Sauropod 3D Marine Seismic Survey (WA-527-P)

Environment Plan

28 October 2019

Project No.: 0500168

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
°	Degrees
°C	Degrees Celsius
‘	Minutes
“	Seconds
3D	Three dimensional
AFZ	Australian Fishing Zone
AHS	Australian Hydrographic Society
ALARP	As low as reasonably practicable
AMMC	Australian Marine Mammal Centre
AMOSC	Australian Marine Oil Spill Centre
AMP	Australian Marine Park
AMSA	Australian Marine Safety Authority
API	American Petroleum Institute gravity (A measure of how heavy or light a petroleum liquid in comparison to water)
ASBTIA	Australian Southern Bluefin Tuna Industry Association
BIA	Biologically important area
BoM	Bureau of Meteorology
BWMC	Ballast Water Management Certificate
BWMP	Ballast Water Management Plan
CCWA	Conservation council of Western Australia
CFA	Commonwealth Fisheries Association
COLREGS	International Regulations for Preventing Collisions at Sea 1972
cP	Centipoise (unit of viscosity)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWR	Department of Agriculture and Water Resources
dB	Decibel
DEC	Department of Environment and Conservation
DEH	Department of Environment and Heritage
DoEE	Department of the Environment and Energy
DOF	Department of Fisheries
DoT	Department of Transport
DPIRD	Department of Primary Industries and Regional Development
DPLH	Department of Planning, Lands and Heritage
DSEWPaC	Department of Sustainability, Environment, Water…
E	East
EEZ	Exclusive Economic Zone

Name	Description
EMBA	Environment that may be affected
ENVID	Environmental hazard identification
EP	Environment Plan
EPBC	Environment Protection and Biodiversity Conservation
EPO	Environmental performance outcome
EPS	Environmental performance standard
ERM	Environmental Resources Management
ESD	Ecologically sustainable development
FRMA	Fish Resources Management Act 1994
GHG	Greenhouse gas
g/m^2	Grams per square meter (unit of surface or area density)
GMEM	Gippsland Marine Environmental Monitoring
HF	High frequency
hrs	Hours
Hz	Hertz
IAGC	International Association of Geophysical Contractors
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IMO	International Maritime Organisation
IMS	Invasive marine species
IOGP	International Association of Oil and Gas Producers
ISPP	International Sewage Pollution Prevention
IUCN	International Union for the Conservation of Nature
JASCO	JASCO Applied Sciences
KEF	Key Ecological Feature
KLC	Kimberley Land Council
km	Kilometre
km^2	Square kilometres
LF	Low frequency
m	Metre
m^2	Metres squared
m^3	Metres cubed
M	Million
m/s	Metres per second
MAMF	Marine Aquarium Managed Fishery
MARPOL	International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978
MDO	Marine diesel oil
MEPC	Marine Environment Protection Committee
MF	Medium frequency

Name	Description
MFO	Marine fauna observer
MGO	Marine gas oil
MMF	Mackerel Managed Fishery
MOD	Maximum-over-depth
MPA	Marine Protected Area
MSS	Marine Seismic Survey
MUZ	Multiple Use Zone
N	North
NBPMF	Nickol Bay Prawn Managed Fishery
NDSMF	Northern Demersal Scalefish Managed Fishery
nm	Nanometre
NMSC	National Marine Safety Committee
NNTT	National Native Title Tribunal
NOAA	National Oceanic and Atmospheric Administration
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NWMR	North-west Marine Region
NWS	North West Shelf
NWSTF	North West Slope Trawl Fishery
OBN	Ocean bottom nodes
OIW	Oil in Water
OPGGS	Offshore Petroleum and Greenhouse Gas Storage Act 2006
PFTIMF	Pilbara Fish Trawl Interim Managed Fishery
PK	Peak pressure levels
PLF	Pilbara Line Fishery
pm	Picometre
PMI	Potential mortality injury
PMST	Protected Matters Search Tool
POLREP	Oil Pollution Report
PPA	Pearl Producers Association
ppb	Parts per billion
PSMA	Department of the Prime Minister and Cabinet Australia
PSU	Practical salinity unit
PTMF	Pilbara Trap Managed Fishery
PTS	Permanent threshold shift
RPS	RPS Group
RWDC	Restricted work day case
S	South
SBTF	Southern Bluefin Tuna Fishery

Name	Description
SEL	Sound exposure levels
SITREP	Situation Report
SOLAS	International Convention for the Safety of Life at Sea
SOPEP	Shipboard Oil Pollution Emergency Plan
SSMF	Specimen Shell Managed Fishery
TSSC	Threatened Species Scientific Committee
TSS	Temporary threshold shift
µg/l	Micrograms per litre
UNESCO	United Nations Educational, Scientific and Cultural Organization
µPa	Micropascals
UTM	Universal Transverse Mercator
UXO	Unexploded ordinance
VOC	Volatile organic compounds
W	West
WA	Western Australia
WAFIC	Western Australian Fishing Industry Council
WAM	Western Australian Museum
WASF	Western Australian North Coast Shark Fishery
WDCS	Whale and Dolphin Conservation Society
WSTF	Western Skipjack and Tuna Fishery
WTBF	Western Tuna Billfish Fishery
WWF	World Wildlife Fund for Nature

1. INTRODUCTION

1.1 Scope of This Environment Plan

3D Oil Limited (3D Oil) is proposing to undertake the Sauropod 3D marine seismic survey (hereafter referred to as the Sauropod 3D MSS) in exploration permit area WA-527-P, which is located on the North West Shelf in the Roebuck Basin. 3D Oil is the Operator and sole titleholder of WA-527-P, which covers an area of 6,600 km^2. The purpose of the Sauropod 3D MSS is to collect three-dimensional (3D) geophysical data about the underlying rock types to inform oil and gas exploration.

This Environment Plan (EP) has been prepared in accordance with the requirements of the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) and associated Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS (E) Regulations). It has also been prepared with reference to the Environment Plan Content Requirements Guidance Note (Rev 4, April 2019) produced by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

1.2 Proponent

3D Oil is an Australian Stock Exchange (ASX)-listed exploration company with a growing portfolio of exploration acreage. 3D Oil currently has interests in exploration permits in the offshore Gippsland (VIC/P57) and Otway Basins (T/49P) of South East Australia and the Roebuck Basin Offshore Western Australia (WA-527-P).

Further information about 3D Oil is available at their website at: www.3doil.com.au.

1.3 Titleholder and Nominated Liaison Person

Permit titleholder and titleholder nominated liaison person details for WA-527-P are provided in Table 1-1.If there is a change in the titleholder, the titleholder’s nominated liaison person or a change in the contact details for the titleholder or liaison person, 3D Oil will notify NOPSEMA and provide the updated details (as described in Section 9.10 of this EP).

Table 1-1 Details of WA-527-P Titleholder and Nominated Liaison Person

Titleholder Details	Liaison Person Details
3D Oil Limited Level 18, 41 Exhibition St, Melbourne 3000	Dr Dave Briguglio Exploration Manager E: dbriguglio@3doil.com.au T: +61 03 9650 9866

2. ENVIRONMENTAL REQUIREMENTS

The *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) provides the regulatory framework for all offshore petroleum exploration, production and greenhouse gas (GHG) activities in Commonwealth waters. The related OPGGS (E) Regulations 2009 require titleholders to undertake their petroleum activity in accordance with an EP accepted by NOPSEMA. This EP has been prepared to meet the requirements of the OPGGS (E) Regulations. This section provides information on the requirements that apply to the activity. Requirements include relevant laws, codes, standards, agreements, treaties, conventions or practices (in whole or part) that apply to the jurisdiction in which the activity will take place.

The Sauropod 3D MSS will take place within Commonwealth waters. Relevant requirements associated with the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), related policies, guidelines, plans of management, recovery plans, threat abatement plans and other relevant advice issued by the Department of the Environment and Energy (DoEE) are detailed in Section 4 in the applicable sub-sections, as part of the description of the existing environment.

Table 2-1 provides a summary of requirements that apply to the activity and are relevant to the activity's environmental management, while Table 2-2 summarises the international conventions and agreements for which Australia is a signatory that are relevant to the Sauropod 3D MSS.

Table 2-1 Summary of Requirements Relevant to the Activity and its Environmental Management

Requirements	Scope (as Relevant to this EP)	Application to Sauropod 3D MSS	Administering Authority
Australian Maritime Safety Authority Act 1990	Facilitates international cooperation and mutual assistance in preparing and responding to major oil spill incidents, and encourages countries to develop and maintain an adequate capability to deal with oil pollution emergencies.	Under this Act, any hydrocarbon spill to the marine environment, resulting from the survey must be reported. In Commonwealth waters the Australian Maritime Safety Authority (AMSA) is the Statutory Agency for vessels and must be notified of all incidents involving a vessel. Hydrocarbon spill risks are detailed in Section 8.	AMSA
Biosecurity Act 2015 *Biosecurity Regulations 2016*	The objects of this Act are: (a) to provide for managing the following: (i) biosecurity risks; (ii) the risk of contagion of a listed human disease; (iii) the risk of listed human diseases entering Australian territory or a part of Australian territory, or emerging, establishing themselves or spreading in Australian territory or a part of Australian territory; (iv) risks related to ballast water; (v) biosecurity emergencies and human biosecurity emergencies; (b) to give effect to Australia's international rights and obligations, including under the International Health Regulations, the SPS Agreement and the Biodiversity Convention.	The Biosecurity Act and regulations apply to 'Australian territory' which is the airspace over and the coastal seas out to 12 nm from the coast line. Biosecurity risks associated with the survey are detailed in Section 8.8.	Department of Agriculture and Water Resources (DAWR)
Biosecurity Act 2015	Australian Ballast Water Management Requirements (DAWR 2017)	Provides guidance on how vessel operators should manage ballast water when operating within Australian seas in order to comply with the Biosecurity Act. Section 8.8 details these requirements.	DAWR

Requirements	Scope (as Relevant to this EP)	Application to Sauropod 3D MSS	Administering Authority
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	The EPBC Act aims to protect the environment, particularly matters of national environmental significance for which Australia has made international agreements. The EPBC Act streamlines national environmental assessment and approval processes, and promotes ecologically sustainable development and conservation of biodiversity. It also provides for a cooperative approach to the management of natural, cultural, social and economic aspects of ecosystems, communities and resources. Section 3A of the Act defines the principles of ecological sustainable development. The following principles are principles of ecologically sustainable development: (a) decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations; (b) 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; (c) 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; (d) the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making; (e) improved valuation, pricing and incentive mechanisms should be promoted.	Petroleum activities are excluded from within the boundaries of a World Heritage Area (Sub regulation 10A(f). Petroleum activities must be carried out in a manner consistent with the principles of ecological sustainable development set out in Section 3A of the EPBC Act. Determination of impact and risk Acceptability details that residual risks are ALARP and the principles of ecologically sustainable development have been met (Section 6). Assessment of impacts and risks to Matters of National Environmental Significance (MNES) from the survey are described in Section 7 and 8.	DoEE

Requirements	Scope (as Relevant to this EP)	Application to Sauropod 3D MSS	Administering Authority
Environment Protection and Biodiversity Conservation Regulations 2000	Provides additional regulations in regards to Matters of National Environmental Significance.	Part 8 of the Regulations details requirements for operating vessels and aircraft in relation to cetaceans. Section 7.2 detail these requirements.	DoEE
EPBC Act Policy Statement 2.1 Interaction between offshore seismic exploration and whales	The aim of this Policy Statement is to: provide practical standards to minimise the risk of acoustic injury to whales in the vicinity of seismic survey operations; provide a framework that minimises the risk of biological consequences from acoustic disturbance from seismic survey sources to whales in biologically important habitat areas or during critical behaviours; and provide guidance to both proponents of seismic surveys and operators conducting seismic surveys about their legal responsibilities under the EPBC Act.	The policy statement provides guidance on undertaking seismic activities in Australian waters to limit potential impacts to whales. Section 7.1 details how the policy statement has been applied to this survey.	DoEE
Historic Shipwrecks Act 1976	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.	Anyone who finds the remains of a ship, or an article associated with a ship, needs to notify the relevant authorities, as soon as possible but ideally no later than after one week, and to give them information about what has been found and its location. Refer to Section 4 for information on historic shipwrecks in relation to the Sauropod 3D MSS.	DoEE
Navigation Act 2012	Regulates international ship and seafarer safety, shipping aspects of protecting the marine environment and the actions of seafarers in Australian waters. It gives effect to the relevant international conventions (MARPOL 73/78, COLREGS 1972) relating to maritime issues to which Australia is a signatory.	Several Marine Orders are enacted under this Act relating to offshore petroleum activities, including: Marine Order 21: Safety and emergency arrangements Marine Order 27: Safety of navigation and radio equipment Marine Order 30: Prevention of collisions Marine Order 31: Vessel surveys and certification Marine Order 58: Safe management of vessels	AMSA

Requirements	Scope (as Relevant to this EP)	Application to Sauropod 3D MSS	Administering Authority
	The Act also has subordinate legislation contained in Regulations and Marine Orders.	Section 7 details where the applicable requirements apply to the survey.	
Offshore Petroleum and Greenhouse Gas Storage Act 2006 *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009*	Addresses all licensing, health, safety, environmental and royalty issues for offshore petroleum exploration and development operations extending beyond the three nautical mile limit. Ensures that petroleum activities are undertaken in an ecologically sustainable manner and in accordance with an approved EP.	A titleholder must have an in force EP prior to the commencement of any petroleum activity. This requirement is met by submission and acceptance of this EP. A significant modification, change or new stage of an existing activity that is not included in an in-force EP requires a revision of the EP to be submitted to NOPSEMA for acceptance. 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 must be met by the titleholder before NOPSEMA can accept the EP.	NOPSEMA
Offshore Petroleum and Greenhouse Gas Storage (Regulatory Levies) Act 2003 *Offshore Petroleum and Greenhouse Gas Storage (Regulatory Levies) Regulations 2004*	An Act to impose levies relating to the regulation of offshore petroleum activities and greenhouse gas storage activities.	Requires that EP levies are imposed on EP submissions, including revisions, where the activities to which the EP relates are authorised by one or more Commonwealth titles. This requirement applies once the EP is accepted.	NOPSEMA

Requirements	Scope (as Relevant to this EP)	Application to Sauropod 3D MSS	Administering Authority
Protection of the Sea (Prevention of Pollution from Ships) Act 1983	Regulates ship-related operational activities and invokes certain requirements of the MARPOL Convention relating to discharge of noxious liquid substances, sewage, garbage, air pollution etc.	Provides for discharges and emissions from ships as per MARPOL Annex I, II, III, IV, V and VI. Several Marine Orders are enacted under this Act relevant to the activity, including: Marine Order 91: Marine pollution prevention – oil Marine Order 93: Marine pollution prevention – noxious liquid substances Marine Order 94: Marine pollution prevention – packaged harmful substances Marine Order 95: Marine pollution prevention – garbage Marine Order 96: Marine pollution prevention – sewage Marine Order 97: Marine pollution prevention – air pollution Marine Order 98: Marine pollution prevention – anti-fouling systems. Provides exemptions for the discharge of materials in response to marine pollution incidents. Requires ships greater than 400 gross tonnes to have pollution emergency plans. Section 7 details where the applicable requirements apply to the survey.	AMSA
Protection of the Sea (Harmful Antifouling Systems) Act 2006	Is an offence to engage in negligent conduct that results in a harmful anti-fouling compound being applied to a ship. Australian ships must hold 'anti-fouling certificates', provided they meet certain criteria.	If required a ship must have a current anti-fouling certificate and must not use harmful antifouling compounds. Marine Order 98: Marine Pollution Prevention – anti-fouling systems is enacted under this Act. Section 7 details where the applicable requirements apply to the survey.	AMSA
International Association of Geophysical Contractors (IAGC) Environment Manual for	Provides the industry with useful information for conducting geophysical field operations in an environmentally sensitive manner.	Provide guidelines for best practice operations of seismic surveys to minimise environment impacts. Section 7.1 details applicable guidance.	IAGC

Requirements	Scope (as Relevant to this EP)	Application to Sauropod 3D MSS	Administering Authority
Worldwide Geophysical Operations (2013)			
IAGC Mitigation Measures For Cetaceans during Geophysical Operations (February 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.	Provide recommended mitigation measures for cetaceans during geophysical operations. Section 7.1 details applicable requirements.	IAGC
International Maritime Organisation (IMO) Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species (Biofouling Guidelines) 2011	Provide a globally consistent approach to the management of biofouling. They were adopted by the Marine Environment Protection Committee (MEPC) in July 2011 and were the result of three years of consultation between IMO Member States	Specific requirements are that vessels have a biofouling management plan and biofouling record book. Section 8.8 details these requirements.	IMO
WA Department of Fisheries (DoF) Guidance Statement on Undertaking Seismic Surveys in WA Waters	Identifies potential issues of concern associated with seismic surveys on fish and fish habitats, as defined under the Fish Resources Management Act 1994 (FRMA). It is aimed at giving proponents direction on general standards and protocols designed to avoid or mitigate the potential impacts of seismic surveys on fish. It is expected that proponents will incorporate these standards and protocols when planning and implementing seismic surveys.	Provides guidance and mitigation strategies to avoid or minimise potential impacts of seismic surveys on fish. Section 7.1 details applicable requirements.	WA Department of Primary Industries and Regional Development (DPIRD)
Draft National Strategy for Mitigating Vessel Strike of Marine Mega-fauna (2016)	The overarching goal of the Strategy is to provide guidance on understanding and reducing the risk of vessel collisions and the impacts they may have on marine mega-fauna.	Though in draft the strategy provides information and guidance on reducing vessel collisions with marine mega-fauna. Section 8.4 details applicable information and requirements.	DoEE

Requirements	Scope (as Relevant to this EP)	Application to Sauropod 3D MSS	Administering Authority
International Association of Oil & Gas Producers (IOGP) Recommended monitoring and mitigation measures for cetaceans during marine seismic survey geophysical operations (March 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).	Provides recommended mitigation measures for cetaceans during a marine seismic survey, including exclusion zones, soft starts, seismic testing procedures, and recording Marine Fauna Observer (MFO) observations. Section 7.1 details applicable requirements.	IOGP

Table 2-2 Summary of Relevant International Agreements

Agreement	Scope (as Relevant to this EP)	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 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 (> 400 GT) will have a SOPEP in place (Section 9.6).
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).	Pollution from the survey activities will be managed in accordance with MARPOL requirements, as described in Sections 7 and 8.
International Regulations for Preventing Collisions at Sea, 1972 (COLREGS)	The COLREGS outline internationally agreed rules for safe navigation, including 'give way' rules between vessels and other requirements for safe conduct including the requirement to keep a look out, travel at a safe speed, and how to operate vessels in narrow channels.	The survey will adhere to the requirements of COLREGS as implemented in Commonwealth waters through the Navigation Act 2012 (refer to Table 2-1).
International Contention for the Safety of Life at Sea, 1974 (SOLAS)	This convention outlines the minimum safety standards in the construction, equipment and operation of merchant ships.	The survey will adhere to the requirements of SOLAS as implemented in Commonwealth waters through the Navigation Act 2012 (refer to Table 2-1).
International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001	The Convention prohibits the use of harmful organotins in anti-fouling paints used on ships and establishes a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems.	The survey will adhere to the requirements of the convention as implemented through the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*.

3. DESCRIPTION OF THE ACTIVITY

3.1 Survey Location

The Sauropod 3D MSS will take place within Commonwealth waters off the north-west Western Australian (WA) coast, within the Roebuck Basin in exploration permit area WA-527-P. The survey will be undertaken within an 'Acquisition Area', where seismic data acquisition will occur. The Acquisition Area will be located within a broader 'Operational Area', which includes additional space for vessel activities such as line turns, run-ins, run-outs, soft-start procedures and seismic source testing.

The Acquisition Area will be up to a maximum of approximately 3,500 km^2, with an Operational Area of approximately 6,000 km^2 (Figure 3-1). At its closest point the Operational Area is approximately 120 km from the WA coast at Eighty Mile Beach, 190 km from Port Hedland and 230 km from Broome. Water depths in the Acquisition Area range from approximately 95 to 172 m.

