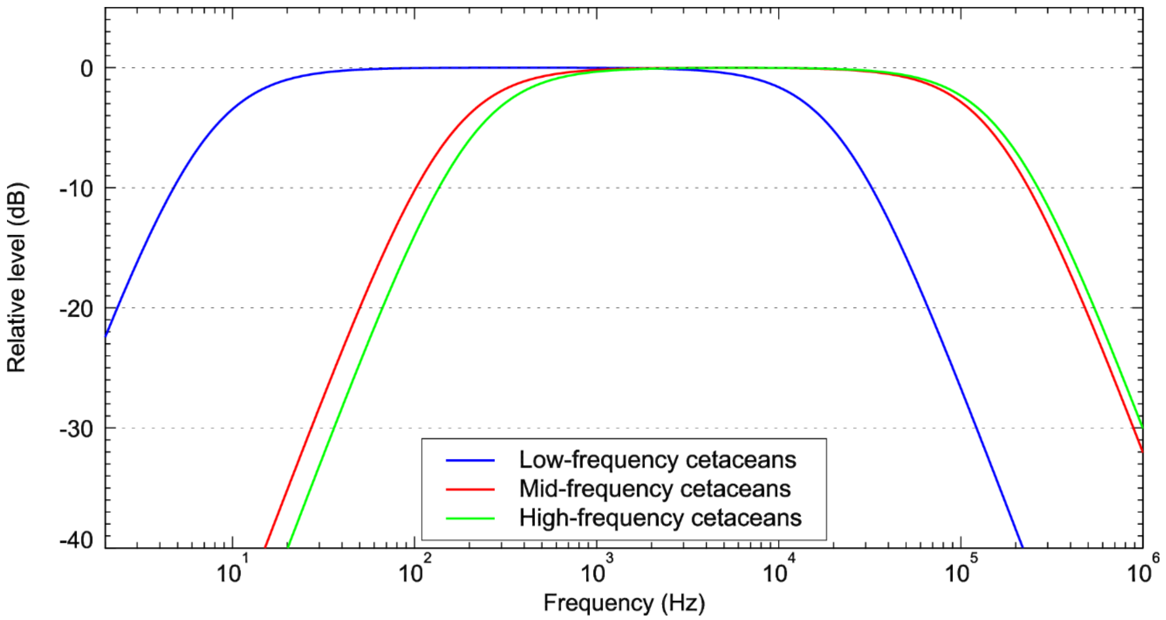

Figure A-1. Auditory weighting functions for functional cetacean hearing groups used in this project as recommended by NMFS (2018).

Appendix B. Acoustic Source Model

B.1. Airgun Array Source Model

The source levels and directivity of the seismic source were predicted with JASCO's Airgun Array Source Model (AASM). AASM includes low- and high-frequency modules for predicting different components of the seismic source spectrum. The low-frequency module is based on the physics of oscillation and radiation of airgun bubbles, as originally described by Ziolkowski (1970), that solves the set of parallel differential equations that govern bubble oscillations. Physical effects accounted for in the simulation include pressure interactions between airguns, port throttling, bubble damping, and generator-injector (GI) gun behaviour discussed by Dragoset (1984), Laws et al. (1990), and Landro (1992). A global optimisation algorithm tunes free parameters in the model to a large library of airgun source signatures.

While airgun signatures are highly repeatable at the low frequencies, which are used for seismic imaging, their sound emissions have a large random component at higher frequencies that cannot be predicted using a deterministic model. Therefore, AASM uses a stochastic simulation to predict the high-frequency (800−25,000 Hz) sound emissions of individual airguns, using a data-driven multiple-regression model. The multiple-regression model is based on a statistical analysis of a large collection of high quality seismic source signature data recently obtained from the Joint Industry Program (JIP) on Sound and Marine Life (Mattsson and Jenkerson 2008). The stochastic model uses a Monte-Carlo simulation to simulate the random component of the high-frequency spectrum of each airgun in an array. The mean high-frequency spectra from the stochastic model augment the low-frequency signatures from the physical model, allowing AASM to predict airgun source levels at frequencies up to 25,000 Hz.

AASM produces a set of "notional" signatures for each array element based on:

- Array layout
- Volume, tow depth, and firing pressure of each airgun
- Interactions between different airguns in the array

These notional signatures are the pressure waveforms of the individual airguns at a standard reference distance of 1 m; they account for the interactions with the other airguns in the array. The signatures are summed with the appropriate phase delays to obtain the far-field source signature of the entire array in all directions. This far-field array signature is filtered into 1/3-octave-bands to compute the source levels of the array as a function of frequency band and azimuthal angle in the horizontal plane (at the source depth), after which it is considered a directional point source in the far field.

A seismic array consists of many sources and the point source assumption is invalid in the near field where the array elements add incoherently. The maximum extent of the near field of an array (R_{nf}) is:

$$R_{\mathrm{nf}} < \frac{l^2}{4\lambda} \tag{B-1}$$

where λ is the sound wavelength and l is the longest dimension of the array (Lurton 2002, §5.2.4). For example, a seismic source length of l = 21 m yields a near-field range of 147 m at 2 kHz and 7 m at 100 Hz. Beyond this R_{nf} range, the array is assumed to radiate like a directional point source and is treated as such for propagation modelling.

The interactions between individual elements of the array create directionality in the overall acoustic emission. Generally, this directionality is prominent mainly at frequencies in the mid-range between tens of hertz to several hundred hertz. At lower frequencies, with acoustic wavelengths much larger than the inter-airgun separation distances, the directionality is small. At higher frequencies, the pattern of lobes is too finely spaced to be resolved and the effective directivity is less.

B.2. Array Source Levels and Directivity

Figure B-1 shows the broadside (perpendicular to the tow direction), endfire (parallel to the tow direction), and vertical overpressure signature and corresponding power spectrum levels for the 2495 in^3 array (Appendix D.4).

Horizontal 1/3-octave-band source levels are shown as a function of band centre frequency and azimuth (Figure B-2); directivity in the sound field is most noticeable at mid-frequencies as described in the model detail in Appendix B.1.

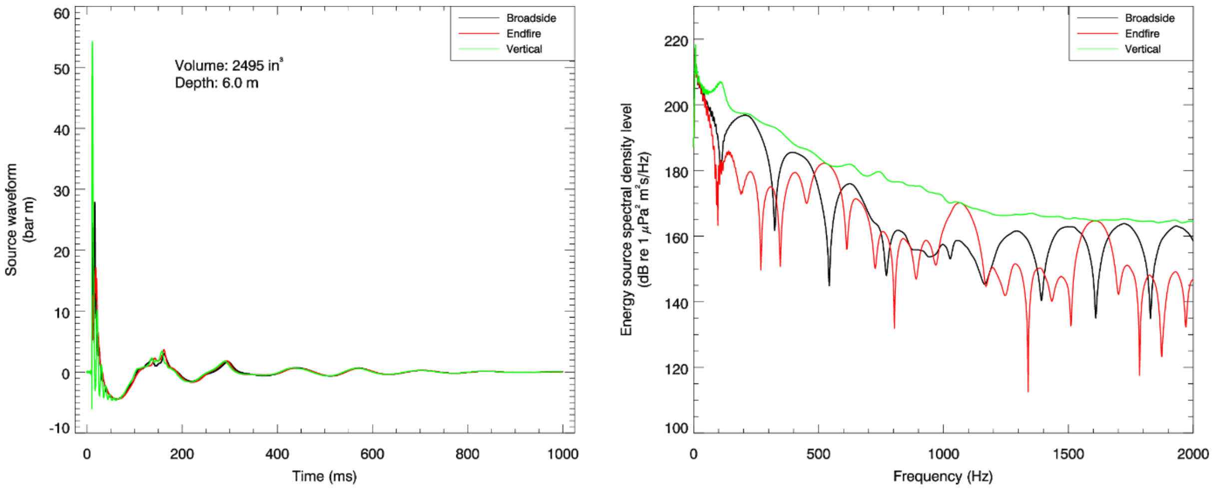

Figure B-1. Predicted source level details for the 2495 in^3 array at a 6 m towed depth. (Left) the overpressure signature and (right) the power spectrum for in-plane horizontal (broadside), perpendicular (endfire), and vertical directions.

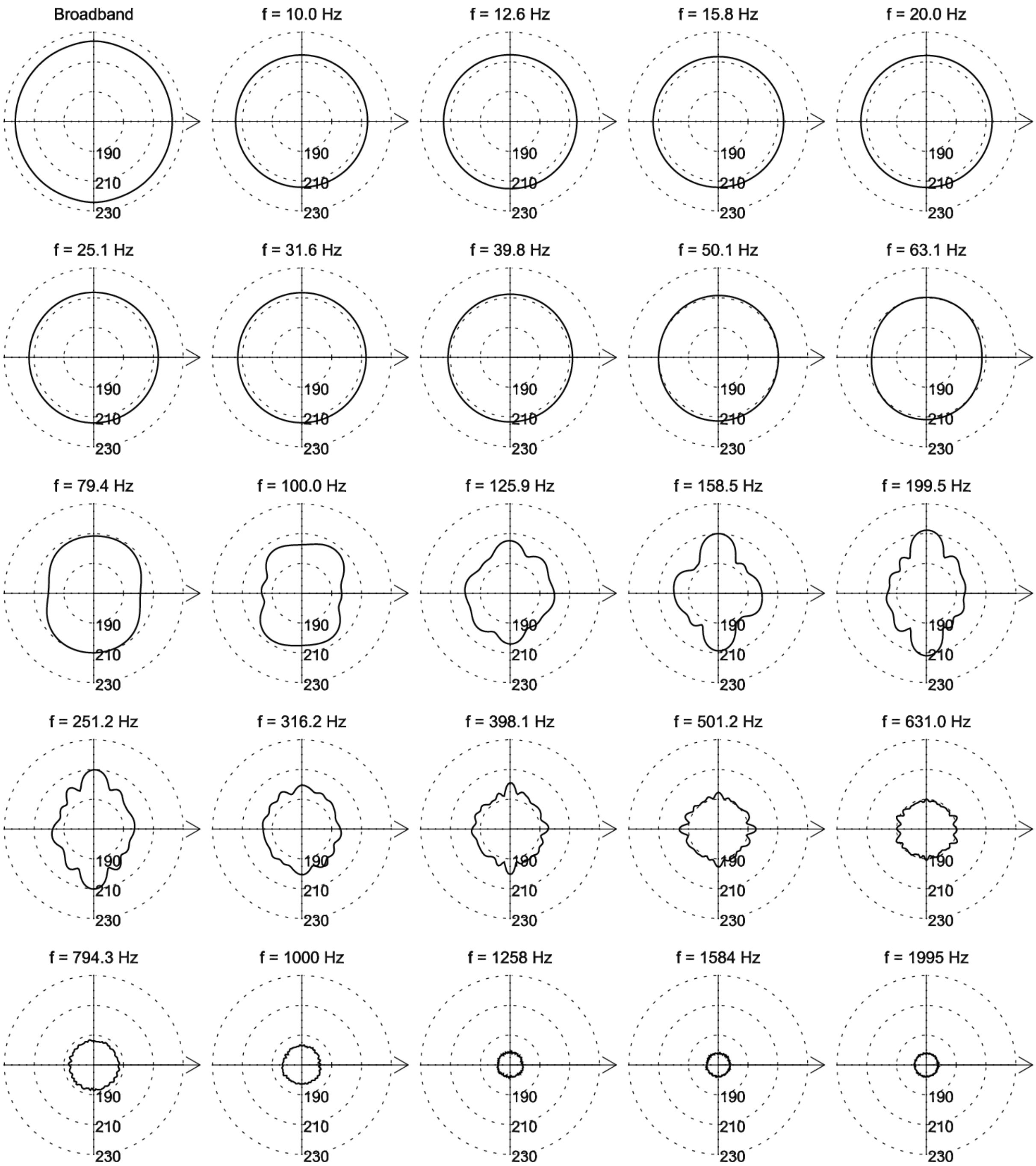

Figure B-2. Directionality of the predicted horizontal source levels for the 2495 in^3 seismic source array, 10 Hz to 2 kHz. Source levels (in dB re 1 µPa^2·s m^2) are shown as a function of azimuth for the centre frequencies of the 1/3-octave-bands modelled; frequencies are shown above the plots. The perpendicular direction to the frame is to the right. Tow depth is 6 m (see Figure B-1).

Appendix C. Sound Propagation Models

C.1. MONM-BELLHOP

Long-range sound fields were computed using JASCO's Marine Operations Noise Model (MONM). Compared to VSTACK, MONM less accurately predicts steep-angle propagation for environments with higher shear speed but is well suited for effective longer-range estimation. This model computes sound propagation at frequencies of 10 Hz to 1.25 kHz via a wide-angle parabolic equation solution to the acoustic wave equation (Collins 1993) based on a version of the U.S. Naval Research Laboratory's Range-dependent Acoustic Model (RAM), which has been modified to account for a solid seabed (Zhang and Tindle 1995). MONM computes sound propagation at frequencies > 1.25 kHz via the BELLHOP Gaussian beam acoustic ray-trace model (Porter and Liu 1994).

The parabolic equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al. 1996). MONM accounts for the additional reflection loss at the seabed, which results from partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces, and it includes wave attenuations in all layers. MONM incorporates the following site-specific environmental properties: a bathymetric grid of the modelled area, underwater sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor.

This version of MONM accounts for sound attenuation due to energy absorption through ion relaxation and viscosity of water in addition to acoustic attenuation due to reflection at the medium boundaries and internal layers (Fisher and Simmons 1977). The former type of sound attenuation is significant for frequencies higher than 5 kHz and cannot be neglected without noticeably affecting the model results.

MONM computes acoustic fields in three dimensions by modelling transmission loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as N×2-D. These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding N = 360°/$\Delta\theta$ number of planes (Figure C-1).

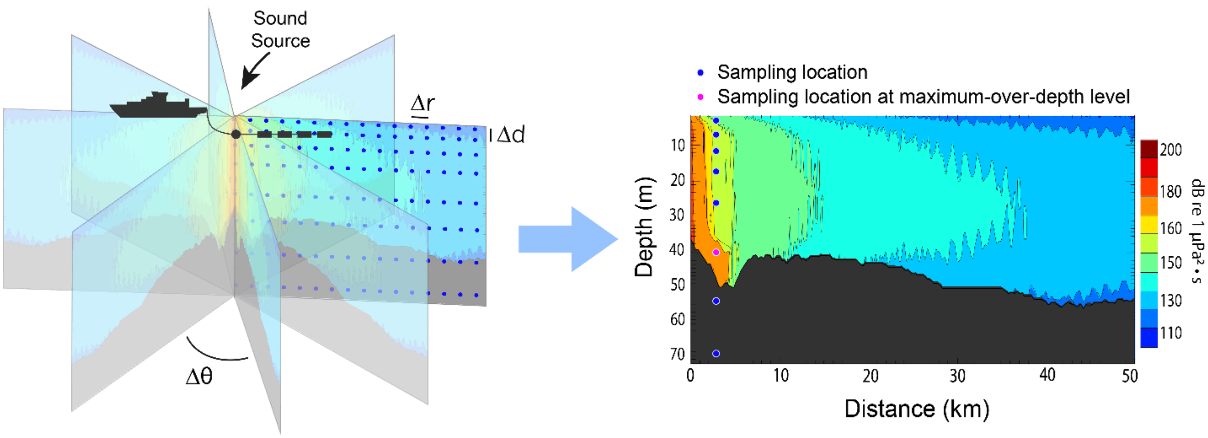

Figure C-1. The N×2-D and maximum-over-depth modelling approach used by MONM.

MONM treats frequency dependence by computing acoustic transmission loss at the centre frequencies of 1/3-octave-bands. Sufficiently many 1/3-octave-bands, starting at 10 Hz, are modelled to include most of the acoustic energy emitted by the source. At each centre frequency, the transmission loss is modelled within each of the N vertical planes as a function of depth and range from the source. The 1/3-octave-band received per-pulse SEL are computed by subtracting the band transmission loss values from the directional source level in that frequency band. Composite broadband received per-pulse SEL are then computed by summing the received 1/3-octave-band levels.

The received per-pulse SEL sound field within each vertical radial plane is sampled at various ranges from the source, generally with a fixed radial step size. At each sampling range along the surface, the sound field is sampled at various depths, with the step size between samples increasing with depth below the surface. The step sizes are chosen to provide increased coverage near the depth of the source and at depths of interest in terms of the sound speed profile. For areas with deep water, sampling is not performed at depths beyond those reachable by cetaceans. The received per-pulse SEL at a surface sampling location is taken as the maximum value that occurs over all samples within the water column, i.e., the maximum-over-depth received per-pulse SEL. These maximum-over-depth per-pulse SEL are presented as colour contours around the source.

An inherent variability in measured sound levels is caused by temporal variability in the environment and the variability in the signature of repeated acoustic impulses (sample sound source verification results is presented in Figure C-2). While MONM's predictions correspond to the averaged received levels, cautionary estimates of the threshold radii are obtained by shifting the best fit line (solid line, Figure C-2) upward so that the trend line encompasses 90% of all the data (dashed line, Figure C-2).

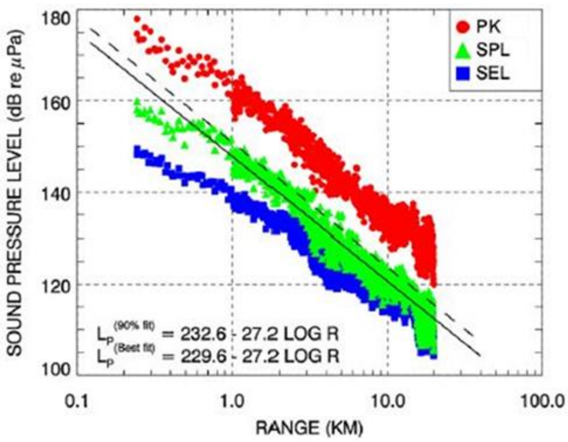

Figure C-2. PK and SPL and per-pulse SEL versus range from a 20 in^3 seismic source. Solid line is the least squares best fit to SPL. Dashed line is the best fit line increased by 3.0 dB to exceed 90% of all SPL values (90th percentile fit) (Ireland et al. 2009, Figure 10).

C.2. Full Waveform Range-dependent Acoustic Model: FWRAM

For impulsive sounds from the seismic source, time-domain representations of the pressure waves generated in the water are required to calculate SPL and PK. Furthermore, the seismic source must be represented as a distributed source to accurately characterise vertical directivity effects in the near-field zone. For this study, synthetic pressure waveforms were computed using FWRAM, which is a time-domain acoustic model based on the same wide-angle parabolic equation (PE) algorithm as MONM. FWRAM computes synthetic pressure waveforms versus range and depth for range-varying marine acoustic environments, and it takes the same environmental inputs as MONM (bathymetry, water sound speed profile, and seafloor geoacoustic profile). Unlike MONM, FWRAM computes pressure waveforms via Fourier synthesis of the modelled acoustic transfer function in closely spaced frequency bands. FWRAM employs the array starter method to accurately model sound propagation from a spatially distributed source (MacGillivray and Chapman 2012).

Besides providing direct calculations of the PK and SPL, the synthetic waveforms from FWRAM can also be used to convert the SEL values from MONM to SPL.

C.3. Wavenumber Integration Model

Sound pressure levels near the seismic source were modelled using JASCO's VSTACK wavenumber integration model. VSTACK computes synthetic pressure waveforms versus depth and range for arbitrarily layered, range-independent acoustic environments using the wavenumber integration approach to solve the exact (range-independent) acoustic wave equation. This model is valid over the full angular range of the wave equation and can fully account for the elasto-acoustic properties of the sub-bottom. Wavenumber integration methods are extensively used in the field of underwater acoustics and seismology where they are often referred to as reflectivity methods or discrete wavenumber methods. VSTACK computes sound propagation in arbitrarily stratified water and seabed layers by decomposing the outgoing field into a continuum of outward-propagating plane cylindrical waves. Seabed reflectivity in the model is dependent on the seabed layer properties: compressional and shear wave speeds, attenuation coefficients, and layer densities. The output of the model can be post-processed to yield estimates of the SEL, SPL, and PK.

VSTACK accurately predicts steep-angle propagation in the proximity of the source, but it is computationally slow at predicting sound pressures at large distances due to the need for smaller wavenumber steps with increasing distance. Additionally, VSTACK assumes range-invariant bathymetry with a horizontally stratified medium (i.e., a range-independent environment) which is azimuthally symmetric about the source. VSTACK is thus best suited to modelling the sound field near the source.

Appendix D. Methods and Parameters

This section describes the specifications of the seismic source that was used at all sites and the environmental parameters used in the propagation models.

D.1. Estimating Range to Thresholds Levels

Sound level contours were calculated based on the underwater sound fields predicted by the propagation models, sampled by taking the maximum value over all modelled depths above the sea floor for each location in the modelled region. The predicted distances to specific levels were computed from these contours. Two distances relative to the source are reported for each sound level: 1) R_{max}, the maximum range to the given sound level over all azimuths, and 2) $R_{95\%}$, the range to the given sound level after the 5% farthest points were excluded (see examples in Figure D-1).

The $R_{95\%}$ is used because sound field footprints are often irregular in shape. In some cases, a sound level contour might have small protrusions or anomalous isolated fringes. This is demonstrated in the image in Figure D-1(a). In cases such as this, where relatively few points are excluded in any given direction, R_{max} can misrepresent the area of the region exposed to such effects, and $R_{95\%}$ is considered more representative. In strongly asymmetric cases such as shown in Figure D-1(b), on the other hand, $R_{95\%}$ neglects to account for significant protrusions in the footprint. In such cases R_{max} might better represent the region of effect in specific directions. Cases such as this are usually associated with bathymetric features affecting propagation. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment.

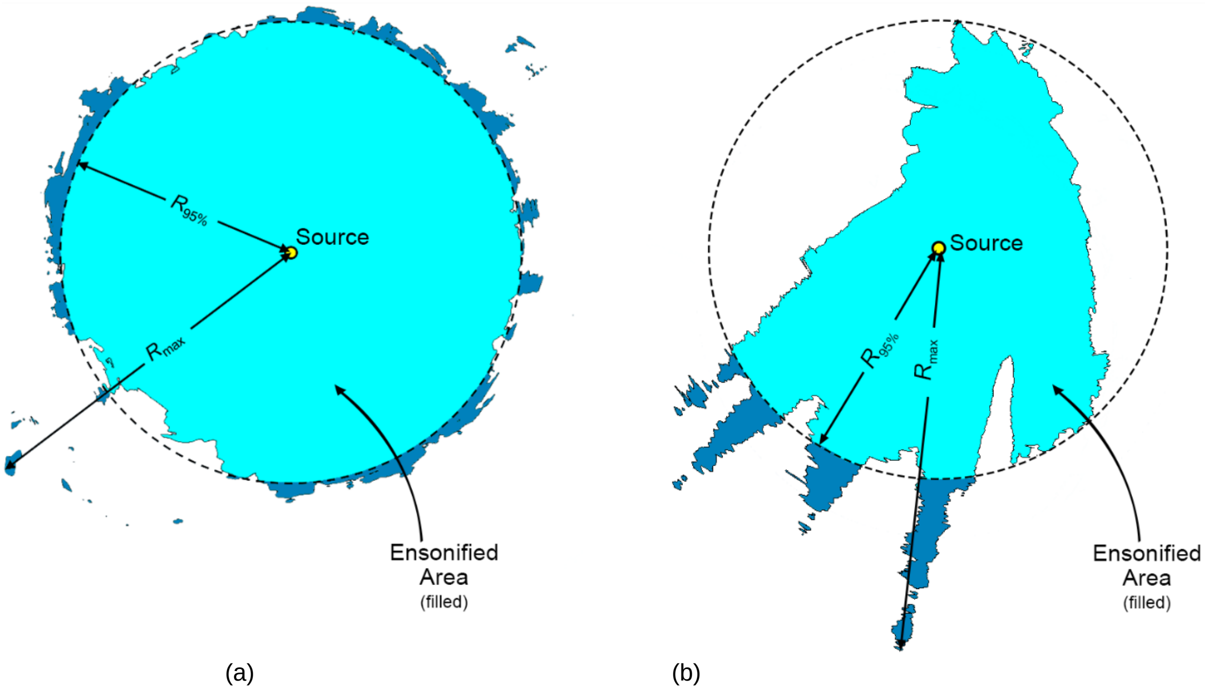

Figure D-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified areas bounded by $R_{95\%}$; darker blue indicates the areas outside this boundary which determine R_{max}.

D.2. Estimating SPL from Modelled SEL Results

The per-pulse SEL of sound pulses is an energy-like metric related to the dose of sound received over a pulse's entire duration. The pulse SPL on the other hand, is related to its intensity over a specified time interval. Seismic pulses typically lengthen in duration as they propagate away from their source, due to seafloor and surface reflections, and other waveguide dispersion effects. The changes in pulse length, and therefore the time window considered, affect the numeric relationship between SPL and SEL. This study has applied a fixed window duration to calculate SPL (T_{fix} = 125 ms; see Appendix A.1), as implemented in Martin et al. (2017b). Full-waveform modelling was used to estimate SPL, but this type of modelling is computationally intensive, and can be prohibitively time consuming when run at high spatial resolution over large areas.

For the current study, FWRAM (Appendix C.2) was used to model synthetic seismic pulses over the frequency range 5–1024 Hz. This was performed along all broadside and endfire radials at two sites. FWRAM uses Fourier synthesis to recreate the signal in the time domain so that both the SEL and SPL from the source can be calculated. The differences between the SEL and SPL were extracted for all ranges and depths that corresponded to those generated from the high spatial-resolution results from MONM. A 125 ms fixed time window positioned to maximize the SPL over the pulse duration was applied. The resulting SEL -to-SPL offsets were averaged in 0.3 km range bins along each modelled radial and depth, and the 90th percentile was selected at each range to generate a generalised range-dependent conversion function for each site. The range- dependent conversion function was averaged between the two sites and applied to predicted per-pulse SEL results from MONM to model SPL values. Figure D-2 shows the conversion offsets for each site; the spatial variation is caused by changes in the received airgun pulse as it propagates from the source. Modelling was conducted using the average conversion function from both sites.

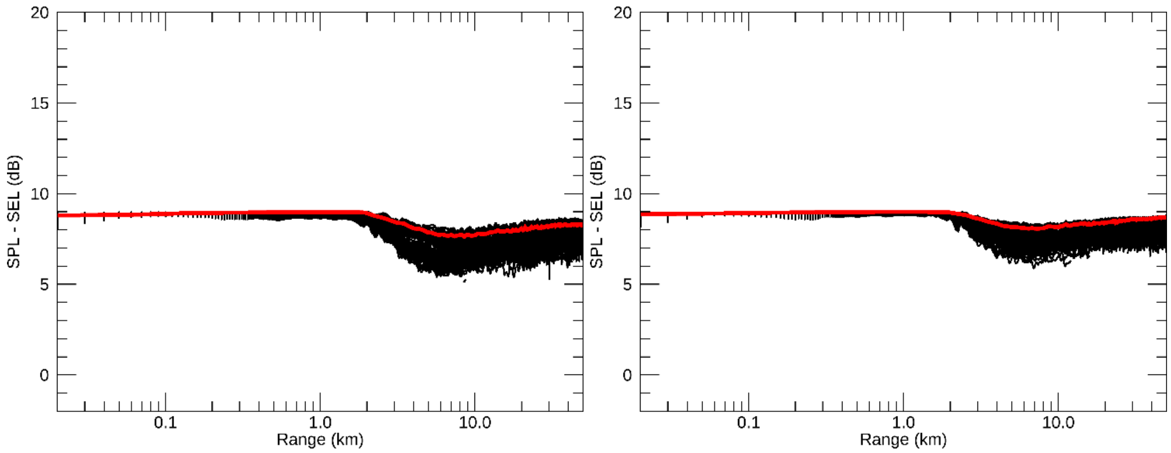

Figure D-2. Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Slices are shown for the 2495 in^3 modelled Site 1 (left) and Site 2 (top right). Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

D.3. Environmental Parameters

D.3.1. Bathymetry

Water depths throughout the modelled area were extracted from the Australian Bathymetry and Topography Grid, a 9 arc-second grid rendered for Australian waters (Whiteway 2009) for the region shown in Figure 1. Bathymetry data were extracted and re-gridded onto a Universal Transverse Mercator (UTM) coordinate projection (Zone 52 S) with a regular grid spacing of 100 × 100 m to generate the bathymetry in Figure D-3.

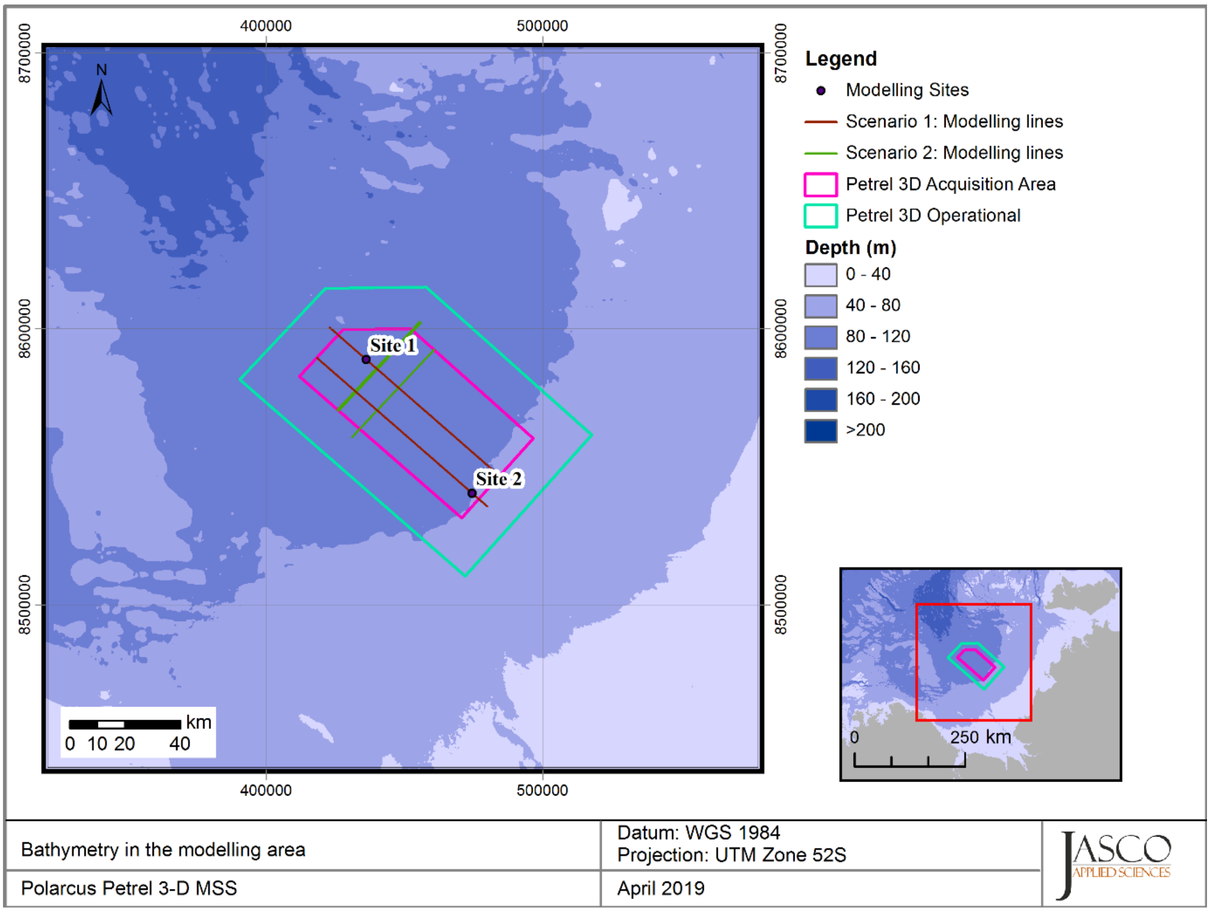

Figure D-3. Bathymetry map of the modelling area.

D.3.2. Sound speed profile

The sound speed profiles for the modelled sites were derived from temperature and salinity profiles from the U.S. Naval Oceanographic Office’s *Generalized Digital Environmental Model V 3.0* (GDEM; Teague et al. 1990, Carnes 2009). GDEM provides an ocean climatology of temperature and salinity for the world’s oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the U.S. Navy’s Master Oceanographic Observational Data Set (MOODS). The climatology profiles include 78 fixed depth points to a maximum depth of 6800 m (where the ocean is that deep). The GDEM temperature-salinity profiles were converted to sound speed profiles according to Coppens (1981).

Mean monthly sound speed profiles (January to December) were derived from the GDEM profiles within a 200 km box radius encompassing the modelling sites. The June sound speed profile is expected to be most favourable to longer-range sound propagation across the entire year. As such, June was selected for sound propagation modelling to ensure precautionary estimates of distances to received sound level thresholds. Figure D-4 shows the resulting profile used as input to the sound propagation modelling.

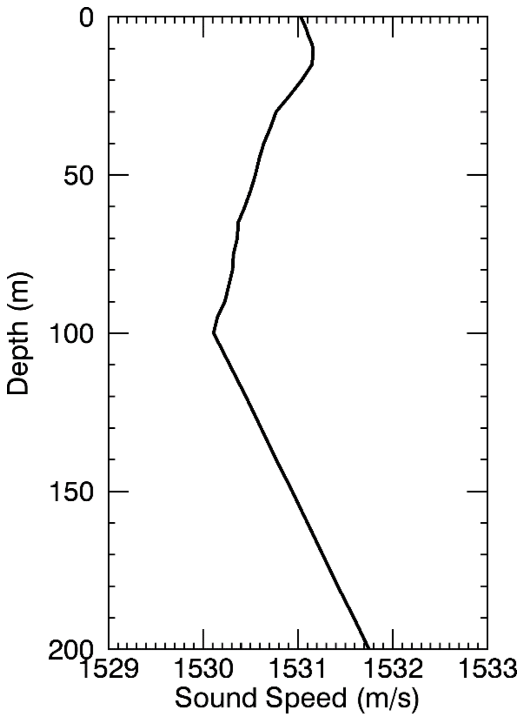

Figure D-4. The final sound speed profile (June) used for the modelling. Throughout the modelling area, the maximum water depth was 154 m. The profile is calculated from temperature and salinity profiles from GDEM V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

D.3.3. Geoacoustics

The modelling sites are located in the North West Marine Region of Australia (Baker et al. 2008), more specifically the middle shelf region, which is dominated by calcareous sand; the sand content of the sites is 40–60% (Baker et al. 2008). Grain size distributions are spatially variable in the area. Overall sediment thicknesses are over 1 km (Whittaker et al. 2013). To provide precautionary estimates of underwater sound levels in the spatially heterogeneous environments, a simplified profile was constructed assuming increasingly consolidated sediment (Table D-1). Geoacoustic parameters for each site were estimated from the sediment model of Buckingham (2005).

Table D-1. Geoacoustic profile for all sites in this study. Within each depth range, each parameter varies linearly within the stated range. The compressional wave is the primary wave. The shear wave is the secondary wave.

Depth below seafloor (m)	Material	Density (g/cm^3)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed (m/s)	Attenuation (dB/λ)
0–10	Muddy sand	1.88	1624–1724	0.34–0.71	262	3.65
10–20		1.88	1724–1777	0.71–0.88		
20–50		1.88–1.90	1777–1874	0.88–1.14		
50–100		1.90–1.92	1874–1978	1.14–1.37		
100–200		1.92–1.96	1978–2118	1.37–1.62		
200–500		1.96–2.06	2118–2392	1.62–1.93		
>500		2.06	2392	1.93		

D.4. Seismic Source

The layout of the seismic sources considered in Appendix B is provided in Figure D-5. Details of the airgun parameters are provided in Table D-2.

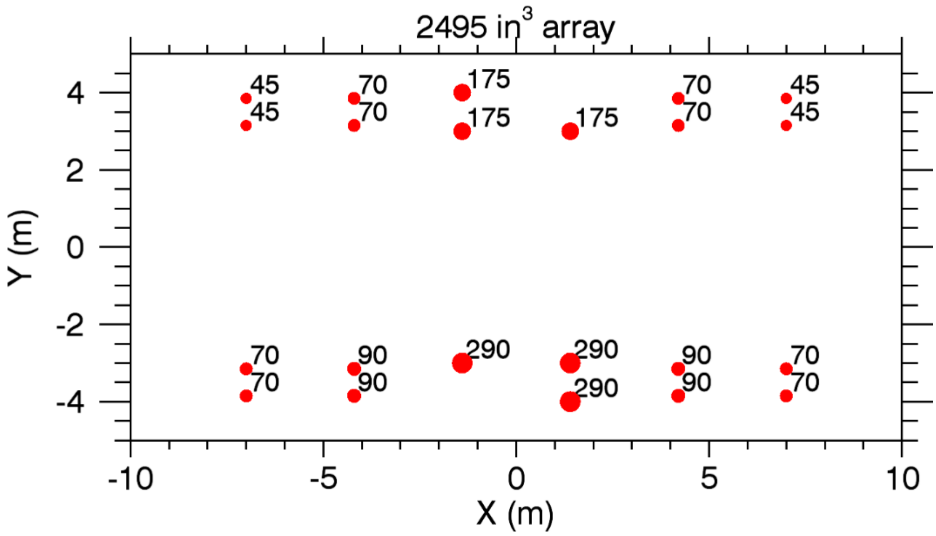

Figure D-5. Layout of the modelled 2495 in^3 seismic source array. Tow depth is 6 m. The labels indicate the firing volume (in cubic inches) for each airgun. Also see Table D-2.

Table D-2. Layout of the modelled 2495 in^3 seismic source array. Tow depth is 6 m. Firing pressure for all guns is 2000 psi. Also see Figure D-5.

Gun	x (m)	y (m)	z (m)	Volume (in^3)	Gun	x (m)	y (m)	z (m)	Volume (in^3)
1	−7	3.85	6	45	12	−7	−3.15	6	70
2	−7	3.15	6	45	13	−7	−3.85	6	70
3	−4.2	3.85	6	70	14	−4.2	−3.15	6	90
4	−4.2	3.15	6	70	15	−4.2	−3.85	6	90
5	−1.4	4	6	175	16	−1.4	−3	6	290
6	−1.4	3	6	175	17	1.4	−3	6	290
7	1.4	3	6	175	18	1.4	−4	6	290
8	4.2	3.85	6	70	19	4.2	−3.15	6	90
9	4.2	3.15	6	70	20	4.2	−3.85	6	90
10	7	3.85	6	45	21	7	−3.15	6	70
10	7	3.15	6	45	22	7	−3.85	6	70

D.5. Model Validation Information

Predictions from JASCO's Airgun Array Source Model (AASM) and propagation models (MONM, FWRAM and VSTACK) have been validated against experimental data from a number of underwater acoustic measurement programs conducted by JASCO globally, including the United States and Canadian Artic, Canadian and southern United States waters, Greenland, Russia and Australia (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b, Matthews and MacGillivray 2013, Martin et al. 2015, Racca et al. 2015, Martin et al. 2017a, Martin et al. 2017b, Warner et al. 2017, MacGillivray 2018, McPherson et al. 2018, McPherson and Martin 2018).

In addition, JASCO has conducted measurement programs associated with a significant number of anthropogenic activities which have included internal validation of the modelling (including McCrodan et al. 2011, Austin and Warner 2012, McPherson and Warner 2012, Austin and Bailey 2013, Austin et al. 2013, Zykov and MacDonnell 2013, Austin 2014, Austin et al. 2015, Austin and Li 2016, Martin and Popper 2016)

APPENDIX F OIL SPILL MODELLING REPORT




QUANTITATIVE OIL SPILL MODELLING STUDY FOR PETREL-8 JOSEPH BONAPARTE GULF

Prepared for:

Santos Ltd

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EXECUTIVE SUMMARY

Background

Santos plans to undertake appraisal drilling at the Petrel-8 well site, located in 98m of water offshore Joseph Bonaparte Gulf. Santos commissioned Asia-Pacific Applied Science Associates (APASA), to undertake a hypothetical worst-case oil spill modelling study for the planned operations at the Petrel-8 well site.

The study was carried out to assess the zones of potential impact to the sea surface, water column and shorelines from two hypothetical worst-case scenarios:

- Scenario 1 – A seasonal assessment of a maximum credible spill of 1,014 m^3 of Shell Diesoline over 6 hours to represent the maximum possible loss of one support vessel's fuel load and a most likely spill, being a refuelling accident release of 2.5 m^3 Shell Diesoline over 1 hour.
- Scenario 2 – An annual assessment of a worst-case seabed blowout of gas and condensate (704 bopd) over a 90 day period.

Methodology

The modelling study was carried out in several stages. High resolution tidal currents for the region were combined with the three-dimensional CSIRO's BRAN (Bluelink ReAnalysis) ocean current database. This combined dataset covered a five year period (2001 to 2005) and provided the total water movement within the region. Finally, these currents and local winds were used as inputs for the spill simulations. Spill simulations were performed using OILMAP-DEEP (to simulate the gas plume dynamics) and SIMAP (to simulate the fate of spilt liquid hydrocarbons) which meets and exceeds the ASTM Standard F2067-07 "*Standard Practice for Development and Use of Oil Spill Models*". Both physical fates models calculate the transport, spreading, entrainment, dispersion and evaporation of spilled gas and oil over time, based on the prevailing metocean conditions and the physical and chemical properties of the gas and oil. The probability of exposure to surrounding waters and contact with shorelines was calculated using a stochastic modelling approach, involving repeated simulations of the same spill scenario under different, randomly sampled, conditions. This ensures the modelling objectively defined the range of possible outcomes and zones of exposure above various thresholds.

Results of Scenario 1 – maximum credible and most likely surface release of diesel

The modelling indicated that the hypothetical worst-case spill of diesel at Petrel-8, across all seasons, would typically evaporate significantly and reduce its surface thickness overtime (< 25 microns within a radius of 24 km and < 10 microns within a radius of 40 km). The direction of drift will be typically with the currents when winds are light, but typically with the winds during moderate winds. Under strong winds, diesel slicks were predicted to entrain into the water column as droplets. If the spill were to occur during strong winds, spilt oil, still very fresh, will entrained and some low level exposure to aromatic compounds dissolving from the diesel droplets was predicted to occur, but limited to within a 20km radius of the spill site and only under strong wind conditions.

Beyond this extent, the modelling quantified that diesoline slicks may also entrain but would have significantly lost its aromatic content to evaporative processes by that time, as to remove the risk significantly for any potential in-water impact. It is important to note that diesel typically contains some heavy components (or low volatile components) that can re-float to the surface if the strong winds abate. In the event of a substantial diesel spill, the heavier components of diesel can remain on the sea surface for an extended period as brightly coloured and silvery reflective sheens which are highly visible, but below levels which could be responded to effectively and below levels that could cause any potential environmental harm.

For the smaller refuelling accident scenario, being the most likely spill, the modelling indicated that the results remained unchanged from the modelling of this same scenario for the nearby Petrel-7 location, that is, slicks did not travel any further than 50km from the release site and did not persist for more than 72 hours as a visible slick on the water's surface.

Results of Scenario 2 – Worst-case subsea blowout

The modelling indicated following the loss of well control at the seabed that a massive gas plume would develop within 23 seconds. Condensate within the gas plume will get substantial lift through the water column, albeit highly turbulent, which liberates water soluble aromatics and creates entrained oil droplets in the order of tens to hundreds of microns in diameter in near surface waters. Most notable, is the ascent or rise speed of the gas plume, predicted to create a violent bubble plume which will entrain surrounding waters and hit the surface at significant speeds, which will induce radially-outward currents at the surface, moving water and entrained oil droplets at about 8 to 9 knots from the plume core. Potentially, if ships are onsite, such a plume would produce explosive concentrations of gas and create a capsize risk for any vessel in the immediate vicinity of such a gas plume.

The SIMAP model quantified that surface slicks resulting from the turbulent gas plume are typically less than 10µm thick even above the release site due to the dispersive behaviour of the turbulence associated with the massive gas plume. At the Petrel-8 site, rise locations changed with the tides and produced short-term surface slicks that fully evaporated as they moved away from the site. The modelling also confirmed that thin visible slicks can occur away from the gas plume from rising oil droplets during calm conditions, but typically only as short-lived visible surface patches. Further, the modelling quantified that there would be no shoreline impacts from surface oil.

The SIMAP model also quantified that the smaller size entrained condensate droplets could persist in surface waters for up to 50 km at low concentrations. This persistence of subsurface small droplets resulted in the dissolution of aromatics into the water column. The model quantified that due to the high aromatic content within the condensate, dissolved aromatics concentrations reached low exposure levels at times which were more persistent than the surface slicks. However, given the significant depths of water at this offshore location in the Joseph Bonaparte Gulf, subsurface plumes will dilute over time. For all seasons, the model predicted that the drift currents passing by the spill location will transport low level dissolved aromatic plumes until diluted below the thresholds.

1 INTRODUCTION

Santos commissioned Asia-Pacific Applied Science Associates (APASA), to undertake an oil spill modelling study for the planned drilling operations at the Petrel-8 field, in the Bonaparte Basin (Table 1 and Figure 1). The Petrel-8 appraisal well is located approximately 260 km west south-west of Darwin in the Northern Territory (NT) and 165 km north-east of Cape Londonderry (WA) in approximately 100 m of water.

The study was carried out to assess the zones of potential impact to the sea surface, water column and shorelines from two hypothetical worst-case scenarios:

- Scenario 1 – A seasonal assessment of a worst-case hypothetical spill of 1,014 m^3 of Shell Diesoline over 6 hours to represent the loss of one support vessel's maximum fuel load. Santos indicated that the support vessels and their associated fuel loads, likely to be used for Petrel 8 are the Promoter (569 m^3), Lady Grete (1,014 m^3) and Far Saltire (880 m^3). Further, a most likely spill scenario was also considered, being a refuelling accident release of 2.5 m^3 Shell Diesoline over 1 hour.

- Scenario 2 – An annual assessment of a worst-case hypothetical seabed blowout of gas and condensate. Santos advised that the flow rate of the Petrel-8 Pilot Well would be the worst-case flow rate and a 90 day response time provided the worst-case duration, hence spill volume for this scenario. Only an annual (all months) assessment was conducted, as the previous spill modelling conducted for the nearby Petrel 7 drilling campaign (9km south east of Petrel 8) indicated very little to no seasonal patterns of surface oil due to its highly evaporative rate and short-lived nature once on the sea surface.

The probability of exposure to surrounding waters and contact with shorelines was calculated using the three-dimensional trajectory and fates capability with OILMAP and SIMAP, respectively. Both physical fates models calculate the transport, spreading, entrainment, dispersion and evaporation of spilled oil over time, based on the prevailing metocean conditions and the physical and chemical properties of the oil.

A stochastic modelling approach, involving collating and analysing repeated simulations of the same spill scenario under different, randomly sampled, environmental conditions, was used. This type of modelling can objectively define the probability of potential impact from a range of potential spill outcomes and quantify exposure to surrounding waters from hydrocarbons.

Note that the modelling conducted here does not take into consideration any of the spill prevention, mitigation and response capabilities that Santos propose to have in place during the drilling campaign. The modelling makes no allowance for intervention following a spill to reduce volumes and/or prevent hydrocarbons from reaching sensitive areas.

Please note that the OILMAP and SIMAP systems, and the methods and analysis presented herein use modelling algorithms which have been anonymously peer reviewed and published in international journals. Further, Asia-Pacific ASA warrants that this work meets and exceeds the ASTM Standard F2067-07 "*Standard Practice for Development and Use of Oil Spill Models*".