3.2 Schedule

The Sauropod 3D MSS will take a maximum of 60 days to acquire, and will be undertaken within the acquisition window of January to April 2020, or January to April 2021.

The precise timing of the survey is subject to vessel availability, weather conditions and other operational considerations, and will take into account the seasonality of environmental sensitivities, where practicable. The exact start and end dates will be communicated to stakeholders (refer to Section 9.5.

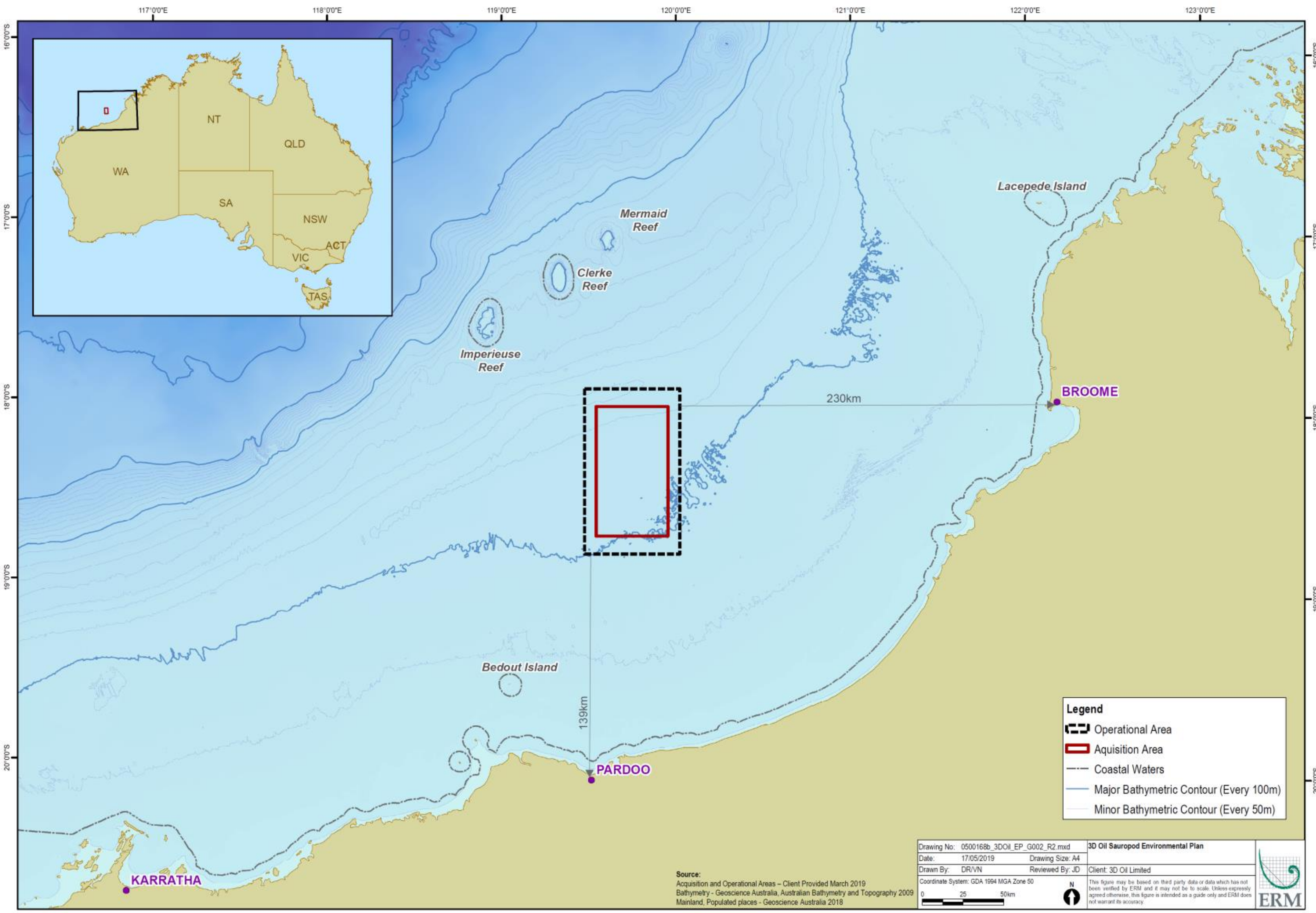


Figure 3-1 Location of Sauropod 3D MSS

3.3 Activity Details

The core activity that forms the basis for this EP is the undertaking of the Sauropod 3D MSS. Associated activities in support of the survey are likely to include 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 proposed seismic survey are summarised in Table 3-1 and described below.

The Sauropod 3D MSS will be undertaken by a seismic survey vessel towing an underwater seismic source and a series of up to 12 streamers behind it. The seismic source will consist of an array of airguns of varying volumes, distributed in three separate sub-arrays that will be discharged alternately. The airguns emit high pressure pulses of sound, with the primary energy directed downwards into the subsurface (not horizontally away from the source). The streamers contain underwater microphones (known as hydrophones) which record the sound waves reflected off the seabed and underlying rock formation. These data are later processed to provide information about the structure and composition of geological formations below the seabed.

The survey vessel will tow the seismic source at 5-10 m beneath the sea surface, with a total discharge volume of up to 3,090 cubic inches (in^3). The total volume size of the airgun array has been chosen based on the range of water depths within the survey area, and depth of the target within the subsurface to ensure adequate seismic imaging.

The hydrophone streamers will extend approximately 7 km behind the vessel and measure approximately 825 m across. The streamers will be towed at a depth of approximately 15 m below the surface. Tail buoys will be used to maintain position in the water and clearly indicate the streamer ends. As tail buoys are self-inflating, they 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. Depth monitoring and control devices positioned along the streamers will be used to maintain the preferred tow depth.

Table 3-1 Key Details for the Sauropod 3D MSS

Parameter	Sauropod 3D MSS
Survey Area	
Permit area	WA-527-P
Acquisition area	Approximately 3,500 km^2
Operational area	Approximately 6,000 km^2
Seismic Activity	
Survey earliest commencement date	January 2020
Survey latest completion date	April 2021
Duration of survey	60 days
Length of sail lines	83 km
Time to traverse a sail line	~10 hours
Orientation of sail lines	North-South
Distance between sail lines	450 m
Seismic vessel sail line speed	4.5 knots
Seismic source discharge interval	Approximately every 12.5 m (approximately every 5.4 seconds) along survey lines
Seismic Source	

Parameter	Sauropod 3D MSS
Type	Airgun / three sub-arrays, which will be discharged alternately
Size	3,090 in^3
Pressure	2,000 psi
Source levels (at 0–2,000 Hz)	255 dB re 1 µPa m (PK) 228-231 dB re 1 µPa^2m^2s (SEL)
Sound source tow depth	5-10 m
Streamers	
Number	12
Streamer length	7,000 m
Distance from seismic vessel bow to tail buoy	7,525 m
Distance between streamers	75 m
Streamer tow depth	15 m
Vessels	
Seismic vessel	One vessel - specific vessel yet to be determined
Support vessels	Two support vessels (one supply and one chase) – specific vessels yet to be determined
Refuelling	Refuelling at sea will occur approximately every 2-4 weeks (depending on the specific vessel and contractor)
Crew changes	Via helicopter or support vessel every 4-6 weeks.

3.3.1 Seismic Source Operation

When acquiring data, the vessel will travel along a series of pre-determined lines within the Acquisition Area at approximately 4.5 knots (8 km/hour), discharging the seismic source at 12.5 m intervals (approximately every 5.4 seconds).

The Sauropod 3D MSS is a typical 3D survey using methods and procedures similar to others conducted in Australian waters. No unique or unusual equipment or operations are proposed. The survey will be conducted 24 hours a day. Figure 3-2 represents an indicative seismic survey process. Survey and equipment parameters are provided in Table 3-1.

The seismic survey vessel will typically acquire the 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, offset approximately 900 m from the previous line. This pattern is repeated until the required coverage is completed. The vessel will sail lines that are typically in a north-south orientation. Each sail line is approximately 83 km long and will take approximately 10 hours to acquire. The time required to complete each sail line is dependent on vessel speed and currents.

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.

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 survey 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 in the 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 in accordance with control measures and performance standards specified in this EP.

3.3.2 Infill

When acquiring 3D marine seismic data, surface currents may shift the streamers away from their nominal positions. This shift, called feathering, can lead to holes in the data coverage. Holes in data coverage can also occur when the airgun array is turned off due to technical or logistical reasons (e.g. technical problems or marine fauna interactions). These holes are typically filled in by steering the vessel closer to the previous sail-line or by acquiring additional sail-lines along the coverage holes. These extra sail-lines are commonly known as infill. Infill can be a large part of the time and cost for a marine seismic survey. Without infill activity, seismic surveys would be incomplete, the data compromised and contract requirements not fulfilled.

It is not possible to estimate what the amount of feather (and resulting coverage) will be. Typically, pre-plot sail lines will be completed and the infills are left to the end of a survey, once the seismic data have been partially processed and all infill locations identified.

With proper infill management, unnecessary infill lines may be reduced or avoided. The on-board navigator steers the seismic vessel for coverage to minimise the amount of infill. Additionally, steerable streamers and fan-mode technique for the streamer spread are used to minimise infill requirements.

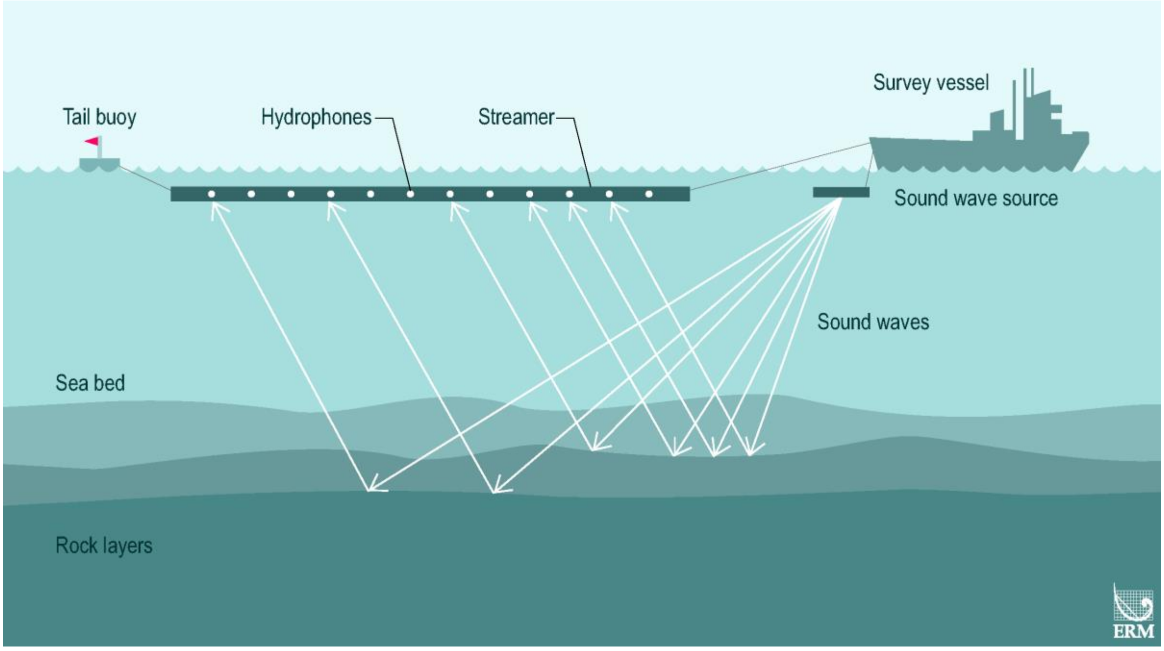


Figure 3-2 Representative Seismic Survey Process

3.3.3 Vessels

3.3.3.1 *Seismic Vessel*

A purpose-built survey vessel will be used for the Sauropod 3D MSS and will carry up to approximately 70 people. The specific vessel for the survey has yet to be determined.

3.3.3.2 *Support Vessels*

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

- One chase vessel accompanying the seismic vessel to assist with managing potential interactions with other marine users; and
- One supply vessel responsible for resupply, refuelling, and other support functions.

Refuelling and resupply at sea by a supply vessel is expected to occur approximately every 2-4 weeks during the survey (depending on the specific vessel and contractor). At-sea refuelling of the seismic vessel will only take place during daylight hours and within strict weather limit guidelines. Refer to Section 8.3 for details of control measures to be implemented during refuelling.

Crew changes are expected to be undertaken by a supply vessel or helicopter approximately every 4-6 weeks.

4. DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 Overview

This Section describes the environmental and socio-economic values and sensitivities within the existing environment of the Operational Area and 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 could be affected in any credible impact scenario. In this case, the EMBA represents an unplanned release of marine diesel oil (MDO). The EMBA was derived from oil spill modelling for an instantaneous release of 280 m^3 at the north-west corner of the Operational Area. It is important to note that the EMBA covers a much larger area than the area that is likely to be affected during any one single spill event. The modelling was run for a variety of weather and metocean conditions (300 simulations in total), and the resulting EMBA for the north-west corner of the Operational Area was extrapolated to the three other corners. Other nearby sensitivities that were considered potentially relevant to the EP are also described in this Section. The information contained in this Section has been used to inform the assessment of impacts and risks in Section 7 and Section 8.

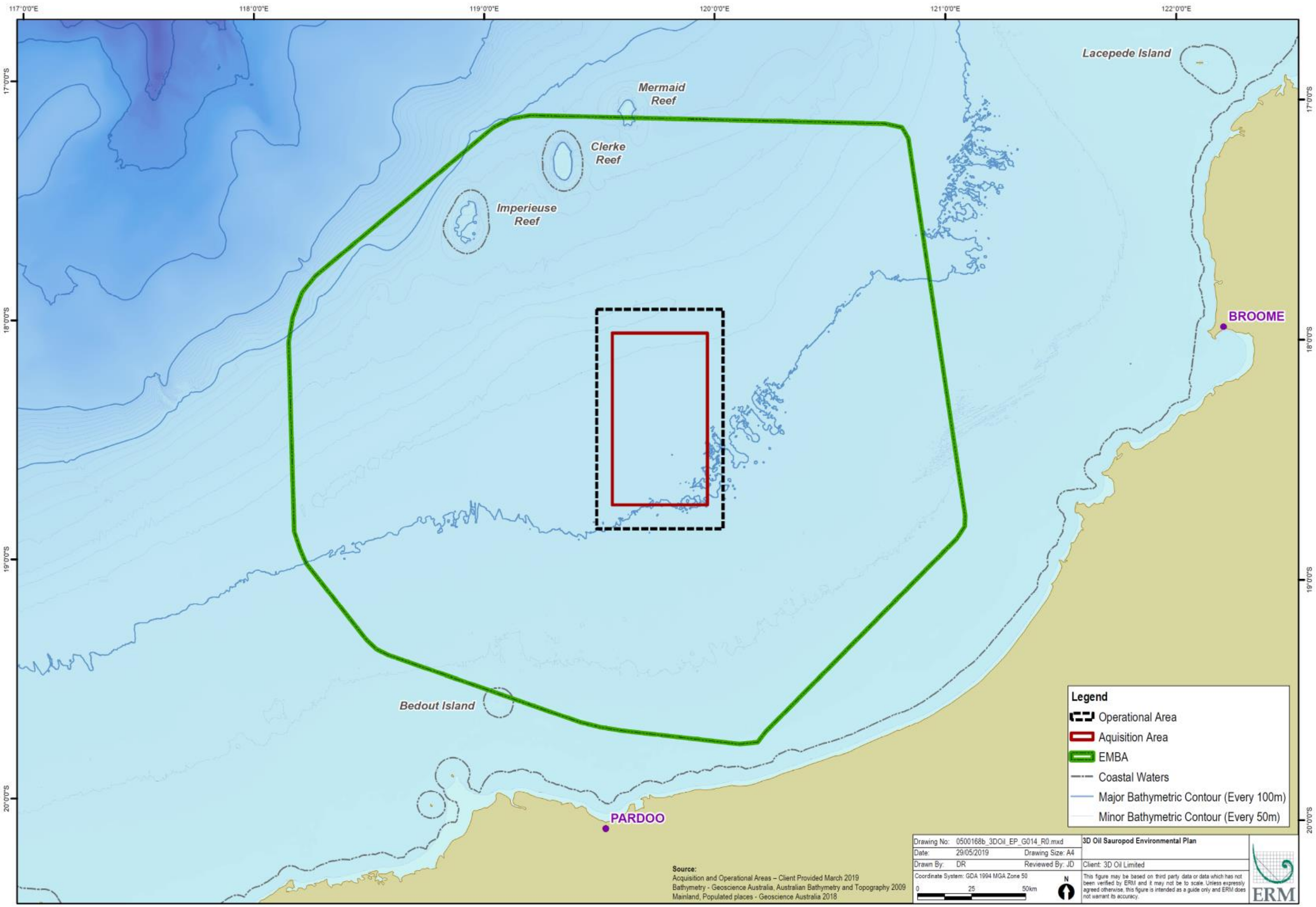


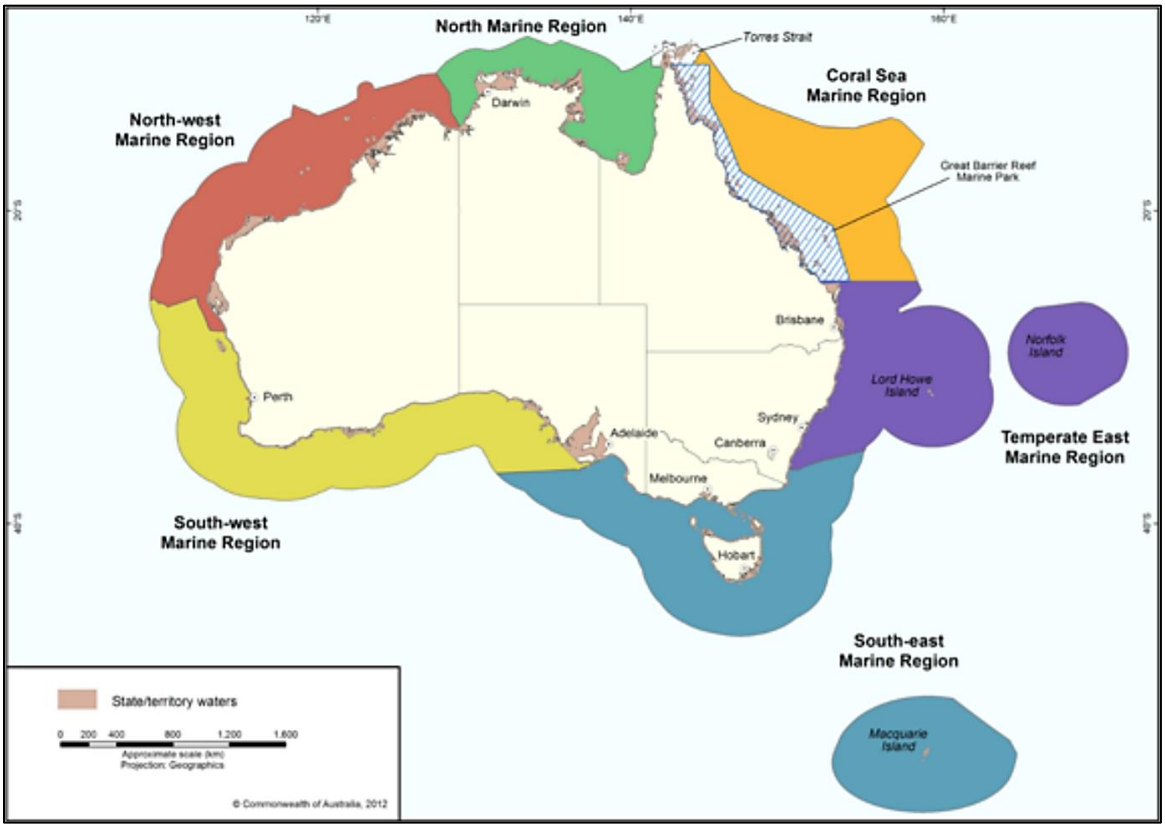
Figure 4-1 Operational Area and EMBA for the Sauropod 3D MSS

4.1.1 Regional Context – The North-west Marine Region

The Operational Area is located in the centre of the North West Shelf (NWS), an area of significant environmental, economic and cultural value. In 2008, the former Department of the Environment, Water, Heritage and the Arts (DEWHA) (now the Department of Energy and Environment) 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 Operational Area is located within the North-west Marine Region (NWMR).