Table 1: Summary of the release site used as part of the oil spill modelling study

Location	Latitude (South)	Longitude (East)	Water Depth (m)
Petrel-8	12° 50' 31.41625" S	128° 29' 50.85638" E	98

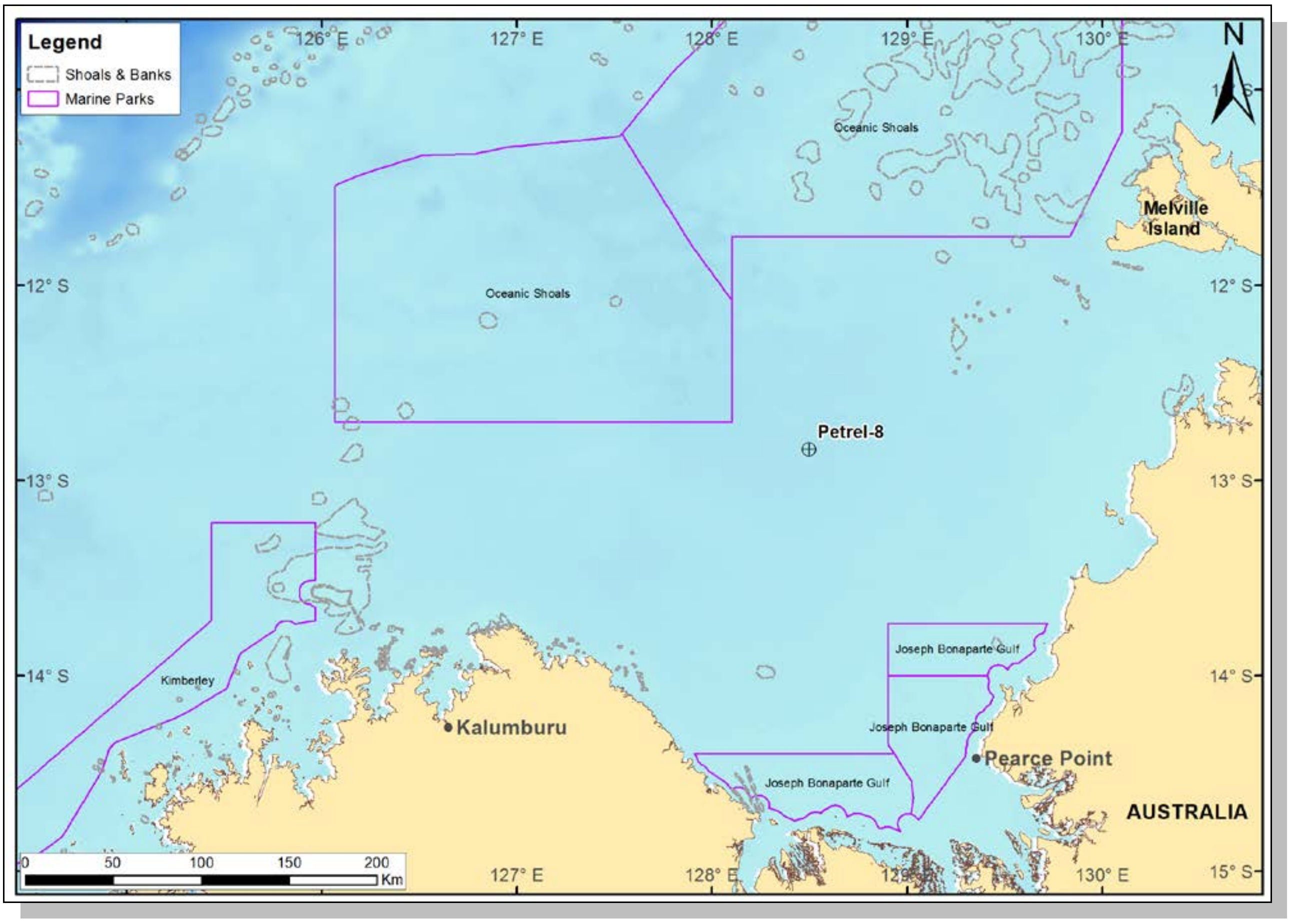


Figure 1: Map showing the location of the proposed drilling site in the Joseph Bonaparte Gulf and surrounding waters. Outlines of submerged shoals and proposed marine areas that might have conservation value are also indicated.

2 SCOPE OF WORK

The scope of work included the following components:

1. Generate the tidal current patterns of the receiving waters using a validated ocean/coastal model, HYDROMAP;
2. Create a 5 year (2001 to 2005, inclusive) dataset describing the large scale flow of ocean waters from the CSIRO's Bluelink ReANalysis (BRAN) ocean model and combine with tidal currents. This combined dataset was used to describe the total water current within the region over a 5 year period to capture climatic extremes;
3. Use the characteristics of the reservoir behaviour under a loss of well control situation as input into the near-field (plume dynamics and initial dilution) model OILMAPDEEP to simulate the near-field properties of the multi-phase hydrocarbon (gas bubbles and oil droplets) plume, and use these as input to the far-field model SIMAP;
4. Use 5 years of spatially varying ambient wind data, the combined currents datasets, and the diesel and condensate characteristics as input into the oil spill model OILMAP and SIMAP, to predict the movement and fate of any oil originating from the proposed drilling site;

5. Use stochastic (or probability) modelling to combine all input data to quantify the probability of contact to the sea surface and shorelines and any relevant zones of potential impact for each hypothetical spill scenario.

3 BONAPARTE CURRENTS

The climate in the region is characterized by seasonal reversal of the prevailing winds. Transport within the Bonaparte Gulf waters is generally dominated by seasonal wind regimes and tidal currents, with tidal range exceeding 7 m during the spring tide.

In contrast, net transport in the deeper offshore waters is influenced less by tides and more by oceanic currents, particularly in water depths greater than 100 m.

Literature suggests that the waters surrounding the proposed appraisal well would be slightly affected by the Indo-Pacific through-flow (Figure 2). The Indo-Pacific through-flow waters are said to drain across the Bonaparte Gulf from the Arafura Sea/Gulf of Carpentaria in the form of the Holloway Current at the end of the Northwest Monsoon, and would also comprise surface waters at other times of the year (DEWHA, 2007, DEC 2009). Additionally, inter-annual variations in the strength of the currents are affected by El Niño- Southern Oscillation events (Pearce, 1991). A comprehensive description of the circulation patterns of the Northwest Shelf and Bonaparte Gulf is provided in a review by Condie and Andrewartha (2008).

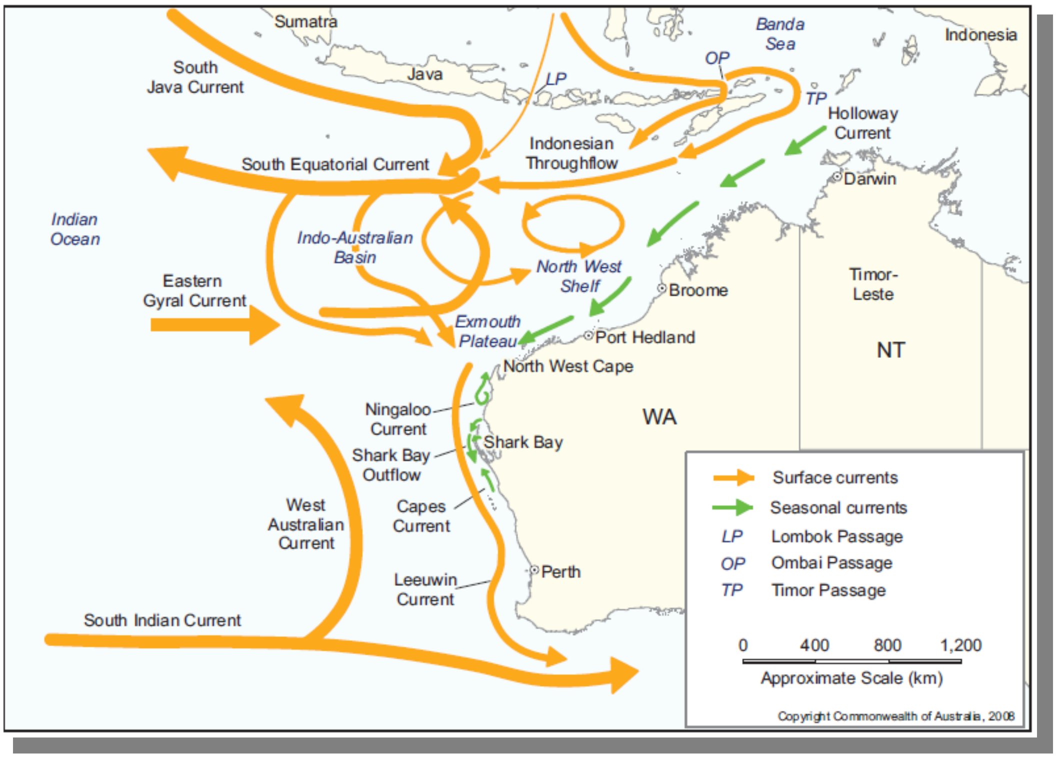


Figure 2: Schematic of ocean currents along the northwest Australian continental shelf. Image copied from DEWHA 2008.

3.1 Tidal Model – HYDROMAP

The tidal speeds and directions (as a function of time) off the coast of Western Australia were generated using the ocean/coastal model (HYDROMAP). The model formulations and output (current speed/direction and sea levels) for predicted current and sea levels have been verified through field measurements around the world over the past 23 years (Isaji and Spaulding, 1984; Isaji et al., 2001; Zigic et al., 2003).

The HYDROMAP model simulates the flow of ocean currents within a model region due to forcing by astronomical tides, wind stress and bottom friction for any location around the globe. The model employs a sophisticated nested-gridding strategy, supporting up to six levels of spatial resolution. This allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, or of particular interest to a study.

To simulate the ocean-circulation over the area of interest, the model was provided with the following data:

1. Measured bathymetry for the area, which defined the shape of the seafloor; and;
2. The amplitude and phase of tidal constituents, which are used to calculate sea heights over time at the open boundaries of the model. Changes in sea height are used, in turn, to calculate the propagation of tidal currents throughout the model region.

A more detailed presentation of the model can be found in Isaji et al. (2001), Isaji and Spaulding (1984) and Owen (1980).

3.1.1 Grid Setup

The grid domain encompassed approximately 1,500 km of coastline from Warrum (Northern Territory) to Bedout Island (Western Australia), and was extended offshore to cover the Timor Sea (refer to Figure 3 and Figure 4). Employing HYDROMAP's novel gridding approach, the base cell size (level 0) was set to 14km x 14km. Each level of sub-gridding halves the cell size. Hence the cells along the coastlines were resolved to level one (hence, reducing the base cell from 14 km to 7 km), with a further reduction to 0.875 km to resolve complex passages through the islands. The total size of the final gridded area is approximately 1,250 km N-S x 1,540 km E-W, with a total active grid cell count of 15,389 cells.

3.1.2 Ocean Boundary Conditions

The ocean boundary data for the regional model was obtained from satellite measured altimetry data (TOPEX/Poseidon 7.2) which provided estimates of the eight dominant tidal constituents at a horizontal scale of approximately 0.25 degrees. The eight major tidal constituents used were K_2, S_2, M_2, N_2, K_1, P_1, O_1 and Q_1.

The Topex-Poseidon tidal data has been widely used amongst the oceanographic community for global ocean models and for tidal open boundary conditions in hydrodynamic models (see also Vikebo et al., 2005,).

To define the shape of the seafloor, the updated bathymetric data was obtained from extensive digitised nautical charts and Geoscience Australia, and was spatially interpolated to fill the entire model domain (Figure 4). The minimum, average and maximum depths across the gridded region were 1 m, 246 m and 2,549 m, respectively.

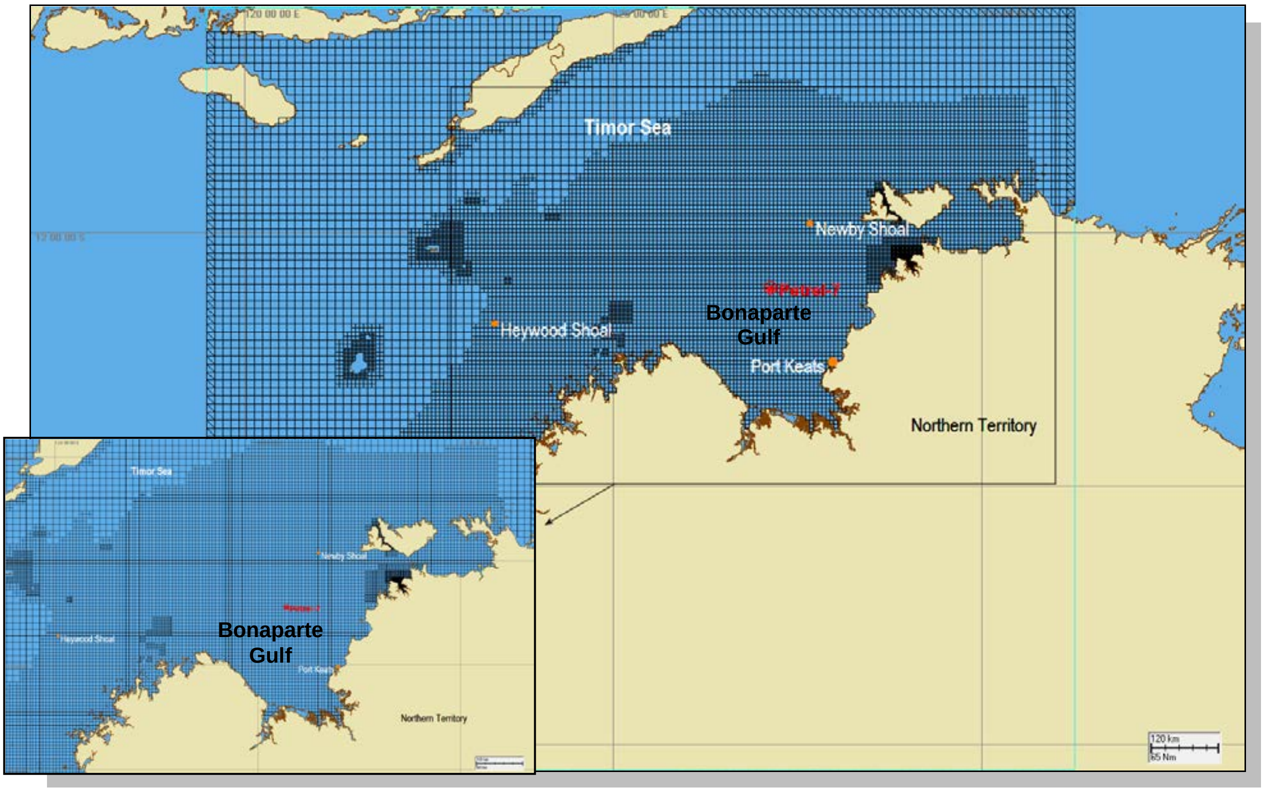


Figure 3: Map showing the extents of the grid and inset showing finer grid resolution (nested cells) along the coastline and Islands nearby the release sites.

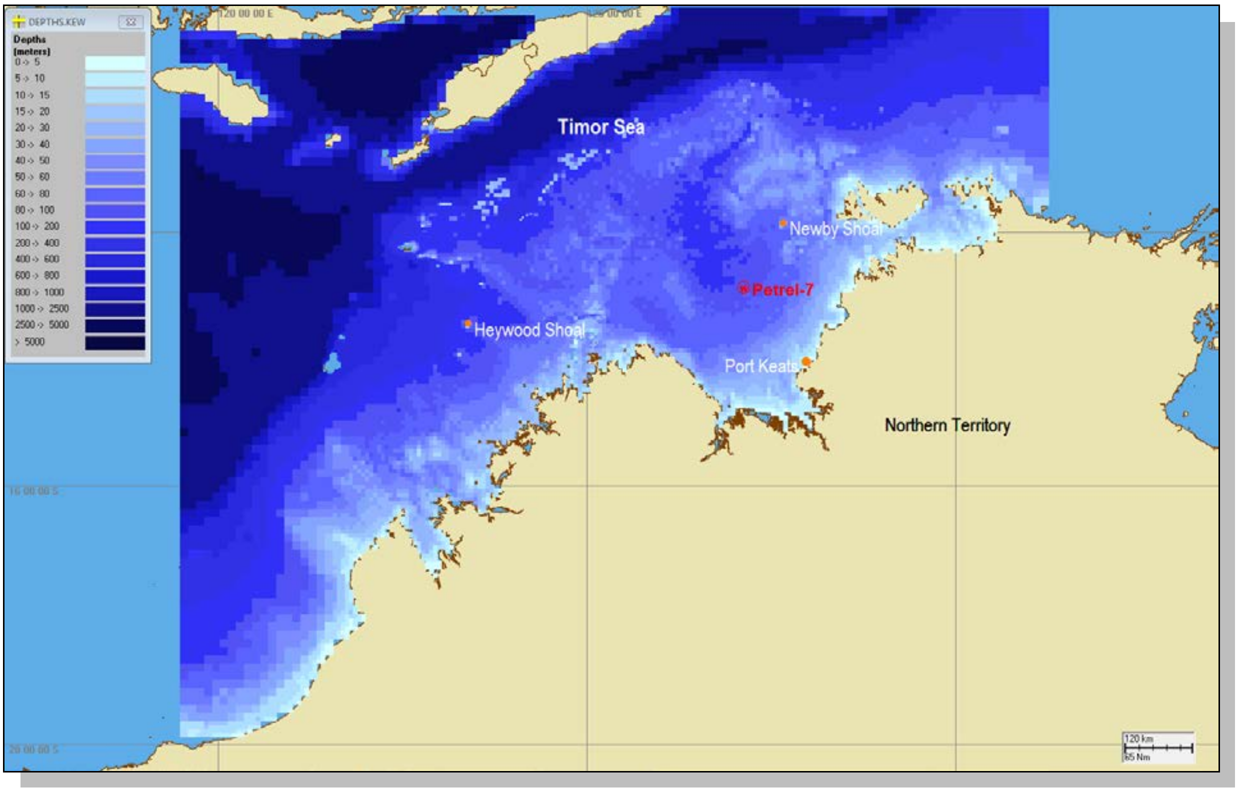


Figure 4: Bathymetry grid used to define the depths throughout the model domain, and the location of the time-series points (in orange) for surface elevation model validation.

3.1.3 Model Parameters and Validation

To account for the drag between the seabed layer and the seabed, a Manning's bottom roughness coefficient of 0.02 was used. The model was set up to start on March 1st 2008 and was run for 35 days, to finish on the April 5th 2008.

For the purposes of verification, three time-series points (recording surface elevation data) were defined along the coastline (refer to Figure 4 for locations). Predicted and observed data was then used to validate the HYDROMAP model. The observed tidal information was obtained from a tidal database.

Figure 5 shows the time-series comparisons between the predicted and observed tides from the 1st to 31st March 2008.

As each graph confirms, the model input data, settings and formulations had accurately reproduced the phase and amplitudes throughout the spring and neap tidal cycles at the three locations.

Table 2 shows the summarized correlation values for the predicted against the observed data. The 'R^2' value represents the phasing correlation, so 0.9578 indicates an average explanation of variance of 95.78% of the tidal fluctuation. The 'm' value represents the amplitude correlation (note: 'm' values over 1.0 are over predicting the surface elevation, where values less than 1.0 are under predicting the surface elevation).

Table 2: Statistical comparison between the observed and HYDROMAP predicted surface elevation data from the 1st to 31st March 2008.

Tide Station	R^2	m
Port Keats	0.9728	0.9145
Heywood shoal	0.9577	0.9979
Newby Shoal	0.943	0.9486
Average	**0.9578**	**0.9537**

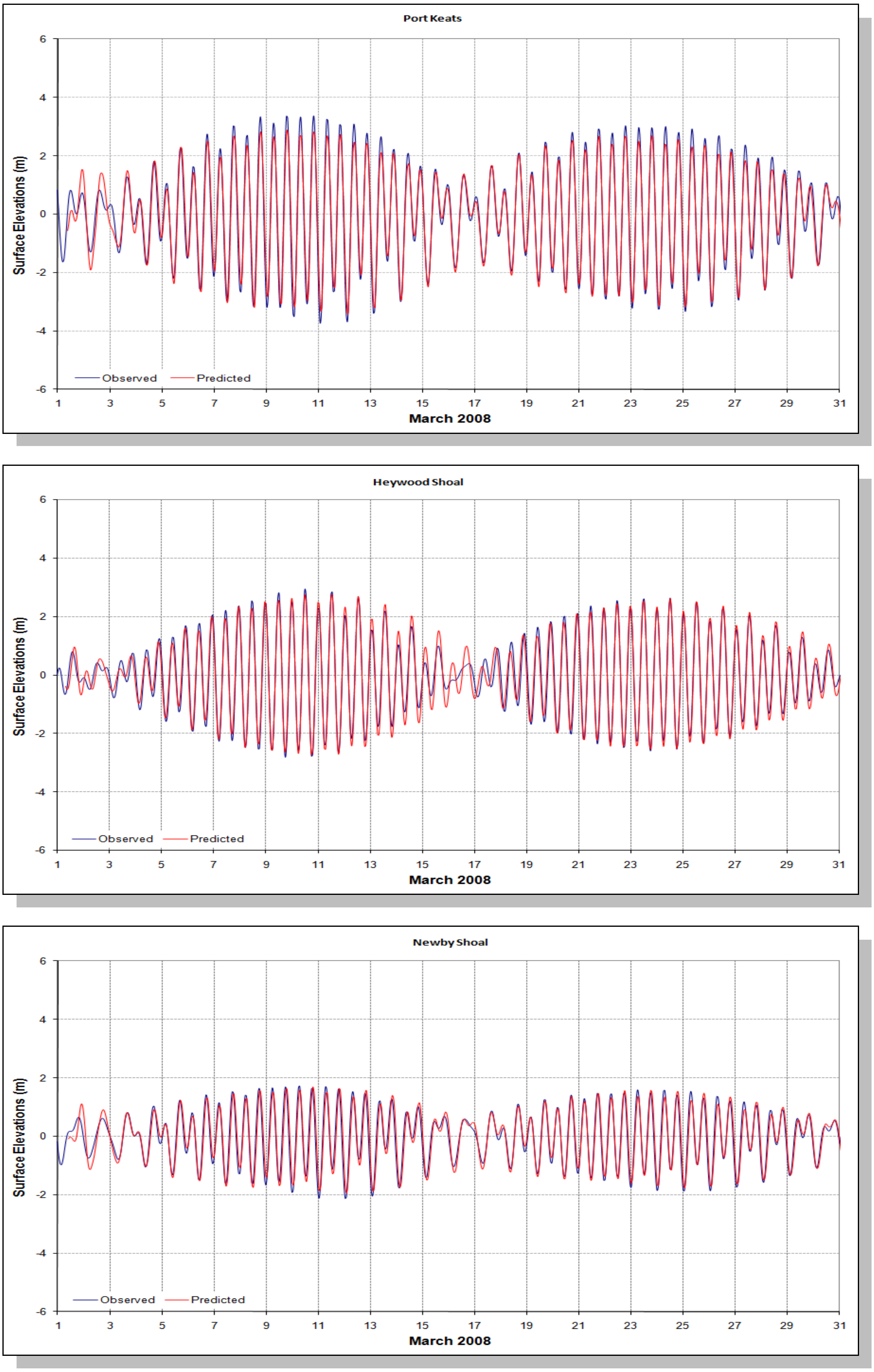


Figure 5: Comparison between predicted (red line) and observed (blue line) surface elevation variation at Port Keats (top), Heywood Shoal (middle) and Newby Shoal (bottom), between the 1st and the 31st of March 2008

3.2 Deep Ocean Large Scale Currents – BRAN

Data describing the ocean currents was obtained from CSIRO's BRAN – (Bluelink ReAnalysis – Oke et al., 2008, 2009; Schiller et al., 2008; Andreu-Burillo et al., 2010) ocean hindcast database. BRAN has been developed through a partnership with CSIRO, Bureau of Meteorology and Royal Australian Navy. The BRAN ocean model realistically reproduces the large to meso-scale circulation around Australia, representing both the broad-scale circulation with extensive assimilation of satellite observed ocean measurement data (Oke et al., 2008).

BRAN data was obtained for the years 2001 to 2005 (inclusive) and combined with the generated high resolution tidal current database. Seasonal current roses derived from the BRAN data are presented for Petrel-8 in Figure 6. Figure 7 shows a snapshot of the BRAN Ocean surface currents with tides over the region.

The combined sea and tidal currents were shown to vary with the time of year and in some areas currents reached speeds of over 1 m/s.

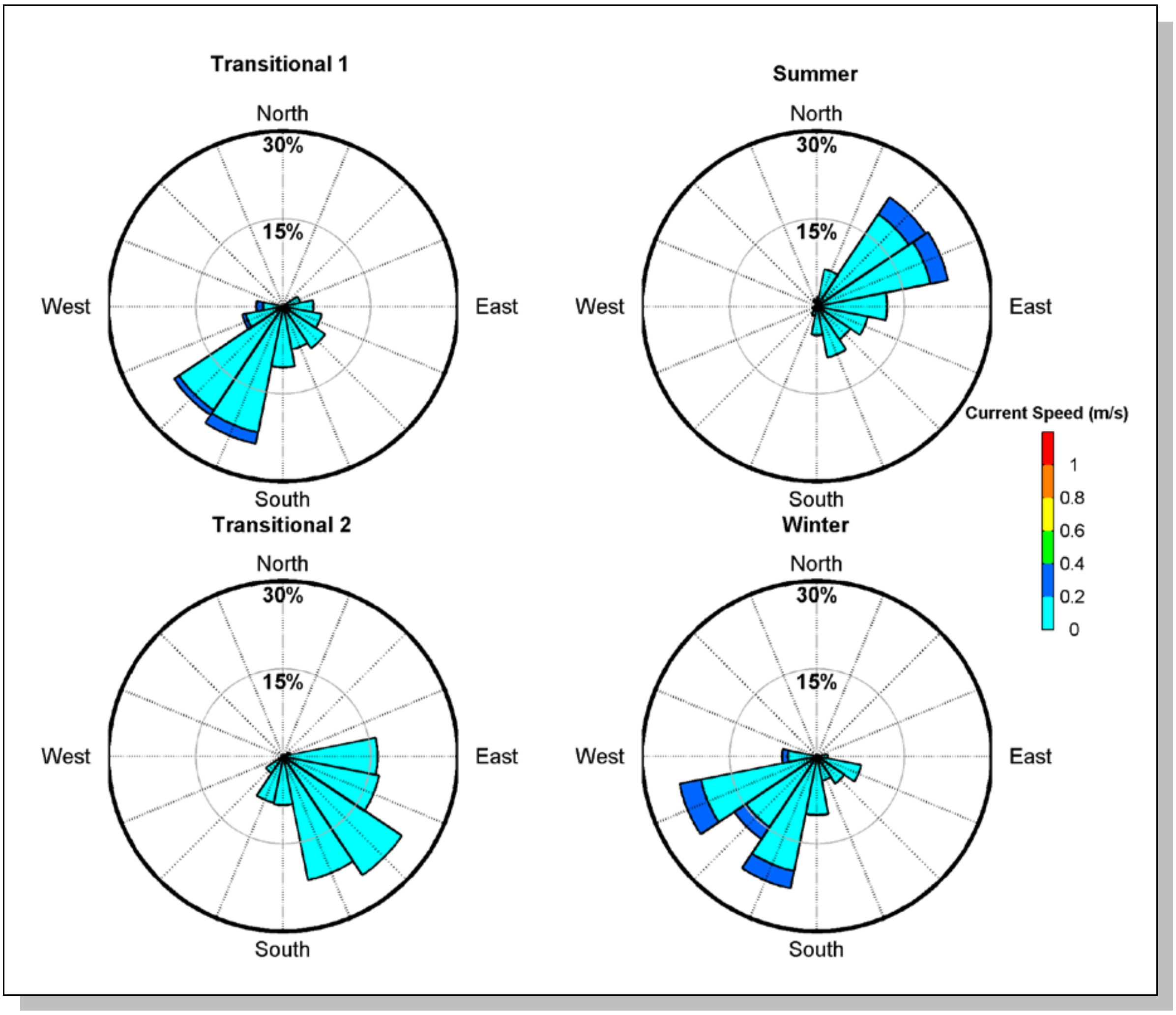


Figure 6: Seasonal ocean surface current roses derive from the BRAN Ocean model from 2001 to 2002 (inclusive), at Petrel-8. The colour key shows the current magnitude, the compass direction provides the current direction flowing TO and the length of the wedge gives the percentage of the record for a particular speed and direction combination.

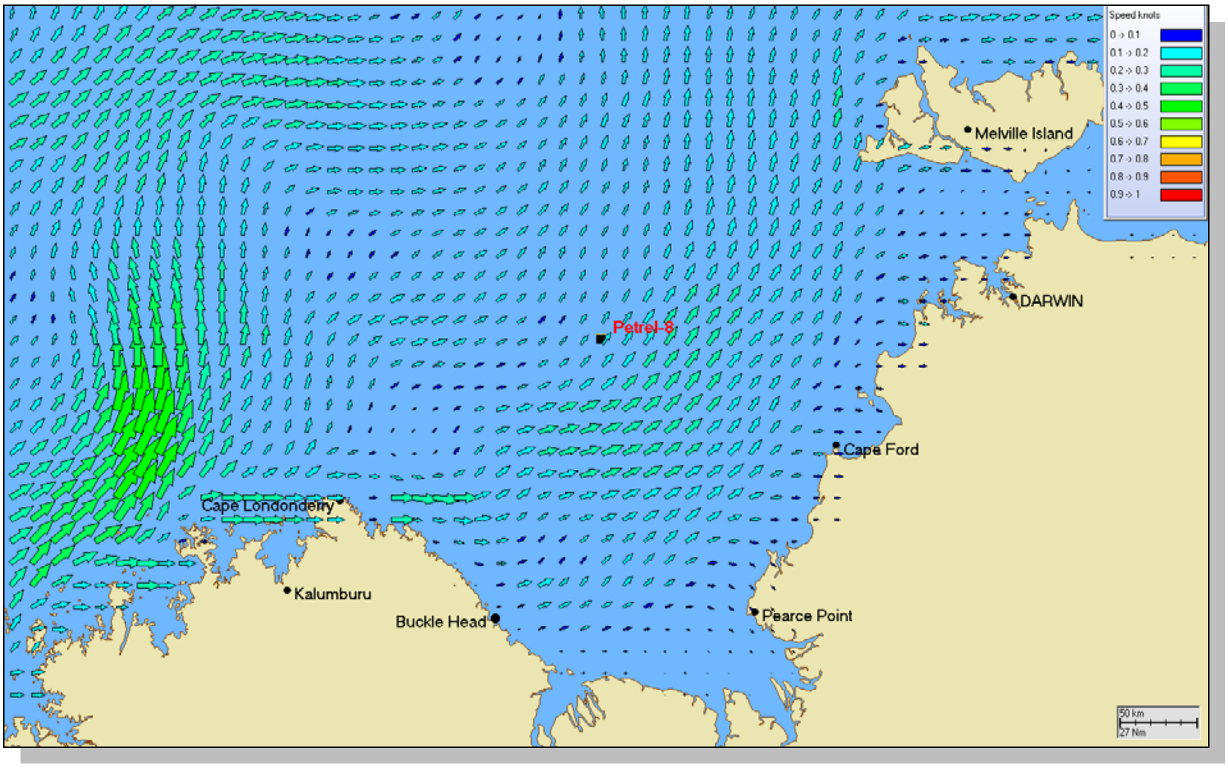


Figure 7: Snapshots of the combined ocean surface currents from BRAN and HYDROMAP tidal currents during the winter period and an incoming tide.

4 WIND DATA

To account for the wind influence, local wind data was sourced from the National Centers for Environmental Predictions (NCEP) reanalysis global model, which is made available by NOAA's (National Oceanic and Atmospheric Administration) Climate Diagnostics Center. The NCEP wind data is the integration of extensive historic and observed atmospheric data into a state-of-the-art atmospheric model, with global coverage predictions at 6-hourly intervals.

NCEP wind data for the years 2001 to 2005 (inclusive) was extracted across the entire model domain for input into the oil spill model (Figure 7). Figure 8 shows the yearly and monthly wind rose distributions for the nearest NCEP wind station to the appraisal well(s) site (station 6309). Note that the atmospheric convention for defining wind direction, that is, the direction the wind blows from, is used to reference wind direction throughout this report. Each branch of the rose represents wind coming from that direction, with north to the top of the diagram. Eight directions are used. The branches are divided into segments of different thickness, which represent wind speed ranges from that direction. Speed intervals of 5 knots are used in these wind roses. The width of each segment within a branch is proportional to the frequency of winds blowing within the corresponding range of speeds from that direction.

The data indicates that during the months from November to February, the winds are predominantly from the west or northwest and variable in intensity (average: 12 knots and maximum: 34 knots). From April to August, the majority of winds are moderate and come from the east or southeast (average: 11 knots and maximum: 29 knots). During the transitional months the winds come from all directions with a slight bias from the westerly sector (average: 7 knots and maximum: 29 knots).

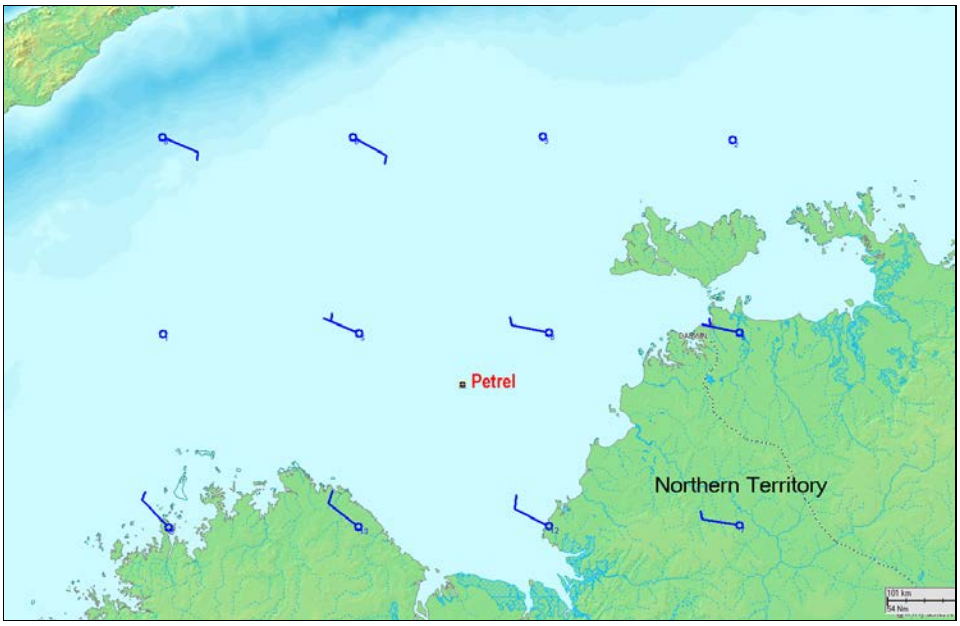


Figure 8: Map showing the spatial resolution of the wind data used as input into the oil spill model.

5 SEA SURFACE WATER TEMPERATURE AND SALINITY

Sea surface temperatures vary seasonally within the monthly-averaged limits of 24°C (winter and early spring) to 27°C (summer), while water salinity is almost constant at approximately 36 parts per thousand (ppt) throughout the seasons this far offshore (Levitus World Oceanographic database).

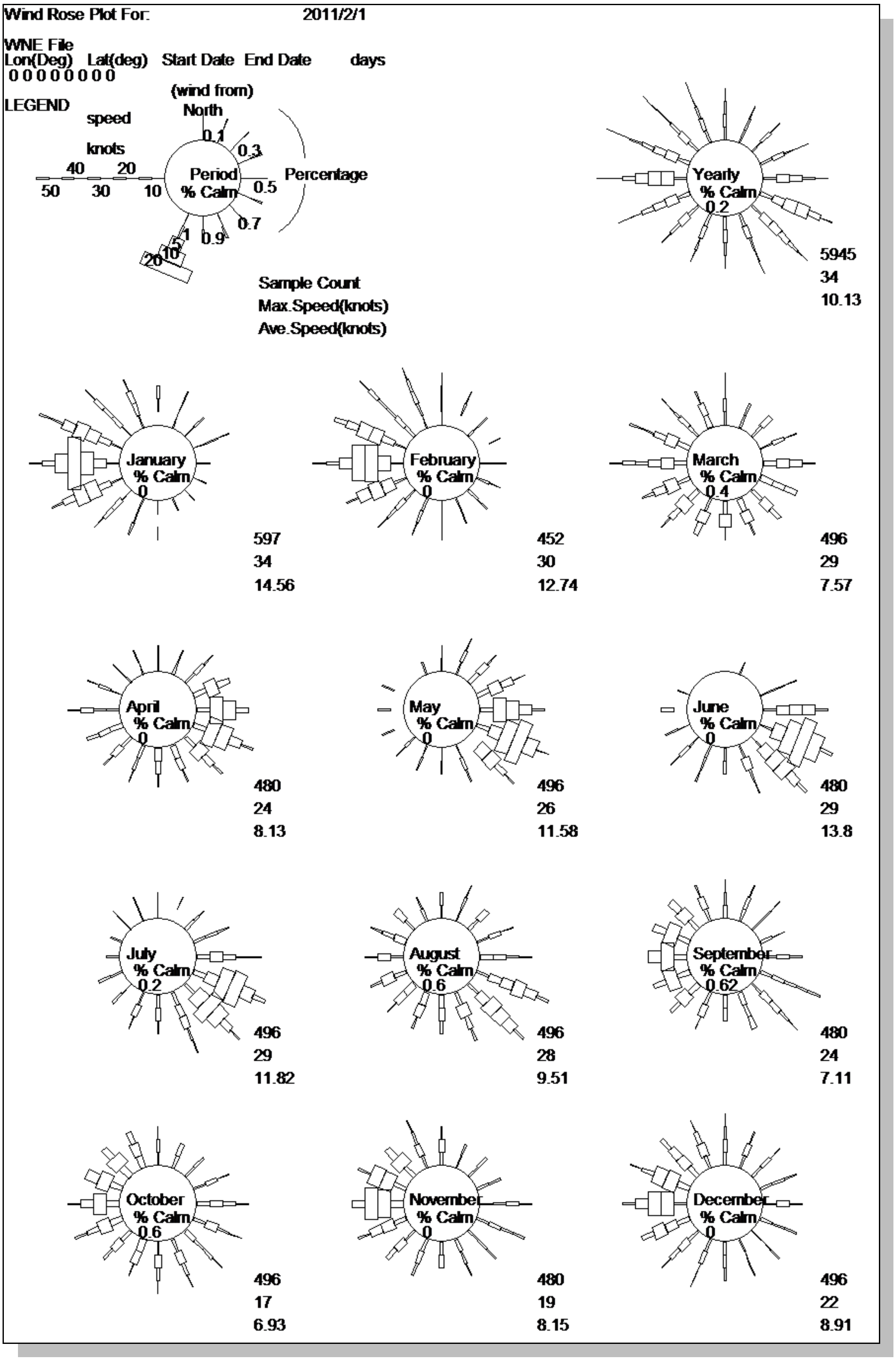


Figure 9. Monthly and annual wind rose distribution for the closest NCEP station (6309) during 2001 to 2005, inclusive.

6 NEAR-FIELD OIL SPILL MODEL – OILMAP-DEEP

Modelling an oil and gas blowout plume can be separated into two phases, near-field and far-field, analogous to a traditional thermal plume modelling exercise. The near-field behaviour of multi-phase hydrocarbon plumes released during subsea blowouts is complex and is an on-going and active field of research; however, the science is currently at a phase where accurate predictions of plume behaviour can be made.

ASA developed a near-field blowout model, OILMAP-DEEP, which is based on the work of McDougall (1978, gas plume model), Fanneløp and Sjøen (1980, plume/free surface interaction), Spaulding (1982, oil concentration model), Kolluru, (1993, World Oil Spill Model implementation) and Spaulding et al. (2000, hydrate formation). A simplified integral jet theory is employed for the vertical as well as for the horizontal motions of the gas-oil plume. The necessary model parameters defining the rates of entrainment and spreading of the jet are obtained from laboratory studies (Fanneløp and Sjøen 1980). The gas plume analysis is described in McDougall (1978), Spaulding (1982), and Fanneløp and Sjøen (1980). The hydrate formation and dissociation is formulated based on a unique equilibrium kinetics model developed by R. Bishnoi and colleagues at the University of Calgary. A brief description of the governing equations used in ASA's blowout model and the solution methodology are described in Spaulding et al. (2000).

The results of the near-field blowout model provide information to the far field fates model about the plume (the three dimensional extent of the mixture of gas/oil/water) and a characterisation of the initial dispersion/mixing of the oil discharged during the blowout. Key factors in this analysis are the volume flux of oil and gas, gas to oil ratio (GOR), depth, exit flow velocity and environmental water column conditions (the profile of water temperature and density) which affect both the trap height and the potential for hydrate formation. Other factors such as duration of the blowout and ambient currents are also included but are less important.

The OILMAP-DEEP blowout model implementation is done in two parts; the first is the plume model, based on the McDougall bubble plume model; the second is the oil droplet size distribution and volume fraction calculation. While they are based on the same scenario blowout specifications (e.g. oil type and flow rate, gas oil ratio and depth), the model predictions are treated separately and do not interact. The two parts of the model predictions only come together at the collapse of the near field plume, at the trap height, where the depth and droplet distribution predictions are used for initialization of the far field model simulation.

The plume model prediction is defined by a small set of parameters including:

- Blowout release depth
- Oil discharge rate
- Oil density
- Gas to oil ratio at the surface
- Atmospheric pressure
- Ambient seawater density profile
- Plume spreading coefficient
- Entrainment parameter
- Slip velocity of gas bubbles in the oil plume
- Ambient current velocity

The blowout model predictions for oil droplet size-distribution is based on the CDOG model (Yapa & Zheng, 2001) which uses a maximum diameter calculation and the Rosin-Rammler (1933) log normal distribution curve to specify the overall droplet size distribution by volume.

The oil droplet size distribution is defined by a small set of input parameters including:

- Release depth
- Oil discharge rate
- Gas to oil ratio (GOR) at the surface, used to calculate GOR at depth
- Pipe opening diameter
- Blowout jet temperature
- Ambient salinity (used with jet temp for density calculation)

More detail on the OILMAP-DEEP model, including the governing equations, can be found in the OILMAP-DEEP Technical Manual (ASA 2011).

7 THREE-DIMENSIONAL FAR-FIELD OIL SPILL MODEL – SIMAP

SIMAP is designed to simulate the fate and effects of spilled hydrocarbons for both the surface slick and the three-dimensional plume that is generated in the water column from sub-surface releases (French et al., 1999; French McCay, 2003; French McCay, 2004; French McCay et al., 2004).

The SIMAP physical fates model calculates the transport, spreading, entrainment, evaporation and decay of surface slicks and the entrained and dissolved oil released from the slicks. Input specifications for oil-types include density, viscosity, pour point, distillation curve (volume lost versus temperature) and the aromatic/aliphatic component ratios within given boiling point ranges. The oil specifications are used to proportion the distribution of the oil (as mass and concentrations) over time into the following components:

- Surface bound oil
- Entrained oil (non-dissolved oil droplets that are physically entrained by wave action)
- Dissolved hydrocarbons (principally the aromatic hydrocarbons)
- Evaporated hydrocarbons
- Sedimented hydrocarbons
- Decayed hydrocarbons

The SIMAP trajectory model separately calculates the transport of the material that is on the water surface (as surface slicks), in the water column (as either entrained whole oil droplets or dissolved hydrocarbon), has stranded on shorelines, or that has precipitated out of the water column onto the seabed. The model calculates the transport of surface slicks as a combination of the forces exerted by surface currents and wind acting on the oil.

7.1 Stochastic Modelling

The OILMAP and SIMAP models may be used to simulate the fate of a single oil spill at a specified time and therefore under a given set of time-varying winds and currents. This is the general approach for an exercise or known spill event.

As spills can occur during any set of wind and current conditions, the OILMAP and SIMAP stochastic models were used to quantify the likelihood of sea surface and subsurface exposure and shoreline contact for the two spill scenarios over the different seasons. The model runs many single spill trajectories (e.g.100 per season and location) using the same spill information (i.e. release location, spill volume, duration and oil type) but varies the start time, and in turn, the prevailing wind and current conditions. This approach ensures that the predicted transport and weathering of an oil slick is subjected to range of current and wind conditions.

During each spill trajectory, the model records the grid cells exposed to oil, as well as the time elapsed. Once all of the spill trajectories have been run, the model then combines the results from the individual simulations to determine the following:

1. Probability that a grid cell (sea surface and shorelines) is exposed to the oil spill trajectories; and
2. Minimum time that a grid cell is exposed to the oil spill trajectories.

The stochastic model output does not represent the extent of any one spill trajectory (which would be significantly smaller) but rather provides a summary of all trajectories run for each season of each scenario.

For this assessment, 100 simulations were performed for the short-term diesel spill scenario (using OILMAP) and 50 simulations for the long-term blowout scenario (using SIMAP). These simulations were repeated for each season and each single stochastic output was post processed for the specified reporting thresholds. This equated to a total of 450 individual simulations for the entire assessment, ensuring that the predicted transport and weathering of an oil spill simulation was subjected to a range of wind and current conditions for each scenario and season.

7.2 Sea surface, Shoreline and Water Column Oil Thresholds

The SIMAP model is able to track hydrocarbons to levels that are lower than biological significance or visible to the naked eye. Therefore, reporting thresholds have been specified (based on scientific literature) to control the recording of “contact/exposure” to locations when at meaningful levels only.

Based on literature reviews of oil effects on aquatic birds and marine mammals by Engelhardt (1983), Clark (1984), Geraci and St. Aubin (1988), and Jenssen (1994), the threshold thickness of oil that would impart a lethal dose to the most sensitive of species is 10 µm (~10 g/m^2) only. Hence, 10 g/m^2 has been selected to conservatively define the moderate exposure zone.

Scholten et al. (1996) indicates that at a layer 25 µm thick would be harmful for birds that contact the slick. Therefore, this thickness was used to conservatively describe zones of heavy exposure. Figure 10 and Figure 11 are photographs illustrating the difference in appearance of spilled oil in the marine environment. Table 3 details the Bonn Appearance Code for relating visual appearance of oil on water to its thickness on the water surface.

Table 3: The Bonn Agreement Oil Appearance Code.

Code	Description Appearance	Layer Thickness Interval (µm)	Litres per km^2
1	Sheen (silvery/grey)	0.04 – 0.30	40 – 300
2	Rainbow	0.30 – 5.0	300 – 5,000
3	Metallic	5.0 – 50	5,000 – 50,000
4	Discontinuous True Oil Colour	50 – 200	50,000 – 200,000
5	Continuous True Oil Colour	200 –>200	200,000 –>200,000

Figure 10: A photograph showing the difference between silvery sheen and rainbow sheen oil around the edges. The thickness of the silvery sheen is between 0.04 g/m^2 – 0.3 g/m^2. The thickness of the rainbow sheen is 0.3 g/m^2 – 5.0 g/m^2 (source: Bonn Agreement Aerial Surveillance Handbook, 2004 – Part 3, Annex A).

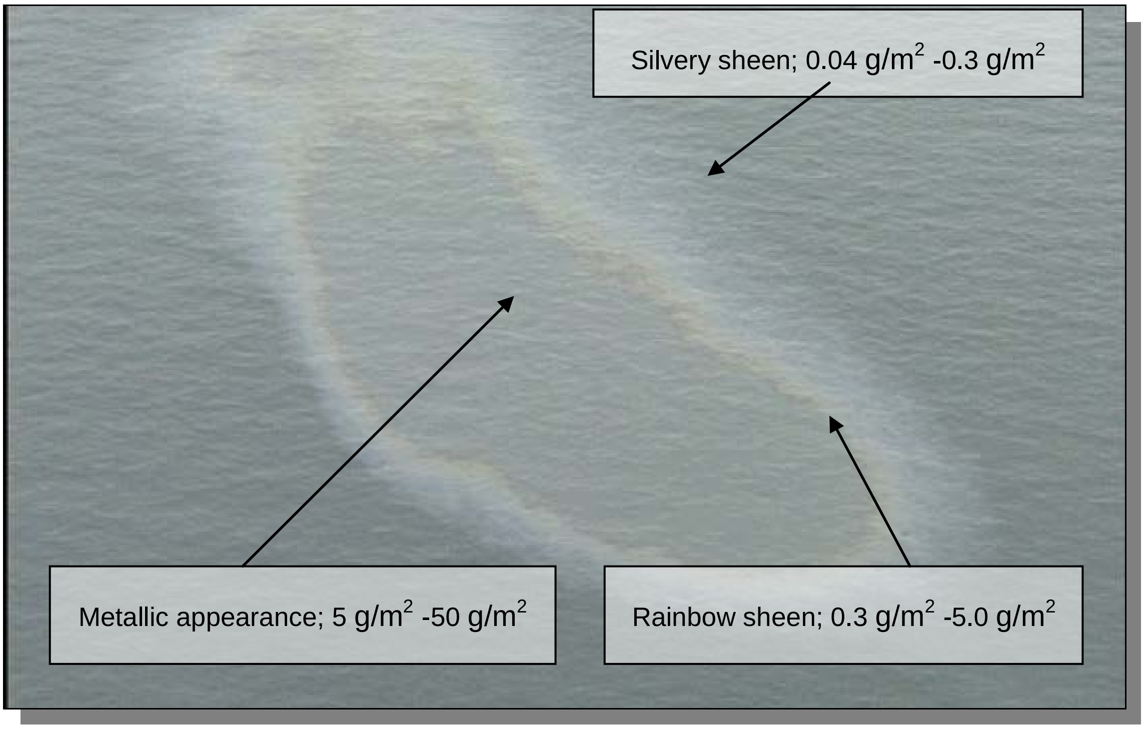


Figure 11: A photograph showing the difference between metallic appearance in the centre and the silvery and rainbow sheen oil around the edges. The thickness of the metallic is between 5 g/m^2 – 50 g/m^2; rainbow sheen is between 0.3 g/m^2 – 5.0 g/m^2; and silvery sheen is between 0.04 g/m^2 – 0.3 g/m^2. (source: Bonn Agreement Aerial Surveillance Handbook, 2004 – Part 3, Annex A).

As the dissolved aromatic and entrained in-water concentrations were quantified for Scenario 1 and 2, it was necessary to establish applicable trigger values. Studies indicate that the dissolved aromatic compounds (typically the mono-aromatic hydrocarbons and the two and three ring poly-aromatic hydrocarbons) are commonly the largest contributor to the toxicity of solutions generated by mixing oil into water (Di Toro et. al., 2007). The dosage level (threshold value x duration) was used to assess the potential for sub-surface exposure to sub-surface habitats and species by entrained and dissolved aromatic hydrocarbons. The threshold value for species toxicity in the water column is based on global data from French et al. (1999) and French-McCay (2002, 2003), which showed that species sensitivity (fish and invertebrates) to dissolved aromatics exposure > 4 days (96-hour LC50) under different environmental conditions varied from 6 to 400 µg/l (ppb) with an average of 50 ppb. This range covered 95% of aquatic organisms tested, which included species during sensitive life stages (eggs and larvae). Based on scientific literature, a minimum threshold of 6 parts per billion (ppb) over 96-hours or equivalent was used to assess in-water low exposure zones, respectively (Engelhardt, 1983; Clark, 1984; Geraci and St. Aubin, 1988; Jenssen, 1994 and Tsvetnenko, 1998 all found some degree of toxicity to very sensitive species at this level). French-McCay (2002) indicates that an average 96 hour LC_{50} of 50 ppb and 400 ppb could serve as an acute lethal threshold to the most sensitive or 5% of biota and 50% of biota, respectively. Hence, these thresholds were used to conservatively represent the moderate and high exposure zones, respectively.

In lieu of well-defined information, conservative thresholds were used to indicate possible effect areas for entrained condensate. The lowest threshold concentration was set at 10 ppb, which also corresponds generally with the lowest trigger levels for total hydrocarbons in water recommended in the ANZECC (2000) water quality guidelines for Australia. Due to the requirement for relatively long exposure times for these concentrations to be significant, they are likely to be more meaningful for juvenile fish, larvae and planktonic organisms that might be entrained (or otherwise moving) within the entrained plumes, or when entrained condensate adheres to organisms or is trapped against a shoreline for periods of several hours or more. To indicate areas that could be affected by higher concentrations, which may be more meaningful over shorter durations, additional thresholds were set one order of magnitude higher (100 ppb) and 50 times higher (500 ppb).

Table 4 provides a summary of the threshold values applied during the modelling study for reporting the sea surface and shoreline exposure and Table 5 and

Table 6 provides a summary of the in-water dissolved aromatic and entrained threshold values applied during the modelling study.

Table 4: Sea surface and shoreline threshold values applied as part of the modelling study.

Threshold value (µm or g/m^2)	Level of exposure
0.1	Very light exposure
1	Light exposure
10	Moderate exposure

25	Heavy exposure

Table 5: Dissolved aromatic in-water threshold values applied as part of the modelling study.

Trigger value for dissolved aromatic concentrations for a 96 hour LC_{50} (ppb)	Equivalent dosage of dissolved aromatics (ppb.hrs)	Range of sensitive species potentially impacted from acute exposure	Reported zones
6	576	Very sensitive species (99th percentile)	Low exposure
50	4,800	Average sensitive species (95th percentile)	Moderate exposure
400	38,400	Tolerant sensitive species (50th percentile)	High exposure

Table 6: In-water (entrained) threshold values applied as part of the modelling study

Trigger value for entrained oil concentrations (ppb)	Equivalent dosage of entrained oil (ppb.hrs)	Range of sensitive species potentially impacted from acute exposure	Reported zones
10	960	Very sensitive species (99th percentile)	Low exposure
100	9,600	Average sensitive species (95th percentile)	Moderate exposure
500	48,000	Tolerant sensitive species (50th percentile)	High exposure

7.3 Model Sample Numbers and Assumptions

The study was carried out to assess the zones of potential impact to the sea surface, water column and shorelines from two hypothetical worst-case scenarios.

Scenario 1 employed a seasonal assessment of a worst-case hypothetical spill of 1,014 m^3 of Shell Diesoline over 6 hours to represent the loss of one support vessel's maximum fuel load. Santos indicated that the support vessels and their associated fuel loads, likely to be used for Petrel 8 are the Promoter (569 m^3), Lady Grete (1,014 m^3) and Far Saltire (880 m^3). The Seasonal Assessment involved 50 simulations for each season as follows:

- Summer season (September to March);
- Transitional months (April and August); and
- Winter season (May to July).

Scenario 2 employed an annual assessment of a worst-case hypothetical seabed blowout of gas and condensate. Santos advised that the flow rate of the Petrel-8 Pilot Well would be the worst-case flow rate and a 90 day response time provided the worst-case duration, hence spill volume for this scenario. Only an annual (all months) assessment was conducted, as the previous spill modelling conducted for the Petrel 7 drilling campaign, 9 km south east of Petrel 8, indicated very little to no seasonal patterns of surface oil due to its highly evaporative rate and short-lived nature once on the sea surface.

7.4 Hydrocarbon Properties

For the purpose of this study, the two oil types used within the oil spill models were based on specifications provided by Santos being Shell Diesoline, a marine diesel used by the support vessel fleet, and the reservoir composition of the Petrel-8 pilot well.

Shell Diesoline has variable density typically of 830 kg/m^3 and a dynamic viscosity of 10 cP. Figure 12 illustrates a sample weathering and fates graphs for a 1,014 m^3 surface release of diesel over 6 hours, under 3 constant winds of different magnitudes (5, 10 and 15 knots).

It is important to note that diesel typically contains some heavy components (or low volatile components) that have a strong tendency to physically entrain into the upper water column in the presence of moderate winds (i.e. >12 knots) and breaking waves, but can re-float to the surface if these energies abate. In the event of a substantial diesel spill, the heavier components of diesel can remain on the sea surface for an extended period. As brightly coloured and silvery reflective sheens which are highly visible, but below levels which could be responded to effectively and could cause any potential environmental harm.

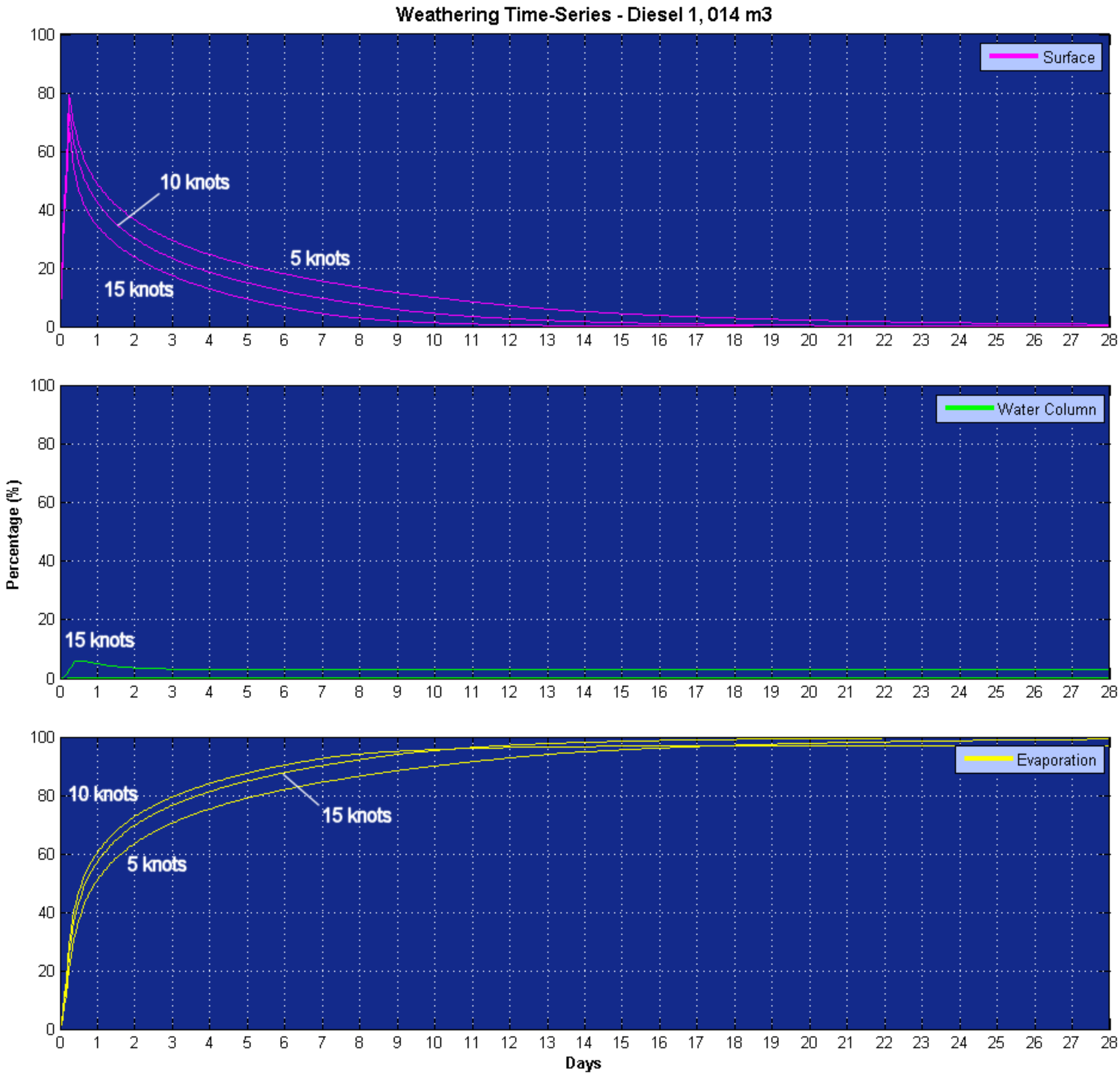


Figure 12: Predicted weathering and fates graphs expressed as a percentage of total spill volume, under 3 constant wind conditions. Results from a simulation of the 1,014 m^3 surface release of Shell Diesoline over 6 hours.

The condensate has a density of 749 kg/m^3 (at 30ºC) and a viscosity of 0.52ºcP (at 30ºC). Table 7 shows the boiling ranges and physical characteristics of this condensate. This condensate contains 99.57% volatile and semi- to low-volatile (or non-persistent) constituents that are likely to evaporate when available to the atmosphere (see Figure 13). Further, 1.3 wt % of the liquid is wax that when highly weathered are likely to form semi-solid waxy flakes on the water surface.

Table 7: Boiling ranges and chemical characteristics of the Petrel-8 Condensate.

Characteristic	Volatiles (%)	Semi-volatiles (%)	Low volatiles (%)	Residual (%)	Density (kg/m^3)	Aromatic Content (%)
Boiling point (°C)	<180	180 – 265	265 – 380	>380		
Petrel-8 Condensate	83.59	14.42	1.56	0.43	749 @ 39°C	41.4

Not persistent ← → Persistent

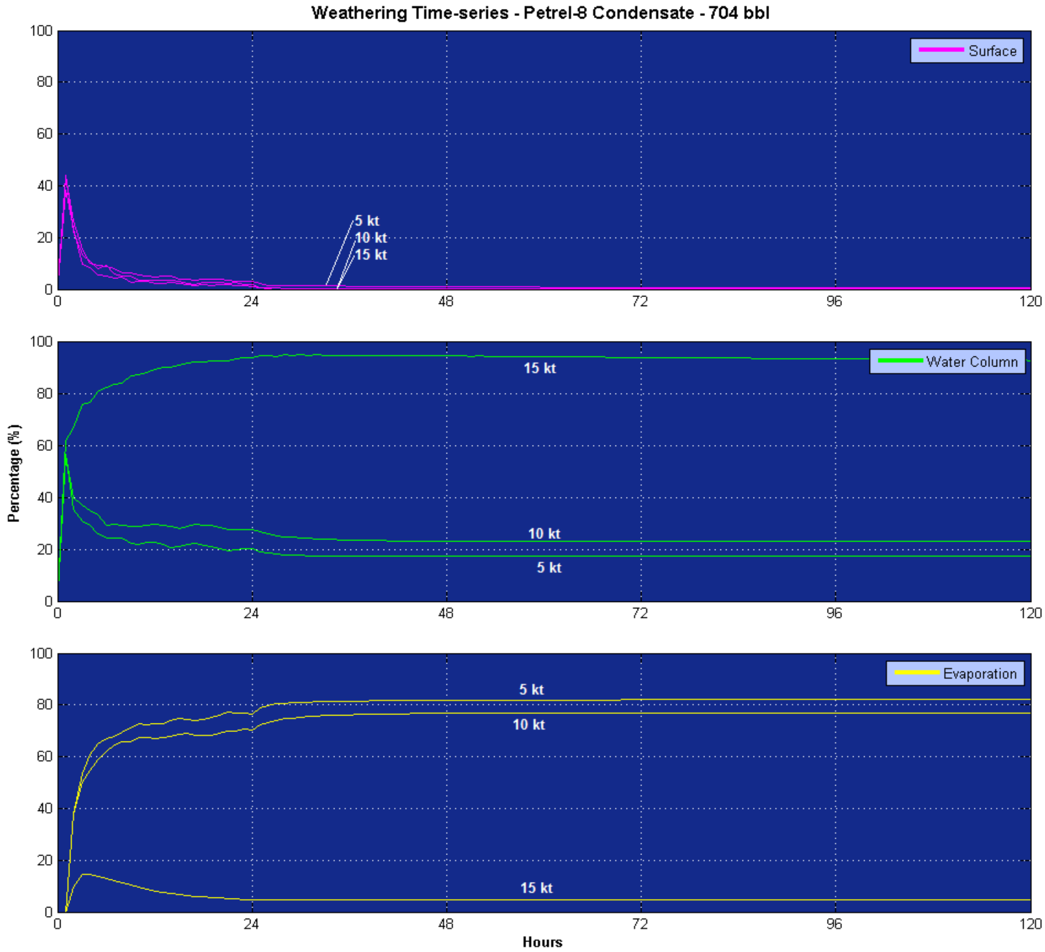


Figure 13: Predicted weathering and fates graphs expressed as a percentage of the daily spill volume, under 3 constant wind conditions which demonstrates the highly evaporative potential of the Petrel-8 condensate once it reaches the surface.

Table 8 to Table 10 presents the input and output results from the near-field model OILMAP-DEEP some of which are then used as input parameters to the far-field model SIMAP. As a result of the release depth and the high gas to oil ratio, OILMAPDEEP indicated that under a worst-case loss of well control situation, the condensate liquids would be rapidly transported to the surface within a massive gas plume, taking 23 seconds to rise 98 meters to the water surface as depicted in Figure 14. This substantial initial lift through the water column from the significant gas content of the release was also predicted to liberate and dissolve the water soluble aromatics and creates entrained oil droplets in the order of tens to hundreds of microns in diameter in near surface waters. Most notable, is the ascent or rise speed of the gas plume, predicted to create a violent bubble plume which will hit the surface at significant speeds, which will induce radially-outward currents at the surface, moving water and entrained oil droplets at about 8 to 9 knots from the plume core. Potentially, if ships are onsite, such a plume would produce explosive concentrations of gas and create a capsize risk for any vessel in the immediate vicinity of such a gas plume.

Table 8: Input for the near-field blowout model

Variable	Value
Location	Petrel-8
Depth (m)	98
Oil Density (gm/cm^3)	0.749
Oil Viscosity (cP)	0.52
Oil temp (deg C)	30
GAS:OIL ratio (scf/bbl)	238,095
Amount (bbl/day)	704
Spill duration (days)	90

Table 9: Forecasts for the oil droplet size distribution set up by the blowout dynamics

Calculated oil droplet size distribution	5.49% droplets of size (µm)	34.6
	22.04% droplets of size (µm)	69.2
	32.08% droplets of size (µm)	103.9
	26.71% droplets of size (µm)	138.5
	13.68% droplets of size (µm)	173.1

Table 10: Summary of near field plume dynamics at the Petrel-8 well

	Petrel-8
Average plume rise velocity (m/s)	3.96
Maximum plume rise velocity (m/s)	6.79
Plume rise time (until plume collapse)	23 sec
Maximum plume core radius (m)	10.75
Maximum plume height above the seabed (m)	Hits the surface at about 8-9 knots

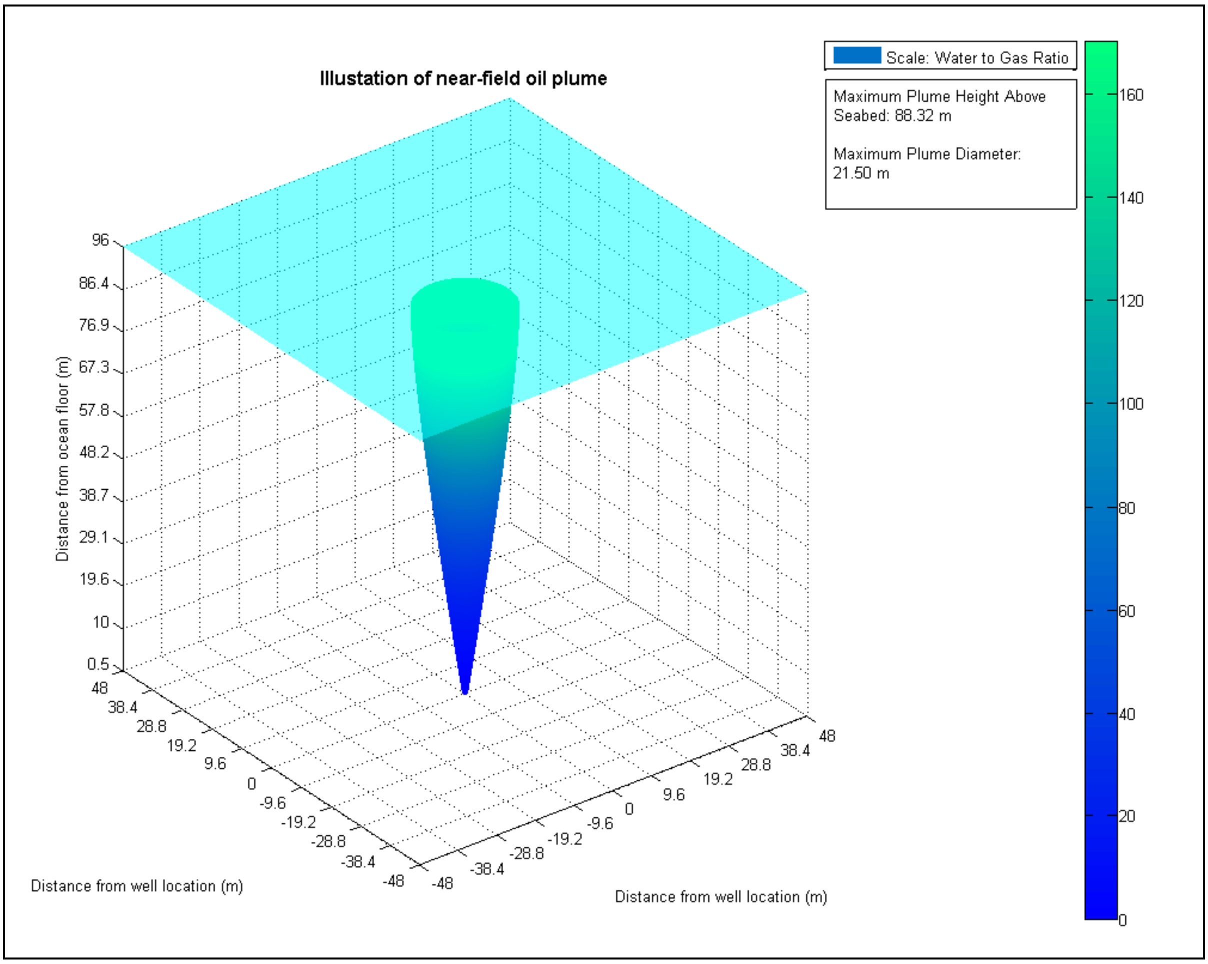


Figure 14: Schematic of the near field plume generated from a worst-case blowout of gas and condensate at peak flow pressure and volume. Height of plume above sea floor is shown on the y-axis where plume radius is shown across the x-axis.

8 RESULTS: SCENARIO 1 – 1, 014 M^3 SURFACE RELEASE OF DIESEL

The SIMAP stochastic module was used to simulate multiple (50 per season) worst-case (1,014 m^3) surface diesel spills to quantify the: (i) probability of exposure to the sea surface and shorelines and (ii) minimum time to sea surface contact for the 1 g/m^2 threshold. This threshold is above the extent of visible oil, but is one order of magnitude below the 10 g/m^2 potential impact threshold and defines the extent that spill response measures can be useful in reducing surface oil (such as mechanical dispersion using water jetting or prop wash to disperse any surface diesel slicks whilst they remain in deep water). The modelling also quantified the potential extents of dissolved aromatics and entrained diesel oil for the hypothetical spill to define the in water zone of potential impact.

Note the results herein provide the reader with a better understanding of a range of simulated trajectories and weathering, not actual occurrences.

8.1 Stochastic Trajectory Analysis

When interpreting the stochastic results, it should be noted that the estimators (probability and surface load/thickness) are calculated independently for each surface location in the model domain. Hence, the plots do not show the extent of effect that would be expected from any single release. Rather, the contours show likelihood of contact, given the predicted weathering rates, wind and current patterns for randomly selected time-periods. For example, areas enclosed by a 0-5% probability contour were exposed (above the chosen thickness threshold of 1 µm) by at least 1 and up to 5% of the total number of simulated spills undertaken.

Locations with higher probability ratings were exposed during a greater number of spill simulations, indicating that the combination of the prevailing wind and current conditions are more likely to result in contact to these locations. The areas outside of the 0-100% contour indicate that contact will be unlikely under the range of prevailing conditions for this region and the respective season above the threshold. It is important to note that the probabilities are derived from the samples of data used in the modelling. Therefore, a zero value does not necessarily indicate absolutely “no likelihood” of an outcome, but a generally low probability.

The stochastic results of the sea surface and shoreline contact for each season modelled are summarized and discussed below showing the: (i) probability of contact to the sea surface and shorelines; (ii) minimum time to sea surface contact; (iii) potential areas and level of exposure on the water surface; (iii) potential zones exposure from dissolved aromatics; and (iv) the potential zones exposure from entrained hydrocarbons.

Sea-surface and Shoreline Contact

Figure 15 to Figure 17 show the probability of, and the predicted minimum time before, sea surface exposure for each season, reported for a minimum threshold thickness of 1 µm (or very light oiling).

During the summer conditions, the majority of slicks were shown to migrate in an east-southeast direction from the release site. The furthest distance surface slicks above 1 µm (or very light oiling) were observed, during the summer conditions, was 113 km.

During the transitional periods, the majority of slicks also moved in a southeast direction however a small number of slicks were shown to travel towards the west. The furthest distance surface slicks above 1 µm (or very light oiling) were observed, during the transitional period conditions, was 450 km.

During the winter season, waters to the northwest of the release site were shown to have the greatest probability of being exposed to diesel slicks, with a small number of slicks migrating to the southwest The furthest distance surface slicks above 1 µm (or very light oiling) were observed, during the summer conditions, was 215 km.

Figure 18 to Figure 20 show the zones of potential sea surface exposure for low exposure (1 µm), moderate exposure (10 µm) and high exposure (> 25 µm), for each season.

The maximum extents of the zones of potential moderate and high exposure for the summer season were within a radius of 40 km and 24 km from the release site, respectively.

The maximum extents of the zones of potential moderate and high exposure for the transitional period were within a radius of 38 km and 18 km from the release site, respectively.

The maximum extents of the zones of potential moderate and high exposure for the summer season were within a radius of 30 km and 19 km from the release site, respectively.

In terms of shoreline contact, modelling for all seasons did not identify any shoreline impacts above the thresholds specified (1 µm).

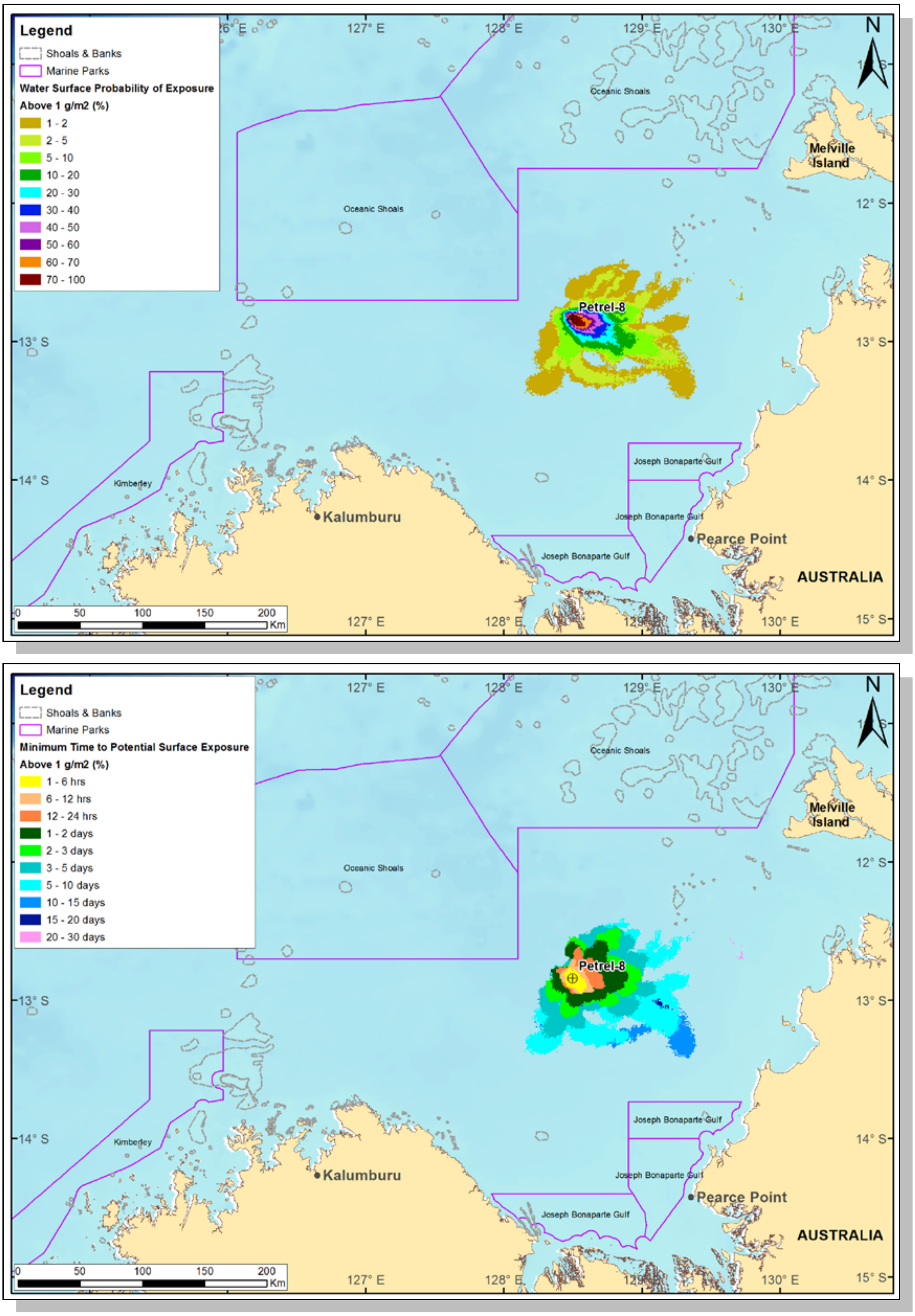
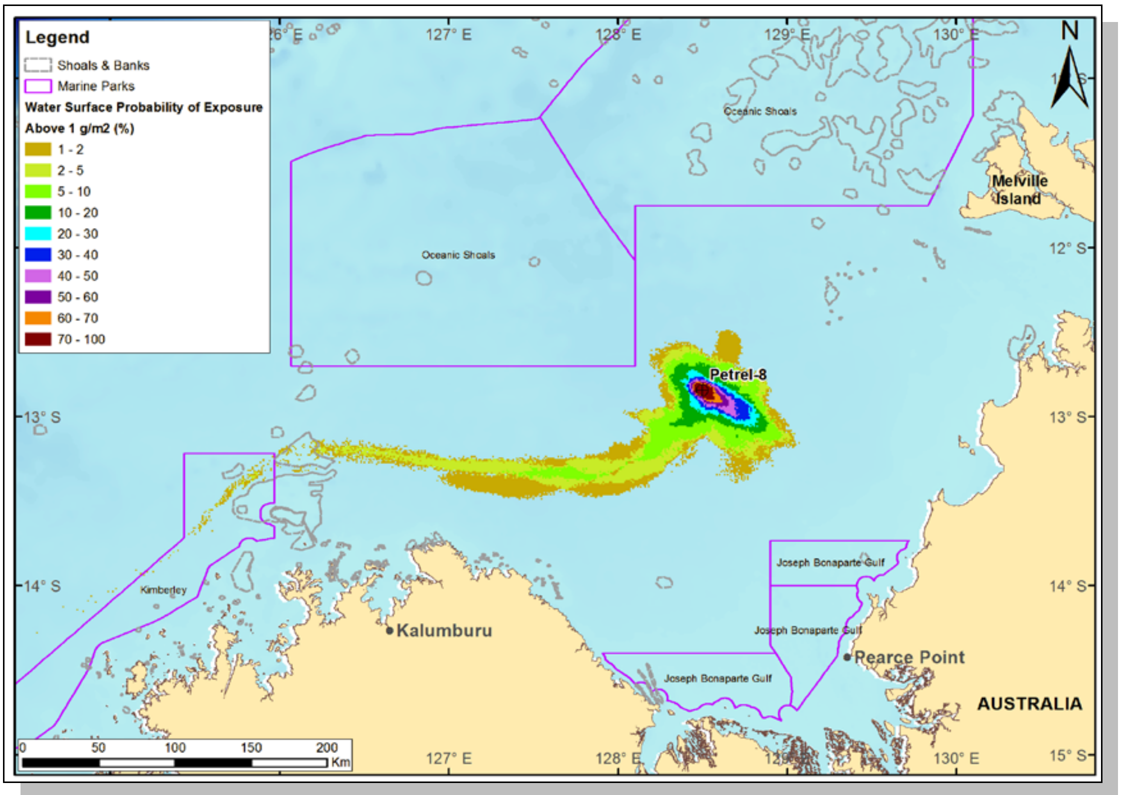


*Figure 15: The <u>probability of sea surface exposure (top) and minimum time before surface exposure (bottom),</u> reported to **1 µm** or **light exposure**, in the event of a 1,014 m^3 surface release of diesel at the Petrel-8 field. The output is calculated for each grid cell and provides a summary from 50 spill trajectories modelled, during <u>**summer season**</u> wind and current conditions.*



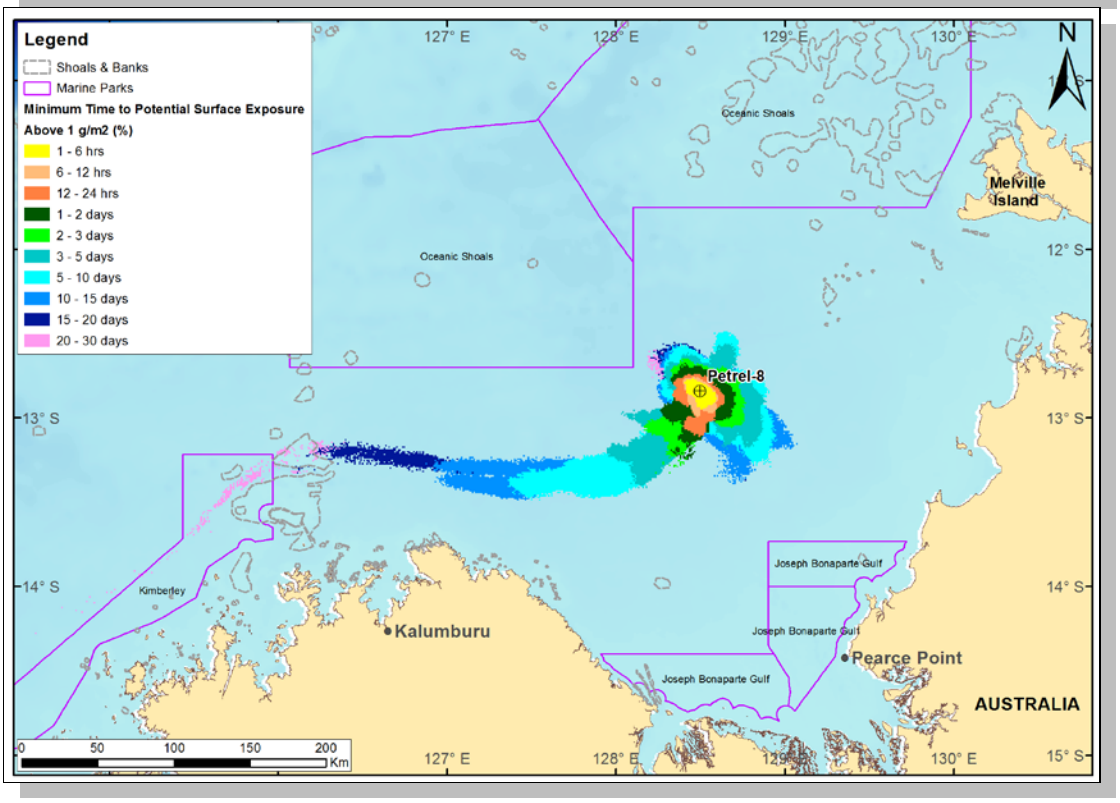


*Figure 16: The probability of sea surface exposure (top) and minimum time before surface exposure (bottom), reported to **1 µm** or **light exposure**, in the event of a 1,014 m^3 surface release of diesel at the Petrel-8 field. The output is calculated for each grid cell and provides a summary from 50 spill trajectories modelled, during **transitional period** wind and current conditions.*

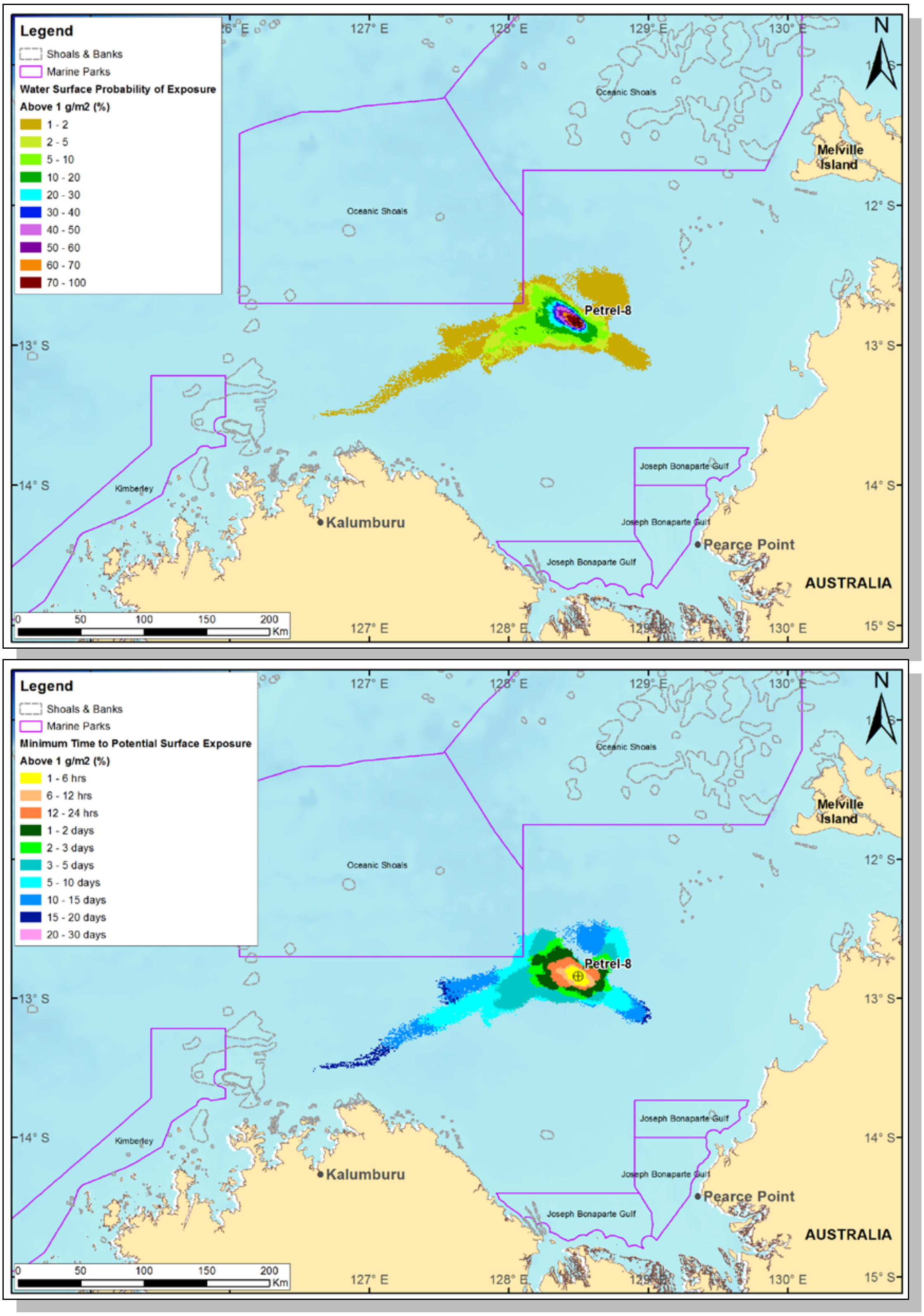


Figure 17: The *<u>probability of sea surface exposure (top) and minimum time before surface exposure (bottom),</u>* *reported to* ***1 µm*** *or* ***light exposure****, in the event of a 1,014 m^3 surface release of diesel at the Petrel-8 field. The output is calculated for each grid cell and provides a summary from 50 spill trajectories modelled, during* ***<u>winter season</u>*** *wind and current conditions.*

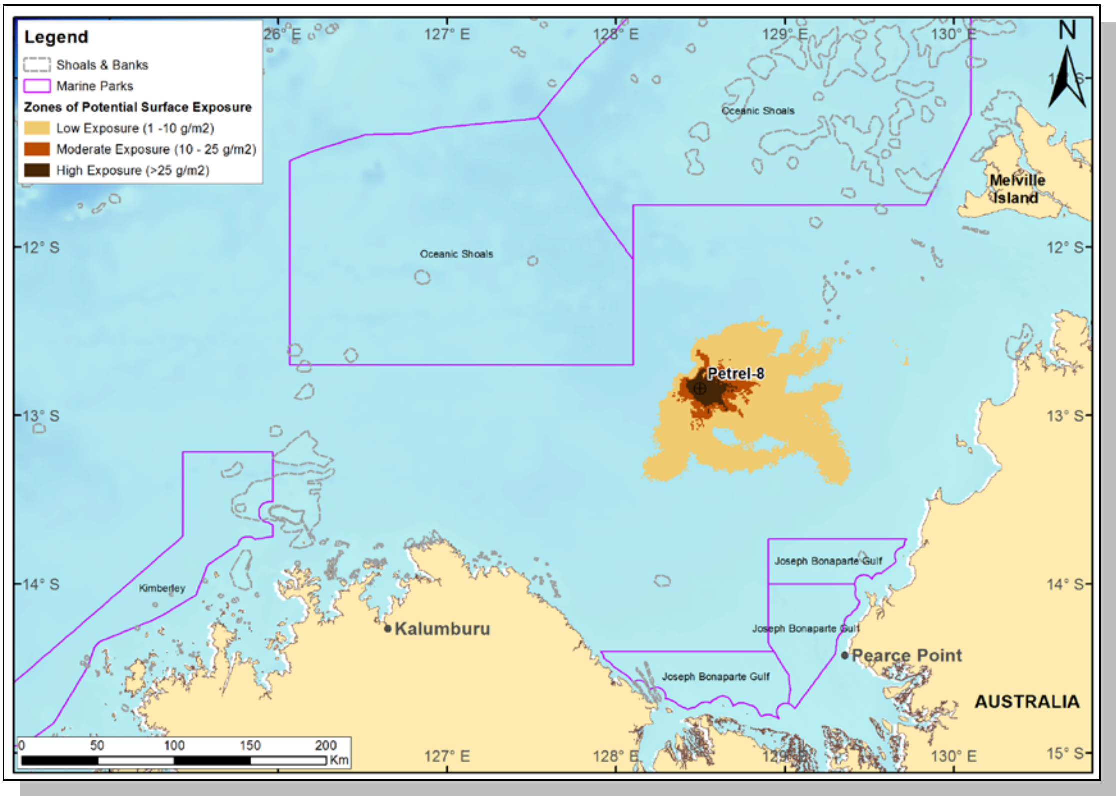


Figure 18. Zones of the potential surface exposure, in the event of a 1,014 m3 surface release of diesel at the Petrel-8 field. The output is calculated for each grid cell and provides a summary from 50 spill trajectories modelled, during ***summer season***

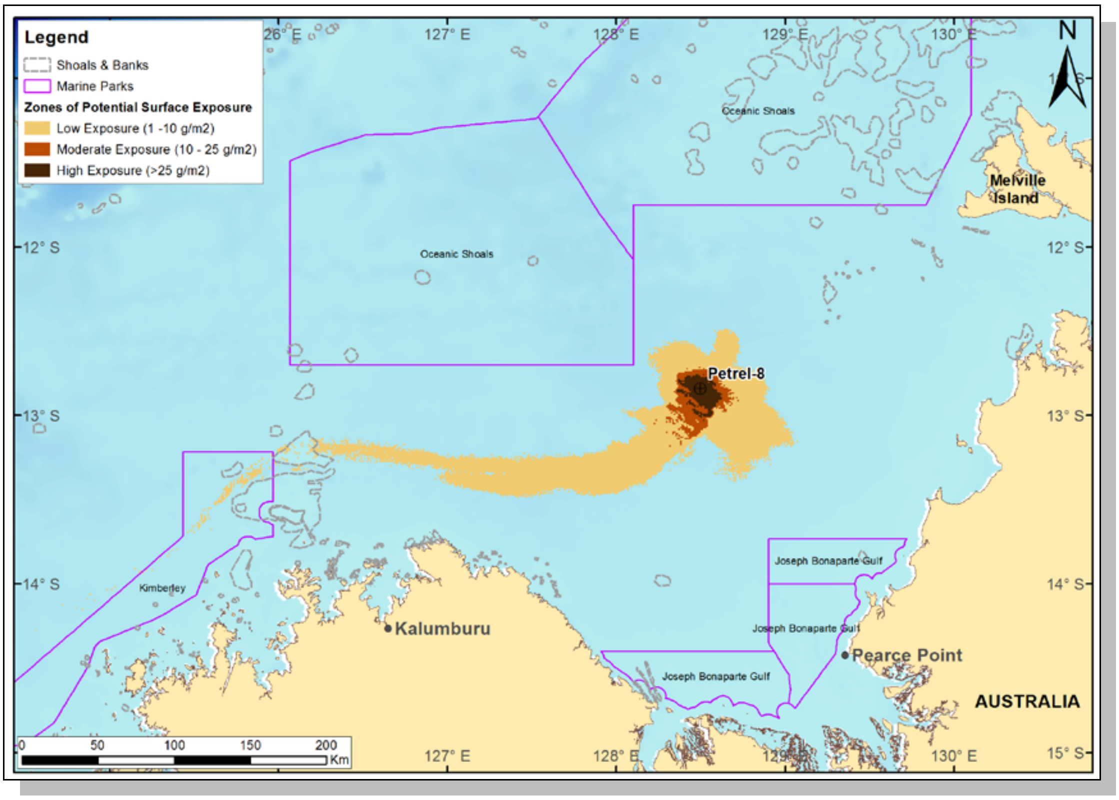


Figure 19: Zones of the potential surface exposure, in the event of a 1,014 m^3 surface release of diesel at the Petrel-8 field. The output is calculated for each grid cell and provides a summary from 50 spill trajectories modelled, during ***transitional season****.*

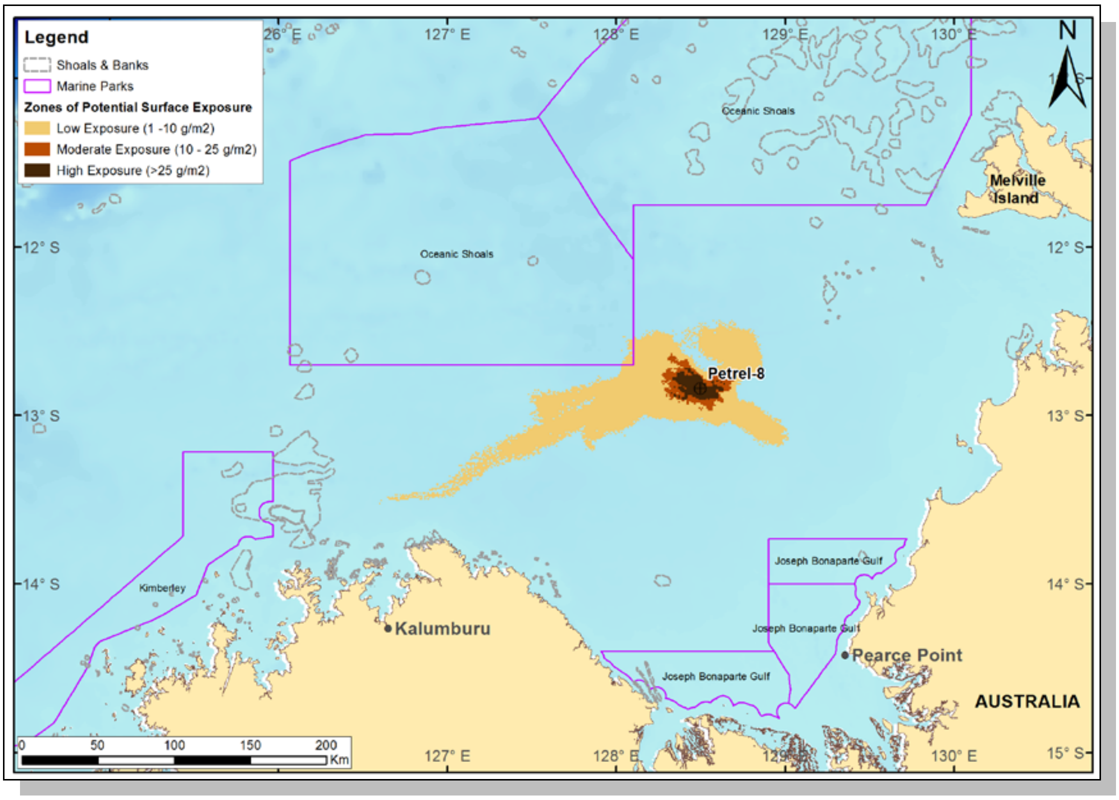


*Figure 20: <u>Zones of the</u> <u>potential surface exposure</u>, in the event of a 1,014 m^3 surface release of diesel at the Petrel-8 field. The output is calculated for each grid cell and provides a summary from 50 spill trajectories modelled, during **<u>winter season</u>** wind and current conditions.*

<u>In Water concentrations</u>

In addition to quantifying the exposure to the sea surface, the modelling also explored the potential zones of exposure from dissolved aromatics and entrained hydrocarbon concentrations for each season. These occur when diesel slicks were entrained into the water column by high wind events for prolonged periods. Diesel droplets, when entrained into the water column, leached their aromatic content via dissolution rather than evaporation processes which the modelling took into account and quantified based on the wind conditions and oil chemistry at the time of the high wind event.

Figure 21 to Figure 23 illustrate the zones of potential low exposure, and moderate and high impact from dissolved aromatic hydrocarbons in the upper water column (0-3 m below the sea surface), for each season.

For all seasons, waters bounded within 20 kms of the spill location were quantified to be at some potential risk of low level exposure to dissolved aromatic concentrations above the lowest dosage threshold of 576 ppb hrs (that is, exposures were lower than 6 ppb dissolved aromatics for 96 hours outside of this zone).

No zones of potential moderate or high impact from dissolved aromatics were found from any of the 50 simulations for any season.