The NWMR comprises Commonwealth waters from Western Australia–Northern Territory border to Kalbarri, south of Shark Bay. The NWMR is characterised by the following aspects (DEWHA 2008):

- Containing a large portion of continental shelf and continental slope;
- highly variable tidal regions and very high cyclone incidence;
- shallow-water tropical marine ecosystems which is home to globally significant populations of internationally threatened species;
- containing threatened and migratory species listed under the EPBC Act, including cetaceans, dugong, marine reptiles, seabirds and migratory shorebirds, seahorses and pipefish, sharks and sawfishes; and
- containing biologically important areas (BIAs), where protected species display biologically important behaviour such as breeding, foraging, resting or migration.



(Source: DSEWPaC 2012a)

Figure 4-2 Marine Bioregions of Australia

Within the NWMR, marine habitats are further categorised into eight provincial bioregions. The Operational Area is located within the Northwest Shelf Province, and the EMBA overlaps with part of the Northwest Transition (Figure 4-3). These two provincial bioregions are described below.

4.1.1.1 *Northwest Shelf Province*

The Operational Area is located within the Northwest Shelf Province, a bioregion that covers 238, 759 km^2 of waters on the continental shelf in depths of up to 200 m. The Northwest Shelf Province is described as a dynamic oceanographic environment, influenced by strong tides, cyclonic storms, long-period swells and internal tides (DEWHA 2008). Waters are generally warm and currents are primarily driven by the Indonesian throughflow (ITF). Diverse pelagic and demersal fish communities occupy the bioregion, and are thought to be closely associated with depth ranges. The region facilitates seasonal migrations of iconic megafauna such as the blue whale, humpback whale and whale shark. Coastal areas provide important breeding sites for a variety of seabirds, including Eighty Mile Beach and the Lacepede Islands. The region is commercially important to both the petroleum industry and commercial fishing industry.

4.1.1.2 *Northwest Transition*

The EMBA overlaps with part of the Northwest Transition, a bioregion that covers 184, 424 km2 and includes shelf break and continental slope and the majority of the Argo Abyssal Plain, covering depths up to 5,980 m. The Rowley Shoals are a key topographic feature of the bioregion (see Section 4.3.2 and Section 4.4.2.1). The continental slope portion of the bioregion is thought to support fish communities with high levels of species diversity and endemism, however little is known about the benthic biological communities in the deeper parts of the bioregion (DEWHA 2008). A range of pelagic migratory species including billfish, sharks, tuna and cetaceans occur within the bioregion, particularly in association with the Rowley Shoals.

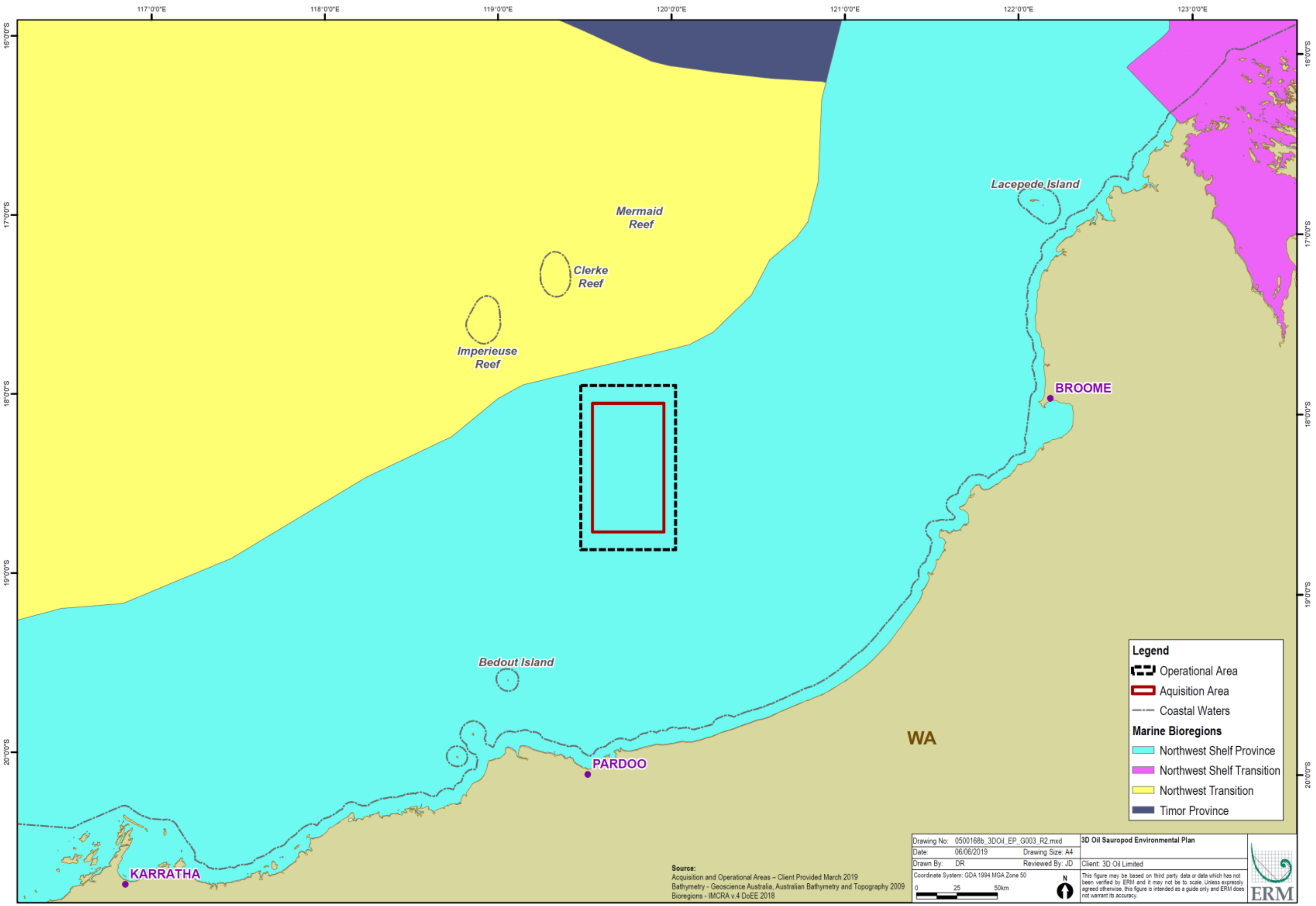


Figure 4-3 Provincial Bioregions (IMCRA v4.0)

4.2 Physical Environment

4.2.1 Climate

4.2.1.1 *Seasonal Patterns*

The climate of the NWMR is dry tropical, exhibiting a hot summer season from October to April and a milder winter season between May and September (BoM 2019). There are often distinct transition periods between the summer and winter regimes, which are characterised by periods of relatively low winds (Pearce et al. 2003).

4.2.1.2 *Air Temperature and Rainfall*

Air temperatures in the region, as measured at the Rowley Shoals platform (approximately 107 km from the Operational Area), indicate maximum average temperatures during summer of 30.4ºC and minimum temperatures of 23.6ºC in winter (BoM 2019).

The region experiences a tropical monsoon climate, with distinct wet (October to April) and dry (May to September) seasons (Pearce et al. 2003). Rainfall in the region (measured at Wallal Downs station) typically occurs during the wet season (summer), with highest falls observed during late summer (BoM 2019), and often associated with the passage of tropical low pressure systems and cyclones (Pearce et al. 2003). Rainfall outside this period is typically low.

4.2.1.3 *Wind*

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

Table 4-1 Predicted Monthly Average and Maximum Winds within the Operational Area (RPS 2019, Derived From CFSR Hindcast Model)

Month	Average Wind (knots)	Maximum Wind (knots)	General Direction (from)
January	11	35	W
February	11	47	W
March	9	58	Variable
April	8	27	Variable
May	13	32	ESE
June	13	30	ESE
July	13	29	ESE
August	11	29	ESE
September	11	31	Variable
October	10	25	WSW
November	10	27	WSW
December	11	36	W
Minimum	8	25	-
Maximum	13	58	-

4.2.1.4 *Tropical Cyclones*

Tropical cyclones are a relatively frequent event for the region, with the Pilbara coast experiencing more cyclonic activity than any other region of the Australian mainland coast (BoM 2019). Tropical cyclone activity can occur between November and April and is most frequent in the region during January to March, with an annual average of approximately one storm per month. Cyclones are less frequent in the months of November, December and April but historically the worst storms have occurred in April.

4.2.2 Oceanography

4.2.2.1 *Tides*

Tides in the region of the NWS are semi-diurnal and have a pronounced spring-neap cycle, with tidal currents flooding towards the south-east and ebbing towards then north-west (Pearce et al. 2003). Within the Northwest Shelf Province, tidal activity is considered a significant factor for the oceanography. Tides in this part of the bioregion are large and tend to increase in magnitude from south to north (from an amplitude of one metre at Exmouth to over three metres at Broome). In shallower waters, the tides contribute to the vertical mixing of the surface water layer and sediments. It should be noted that in the shallower coastal waters there is a high evaporation rate, which results in slower offshore movement of denser, more saline waters across the North West Shelf. This dense, more saline water is typically found as a bottom layer of coastal water out as far as the 200 m depth contour.

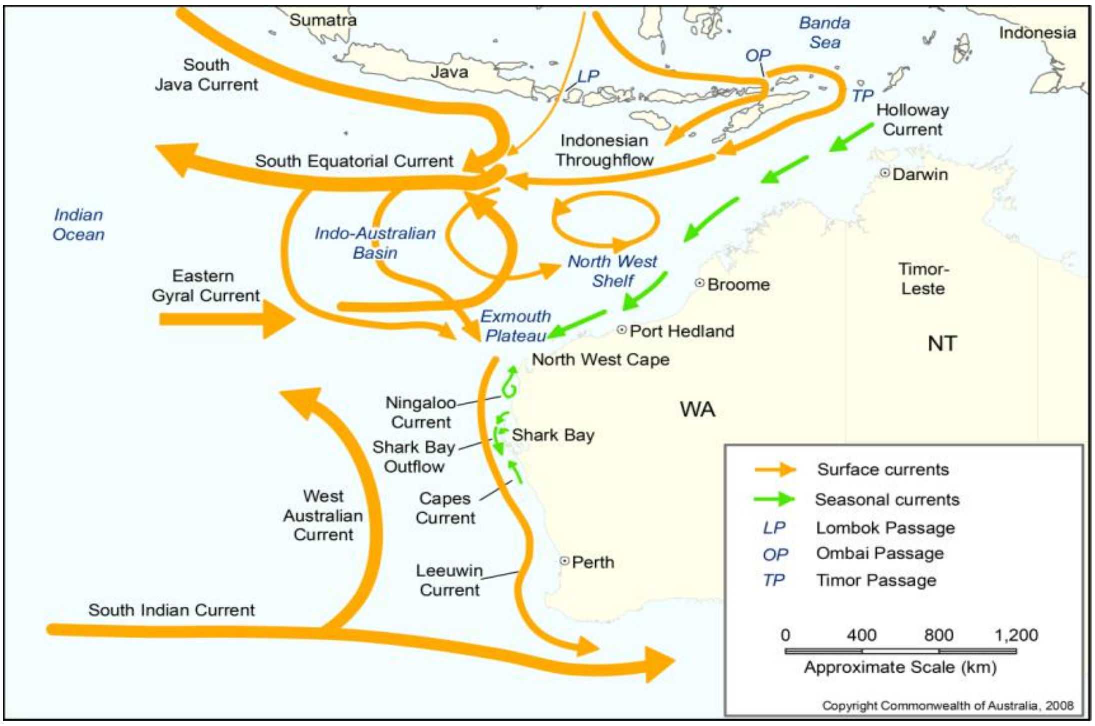
4.2.2.2 *Waves*

Internal tides are typically generated around the shelf break, and appear to contribute to the biological productivity of the region. When the internal waves break, it causes mixing of more nutrient-rich water with the photic zone, and therefore producing a biological productivity.

Furthermore, the region is known to have seasonal cyclonic events, which are key drivers in the bioregion. Tropical cyclone activity can occur between November and April and is most frequent in the region during January to March, with an annual average of approximately one storm per month. Cyclones are less frequent in the months of November, December and April but historically the worst storms have occurred in April. During cyclone season, wave action in the bioregion is increased.

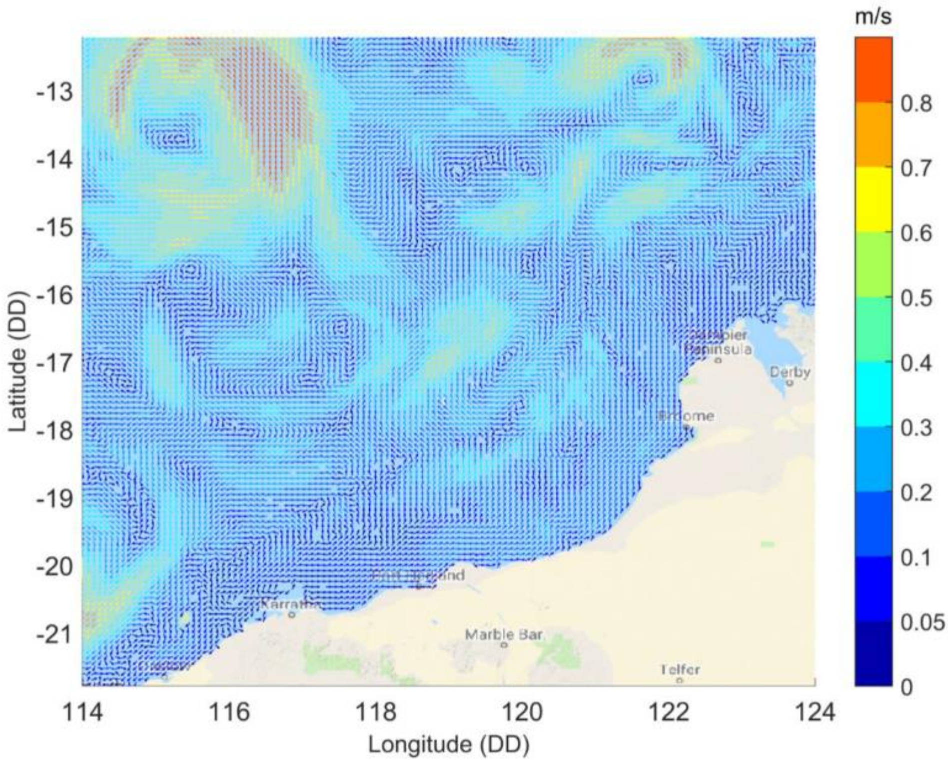
4.2.2.3 *Currents*

The oceanography of this bioregion is generated by the movement of surface currents from the waters of the Indonesian Throughflow (Figure 4-4). The Throughflow waters are circulated from the North-west Marine region through the South Equatorial and Eastern Gryal Currents. Within the Northwest Shelf Province water circulation is highly seasonal. During winter, the Throughflow’s southern flow is at its strongest and tends to dominate the water column. On the other hand, during summer, the Throughflow is weaker and strong winds from the southwest and causes intermittent reversal of the currents which generates upwellings of colder and deeper water. Typical ocean current circulation patterns during summer months (the main proposed timing of the Sauropod 3D MSS) are shown in Figure 4-5.



Source: DEWHA (2008)

Figure 4-4 Surface Currents in Western Australian Waters



Source: RPS (2019)

Figure 4-5 Typical Ocean Current Circulation Pattern During Summer Months

4.2.2.4 *Temperature*

The offshore oceanic seawater characteristics of the NWS exhibit seasonal and water depth variation in temperature and salinity, being greatly influenced by major currents in the region. Surface waters are relatively warm year round due to the tropical water supplied by the ITF and the Leeuwin Current, with temperatures reaching 30ºC in summer and dropping to 22ºC in winter (Pearce et al. 2003). This is reflected in data available from NOAA, where the average annual surface temperature water in the EMBA and Operational Area is ~27°C (NOAA 2019).

4.2.2.5 *Salinity*

Variation in surface salinity along the NWS throughout the year is minimal (between 35.2 and 35.7 PSU), with slight increases occurring during the summer months due to intense coastal evaporation (Pearce et al. 2003; James et al. 2004). This small increase in salinity during summer is then countered by the arrival of the lower salinity waters of the Leeuwin Current and Indonesian Throughflow in autumn and winter (James et al. 2004). This is also reflected in more recent publically available data from the NOAA, 2019b, where annual surface salinity levels are ~35 PSU.

4.2.2.6 *Water Quality*

Water quality in the NWMR is regulated by the ITF, a low-salinity water mass that plays a key role in initiating the Leeuwin Current (DSEWPaC 2012a). It brings warm, low-nutrient, low-salinity water from the western Pacific Ocean through the Indonesian archipelago to the Indian Ocean. It is the primary driver of the oceanographic and ecological processes in the region (DEWHA 2008). South of the NWMR, the Leeuwin Current continues to bring warm, low-nutrient, low-salinity water further south. Eddies formed by the Leeuwin Current transport nutrients and plankton communities offshore (DEWHA 2008). During summer, the Leeuwin Current typically weakens and the Ningaloo Current develops, facilitating upwellings of cold, nutrient-rich waters up onto the NWS (DSEWPaC 2012a). Other areas of localised upwelling in the NWMR include the Wallaby Saddle and Exmouth Plateau, where these seabed topographical features force the surrounding deeper, cooler, nutrient-rich waters up into the photic zone (DSEWPaC 2012a).

Turbidity is primarily influenced by sediment transport by oceanic swells and primary productivity (Semeniuk et al. 1982; Pearce et al. 2003). Upwelling of nutrient-rich waters may increase phytoplankton productivity in the photic zone, which may increase local turbidity (Semeniuk et al. 1982; Wilson et al., 2003). In nearshore areas, turbidity is highly variable due to storm runoff, wind generated waves and large tidal ranges (Pearce et al. 2003). Periodic events, such as major sediment transport associated with tropical cyclones, may influence turbidity on a regional scale (Brewer et al. 2007).

4.2.3 Bathymetry and Geomorphology

The Operational Area is located in waters approximately 95-172 m deep on the continental shelf. The bathymetry within the Operational Area is predominately characterised by relatively flat seabed. The water depth is approximately 95 m in the south-eastern corner of the Operational Area, and increases to 150 m in the north-west corner of the Operational Area (Figure 4-6).

In the wider EMBA, the Northwest Shelf Province encompasses more than 60% of the continental shelf in the NWMR (Baker et al. 2008), gradually sloping from the coastline to the shelf break at the edge of the region and includes water depths of 0–200 m. Approximately half the province is in water depths of 50–100 m (DEWHA 2008). The NWS Province includes a number of seafloor features such as submerged banks and shoals, and valley features that are thought to be morphologically distinct from other features of these types in different regions of the NWMR (DEWHA 2008).

Several steps and terraces caused by Holocene sea level changes are present in the NWMR with the most prominent of these features occurring as an escarpment along the North West Shelf and Sahul Shelf at a depth of 125 m. This escarpment is related to an ancient sub-aerially exposed land surface and coastline (beach and dune deposits), known as the ancient coastline. The ancient coastline at the 125 m depth contour is designated as a KEF and overlaps at the middle portion of the Operational Area (Section 4.4.3, Figure 4-14).

Previous movements in sea-level have had a significant influence on the geology of the region of the Operational Area. Between 21,000 and 19,000 years Before Present the sea level was approximately 120 to 125 m lower than present day (Lewis et al. 2013). Therefore, the processes responsible for the formations present in the region include sub-aerial exposure of sediment and processes associated with land and coastal environments. Across the NWS region, the occurrence of an undulating cemented surface, expressed at the seabed as a series of ridges interspersed with sediment ponds infilling hollows and troughs, is related to an ancient sub-aerially exposed land surface and coastline (beach and dune deposits). Other coastal features including sand bars and river outlets are also present in this region, complicating the geology and geological sequence adjacent (seaward) to the area of ridges. A complex geological feature in close proximity to the Operational Area and located within the EMBA is the Rowley Shoals, which contains the Mermaid Reef KEF (Section 4.4.3, Figure 4-14).