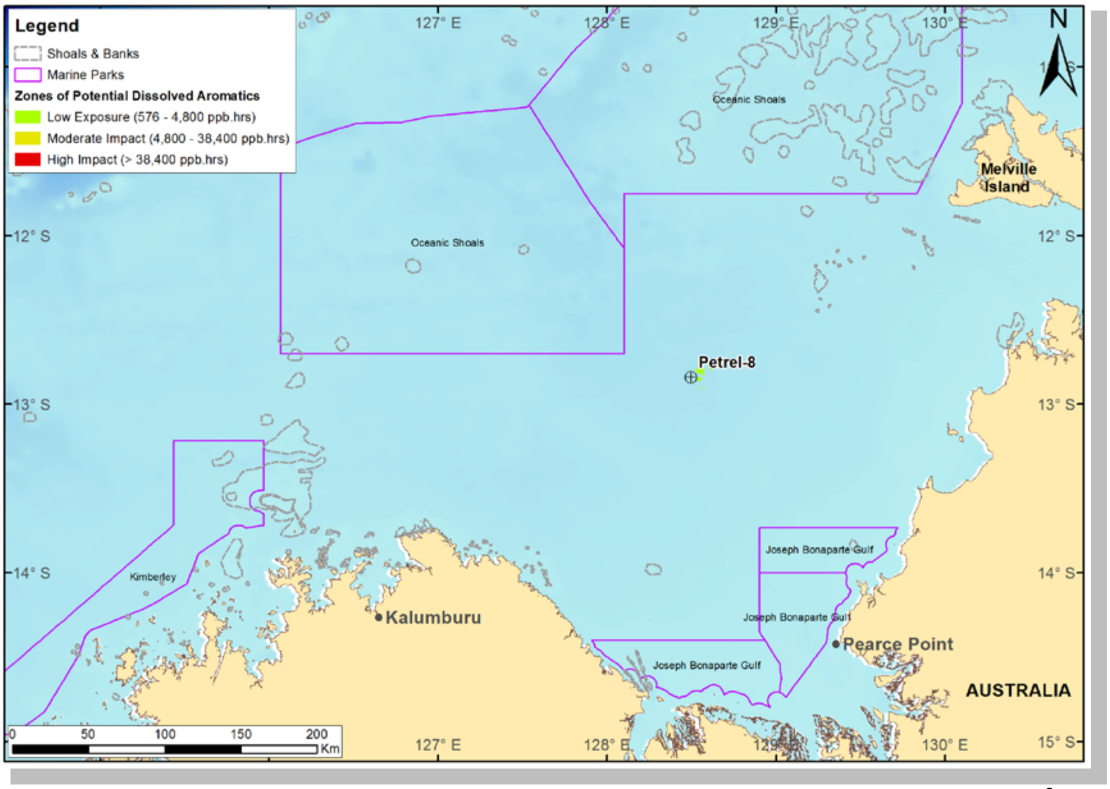


*Figure 21: Zones of potential exposure from dissolved aromatics, in the event of a 1,014 m^3 surface release of diesel at the Petrel-8 field. The output is calculated for each grid cell and provides a summary from 50 spill trajectories modelled, during **summer season** wind and current conditions.*

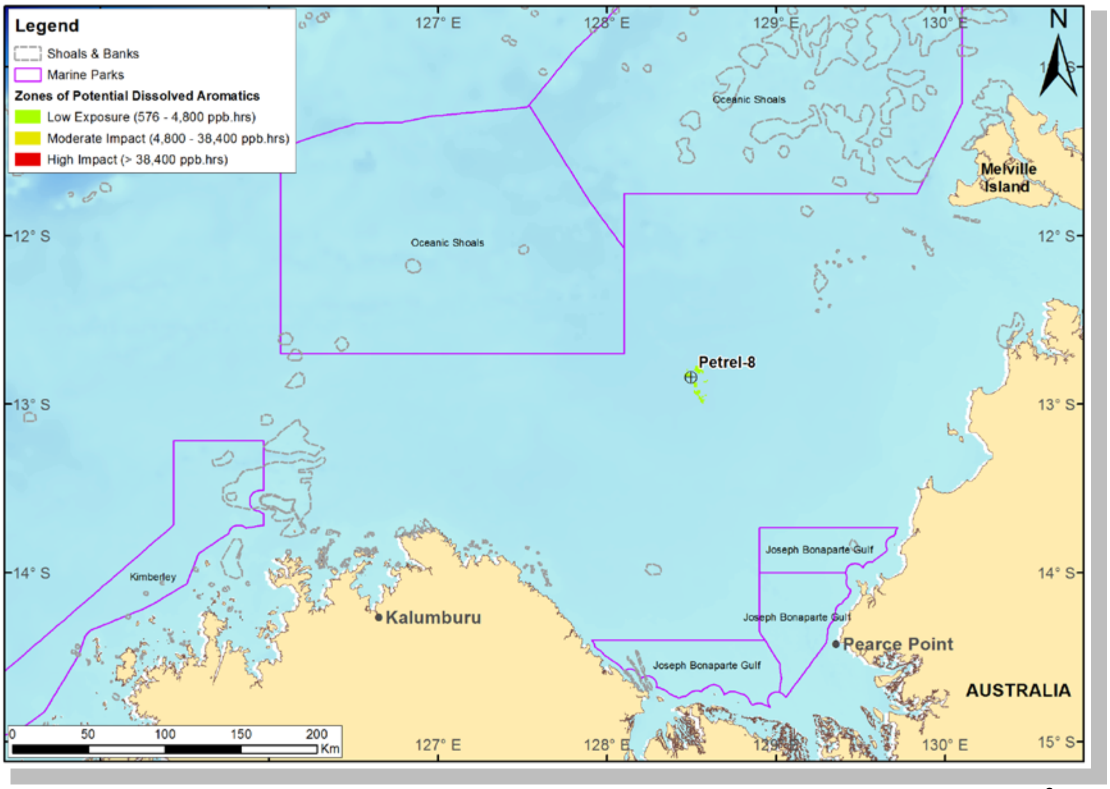


*Figure 22: Zones of potential exposure from dissolved aromatics, in the event of a 1,014 m^3 surface release of diesel at the Petrel-8 field. The output is calculated for each grid cell and provide a summary from 50 spill trajectories modelled, during **transitional period** wind and current conditions.*

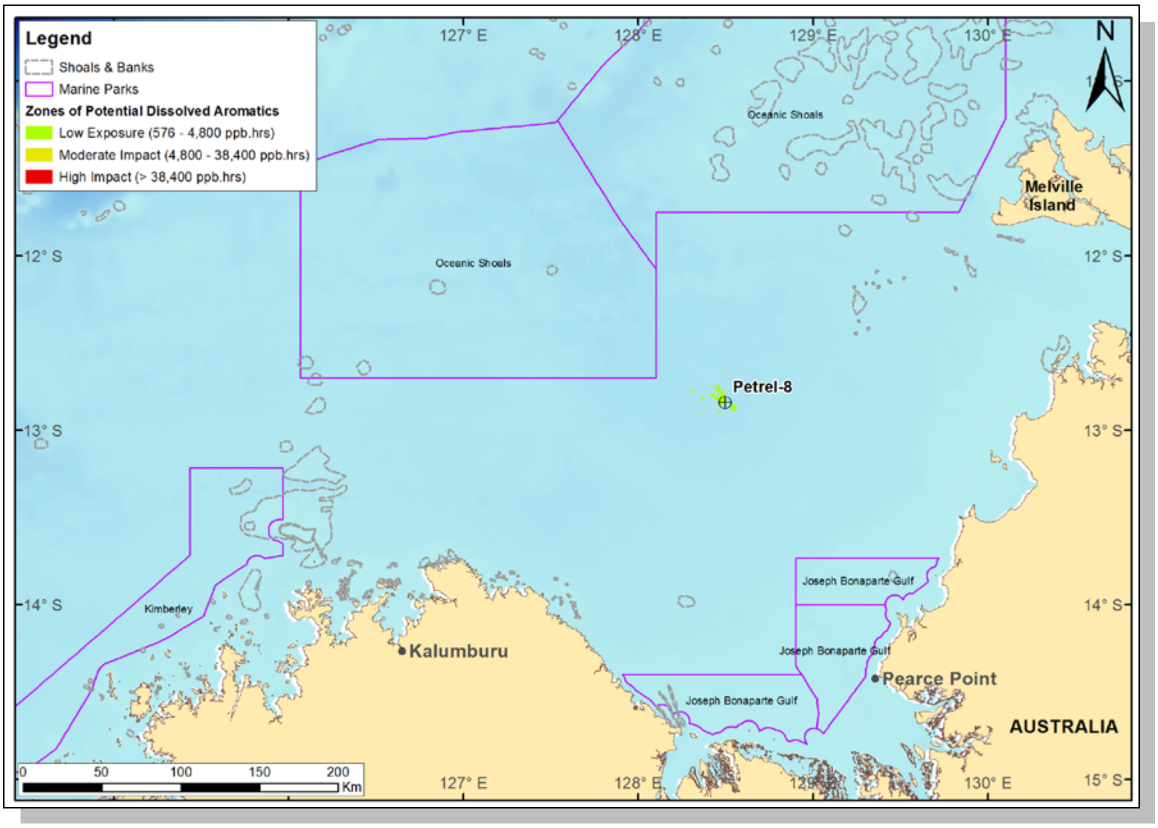


Figure 23: Zones of potential exposure from dissolved aromatics, in the event of a 1,014 m^3 surface release of diesel at the Petrel-8 field. The output is calculated for each grid cell and provides a summary from 50 spill trajectories modelled, during ***winter season*** *wind and current conditions.*

Figure 24 to Figure 26 illustrate the zones of potential low, moderate and high exposure from entrained hydrocarbon droplets in the upper water column (0-5 m below the sea surface), for each season that resulted from simulated high wind events.

During summer, the zones of potential low exposure to entrained hydrocarbon droplets extended mostly towards the northeast and almost as far as Melville Island and essentially coincided with path of the surface slicks. Note that these extents do not map the subsurface drift of entrained diesel droplets just that surface slicks, when entrained, will produce droplets within the water column at these distances. The extent of subsurface plumes simply follow the extent that surface slicks of diesel travelled in a high wind event. The results are also indicative of the outcomes of mechanical dispersion in terms of in water concentrations when the wind event occurs. For summer, zones of moderate exposure were shown to be limited to 18 km.

During the transitional period the zones of potential low exposure to entrained hydrocarbons extended mostly towards the southwest and as far Kimberly coastline. Zones of moderate exposure were shown up to 13 km from the release site.

During winter the zones of potential low exposure to entrained hydrocarbons extended mostly towards the southwest and as far Kimberly coastline. Zones of moderate exposure were shown up to 38 km from the release site.

There were no zones of potential high exposure from entrained oil concentrations for all three seasons.

No exposure of entrained hydrocarbons doses of meaningful levels to any reef or island was registered for any season.

Additionally, no moderate or high exposure zones were predicted in nearby waters to the surrounding sensitive marine environment and shorelines.

Summary of Outcomes.

The modelling indicated that the hypothetical worst-case spill of diesel at Petrel-8, across all seasons, would typically evaporate significantly and reduce its surface thickness overtime (< 25 microns by 24 km and < 10 microns by 40 km). The direction of drift will be typically with the currents when winds are light, but typically with the winds during moderate winds. Under strong winds, diesel slicks will entrain into the water column as droplets. If the spill were to occur during strong winds, spilt oil, still very fresh, will entrain and some exposure to aromatic compounds dissolving from the diesel droplets is predicted to occur, but limited to within 20km of the spill site and at low levels only. Beyond this extent, the modelling quantified that a diesoline slicks up to this size may entrain but would have significantly lost its aromatic content to evaporative processes by that time, as to remove the risk significantly for any potential in-water impact.

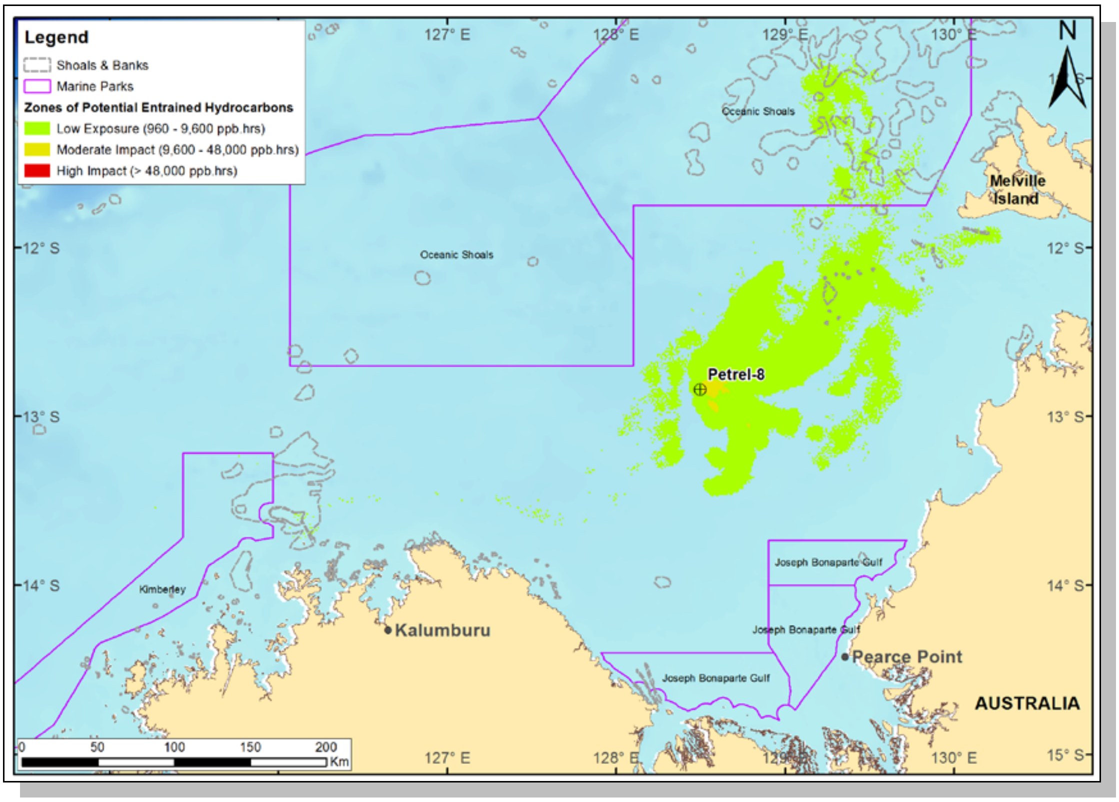


*Figure 24: Zones of potential exposure from entrained hydrocarbons, in the event of a 1,014 m^3 surface release of diesel at the Petrel-8 field. The output is calculated for each grid cell and provides a summary from 50 spill trajectories modelled, during **summer season** wind and current conditions.*

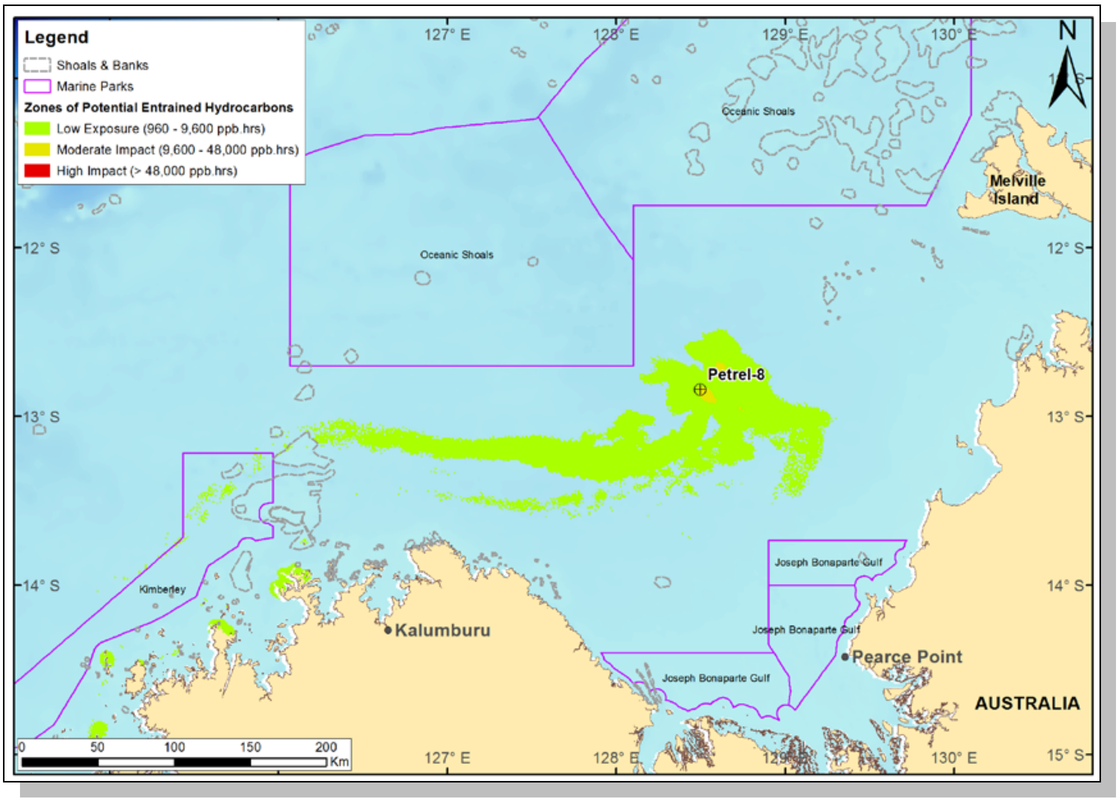


*Figure 25: Zones of potential exposure from entrained hydrocarbons, in the event of a 1,014 m^3 surface release of diesel at the Petrel-8 field. The output is calculated for each grid cell and provides a summary from 50 spill trajectories modelled, during **transitional period** wind and current conditions.*

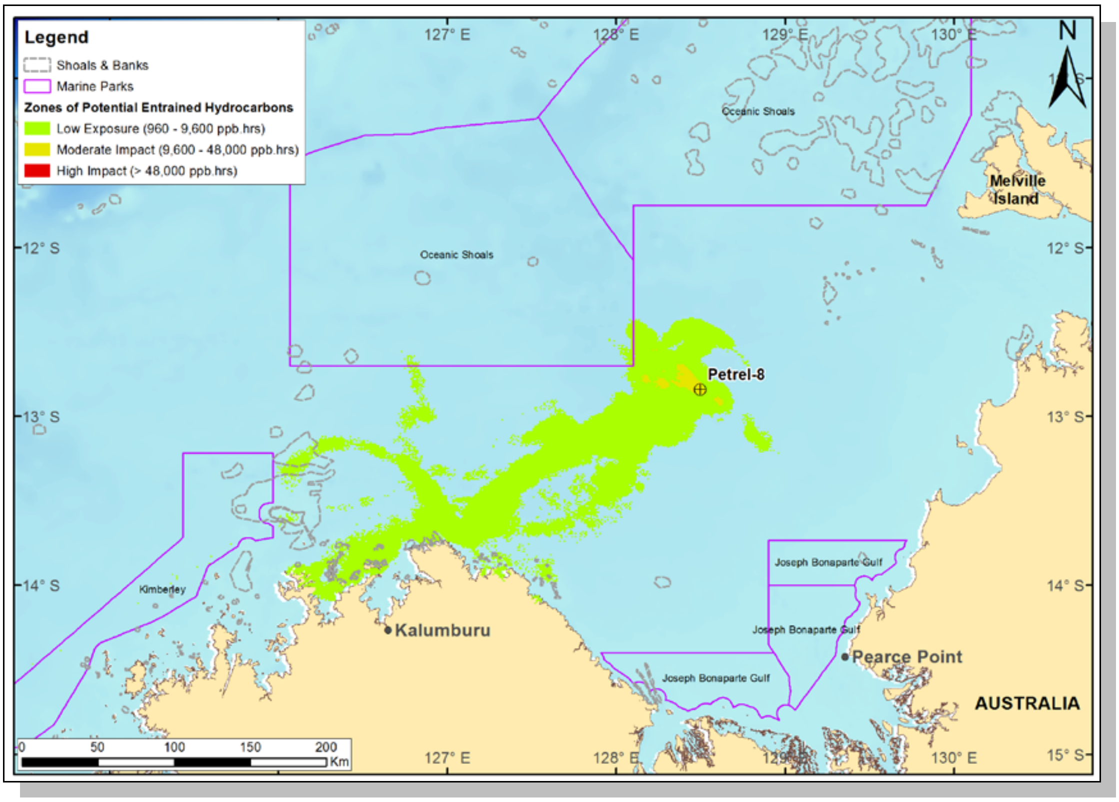


*Figure 26: Zones of potential exposure from entrained hydrocarbons, in the event of a 1,014 m^3 surface release of diesel at the Petrel-8 field. The output is calculated for each grid cell and provides a summary from 50 spill trajectories modelled, during **winter season** wind and current conditions.*

9 RESULTS: SCENARIO 2 – WORST-CASE BLOWOUT OVER 90 DAYS

The dynamics of the subsurface release associated with a worst-case blowout at Petrel-8 were quantified by OILMAPDEEP which indicated that the condensate liquids would be rapidly transported to the surface within the massive gas plume that would occur with the uncontrolled flow. This substantial initial lift through the water column from the significant gas content of the release was also predicted to create entrained condensate droplets in the order of tens to hundreds of microns in diameter in near surface waters. At the surface, the gas will significantly bubble off, some small gas bubbles, entrained condensate droplets and water will move radially outwards at speeds in excess of 8 knots adjacent to the rise location. From these conditions, SIMAP was then used to calculate the fate of the entrained oil droplets and aromatic compounds dissolving from the condensate under these turbulent conditions.

9.1 Stochastic Trajectory Analysis

When interpreting the stochastic results, it should be noted that the estimators (probability and load) are calculated independently for each surface location in the model domain. Hence, the plots do not show the extent of effect that would be expected from any single release. Rather, the contours show likelihood of contact, given the predicted weathering rates, wind and current patterns for randomly selected time-periods. For example, areas enclosed by a 0-5% probability contour were exposed (above the chosen thickness threshold of 1 µm) by at least 1 and up to 5% of the total number of simulated spills undertaken.

Locations with higher probability ratings were exposed during a greater number of spill simulations, indicating that the combination of the prevailing wind and current conditions are more likely to result in contact to these locations. The areas outside of the 0-100% contour indicate that contact will be unlikely under the range of prevailing conditions for this region and the respective season. It is important to note that the probabilities are derived from the samples of data used in the modelling. Therefore, a zero value does not necessarily indicate absolutely “no likelihood” of an outcome, but a generally low probability.

The stochastic results of the sea surface and shoreline contact for each season modelled are summarized and discussed below showing the: (i) probability of contact to the sea surface and shorelines; (ii) minimum time to sea surface contact; (iii) potential areas and level of exposure on the water surface; (iii) potential zones of exposure from dissolved aromatics; and (iv) the potential zones of exposure from entrained hydrocarbons.

<u>Sea-surface and Shoreline Contact</u>

Figure 27 show the zones of potential sea surface exposure for the extent of oil low exposure (1 µm), moderate exposure (10 µm) and high exposure (> 25 µm). Figure 28 and Figure 29 show the probability of, and the predicted minimum time before, sea surface exposure for all seasons, reported for the extents of visible surface slicks (0.1 µm) and a minimum threshold thickness of 1 µm (or light oiling). The SIMAP model quantifies that surface slicks resulting from the turbulent gas plume are typically less than 10µm thick even above the release site due to the dispersive behaviour of the turbulence associated with the gas plume. The modelling also confirmed that visible slicks can occur away from the gas plume, but typically only as short-lived visible surface patches. The rise locations were typically tidal in nature.

In terms of shoreline contact, modelling for all seasons identified no shoreline impacts. There were also no extents of potential moderate and high exposure for surface oil, again due to the highly evaporative behaviour of condensate once it reaches the sea surface.

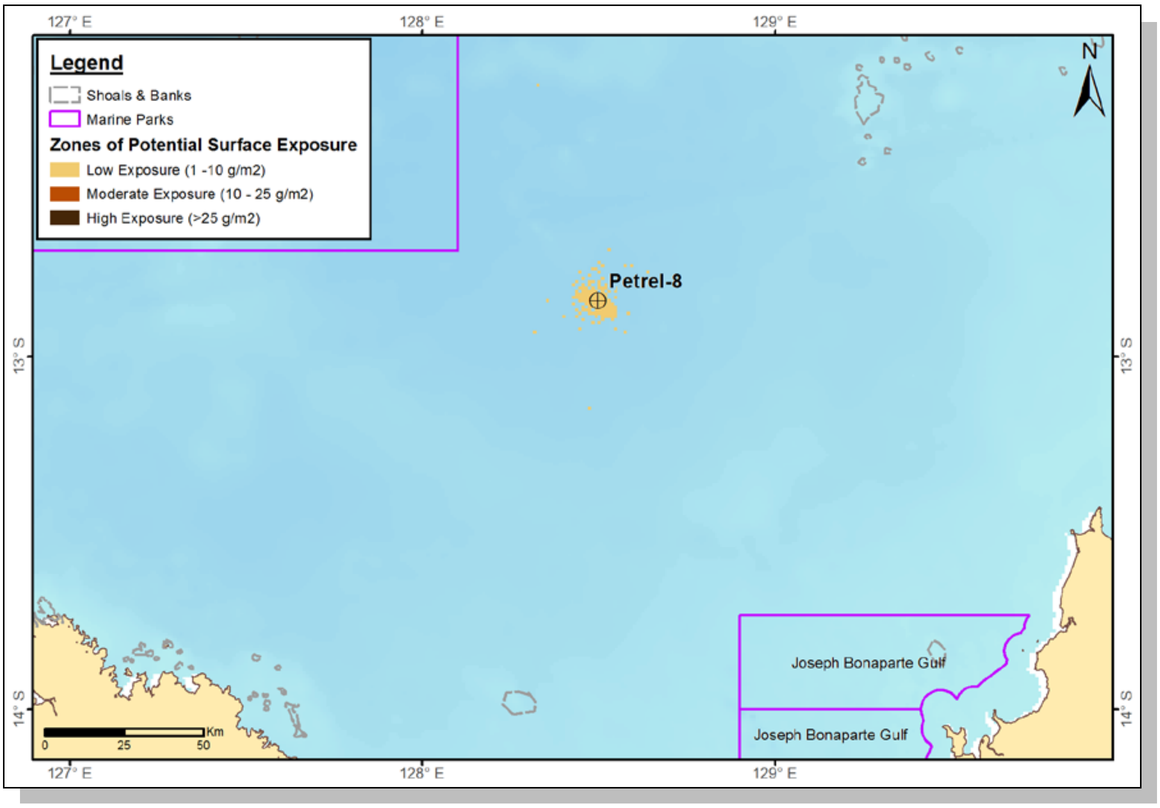


*Figure 27. Zones of potential exposure in the event of a 704 bopd for 90 day blowout at the Petrel-8 field. The output is calculated for each grid cell and provides a summary from 50 spill trajectories modelled, during **annual** wind and current conditions.*

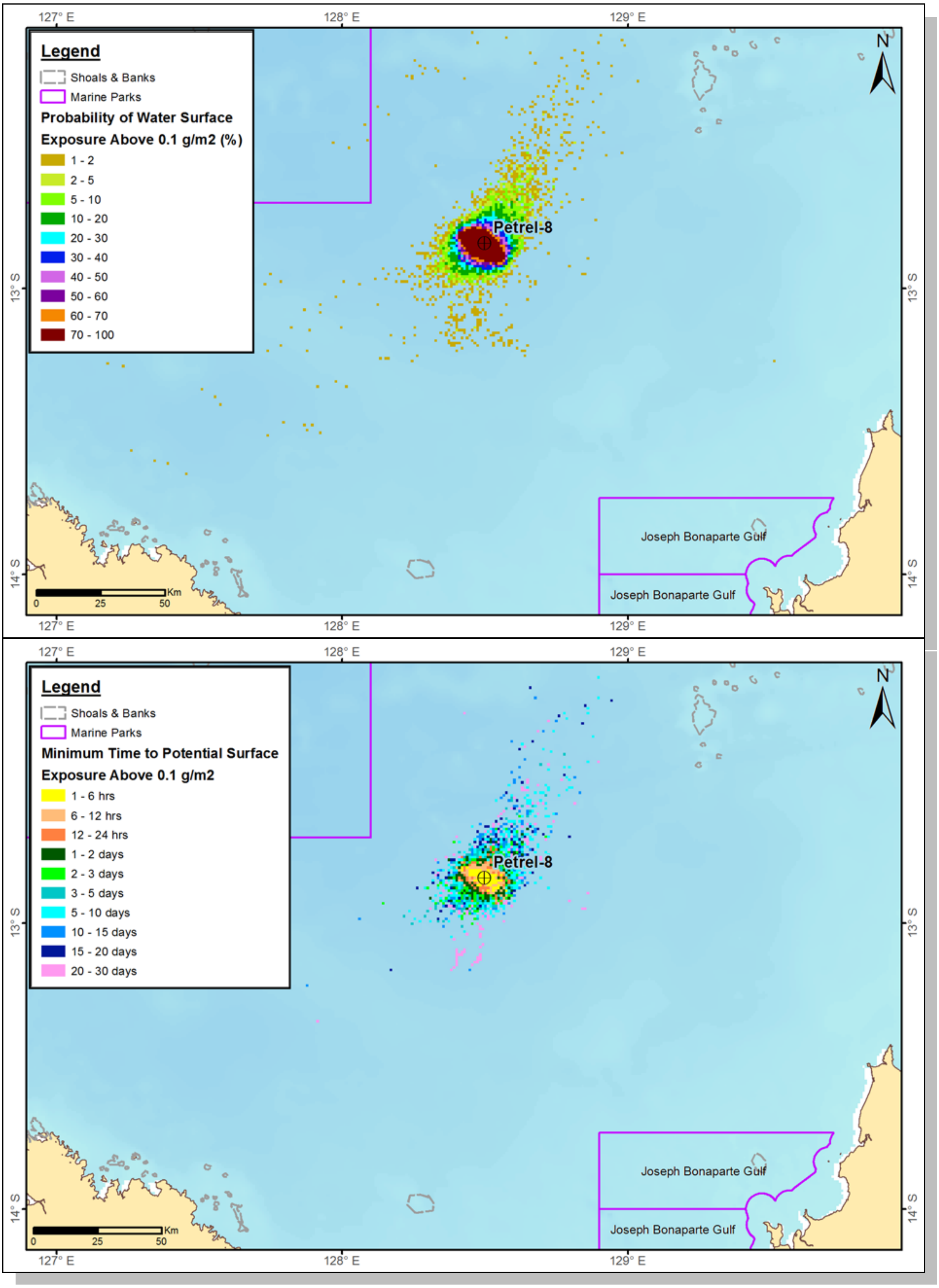


*Figure 28. The probability of sea surface exposure (top) and minimum time before surface exposure (bottom), reported to **0.1 µm** or the extent of visible surface slicks, in the event of a 704 bopd for 90 day blowout at the Petrel-8 field. The output is calculated for each grid cell and provides a summary from 50 spill trajectories modelled, during **annual** wind and current conditions.*

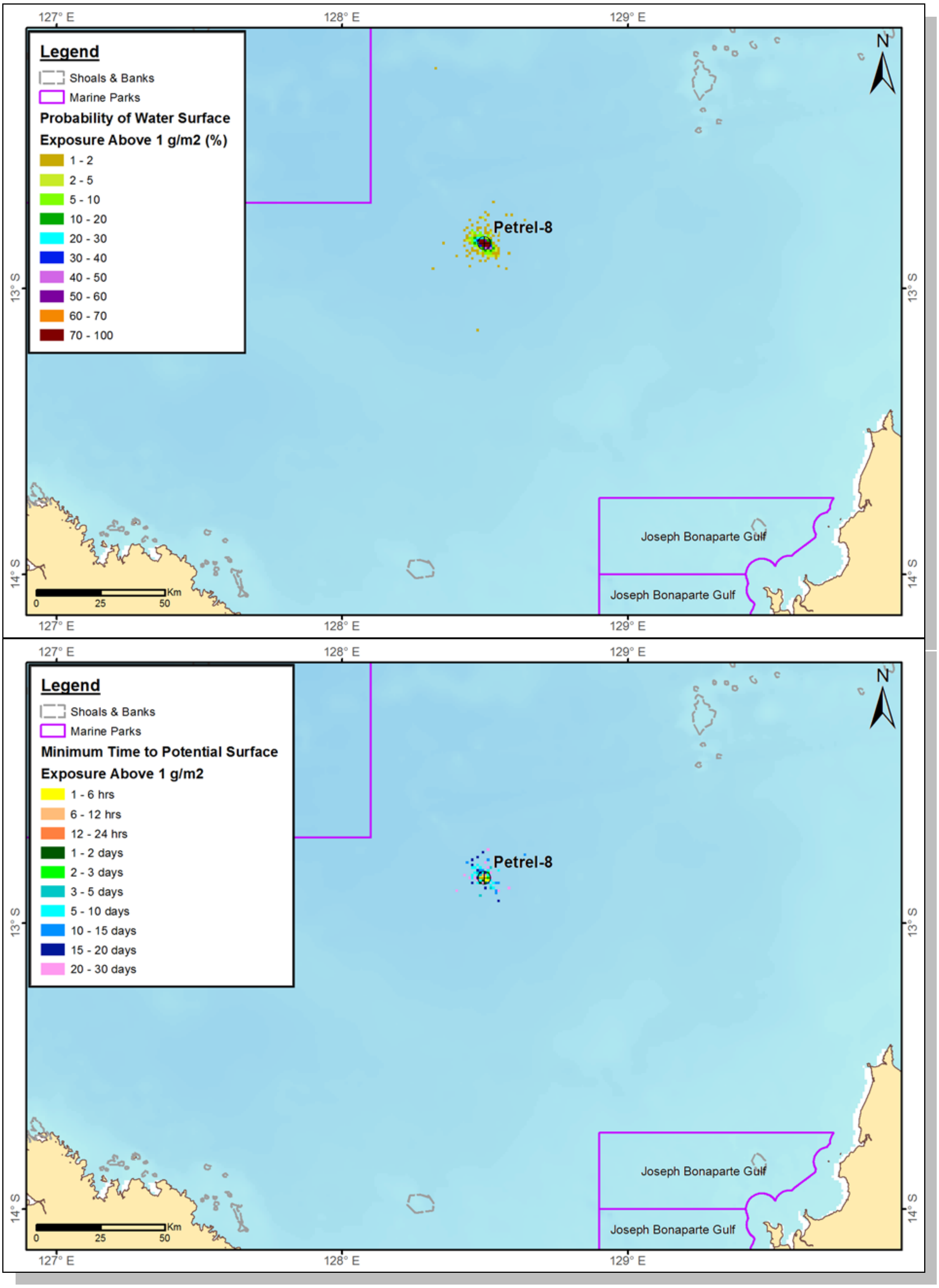


*Figure 29. The <u>probability of sea surface exposure (top) and minimum time before surface exposure (bottom),</u> reported to **1 µm** or **light exposure**, in the event of a 704 bopd for 90 day blowout at the Petrel-8 field. The output is calculated for each grid cell and provides a summary from 50 spill trajectories modelled, during <u>**annual**</u> wind and current conditions.*

In Water concentrations

In addition to quantifying the exposure to the sea surface, the modelling also explored the potential zones of exposure from dissolved aromatics and entrained hydrocarbon concentrations under all seasonal conditions. These were predicted to be a significant feature of a worst-case blowout at Petrel-8 due to the light density and viscosity of the condensate, its high aromatic content and the turbulence associated with the significant gas to condensate ratio. Indeed, the high turbulent gas plume ensured that significant amounts of entrained condensate droplets were atomised. Consequently, SIMAP also predicted that these small droplets would readily leached their aromatic content via dissolution rather than evaporation processes.

Figure 30 and Figure 31 illustrates the zones of potential low exposure, and moderate and high impact from dissolved aromatic hydrocarbons in the upper water column which demonstrates dissolved aromatics reach low exposure levels that originate in near surface waters, but mix downward over time limiting their ability to evaporate into the atmosphere. While the downward mixing does create persistence it also enhances dilution, given the significant depths of water at this location in the Joseph Bonaparte Gulf.

For all seasons, seasonal drift currents passing by the spill location will either carry dissolved aromatic plumes at low levels along the seasonal drift path in play at the time of the blowout.

No zones of potential moderate or high impacts from dissolved aromatics were found from any of the 50 simulations for any season.

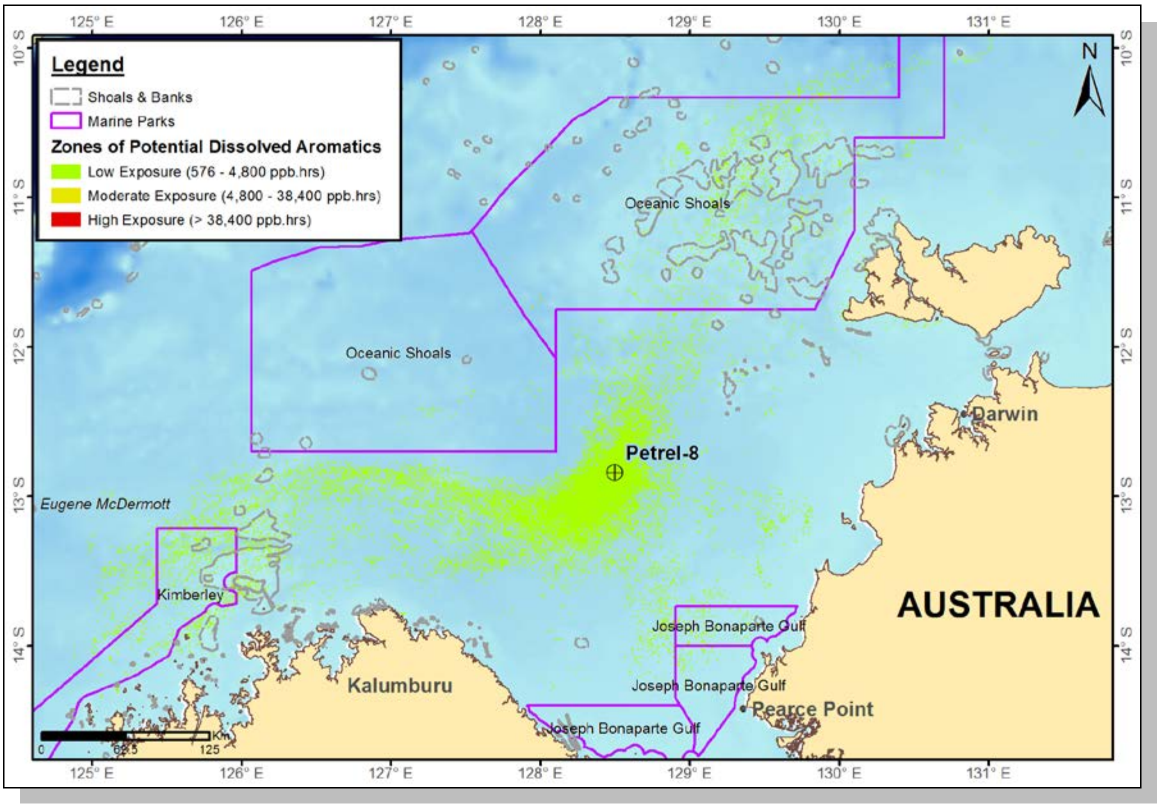
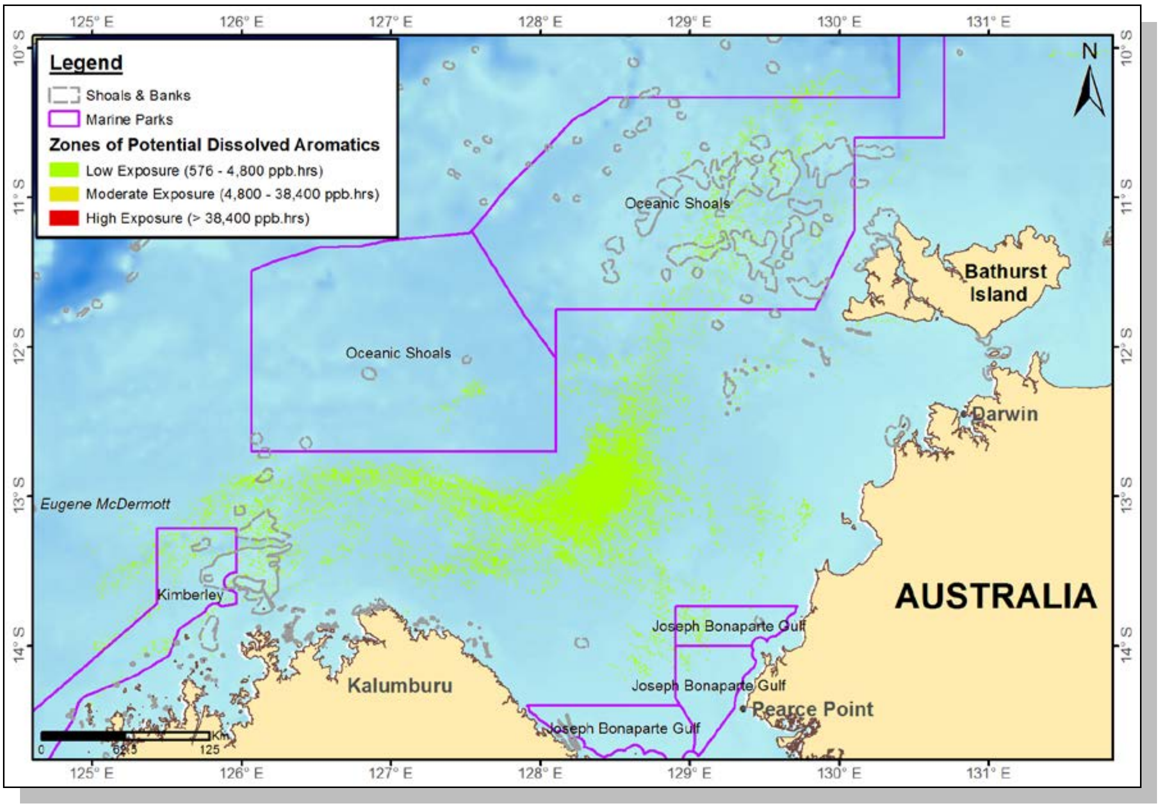


*Figure 30. <u>Zones of potential exposure of dissolved aromatics between the surface and 10 m depth</u>, in the event of a 704 bopd for 90 days blowout at the Petrel-8 field. The output is calculated for each grid cell and provide a summary from 50 spill trajectories modelled, for an **<u>annual</u>** wind and current conditions.*



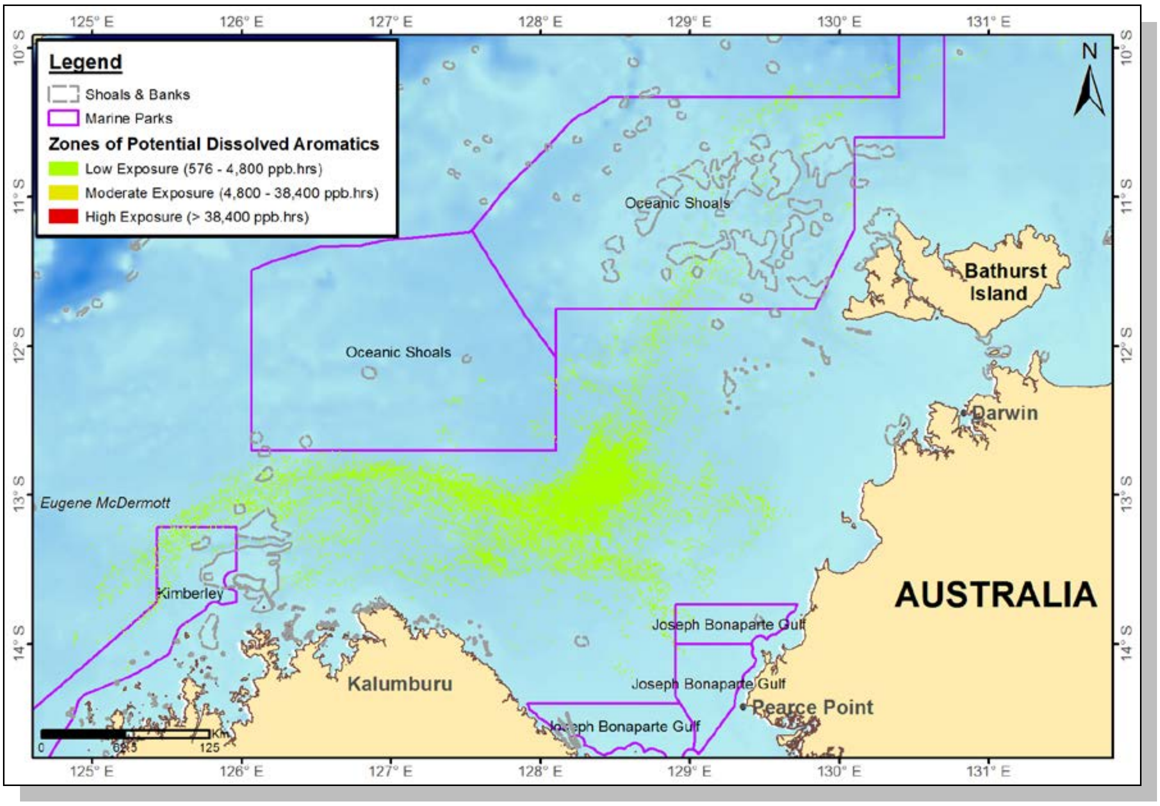


*Figure 31. Zones of potential exposure of dissolved aromatics between 10 m and 30 m depth (top) and between 30 m and 50 m depth, in the event of a 704 bopd for 90 days blowout at the Petrel-8 field. The output is calculated for each grid cell and provide a summary from 50 spill trajectories modelled, for an **annual** wind and current conditions.*

Figure 32 illustrate the quantified risk zones of potential low, moderate and high exposure from entrained hydrocarbon droplets in the upper water column (0-10 m below the sea surface) from the blowout. This model result indicates that the smaller size entrained droplets persist in surface waters up to 50 km at low concentrations only in the far field. This persistence as small droplet size promoted the high dissolution of aromatics predicted as shown above.

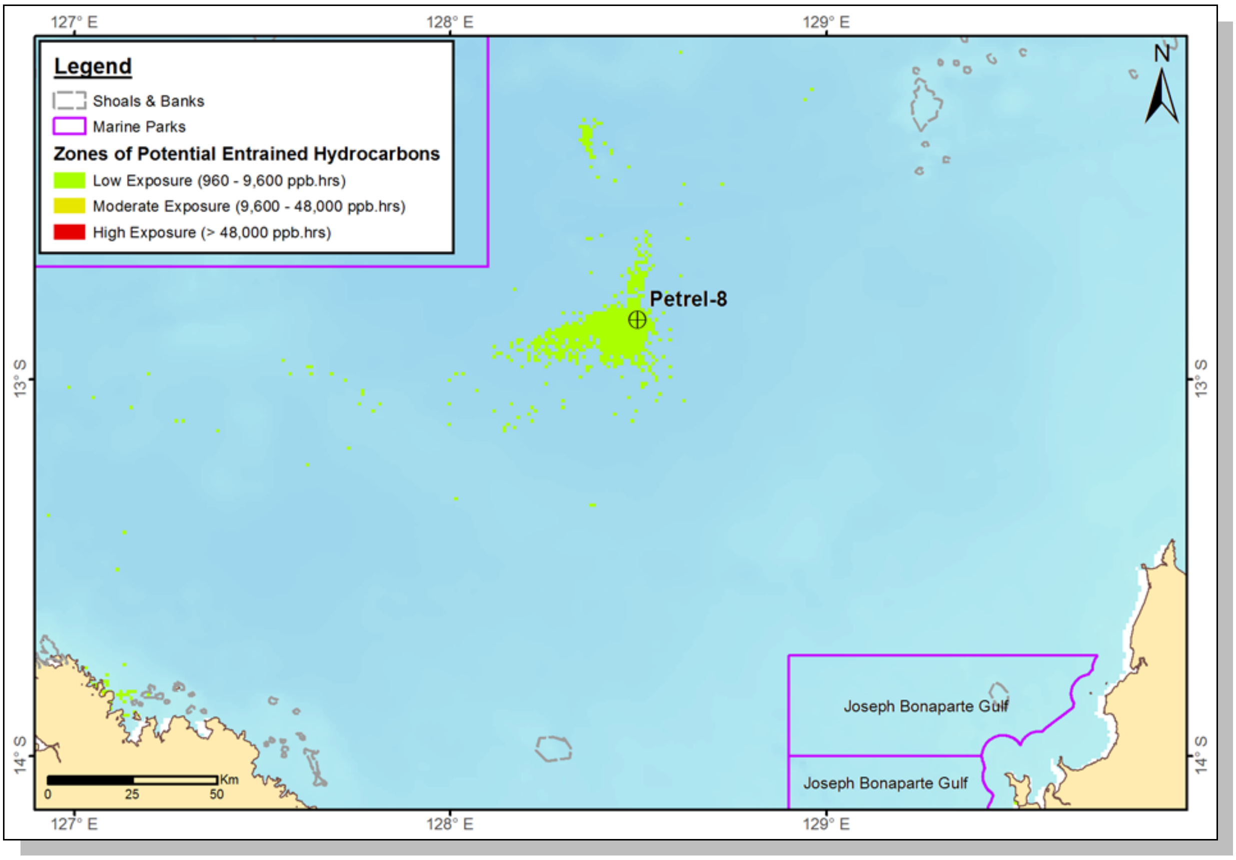


*Figure 32. Zones of potential exposure from entrained hydrocarbons, in the event of a 704 bopd for 90 days blowout at the Petrel-8 field. The output is calculated for each grid cell and provide a summary from 50 spill trajectories modelled, during **annual** wind and current conditions.*

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APPENDIX G SHIPBOARD OIL POLLUTION EMERGENCY PLAN

DET NORSKE VERITAS

DNV Id No.: **29276**

SHIPBOARD OIL POLLUTION EMERGENCY PLAN (SOPEP)

This manual is approved by Det Norske Veritas AS
on behalf of the government of

THE COMMONWEALTH OF THE BAHAMAS

The plan includes the requirements of MARPOL 73/78,
Annex I, Reg. 37.

Name of ship: **"POLARCUS NAILA"**

IMO number: **9538098**

**IF CHANGING VESSEL'S OWNERSHIP / MANAGEMENT
THIS PLAN IS SUBJECT TO REVISION AND RE- APPROVAL**

DET NORSKE VERITAS 1864

APPROVED

2010-02-17

Sign. JOFA / PHOSO

DET NORSKE VERITAS AS
Høvik

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REV.	DATE	STATUS	PREPARED	CHECKED	APPROVED
C1	06-02-10	Issued for Approval	MM	RD	NP
C2	07-08-18	Update	ON	DL	SH

Drydocks World-Dubai

PROJECT	**POLARCUS SX 124 Seismic Research Vessel**
TITLE	**SHIPBOARD OIL POLLUTION EMERGENCY PLAN (S.O.P.E.P) FOR POLARCUS NAILA**

DD REFERANCE NO.	HULL NO.	DOCUMENT NO.	SHEET NO.
S 9951	NB67	S9951-A-C- 003	1/42

Polarcus
EXPLORE GREEN

Drydocks World

SHIPBOARD OIL POLLUTION EMERGENCY PLAN (S.O.P.E.P)

Polarcus Naila

Contents

SHIP PARTICULARS

Ship's Name	:	Polarcus Naila
Flag	:	Bahamas
Port of Registry	:	Nassau
Official Number	:	8001617
IMO Number	:	9538098
Call Sign	:	C6XK5
GRT	:	7578
NRT	:	1974
Length Overall	:	90.8m
Breadth Overall	:	19.0 m
Draft	:	6.0 m
Classification Society	:	DNV
Type of Ship	:	Seismic vessel
Operator	:	Polarcus DMCC
		Almas Tower, Level 32, Jumeirah Lakes Towers P.O. Box 283373, Dubai, U.A.E.