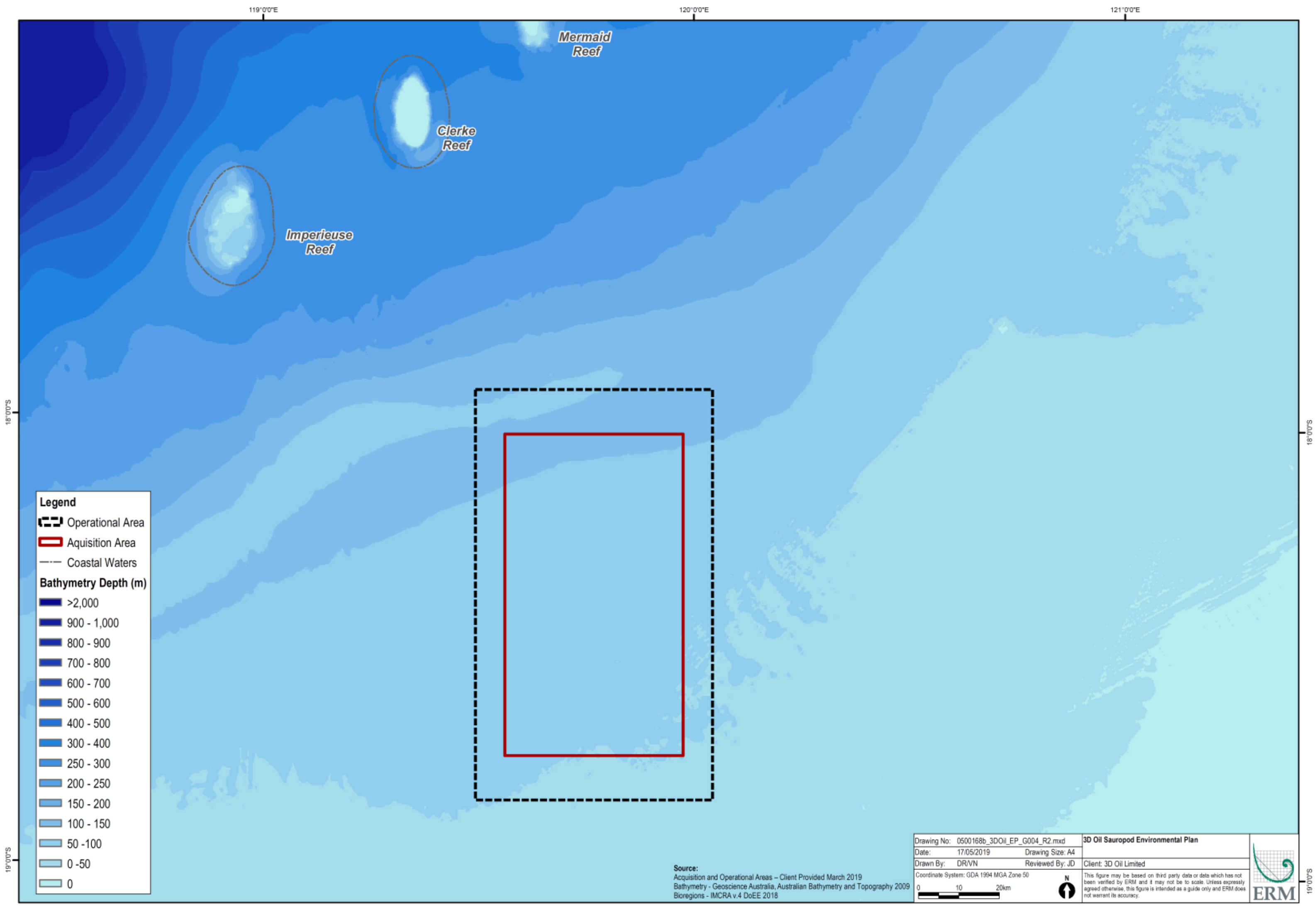


Figure 4-6 Bathymetry within the Operational Area and Surrounds

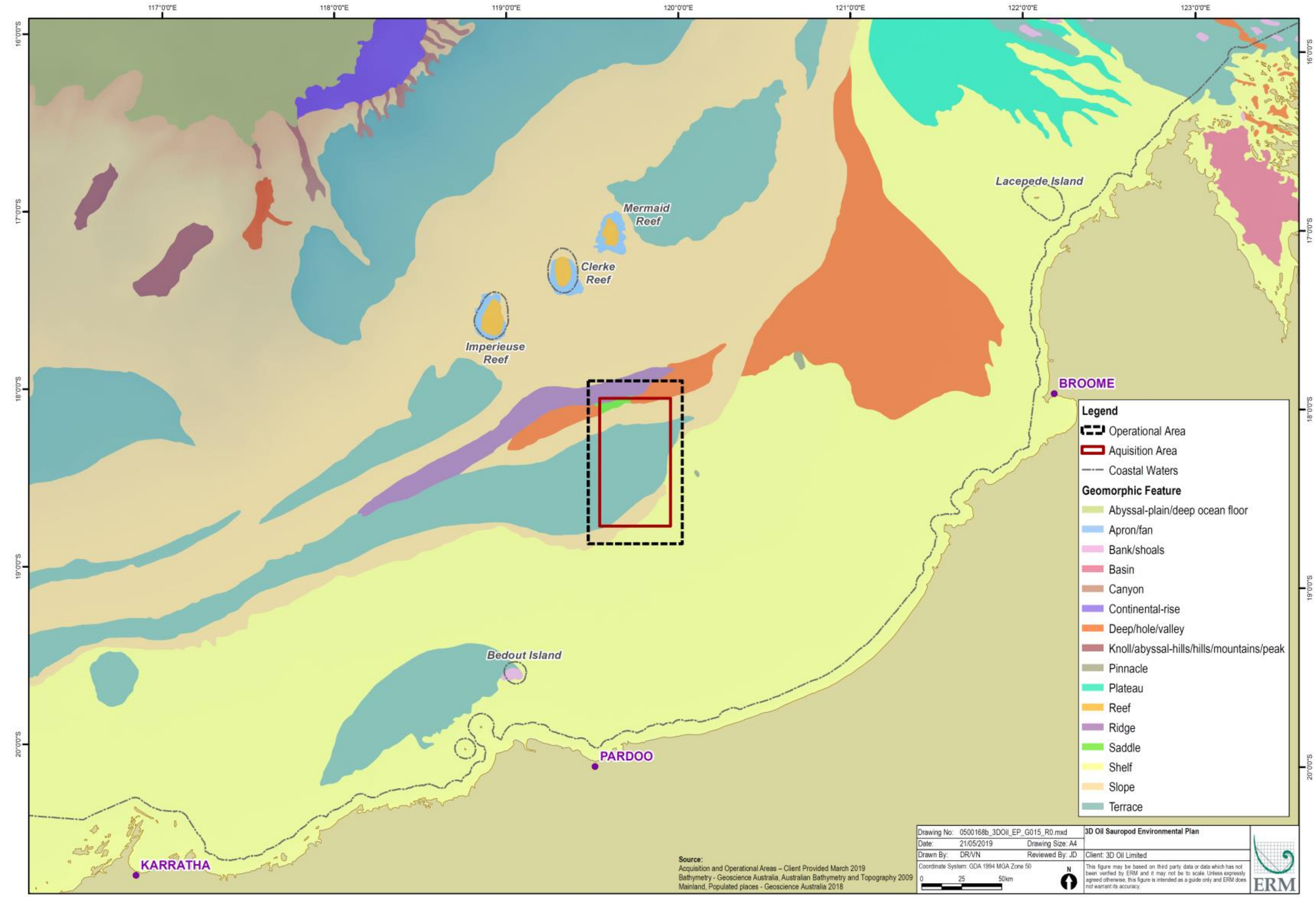


Figure 4-7 Geomorphic Features of the North West Shelf

4.2.4 Sedimentology

Sediment differentiation in the Northwest Shelf Province occurs on a north-south gradient and is thought to differ from the rest of the NWMR (DEWHA 2008). Sediment in the region is broadly characterised by calcareous gravel, sand and silt (CSIRO 2015). South of Broome, sediment is relatively homogenous and dominated by sand, typically only containing a small amount of gravel. Sediment becomes highly variable north of Broome, with sand being dominant in some areas and gravel dominant in others (DEWHA 2008). Within 100 km of the coast and 100 km of the shelf break there is the slight presence of mud in the sediment. Sediments within the Operational Area are expected to be relatively homogenous and dominated by calcareous gravel, sand and silt (DEWHA 2008; CSIRO 2015).

4.3 Biological Environment

4.3.1 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 being 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.

Spatial distribution of phytoplankton and zooplankton is irregular, both vertically and horizontally. Sporadic/short-lived and potentially localised episodes of nutrient upwelling can occur as a result of internal waves (the rising and sinking of seawater layers of different densities) at the shelf break, wind-driven currents, or cyclonic activity, which influence higher plankton concentrations.

Plankton within the Operational Area are expected to reflect the conditions of the wider upper continental slope. Surface waters of the NWS have low nutrient availability, with phytoplankton occurring in higher concentrations near areas where upwelling of deeper, nutrient-rich water occurs (Thomson 2015). The most common plankton in the offshore waters of the NWS are diatoms, single-cell algae with cell walls made of silica. Recent sampling by the UWA Oceans Institute (Thomson 2015) across the NWMR found that large summer blooms of diatoms occur in Pilbara offshore waters west of Broome. These blooms occur at the junction of stratified cool and warm water mass at depths of at least 45 m. High concentration of diatoms (Chlorophyll concentration of 1.39 – 2.10 µg/l) were recorded to occur in an area between 40 and 120 km east of the Operational Area.

4.3.2 Benthic Habitats and Communities

The distribution of benthic communities in the NWMR depends on the water depth, the substrate and sediment characteristics and availability of food. The sediments within the Operational Area are expected to be broadly characterised by calcareous gravel, sand and silt. This type of substrate is known to support relatively little seabed structure or sessile epibenthos.

The Operational Area is expected to be sparsely covered by sessile filter-feeding organisms (e.g. gorgonians, sponges, ascidians and bryozoans) and mobile invertebrates such as echinoderms, prawns and detritus-feeding crabs (Brewer et al. 2007; DEWHA 2008). Heyward et al. (1997) also noted that benthic macro-invertebrate infauna and epifauna such as worms, crustaceans, molluscs, gastropods, sea urchins, starfish, sea cucumbers, etc. typically occur in low numbers in water depths greater than 50 m in the NWMR. Macro-invertebrates that are present in these habitats comprise mainly polychaete worms, small crustaceans, amphipods and isopods such as shrimps and lice. Other invertebrates that may occur in these habitats include occasional sea cucumbers, sea urchins, molluscs, hydroids and sponges, and other worm species.

In 2019, Santos WA commissioned a study to investigate the presence of pearl oyster habitat targeted at 40 to 60 m water depths within the Keraudren Seismic Survey Operational Area (located

5 km from the Sauropod 3D MSS Operational Area. The study collected 17 transects of towed video footage covering a total length of 21.9 km of seabed over a three-day period The key findings of the study as presented within the Santos Keraudren Seismic Survey EP Summary, were as follows:

- Thirteen main habitat types were defined, representing flat and gently sloping seabeds comprising mainly sand/gravel and rock with sediment veneer.
- No ‘potato habitat’ (ascidians and sponges on hard substrate) was identified on the 17 transects.
- Variants of potential ‘garden habitat’ (containing hydroids, sponges, octocorals, soft corals, ascidians and crinoids) comprised approximately 50% of the area surveyed and the habitat where the 2 pearl oysters were found comprised 16.4% of the area surveyed.

The epibenthos recorded in this depth range is summarised as follows:

- Common epibiota included sponges, hydroids, whip corals, soft corals, crinoids, echinoderms (starfish, basket stars and sea cucumbers), gorgonians and ascidians.
- Densities and growth forms of epibiota (e.g. hydroids and sponges) were often a characteristic of specific habitat types. For example, habitats characterised by low abundance, short, turf-like forms were often characterised by mobile sand habitats with patches/troughs of more consolidated gravel/rock prone indicating periodic inundation by sand waves.
- Most transects comprised several different habitat types with high abundance, diverse assemblages in patches interspersed by lower abundance/diversity sand or sandy gravel habitats.
- Most common substrate type was consolidated sandy gravel with shell fragments, which was stabilised by patchy, very low-lying hydroid/bryozoan turf (40 - 75% cover). Large epibiota was generally evenly distributed as shorter forms at relatively low abundance (<5% cover) or occurred as denser patches of larger growth forms on consolidated gravel in depressions or troughs (up to 24% cover).
- Another common habitat observed was large sand waves (with gently sloping relief) and very low abundance of epibiota (<1%) or no conspicuous epibiota.
- Of particular note was a mesophytic gorgonian forest with high densities of large epibiota on relatively flat emergent bedrock with sand/gravel veneer. Gorgonians were estimated at between 1 to 1.8 m high, with shorter colonies also present.

It is expected that the Sauropod 3D MSS Operational Area and wider EMBA would support similar epibenthos as those found in the Santos study due to shared bioregions and comparable benthic habitat, sediments, and geomorphic features. However, it is important to note that the depths within the Sauropod 3D MSS Operational Area range between 95 to 172 m and the Santos study focused on water depths between 40 to 60m. As there are no known banks, shoals or shallow areas within the Operational Area, the Operational Area is unlikely to support diverse benthic assemblages, such as hard and soft corals, gorgonians, encrusting sponges, seagrass and macroalgae.

There are a number of banks and shoals located within the EMBA that may support diverse benthic assemblages. These banks and shoals are discussed further below.

Rowley Shoals

The Rowley Shoals are located within the EMBA for the Sauropod 3D MSS and comprise three reef systems distanced 30-40 km apart. These are Clerke Reef, Imperieuse Reef and Mermaid Reef, located approximately 65, 60 and 80 km from the Operational Area respectively. The marine reef fauna of the Rowley Shoals is considered to be exceptionally rich and diverse, including species typical of the oceanic coral reef communities of the Indo-West Pacific (DEC 2007).

The major habitats of the Rowley Shoals include intertidal and subtidal reefs that support a diverse range of benthic communities. Surveys carried out by the Western Australian Museum (WAM), identified 184 species of corals (primarily Indo-West Pacific species), 264 species of molluscs, 82 species of echinoderms and 389 species of finfish were also identified (DEC 2007).

Over 200 species of hermatypic (hard) corals have been recorded at the shoals over a range of depths (Veron 1986; Veron 1993; McKinney 2009). Sparse seagrass is found within the subtidal coral reef communities, but are not a major habitat type at the Rowley Shoals (Berry 1986; Walker & Prince 1987). Invertebrate species (excluding corals) at the Rowley Shoals include sponges, cnidarians (jellyfish, anemones), worms, bryozoans (sea mosses), crustaceans (crabs, lobsters, etc.), molluscs (cuttlefish, baler shells, giant clams, etc.), echinoderms (starfish, sea urchins) and sea squirts (Veron 1986).

Ancient coastline at 125m depth contour

The ancient coastline at 125m depth contour is a series of several steps and terraces that form an escarpment along the NWS. The ancient coastline at 125 m depth contour is defined as a key ecological feature (KEF) as it is a unique seafloor feature with ecological properties of regional significance. The hard substrate may contribute to higher diversity and enhanced species richness relative to the soft sediment habitat, and may include sponges, crinoids, molluscs, echinoderms and other benthic invertebrates (DSEWPaC 2012). The topographic complexity of these escarpments may also provide a relatively nutrient-rich environment for sessile communities (DSEWPaC 2012). The Ancient coastline at 125 m depth contour KEF is further described in Section 4.3.3 and Section 4.4.3.1.

4.3.3 Fish Assemblages

Fish communities in this region are diverse and are closely related to different depth ranges (DEWHA, 2008). Fish species of the inner shelf include lizardfish, goatfish, trevally, angelfish and tuskfish. In waters with a depth between 100m – 200m, goatfish, deep lizardfish, ponyfish, deep threadfin bream, adult trevally, billfish and tuna are usually present (DEWHA 2008).

The Protected Matters Database search (Appendix A) identified 29 pipefish species, 6 seahorse species, 4 pipehorse species and 1 seadragon species that may occur in the EMBA. Pipefish are a listed marine species, however are not listed as threatened or migratory under the EPBC Act. The species group report card – bony fishes (DSEWPAC 2012b), which supplements and supports the NWMR bioregional plan, 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. The water depths of the Operational Area range from 65 m – 172 m. Only seven species of the 40 syngnathids species identified as potentially occurring within the EMBA have been recorded in water depths greater than 65 m (DoEE 2019a; Bray and Thompson 2019; Austin and Pollom 2019; Froese and Pauly 2019). Therefore, the majority of the identified species are not expected to occur across the flat, soft substrates that predominate the Operational Area and EMBA.

Ancient coastline at the 125m depth contour

The Ancient coastline at the 125 m depth contour KEF is thought to provide areas of hard substrate that may contribute to higher biological diversity. Little published information is currently available, but the hard substrate may provide suitable habitat for demersal fish species including those that are site-attached. Site-attached fish species are typically associated with banks, shoals and coral reefs. Site-attached species show strong habitat preferences and site fidelity and are therefore less likely or unable to move away from disturbance. The Operational Area partially overlaps with approximately 9% of the KEF.

Santos WA commissioned a study in 2018, to describe the fishes associated with the ancient coastline KEF within and adjacent to the Acquisition Area of the Keraudren Seismic Survey. The

Keraudren Seismic Survey Acquisition Area is located approximately 20 km from the Sauropod Operational Area and shares similar environmental characteristics. The SBRUVS technique (stereo baited remote underwater video system) was utilised for the survey. The key findings of the study as presented within the Santos Keraudren Seismic Survey EP Summary, were as follows:

- A total of 638 fish from 48 species and 18 families;
- A number of commercially important species were observed including red emperor (1 individual), goldband snapper (35 individuals), and saddletail snapper (1 individual);
- Four most ubiquitous species were threadfin bream (observed in 97% deployments), lunartail puffer (observed in 95% deployments), longnose trevally (observed in 76% deployments) and giant trevally (observed in 60% deployments);
- Four most abundant species were longnose trevally (153 individuals), threadfin bream (103 individuals), lunartail puffer (78 individuals) and goldband snapper (35 individuals);
- No consistent structurally complex seabed feature was evident that 'site-attached' fish would normally be associated with.

It is expected that the Sauropod Operational Area would support similar fish assemblages as those identified in the Santos study (results mentioned above). It is assumed that fish abundance will decrease as water depths of the Operational Area increases. As water depths of the Operational Area are greater than 60 m, demersal fish abundance and species richness is unlikely to be significant.

4.3.4 Commercially Targeted Fish Stocks

The NWMR provides fishing grounds for several commercial fisheries which target a variety of demersal and pelagic fish species. During the consultation process the Department of Primary Industries and Regional Development (DPIRD Fisheries) provided information on the spawning and distribution of fish species that are used to provide an indication of fish stocks targeted by fisheries relevant to the Operational Area. These species are known as key indicator species and are relevant to the management of commercial fish stocks. Table 4-2 describes the indicator species that are relevant to the Operational Area. The timing of key biological sensitivities for commercially targeted fish stocks and other species relevant to the Operational Area and wider EMBA is described at the end of this Section in Table 4-10.