INTRODUCTION

1) This plan is written in accordance with the requirements of regulations 37 of annex I of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the protocol of 1978 relating thereto.

2) The purpose of the Plan is to provide guidance to the master and officers on board the ship with respect to the steps to be taken when a pollution incident has occurred or is likely occur.

3) Without interfering with ship owners' liability, some coastal States consider that it is their responsibility to define techniques and means to be taken against a marine pollution incident, and approve such operations, which might cause further pollution. The plan required by MARPOL in the regulations referred to in paragraph 1 above, will not fully meet regulations in such States applicable to ships which carry oil in bulk. The USA is the notable example, and owners or operators of ships carrying oil as cargo in US waters must additionally:

a) identify and ensure, through contract or other approved means, the availability of private firefighting, salvage, lightering and clean-up resources;

b) identify a qualified individual with full authority to implement the response plan, including the activation and funding of contracted clean-up resources; and

c) describe training and drill procedures.

4) The plan contains all information and operational instructions required by the Guidelines. The appendices contain names, telephone, telex numbers, etc., of all contacts referenced in the Plan, as well as other reference material.

5) This Plan has been approved on behalf of the Administration and, except as provided below, no alternation or revision shall be made to any part of it without the prior approval of the Administration.

6) Changes to section 5 and the appendices will not be required to be approved by the Administration. The Company should maintain the appendices up to date.

REVISIONS

1) Revisions and amendments shall be indicated on the revision sheet.

2) This Plan will be regularly reviewed and updated. Revisions, other than those to section 5 and the appendices will be submitted to the Administration for approval. Review and revisions of the plan is the responsibility of The Company and will be carried out at intervals 12 months.

1. PREAMBLE

Recent oil incidents have focused attention on the desirability of shipboard contingency plans. As a consequence, MARPOL 73/78 requires all ships to carry an oil spill contingency plan.

The emphasis throughout this plan is on practical actions which might be taken after a spill by shipboard personnel in order to assist those dealing with the spill to reduce the severity of the spill. These actions would result in a reduction of any damage to sensitive coastal resources and the environment in general.

Action taken to reduce effects of spill may expose ship and its personnel to increasing hazard and it is stressed that the master's priority in the event of a spill is to take measures to ensure the safety of personnel and the ship.

One copy of his plan is to be kept available onboard and one copy in the operational office on shore to assist personnel in dealing with an unexpected discharge of oil. Its primary purpose is to set in motion the necessary actions to stop or minimize the discharge and to mitigate its effects. Effective planning ensures that the necessary actions are taken in a structured, logical and timely manner.

2. REPORTING REQUIREMENTS

2.1 When to Report

The provisions of MARPOL 73/78 require an incident report to be made by the ship to the nearest coastal state whenever the incident involves actual or probable discharge.

It should be borne in mind that the master has a duty to report even when no actual spill has occurred, but there is a probability that one could occur.

The master should first report as fast as possible to head office/duty management and then to the local administration.

2.1.1 Actual Discharge

The definition of actual discharge is as follows:

a) a discharge, resulting from damage to the ship or its equipment, or for the purpose of securing the safety of a ship or saving life at sea;

or

b) a discharge during the operation of the ship in excess of the quantity or instantaneous rate permitted under MARPOL 73/78.

2.1.2 Probable discharge

Where a report should be made when there is a probability of discharge, depends on the following factors:

a) the nature of the damage, failure or breakdown of the ship, machinery or equipment;

b) ship location and proximity to land or other navigational hazards

c) Weather, tide current and sea state; and

d) Traffic density.

e) Morale, health and ability of the crew on board to deal with the situation.

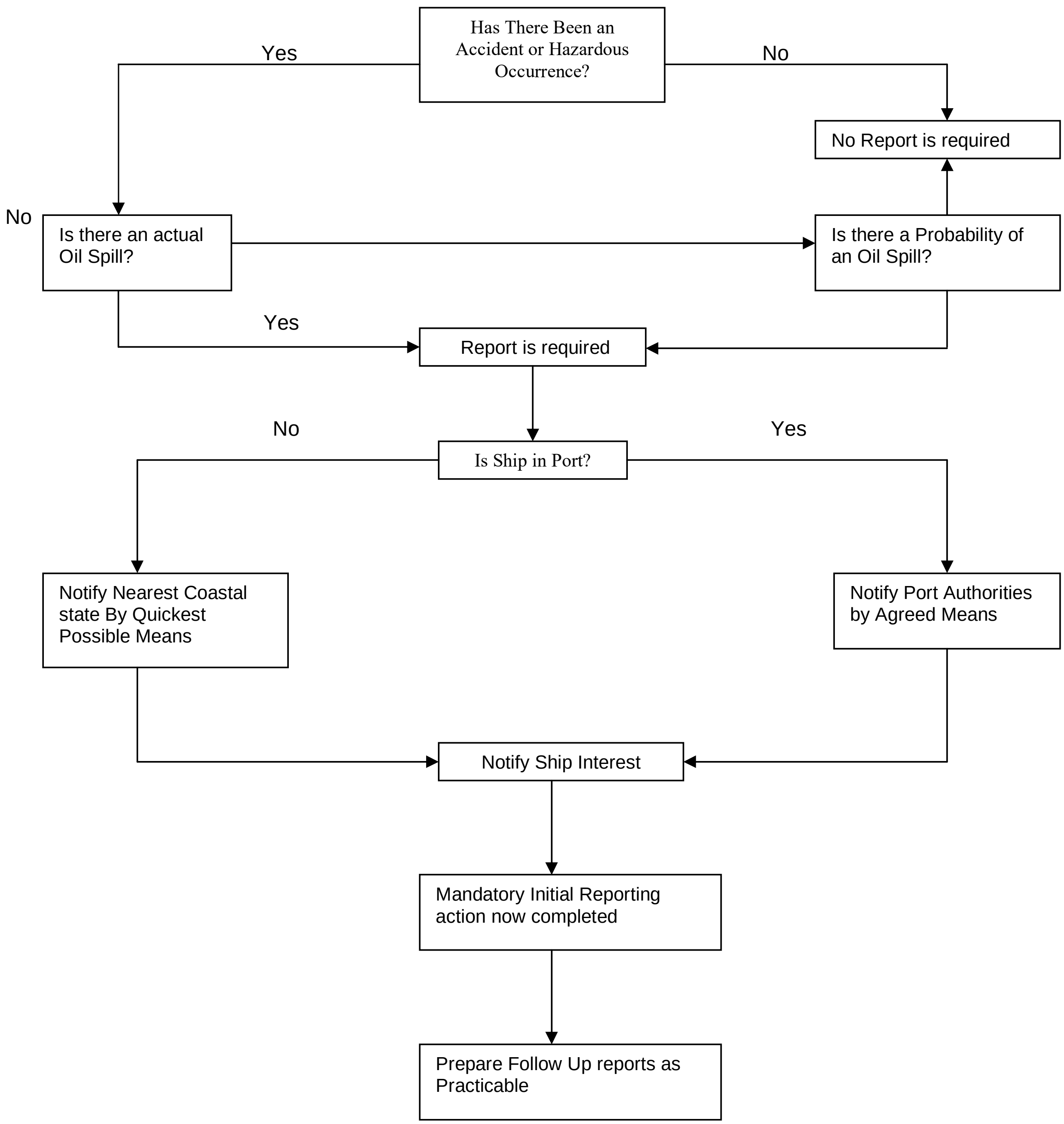
It is impractical to lay down precise definitions of all types of situations involving probable discharge, which would warrant an obligation to report.

As a general guideline, the master should make a report in cases of:

a) Damage, failure or breakdown which affects the safety of ship; example of such situations are collisions, grounding, fire, explosion, structural failure, flooding, cargo shifting; and

b) Failure or breakdown of machinery or equipment which results in impairment of the safety of navigation; example of such incidents are failure or breakdown of steering gear, propulsion, electrical generating system, essential shipboard navigational aids.

Reporting Requirements



2.2 Reporting Procedure

The reporting procedure to be followed by the Master or other persons in charge of the ship after an oil pollution incident is based on guidelines developed by the International Maritime Organization. ("*General principles for ship reporting system and ship reporting requirements, including guidelines for reporting incidents involving dangerous goods*, *harmful substances and/or marine pollutants*" adopted by the International Maritime Organization by Resolution A 648 (16)).

2.3 Information Required

2.3.1 Initial Report to Authorities

Reference should be made to IMO A. 648(16) for making the initial report to the authorities.

The Initial Report should contain the following information, and be in the form of (Table 1, page 15): -

a) Name of ship, call sign and flag.

b) Date, and time (GMT) of incident.

c) Ship's position (either latitude/longitude or true bearing and distance from a clearly stated landmark.)

d) Course at time of incident

e) Speed at time of incident.

f) Name of last port of call.

g) Name of next schedule port of call.

h) Full details of radio stations and frequencies being monitored

i) Type(s) and quantity(s) of cargo and board

j) Brief details of effects, damage, deficiencies or other limitations. This must include the condition of the ship and the ability to transfer cargo/ballast/fuel.

k) Brief details of any pollution. This should include the type of oil discharged, an estimate of the quantity discharged, whether the discharge is continuing, the cause of the discharge and if possible an estimate of the movements and area of the slick.

l) Brief details of weather and sea conditions

m) Name, address, telex and telephone number of owner or operator.

n) Ship size (Length, Breadth, Draft) in m and type of ship.

o) Brief details of incident

p) Need for outside assistance

q) Actions being taken

r) Number of persons on board

s) Details of P and I Club and local correspondent

2.3.2 Additional Information to Head Office

The following additional information should be sent to the head office either at the same time as the initial report or as soon as possible thereafter:

a) Number of casualties.

b) Further details of damage to ship and equipment.

c) Whether damage is still being sustained.

d) Assessment of fire risk and precautions taken.

e) Damage to other ship or property.

f) Disposition of cargo on board and quantities involved:

g) Time (GMT) assistance was requested and time (GMT) assistance expected to start.

h) Name of salver and type of salvage agreement. (Note, Head office to be consulted prior to engaging a salver).

i) Whether further assistance is required.

j) Priority requirements for spare parts and other materials.

k) Details of outside parties advised or aware of the incident.

2.3.3 Follow-up Reports to authorities and head office

Once the ship has transmitted the initial report to the shore authorities, further reports should be regularly sent to the authorities and head office; in order to keep them informed as the incident develops. Follow-up reports should include information on any significant changes in the ship's condition, the rate of release and spread of oil, weather conditions and details of agencies notified and any clean-up activities. Head office should also be advised of contact details for the on-scene commander appointed to control the clean up.

2.3.4 Characteristics of Oil Spilled

As well as giving details of the exact description of the oil lost, it will assist those involved in organizing the clean-up response if the precise characteristics of the oil are advised to shore authorities and head office. This information should include the following, if available, (and if known): -

- Type of bunker oil (cargo or bunkers)
- Specific Gravity, either in terms of API gravity or grams per cc.

- Viscosity at one or more temperatures, with the units and temperatures specified.

This information will enable those involve with the spill to assess the likely fate of the oil and organize the most appropriate response.

2.3.5 Cargo, Ballast and Bunker Disposition

When trying to Asses the on-going threat posed by a damage vessel, it will assist those involve if they are provided with details of bunker oil disposition and cargo oil (if any) obtained from the general arrangement plan.

Information on the current cargo, bunkers and ballast (including quantities), specification and location is to be kept with this plan. The Master is responsible for ensuring that this information is kept up to date before the commencement of each leg of the voyage.

SHIPBOARD OIL POLLUTION EMERGENCY PLAN EMERGENCY PLAN

Sample format for initial notification

AA (Ship name, call sign, flag)

BB (date and time of event, UTC)

[D][D][H][H][M][M]

CC (position, latitude, longitude)OR DD (bearing, distance from landmark)

[d][d][m][m][N or S] [d][d][d] [N miles]
[d][d][m][m][E or W]

EE (course) FF (speed, knots)

[d][d][d] [kn][kn][1/10]

LL (intended track)

MM (radio station(s)guarded)

NN (date and time of next report, UTC)

[D][D][H][H][M][M]

PP (type and quantity of cargo/bunkers on board)

QQ (brief details of defects/defects/deficiencies/damage)

RR (brief details of pollution, including estimate of quantity lost)

SS (brief details of weather and sea conditions)

Direction [ ][ ] [ ] Direction [ ][ ] [ ]

WIND { SWEEL{

Speed (Beaufort) Height (m)

TT (contact details of ship's owner/operator/agent)

UU (ship size and type)

Length: (m) Breadth: (m) Draught: (m) Type:

XX (Additional Information)

Brief details of incident

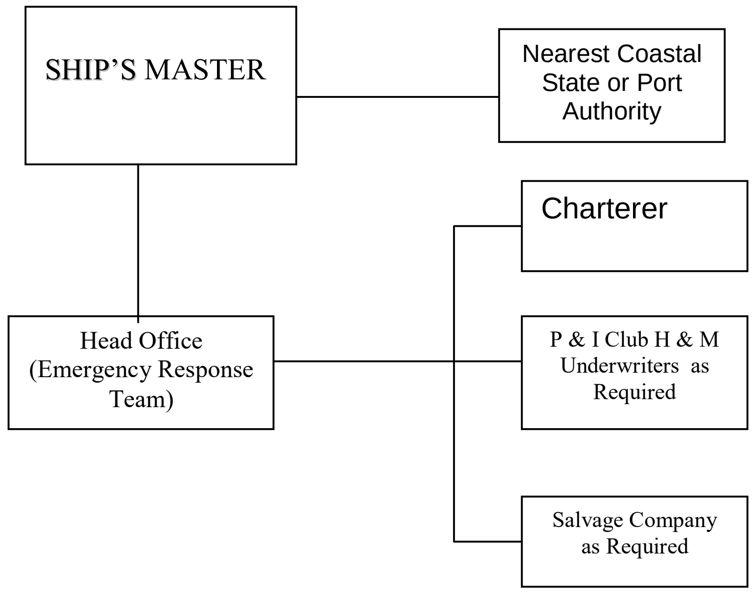
Need for outside assistance

Actions being taken

Number of crew and details of injuries

Details of P & I Club and local correspondent & Others

2.4 Whom to contact



Note: When an oil spill problem arises, the Master of the vessel should call the head office (The Company) as soon as possible, and the nearest coastal state or report authority. He should use the order of reporting to the Company as indicated in Appendix 3. Detailed instructions are indicated below.

2.4.1 Coastal States

The master has a statutory obligation to report an incident to the nearest coastal state, which should also be advised of the way the casualty situation progress. Full Co-operation should be extended to the authorities and all reasonable requests for information should be met.

Such reports should be transmitted either:-

a) When the ship is within or near to an area where a ship movement reporting system has been established, to the designated radio station of that system.

b) To the nearest coast radio station, designated ship movement reporting station or rescue co-ordination center on appropriate frequencies in the bands 405-525 kHz, 1605-2850 kHz: or

c) If the ship is not within reach of an MF or VHF coast radio station, to the most appropriate HF coast radio station.

d) The relevant maritime satellite communication system, as applicable.

In order to expedite response and minimize damage from a pollution incident, it is essential that appropriate coastal states be notified without delay. This process should begin with the initial report mentioned above (Table 1, page 15).

See Appendix 1 for list of authorities or officials of administrations responsible for receiving and processing reports as developed and updated by the Organization in conformance with article 8 of the Convention.

Should the master experience undue delay in contacting the responsible authority by direct means, or in the absence of a listed focal point, the master is advised to contact the nearest coastal radio station, designated ship movement reporting station or rescue co-ordination center by quickest available means.

2.4.2 Port Contacts

For ships in port, notification of local agencies will speed response.

Information on regularly visited ports is included in the appendix 2.

Should the port details not be included in the appendix, it is the responsibility of the master to obtain details of reporting procedures upon arrival in port. The Master shall append this information into the appendix for future use.

2.4.3 Ship Interest Contacts

Company Management

On becoming aware that a spill may be probable or if one has occurred, the master is to report the situation to one of the company executives listed in the Appendix 3. The head office response team shall contact relevant parties such as P & I Club, Insurers, and Classification Societies, cargo owners and salvers.

3. STEPS TO CONTROL DISCHARGE

3.1 Operational spills, which occur during the transfer of bunkers.

If, despite the adherence to proper procedures, an oil spill does occur, all bunker operations should be stopped by the quickest means and should not be restarted until the source of the leak has been identified and cured and hazards from the released oil have been eliminated. In most cases the cause of the leak will be obvious but, in some instances, such as spillage resulting from slight hull leakage, the source may be difficult to locate requiring the services of a diver.

The master is to ensure proper disposal of removed oil and clean materials.

This may be through the use of on board resources or by hiring a clean up company, which shall be decide by the head office after consultation with the master.

3.1.1 Pipe Leakage

Should the leakage be from the ship's on-deck pipe work, the affected sections should be drained down to an availability empty or slack tank.

At its simplest, opening up the line to an empty tank could relieve pressure; other methods could involve using a pump to empty and de-pressurize. This latter option is used only when all compartments are full and the crew has a full understanding and appreciation of the safety implications involved, especially those relating to personnel access.

3.1.2 Tank Overflow

Should the spillage be due to the overflowing of a tank, dropping back to an empty or slack tank should lower the level within the tank. Should all other tanks be full, pumps should be ready and the excess oil transferred ashore.

3.1.3 Hull Leakage

Should spillage be due to suspected hull leakage, measures should be taken to reduce the head of oil in the tank involved either by transfer or discharge ashore. Unless timely corrective action is taken, oil will continue to flow out to sea until hydrostatic balance is achieved between the head of oil remaining in the tank and the seawater pressure exerted on the outer hull. Should it not be possible to identify the specific tank from which leakage is occurring, the levels of all tanks in the vicinity should be reduced, taking into account the effect on hull stress and stability. Should it be suspected that leakage is from a fracture in the bottom plating or lower shell plating, consideration should be given to reducing the level in the tank, if full, and then pumping water into the damage tank to prevent any further oil spillage.

Furthermore, no action should be taken that in any way could jeopardize the safety of personnel either onboard or ashore.

3.2 Spills resulting From Casualties (see checklist2, page 29)

A casualty spill is an oil spill, which occurs as a result of equipment or vessel damage. The most common cause is collision, fire or combination of these.

Each of the casualties listed below are treated separately, using checklists or other means where required. This ensures that the master considers all appropriate factors when addressing a casualty.

Specific personnel assignments for anticipated task are identified, however reference to fire control plans and muster lists onboard is sufficient to identify personnel responsibilities.

The following provides the master with guidance concerning:

- Priority actions
- Stress and stability considerations
- Lightening
- Grounding
- Fire/Explosion
- Collision
- Hull Failure
- Excessive List

3.2.1 Priority Actions

In the event of a casualty, the master's priority will be to ensure the safety of personnel and to take action to prevent escalation of the incident. In casualties involving spills, immediate consideration should be given to measures aimed at preventing fire and explosion, such as altering course so that the ship is unwind of the slick or shutting down non-essential air intakes.

If the ship is aground, and cannot therefore manoeuvre, all possible sources of ignition should be eliminated and action taken to prevent flammable vapours entering accommodation and engine room spaces.

When it is possible to maneuver, the master in conjunction with the appropriate shore authorities, may consider moving his ship to a more suitable location, for example, to facilitate emergency repair work or lightening operations , or to reduce the threat posed to any particularly sensitive shoreline areas.

Prior to considering remedial action, the master will need to obtain detailed information on the damage sustained to the ship. A visual inspection should be carried out and all bunker tanks, and other compartments sounded. Due regard should be paid to the indiscriminate opening of sounding pipe caps, especially when the ship is aground, as loss of buoyancy could result.

Having assessed the damage sustained by the ship, the master will be in a position to decide what action should be taken to prevent or minimize further spillage. When bottom damage is sustained, hydrostatic balance will be achieved fairly rapidly, especially if the damage is severe, in which case the time available for preventive action will often be limited.

When significant side damage is sustained in way of oil tanks, bunkers will be released fairly rapidly until hydrostatic balance is achieved and the rate of release will then reduce and be governed by the rate at which oil is displaced by water flowing in under the oil. When the damage is fairly limited and restricted, for example, to one or two compartments, consideration may be given to transferring oil internally from damaged to intact tanks.

3.2.2 Stress and Stability Considerations

Great care in casualty response must be taken to consider stability and stress when taking actions to mitigate the spillage of oil or to free the ship if aground. The master is ensure that these aspects are properly considered.

Internal transfers should be undertaken only with a full appreciation of the likely impact on the ships' overall stress and stability. When the damage sustained is extensive, the impact of internal stress and stability may be impossible for ship personnel to assess. Contact may have to be made with the head office in order that information can be provided so that damage stability and damage longitudinal strength assessments may be made.

The master shall make appropriate damage stability assessments using the stability booklet kept on board.

When the ship is damage, the following information should be sent to the head office (Appendix 3) in order that the stability and stress of the ship can be calculated:-

a) Loading Condition (Intact)

- Cargo/Ballast – amount and disposition
- Fuel oil – amount and disposition
- Draught – when free floating

b) Damage

- Location and extent

c) Condition of the ship

- Extent to which aground (soundings around ship)
- Draught – forward, amidships (port and starboard), aft
- Cargo and fuel – loss or change in amount or disposition
- Action already taken

d) Local Conditions

- Tide – range and weather rising or falling
- Wind – strength and direction
- Sea and swell - height and direction
- Current
- Weather forecast
- Air and Sea temperatures
- Other locally significant features

The above information, some of which will only be relevant in the case of grounding, should be supplemented with as much as detail as possible.

Once the stability of the ship has been computed, the head office will be in a position to advise the master on action that can be safely taken to minimize damage and prevent further pollution.

3.2.3 Lightening

Should the ship sustain extensive structural damage, it may be necessary to transfer all or part of the bunkers to another ship. During ship-to-ship transfer of bunkers, the master must ensure that safety standards and minimum equipment level are to be observed.

3.2.4 Grounding

If the ship is aground, and can not therefore maneuver, all possible source of ignition should be eliminated and action taken to prevent flammable vapors entering master, in conjunction with the appropriate shore authority, may consider moving the ship to a more suitable location in order, for example, to facilitate emergency repair work or lightening operations, or to reduce the thread posed to any particular sensitive shoreline areas. Such maneuvering may be subject to coastal state jurisdiction.

3.2.5 Fire / Explosion

In casualties involving spills, immediate consideration should be given to measures aimed at preventing fire and explosions, such as altering course so that the ship is upwind of a slick, shutting down non essential air intakes etc.

3.2.6 Collision

If a collision occurs:

- Sound the emergency alarm and initiate emergency procedures.
- Determine whether there are casualties.

The master should assess the situation for pollution purposes as follows, taking action where appropriate:

- Decide whether separation of the vessel may cause or increase the spillage of oil.
- If any oil tanks are penetrated, reduce the risk of further spillage by isolating penetrated tanks or transferring oil to slack or empty tank.
- If there is a spill of oil in connection with the collision, inform the appropriate parties in accordance with Section 2 of this plan.

3.2.7 Hull Failure

If the vessel suffers severe structural hull failure:

- Sound the emergency alarm and muster the crew.
- Reduced speed or stop to minimize stress on the hull
- Assess the immediate danger of sinking or capsize.
- Initiate damage control measures.

The master should then assess the situation for pollution purposes as follows:

- If oil has spilled, or it is necessary to jettison oil in order to maintain stability, inform the appropriate parties in accordance with Section 2 of this Plan.
- If the change in stability and stress cannot be calculated on board, contact the Company and arrange for the necessary calculations to be carried out.
- Consider the forecast weather conditions and the effect they may have on the situation.

3.2.8 Hull Failure

If excessive list occurs rapidly and unexpectedly it may be due to:

- Failure of the hull plating.
- Failure of an internal bulkhead between compartments
- Shift of cargo
- Flooding of the engine room, where free surface can cause a list
- Damage through grounding or collision.
- Incorrect operation procedures.
-

Steps to be taken immediately:

- Stop any bunkering or ballast operations in progress.
- Sound the emergency alarm and muster the crew.
- If under way. Reduce speed or stop.
- Establish reason for list.

Further measures

- If oil spilled, or it is necessary to jettison oil in order to maintain stability, inform the appropriate parties in accordance with section 2 of this plan.
- If possible, take corrective action to rectify the situation.

3.3 Initiating the clean up response

3.3.1 Small Operational Spills

In most instances, the ship's initial report to local authorities will trigger the mobilization of the local response organization. It is not normally practical for ship's personnel to be directly involved in the clean-up activities and their prime role is to provide as much information as is necessary to assist the response and co-operate fully with clean-up personnel. However, where their is no local response or there is a delay in it being activated, the master should the use of available shipboard materials to clean up or contain the spilled oil by, for example, using ship-stocked sawdust and rugs.

In cases of small operational spills, the ship should take whatever actions are necessary to prevent the oil escaping over side and, having done so, will need to take action to clean up the oil contained on deck.

It must be stressed that spilled oil should never be washed over side, nor should dispersant or de-greasants be used on oil in the water because their use could contravene local regulations. Once the oil is in the water, there is very little that the ship can do to respond practically and reliance must be placed on shore authorities and organizations.

3.3.2 Large Spills

In case of larger spills, the ship is even more restricted as to what action it can take to respond practically to the spill. In the case of a casualty, the safety of the ship and crew will also take priority. Invariably therefore, ship's actions will be limited to reporting details to the relevant authorities and head office and to requesting the appropriate clean-up response, if equipment is on board for fighting the oil spill overboard then the vessel should take immediate action to try to control the spill.

Operational Oil Spill Response (check list 1)

	Actions To Be Taken	Persons Responsible	Done
A	**IMMEDIATE ACTION**		
	Sound emergency alarm.	Any person	

	Initiate emergency procedures	Duty Officer	
B	**INITIAL RESPONSE**		
	Stop all bunkering operations.	Duty Engineer	
	Close all manifold valves.	Duty Engineer	
	Stop air intake to accommodations.	Duty Engineer	
	Stop non-essential air intake to engine room	Duty Engineer	
	Locate source of leakage.	Duty Engineer	
	Stop or reduce flow of bunkers.	Duty Engineer	
	Commence clean up operation using absorbent & permitted solvents.	Duty Officer	
	Comply with reporting procedures.	Master	
C	**SECONDARY RESPONSE**		
	Assess the fire risk from release of flammable substances.	Chief Officer	
	Reduce level of bunker in leaking tank by transferring to an unaffected tank.	Chief Engineer	
	Drain affected line to empty or slack tank.	Chief Engineer	
	Prepare pump for transfer of oil to other tanks, or to shore/lighter.	Chief Engineer	
	Prepare portable pumps if it is possible to transfer spilt oil to empty tank	Chief Engineer	
D	**FURTHER RESPONSE**		
	Pump water into leaking tank to create water cushion and prevent further oil loss	Chief engineer	
	Arrange diver for investigation if leakage is below waterline.	Master	
	Estimate stress and stability of the vessel, request shore assistance.	Chief Officer	
	Transfer bunker to alleviate high stress.	Chief Engineer	

Casualty Oil Spill Response (checklist 2)

	Actions To Be Taken	Responsible Person	Done
A	**IMMEDIATE ACTION**		
	Sound emergency alarm.	Duty Officer	
	Initiate emergency procedures	Duty Officer	

B	**INITIAL RESPONSE**		
	Stop air intake accommodation	Duty Officer	
	Stop non-essential air intake to engine room.	Duty Engineer	
	Assess further danger to ship & personnel such as capsize or immediate sinking of the ship	Master	
	Stop all bunkering and other non-essential operations.	Duty Engineer	
	Visual inspection of damage	Chief Officer	
	Sound all holds, ballast tanks, and void spaces	Chief Officer	
	Assess whether oil has actually been spilt or there is a probability that it will be spilt	Duty Officer	
	Comply with reporting procedures.	Master	
	Request for outside assistance	Master	
	Counter excessive list (if any).	Chief Officer	
	Contain spilt oil.	Duty Officer	
	Commence clean up operation using absorbent and permitted solvents.	Chief Officer	
C	**FURTHER RESPONSE**		
	Consider evacuation of non-essential crew.	Master	
	Assess likelihood of further damage to vessel or cargoes.	Master	
	Estimate stress and stability of the vessel, request for shore assistance	Chief Engineer	
	Request assistance to escort to port of refuge.	Master	
	Maneuver upwind of spill, or away from land. (if not grounded)	Master	
	Assess whether tide will worsen situation.	Duty Officer	
	Obtain weather forecast and assess its effects.	Master	
	Prepare pumps for transfer of oil or bunker to another tanks, or to shore/lighter	Chief Engineer	

4. NATIONAL AND LOCAL CO-ORDINATION

Quick efficient co-ordination between the ship and coastal state or other involved parties becomes vital in mitigating and effects of a pollution incident.

It is most important that assistance from local, national or international companies and organizations, if available, is obtained as quickly as possible by reporting any spill as detained in section 2 of this Plan. Additional assistance, if required and liaison with national and local agencies will be organized by the Company.

It is more important that the master obtains authorization from the relevant coastal state before undertaking certain mitigation actions. Authorization must always be sought when considering the use of dispersants to combat an oil spill. Many nations have regulations, which prohibit or strictly limit the use of dispersants. Thus, while there may be a temptation to use dispersant quickly before oil becomes emulsified, the master must not authorize such actions without the prior authorization of the nearest coastal state.

5. ADDITIONAL INFORMATION

5.1 Record Keeping and Sampling Procedures

It is essential that personnel onboard maintain a comprehensive, detailed record of spill events. Apart from detailing all actions taken on board, the log should also contain a record of communications with outside authorities, head office and other parties, as well as a brief summary of information passed and received, and decisions made. The observed movement of the spilled oil should also be recorded together with details of prevailing wind, current and sea conditions. When the spill occurs in port a brief description of areas contaminated by the oil will be useful together with information on other craft and facilities likely to be affected. Written data should be supported by photographs whenever possible.

Brief details of any response initiated by shore authorities should also be recorded and, when known, information on numbers of personnel engaged in the clean-up as well as type and quantity of clean-up equipment and material being used. It may be particularly useful to collect samples of all the different types of oil carried on board as well a sample of the spilled oil, especially in cases where it is suspected that not all the oil pollution comes from our source. If the ship is not responsible for a particular spill, photographs of the hull and deck may help in verifying this. Similarly, if another ship is observed spilling oil, this should be photographed, if possible, and reported on sighting.

Photographs of the oil on the sea close to the tanker may help in ascertaining the magnitude of the spill.

When taking samples, which may eventually be required as evidence in legal proceedings, it is essential to establish their authenticity. Collection of samples should therefore be witnessed and containers should be properly sealed and labeled. As pollution control authorities will probably also require samples for their own use, it may be appropriate for sampling to be undertaken as a joint exercise with samples being split between the two parties and authenticated at the same time.

5.2 Shipboard Response Materials

The following minimum stock shall be carried in the Bosun's Store, and must be replacement as required to ensure that it is always available:-

- 1 roll of Plastic Bags
- 2 pcs Sorbent Pads U94200
- 6 pcs Spill Kit Gloves
- 6 pcs 1- Time Suits
- 6 pair of Safety Boots
- 25 litres Aquabreak PX (waterbased cleaning chemical)
- 1pcs Jet Spray
- 5 litres Natural Handcleaner
- 1 pcs Oil Spill Kit Bag 1000 litres
- 8 pcs Sorbent Booms U94410S
- 1 pcs Oil Spill Kit Bag 1000 litres
- 1 pck Sorbent Pads U9450
- 1 pck Sorbent Rolls U94150S

5.3 Training and Exercise of Plan

The master shall be responsible for training procedures. Regular exercise will ensure that contingency arrangements function properly and all those likely to be involved in a spill, or the threat thereof, become fully familiar with their responsibilities. For any plan to be effective it has to be:

- Familiar to those with key functions on board the ship.
- Review and updated regularly, and
- Tested for viability in regular exercise.

5.4 Health and safety

Whilst cleaning up oil on deck, the crew must wear the necessary protective clothing.

Although it is unlikely that vapor from oil spilled on open water or open deck will remain in the area in sufficient concentration to present a major problem, the following precaution should be taken.

- All sources of ignition in the area must be removed or isolated.
- Spill should always be approached from an upwind direction.

5.5 References

The following publications are referred o in the text or are of particulars relevance to oil spill contingency planning:-

Manual on Oil pollution, Section II, Contingency Planning – (IMO)

ISBN 92 801 1233 3

Available from IMO, Publication Section 3.4

Albert Embankment, London SEI 7SR

Response to Marine Oil Spills – (ITOPF)

Available from Witherby & Co. Ltd.

32-36 Aylesbury Street, London ECIR OET

Provisions concerning the Reporting of Incidents Involving Harmful Substances under

MARPOL 73/78 – (IMO)

ISBN 92 810 1261 9

Available from IMO Publications Section

Peril at Sea and Salvage – A Guide for Masters – (ICS/OCIMF)

ISBN 0 948691 46 8

Available from Witherby & Co. Ltd., London

Resolution 684(16) International Maritime Organization

APPENDICES

Appendix 1 List of Coastal State Contacts

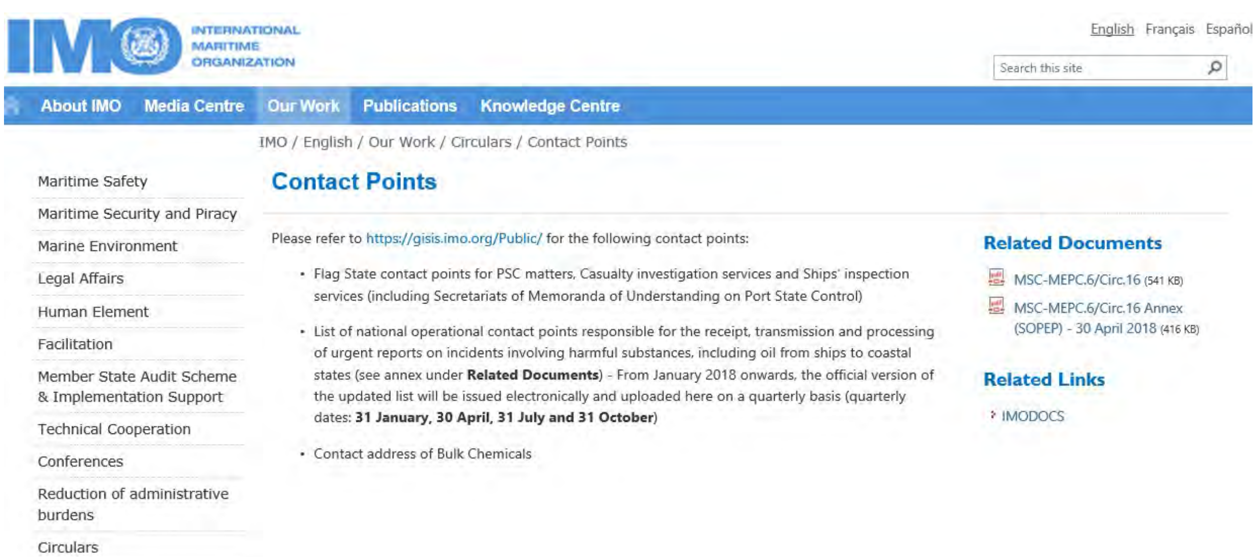
Regulation 37 of Annex 1 and regulation 17 of Annex II of the MARPOL Convention, and the associated Guidelines developed by IMO, oblige a ship to report a pollution incident to the nearest coastal state, and in order to be able to do so the shipboard marine pollution emergency plan is required to include, as an appendix, a list of authorities or persons to be contacted in the event of a pollution incident. The list should show the agencies or officials of administrations responsible for receiving and processing reports

An equal obligation was placed on governments that are parties to the Convention to notify IMO with complete details of authorities responsible for receiving and processing reports on incidents, for circulation to other Parties and Member States of the Organization. Governments advise IMO of changes when they occur. As a result, a complete list is now available, and can be used to provide the master of a ship with the route to inform the coastal state about a spillage.

Shipping companies compiling a pollution emergency plan may obtain from a ship's administration a printed copy of the IMO circular containing the information, under the title MEPC.6/ Circ.7 Annex 2, re-issued each year, and entitled "List of national operational contact points responsible for the receipt, transmission and processing of urgent reports on incidents involving harmful substances, including oil from ships to coastal states". The document is also available on the Internet as follows: **http://www.imo.org** (select 'Circulars' then select 'Contact points'). The lists on the Internet will be up-dated as changes and amendments are received, but the printed copy of the list will only be revised and re-issued annually.

The contact points actually listed in a SMPEP will vary according to the policy of the company and the trading pattern of the ship.

In the absence of a listed focal point, or should any undue delay be experienced in contacting the responsible authority by direct means, the master should be advised to contact the nearest coastal radio station, designated ship movement reporting station or rescue co-ordination centre (RCC) by the quickest available means.



The list should show the agencies or officials of administrations responsible for receiving and processing reports about spillages of oil and noxious liquid substances.

For ships in port, notification of local agencies will speed response. The variety of trades in which ships engage makes it impractical to specify in this model plan a definitive approach to listing these agencies, but the table below is a suggested pro-forma for developing a list.

Information on regularly visited ports should be included, but where this is not feasible, the master should be required to obtain the necessary details concerning local reporting procedures upon arriving in the port. Ships' agents could urge a port to make the details readily available.

PORT	INSTITUTION AND PERSON TO BE CONTACTED	MEANS OF CONTACT	REMARKS
Protection & indemnity insurance club.	SKULD Offshore	Phone: +47-95292200 Mail offshore@skuld.com Inmarsat- Fax:	
(Hull Club 24 hour emergency) Arthur J. Gallagher (UK) Limited	Norwegian hull club, olav kyrresgt 11, 5014 Bergen	Phone: +47-55559500 Fax: +47-55559555 Emergency: +47-22428844	
Watch telephone		Phone:	

Updated information of agent port contacts available on the bridge, including Guidlines.

The list should show details of all those parties with an interest in the ship who should be advised in event of spillages of oil and noxious liquid substances. When compiling the contact list, it should be remembered that in the event of a serious incident following a casualty, ship's personnel may be fully engaged in minimising the effects of the casualty, and onerous non-essential communications requirements should not be imposed.

Procedures will vary from company to company, and it is impractical to specify in this model plan a definitive approach to ensuring all parties are informed. It may be found appropriate to refer to any flow chart incorporated in the body of the plan under section 2.3. The table below is a suggested pro-forma for developing a list.

INSTITUTION AND PERSON TO BE CONTACTED	ADDRESS	MEANS OF CONTACT	REMARKS
Operator / Head office. Polarcus DMCC Contact person: Morten Meyer	Almas Tower, Level 32, Jumeirah Lakes Towers P.O. Box 283373, Dubai, U.A.E.	Tel.office: +971 4 43 60 898 Mob. +971 56 177 43 64	
Owner. Polarcus DMCC		Tel.office: +971 4 43 60 800 Fax: +971 4 43 60 808	
DnV (Class)	Bur Juman Office Tower, 14th Floor, Trade Center Road, Dubai, United Arab Emirates	Telephone :+971 4 3526626	
P&I Club and correspondents GARD Skuld Offshore	SKULD Offshore P.O. Box 1376 Vika NO-0114 Oslo Norway	Telephone : +47 22 00 22 87 Telefax: -47 952 92 287 24 hour Telephone: +4795292200	

POLLUTION PREVENTION TEAM

The master of the ship should appoint a pollution prevention team on board. The primary function should be to initiate immediate recovery or clean-up procedures if an incident occurs during cargo operations or bunker transfer. The company's spill response plan should be brought to the attention of everyone in the team, so that they understand their own part in the broader picture.

In the event of a spillage of oil or a noxious liquid substance the team should be called out immediately.

The team should be given the necessary training in the use of spill containment equipment or absorbents carried on the ship. All members of the Pollution Prevention Team should be aware of their duties should a spill occur.

Suggested instructions to a Pollution Prevention Team

Master	In overall charge Inform terminal authorities of incident. Inform local agent and request agent to inform the local P&I Club representative. Advise company's head office. Keep everyone updated at regular intervals. Advise of any changes in status of the emergency. Request assistance as deemed necessary.
Chief Officer	In charge of deck operation. Keep master informed and updated on the situation. Ensure event log is maintained. Report results of steps taken to limit liquid outflow.
Chief engineer	In charge of bunker operations. If bunkering in progress, stop operation. Organise distribution of oil spill detergent or appropriate treatment. Organise starting of foam pump if required.
Deck officer on duty	Tank spillage: Open an empty or slack tank. Stop pumping of that cargo; consider stopping cargo operations. Alert and inform chief officer and master of the situation. Alert shore staff.
Engineer officer on duty	Prepare for fire fighting. Assist chief engineer.
Rating on duty	If a leakage is detected, alert duty officer immediately.

EXAMPLE CHECKLISTS FOR USE IN EMERGENCIES

A. Checklist for response to operational spill of oil or noxious liquid substance:

This checklist is intended for response guidance when dealing with a spill of oil or a noxious liquid substance during cargo or bunkering operations. Responsibility for action to deal with other emergencies which result from the liquid spill will be as laid down in existing plans, such as the Emergency Muster List.

ACTION TO BE CONSIDERED	ACTION TAKEN Yes	No	PERSON RESPONSIBLE
Immediate Action			
Sound Emergency Alarm	☐	☐	Person discovering incident
Initiate ship's emergency response procedure	☐	☐	Officer on duty
Initial Response			
Stop all cargo and bunkering operations	☐	☐	Officer on duty
Close manifold valves	☐	☐	Officer on duty
Stop air intake to accomodation	☐	☐	Officer on duty
Stop non-essential air intake to machinery spaces	☐	☐	Engineer on duty
Locate source of leakage	☐	☐	Officer on duty
Close all tank valves and pipeline master valves	☐	☐	Officer on duty
Commence clean-up procedures using absorbents and permitted solvents.	☐	☐	Chief Officer
Comply with reporting procedures	☐	☐	Master
Secondary Response			
Assess fire risk from release of flammable liquids or vapour	☐	☐	Chief Officer
Reduce liquid level in relevant tank by dropping into an empty or slack tank	☐	☐	Chief Officer
Reduce liquid levels in tanks in suspect area	☐	☐	Chief Officer
Drain affected pipeline to empty or slack tank	☐	☐	Chief Officer
Reduce inert gas pressure to zero	☐	☐	Chief Engineer
If leakage is at pumproom seavalve, relieve pipeline pressure	☐	☐	Chief Officer
Prepare pumps for transfer of liquid to other tanks or to shore or to lighter	☐	☐	Chief Engineer
Prepare portable pumps for transfer of spilt liquid to empty tank	☐	☐	Chief Engineer
Further response			
Consider mitigating activities to reduce effect of spilt liquid	☐	☐	Master
Pump water into leaking tank to create water cushion under oil or light chemical to prevent further loss	☐	☐	Chief Officer
If leakage is below waterline, arrange divers to investigate	☐	☐	Master
Calculate stresses and stability, requesting shore assistance if necessary	☐	☐	Chief Officer
Transfer cargo or bunkers to alleviate high stresses	☐	☐	Chief Officer
Designate stowage for residues from clean-up prior to disposal	☐	☐	Officer on duty

B. Checklist for response to spill of oil or noxious liquid substance after a casualty:

This checklist is intended for response guidance when dealing with a spill of oil or a noxious liquid substance following a casualty. Responsibility for action to deal with the casualty itself will be as laid down in existing plans, such as the Emergency Muster list.
The term "Navigator" refers to the officer responsible for passage planning and voyage analysis, usually the second officer.

ACTION TO BE CONSIDERED	ACTION TAKEN Yes	ACTION TAKEN No	PERSON RESPONSIBLE
Immediate Action			
Sound Emergency Alarm	☐	☐	Person discovering incident
Initiate ship's emergency response procedure	☐	☐	Officer on duty
Initial Response			
Stop air intake to accomodation	☐	☐	Officer on duty
Stop non-essential air intake to machinery spaces	☐	☐	Engineer on duty
Assess further danger to ship or personnel by such as capsize or immediate sinking	☐	☐	Master
Stop all cargo and ballasting operations	☐	☐	Officer on duty
Close all tank valves and pipeline master valves	☐	☐	Officer on duty
Assess whether oil or NLS has actually been spilt	☐	☐	Chief Officer
Assess whether oil or NLS will probably be spilt	☐	☐	Master
Assess security of tank environmental control systems	☐	☐	Chief Officer
Assess risk of complex chemical reaction in NLS cargo	☐	☐	Chief Officer
Comply with reporting procedures	☐	☐	Master
Sound all compartments	☐	☐	Chief Officer
Sound around ship if it is aground	☐	☐	Chief Officer
Request outside assistance	☐	☐	Master
Stop or reduce outflow of oil or NLS	☐	☐	Chief Officer
Counter excessive list	☐	☐	Chief Officer
Contain spilt liquid still on deck	☐	☐	Officer on duty
Commence clean-up procedures using absorbents and permitted solvents.	☐	☐	Chief Officer
Further response			
Reduce inert gas pressure to zero	☐	☐	Chief Engineer
Assess fire risk from release of flammable liquids or vapour	☐	☐	Chief Officer
Consider evacuation of non-essential crew	☐	☐	Master
Assess liklelihood of further damage to ship or cargo	☐	☐	Master
Calculate stresses and stability, requesting shore assistance if necessary	☐	☐	Chief Officer
Transfer cargo or bunkers to alleviate high stresses	☐	☐	Chief Officer
Request assistance or escort to place of refuge	☐	☐	Master
Manoeuvre upwind of spill and / or away from land	☐	☐	Master
Assess effect of tide and current, on ship and spilt liquid	☐	☐	Navigator
Obtain weather forecast and assess effect on ship	☐	☐	Master
Prepare pumps for transfer of liquid to other tanks or to shore or to lighter	☐	☐	Chief Engineer
Reduce liquid levels in tanks in suspect area	☐	☐	Chief Officer
Designate stowage for residues from clean-up prior to disposal	☐	☐	Officer on duty

EMERGENCY STRESS AND STABILITY CALCULATIONS

When taking steps to mitigate the spillage of oil or noxious liquid substances, great care must be taken to consider stability and strength of the ship, especially if the hull is damaged due to collision or grounding. When the damage sustained is extensive, the impact of internal transfers on stress and stability may be impossible for the ship to assess. Contact may have to be made with shore entity with the necessary capability.

Before the transfer of noxious liquid substances in bulk, there must be consideration of the compatibility of all substances involved, such as other cargoes, bunkers, tank materials and coatings, pipelines, etc..

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INSTITUTION AND PERSON TO BE CONTACTED

MEANS OF CONTACT

Vessel Manager: DNV Emergency Response Service

Tel. +47 91 84 97 15 (primary)
Tel. +47 67 57 76 88 (backup)
Email: emergency@dnv.com
Fax.: +47 67 57 76 95

INFORMATION TO HAVE READY FOR TRANSMISSION IN INITIAL CONTACT.