Table 4-2 Key Indicator Species Potentially Occurring Within the Operational Area and EMBA

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. Goldband snapper are 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.	October – May (extended peak spawning period)	Given known distribution and habitat depths, goldband snapper may occur and spawn within the Operational Area. The Operational Area overlaps with 3,785 km^2 of the goldband snapper's (Pilbara stock) approximate 69,000 km^2 range (5.5%). The acquisition period overlaps with four months of the goldband snapper's eight month extended peak spawning period.
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 known distribution and habitat depths, Rankin cod may occur and spawn within the Operational Area. The Operational Area overlaps with 3,334 km^2 of the Rankin cod's (Pilbara stock) approximate 93,000 km^2 range (3.6%). The acquisition period overlaps with one month of the Rankin cod's 8 month spawning period, and avoids the 3 month peak spawning period from August – October.
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 known distribution and habitat depths, red emperor may spawn within the Operational Area. The Operational Area overlaps with 3,785 km^2 of the red emperor's (Pilbara stock) approximate 99,000 km^2 range (3.8%). The acquisition period overlaps with four months of the red emperor's 10 month spawning period, including three months of the six month bimodal peak.
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	July – March (extended peak spawning period)	Given known distribution and habitat depths, blue-spotted emperor may spawn within the Operational Area. The Operational Area overlaps with 1,147 km^2 of the blue-spotted emperor's (Pilbara stock) approximate 88,000 km^2 range (1.3%).

Species	Description	Spawning	Relevance to EP
	connectivity between populations over large distances (Moran et al. 1993).		The acquisition period overlaps with three months of the blue-spotted emperor's nine month spawning period.
Giant ruby snapper (*Etelis carbunculus*)	Ruby snapper occurs across the Indo-West pacific region. In Australia, ruby snapper is recorded from north-western Western Australia to north-eastern Queensland (Australian Museum 2019). The species occurs in water depths of 150 – 480 m. Ruby snapper spawn throughout their range. Like other snappers, they are understood to be serial, broadcast spawners.	December-April (peak spawning period January-March)	Given known distribution and habitat depths, ruby snapper may spawn within the Operational Area. The Operational Area overlaps with approximately 955 km^2 of the ruby snapper's range in the Pilbara region (2.2%). The acquisition period overlaps with the ruby snapper's spawning period.
Spanish mackerel (Pilbara stock) (*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 – December (peak spawning)	Given known distribution and habitat depths, the species is highly unlikely to spawn in the Operational Area, but may spawn in the wider EMBA. The acquisition period does not overlap with the Spanish mackerel's four month spawning period.
Sandbar shark (*Carcharhinus plumbeus*)	Offshore populations of sandbar shark are most commonly found on banks, near islands, flat reefs and other topographic features in open waters (Musick et al. 2009). This species is found in depths up to 280 m but typically in waters less than 100 m.	October – January	Given known distribution and habitat depths, sandbar shark may spawn within the Operational Area. The acquisition period overlaps with one month of the sandbar shark's four month spawning period.
Blacktip shark (*Carcharhinus tilstoni and C. limbatus*)	Blacktip shark are most commonly found in nearshore waters off beaches, in bays, estuaries, over coral reefs and off river mouths (Burgess & Branstetter 2009). This species is found in depths up to 150 m.	November – December	Given known distribution and habitat depths, sandbar shark may spawn within the Operational Area. The acquisition period avoids the blacktip shark's two month spawning period.

4.3.5 Threatened and Migratory Species

The EPBC Act Protected Matters Search Tool (PMST) was used to identify listed species under the EPBC Act that may occur within the Operational Area and EMBA. The results of the search inform the assessment of planned events in Section 7 as well as unplanned events in Section 7. 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.

A total of 33 EPBC Act listed species were identified as potentially occurring within the Operational Area. Of those listed, 16 are considered threatened marine species and all 33 are migratory species under the EPBC Act (Table 4-3).

An additional nine EPBC Act listed species were identified as potentially occurring within the wider EMBA. Of those nine additional species, three are considered threatened marine species and six are migratory species under the EPBC Act (Table 4-3).

Three migratory terrestrial species were identified in the EPBC search as occurring within the EMBA, including the Barn Swallow (*Hirundo rustica*), Grey Wagtail (*Motacilla cinerea*) and Yellow Wagtail (*Motacilla flava*). These have been excluded from further assessment due to lack of a credible impact scenario.

The full list of species identified from the PMST is provided in the EPBC Act Protected Matters Search Report (Appendix A).

Table 4-3 Threatened and Migratory Marine Species Listed Under The EPBC Act Potentially Occuring Within The Operational Area and Wider EMBA

Scientific Name	Common Name	Threatened	Migratory	Relevance to EP
Marine Mammals				
Balaenoptera borealis	Sei Whale	Vulnerable	✓	Operational Area
Balaenoptera musculus	Blue Whale	Endangered	✓	
Balaenoptera physalus	Fin Whale	Vulnerable	✓	
Megaptera novaeangliae	Humpback Whale	Vulnerable	✓	
Balaenoptera edeni	Bryde's Whale	N/A	✓	
Orcinus orca	Killer Whale	N/A	✓	
Physeter macrocephalus	Sperm Whale	N/A	✓	
Tursiops aduncus	Spotted Bottlenose Dolphin (Arafura/Timor Sea Populations)	N/A	✓	
Dugong dugon	Dugong	N/A	✓	EMBA
Marine Reptiles				
Caretta caretta	Loggerhead Turtle	Endangered	✓	Operational Area
Chelonia mydas	Green Turtle	Vulnerable	✓	
Dermochelys coriacea	Leatherback Turtle	Endangered	✓	
Eretmochelys imbricata	Hawksbill Turtle	Vulnerable	✓	
Natator depressus	Flatback Turtle	Vulnerable	✓	
Aipysurus apraefrontalis	Short-nosed Seasnake	Critically Endangered	X	EMBA
Sharks and Rays				
Anoxypristis cuspidata	Narrow Sawfish	N/A	✓	Operational Area

Scientific Name	Common Name	Threatened	Migratory	Relevance to EP
Carcharodon carcharias	Great White Shark	Vulnerable	✓	
Isurus oxyrinchus	Shortfin Mako Shark	N/A	✓	
Manta alfredi	Reef Manta Ray	N/A	✓	
Manta birostris	Giant Manta Ray	N/A	✓	
Pristis pristis	Freshwater Sawfish	Vulnerable	✓	
Pristis zijsron	Green Sawfish	Vulnerable	✓	
Rhincodon typus	Whale Shark	Vulnerable	✓	
Isurus paucus	Longfin Mako	N/A	✓	EMBA
Pristis clavata	Dwarf Sawfish	Vulnerable	X	
Avifauna				
Numenius madagascariensis	Eastern Curlew	Critically Endangered	✓	Operational Area
Calidris canutus	Red Knot	Endangered	✓	
Papasula abboti	Abbott's Booby	Endangered	X	
Fregata minor	Great Frigatebird	N/A	✓	
Actitis hypoleucos	Common Sandpiper	N/A	✓	
Anous stolidus	Common Noddy	N/A	✓	
Calidris acuminata	Sharp-tailed Sandpaper	N/A	✓	
Calidris melanotos	Pectoral Sandpiper	N/A	✓	
Calonectris leucomelas	Streaked Shearwater	N/A	✓	
Fregata ariel	Lesser Frigatebird	N/A	✓	
Pandion haliaetus	Osprey	N/A	✓	
Phaethon lepturus	White-tailed Tropicbird	N/A	✓	
Calidris ferruginea	Curlew Sandpiper	Critically Endangered	✓	EMBA
Phaethon rubricauda	Red-tailed Tropicbird	N/A	✓	
Sternula albifrons	Little Tern	N/A	✓	
Sula leucogaster	Brown Booby	N/A	✓	
Sterna bengalensis	Lesser Crested Tern	N/A	✓	

4.3.5.1 *Listed Threatened Species Recovery Plans and Conservation Advices*

Species Recovery Plans set out the research and management actions necessary to stop the decline of, and support the recovery of, listed threatened species or threatened ecological communities (DoEE, n.d.). Recovery plans are enacted under the EPBC Act and remain in force until the species is removed from the threatened list. Conservation advice provides guidance on immediate recovery and threat abatement activities that can be undertaken to ensure the conservation of a newly listed species or ecological community (DoEE, n.d.).

Table 4-4 lists the applicable recovery plans and/or conservation advice for EPBC Act-listed species within the Operational Area and EMBA, as identified by the PMST search. Any relevant requirements applicable to the activity will be considered as part of the Environmental Risk Assessment (Section 7 and Section 8).

Table 4-4 Recovery Plans and Conservation Advice For EPBC Act-Listed Species Occurring Within The Operational Area and EMBA

Species	Recovery Plan / Conservation Advice	Key Threats Identified In The Plan / Advice	Actions Relevant To The Sauropod 3D MSS	Environmental Risk Assessment Section
All vertebrate fauna	Threat abatement plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE, 2018).	■ Marine-based sources of debris.	■ Contribute to long-term prevention of marine debris, through waste management and resource recovery. ■ Limit the amount of single use plastic material lost to the environment in Australia.	Section 8.7
Mammals				
Sei whale	Conservation advice *Balaenoptera borealis* sei whale (TSSC, 2015a).	■ Anthropogenic noise and acoustic disturbance. ■ Vessel strike.	■ Assessing and addressing anthropogenic noise.	Section 7.1, Section 7.2, 7.2
			■ Minimising vessel collisions.	Section 8.4
Blue whale	Conservation management plan for the blue whale: A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 2015-2025 (DoEE, 2015a).	■ Noise interference. ■ Vessel disturbance.	■ Assessing and addressing anthropogenic noise.	Section 7.1, Section 7.2, 7.2
			■ Minimising vessel collisions.	Section 8.4
Fin whale	Conservation advice *Balaenoptera physalus* fin whale (TSSC, 2015b).	■ Anthropogenic noise and acoustic disturbance. ■ Vessel strike.	■ Assessing and addressing anthropogenic noise.	Section 7.1, Section 7.2, 7.2
			■ Minimising vessel collisions.	Section 8.4
Humpback whale	Approved Conservation Advice for *Megaptera novaeangliae* (humpback whale) (TSSC, 2015c).	■ Noise Interference (including seismic surveys). ■ Vessel disturbance and strike.	■ Assessing and addressing anthropogenic noise.	Section 7.1, Section 7.2, 7.2
			■ Minimising vessel collisions.	Section 8.4
Reptiles				
Loggerhead Turtle		Threats to the WA stock include:	■ Minimise light pollution	Section 7.7

Species	Recovery Plan / Conservation Advice	Key Threats Identified In The Plan / Advice	Actions Relevant To The Sauropod 3D MSS	Environmental Risk Assessment Section
	Recovery plan for marine turtles in Australia (DoEE, 2017)	■ Light pollution. ■ Vessel disturbance (strike) – rated as 'almost certain' likelihood of occurrence, minor consequence. ■ Noise interference (acute) – rated as a 'likely' likelihood of occurrence, minor consequence. An "almost certain" rating means the event is expected to occur every year. A "minor" rating means that individuals are affected, but there is no effect at stock level.	■ No specific actions for vessel disturbance are identified by the plan. The Australian Government is developing a National Strategy for Mitigating Vessel Strike of Marine Mega-fauna to provide guidance on reducing the risk of vessel collisions and the impacts they may have on marine fauna.	Section 8.4
			■ A precautionary approach to acute noise exposure should be applied to seismic surveys.	Section 7.1, Section 7.2, 7.2
Hawksbill Turtle	Recovery plan for marine turtles in Australia (DoEE, 2017)	Threats to the WA stock include: ■ Light pollution. ■ Vessel disturbance – rated as 'almost certain' likelihood of occurrence, minor consequence. ■ Noise interference (acute) – rated as a 'possible' likelihood of occurrence, minor consequence. A "possible" rating means the event might occur at some time.	■ Minimise light pollution	Section 7.7
			■ No specific actions for vessel disturbance are identified by the plan. The Australian Government is developing a National Strategy for Mitigating Vessel Strike of Marine Mega-fauna to provide guidance on reducing the risk of vessel collisions and the impacts they may have on marine fauna.	Section 8.4
			■ A precautionary approach to acute noise exposure should be applied to seismic surveys.	Section 7.1, Section 7.2, 7.2
Green Turtle	Recovery plan for marine turtles in Australia (DoEE, 2017)	Threats to the WA stock include: ■ Light pollution.	■ Minimise light pollution	Section 7.7

Species	Recovery Plan / Conservation Advice	Key Threats Identified In The Plan / Advice	Actions Relevant To The Sauropod 3D MSS	Environmental Risk Assessment Section
		■ Vessel disturbance (strike) – rated as a 'likely' likelihood of occurrence, minor consequence. ■ Noise interference (acute and chronic) – rated as 'unknown' likelihood of occurrence, minor consequence. A "likely" rating means the event is expected to occur at least once every five years.	■ No specific actions for vessel disturbance are identified by the plan. The Australian Government is developing a National Strategy for Mitigating Vessel Strike of Marine Mega-fauna to provide guidance on reducing the risk of vessel collisions and the impacts they may have on marine fauna.	Section 8.4
			■ A precautionary approach to acute noise exposure should be applied to seismic surveys.	Section 7.1, Section 7.2, 7.2
Flatback Turtle	Recovery plan for marine turtles in Australia (DoEE 2017)	Threats to the Pilbara stock include: ■ Light pollution. ■ Vessel disturbance (strike) - rated as an 'almost certain' likelihood of occurrence, minor consequence. ■ Noise interference (acute) – rated as a 'likely' likelihood of occurrence, minor consequence.	■ Minimise light pollution	Section 7.7
			■ No specific actions for vessel disturbance are identified by the plan. The Australian Government is developing a National Strategy for Mitigating Vessel Strike of Marine Mega-fauna to provide guidance on reducing the risk of vessel collisions and the impacts they may have on marine fauna.	Section 8.4
			■ A precautionary approach to acute noise exposure should be applied to seismic surveys.	Section 7.1, Section 7.2, 7.2
Olive Ridley Turtle	Recovery plan for marine turtles in Australia (DoEE 2017)	Threats to the North-Western Cape York stock include: ■ Light pollution. ■ Vessel disturbance – rated as a 'possible' likelihood of occurrence, minor consequence. ■ Noise interference (acute) – rated as an 'unlikely' likelihood	■ Minimise light pollution	Section 7.7
			■ No specific actions for vessel disturbance are identified by the plan. The Australian Government is developing a National Strategy for Mitigating Vessel Strike of Marine Mega-fauna to provide guidance on reducing the risk of vessel collisions and the impacts they may have on marine fauna.	Section 8.4

Species	Recovery Plan / Conservation Advice	Key Threats Identified In The Plan / Advice	Actions Relevant To The Sauropod 3D MSS	Environmental Risk Assessment Section
		of occurrence, no long term effect. A "no long term effect" rating means there is no long-term effect expected on individuals or stock.	■ A precautionary approach to acute noise exposure should be applied to seismic surveys.	Section 7.1, Section 7.2, 7.2
Leatherback Turtle	Recovery plan for marine turtles in Australia (DoEE 2017)	■ Vessel disturbance	■ Minimising vessel collisions.	Section 8.4
	Approved conservation advice for *Dermochelys coriacea* (Leatherback Turtle) (DEWHA 2008b)			
Short-nosed Seasnake	Approved Conservation Advice for *Aipysurus apraefrontalis* (Short-nosed Sea Snake) (DSEWPaC 2011)	No threats identified that are applicable to this EP.	N/A	N/A
Sharks and Rays				
Great white shark	Recovery plan for the white shark (Carcharodon carcharias) (DSEWPaC 2013)	No threats identified that are applicable to this EP.	N/A	N/A
Dwarf sawfish	Approved conservation advice for *Pristis clavata* (dwarf sawfish) (TSSC 2009)	No threats identified that are applicable to this EP.	N/A	N/A
	Sawfish and river shark multispecies recovery plan (DoE 2015b)	No threats identified that are applicable to this EP.	N/A	N/A
Green sawfish	Approved Conservation Advice for Green Sawfish (TSSC 2008)	No threats identified that are applicable to this EP.	N/A	N/A
	Sawfish and river shark multispecies recovery plan (DoE 2015b)	No threats identified that are applicable to this EP.	N/A	N/A

Species	Recovery Plan / Conservation Advice	Key Threats Identified In The Plan / Advice	Actions Relevant To The Sauropod 3D MSS	Environmental Risk Assessment Section
Whale shark	Conservation advice *Rhincodon typus* whale shark (TSSC 2015d)	■ Vessel disturbance	■ Minimising vessel collisions.	Section 8.4
	Whale shark (*Rhincodon typus*) recovery plan 2005-2010 (DEH 2005)	No threats identified that are applicable to this EP.	N/A	N/A
Grey nurse shark	Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*) (DoE, 2014)	No threats identified that are applicable to this EP.	N/A	N/A
Seabirds				
Red Knot	Conservation advice *Calidris canutus* red knot (TSSC 2016)	■ Habitat degradation (oil pollution). ■ Human disturbance (general).	■ Manage disturbance at important sites when red knots are present.	Section 7.1, Section 7.2, Section 7.7, Section 8.4
Curlew Sandpiper	Conservation advice *Calidris ferruginea* curlew sandpiper (DoE 2015c)	■ Habitat degradation (oil pollution). ■ Human disturbance (general).	■ Manage disturbance at important sites when curlew sandpipers are present.	Section 7.1, Section 7.2, Section 7.7, Section 8.4
Eastern Curlew	Conservation advice *Numenius madagascariensis* eastern curlew (DoE 2015d)	■ Habitat degradation (oil pollution). ■ Human disturbance (general).	■ Manage disturbance at important sites when eastern curlews are present.	Section 7.1, Section 7.2, Section 7.7, Section 8.4
Common Sandpiper, Red Knot, Pectoral Sandpiper, Sharp-tailed Sandpiper	Wildlife conservation plan for migratory shorebirds (Commonwealth of Australia 2015)	■ Habitat degradation (oil pollution n).	■ Ensure all areas important to migratory shorebirds in Australia continue to be considered in development assessment processes.	Section 7.1, Section 7.2, Section 7.7, Section 8.4
Abbott's Booby	Conservation Advice *Papasula abbotti* Abbott's booby (TSSC 2015e)	No threats identified that are applicable to this EP.	N/A	N/A

4.3.5.2 *Biologically Important Areas*

Biologically Important Areas (BIAs) are regions where a particular species is known or likely to display important behaviours such as breeding, foraging, nesting or migration (DoEE n.d.). BIAs have no legal status, however they provide information to help inform regulatory and management decisions. Table 4-5 identifies the BIAs associated with threatened and migratory species potentially occurring within the Operational Area and wider EMBA, as identified during the PMST search. Further information on BIAs is provided in the individual species descriptions below (Section 4.3.6 Section 4.3.9).

Table 4-5 Threatened and Migratory Species' BIAs within the Operational Area and EMBA

Species	BIA	Location	Distance from the Operational Area
Humpback whale	Migration	North-west WA coast	15 km
Pygmy blue whale	Distribution	South and west Australia waters	Overlaps
	Migration	WA waters	72 km
Whale shark	Foraging	NWS 200 m isobath	Overlaps
Flatback turtle	Internesting	Eighty Mile Beach	20 km
	Internesting*	Eighty Mile Beach	60 km
Lesser Frigatebird	Foraging	Bedout Island	Overlaps
	Breeding and foraging	Bedout Island	40 km
White-tailed Tropicbird	Breeding and foraging	Rowley Shoals	Overlaps
Little Tern	Resting	Rowley Shoals	23 km
Brown booby	Breeding	Pilbara coast	40 km

* Habitat critical to the survival of a marine turtle species (DoEE 2017).

4.3.6 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 27 marine mammal species known to occur regularly in the NWMR, including sixteen whale species and at least eleven species of dolphin (DEWHA 2008).

Four 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 EMBA.

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. spotted bottlenose dolphin) are thought to be resident in the region throughout the year (DEWHA 2008).

Dugongs are also present in the region, preferring shallow waters along the coast and around shoals where seagrass habitats are available (DEWHA 2008). The Operational Area is highly 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 4-6 including their distribution, migratory movements, preferred habitat and likely presence within the Operational Area and EMBA.

Two species have biologically important areas within the Operational Area and wider EMBA, as follows:

- 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 migration BIA is located approximately 15 km south of the Operational Area. The breeding, nursing and calving BIA is located 255 km east of the Operational Area and outside the wider EMBA.
- Pygmy blue whale migration and distribution BIAs pass along the shelf edge at depths between 500 m and 1,000 m. The Operational Area overlaps with the distribution BIA, however the migration BIA is located 72 km to the north of the Operational Area.