Identity of ship

Type of casualty

Present and expected weather

Details of damage

Appendix 7 Ship's Plans, Drawings and Specific Detail

DRAWING LIST:

U10760_101-100-01	GENERAL ARRANGEMENT
U10760_101-105-01	TANK PLAN
U10760_103-310-01	CAPACITY PLAN
U10760_500-600-01	FIRE CONTROL & SAFETY PLAN
U10760_700-600-01	FUEL OIL SYSTEM
U10321_710-600-01	LUB. OIL SYSTEM
U10760_803-600-01	BILGE SYSTEM
U10760_813-600-01	FIRE LINE SYSTEM
U10321_433-650-01/02	PIPE ARR. WINDLASS / MOORING EQUIPMENT

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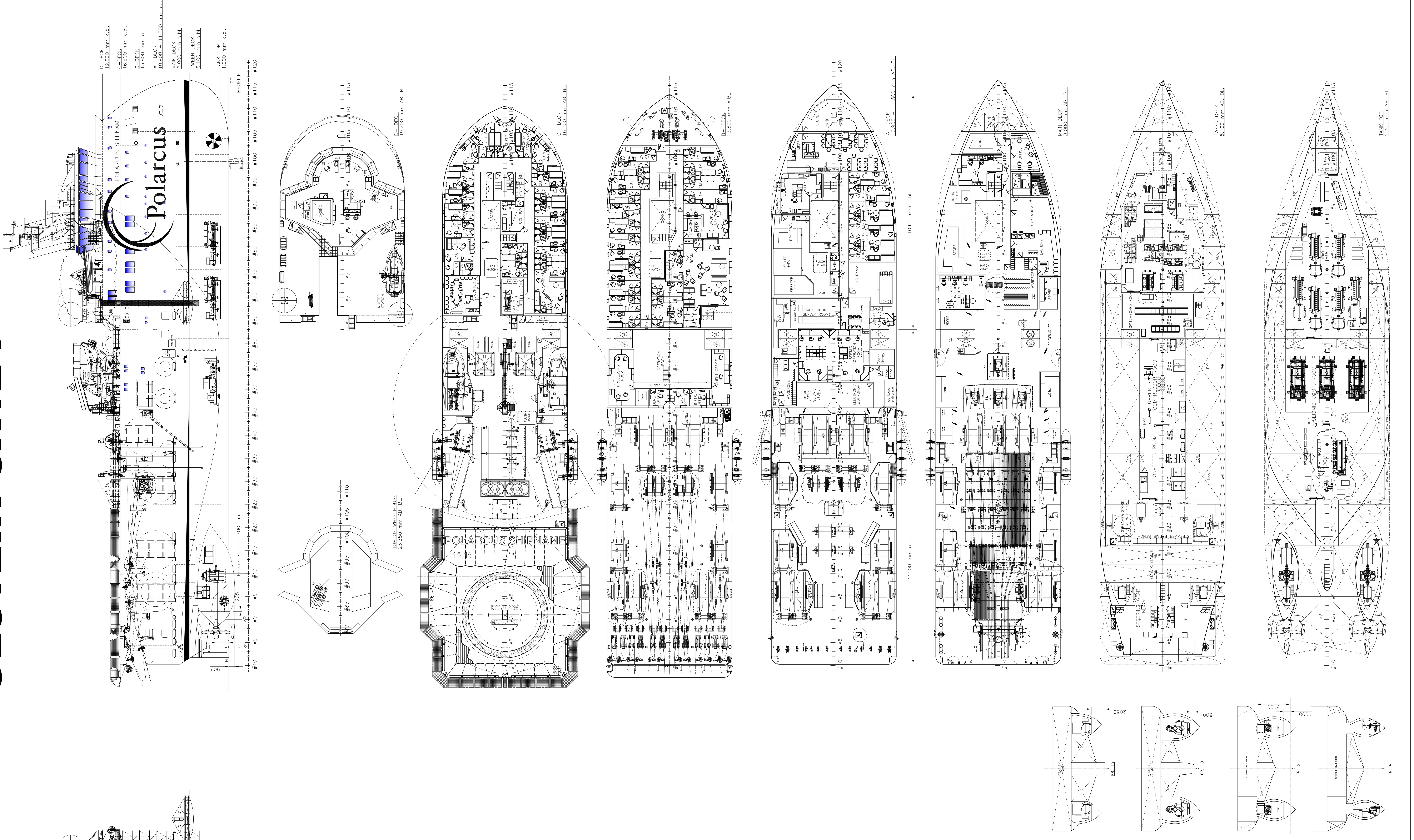

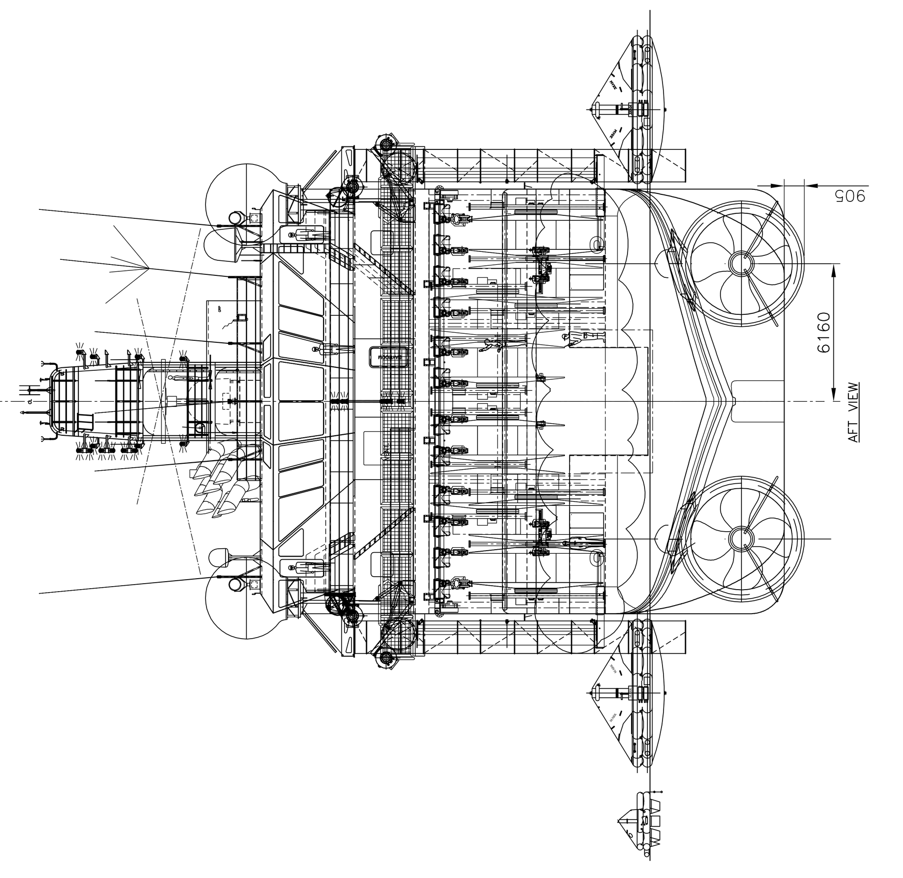

PRINCIPAL DIMENSIONS:

L.O.A. ....APPROX.. : 90,8 m
L.P.P. .... : 82,0 m
BREADTH MOULDED .... : 19,0 m
DEPTH TO MAIN DECK...... : 8,0 m
MAX. DRAUGHT................ : 6,6 m
DESIGN DRAUGHT .... : 6,0 m

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		DOC. INDEX	FORMAT: A0
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ULSTEIN DESIGN AS Postbox 158 6067 Ulsteinvik Norway Phone +47 7000 8000 Fax +47 7000 8559 www.ulsteingroup.com	ULSTEIN SX124		
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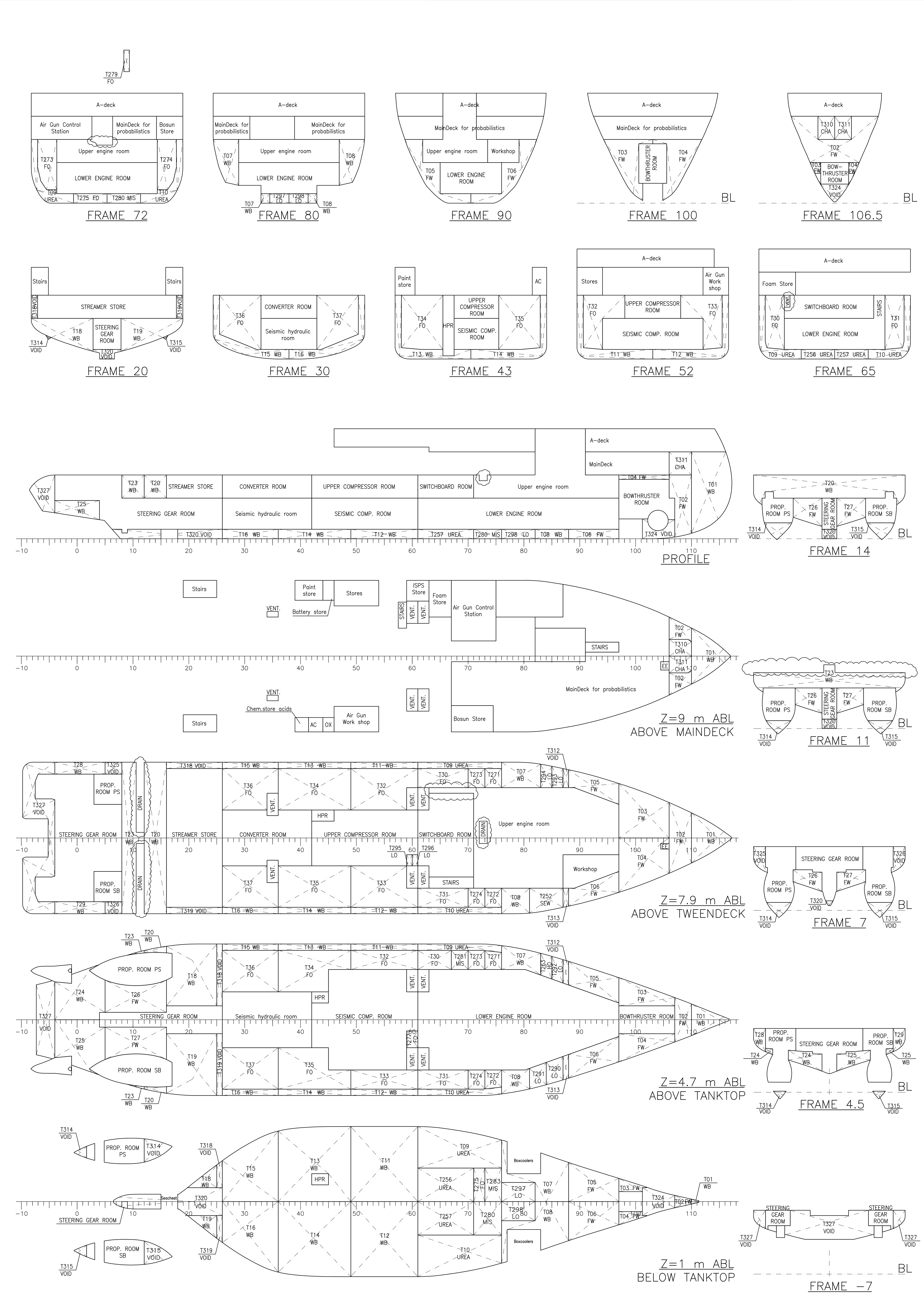
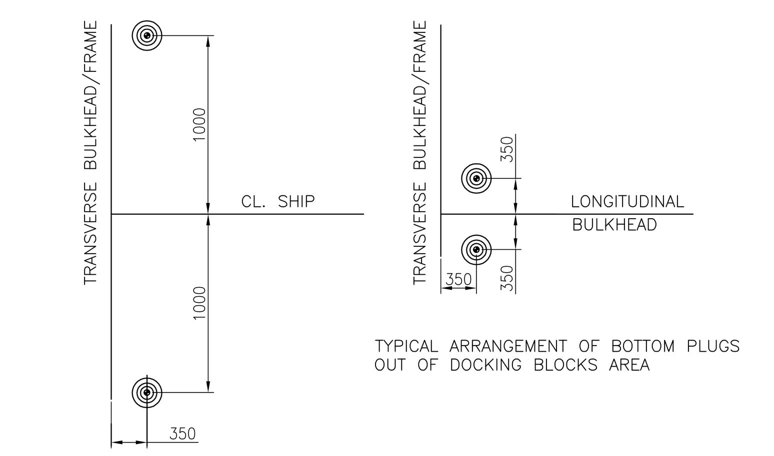


TANK	MAX. AIR PIPE	TANK ID.	FRAME		CONTENTS	DENSITY	MAX DENSITY	VOLUME	WEIGHT (t)								CENTER OF GRAVITY (m)			IT	TANK
NO.	HEIGHT ABL. (m)		MIN.#	MAX.#		(t/m3)	(t/m3)	(m3)	FO	FW	HO	LO	MIS	SEW	UREA	WB	LCG(AP)	TCG(CL)	VCG(BL)	(m4)	NO.
001	14,71	Forepeak WB	110	117	WB	1,025	1,025	114,2								117,03	78,70	0,00	7,35	47,6	001
002	14,64	DB/Wing Tk.1 FW	106	110	FW	1,000	1,000	114,0		113,98							75,56	0,00	6,67	172,6	002
003	14,63	DB/Wing Tk.2 FW PS	97	107	FW	1,000	1,000	105,7		105,70							70,49	-3,05	5,48	108,0	003
004	14,64	DB/WING TK.2 FW SB	97	107	FW	1,000	1,000	105,3		105,30							70,48	3,06	5,47	105,4	004
005	14,64	DB/Wing Tk.3 FW PS	88	97	FW	1,000	1,000	111,2		111,25							64,73	-4,37	3,79	40,4	005
006	14,64	DB/Wing Tk.3 FW SB	88	97	FW	1,000	1,000	111,2		111,25							64,73	4,37	3,79	40,4	006
007	10,85	DB/Wing Tk.4 WB PS	76	88	WB	1,025	1,025	103,9								106,54	56,35	-6,14	3,91	87,5	007
008	10,29	DB/Wing Tk.4 WB SB	76	88	WB	1,025	1,025	84,9								86,99	56,12	5,86	3,58	87,5	008
009	10,79	DB/Wing Tk.5 UREA PS	61	76	UREA	1,130	1,130	114,4							129,27		47,89	-7,72	2,63	96,2	009
010	11,46	DB/Wing Tk.5 UERA SB	61	76	UREA	1,130	1,130	114,4							129,27		47,89	7,72	2,63	96,2	010
011	10,97	DB/Wing Tk.6 WB PS	49	61	WB	1,025	1,025	135,5								138,94	38,50	-6,10	1,93	594,5	011
012	11,27	DB/Wing Tk.6 WB SB	49	61	WB	1,025	1,025	135,5								138,94	38,50	6,10	1,93	594,5	012
013	10,91	DB/Wing Tk.7 WB PS	36	49	WB	1,025	1,025	143,2								146,77	29,76	-6,12	1,97	615,6	013
014	10,89	DB/Wing Tk.7 WB SB	36	49	WB	1,025	1,025	145,5								149,10	29,77	6,07	1,95	627,0	014
015	11,21	DB/Wing Tk.8 WB PS	26	36	WB	1,025	1,025	104,1								106,74	21,80	-5,92	2,30	291,3	015
016	11,21	DB/Wing Tk.8 WB SB	26	36	WB	1,025	1,025	104,1								106,74	21,80	5,92	2,30	291,3	016
018	10,84	Wing Tk.9 WB PS	16	25	WB	1,025	1,025	133,1								136,42	14,71	-4,90	3,46	238,7	018
019	10,84	Wing Tk.9 WB SB	16	25	WB	1,025	1,025	133,1								136,42	14,71	4,90	3,46	238,7	019
020	10,84	Stab Tk.9 WB	12	16	WB	1,025	1,025	147,8								151,48	9,80	0,00	6,55	1600,4	020
023	10,84	Stab Tk.10 WB	8	12	WB	1,025	1,025	132,5								135,76	6,89	0,00	6,43	1600,4	023
024	9,96	Wing Tk.11 WB PS	-4	5	WB	1,025	1,025	55,6								56,99	0,51	-3,06	4,48	105,6	024
025	9,96	Wing Tk.11 WB SB	-4	5	WB	1,025	1,025	55,6								56,99	0,51	3,06	4,48	105,6	025
026	10,18	FW TK.10 PS	5	16	FW	1,000	1,000	68,2		68,23							7,75	-2,60	3,76	30,0	026
027	10,18	FW TK.10 SB	5	16	FW	1,000	1,000	68,2		68,23							7,75	2,60	3,76	30,0	027
028	11,06	Wing Tk.12 WB PS	-4	5	WB	1,025	1,025	19,6								20,12	0,48	-8,68	6,89	1,8	028
029	11,11	Wing Tk.12 WB SB	-4	5	WB	1,025	1,025	19,6								20,12	0,48	8,68	6,89	1,8	029
030	12,05	Store Tk.1 FO PS	61	70	FO	0,860	0,860	79,3	68,16								45,36	-7,49	5,01	7,3	030
031	12,05	Store Tk.1 FO SB	61	70	FO	0,860	0,860	96,5	83,03								45,82	7,48	4,70	7,3	031
032	12,05	Store Tk.2 FO PS	49	61	FO	0,860	0,860	185,8	159,82								38,29	-6,72	5,22	89,7	032
033	12,05	Store TK.2 FO SB	49	61	FO	0,860	0,860	185,8	159,82								38,29	6,72	5,22	89,7	033
034	12,05	Store Tk.3 FO PS	36	49	FO	0,860	0,860	278,3	239,34								29,44	-6,20	4,80	106,6	034
035	12,05	Store Tk.3 FO SB	36	49	FO	0,860	0,860	278,3	239,34								29,44	6,20	4,80	106,6	035
036	12,05	Store Tk.4 FO PS	26	36	FO	0,860	0,860	210,3	180,85								21,78	-5,99	4,92	82,0	036
037	12,05	Store Tk.4 FO SB	26	36	FO	0,860	0,860	210,3	180,85								21,78	5,99	4,92	82,0	037
252	23,83	Sewage Tk.	81	87	SEW	1,000	1,000	28,8						28,83			58,67	7,55	6,63	8,2	252
256	10,56	Urea TK.	61	71	UREA	1,130	1,130	34,2							38,67		46,20	-2,10	0,60	43,2	256
257	10,87	Urea TK.	61	71	UREA	1,130	1,130	34,2							38,67		46,20	2,10	0,60	43,2	257
263	10,26	HO Tk. PS	83	85	HO	0,924	0,924	10,5			9,74						58,80	-6,44	3,50	3,1	263
271	12,05	Settling Tk.1 FO PS	73	76	FO	0,860	0,860	26,6	22,91								52,13	-7,38	5,18	2,4	271
272	12,05	Settling Tk.2 FO SB	73	76	FO	0,860	0,860	26,6	22,91								52,13	7,38	5,18	2,4	272
273	12,05	Service Tk.1 FO PS	70	73	FO	0,860	0,860	28,7	24,68								50,04	-7,43	5,02	2,4	273
274	12,05	Service Tk.2 FO SB	70	73	FO	0,860	0,860	28,7	24,68								50,04	7,43	5,02	2,4	274
275	10,56	FO Drain TK.	71	73	FO	0,860	0,860	6,8	5,89								50,40	-2,10	0,60	8,6	275
277	12,05	Overflow Tk.FO SB	59	61	FO	0,860	0,860	21,4	18,39								42,00	3,63	2,86	13,7	277
279	-	Emrg.gen. FO Tk.	72	74	FO	0,860	0,860	2,6	2,21								51,10	2,45	17,85	0,0	279
280	10,85	Bilge water Tk.	71	76	MIS	1,000	1,000	17,3					17,29				51,45	2,10	0,60	21,6	280
281	23,83	Sludge settl. Tk.	67	70	MIS	1,000	1,000	17,5					17,47				47,94	-7,42	3,29	2,4	281
283	23,83	Sludge Tk.1	73	76	MIS	1,000	1,000	10,4					10,37				52,15	-2,10	0,60	13,0	283
290	10,26	LO Tk.1 SB	84	87	LO	0,900	0,900	16,4				14,76					59,86	6,10	3,50	5,2	290
291	10,26	LO Tk.2 SB	81	84	LO	0,900	0,900	13,7				12,34					57,81	6,82	3,71	4,2	291
292	10,26	LO Tk.3 PS	85	87	LO	0,900	0,900	11,0				9,93					60,20	-5,98	3,50	3,5	292
293	10,26	LO Tk.4 PS	85	87	LO	0,900	0,900	8,5				7,67					60,18	-7,39	6,65	2,0	293
294	10,26	LO Tk.5 PS	83	85	LO	0,900	0,900	9,8				8,79					58,79	-7,54	6,63	2,7	294
295	10,44	LO Loose Tk.1 SB	59	60	LO	0,900	0,900	2,8				2,51					41,65	2,80	6,55	0,2	295
296	10,44	LO Loose Tk.2 SB	60	61	LO	0,900	0,900	2,8				2,51					42,35	2,80	6,55	0,2	296
297	10,59	LO Drain Tk.	76	82	LO	0,900	0,900	11,9				10,67					55,30	-1,20	0,60	4,8	297
298	10,81	Dirty LO Tk.	76	82	LO	0,900	0,900	11,9				10,67					55,30	1,20	0,60	4,8	298
310	-	Chainlocker PS	106	110	CHA	1,025	1,025	16,8									75,58	-1,04	9,45	2,1	310
311	-	Chainlocker SB	106	110	CHA	1,025	1,025	16,8									75,58	1,04	9,45	2,1	311
312	14,66	Void PS	87	88	VOID	1,025	1,025	9,6									61,25	-6,29	4,77	1,8	312
313	14,66	Void SB	87	88	VOID	1,025	1,025	9,6									61,25	6,29	4,77	1,8	313
314	10,90	VOID BELOW PROP. ROOM PS	-1	21	VOID	1,025	1,025	34,9									6,95	-6,44	1,05	11,0	314
315	10,90	VOID BELOW PROP. ROOM SB	-1	21	VOID	1,025	1,025	34,9									6,95	6,44	1,05	11,0	315
318	11,18	Void PS	16	26	VOID	1,025	1,025	36,3									16,44	-6,90	4,67	27,2	318
319	11,18	Void SB	16	26	VOID	1,025	1,025	36,3									16,44	6,90	4,67	27,2	319
320	11,03	Aft Void1	6	26	VOID	1,025	1,025	28,6									12,79	0,00	0,65	22,8	320
324	14,66	Void below bowthruster	101	107	VOID	1,025	1,025	17,1									72,77	0,00	1,47	21,8	324
325	10,93	VOID PS	5	8	VOID	1,025	1,025	8,6									4,55	-8,64	6,60	0,6	325
326	10,91	VOID SB	5	8	VOID	1,025	1,025	8,6									4,55	8,64	6,60	0,6	326
327	11,23	VOID CE	-10	-4	VOID	1,025	1,025	146,7									-4,52	0,00	6,35	1602,5	327
		TOTAL WEIGHTS							**1432,88**	**683,92**	**9,74**	**79,84**	**45,13**	**28,83**	**335,89**	**1812,08**					
		TOTAL VOLUMES							**1666,14**	**683,92**	**10,54**	**88,71**	**45,13**	**28,83**	**297,24**	**1767,88**					
									FO	FW	HO	LO	MIS	SEW	UREA	WB					

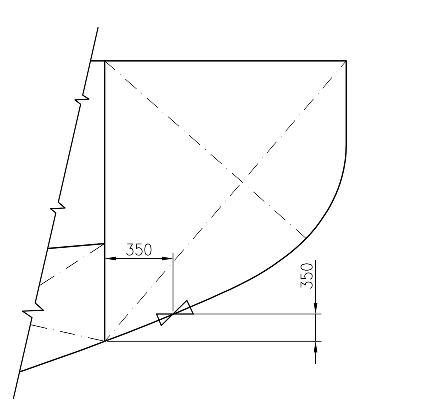


TYPICAL ARRANGEMENT OF BOTTOM PLUGS OUT OF DOCKING BLOCKS AREA

BOTTOM PLUGS M42x2 (STAINLESS STEEL) ACC. TO NS 2573 (ISO 5483).
PLUGS TO BE PREVENTED FROM UNLOCKING.
WELDING SEAMS WITH TANK NUMBERS BY EACH BOTTOM PLUG
WELDING SEAM ON EACH CORNER OF TANK.

NOTE:
PLUGS FOR DW/WB AND FW TANKS TO BE OF HEXAGONAL TYPE, OTHER TANKS TO BE OF QUADRATIC TYPE.

GENERAL PRINCIPLE WHEN INSERT BOTTOM PLUG WHEN NOT AT FLAT BOTTOM

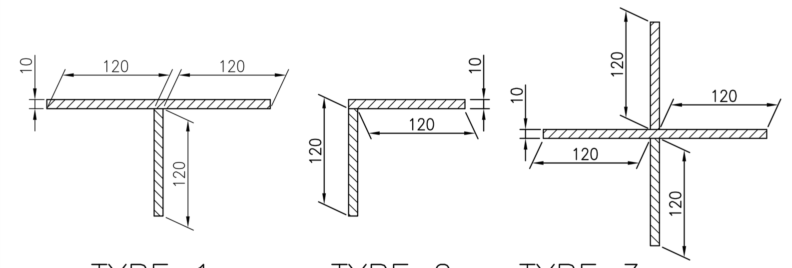


BOTTOM PLUG TO BE PLACED AT LOWEST END OF TANK

PRINCIPAL DIMENSIONS:

L.O.A. ....APPROX.. : 90,8 m
L.P.P. .... : 82,0 m
BREADTH MOULDED .... : 19,0 m
DEPTH TO MAIN DECK..... : 8,0 m
MAX. DRAUGHT................ : 6,6 m
DESIGN DRAUGHT .... : 6,0 m

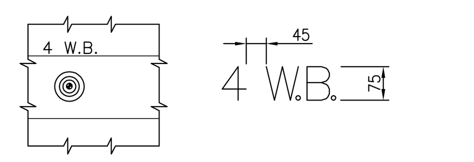
TANK MARKING ON HULL



TYPE 1 TYPE 2 TYPE 3

EXAMPLE TANK MARKING BY EACH BOTTOM PLUG

(SEE MANHOLE PLAN, DWG NO. U10321_304-310-01)



NOTE:
LINE OF WELDING TO BE USED TO MARK TANKS

REV.	DATE	DESCRIPTION	DRAWN:
E	27.02.14	Updated according to steel strucuture model, air pipe heights updated	RaG
D	14.02.14	Updated according to steel strucuture model	RaG
B	23.01.14	Updated according to steel strucuture model	RaG
A	27.11.13	Air pipe heights updated	RaG

DRAWING TITLE: TANK PLAN

DESIGN: ULSTEIN SX124

CLIENT INFO: Polarcus

DRAWN: RaG | DATE: 27.02.2014 | NUMBER OF SHEET: 1
SCALE: 1:200 | FORMAT: A0 | REVISION: E

DRAWING NO.: U10321_101-105-01

PROJECT NO. | SFI CODE | DOC. CODE | SHEET N

ULSTEIN

Ulstein Design & Solutions AS. Postbox 278, 6067 Ulsteinvik, Norway
www.ulstein.com

APPROVED BY:

M/V" POLARCUS NAILA "

OWNER: Polarcus

Class and notation: DnV + 1A1, SF, E0, DYN POS AUTR, NAUT-AW, CLEAN DESIGN, COMF-V(3), HELIDK, ICE-C, SPS.

ULSTEIN SX124

MAIN ENGINE

6 Main engines: Wärsila Finland OY, Type: 9L20
Output 1800 kW at 1000 rpm
Fuel oil consumption at 100% load 188 g/kWh
6 Main engine generator: AVK
Output 1900 kVA – 690 V – 50 Hz at 1000 rpm.

AUXILIARY MACHINERY

2 Starting air compressors: SPERRE HL2/77–90–105
Capacity 25 m³/h – 30 bar
1 Working Air Compressor: Tamrotor Marine Type:EMH 35
258 m³/h – 7 bar
1 Emergency generator: Pon Power Type: C9 DI–TA
Output 215 kW at 1500 rpm
2 Bilge pump: ALLWEILER: AEB 1E 750–IE SK33F
Type: AEB 1E 750 IE/011P01 G 122PP 5846
Capacity 65 m³/h – 2 bar
1 Sludge pump: 2 speed ALLWEILER
Type: AEB 1E 100 IE/011P01 122PP 5846
Capacity 10–5 m³/h – 3–2 bar
2 Fire pump: ALLWEILER NB 050–200/205–U3.1D–W3–IEC 160
capacity: 50 m³/h–6 bar
1 Em. Fire Pump: ALLWEILER NB 050–200/–U3.1D–W3–IEC 160
capacity: 40 m³/h–6 bar
1 Foam Pump: UNITOR DPFV 4–130
Capacity: 4,2 m³/h–9 bar
1 Retractable Azimuth Truster: Brunvoll Type: AR–63–LNC–1650
Input 850 kW / speed 0–1250 rpm.
Propeller diameter 1650 mm
2 Azimuth Truster: Schottel Type: SRP 3030 CP
Propeller diameter 3400 mm
1 Bowthruster: Brunvoll type: FU–100–LTC–2450
0–900 rpm, propeller diam. 2450 mm

HYDRAULIC EQUIPMENT

2 Streamer winches, double (FR 6): ODIM
Drum dia. 2xØ6000/Ø1800x1300 mm
Pulling force: Inner layer: 6T
Outer layer: 12T
With one Steamer lead–in compartment each: Ø4800/Ø4500
Pull force: 6,4t Brake load: 13,5t.
2 Streamer winches, double (FR 40): ODIM
Drum dia. 2xØ6000/Ø1800x1300 mm
Pulling force: Inner layer: 6T
4 Gun winches, double: ODIM
Drum 2xØ3100/Ø1600x550
Pulling force: Inner layer: 7T
2 Streamer winches, single: ODIM
Drum dia. Ø6000/Ø1800x1300 mm
Pulling force: Inner layer: 12T
2 Streamer winches, single: ODIM
Drum dia. Ø6000/Ø1800–1300
Pulling force: Inner layer: 8T
6 Streamer storage winches, single: ODIM
Drum dia. Ø2100/Ø1400–2000 mm
Pulling force: Inner layer: 0,68T
Outer layer: 0,37T
12 Auxiliary winches: ODIM
Drum dia. Ø520/Ø355x130
Pulling force: 2,75T on inner layer– 175 bar
2,2T on inner layer– 140 bar
2 Auxiliary winches, big drum: ODIM
Drum dia. Ø850/Ø355x200
Pulling force: Inner layer: 2,75T at 175 bar
2 Wide towing winches: ODIM
Drum dia. Ø2200/Ø1200x1400
Pulling force: Inner layer: 40T
2 Lead in winch: Evotec
Drum dia. Ø2600/Ø1400x750
Pulling force: Inner layer: 12,2T
4 Blocks, Streamer Lead–in: Evotec
SWL 17t, at max 45 degree angle of contact
4 Towing points 18T: ODIM
8 Towing points 35T: ODIM
2 Capstans: ODIM
10,0T at p=250 bar
1 Windlass mooring winch: ODIM
Drum dia. Ø1400/Ø559
Pulling force: First layer: 14,4T at 0–10,6 m/min
70T at 0–21,3 m/min
1 Offshore crane: DREGGEN, Type: DKF 220
SWL 12T–17M
Weight 20T

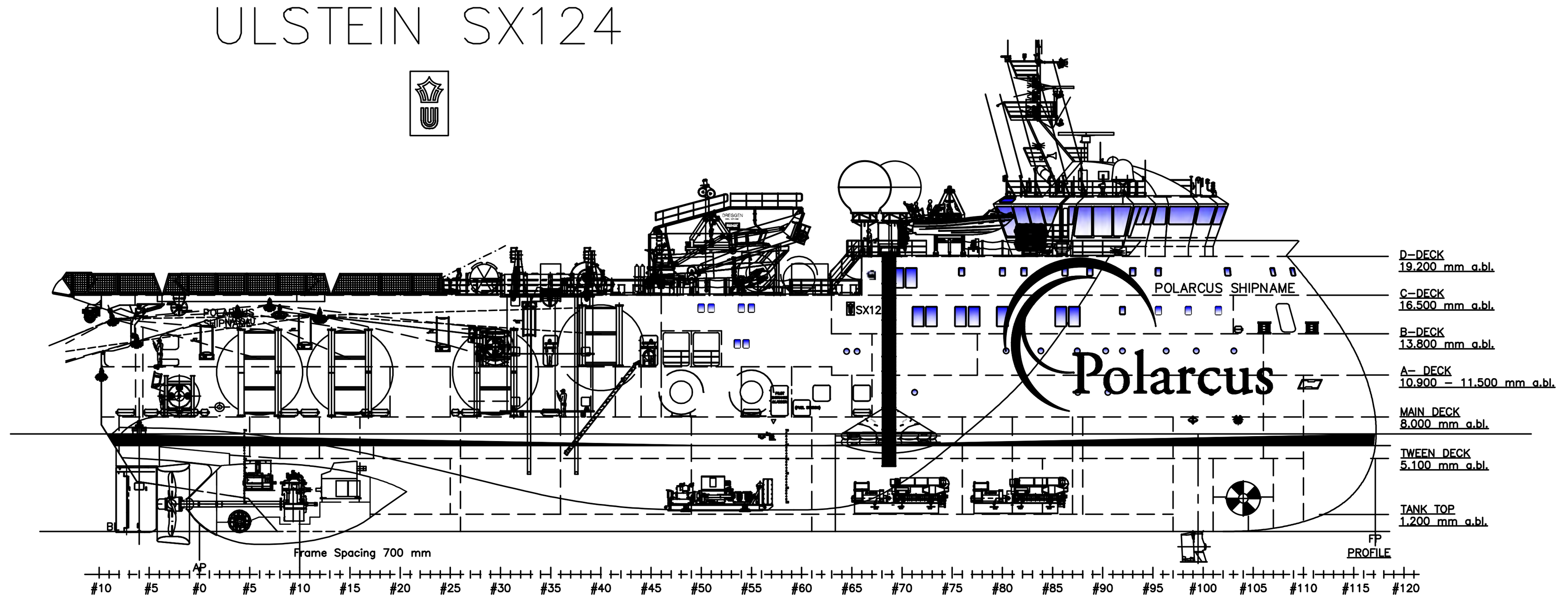
282	FREEBOARD (METRES)	DRAUGHT (MOULDED)	DEADWEIGHT (TONNES)
TF	1,144	6,864	3870,6
T	1,270	6,738	3680,5
F	1,282	6,726	3662,4
S	1,408	6,600	3472,9
W	1,546	6,462	3266,1
WNA	1,596	6,412	3191,4

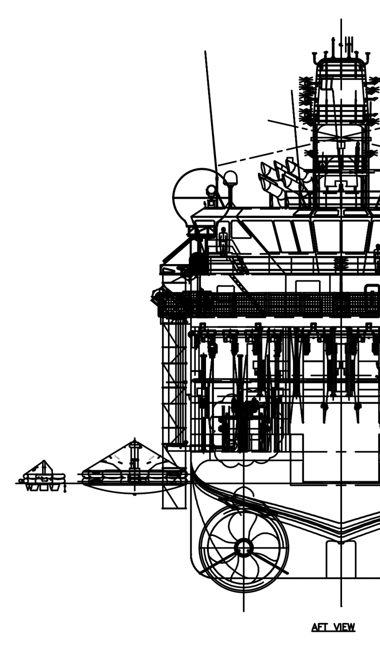
ANCHOR EQUIPMENT

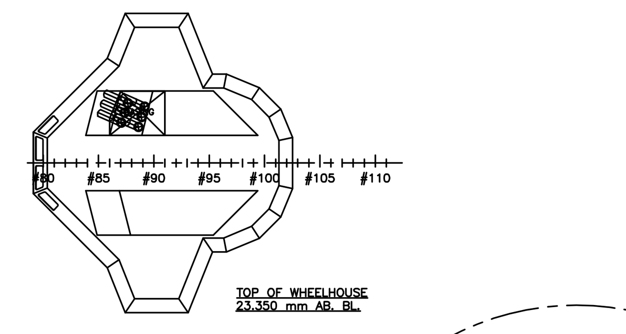
Equipment number: 1116
Equipment letter: x sh
2 Stockless bow anchors, each 3300 kg
Chain cable grade NVK3 46mm. 495 m

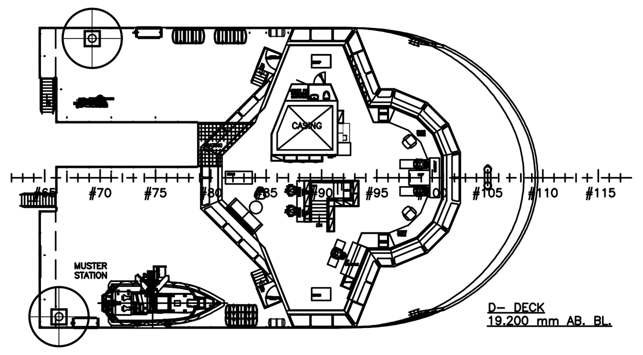
LIFE–SAVING EQUIPMENT

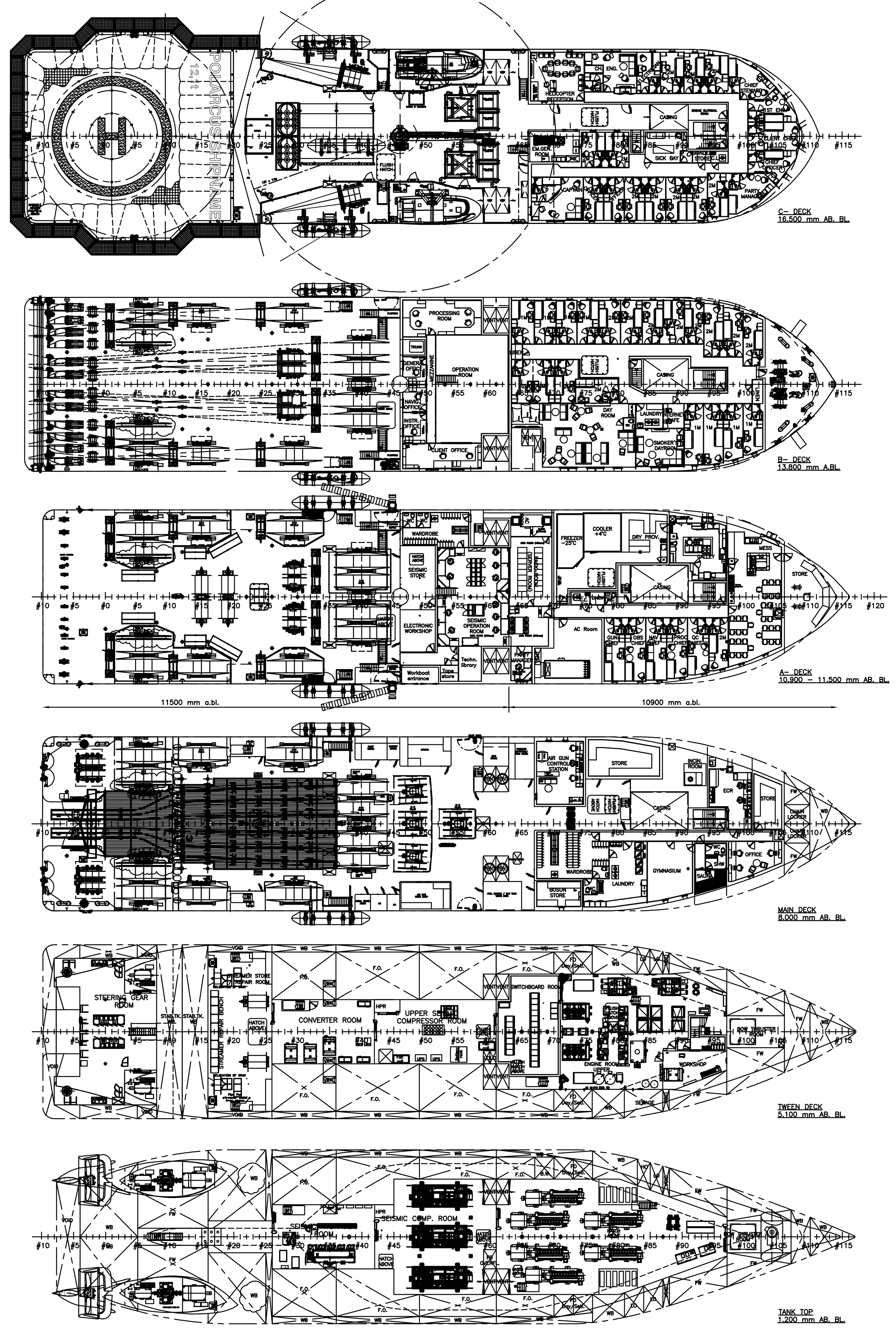
1 RESCUE BOAT TYPE NORSAFE/MAGNUM 7,5
1 SINGLE POINT DAVIT NDA 40 RESCUE BOAT DAVIT
4 LIFERAFT 65 PERS. THROW OVERBOARD TYPE–BRUDE SAFETY
2 MES EVACUATION CHUTE–BRUDE SAFETY
2 LIFERAFTS 10 PERSONS SPARE–BRUDE SAFETY



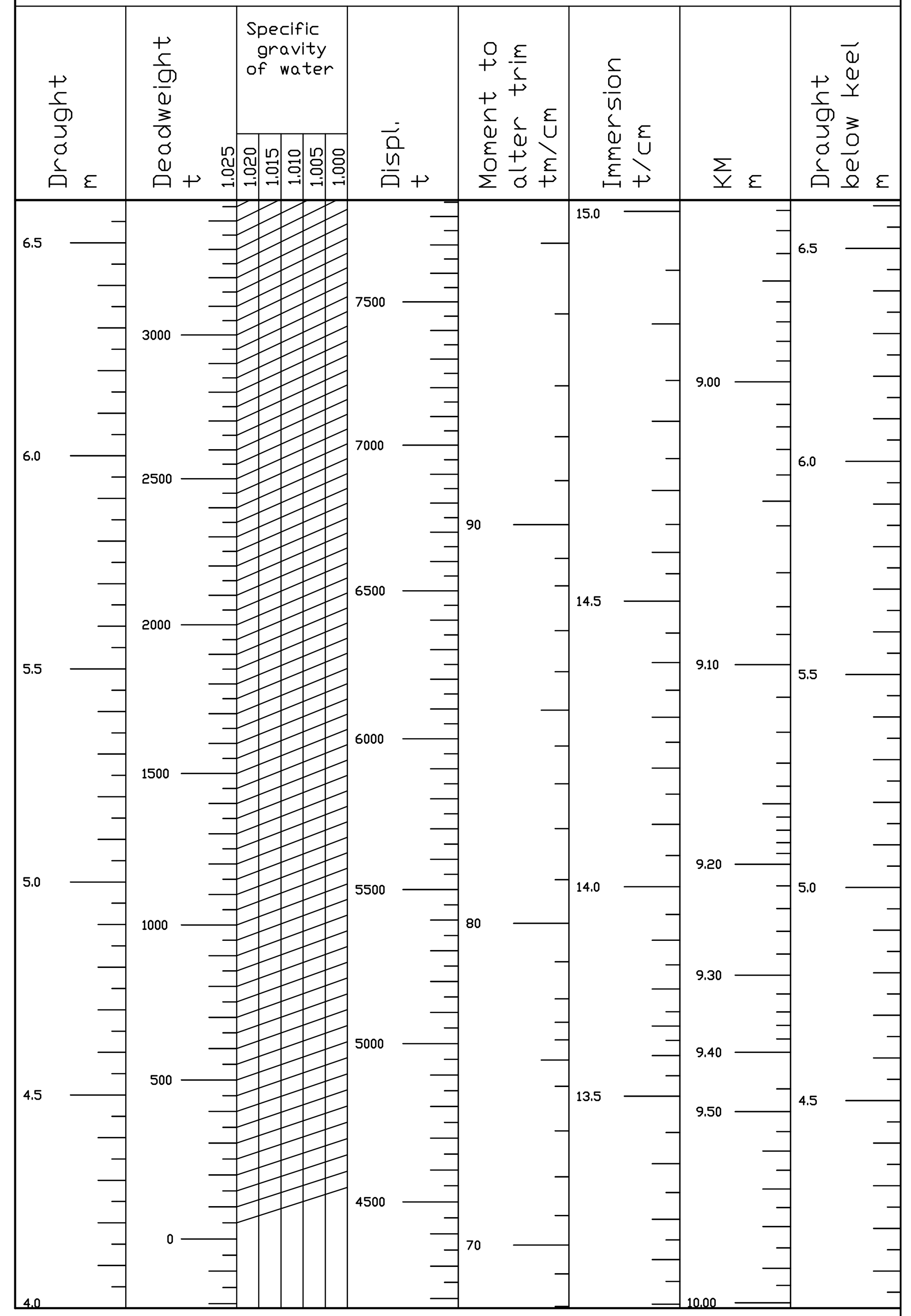








LOADING SCALE



NAVIGATION AND RADIO EQUIPM.

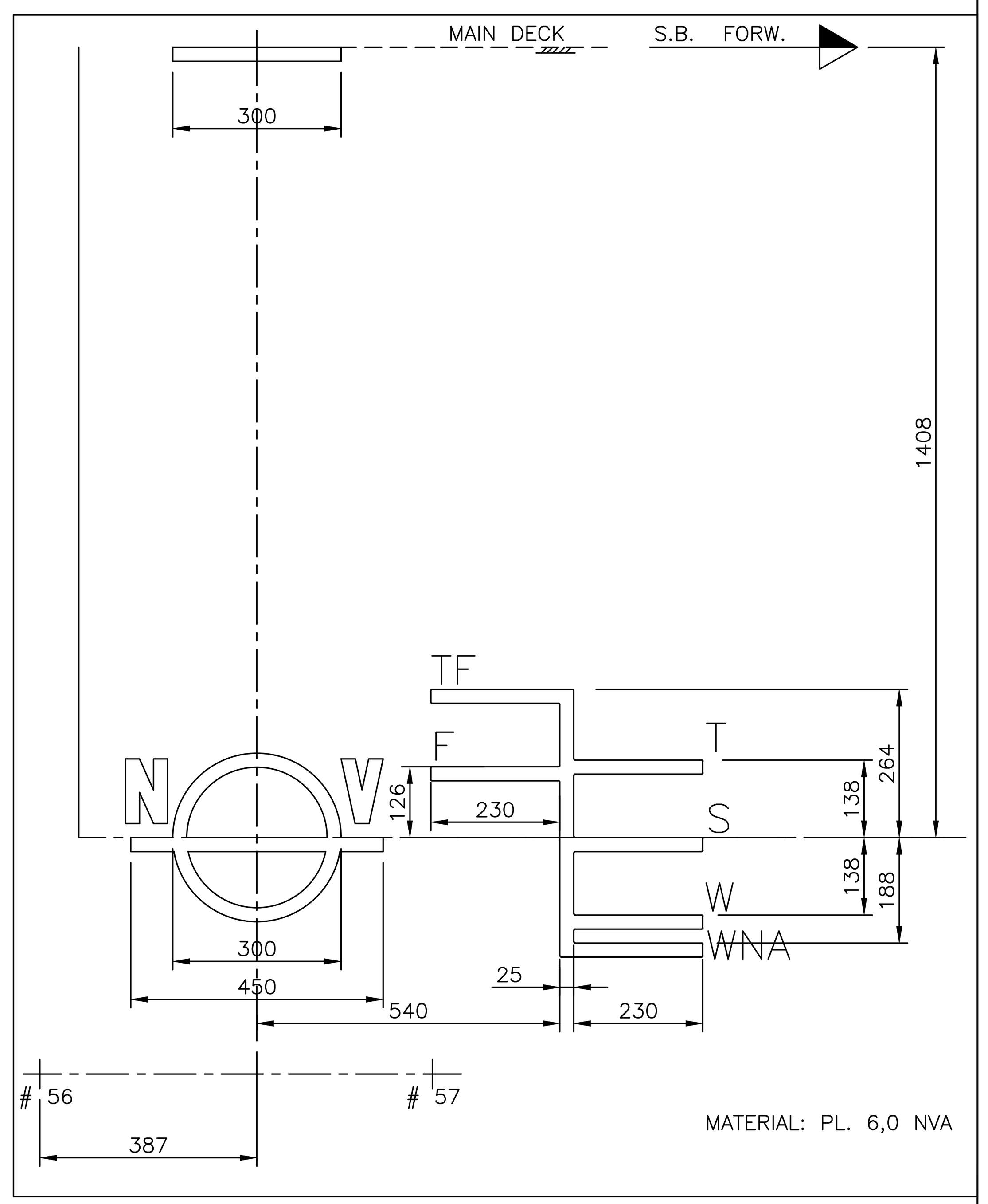
1 Furuno S–Band Chart Radar, FCR–2837S
1 Furuno X–Band ARPA Radar, FAR–2827
1 Furuno RADAR SLAVE, 17" LCD Monitor
2 Furuno ECDIS, Model TECDIS T–2136
1 Furuno DGPS Navigator, Model GP–150
1 Furuno GPS Navigator, Model GP–150
2 Anschutz Standard 22 GG–R/GGM–R
1 Anschutz Standard 22 compact
1 Anschutz Autopilot, adaptive
1 Magnetic compass Plath type, reflecta 1 fiberline
1 Furuno Echosounder, Model FE–700
1 Furuno Doppler Speed Log, Model DS–80
1 Furuno AIS transponder, Model FA–150
1 Furuno Voyage Data Recorder System, Model VR–3000–6G
1 Ulstein Bridge Alarm System, UBAS
1 Zenitel Sound Signal Reception System, Model VSS–111
1 Furuno Conning System
1 Sailor Inmarsat–Ssas, Integrated in Sat C model TT3000EB
1 Anschutz TMC– Transmitting Mag. Compass
1 ULSTEIN UPS
1 FURUNO Weather FAX, Model FAX–408
1 ULSTEIN Nav cabinet
2 Sailor MF/HF/DSC 250W Simplex Radiostation, System 5000
1 Furuno NX–700B Navtex Receiver
2 JOTRON 40S freefloat
2 JOTRON Radar Transponder, Model TRON SART
3 JOTRON GMDSS approved portable VHF, Model TRON TR–20
1 JOTRON 40 SX
1 Sailor Inmarsat–C w/EGC, Model TT3000EB
1 Sailor Inmarsat–FLEET 77, Model TT3084A
2 Sailor VHF/DSC Simplex, Model RT5022
3 Sailor VHF Simplex radiotelephone, Model RT2048
10 Motorola Portable UHF, Model GP380
7 Motorola Fixed UHF, Model GM380
1 TeleSupply Helibeacon, Model Tele Supply TS–1B
1 Jotron MD VHF/AM AIRBAND RADIO, Model TR–810
2 Icom AIR VHF/AM AIRBAND RADIO, Model IC–A3E

PRINCIPAL PARTICULARS

LENGTH O.A.	90,8 M
LENGTH BEETW. PERP	82,0 M
BREADTH MLD.	19,0 M
DEPTH MLD. TO MAIN DK	8,0 M
DRAUGHT MOULDED (summer)	6,6 M
FRAME SPACING	700 MM
GROSS TONNAGE	6578 GRT
NET TONNAGE	1974 NRT
LIGHTSHIP WEIGHT	4384,23 TONNES
CALLSIGNAL	C6XK5
IMO NUMBER	9538098

TANK CAPACITIES

	DENSITY T/m^3	VOLUME m^3	TONNES
FRESH WATER	1,0	683,92	683,92
WATER BALLAST	1,025	1767,90	1812,10
FUEL OIL	0,860	1666,14	1432,88
HYDR.OIL	0,924	10,54	9,74
LUB OIL	0,924	88,71	79,84
UREA	1,0	297,24	335,89



GENERAL ARRANGEMENT SCALE 1:200

Loading scale, Pricipal particulars and Tank capacties updated after inclining test	10.06.14	KSL	E
New propultion and upgraded to SPS for 60 persons. New lead-in winches added. Streamer lead-in compartments added to Double streamer winches at #6	17.01.14	KSL	D
Updated acc to yards comments	21.12.09	SAR	C
2nd sheet created, revision jump to equalize with the first sheet.			

TITLE: CAPACITY PLAN	SCALE: 1:400 1:200	DRAWN: AK	13.11.09
		FORMAT:	A1
		ARCHIVE BOOK:	
ULSTEIN®	YARD NO.: 67		
Ulstein Verft AS, Postboks 158, 6067 Ulsteinvik, Norway, Tlf: (+47) 7000 8000, Fax: (+47) 7000 8448, www.ulsteinverft.com	ULSTEIN SX124	PROJECT NO: U10321	
APPROVED BY:	DRAWING: U10321_103-310-02 E		
	REPLACEMENT:		
	DEP: 285	SHEET: 1/1	UA

FIRE CONTROL AND SAFETY PLAN

Section	Description	Top wheelhouse	Bridge deck/ D-deck	C-deck	B-deck	A-deck	Main deck	Tween deck	Tank top	Total	Remarks
FIRE SIGNALS AND ALARMS	MANUAL PUSH BUTTON FOR FIRE ALARM	-	3	8	3	7	8	13	7	49	
	MAN OVERBOARD ALARM PUSH BUTTON	-	1	2	-	4	4	-	-	11	
	PUSH BUTTON FOR GENERAL ALARM	-	1	-	-	-	1	-	-	2	
	SMOKE AND HEAT DETECTOR ACC / *WAT	2	4+2	33 / 2	47 / 4	29 / 4	18 / 7	16 / 2	13 / 1	184	*Watertight indicated:
	HEAT DETECTOR ACC / *WAT	-	2 / -	-	1 / -	1 / 15	1 / 24	1 / 6	1 / 1	53	*Watertight indicated as
	FLAME DETECTOR	-	-	-	-	-	1	2	4	7	
	BELL FIRE ALARM	-	1	5	8	8	7	8	7	44	
	TYFON FIRE/GENERAL ALARM	1	-	-	-	-	-	-	3	4	
	SOUNDER BEACON	-	-	-	-	-	-	2	1	3	
	FIRE ALARM PANEL	-	1	-	-	-	1	-	-	2	
EMERGENCY START/STOP	REMOTE CONTROL EMERGENCY FIRE PUMP	-	1	-	-	-	1	-	-	2	
	REMOTE CONTROL FIRE PUMPS	-	1*	-	-	-	-	-	1	2	* VIA IAS
	REMOTE CONTROL FOR GENERAL SERVICE P.	-	1	-	-	-	-	-	-	1	
	REMOTE SHUT-OFF FUEL OIL PUMPS	-	1	-	-	-	-	-	-	1	
	REMOTE SHUT-OFF FUEL OIL VALVES	-	-	-	-	-	1	-	-	1	
	REMOTE CONTROL WATERTIGHT DOORS	-	1	-	-	-	-	-	-	1	
	REMOTE CONTROL FIRE DOORS	-	1	-	-	-	-	-	-	1	
	EMERGENCY STOP PROPELLERS	-	1	-	-	-	-	-	-	1	
	EMERGENCY STOP VENT.FANS FOR ACC.	-	1	-	-	-	-	-	-	1	
	EMERGENCY STOP VENT.FANS FOR ENGINE R.	-	1	-	-	-	-	-	-	1	
	EMERGENCY STOP VENT.FANS FOR STORES	-	1	-	-	-	-	-	-	1	
	EMERGENCY BATTERY	1	-	-	-	-	-	-	-	1	
	EMERGENCY GENERATOR	-	-	1	-	-	-	-	-	1	
	EMERGENCY SWITCHBOARD	-	-	1	-	-	-	-	-	1	
PUMPS	EMERGENCY FIRE PUMP -40 m3/h - 6 bar	-	-	-	-	-	-	-	1	1	
	FIRE PUMP 1 & 2 -50 m3/h - 6 bar	-	-	-	-	-	-	-	2	2	
	BILGE PUMP 1 & 2 -65 m3/h - 2 bar	-	-	-	-	-	-	-	2	2	
	GENERAL SERVICE PUMP -120 m3/h - 8 bar	-	-	-	-	-	-	-	1	1	
	WATERMIST PUMP -30 m3/h - 5 bar	-	-	-	-	-	-	-	1	1	
	HI-FOG PUMP UNIT (5+1) & FOAM	-	-	-	-	-	-	1	-	1	
FIRE FIGHTING DEVICE	STOP VALVE FIRE MAIN PIPE	-	-	-	-	-	1	-	-	1	
	STOP VALVE FOAM MONITOR	-	-	2	-	-	-	-	-	2	
	SECTION VALVE HI-FOG	-	-	-	-	-	4	9	-	13	
	RELEASE STATION FOR WATER EXTINGUISHING SYSTEM	-	-	-	-	-	1	-	-	1	
	RELEASE STATION FOAM SYSTEM	-	2	-	-	-	-	-	-	2	→
	RELEASE STATION FOR LOCAL/TOTAL FIREFIGHTING SYSTEM, HI-FOG	-	1	-	-	1	2	1	1	6	
	FOAM TANK	-	-	-	-	-	-	1	-	1	
	SPACE/EQUIPMENT PROTECTED BY FOAM SYSTEM	-	-	1	-	-	-	-	-	1	→
	SPACE/EQUIPMENT PROTECTED BY WATERMIST	-	1	2	1	3	3	3	6	19	→
	SPACE/EQUIPMENT PROTECTED BY WATER FIRE EXTINGUISHING SYSTEM	-	-	-	-	1	2	-	-	3	→
	FIRE HOSE WITH JET/FOG NOZZLE	-	2	7	2	6	7	6	4	34	
	FIRE VALVE	-	2	7	2	6	7	6	4	34	
	INTERNATIONAL SHORE CONNECTION IMO-FLANGE	-	-	-	-	-	1	-	-	1	
	OXYGEN AND ACETYLENE CYLINDERS	-	-	-	-	-	4+2	-	-	4+2	
	FIRE BLANKET	-	-	-	-	1	-	-	-	1	
	POWDER EXTINGUISHER 2 kg +SPARE	-	1	-	-	-	+1*	-	-	1+1	IN RESCUE BOAT * SPARE 3kg
	POWDER EXTINGUISHER 12 kg +SPARES	-	-	3	1	5	4+21	5	5	23+23	
	POWDER EXTINGUISHER 25 kg +SPARES	-	-	1	-	-	+1	-	-	1+1	
	POWDER EXTINGUISHER 50 kg +SPARES	-	-	1	-	-	+1	-	1+1	2+2	
	CO2 EXTINGUISHER 5 kg +SPARES	-	2	-	-	3	2+10	2	1	10+10	
	CO2 EXTINGUISHER 22 kg +SPARE	-	-	1	-	-	+1	-	-	1+1	
	WET CHEMICAL EXTINGUISHER 9 L +SPARE	-	-	-	-	1	+1	-	-	2	
	D TYPE EXTINGUISHER 9 kg +SPARE	-	-	-	-	3	1+4	-	-	4+4	
	FOAM MONITOR	-	-	2	-	-	-	-	-	2	
	PORTABLE FOAM APPLICATOR 20 L +SPARES	-	-	1	-	-	2 +200L	-	1	4	
	FIRE AXE	-	-	2	1	1	1	-	-	5	
	FIRE PLAN	-	1+1	1	1	1	2+2	-	-	6+3	+ IN CYLINDER
	BREATHING AIR COMPRESSOR -100 L -300 bar	-	-	-	-	-	1	-	-	1	
	FIRE LOCKER/ FIREMANS OUTFIT SET	-	-	2	-	-	2	-	-	4	→
	FIRE FIGHTING EQUIPMENT SET	-	-	1	-	-	-	-	-	1	→
EMERGENCY RADIO & DISTRESS SIGNALS	SURVIVAL CRAFT PORTABLE RADIO	-	3	-	-	-	-	-	-	3	
	RADAR TRANSPONDER TWO WAY	-	2	-	-	-	-	-	-	2	
	EPIRB (FREE FLOAT) -EMERG. PORT. INDICATING RADIO BEACON	-	2	-	-	-	-	-	-	2	
	DISTRESS SIGNAL SET -4 ROCKET PARACHUTE -6 HAND FLARES -2 BUOY SMOKE SIGNAL	-	1	-	-	-	-	-	-	1	
	PARACHUTE DISTRESS ROCKET SIGNAL -12 ROCKETS	-	1	-	-	-	-	-	-	1	
LIFESAVING EQUIPMENT	MUSTER STATION	-	1	-	-	-	-	-	-	1	
	THROWOVERBOARD LIFERAFT 65 PERS.	-	4	-	-	-	-	-	-	4	
	THROWOVERBOARD LIFERAFT 10 PERS.	-	2	-	-	-	-	-	-	2	
	EVACUATION CHUTE	-	2	-	-	-	-	-	-	2	
	EMBARKATION LADDER	-	2	-	-	-	-	-	-	2	
	RESCUE BOAT	-	1	-	-	-	-	-	-	1	
	LIFE JACKETS WITH LIGHT AND WHISTLE	-	2+69	-	-	-	2	-	-	69+4	
	SURVIVAL SUITS	-	2+4(*)	69	-	-	2	-	-	69+8(*)	(*) ANTI EXPOSURE / WORK SUIT FOR RESCUE BOAT
	LIFEBUOY WITH LIGHT AND SMOKE	-	2	-	-	2	2	-	-	6	
	LIFEBUOY WITH LIGHT	-	-	2	-	-	4	-	-	6	
	LIFEBUOY WITH LINE	-	-	2	-	-	-	-	-	2	
	LINE-THROWING APPLIANCE	-	4	-	-	-	-	-	-	4	
	HOSPITAL	-	-	1	-	-	-	-	-	1	
	HELIDECK RESCUE EQUIPMENT	-	-	1	-	-	-	-	-	1	→
	EYE WASHER	-	-	-	-	-	2	1	-	3	
	SAFETY SHOWER	-	-	-	-	-	1	-	-	1	
EMERGENCY EXIT AND DOORS	WATERTIGHT SLIDING DOORS	-	-	-	-	-	1	7	4	8	
	A-CLASS FIRE DOOR	-	-	-	2	5	13	-	-	20	
	A-CLASS SELF-CLOSING FIRE DOOR	-	-	4	2	10	4	4	-	24	
	B-CLASS FIRE DOOR	-	1	27	33	22	9	1	-	93	ALL INTERNAL DOORS IN ACC MIN B-0 RATED.
	DIRECTION OF ESCAPE										
	SECONDARY ESCAPE										
	EMERGENCY EXIT	-	-	2	1	4	2	2	-	11	
	EEBD EMERGENCY ESCAPE BREATHING APPARATUS	-	1*+4	-	1	1	1	2	3	9+4	* TRAINING SET +4 SPARE
	CONTROL ROOM										
CLOSING APPLIANCE FOR VENTILATION INLET/OUTLET	STREAMER/REPAIR STORE						524 525			2	
	SEISMIC COMPR. ROOM						478 479			2	
	SEISMIC HYDR. ROOM			510 512						2	
	EMERGENCY GENERATOR ROOM			340 341 342						3	
	ACCOMMODATION			100						1	
	GALLEY		210 211							2	
	FIRE DAMPER GALLEY					212				1	
	ENGINE ROOM	476		435 436 437 477						5	
	FIRE DAMPER ENGINE ROOM			475						1	
	INCINERATOR ROOM			445						1	
	FIRE DAMPER INCINERATOR ROOM						447			1	
	FIRE DAMPER INCINERATOR ROOM						600 601 624 627			4	

SPACE/ EQUIPMENT PROTECTED BY HI-FOG — BRIDGE ECR

TOTAL PROTECTED AREAS
- ZONE MAIN ENGINE ROOM
  - ZONE M1 ENGINE ROOM BILGE
  - ZONE M3 MAIN ENGINES 1+4 CL
  - ZONE M4 MAIN ENGINES 2+3 PS
  - ZONE M5 MAIN ENGINES 5+6 SB
  - ZONE M7 UPPER MAIN ENGINE ROOM + FUEL OIL SEP.
  - ZONE M8 ENGINE WORKSHOP
  - ZONE M12 CASING
- ZONE SEISMIC COMPR. ROOM
  - ZONE M2 SEISMIC COMP. ROOM BILGE
  - ZONE M6 SEISMIC COMPR. ROOM
- ZONE M9 SWITCHBOARD ROOM
- ZONE M10 INCINERATOR ROOM
- ZONE M11 ENGINE CONTROL ROOM
- ZONE M12 CASING

LOCAL PROTECTED AREAS — LOCAL
- ZONE M3 MAIN ENGINES 1+4 CL
- ZONE M4 MAIN ENGINES 2+3 PS
- ZONE M5 MAIN ENGINES 5+6 SB
- ZONE M7 UPPER MAIN ENGINE ROOM + FUEL OIL SEP.
- ZONE M10 INCINERATOR
- ZONE M13 EMERGENCY GENERATOR
- ZONE M20 GALLEY DUCT PROTECTION
- ZONE M21 DEEP FAT FRYER PROTECTION

SPACE/EQUIPMENT PROTECTED BY FOAM SYSTEM

LOCAL PROTECTED AREAS
- ZONE U1 HELI DECK (FOAM MONITORS)

WATER FIRE EXTINGUISHING SYSTEM
- ZONE W1 PAINT STORE
- ZONE W2 CHEMICAL STORE
- ZONE W3 STREAMER AREAS

FL — FIREMANS OUTFIT (FIRE LOCKER)

QTY:	EACH SET CONSISTS OF:
1	COMPRESSED AIR BREATHING APPARATUS
1	SPARE BOTTLES (6L, 300 bar).
1	FIRE RESISTANT SAFETY LINE (33m).
1	FIRE RESISTANT SAFETY BELT
1	SAFETY LAMP(RED PAINTED) W/BATTERY
1	FIRE AXE (RED PAINTED)
1	FIRE RESISTANT OVERALL AND JACKET
1	FIRE RESISTANT BOOTS (PAIR)
1*	FIRE RESISTANT GLOVES (PAIR)
1	SAFETY HELMET
	BATTERY DRIVEN DRILLING MACHINE *ONE TO SHARE AT EACH FL LOCATION

FLH — FIREFIGHTING EQUIPMENT

QTY:	EACH SET CONSIST OF:
1	HAND OPERATED FOAM APPLICATOR W/ VALVE AND INDUCTOR
1	FOAM TANK 20 L
1	16 mm SPRAY/JET NOZZLE
2	FIRE HOSE 15 m

H — HELIDECK RESCUE EQUIPMENT

	QTY:	
HELIDECK	1	FIREMAN'S CARPET
	1	ADJUSTABLE WRENCH
	1	CHISEL
	1	FIRE AXE WITH 24" SHAFT
	1	FIRE AXE WITH INSULATED SHAFT
	1	SET OF ASSORTED SCREWDRIVERS
	2	STAINLESS STEEL KNIVES
	2	HANDLIGHTS
	1	CROWBAR, LARGE
	1	PLIERS, SIDE CUTTING
	1	METAL SAW WITH SPARE BLADE
	1	HAMMER
	1	BAR
	1	PLATE SCISSOR
	1	BOLT CUTTER
	1	JACK
	1	RESUE HARNESS+5CMx15M LIFELINE
	1	FIRE RESISTANT GLOVES
	1	POWER CUTTING TOOL
	1	LADDER 3 M.
	1	BOAT HOOK

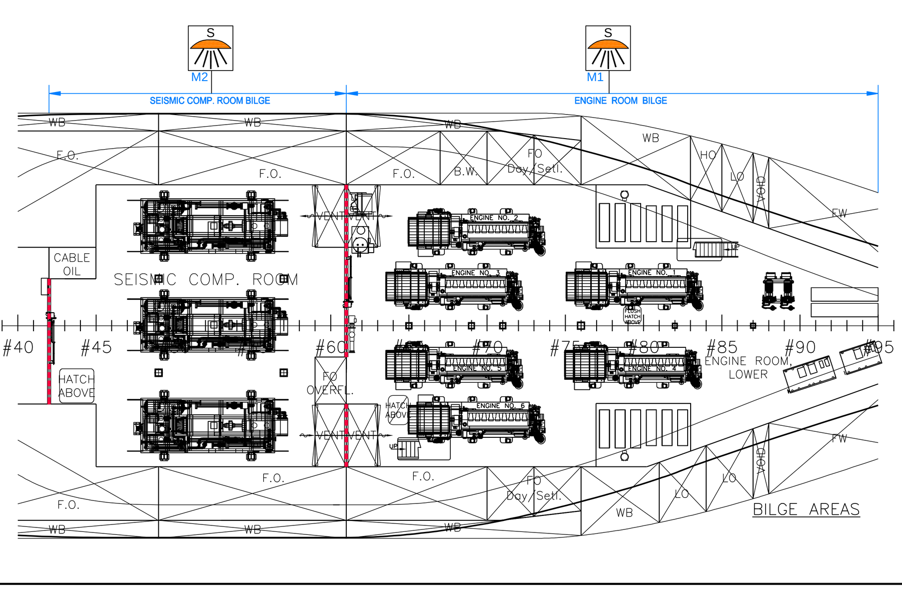
FIRE ZONES
- A-60 FIRE-RATED DIVISION
- A-15 FIRE-RATED DIVISION
- A-0 FIRE-RATED DIVISION
- B-CLASS BHD
- ALL INTERNAL BULKHEADS IN ACC MIN B-0 RATED.

CLASSIFICATION:
+1A1
SF,E0,DYNPOS-AUTR,CLEAN DESIGN,
COMF-V (3), ICE-C, NAUT-AW, HELIDK.
BIS, TMON, SPS

FLAG: BAHAMAS

PRINCIPAL PARTICULARS:

LENGTH OVER ALL:	90,8 m
LENGTH BETW. PERP:	82,0 m
BREADTH MOULDED:	19,0 m
DEPTH FROM MAIN DECK:	8,0 m
MAX. DRAUGHT:	6.60 m
FREEBOARD AT MAX. DRAUGHT:	1.40 m
DESIGN DRAUGHT:	6.00 m
FREEBOARD AT DESIGN DRAUGHT:	m
FRAME SPACING:	700 mm
COMPLEMENTS:	60 persons



Revision	Date	By	Description
C	30.04.14	ASZ	Updated acc. to DNV comments
B	28.02.14	ASZ	Updated acc. to SPS
X1	13.12.09	AKS	As Built
A	24.08.09	SAR	Updated according to DNV & Owner and Yard comments.
2	08.06.09	SAR	Updated according to Owner and Yard comments.

APPROVED BY: 07.07.09 DNV; 10.06.09 Owner

TITLE: FIRE AND SAFETY PLAN

ULSTEIN DESIGN AS
Postboks 158
6067 Ulsteinvik
Norway
Tlf: (+47) 7000 8000
Fax: (+47) 7000 8023
www.ulsteingroup.com

SCALE: 1:200 — DRAWN: SAR 11.02.09 — FORMAT: A0 — ARCHIVE BOOK: 2

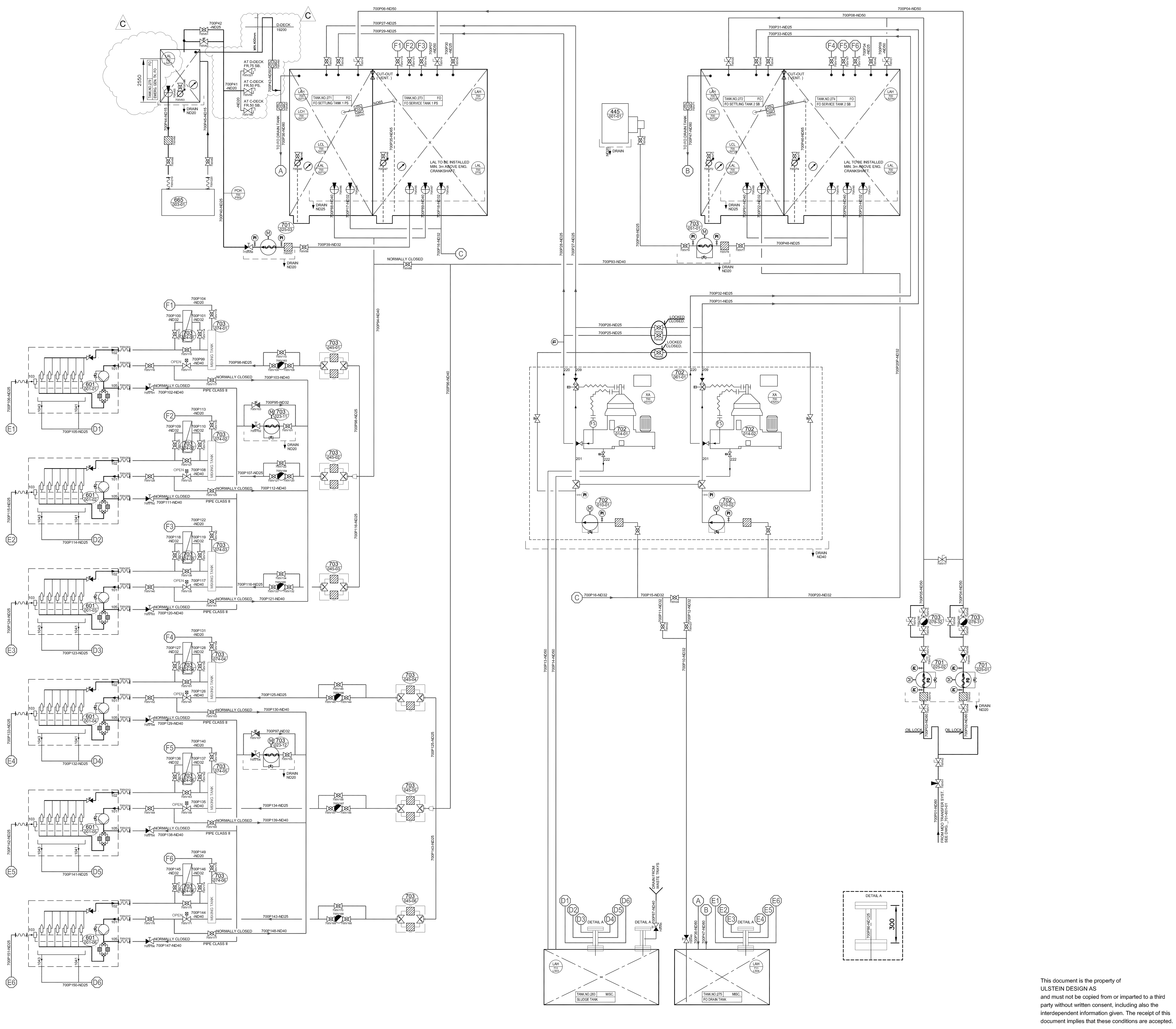
YARD NO.: NB 66

ULSTEIN SX124 — PROJECT NO: U10321

DRAWING: U10321_500-600-01 C

REPLACEMENT:

DEP: 282 — SHEET: 1/1 — MS 99



SYMBOL EXPLANATIONS

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	NR STOP VALVE		NR VALVE SPRING LOADED		REM. CONTROL QUICK CLOSING VALVE		FO CONSUMPTION FLOWMETER
	BALL VALVE		SAFETY VALVE		3-WAY VALVE (L-TYPE)		LEVEL INDICATOR
	REMOTE OPERATED VALVE		SELF CLOSING DRAIN VALVE		3-WAY VALVE (T-TYPE)		FO PIPES
	NR VALVE		STOP VALVE		FLEXIBLE CONNECTION		
	FILTER		BUTTERFLY VALVE		SIGHT GLASS		

REFERENCE LIST

CLASSIFICATION:

DNV +1A1, SF, E0, DYNPOS-AUTR, CLEAN DESIGN, COMF-V (3), ICE-C, NAUT-AW, HELDK,

REGULATIONS:

SOLAS 1974/83, ICLL1966, The International Regulations for Tonnage Measurement (1969), International, Conference for Preventing Collision at Sea. MARPOL 1978 Annex I, IV, V and VI, IMO A 469 (XII) Superseded by IMO MSC 235(82), IMO A.673(16), ILO, ISPS,Rules and Reg. governing Tonnage of Panama Canal, SOLAS Chapter II-1, part B-1. Subdivision and damage stability of cargo ships, UK CAA: CAP 437, Rules of Tonnage of the Suez Canal Authority. [SPS]: Resolution MSC.266 (84) - Code of safety for special purpose ships, 2008

PDIM-700	PIPE DIMENSION		
FO SYSTEM	Seamless press. tube. MATERIAL : St. 37.4	PIPES GENERAL	ARMATURE DIMENSION
ND 8	PT Ø 12 *	1,6	3/8"
ND 12	PT Ø 15 *	1,8	1/2"
ND 15	PT Ø 18 *	2,0	1/2"
ND 20	PT Ø 22 *	2,0	3/4"
ND 25	PT Ø 28 *	2,0	1"
ND 32	PT Ø 35 *	3,0	1 1/4"
ND 40	PT Ø 42 *	3,0	1 1/2"
	acc. to NS 2501 MATERIAL : St. 37.0	PIPES GENERAL	PIPES IN TANKS etc.
ND 40*	Ø 48,3 *	4,5	WALL THICK. ACC. TO CLASS
ND 50	Ø 60,3 *	4,5	
ND 65	Ø 76,1 *	4,5	
ND 80	Ø 88,9 *	4,5	
ND 100	Ø 114,3 *	4,5	
ND 125	Ø 139,7 *	4,5	
ND40* NOT FOR NORMAL USE.			

PIPENO 700P	- DIMENSION - ND50
700P01 - 700P149	FUEL OIL SYSTEM

	FUEL OIL SYSTEM
PIPING SYSTEM CLASS	III (II indicated on drawing)
DESIGN WORKING PRESSURE	3 bar (8 bar)
HYDROSTATIC TEST PRESSURE	1,5 x working pressure
SYSTEM PRESSURE CLASS	PN10
DESIGN WORKING TEMPERATURE	>60 deg.C max.
PIPING MATERIAL	Seamless steel, ISO/DIN 2448,NS2501,St.37.0 / Press. Steel pipe St.37,4 DIN 2391
PIPE CONNECTIONS	Slip on flange NS PN10 steel sleeves Set in flange NS PN10 couplings where permited
VALVES	cast iron butterfly valve PN10 Al.Br.seat, Buna-N =<80 C, Viton > 80 C
VALVES	Ball valve, brass ball / stainless steel

Note:

* For operation of remote operated FO valves 700V111, 700V123, 700V135, 700V147, 700V159 & 700V171, see drawing _700-601-01. The control cabinets for these valves are to be located at a safe position in engine room but outside the space conserned in the event of fire occurring.
* FUEL OIL TYPE ACCORDING TO ISO 8217 ISO-F-DMA
* REMOTE "START/STOP" OF FO SUPPLY PUMP TO E.G. TANK

Nsfi.no.	Indication	Capacity	Type
703-078-32	FLOWMETER FO TRANSFER PUMP NO.2		
703-078-31	FLOWMETER FO TRANSFER PUMP NO.1		
703-074-06	FO MIXING TANK ME6		
703-074-05	FO MIXING TANK ME5		
703-074-04	FO MIXING TANK ME4		
703-074-03	FO MIXING TANK ME3		
703-074-02	FO MIXING TANK ME2		
703-074-01	FO MIXING TANK ME1		
703-051-01	DO CIRC. PUMP FOR INCINERATOR	Cap.: 1,5 m³/h - 1,5 bar Selfpriming three-screw pump	Allweiler AS TRD 20 R37 P712 V
703-045-06	FO DUPLEX FILTER NO.6		Yard delivery
703-045-05	FO DUPLEX FILTER NO.5		Yard delivery
703-045-04	FO DUPLEX FILTER NO.4		Yard delivery
703-045-03	FO DUPLEX FILTER NO.3		Yard delivery
703-045-02	FO DUPLEX FILTER NO.2		Yard delivery
703-045-01	FO DUPLEX FILTER NO.1		Yard delivery
703-024-06	FO HEAT EXCH. MAIN ENG. NO.6	9 kW	Alfa Laval M3-FG
703-024-05	FO HEAT EXCH. MAIN ENG. NO.5	9 kW	Alfa Laval M3-FG
703-024-04	FO HEAT EXCH. MAIN ENG. NO.4	9 kW	Alfa Laval M3-FG
703-024-03	FO HEAT EXCH. MAIN ENG. NO.3	9 kW	Alfa Laval M3-FG
703-024-02	FO HEAT EXCH. MAIN ENG. NO.2	9 kW	Alfa Laval M3-FG
703-024-01	FO HEAT EXCH. MAIN ENG. NO.1	9 kW	Alfa Laval M3-FG
703-023-12	EMERG. FO PUMP NO.2 (ME 4,5&6)	Cap: 1,7 m³/h - 8 bar Selfpriming three-screw pump	Allweiler AS TRE 20 R46U18.1 V W202
703-023-11	EMERG. FO PUMP NO.1 (ME 1,2&3)	Cap: 1,7 m³/h - 8 bar Selfpriming three-screw pump	Allweiler AS TRE 20 R46U18.1 V W202
702-061-01	FO SEPARATOR UNIT NO.1		Alfa Laval Tumba AB Sweden Type: SU 815 DO
702-014-02	FO SEPARATOR NO.2		Alfa Laval Tumba AB Sweden Type: SU 815 DO
702-014-01	FO SEPARATOR NO.1		Alfa Laval Tumba AB Sweden Type: SU 815 DO
702-010-02	SUPPLY PUMP FO SEPARATOR NO.2		Alfa Laval Tumba AB Sweden
702-010-01	SUPPLY PUMP FO SEPARATOR NO.1		Alfa Laval Tumba AB Sweden
701-025-03	FO SUPPLY PUMP TO DECK	Cap.: 1,34 m3/h - 5 Bar Selfpriming three-screw pump	Allweiler AS TRD 20 R37 P712 V
701-025-02	FO TRANSFER PUMP NO.2	Cap.: 16,3 m3/h - 3 Bar Selfpriming three-screw pump	Allweiler AS Trilub 140 R 46
701-025-01	FO TRANSFER PUMP NO.1	Cap.: 16,3 m3/h - 3 Bar Selfpriming three-screw pump	Allweiler AS Trilub 140 R 46
665-003-01	EMERGENCY GEN.SET ENGINE	215 kW - 1500 rpm	Pon Power AS Type C9 DI-TA
601-001-06	MAIN ENGINE NO.6	1800 kW - 1000 rpm	Wärtsilä Finland Oy Type 9L20
601-001-05	MAIN ENGINE NO.5	1800 kW - 1000 rpm	Wärtsilä Finland Oy Type 9L20
601-001-04	MAIN ENGINE NO.4	1800 kW - 1000 rpm	Wärtsilä Finland Oy Type 9L20
601-001-03	MAIN ENGINE NO.3	1800 kW - 1000 rpm	Wärtsilä Finland Oy Type 9L20
601-001-02	MAIN ENGINE NO.2	1800 kW - 1000 rpm	Wärtsilä Finland Oy Type 9L20
601-001-01	MAIN ENGINE NO.1	1800 kW - 1000 rpm	Wärtsilä Finland Oy Type 9L20
445-001-01	INCINERATOR PLANT	400000 kcal/h (465 kW) 400 V/50 Hz	TEAMTEC OG200CS

OVERFLOW ROUTED WITH LOOP ABOVE D-DECK ON/OFF SWITCH DELETED	17.03.14	MRO	C
REVISED AND ISSUED FOR RE-APPROVAL, PROPULSION UPGRADE, SPS CODE, FO SUPPLY FOR MOB-boat, REMOTE START/STOP OF PUMP	31.10.13	MRO	B
APPROVED BY DNV WITH NO COMMENTS. UPDATED ACC TO YARD & OWNER COMMENTS	04.03.09	AEG	A
ISSUED FOR IDC	13.08.08	EERG	1

DnV 28.08.08 — Owner / Yard 19.08.08 — APPROVED BY:

TITLE: **FUEL OIL SYSTEM**

SCALE: 1:1 — DRAWN: EERG 13.08.08 — FORMAT: A1 — ARCHIVE BOOK:

ULSTEIN DESIGN AS
6067 Ulsteinvik
Norway
Tlf: (+47) 7000 8000
Fax: (+47) 7000 8023
www.ulsteingroup.com

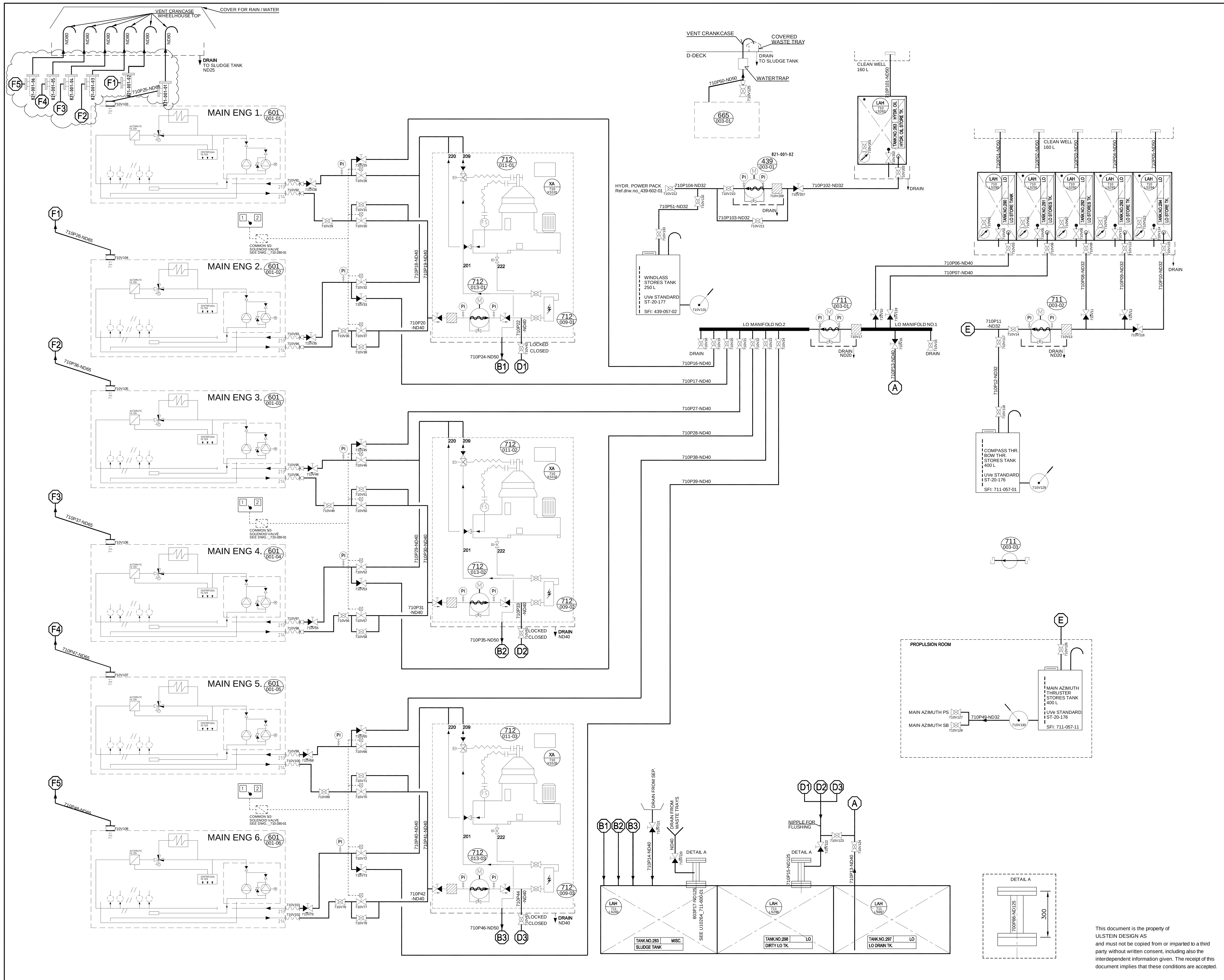
YARD NO.: 66 / 67

ULSTEIN SX124 — PROJECT NO: U10321

DRAWING: U10321_700-600-01 C

REPLACEMENT:

DEP: — SHEET: 1/1



CLASSIFICATION:

DNV +1A1, SF, E0, DYNPOS-AUTR, CLEAN DESIGN, COMF-V (3), ICE-C, NAUT-AW, HELDK.

REGULATIONS:

SOLAS 1974/83, ICLL1966, The International Regulations for Tonnage Measurement (1969), International, Conference for Preventing Collision at Sea. MARPOL 1978 Annex I, IV, V and VI, IMO A 469 (XII) Superseded by IMO MSC 235(82), IMO A.673(16), ILO, ISPS,Rules and Reg. governing Tonnage of Panama Canal, SOLAS Chapter II-1, part B-1. Subdivision and damage stability of cargo ships, UK CAA: CAP 437, Rules of Tonnage of the Suez Canal Authority.

PDIM-710	PIPE DIMENSION		
LO SYSTEM	Seamless press. tube. MATERIAL : St. 37.4	PIPES GENERAL	ARMATURE DIMENSION
ND 8	PT Ø 12 *	1,6	3/8"
ND 12	PT Ø 15 *	1,8	1/2"
ND 15	PT Ø 18 *	2,0	1/2"
ND 20	PT Ø 22 *	2,0	3/4"
ND 25	PT Ø 28 *	2,0	1"
ND 32	PT Ø 35 *	3,0	1 1/4"
ND 40	PT Ø 42 *	3,0	1 1/2"
	acc. to NS 2501 MATERIAL : St. 37.0	PIPES GENERAL	PIPES IN TANKS etc.
ND 40*	Ø 48,3 *	4,5	WALL THICK. ACC. TO CLASS
ND 50	Ø 60,3 *	4,5	
ND 65	Ø 76,1 *	4,5	
ND 80	Ø 88,9 *	4,5	
ND 100	Ø 114,3 *	4,5	
ND 125	Ø 139,7 *	4,5	
ND 150	Ø 168,3 *	4,5	
ND 200	Ø 219,1 *	6,3	
ND40* NOT FOR NORMAL USE.			

PIPENO 710P01	- DIMENSION - ND50
710P01 - 710P51	LUB OIL SYSTEM
710P101 - 104	HYDR. OIL SYSTEM

	LUB OIL SYSTEM
PIPING SYSTEM CLASS	III
DESIGN WORKING PRESSURE	2 bar
SYSTEM PRESSURE CLASS	PN10
DESIGN WORKING TEMPERATURE	60 deg.C max.
PIPING MATERIAL	Seamless steel, ISO/DIN 2448,NS2501,St.37.0 / Press. Steel pipe St.37,4 DIN 2391
PIPE CONNECTIONS	Slip on flange NS PN10 steel sleeves Set in flange NS PN10 couplings where permited
VALVES	Grey cast iron butterfly valve PN10 Al.Br.seat, Buna-N =<80 C, Viton > 80 C
VALVES	Ball valve, brass ball / stainless steel

Nsfi.no.	Indication	Capacity	Type
712-013-03	SUPPLY PUMP LO SEPARATOR NO.3		Alfa Laval Nordic AS
712-013-02	SUPPLY PUMP LO SEPARATOR NO.2		Alfa Laval Nordic AS
712-013-01	SUPPLY PUMP LO SEPARATOR NO.1		Alfa Laval Nordic AS
712-011-03	LO SEPARATOR NO.3		Alfa Laval Nordic AS Type PU 100 E
712-011-02	LO SEPARATOR NO.2		Alfa Laval Nordic AS Type PU 100 E
712-011-01	LO SEPARATOR NO.1		Alfa Laval Nordic AS Type PU 100 E
712-009-03	PREHEATER LO SEPARATOR NO.3		Alfa Laval Nordic AS
712-009-02	PREHEATER LO SEPARATOR NO.2		Alfa Laval Nordic AS
712-009-01	PREHEATER LO SEPARATOR NO.1		Alfa Laval Nordic AS
711-003-03	LO TRANSFER PUMP NO.3	Appr. 2,5 m3/h - 2 Bar Portable and air driven	Allweiler AS Type: NDP 15 B,
711-003-02	LO TRANSFER PUMP NO.2	3,4 m3/h - 2 Bar Screw pump	Allweiler AS TRE 40 R37U18.1 V W202,
711-003-01	LO TRANSFER PUMP NO.1	3,4 m3/h - 2 Bar Screw pump	Allweiler AS TRE 40 R37U18.1 V W202,
665-003-01	EMERGENCY GEN.SET ENGINE	215 kW - 1500 rpm	Pon Power AS Type C9 DI-TA
601-001-06	MAIN ENGINE NO.6	1800 kW - 1000 rpm	Wärtsilä Finland Oy Type 9L20
601-001-05	MAIN ENGINE NO.5	1800 kW - 1000 rpm	Wärtsilä Finland Oy Type 9L20
601-001-04	MAIN ENGINE NO.4	1800 kW - 1000 rpm	Wärtsilä Finland Oy Type 9L20
601-001-03	MAIN ENGINE NO.3	1800 kW - 1000 rpm	Wärtsilä Finland Oy Type 9L20
601-001-02	MAIN ENGINE NO.2	1800 kW - 1000 rpm	Wärtsilä Finland Oy Type 9L20
601-001-01	MAIN ENGINE NO.1	1800 kW - 1000 rpm	Wärtsilä Finland Oy Type 9L20
439-003-01	HO TRANSFER PUMP NO.1	3,4 m3/h - 2 Bar Screw pump	Allweiler AS TRE 40 R37U18.1 V W202,

WATER TRAPS ARE ADDED TO CRANKCASE VENT SYSTEM	14.09.09	DYA	C
EMERGENCY GEN. SET CRANKCASE VENT DIMENSION IS UPDATED	26.08.09	DYA	B
UPDATED DRAWING ACC. TO DNV & YARD/OWNER COMMENTS	06.01.09	AEG	A
ISSUED FOR APPROVAL	13.08.08	EERG	1
ISSUED FOR IDC	11.08.08	EERG	0

SYMBOL EXPLANATIONS

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	NR STOP VALVE		WATER TRAP
	BALL VALVE		
	BALL VALVE w/DOUBLE ACTING PNEUM. ACT.		
	NR VALVE		
	FILTER		

REFERENCE LIST

U10321_821-600-01 VENT PIPE SYSTEM

APPROVED BY: DNV 28.08.08; YARD / OWNER 20.08.08

TITLE

LUB OIL SYSTEM

SCALE 1:1 | DRAWN: EERG 07.08.08 | FORMAT: A1 | ARCHIVE BOOK:

ULSTEIN®
ULSTEIN DESIGN AS
6067 Ulsteinvik
Norway
Tlf: (+47) 7000 8000
Fax: (+47) 7000 8023
www.ulsteingroup.com

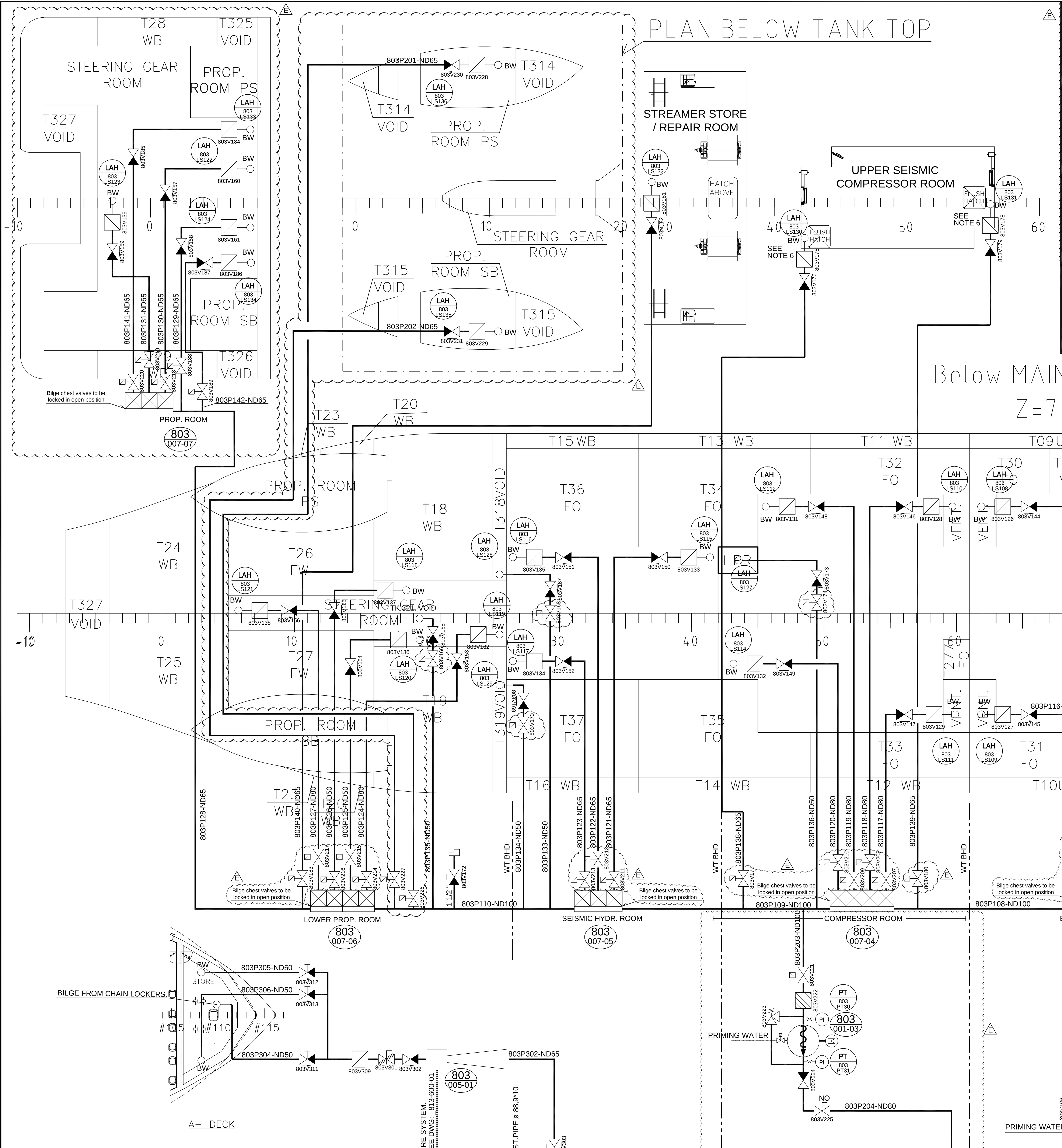
YARD NO.: 66 / 67

ULSTEIN SX124 | PROJECT NO: U10321

DRAWING: U10321_710-600-01 C

REPLACEMENT:

DEP: | SHEET: 1/1



DnV Pt.4 Ch.6 Sec.4H	DnV Pt.4 Ch.6 Sec.4H
STEERING GEAR ROOM: (#-4-#8) * 0,7m =8,4m BRANCH BILGE d=2,15√8,4(19+8,0) +25 = 57,38mm TO THE NEAREST 5 mm -> BRANCH BILGE = ND65	SEISMIC HYDR. ROOM: (#42-#26) * 0,7m = 11,2m BRANCH BILGE d=2,15√11,2(19+8,0) +25 = 62,39mm TO THE NEAREST 5 mm -> BRANCH BILGE = ND65
DnV Pt.4 Ch.6 Sec.4H LOWER STEERING GEAR. ROOM: (#26-#5) * 0,7m =14,7m BRANCH BILGE d=2,15√14,7(19+8,0) +25 = 67,83mm TO THE NEAREST 5 mm -> BRANCH BILGE = ND80	DnV Pt.4 Ch.6 Sec.4H BOW THRUSTER ROOM: (#97-#107) * 0,7m = 7,0m BRANCH BILGE d=2,15√8,4(19+8,0) +25 = 54,56mm TO THE NEAREST 5 mm -> BRANCH BILGE = ND65
DnV Pt.4 Ch.6 Sec.4H PROPULSION ROOM: (#17-#2) * 0,7m =10,5m BRANCH BILGE d=2,15√8,4(19+8,0) +25 = 61,20mm TO THE NEAREST 5 mm -> BRANCH BILGE = ND65	DnV Pt.4 Ch.6 Sec.4H SEISMIC COMP. ROOM: (#42-#61) * 0,7m = 13,3m BRANCH BILGE d=2,15√13,3(19+8,0) +25 = 65,74mm TO THE NEAREST 5 mm -> BRANCH BILGE = ND80
DnV Pt.4 Ch.6 Sec.4H BILGE MAIN d=1,68√82(19+8,0) +25 = 104,05mm TO THE NEAREST 5 mm -> BILGE MAIN = ND100 BILGE PUMP CAPACITY acc. to table H1 = 64 m3/h (each)	DnV Pt.4 Ch.6 Sec.4H ENG.ROOM: (#61-#97) * 0,7m = 25,2m BRANCH BILGE d=2,15√25,2(19+8,0) +25 = 81,08mm TO THE NEAREST 5 mm -> BRANCH BILGE = ND100

CLASSIFICATION:

DNV +1A1, SF, E0, DYNPOS-AUTR, CLEAN DESIGN, COMF-V (3), ICE-C, NAUT-AW, HELDK,

REGULATIONS:

SOLAS 1974/83, ICLL1966, The International Regulations for Tonnage Measurement (1969), International, Conference for Preventing Collision at Sea. MARPOL 1978 Annex I, IV, V and VI, IMO A 469 (XII) Superseded by IMO MSC 235(82), IMO A.673(16), ILO, ISPS,Rules and Reg. governing Tonnage of Panama Canal, SOLAS Chapter II-1, part B-1. Subdivision and damage stability of cargo ships, UK CAA: CAP 437, Rules of Tonnage of the Suez Canal Authority. [SPS]: Resolution MSC.266 (84) - Code of safety for special purpose ships, 2008

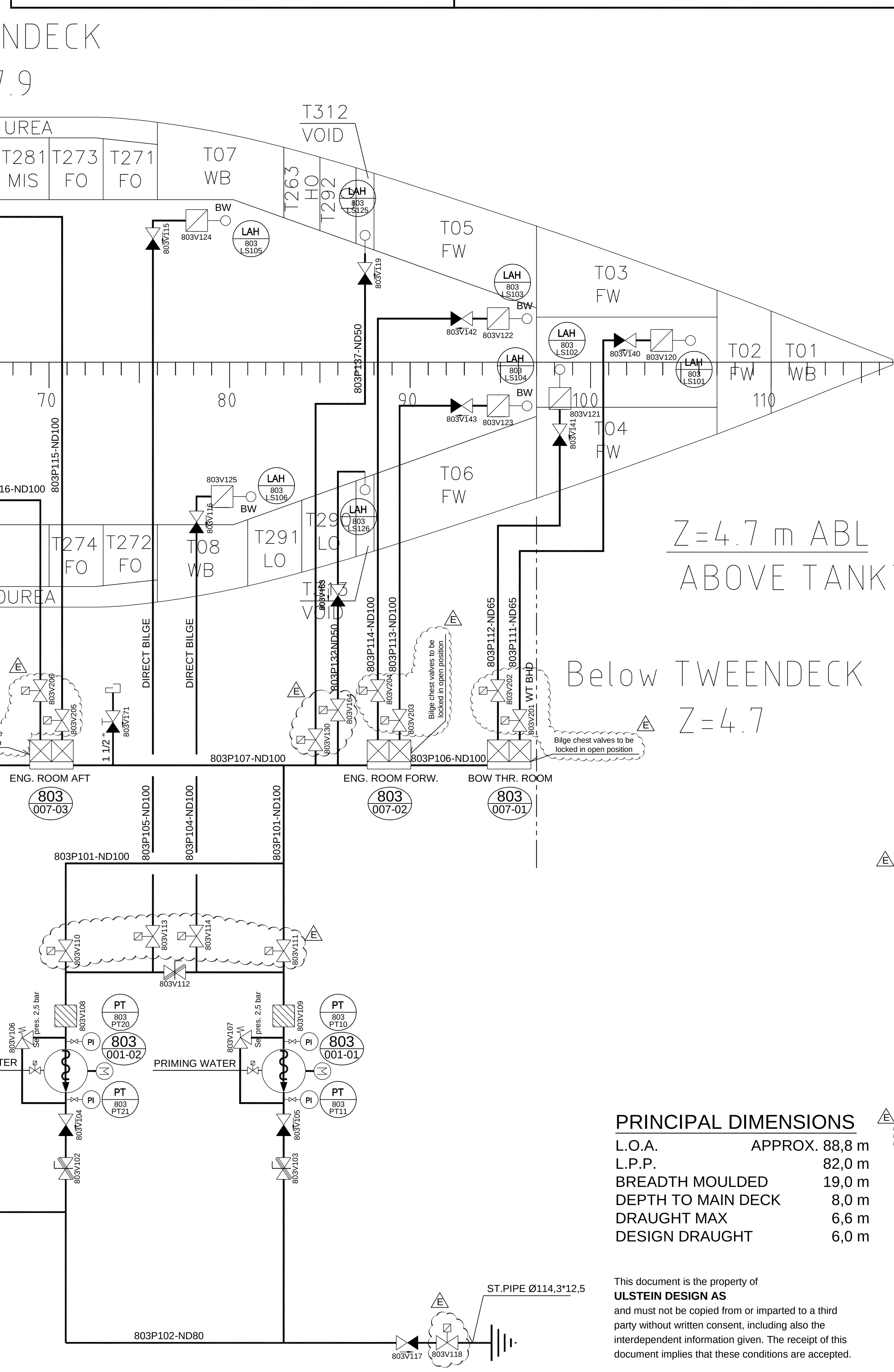
PIPENO 4001	- DIMENSION - ND50
803P101 - 137	BILGE SYSTEM
803P301 - 305	BILGE SYSTEM A-DECK

PDIM-800	PIPE DIMENSION		
BILGE/BALLAST/ FIRE SYSTEM	Galvanized THreaded Pipe. acc. to NS 5587 MATERIAL : St. 37.0	PIPES GENERAL	REF. TO NOM. SIZE
1/2"	THP Ø 21,3 *	3,2	ND15
3/4"	THP Ø 26,9 *	3,2	ND20
1"	THP Ø 33,7 *	4,0	ND25
1 1/4"	THP Ø 42,4 *	4,0	ND32
1 1/2"	THP Ø 48,3 *	4,0	ND40
BILGE/BALLAST/ FIRE SYSTEM	Galvanized Pipe. acc. to NS 2501 MATERIAL : St. 37.0	PIPES GENERAL	PIPES IN TANKS etc.
ND 40*	Ø 48,3 *	4,5	WALL THICKNESS ACC. TO CLASS.
ND 50	Ø 60,3 *	4,5	
ND 65	Ø 76,1 *	4,5	
ND 80	Ø 88,9 *	4,5	
ND 100	Ø 114,3 *	4,5	
ND 125	Ø 139,7 *	4,5	
ND 150	Ø 168,3 *	4,5	
ND 200	Ø 219,1 *	6,3	

ND40* NOT FOR NORMAL USE.