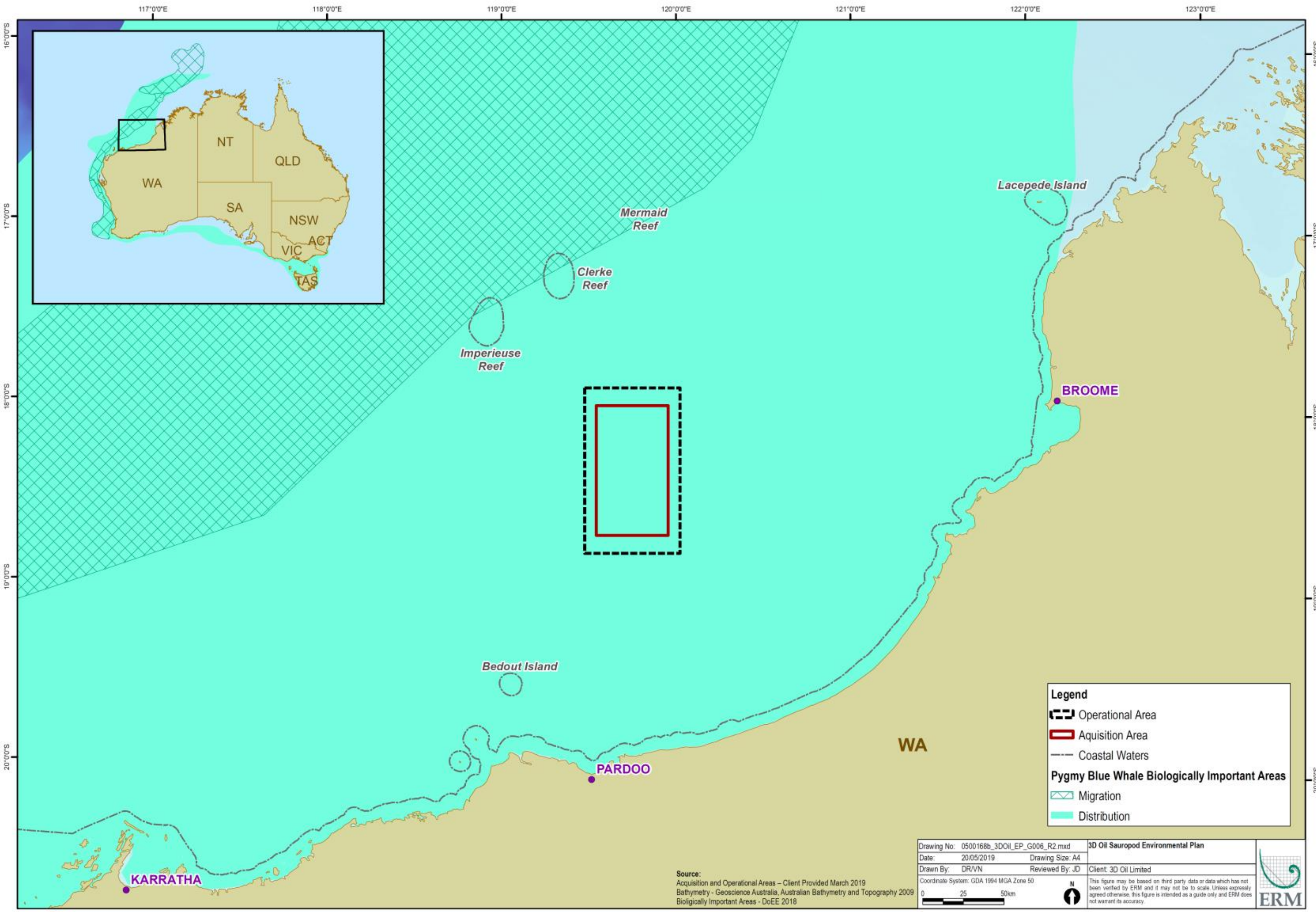


Figure 4-8 Pygmy Blue Whale BIAs

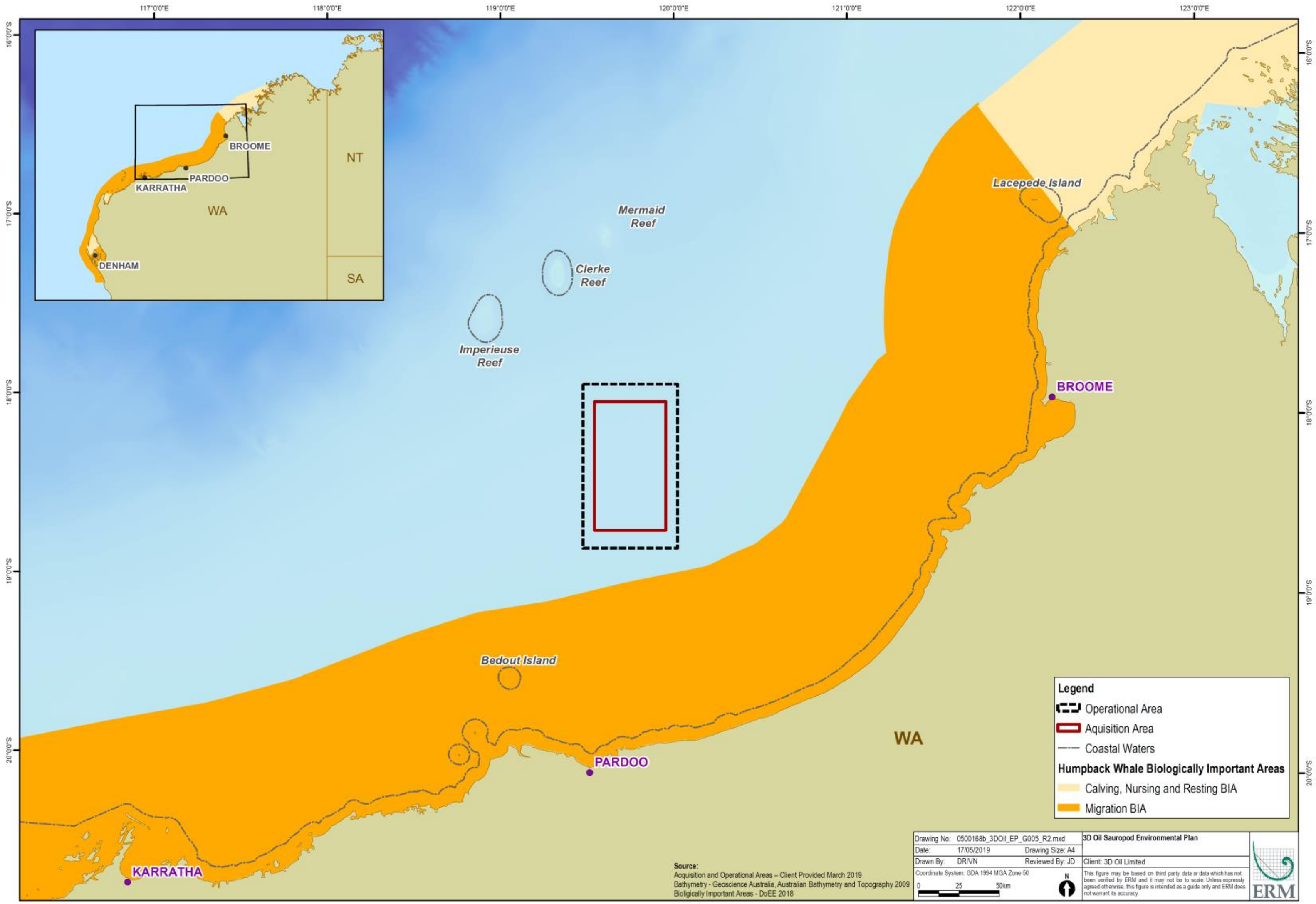


Figure 4-9 Humpback Whale BIAs

Table 4-6 Threatened and Migratory Mammals Potentially Occurring Within the Operational Area and EMBA

Common Name	Habitat and Distribution	Seasonality	Relevance to EP
Mammals Potentially Occurring Within The Operational Area			
Blue Whale	Two subspecies of blue whale are found in the Southern Hemisphere; the pygmy blue whale (*Balaenoptera musculus brevicauda*) and the Antarctic blue whale (*B. m. intermedia*). During the southern hemisphere summer, Antarctic blue whales are usually found south of 60^{0}S, while pygmy blue whales are usually found north of 55^{0}S (DoEE 2019). Therefore, Antarctic blue whales are highly unlikely to be present within or nearby the Operational Area. The pygmy blue whale has a worldwide oceanic distribution and are regularly sighted in Australian waters. Whilst the species prefer deep waters, whale sightings in Australia are usually related to migration purposes or opportunistic feeding. The pygmy blue whale has BIAs for migration, foraging and distribution along the WA coastline. The Operational Area overlaps with the distribution BIA, and the wider EMBA overlaps with the migration BIA. Satellite tacking of pygmy blue whales undergoing their northern migration indicate whales generally follow known migration paths, transiting north of the Rowley Shoals (Double et al. 2012, 2014).	The pygmy blue whale undergoes a seasonal northward migration from foraging grounds at the lower latitudes to breeding grounds in Indonesian waters (DoEE 2019). The whales depart the Perth Canyon/ Naturaliste Plateau region in March and April, and reach Indonesia by June where they remain until at least September (DoEE 2019; Double et al. 2012, 2014). The return southern migration from Indonesia to the subtropical frontal zone (40–45° S) occurs from September and finishes by December (DoEE, 2019).	The Operational Area is located within the pygmy blue whale distribution BIA. However, due to the species' migration BIA being located approximately 72 km north of the Operational Area and absence of known foraging, resting and calving habitat, presence within the Operational Area EMBA is likely to be infrequent and consist of transitory individuals during migration months. Individuals may be present in the northern region of the wider EMBA during seasonal migrations. Acquisition of the survey may overlap the commencement of the northbound migration (April), but avoids the southbound migration period for pygmy blue whales in the region (September to November).
Humpback Whale	Humpback whales occur globally and throughout Australian waters with their distribution being influenced by migratory pathways and aggregation areas for resting, breeding and calving (DoEE 2019). There are two genetically distinct populations of humpback whales in Australia (i.e. west coast and east coast) (DoEE 2019). Major breeding areas have been identified for the western Australian population in the Kimberley region and in particularly between Lacepede Islands and Camden Sound (Jenner et al. 2001). Camden sound is the northern most limit for the majority of west coast whales and is considered to be an important breeding area (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 2019);	Humpback whales undergo an annual migration from the summer feeding grounds in Antarctica to the breeding and calving grounds in Camden Sound (approximately 540 km from the Operational Area) occurs between May and October (DoEE 2019). During migration, individuals travel alone or in temporary aggregations of generally non-related individuals. The numbers of humpback whales at Camden Sound peak between June and September each year (DoEE 2019). The migration corridor tends to be within the 200 m isobath (Jenner et al. 2001).	The Operational Area is located 15 km north of the migration BIA. However, due to the species' breeding and calving BIA being located approximately 250 km north-east of the Operational Area, the presence of the species within the Operational Area is likely to be infrequent and consist of transitory individuals. Individuals are likely to be present in the southern region of the wider EMBA during seasonal migrations.

Common Name	Habitat and Distribution	Seasonality	Relevance to EP
	estimates conducted suggest that in 2008 the population migrating up the WA coast was at 21,750 individuals (Hedley et al. 2011). Humpback whale songs change in composition among years, but most energy is consistently between 200 – 500 Hz (Salgado Kent et al. 2012).		
Bryde's Whale	Bryde's whales are distributed throughout oceanic and inshore, tropical and warm temperate waters, between 40˚N and 40˚S year-round. They have been recorded off all states of Australia, with the exception of the Northern Territory (DoEE 2019). 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 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 (over 740 km away) (DoEE 2019). Aerial surveys carried out in 2009, between mainland Australia and Scott Reef (approximately 465 km north-east of the Operational Area) 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). No specific feeding or breeding grounds have been discovered off Australia.	Inshore coastal forms appear to breed and give birth throughout the year, while the offshore form appears to have a protracted breeding and calving season over several months during winter. There is currently no evidence of large-scale movements of the inshore form of the Bryde's whale. However, the offshore form may migrate seasonal heading towards warmer tropical waters during the winter months. It should be noted that there is limited data on migration, mating, breeding and calving patterns for Bryde's whales.	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 740 km away), the presence of the species within the Operational Area and wider EMBA is likely to be infrequent.
Fin Whale	Fin whales occur from polar to tropical waters, but rarely in inshore waters (DoEE 2019). Fin whales are widely distributed in both hemispheres between latitudes 20–75° S (Mackintosh 1966). This species is common in temperate waters, the Arctic Ocean and Southern Ocean. Fin whales feed intensively in high latitudes and may feed to some extent, depending upon prey availability and locality, in lower latitudes. Fin whales feed on planktonic crustacea, some fish and cephalopods (crustaceans). Fin whales are killed by ship strike more than any other whale, which may be due to surface feeding (DoEE 2019).	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 2019).	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.

Common Name	Habitat and Distribution	Seasonality	Relevance to EP
	The Australian Antarctic waters are important feeding grounds for fin whales. Sightings of fin whales feeding in the Bonney Upwelling area indicate that this area is also a potentially important feeding ground. There is no known mating or calving areas for fin whales in Australian waters.		
Sei Whale	Sei whales are considered a cosmopolitan species, ranging from polar to tropical waters, but tend to be found more offshore than other species of large whales. They show well defined migratory movements between polar, temperate and tropical waters (Mackintosh 1965). Migratory movements are essentially north-south with little longitudinal dispersion. Sei whales have been infrequently recorded in Australian waters (Bannister et al. 1996). The similarity in appearance of sei whales and Bryde's whales has resulted in confusion about distributional limits and frequency of occurrence. This species is known to breed in tropical and subtropical waters, while Australian Antarctic waters are important feeding grounds for sei whales, as are temperate, cool waters (Horwood 1987).	The movements and distributions of sei whales in Australian waters are unpredictable and not well documented. Information suggests that sei whales have the same general pattern of migration as most other baleen whales, although it is timed a little later and they do not go to such high latitudes (Gambell 1968).	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.
Killer Whale	The killer whale is found in all of the world's oceans, from the Arctic and Antarctic regions to tropical seas (Ford et al. 2005). 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 (DoEE 2019). The preferred habitat of the species includes oceanic, pelagic and neritic (relatively shallow waters over the continental shelf) regions, in both warm and cold waters. They may be more common in cold, deep waters, but off Australia, killer whales are most often seen along the continental slope and on the shelf, particularly near seal colonies. Killer whales have regularly been observed within the Australian territorial waters along the ice edge in summer. No areas of significance and no determined migration routes have been identified for this species within waters off WA (DoEE 2019).	Killer whales are known to make seasonal movements, and follow regular migratory routes. Mating is known to occur all year round, whilst the calving season spans several months.	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.

Common Name	Habitat and Distribution	Seasonality	Relevance to EP
Sperm Whale	Sperm whales are abundant from polar waters to the equator and typically found in deep temperate and tropical offshore waters (greater than 600 m) or closer to the shore in water depths greater than 200 m (DoEE 2019). Sperm whales tend to be found where the seabed rises steeply from great depth, and are probably associated with concentrations of major food in areas of upwelling (Bannister et al. 1996). There is limited information on their distribution in Australian waters, although they have been recorded off the coast of all Australian states, where they occur in groups of up to 50 individuals (DoEE 2019). Sperm whales have been recorded from all Australian states. Sperm whales have previously been recorded both acoustically and during aerial surveys, on the North West Shelf, suggesting that they occasionally occur in the deep, oceanic waters of the region (RPS 2010).	Sperm whales are seasonal breeders, but the mating season is prolonged, extending from late winter through to early summer. In the Southern Hemisphere, conceptions occur from July to March, peaking in September and December. Calves may be born in tropical and temperate waters and are mainly born between November and March.	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.
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations)	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 2019). In Australia, the species is generally found in inshore areas such as bays and estuaries, nearshore waters, open coast environments and shallow offshore waters. 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 (Reeves et al. 2003). The closest calving BIA is located at Roebuck Bay, approximately 150 km from the Operational Area. The population present at Roebuck Bay is likely to be resident due to rich and consistent prey available.	Calving peaks occur in spring and summer or spring and autumn. Knowledge of the species seasonal migration and breeding is largely unknown, however it is inferred that only the Arafura-Timor Sea population is migratory.	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 shallower southern region of the wider EMBA.
Mammals potentially occurring within the EMBA			
Dugong	Dugongs are also known to occur along the coast throughout the Kimberley to the Western Australia–Northern Territory border; however, population estimates for these areas are not available (DSEWPaC 2012). Dugongs inhabit protected	The patterns of dugong movement in Western Australia are not well understood, it is thought that dugongs move in response to seagrass and water temperature.	The PMST search identified the species as potentially occurring within the EMBA, and not within the Operational Area.

Common Name	Habitat and Distribution	Seasonality	Relevance to EP
	shallow coastal areas, such as wide shallow bays and mangrove channels. Some of the coastal waters in the region support significant populations of dugongs, including Shark Bay, which has an estimated population of around 10,000 individuals (DSEWPaC 2012). Specific areas supporting dugongs in Western Australia include: Shark Bay; Ningaloo and Exmouth Gulf; the Pilbara coast (Exmouth Gulf to De Grey River) (Marsh et al. 2002); and Eighty Mile Beach and Kimberley Coast Region, including Roebuck Bay (Brown et al. 2014). 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 the Operational Area, along the Dampier Peninsula (approximately 650 km away).	Dugongs are diffusely seasonal breeders and the seasonality of breeding is more marked in the sub-tropics (mostly spring, early summer calving) than in the tropics.	Due to the species' foraging BIA being located 650 km from the Operational Area, absence of suitable habitat and preference for shallow waters, presence of the species within the EMBA is likely to limited.

4.3.7 Sharks and Rays

The NWMR supports high species richness of shark, sawfish and rays stemming from the diversity of marine environments. There are approximately 500 shark and sawfish species globally, with 94 species found within the NWMR (i.e. 19% of the world's shark species) (DEWHA 2008).

One threatened, four threatened and migratory, and five migratory shark and ray species were identified in the PMST search as potentially occurring in the Operational Area and EMBA (Table 4-3).

A description of the identified threatened and/or migratory sharks, sawfish and rays is provided in Table 4-7 including their distribution, migratory movements, preferred habitat and likely presence within the Operational Area and EMBA.

One biologically important area for the shark and ray species described in Table 4-3 has been identified within the Operational Area and wider EMBA:

- The whale shark foraging BIA extends northwards from Ningaloo along the 200 m isobath. The Operational Area overlaps with the BIA (Figure 4-10).

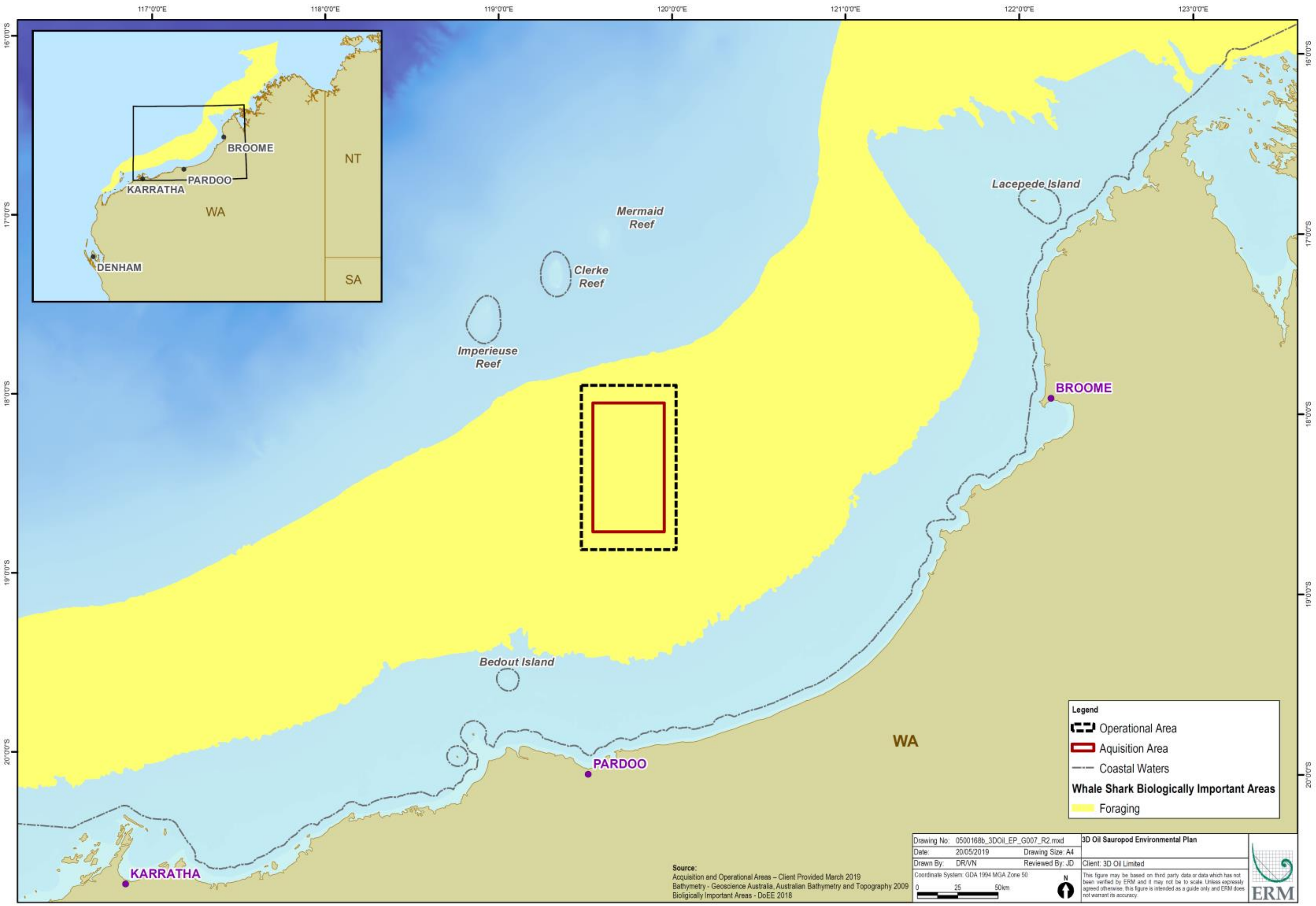


Figure 4-10 Whale Shark BIAs

Table 4-7 Threatened and Migratory Sharks and Rays Potentially Occurring Within the Operational Area and EMBA

Common Name	Habitat and Distribution	Seasonality	Relevance to EP
Sharks And Rays Potentially Occurring Within The Operational Area			
Whale Shark	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 1,700 km away) between December and January and at Ningaloo Reef (approximately 740 m away) between March and July to feed on krill and baitfish associated with coral spawning events (DoEE 2019). 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; Bradshaw et al. 2007). The Operational Area overlaps with the whale shark foraging BIA (Figure 4-10), which extends northwards from Ningaloo along the 200 m isobath.	Whale sharks are regarded as highly migratory - although these 'migration patterns' are poorly understood. The whale shark migration between Christmas Island and Ningaloo Reef is expected to occur between January and March (Colman 1997; Wilson et al. 2006; DoEE 2019). The northern migration route is considered to follow the northern WA coastline along the 200 m isobath consistent with the extent of the whale shark foraging BIA.	Given the recorded migratory routes in the region, the cosmopolitan distribution of the species and overlap with the foraging BIA, whale sharks may be encountered in the Operational Area and wider EMBA in low numbers.
Great White Shark	They have been recorded from central Queensland around the south coast to north-west WA, with movements occurring between the mainland coast and the 100 m depth contour (DoEE 2019). Great white sharks are frequently recorded in waters around fur seal and sea lion colonies such as the islands off the lower west coast of Western Australia (DoEE 2019).	Great white sharks area known to undertake migrations along the WA coast, with some individuals travelling as far north as North West Cape during spring, before returning south for summer (DoEE 2019).	Due to their preference for cold temperate waters and feeding grounds in waters around seal colonies further south, the presence of the species within the Operational Area and wider EMBA is likely to be limited.

Common Name	Habitat and Distribution	Seasonality	Relevance to EP
Shortfin Mako Shark	The shortfin mako is found in tropical and warm-temperate seas in water depths up to 500 m (Cailliet et al. 2009). 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). The species 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.	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.
Narrow Sawfish (previously known as the Knifetooth Sawfish)	The exact distribution of the species 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).	There is insufficient data to prescribe distribution behaviours, migration times and routes and seasonal patterns.	Given the species distribution, and preference for coastal/estuarine areas, the presence of the species within the Operational Area is expected to be limited. The species may occasionally be present in the shallower southern region of the wider EMBA.
Reef Manta Ray (Coastal Manta Ray)	The reef manta ray is found around the northern coast of Australia between south western Australia, and Central New South Wales (DoEE 2019). 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. The species is commonly sighted inshore, however is also found around offshore coral reefs, rocky reefs and seamounts (Marshall et al. 2018).	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 (IUCN 2019).	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 around Rowley Shoals and in the shallower southern region of the wider EMBA.
Giant Manta Ray	The giant manta ray lives in tropical, marine waters worldwide, and occasionally in temperate seas between latitudes 30°N and 35°S. In Australia, the species is recorded from south-western WA, around the tropical north to the southern coast of New South Wales.	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 around Rowley Shoals and in the shallower southern region of the wider EMBA.

Common Name	Habitat and Distribution	Seasonality	Relevance to EP
	Individuals have been recorded to travel up to 70 km over one day (van Duinkerken, 2010).		
Freshwater Sawfish (also known as Largetooth Sawfish)	The largetooth sawfish may potentially occur in all large rivers of northern Australia from the Fitzroy River, Western Australia, to the western side of Cape York Peninsula, Queensland (Allen 2000; DoEE 2019). It is a marine/estuarine species that spends its first three–four years in freshwater (DoEE 2019). The preferred habitat of this species is mud bottoms of river embayments and estuaries, but they are also found well upstream. The species mainly feeds on fishes and benthic invertebrates. The Fitzroy River has been identified as a likely important nursery site for the largetooth sawfish (located 380 km from the Operational Area and outside the EMBA) (Whitty et al. 2008). The freshwater sawfish pupping and foraging BIAs are located along Eighty Mile Beach and Roebuck Bay. Pupping is known to occur from the months of January to May at Eighty Mile Beach. The closest BIA is located 100 km from the Operational Area	A study on the movement patterns of other sawfish species, *P. clavata* and *P. zijsron*, showed that the species had a high fidelity to an area, with movements restricted to only a few square kilometres within the coastal fringe, and influenced by tides (Stevens et al. 2008).	Given the species preferred estuarine habitat, and the location of the pupping and foraging BIAs, the presence of the species within the Operational Area is expected to be low. The species may be present in the shallower southern region of the wider EMBA.
Green Sawfish	In Australian waters, green sawfish have historically been recorded in the coastal waters off Broome, Western Australia, around northern Australia and down the east coast as far as Jervis Bay, NSW (Stevens et al. 2005). 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). Green sawfish are found in Indonesian waters and it is possible that individuals may migrate between Australia and Indonesia. It is probable that the Australian population can be considered geographically separate (Stevens et al. 2005). The Sahul Shelf system is known to support populations of green sawfish (Donovan et al. 2008).	Sawfish are known to return seasonally to inshore coastal waters adjacent to the northern Australian region to breed and pup. Little is known about reproduction in Green Sawfish. It is unknown whether there is migration into Australian waters of Green Sawfish adults or juveniles from populations outside Australia. Green Sawfish are found in Indonesian waters and it is possible that individuals may migrate between Australia and Indonesia, however it is probable that the Australian population can be considered geographically separate (Stevens et al. 2005).	Given the species preferred estuarine habitat, and the location of the pupping and foraging BIAs, the presence of the species within the Operational Area is expected to be low. The species may be present in the shallower southern region of the wider EMBA.

Common Name	Habitat and Distribution	Seasonality	Relevance to EP
Sharks And Rays Potentially Occurring Within The EMBA			
Longfin Mako	Longfin makos inhabit oceanic and pelagic habits, typically in tropical regions. They are a highly mobile species and have a wide-ranging distribution (DSEWPaC 2012), but are rarely encountered. Longfin mako usually occur to depths of 760 m, but has been reported to 1,752 m (Rigby et al. 2019; Ebert et al. 2013, Hueter et al. 2016, Weigmann 2016).In Australian waters, the species is found from Geraldton, in WA, and north to Port Stephens in New South Wales (Last and Stevens 2009).	There is insufficient data to prescribe distribution behaviours, migration times and routes and seasonal patterns.	The PMST search identified the species as potentially occurring within the EMBA, and not within the Operational Area. Given the species wide-distribution and preference for deeper waters, the presence of the species within the EMBA is expected to be low.
Dwarf Sawfish	The dwarf sawfish is found in Australian coastal waters extending north from Cairns around the Cape York Peninsula in Queensland to the Pilbara coast (DoEE 2019). Dwarf sawfish typically inhabit shallow (2 to 3 m) silty coastal waters and estuarine habitats, occupying relatively restricted areas and moving only small distances (Stevens et al., 2008). The majority of capture locations for the species in WA waters have occurred within King Sound and the lower reaches of the major rivers that enter the sound, including the Fitzroy, Mary and Robinson rivers (Morgan et al., 2009). Individuals have also been recorded from Eighty Mile Beach in the Pilbara, and occasional individuals have also been taken from considerably deeper water from trawl fishing (Morgan et al., 2009). A study in north-western Western Australia found that estuarine habitats are used as nursery areas by Dwarf Sawfish, with immature juveniles remaining in these areas up until three years of age (Thorburn et al. 2007a). Adults are known to seasonally migrate back into inshore waters (Peverell 2007), although it is unclear how far offshore the adults travel, as captures in offshore surveys are very uncommon. The dwarf sawfish pupping, nursing and foraging BIAs are located along Eighty Mile Beach, approximately 100 km from the Operational Area.	Dwarf sawfish may move into marine waters after the wet season and during the wet season enter estuarine or fresh waters to breed. Adults are known to seasonally migrate back into inshore waters (Peverell 2007), although it is unclear how far offshore the adults travel.	The PMST search identified the species as potentially occurring within the EMBA, and not within the Operational Area. Given the species distribution and nearby pupping, nursing and foraging BIAs, the presence of the species in the EMBA is expected to be low.

4.3.8 Marine Reptiles

4.3.8.1 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.

Five 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 adjacent to the Operational Area (Figure 4-11). No foraging, internesting, or nesting BIAs overlap with the Operational Area.

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. The closest habitat is the flatback turtle internesting buffer at Eighty Mile Beach, approximately 60 km from the Operational Area. The flatback turtle internesting buffer is the only habitat critical to the survival of a marine turtle species to overlap with the wider EMBA.

4.3.8.2 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 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 2008). Amongst these species, one threatened sea snake species (the Short-nosed seasnake) was identified in the EPBC Act Protected Matters Database search as having the potential to occur in the Operational Area and EMBA. Further details on its habitats, life stages and likely presence within the Operational Area is provided in Table 4-8.

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

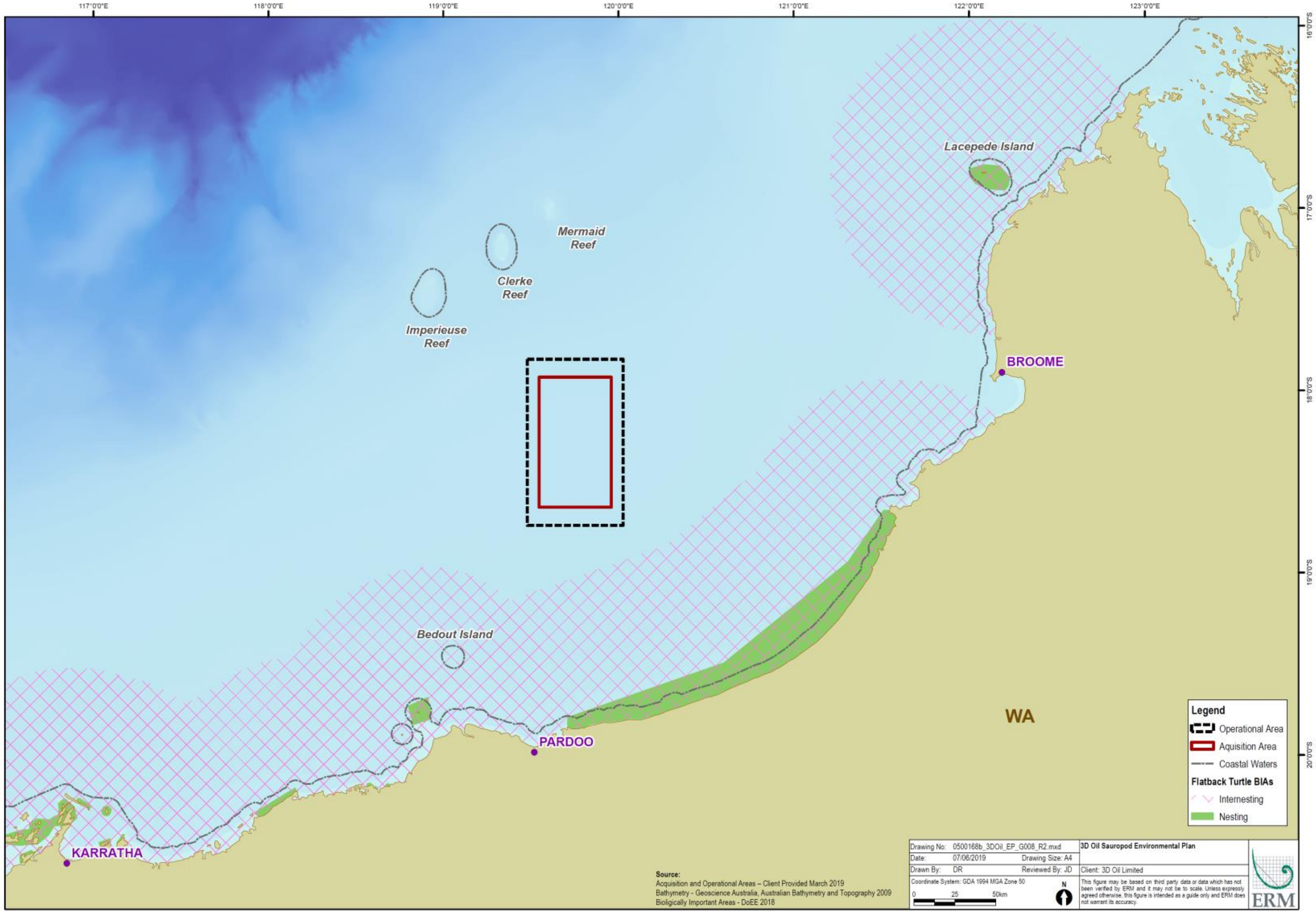


Figure 4-11 Flatback Turtle BIAs

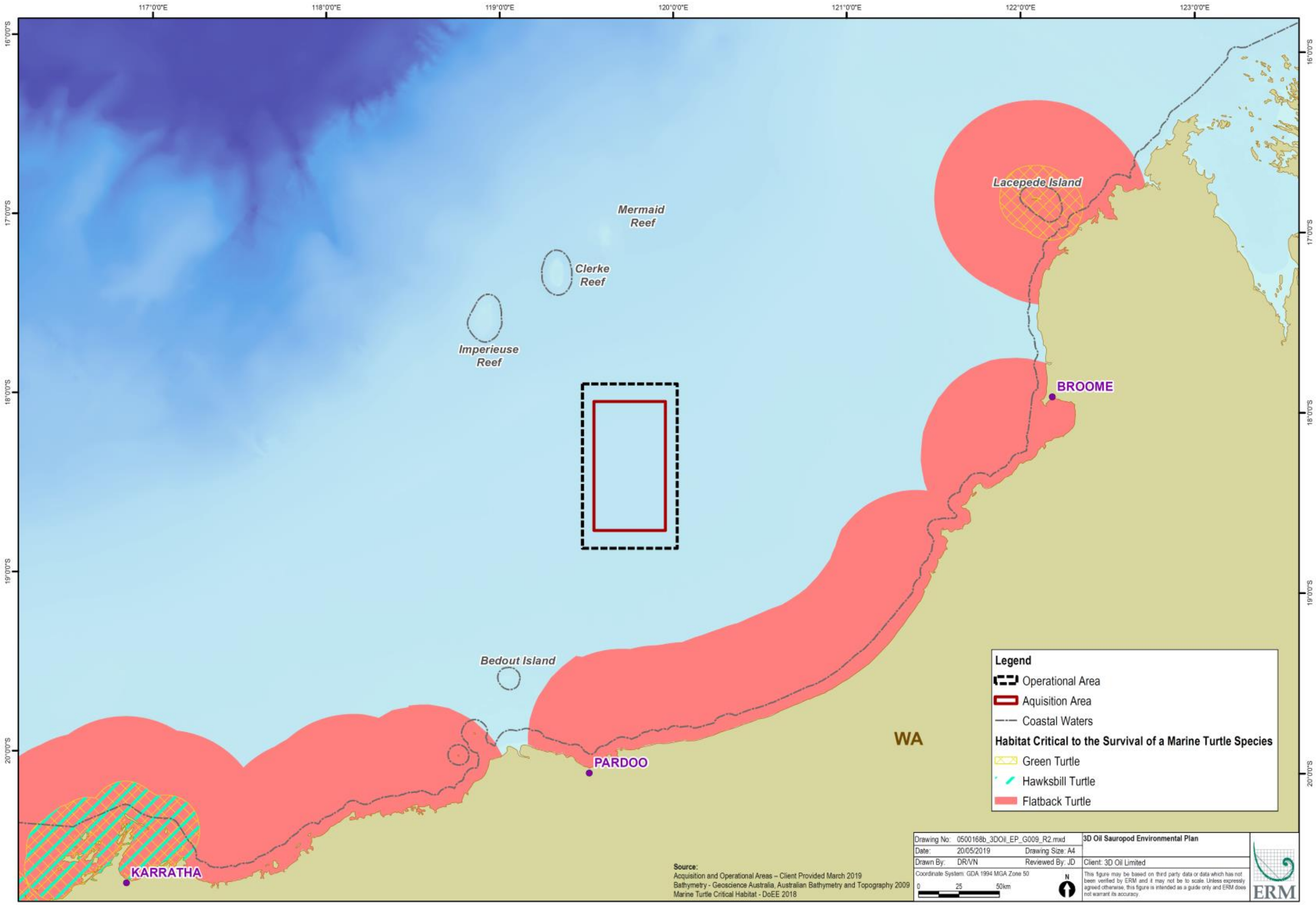


Figure 4-12 Habitat Critical to the Survival of Marine Turtles

Table 4-8 Threatened and Migratory Marine Reptiles Potentially Occurring Within The Operational Area and EMBA

Common Name	Habitat and Distribution	Phenology	Relevance to EP
Marine Reptiles Potentially Occurring Within The Operational Area			
Loggerhead Turtle	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 2019). The species are known to forage nearshore, in water depths up to approximately 50-60 m (DoEE 2019). In WA, the species nests on the Muiron Islands (approximately 630 km away) and on the beaches of North West Cape (approximately 665 km away) (DoEE 2019; Guinea 1995). The species are known to nest between October and February, with a peak in December (DoEE 2019). 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 2019).	Nesting occurs between October and February, with a peak in December (DoEE 2019).	There are no known loggerhead turtle BIAs located within the Operational Area or EMBA, and the Operational Area occurs outside of known foraging depths. Therefore, loggerhead turtles may occur within the Operational Area in low numbers as transitory individuals. Foraging habitat potentially occurs in the wider EMBA where individuals may occur in higher numbers.
Green Turtle	The green turtle has a global distribution and occurs in tropical and subtropical waters, with WA supporting one of the largest green turtle populations in the world (Limpus 2004). Principal rookeries in WA include the Lacepede Islands (approximately 250 km away), Barrow Island (approximately 475 km away), the Montebello Islands (approximately 450 km away), North West Cape (approximately 665 km away) and the Muiron Islands (630 km away) (Commonwealth of Australia 2012; Department of the Environment and Energy 2017). Smaller rookeries in the region include Ashmore Reef and Cartier Island (approximately 670 km away), Browse Island (approximately 550 km away), Cassini Island (approximately 740 km away), Maret Island (approximately 650 km away) and Sandy Islet at Scott Reef (approximately 250 km away) (Commonwealth of Australia 2012; Department of the Environment and Energy 2017). 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	Nesting occurs between November and March (DoEE 2019). 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 undertakes extensive post-nesting migrations from foraging areas to traditional breeding areas (Commonwealth of Australia 2012).	There are no known green turtle BIAs located within the Operational Area or EMBA, and the Operational Area occurs outside of known foraging depths. Therefore, green turtles are unlikely to occur within the Operational Area. Foraging habitat potentially occurs in the wider EMBA where individuals may occur in higher numbers.