	BILGE SYSTEM
PIPING SYSTEM CLASS:	III
DESIGN WORKING PRESS:	2 BAR
SYSTEM PRESSURE CLASS	PN10
DESIGN WORKING TEMPERATURE:	32 deg.C
HYDROSTATIC TEST PRESS.	4 BAR
PIPING MATERIAL ND40 >=	SEAMLESS STEEL, ISO/DIN 2448 OR NS2501,St37.4, GALVANIZED.
PIPE CONNECTIONS ND40 >=	Slip on flange NS PN10, Set-in flange NS PN10, Straub Grip Coupling
VALVES ND40 >=	Cast iron Butterfly valve, PN10, Al.Br. disc, Al.Br. disc, SS stem, Bune -N seal.
HOT DIP GALVANIZED CLASS III PIPING SYSTEM	

1) THE BILGE WELLS ARE NORMALLY TO HAVE A CAPACITY OF AT LEAST 0.15 m3. (DNV, Pt.4, Ch.6, Sec.4H, 601)
2) BRANCH BILGE PIPES FOR DRAINAGE OF MACHINERY SPACES AND SHAFT TUNNELS SHALL BE LED TO MUD BOXES.THE MUD BOXES SHALL HAVE STRAIGHT TAIL PIPES TO THE BILGES AND SHALL BE ARRANGED FOR EASY INSPECTION AND CLEANING.(DNV, Pt.4, Ch.6,
3) VALVES, COCKS AND MUD BOXES SHALL BE LOCATED IN READILY ACCESSIBLE POSITIONS ABOVE OR ON THE SAME LEVEL AS THE FLOOR PLATES.WHERE THIS IS NOT PRACTICABLE, THEY MAY BE PLACED IMMEDIATELY BELOW, PROVIDED THAT THE FLOOR PLATES INDICATES THE PRESENCE OF THESE FITTINGS.(DNV, Pt.4, Ch.6, Sec.4H, 605)
4) DETAILS OF APPROVAL REFERENCES OF BILGE PUMPS ARE TO BE SUBMITTED TO DNV. Sec.4H, 602)
5) OVERBOARD DISCHARGE VALVES CONNECTIONS DETAILS WILL BE SUBMITTED BY YARD TO DNV AS SEPARATE DOCUMENTS.
6) BILGE WELL TO BE ADJACENT TO FLUSH HATCH COAMING WITH A CUT OUT SO THAT COAMING DRAINS INTO BILGE WELL. SEE DETAIL NO.1
7) ALL REMOTE OPE. VALVES TO BE OPERATED FROM IAS, AND FROM ABOVE BULKHEAD DECK.
8) ALL REMOTE OPERATED VALVES TO BE OPERABLE IN A FLOODED SITUATION.
9) VALVES IN BILGE CHESTS TO BE LOCKED IN OPEN POSITION.



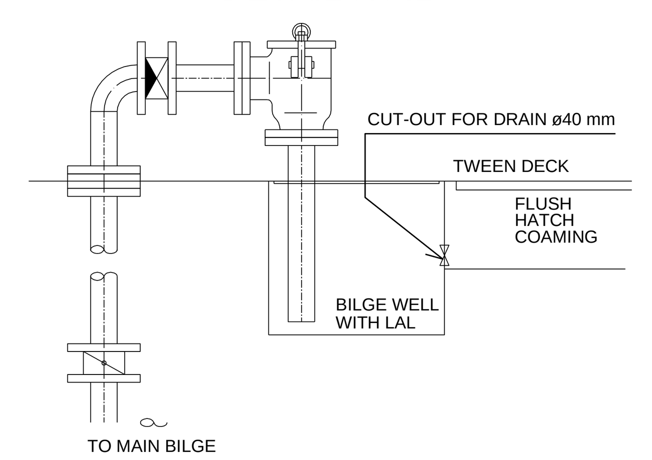
Nsfi.no.	Indication	Capacity	Type
803-007-07	BILGE CHEST NO.7		
803-007-06	BILGE CHEST NO.6		
803-007-05	BILGE CHEST NO.5		
803-007-04	BILGE CHEST NO.4		
803-007-03	BILGE CHEST NO.3		
803-007-02	BILGE CHEST NO.2		
803-007-01	BILGE CHEST NO.1		
803-005-01	BILGE EJECTOR NO.1 CHAIN LOCKER	12 m³/h - 10mWG Drive wtr.: 10 m³/h - 4/5 Bar	Allweiler AS 1 1/2" - 2" - 2 1/2"
803-001-03	BILGE PUMP NO.3	65 m³/h - 2 Bar Eccentric screw pump	Allweiler AS AEB 1 E 0750-IE/011P01 G
803-001-02	BILGE PUMP NO.2	65 m³/h - 2 Bar Eccentric screw pump	Allweiler AS AEB 1 E 0750-IE/011P01 G
803-001-01	BILGE PUMP NO.1	65 m³/h - 2 Bar Eccentric screw pump	Allweiler AS AEB 1 E 0750-IE/011P01 G

PRINCIPAL DIMENSIONS

L.O.A.	APPROX. 88,8 m
L.P.P.	82,0 m
BREADTH MOULDED	19,0 m
DEPTH TO MAIN DECK	8,0 m
DRAUGHT MAX	6,6 m
DESIGN DRAUGHT	6,0 m

Revision	Date	By	Rev.
REVISED AND ISSUED FOR RE-APPROVAL, PROPULSION UPGRADE, SPS CODE	29.10.13	MRO	E
UPDATED, BUTTERFLY VALVES 803V188, 803V189 ARE TURNED INTO GLOBE VALVE ACC. TO OWNER COMMENT	14.10.09	DYA	D
UPDATED, TWO CHESTS ARE TURNED INTO BUTTERFLY VALVES 803V188, 803V189	03.06.09	DYA	C
ADDED BILGE WELLS/BILGE SUCTION FROM UPPER COMPR.ROOM, STREAMER STORE & UPPER PROPULSION ROOM. ADDED DETAIL	09.03.09	AEG	B
UPDATED ACCORDING TO OWNER/ YARD/ DNV COMMENTS	09.09.08	EERG	A
ISSUED FOR APPROVAL	30.06.08	EERG	1
ISSUED FOR IDC	09.06.08	DYA	0

DETAIL NO.1



SYMBOL EXPLANATIONS

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	BUTTERFLY VALVE		STRAINER		REMOTE OPR. BUTTERFLY VALVE
	GLOBE VALVE		MUD BOX		
	BALL VALVE	BW	BILGE WELL		
	NR VALVE		HOSE COUPLING, TODO OR EQUAL.		
	NR STOP VALVE		PRESSURE INDICATOR		

REFERANCE DRAWINGS

U10321_813-600-01 FIRE SYSTEM

DESCRIPTIONS

TITLE	BILGE SYSTEM
SCALE	1:1
DRAWN:	DYA 09.06.08
FORMAT:	A1
ARCHIVE BOOK:	1
YARD NO.:	66 / 67
PROJECT NO:	U10321
	ULSTEIN SX124
DRAWING:	U10321_803-600-01 E
SHEET:	1/1

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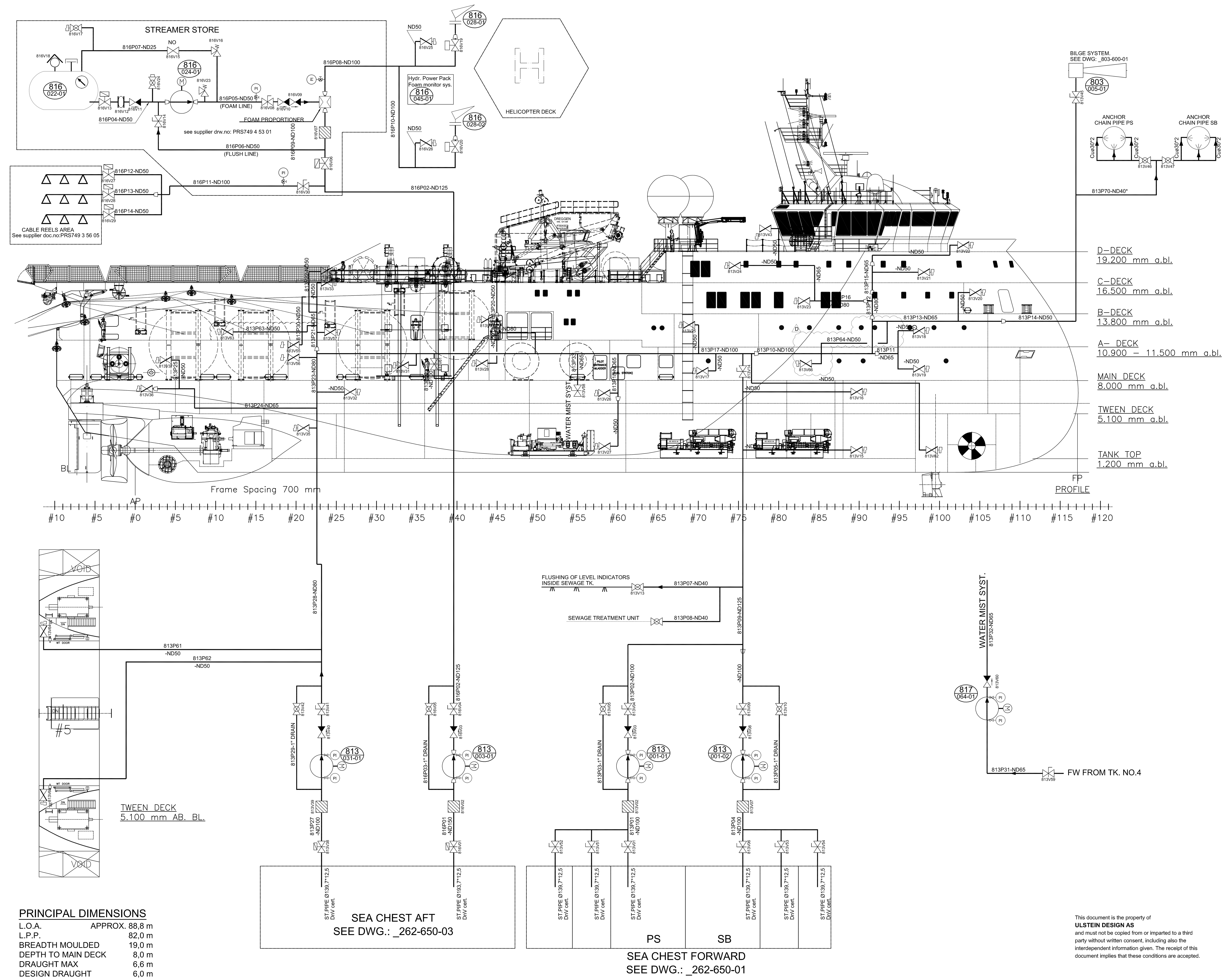
Det Norske Veritas 14.08.08
APPROVED BY:



PRINCIPAL DIMENSIONS

L.O.A.	APPROX. 88,8 m
L.P.P.	82,0 m
BREADTH MOULDED	19,0 m
DEPTH TO MAIN DECK	8,0 m
DRAUGHT MAX	6,6 m
DESIGN DRAUGHT	6,0 m

CLASSIFICATION:
DNV +1A1, SF, E0, DYNPOS-AUTR, CLEAN DESIGN, COMF-V (3), ICE-C, NAUT-AW, HELDK,

REGULATIONS:
SOLAS 1974/83, ICLL1966, The International Regulations for Tonnage Measurement (1969), International, Conference for Preventing Collision at Sea. MARPOL 1978 Annex I, IV, V and VI, IMO A 469 (XII) Superseded by IMO MSC 235(82), IMO A.673(16), ILO, ISPS,Rules and Reg. governing Tonnage of Panama Canal, SOLAS Chapter II-1, part B-1. Subdivision and damage stability of cargo ships, UK CAA: CAP 437, Rules of Tonnage of the Suez Canal Authority. [SPS]: Resolution MSC.266 (84) - Code of safety for special purpose ships, 2008

PDIM-800	PIPE DIMENSION		
	Galvanized THreaded Pipe.		
BILGE/BALLAST/ FIRE SYSTEM	acc. to NS 5587 MATERIAL : St. 37.0	PIPES GENERAL	REF. TO NOM. SIZE
1/2"	THP Ø 21,3 *	3,2	ND15
3/4"	THP Ø 26,9 *	3,2	ND20
1"	THP Ø 33,7 *	4,0	ND25
1 1/4"	THP Ø 42,4 *	4,0	ND32
1 1/2"	THP Ø 48,3 *	4,0	ND40
	Galvanized Pipe.		
BILGE/BALLAST/ FIRE SYSTEM	acc. to NS 2501 MATERIAL : St. 37.0	PIPES GENERAL	PIPES IN TANKS etc.
ND 40*	Ø 48,3 *	4,5	WALL THICKNESS ACC. TO CLASS.
ND 50	Ø 60,3 *	4,5	
ND 65	Ø 76,1 *	4,5	
ND 80	Ø 88,9 *	4,5	
ND 100	Ø 114,3 *	4,5	
ND 125	Ø 139,7 *	4,5	
ND 150	Ø 168,3 *	4,5	
ND 200	Ø 219,1 *	6,3	
ND40* NOT FOR NORMAL USE.			

PIPENO 813P01	- DIMENSION - ND100
813P01 - P32	FIRE LINE SYSTEM.
816P01 - P08	FOAM SYSTEM.

	FIRE LINE SYSTEM
PIPING SYSTEM CLASS	III
DESIGN WORKING PRESSURE	6/ 11 bar
SYSTEM PRESSURE CLASS	PN16
DESIGN WORKING TEMPERATURE	0-32 deg.C
HYDROSTATIC TEST PRESSURE	9/ 16 bar
PIPING MATERIAL ND>=40	SEAMLESS STEEL, ISO/DIN 2448 OR NS2501,St.37.0, GALVANIZED
PIPING MATERIAL ND<40	THREADED HEAVY STELL TUBES NS 5587/ DIN2440,GALVANIZED OR Cu-Ni
PIPE CONNECTIONS ND>=40	SLIP-ON FLANGE NS PN10,SET IN FLANGE STRAUB GRIP COUPLING
PIPING CONNECTIONS ND<40	STEEL UNION,THRE. ENDS,GALVANIZED, OR PRESS. FITTINGS
VALVES ND>=40	GREY CAST IRON BUTTERFLY VALVE PN10 Al.Br. disc,SS stem,Buna-N seal SEA INLET VALVE OF DUCTILE IRON TYPE BUTTERFLY VALVE LT
PIPING CONNECTIONS ND<=40	RED METAL HYDRANT VALVES,BRONZE SEAT SEA INLET VALVE OF BRONZE

DnV Pt.4 Ch.6 Sec.4H

BILGE MAIN d=1,68√82(19+8) +25 = 104,05mm
TO THE NEAREST 5 mm -> BILGE MAIN = ND 100
BILGE PUMP CAPACITY acc. to table H1 = 64 m³/h (each)

DnV Pt.4 Ch.10 Sec.2B (07.2000)
FIRE PUMPS min.: 4/3 x 64 m3/h = 85,33 m³/h (total)
EMERGENCY FIRE PUMP : 40% x 85,33 m³/h = 34,13 m³/h
FIRE PUMPS TAKEN 50m³/h (each)
EMERGENCY FIRE PUMP TAKEN 40 m³/h

Nsfi.no.	Indication	Capacity	Type
817-064-01	FW PUMP NO.1 WATER MIST	30m3/h - 5 bar Centrifugal pump	Allweiler NB 032-200/205-U3.1D-W19-
817-045-01	HYD.POWER PACK, FOAM MONITOR		Wilhelmsen Ships Equipment
816-028-02	FOAM MONITOR	Hydraulic operated	Wilhelmsen Ships Equipment FJM-100 H DIN/JIS Fog/Jet
816-028-01	FOAM MONITOR	Hydraulic operated	Wilhelmsen Ships Equipment FJM-100 H DIN/JIS Fog/Jet
816-024-01	FOAM PUMP	4,2 m3/h - 9 bar	Wilhelmsen Ships Equipment DPVF 4-130
816-022-01	FOAM TANK	400 Ltr.	Wilhelmsen Ships Equipment
813-031-01	EMERGENCY FIRE PUMP	Cap: 40 m³/h - 6 bar Centrifugal pump w/aut.ejector.	Allweiler NB 050-200/205 U3.1D-W3
813-003-01	FOAM/FIRE GEN. SERVICE PUMP	140m3/h - 8 bar Centrifugal pump w/aut.ejector.	Allweiler 'NB 065-250/250 U3.1D-W3
813-001-02	FIRE PUMP NO.2	Cap: 50 m³/h - 6 bar Centrifugal pump w/aut.ejector.	Allweiler NB 050-200/205-U3.1D-W3
813-001-01	FIRE PUMP NO.1	Cap: 50 m³/h - 6 bar Centrifugal pump w/aut.ejector.	Allweiler NB 050-200/205-U3.1D-W3
803-005-01	BILGE EJECTOR NO.1	Cap.: 12 m³/h - 10 mWG Drive wtr: 10 m³/h - 4/5 bar	

VALVE ADDED TO INCENERATOR ROOM ACCORDING TO LAYOUT COMMENTS FROM DNV	21.02.14	MRO	D
REVISED AND ISSUED FOR RE-APPROVAL, PROPULSION UPGRADE, SPS CODE AFT CONSTRUCTION CHANGED	29.10.13	MRO	C
UPDATED FOAM/FIRE GEN. SERVICE PUMP SEA CHEST CONN. PIPE DIM. BOW THRUSTER ROOM HYDRANT CONN. IS ADDED	15.06.09	DYA	B
GEN. UPDATING OF DRAWING, UPDATED FOAM AND WATER SPRAY SYS. REMOVED HOLD	20.02.09	AEG	A
ISSUED FOR APPROVAL	02.07.08	EERG	1
ISSUED FOR IDC	30.05.08	EERG	0

SYMBOL EXPLANATIONS

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	BUTTERFLY VALVE		PIPE REDUCTION PIECE		BUTTERFLY VALVE REMOTE OPERATED(HYDR. ACT.)		
	BALL VALVE		FLEXIBLE CONNECTION				
	BUTTERFLY VALVE REMOTE OPERATED(ELEC. ACT.)		FIRE VALVE				
	NR VALVE		STRAINER				
	PRESSURE RELIEF VALVE	(PI)	PRESSURE INDICATOR				

REFERENCE DRAWINGS

U10321_262-650-01 SEA CHEST FORWARD
U10321_262-650-03 SEA CHEST AFT
U10321_817-600-01 LOCAL PROTECTION OF WATER MIST TYPE
DOCUMENTATION FROM "WILHELMSEN SHIPS EQUIPMENT"

DESCRIPTIONS

TITLE	FIRE LINE SYSTEM
SCALE	1:1
DRAWN:	EERG 23.05.08
FORMAT:	A1
ARCHIVE BOOK:	1
YARD NO.:	66 / 67
PROJECT NO:	ULSTEIN SX124 U10321
DRAWING:	U10321_813-600-01 D
REPLACEMENT:	
DEP:	SHEET: 1/1
DnV	12.09.08
Yard/owner	30.07.08
APPROVED BY:	

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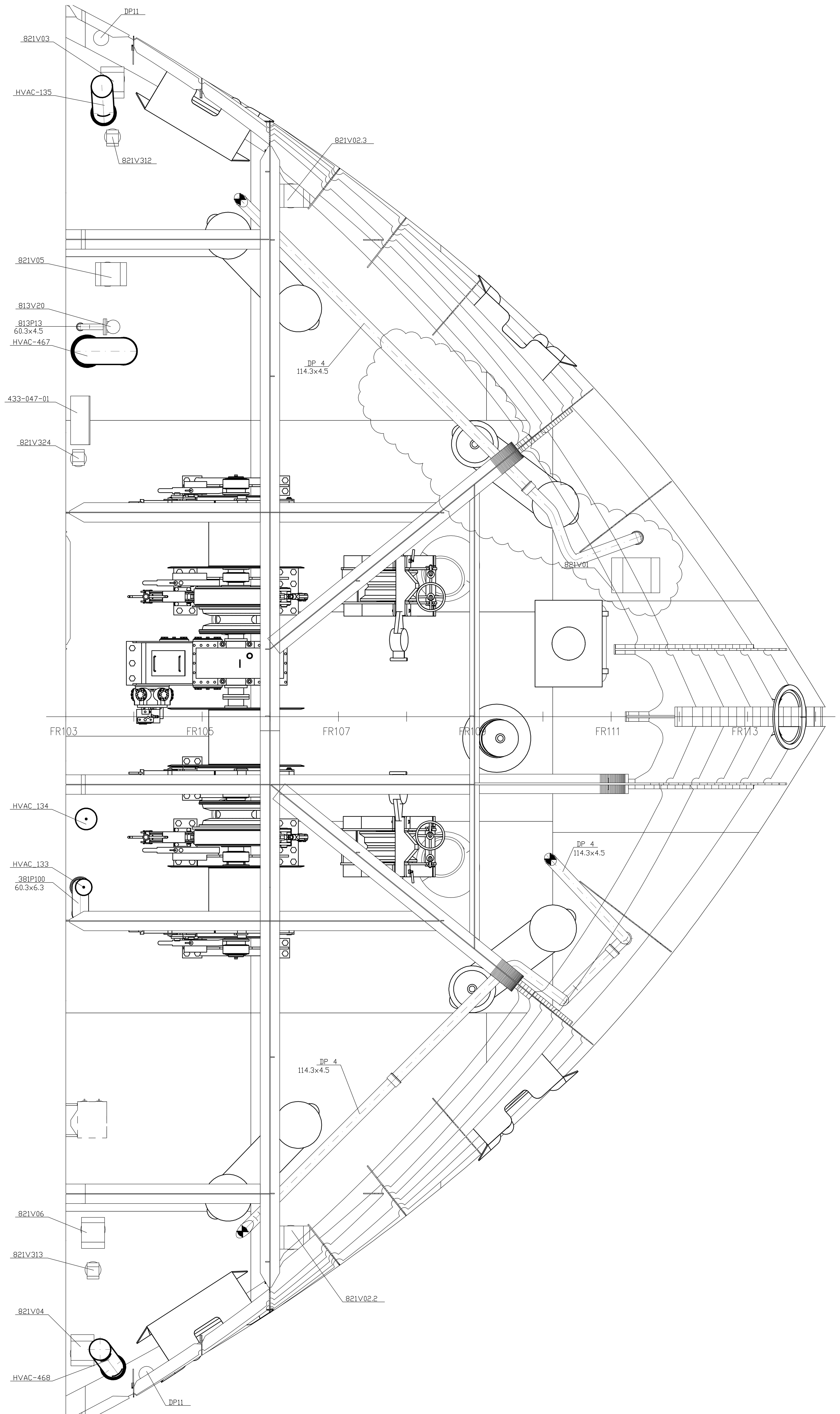
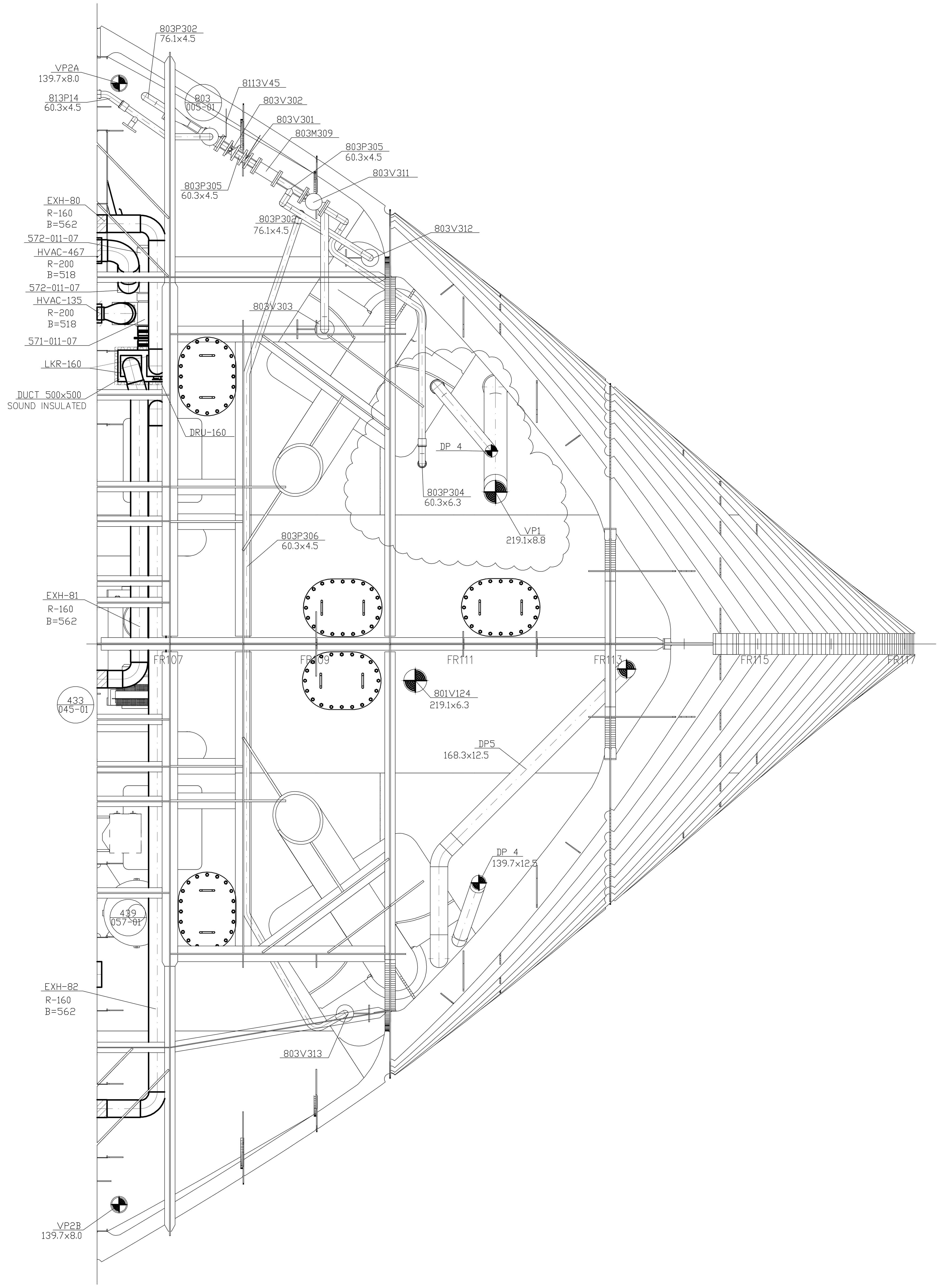


B-DECK PLAN VIEW

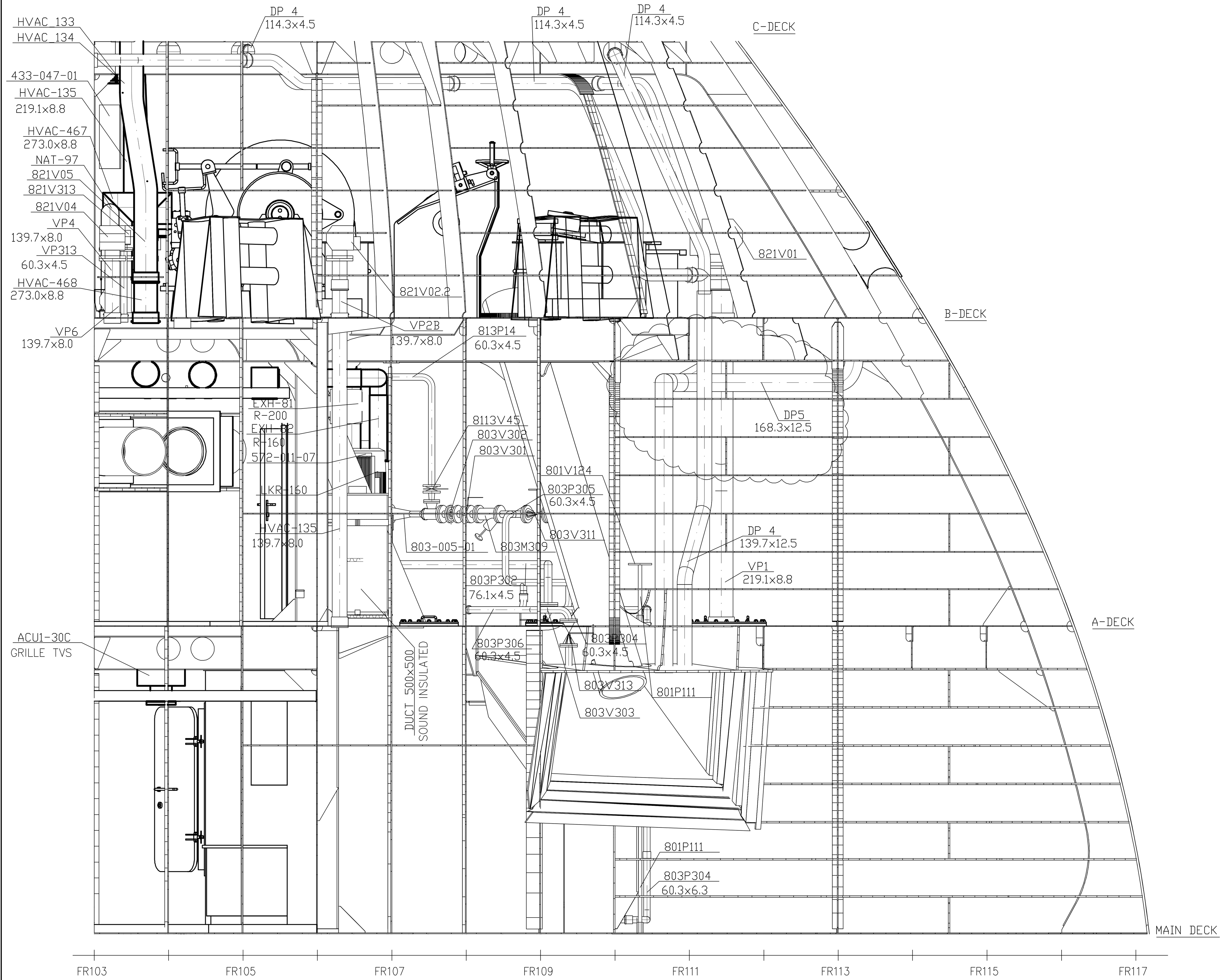


PLAN BELOW B-DECK

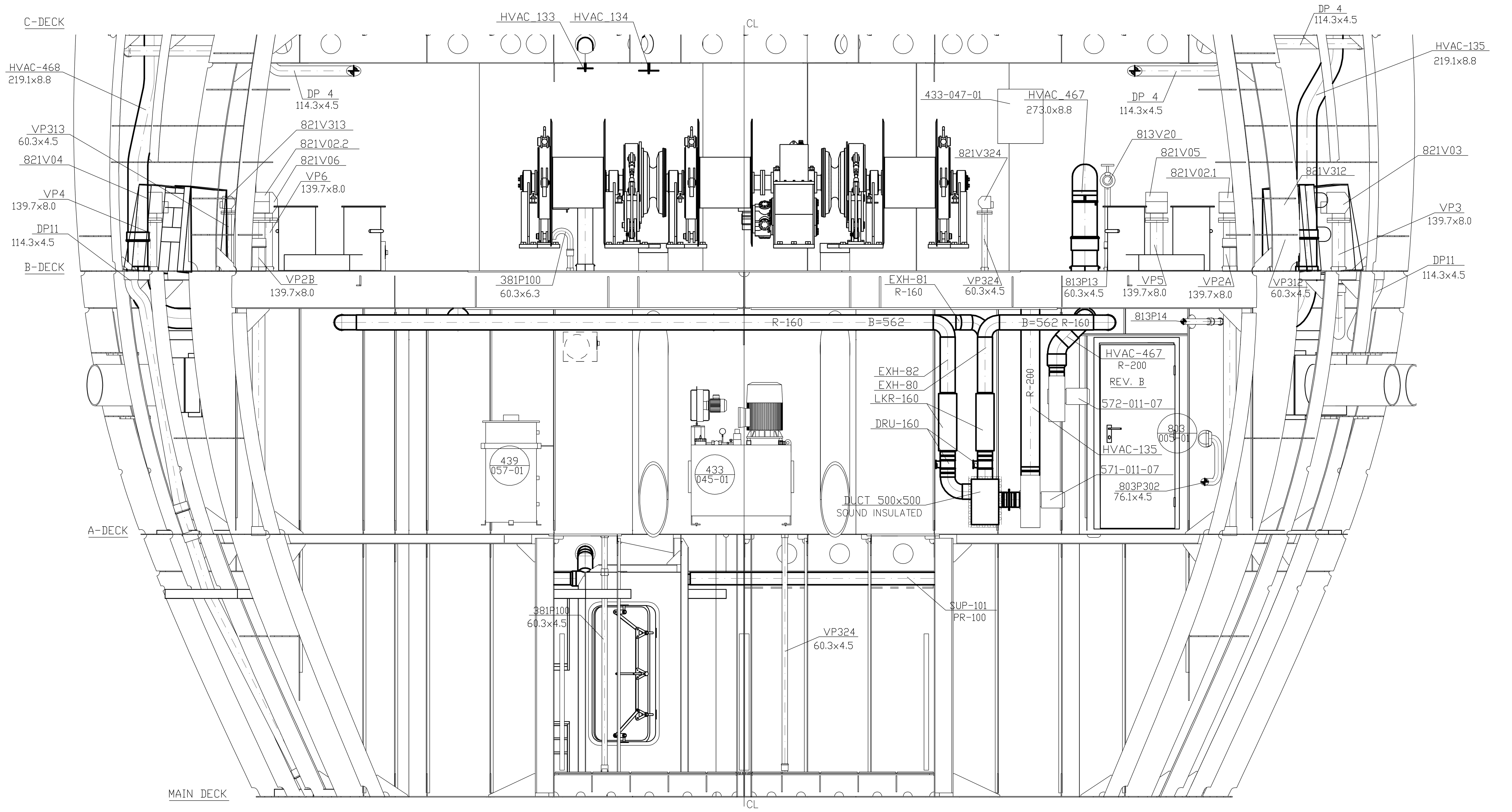
Nsfi	No	Indication	Capacity	Type
803-005-01	1	BILGE EJECTOR –	12 m?/h 1 bar	Allweiler –
572-011-07	1	FOR STORE FOREPEAK E-35, EXHAUST FAN	. 1500 m3/h	NYBORG MSV 160 B1BG
571-011-07	1	FOR MESS ROOM E-5, EXHAUST FAN	. 1600 m3/h	NYBORG MSV 200 B1BG
439-057-01	1	LO STORAGE TANK WINDLASS	250 L –	YARD SUPPLY –
433-045-01	1	HYDR. POWER PACK WINDLASS	100 l/min 270 Bar	ODIM –

Changed pipeline DP4	14.04.09	EER	B
Updated	03.02.09	EER	A

TITLE: PIPE ARR. WINDLASS / MOORING EQUIPMENTS	SCALE: 1:25	DRAWN: EER 13.08.08 FORMAT: A0 ARCHIVE BOOK:
APPROVED BY:	ULSTEIN ULSTEIN DESIGN AS P.O.Box 158 N-6067 Ulsteinvik Norway Tlf: +47 7000 8000 Fax: +47 7000 8559 www.ulsteingroup.com	YARD NO.: NB 66/67 PROJECT NO: ULSTEIN SX124 U10321 DRAWING: U10321_433-650-01 B REPLACEMENT: DEP: 282 SHEET: 1/1 MA

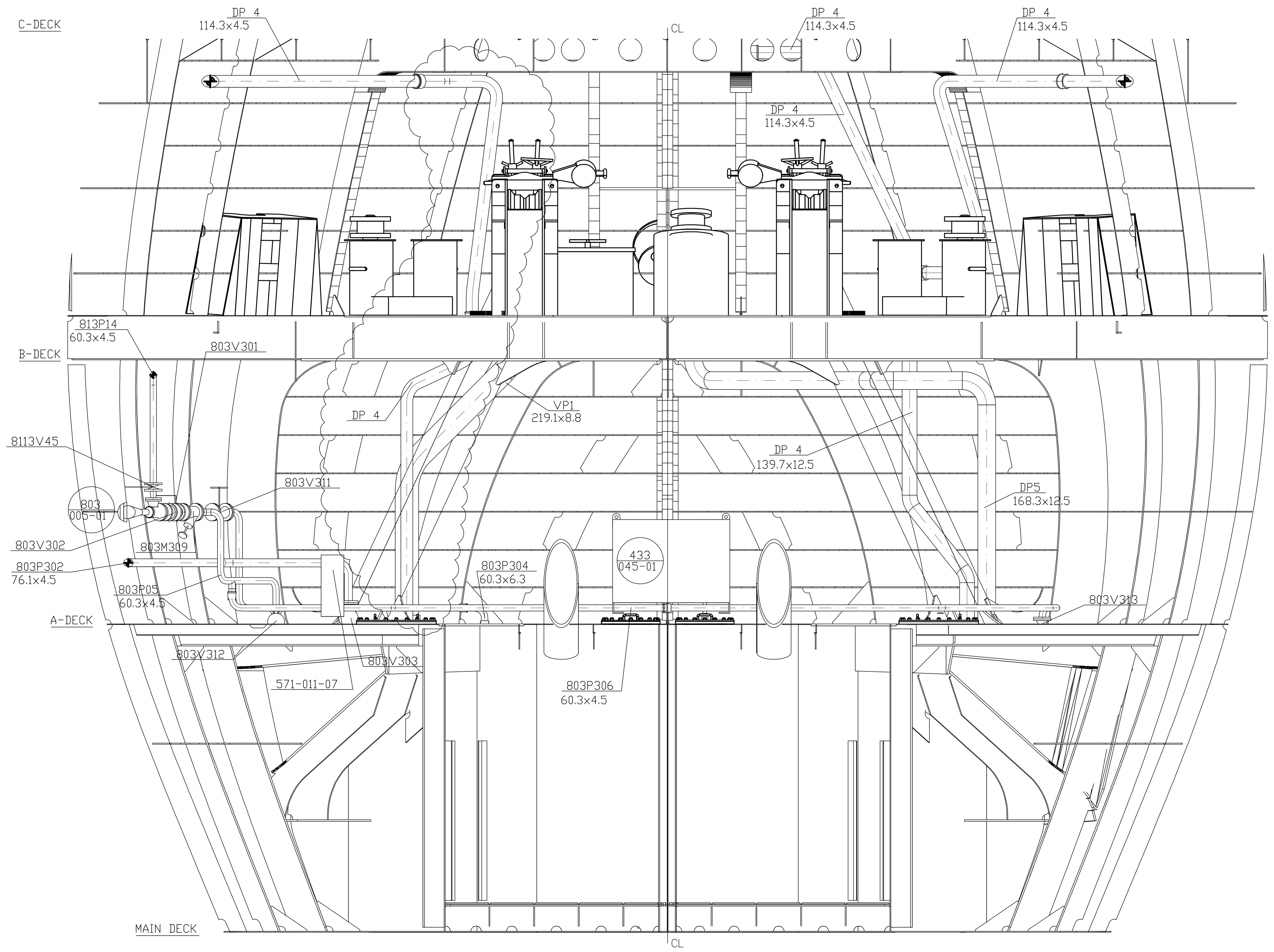


SIDE VIEW



Section FR103-FR107

LOOKING AFT



SECTION FR107-FR117

LOOKING FORE

Nsfi	No	Indication	Capacity	Type

Changed pipeline DP4	14.04.09	EER	B
Updated	03.02.09	EER	A

TITLE: PIPE ARR. WINDLASS / MOORING EQUIPMENTS

SCALE: 1:25

DRAWN: EER 13.08.08

FORMAT: A0

ARCHIVE BOOK:

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P.O.Box 158
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www.ulsteingroup.com

YARD NO.: NB 66/67

ULSTEIN SX124 — PROJECT NO: U10321

DRAWING: U10321_433-650-02 B

REPLACEMENT:

APPROVED BY:

DEP: 282 SHEET: 1/1 MA

APPENDIX 8

LIST OF SPILL RESPONSE EQUIPMENT CARRIED ON BOARD, AND PLANNED MAINTENANCE SCHEDULE

LIST OF SPILL RESPONSE EQUIPMENT CARRIED ON BOARD			
ITEM	**DESCRIPTION**	**STORAGE LOCATION**	**NUMBER**
	OIL boom, 10 x 350 cm		16 pcs
	OIL R pad, 43 x 48 cm		400 pcs
	Bags for waste disposal, 40 ltr		40 pcs
	Disposable Oil resistant coveralls		6 pcs
	Oil resistant gloves		6 pairs
	Oil resistant boots		6 pairs

PLANNED MAINTENANCE SCHEDULE:

1. **Prevention Equipment**

Tank Lids, check that:

- tank lids sit squarely on the coamings
- packing is in good condition
- cleats have sufficient movement
- sighting ports are sitting properly
- packing of sighting ports

Butterworth Plates, check that:

- plates sit squarely on aperture
- packing is properly fitted with no gaps
- all studs have good threads
- retaining nuts screw down tightly

Deck Pipelines (cargo, bunker and hydraulic), check:

- the condition of deck lines, ensuring that there is no apparent leakage
- couplings for signs of leakage
- deck valves for tightness
- that blanks are available for all manifolds, and that all fit well with bolts in each hole
- that sample cocks are fitted tightly with no leakage from either the sampling end or the end connected to the pipework

Hull Plating, check the condition of hull for damage or possible weak spots, and notify Head Office of areas of concern.

If necessary, make temporary repairs to ensure tightness and ensure that Head Office is informed.

Containment Equipment

Check that:

- drip trays are sound with no obvious cracks or holes
- save-alls around bunker vent pipes (where fitted) are sound
- scupper plugs are in good condition and that they are a good fit in the scuppers
- there are sufficient spare scupper plugs on board, and their location is known
- portable pumps and eductors are working satisfactorily
- all drain plugs in drip trays and save-alls can be shut tight
- there are sufficient quantities of detergent on board, and its location is known
- there are sufficient quantities of absorbent material on board, and its location is known
- there are sufficient scoops, buckets and squeegees on board for mopping up operations, and their location is known
- that pipework and gauges associated with deep well cargo pumps are tight.

3. Spillage Equipment

Check that:

- detergent or treatment fluid is in containers which would make it readily available for use
- foam branch pipes and portable spraying equipment is readily available and in good working order
- all methods of communication can be operated effectively

4. Permanent equipment

Check that:

- eductors are in good working order
- all components of the engine room bilge oily water system work satisfactorily, and there is a sign in the vicinity of associated overboard discharge(s), indicating the need for them to be shut and lashed in port
- overboard discharge valves are lashed shut when not in use
- all components of the oil discharge monitoring equipment in the ballast system work satisfactorily
- the MARPOL interface detector is readily available and in good condition

APPENDIX 9

RECORD OF POLLUTION PREVENTION DRILLS

DATE	**TYPE OF SPILL CONTINGENCY**	**LOCATION OF SHIP**	**PARTICIPANTS**

Updated record available on vessel's Insite reporting system.

APPENDIX 10

REFERENCES

The following publications will provide additional assistance n the preparation of ships pollution emergency plans:

"Guidelines for the Development of Shipboard Marine Pollution Emergency Plans. 2001 Edition".
International Maritime Organization (IMO)
Available in English, French and Spanish from IMO, Publications Section, 4 Albert Embankment, London SE1 7SR.
(This booklet contains guidelines for the Shipboard Oil Pollution Emergency Plan (SOPEP) required by ships carrying oil as cargo or as bunkers, and guidelines for the Shipboard Marine Pollution Emergency Plan (SMPEP) required by the above ships that are also certified to carry noxious liquid substances.)

"Provisions Concerning the Reporting of Incidents Involving Harmful Substances under MARPOL 73/78".
International Maritime Organization (IMO)
Available in English, French and Spanish from IMO, as above.

"Peril at Sea and Salvage - A Guide for Masters"
International Chamber of Shipping and Oil Companies International Marine Forum (ICS/OCIMF)
Available from Witherby & Co. Ltd., London
32-36 Aylesbury Street, London EC1R OET

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International Chamber of Shipping, Oil Companies International Marine Forum, and International Association of Ports and Harbors (ICS / OCIMF / IAPH)
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