Common Name	Habitat and Distribution	Phenology	Relevance to EP
	(Hazel et al. 2009). The closest foraging BIA to the Operational Area is located at Bedout Island (approximately 90 km away) and James Price Point (approximately 190 km away). The nearest nesting BIA is located at Lacepede Islands (approximately 230 km away). Females are known to stay within approximately 20 km from nesting beaches (Commonwealth of Australia 2012). The green turtle 'habitat critical to the survival of marine turtles' BIA is located approximately at Adele Island and Lacepede Island, 230 km to the east of the Operational Area.		
Leatherback Turtle	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. Leatherback turtles forage on pelagic soft bodied creatures (such as jellyfish, squid, salps, siphonophores and tunicates) all year round in Australian waters (DoEE 2019). No BIAs have been identified for the species within the Operational Area or wider EMBA.	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 (DoEE 2019)	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.
Hawksbill Turtle	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. Australia has the largest breeding population of hawksbill turtles in the world (Limpus 2008). 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 2019). The closest foraging BIA to the Operational Area is located at Bedout Island (approximately 90 km away). The nearest nesting BIA is located at the Dampier Archipelago (i.e. islands to the west of the Burrup Peninsula), 270 km from the Operational Area. The nesting BIA is surrounded by an internesting BIA (buffer of 20 km). The 'habitat critical to the survival of marine turtles' BIA is also located at the Dampier Archipelago.	Hawksbill turtles nest year round, with a peak between October and December (DEWHA 2008). Inter-nesting females are known to stay within approximately 20 km of nesting beaches. The north-east subpopulation breeds throughout the year with a peak nesting period during July to October (DSEWPaC 2012), whilst breeding in the WA population peaks around October to January. 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 2019).	Given the species nesting, internesting and foraging BIAs are located in close proximity to the Operational Area, transient turtles may be present within the Operational Area and wider EMBA.

Common Name	Habitat and Distribution	Phenology	Relevance to EP
Flatback Turtle	The flatback turtle is found in the tropical waters of northern Australia, Papua New Guinea and Irian Jaya, and nesting is only known to occur in Australia (Limpus 2007). The NWMR is an important nesting area, with major rookeries present from Exmouth to the Lacepede Islands (approximately 250 km away) and along the Kimberley coast and islands. There are significant rookeries on Barrow Island, Thevenard Island, Montebello Islands and Lowendal Islands (Commonwealth of Australia 2012). Nesting occurs between November and March, peaking in January (Commonwealth of Australia 2012). The nearest nesting BIA is located at Eighty Mile Beach, approximately 95 km from the Operational Area (Figure 4-11). A 'habitat critical to the survival of marine turtles' is also located along Eighty Mile Beach, approximately 55 km from the Operational Area (Figure 4-12). Nesting occurs between May and July (DoEE 2019). Internesting habitat is located immediately seaward of nesting habitat. Female flatback turtles may occur within 60 km of nesting beaches during the internesting period (DoEE 2019). An internesting BIA is located 15 km from the Operational Area, at Eighty Mile Beach. Flatback turtles are known to feed on gastropod molluscs, squid, soft corals, hydroids and jellyfish (DoEE 2019). The closest foraging BIA to the Operational Area is located at Bedout Island (approximately 90 km away) and James Price Point (approximately 190 km away).	In the Kimberley and Pilbara regions of Western Australia, from approximately the Lacepede Islands to Exmouth, there is a mid-summer peak nesting season. Flatback turtle hatchlings do not have an offshore pelagic phase. Instead, hatchlings grow to maturity in shallow coastal waters thought to be close to their natal beaches (Commonwealth of Australia 2012). Although turtles remain close to nesting beaches during the internesting period, there is evidence that some flatback turtles undertake long-distance migrations between breeding and feeding grounds. A survey carried out in the region between 2005 and 2012 identified the distances 73 female flatback turtles travelled to their foraging grounds; 11 remained within 100 km of their rookeries, four migrated an average of 400 km and 58 migrated between 1,000 and 1,500 km (Pendoley et al 2014).	Given the species internesting BIA located approximately 15 km from the Operational Area, transient turtles may be present within the Operational Area. Foraging habitat potentially occurs in the wider EMBA where individuals may occur in higher numbers.
Marine Reptiles Potentially Occurring Within The EMBA			
Short-nosed Seasnake	The short-nosed sea snake is endemic to WA and has been recorded from Exmouth Gulf to the reefs of the Sahul Shelf (Commonwealth of Australia 2012). The species is thought to have a very restricted distribution. The species can be found in reef flats and shallow water in water depths to 10 m (Commonwealth of Australia 2012). The species is typically found within 70 km from the shoreline, preferring shallow depths of 10 m; the species' limited range results in the species only occupying an area of less than 10 km^2 around the reef (Lukoschek et al 2010). Few short-nosed sea snakes move further than 50 m from the reef flats (DoEE 2019).	Seasnakes are long-lived and slow-growing with small broods and high juvenile mortality. Little is known of the age at which seasnakes reach sexual maturity. Seasnakes have a gestational period of 6-7 months, indicating that females are unlikely to breed every year.	The PMST search identified the species as potentially occurring within the EMBA, and not within the Operational Area. The species is expected to be restricted to shallow waters and may occur in the shallow coastal waters of the wider EMBA.

4.3.9 Marine Birds

Many migratory shorebirds (including those frequenting offshore islands) and seabird species are known to occur in the NWMR. 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 may also breed within the region.

There are 23 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.

Two threatened, two threatened and migratory, and 13 migratory marine birds were identified by a search of the EPBC Act Protected Matters Database as potentially occurring in the Operational Area and EMBA. Several biologically important areas for marine bird species have been identified within the Operational Area and EMBA (see Table 4-5).

A description of the distribution, migration movements, and preferred habitat and life stages of the identified marine bird species is provided in Table 4-9, including commentary on their likely presence in the Operational Area.

Table 4-9 Threatened and Migratory Seabirds Potentially Occurring Within The Operational Area And EMBA

Common Name	Habitat and distribution	Phenology	Relevance to EP
Marine Birds Potentially Occurring Within The Operational Area			
Eastern Curlew	Within Australia, the eastern curlew has a primarily coastal distribution. They have a continuous distribution from Barrow Island and Dampier Archipelago, Western Australia, through the Kimberley and along the Northern Territory, Queensland, and NSW coasts and the islands of Torres Strait. Elsewhere they are patchily distributed (DoEE 2019). This species does not breed in Australia, rather in the Northern Hemisphere summer, between early May and late June (DoEE 2019). 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 2019).	This species does not breed in Australia, rather in the Northern Hemisphere summer, between early May and late June (DoEE 2019). They start to departure early March and begin to arrive back in late July.	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 density may be encountered in the nearshore waters of the wider EMBA.
Red Knot	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. In Australasia the Red Knot mainly inhabit 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 are usually between September and October.	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 density may be encountered in the nearshore waters of the wider EMBA.
Abbott's Booby	Currently, Abbott's Booby is only known to breed on Christmas Island and to forage in the waters surrounding the island. Christmas Island is close to a number of cold water upwellings that probably provide food	Abbott's boobies travel large distances to feeding grounds during breeding season. It appears that some adults leave	Given the wide distribution and migration pattern, this species may be present in the

Common Name	Habitat and distribution	Phenology	Relevance to EP
	that is seasonal in nature, and upon which a number of the seabirds may depend for raising their young. Abbott's Booby is a marine species. It spends much of its time at sea, but needs to come ashore to breed. It nests in tall rainforest trees in the western, central and northern portions of Christmas Island. Abbott's Booby feeds on fish and squid (Marchant & Higgins 1990; Reville et al. 1990).	Christmas islands for 4-5 months and return in April. Breeding commences in March, when established pairs begin returning to nest sites and start collecting nest material.	Operation Area and EMBA in low numbers or isolated individuals/groups.
Common Sandpiper	Distributed along all coastlines of Australia and many areas inland, the Common Sandpiper is widespread in small numbers. The area of national importance along the coast of Western Australia is Roebuck Bay (approximately 160 km away from the Operational Area). 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.	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 wide distribution and migration pattern, this species may be present in the Operation Area in low numbers or isolated individuals/groups. Higher population density may be encountered in the nearshore waters of the wider EMBA.
Common Noddy	In Australia, the Common Noddy occurs mainly in the ocean off the Queensland coast, but the species also occurs off the north-west and central Western Australian 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 Common Noddy feeds mainly on fish, although they are known to also take squid, pelagic molluscs, medusa and aquatic insects.	The seasonality of breeding varies greatly between sites. At some locations, birds breed annually and at others birds breed twice a year (spring to early summer and again at autumn).	Given the wide distribution of the species and location of breeding habitat, this species may be present in the Operational Area and EMBA in low numbers.
Sharp-tailed Sandpiper	The Sharp-tailed Sandpiper spends the non-breeding season in Australia with small numbers occurring regularly in New Zealand. Most of the population migrates to Australia, mostly to the south-east and are widespread in both inland and coastal locations. In Western Australia they are widely distributed from Cape Arid to Carnarvon, around coastal plains of the Pilbara Region to south-west and east Kimberly Division.	Most of the population migrates to Australia, mostly to the south-east and are widespread in both inland and coastal locations.	Given the wide distribution of this species and the migratory pattern, it is likely the presence of this species will be encountered in low number or isolated individuals within the Operational Area.

Common Name	Habitat and distribution	Phenology	Relevance to EP
	In Australasia, the Sharp-tailed Sandpiper prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emerged grass or low vegetation. The species forages on seeds, worms, molluscs, crustaceans and insects. The Sharp-tailed Sandpiper forages on seeds, worms, molluscs, crustaceans and insects. Eighty-mile beach (approximately 115 km away from the Operational Area) is the closest international important site for the species.	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.	Higher population density may be encountered in the nearshore waters of the wider EMBA.
Pectoral Sandpiper	In Australasia, the Pectoral Sandpiper prefers shallow fresh to saline wetlands. 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.	The pectoral sandpiper breeds in the northern hemisphere during the boreal summer, before undertaking long distance migrations to feeding grounds in the southern hemisphere. The species occurs throughout mainland Australia between spring and autumn.	Given the wide distribution of this species and the migratory pattern, it is likely the presence of this species will be encountered in low number or isolated individuals within the Operational Area. Higher population density may be encountered in the nearshore waters of the wider EMBA.
Streaked Shearwater	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 it does not breed in Australia, it is known to forage in the region. 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 2019)	The species breeds in temperate regions of East and South-east Asia before migrating to tropical regions near the equator, however little is known about their movements during the non-breeding period (Yamamoto et al. 2010).	Given the distribution of the species and habitat, this species may be present in the Operational Area and EMBA

Common Name	Habitat and distribution	Phenology	Relevance to EP
Lesser Frigatebird	Lesser Frigatebird is usually seen in tropical or warmer waters off northern Western Australia, Northern Territory, Queensland and northern New South Wales. 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 & 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 2019). In Australia, Lesser Frigatebird's egg laying occurs mostly about mid-year. A breeding BIA overlaps with a small portion of the southern section of the Operational Area.	The lesser frigatebird breeds between May and December and usually stays within 100 – 200 km of the colony during the breeding season, but when not breeding they range widely throughout tropical seas (Lindsey 1986).	Given the distribution of the species and habitat, this species may be present in the Operational Area and EMBA.
Osprey	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 Western Australia 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 distribution of the species and habitat, this species may be present in the Operational Area and EMBA.
White-tailed Tropicbird	The white-tailed tropicbird is found in pelagic waters and tropical waters. The white-tailed tropicbird, forages in warm waters and over long distances – many kilometres from its breeding sites. A breeding BIA has been identified at the Rowley Shoals, which overlaps with the northern portion of the Acquisition Area.	Breeding is recorded in May and October at the Rowley Shoals.	Given the distribution of the species and nearby breeding habitat, this species may be present in the Operational Area and EMBA.
Great Frigatebird, Greater Frigatebird	Great frigatebirds are found in tropical waters globally. It 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 2019).	Given the distribution of the species and nearby breeding habitat, this species may be present in the Operational Area and EMBA.

Common Name	Habitat and distribution	Phenology	Relevance to EP
Marine Birds Potentially Occurring Within The EMBA			
Curlew Sandpiper	The Curlew Sandpiper's breeding areas are mainly restricted to the Arctic of northern Siberia (DoEE 2019). 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 2019). 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 2019).	The species is known to 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 (DoEE 2019).	Given the distribution of the species and nearby breeding habitat, this species may be present in the nearshore waters of the EMBA.
Red-tailed Tropicbird	The Red-tailed Tropicbird nests in the southern Indian Ocean, and just north of the Tropic of Cancer and south of the Tropic of Capricorn in the Pacific Ocean. It breeds on islands, but can also be found on the south-west coast of Australia. This species feeds mostly on fish, especially flying-fish, large quantities of squid and occasionally crustaceans. Prey is caught by plunge-diving, but flying-fish can be taken in flight. Breeding occurs seasonally in loose colonies on small, remote oceanic islands mostly on inaccessible cliffs.	No regular migrations are known; adults can be found in the vicinity of colonies all year round (del Hoyo et al. 1992).	Given the wide distribution of this species and the migratory pattern, it is likely the presence of this species will be encountered in low number or isolated individuals within the EMBA.
Little Tern	The little tern is widespread in Australia, with breeding sites widely distributed. The species has three separate populations in Australia; the northern subpopulation breeds across northern Australia, the eastern subpopulation breeds in the eastern and south-eastern coast of Australia; and the third subpopulation comprises of Asian migrants that migrate to spend their non-breeding season in Australia. The species has a widespread and continuous distribution from north-western Australia, around the north and east coast to south eastern Australia (DoEE 2019). The little tern is a coastal seabird which usually forages in very shallow water, more often in brackish lagoons and saltmarsh creeks (DoEE 2019). The little tern usually forages close to breeding colonies (DSEWPaC 2012d). The closest breeding site to the Operational Area for the non-Asian migrants of the species is on the coastline of the Kimberley.	Migration about this species is poorly known. However, it is recorded that breeding typically occurs in late April-July and September to early January.	Given the distribution of the species and habitat, this species may be present in the nearshore waters of the EMBA.

Common Name	Habitat and distribution	Phenology	Relevance to EP
	A resting BIA is located around the Rowley Shoals, approximately 25 km from the Operational Area. In addition, a breeding BIA is located approximately 85 km south of the Operational Area.		
Brown Booby	The brown booby occurs in, but is not restricted to, tropical waters of all major oceans. They often stay close to their breeding islands. The species is also known to be present along coastal waters, harbours and estuaries; however, they seldom fly over land. The brown booby generally feeds in inshore water in both shallow and deep waters (DoEE 2019). The brown bobby nests on rugged rocky terrain such as cliffs and steep slopes, on larger islands, beaches, coral rubble and guano flats on cays (DoEE 2019). The species is known to be resident and partly nomadic (i.e. birds dispersing widely between breeding seasons). Breeding occurs in and adjacent to region, including on Ashmore Reef, Adele Island, White Island, Lacepede Islands and Bedout Island. The closest breeding BIA is located approximately 40 km south of the Operational Area.	The species typically leaves breeding islands when not breeding, in search of better foraging grounds (DoEE 2019). Breeding times are unknown.	Given the distribution of the species and habitat, this species may be present in the nearshore waters of the EMBA.
Lesser Crested Tern	This species can be found on islands and coastlines of the tropical and subtropical, ranging from the Atlantic Coast of South Africa, south around the Cape and continuing along the coast of Africa and Asia almost without break to south-east Asia and Australia. The species inhabits tropical and subtropical coastlines, foraging in the shallow waters of lagoons, coral reefs, estuaries, bays, harbours and inlets, along sandy, rocky, coral or muddy shores, on rocky outcrops in open sea, in mangrove swamps and offshore waters. The species has a preference for nesting on offshore islands, low-lying coral reefs, sandy or rocky coastal islets, coastal spits, lagoon mudflats, and artificial islets in saltpans.	The species nests in dense colonies with neighbouring nests very close together (rims may be touching) and usually forages within 3 km of the breeding colony (del Hoyo et al. 1996).	Given the distribution of the species and nearby breeding habitat, this species may be present in the nearshore waters of the EMBA.

4.3.10 Timing of Biological Sensitivities

A number of biological sensitivities related to the phenology of marine fauna are expected to occur within the Operational Area and wider EMBA. Table 4-10 identifies the timing of key biological sensitivities relevant to the Operational Area and wider EMBA. The fauna listed in Table 4-10 are species listed under the EPBC Act and considered relevant to this EP. The fish species are those identified as key indicator species for the relevant fisheries identified in Section 4.4.4.

Table 4-10 Timing of Key Biological Sensitivities Relevant to the Operational Area and Wider EMBA

Sensitivity	January	February	March	April	May	June	July	August	September	October	November	December
Proposed Sauropod 3D MSS timing												
Operational Area												
Humpback whale (north migration)[1]												
Humpback whale (south migration)[1]												
Pygmy blue whale (north migration)[2]												
Pygmy blue whale (south migration)[2]												
Whale shark foraging BIA[3]												
Goldband snapper spawning (Pilbara stock)[4]												
Rankin cod spawning[4]												
Red emperor spawning[4]												
Blue-spotted emperor spawning[4]												
Giant ruby snapper spawning[4]												
Other demersal fish species spawning[4]												
Blacktip shark breeding[4]												
Sandbar shark breeding[4]												
White-tailed tropicbird foraging BIA[5]												
Lesser frigatebird foraging BIA[5]												
EMBA												
Flatback turtle internesting[6]												
Spanish mackerel spawning (Pilbara stock)[4]												
Peak period												
Extended peak period												

[1] (Source: DoEE 2019)
[2] (Source: DoE 2015, Double *et al*. 2012, 2014)
[3] (DoE, 2015; CALM 2005, Environment Australia 2002)

[4] (Source: DPIRD 2019)

[5] (Source: DoEE 2015)

[6] (Source: DoEE 2017, CALM 2005, DSEWPaC 2012)

4.4 Socio-economic and Cultural Environment

4.4.1 Commonwealth Protected Areas

4.4.1.1 Argo-Rowley Terrace Marine Park

The Argo-Rowley Terrace Australian Marine Park (AMP) is located approximately 20 km north of the Operational Area and approximately 270 km west-north-west of Broome (Figure 4-13). The Argo-Rowley Terrace AMP covers an area of 146,003 km^2 in depths between 220 – 6000 m from the continental slope to the edge of the Exclusive Economic Zone (EEZ) (Director of National Parks, 2018). The AMP includes an 83,379 km^2 Marine National Park Zone (IUCN II), a 62,720 km^2 Multiple Use Zone (IUCN VI), and a 1140 km^2 Special Purpose Zone (Trawl). The Argo-Rowley Terrace AMP boundary is contiguous with the Rowley Shoals State Marine Park (Section 4.4.2.1) and Mermaid Reef Australian Marine Park (Section 4.4.1.2), providing continuous protection to the three coral atolls Clerke Reef, Imperieuse Reef and Mermaid Reef (collectively known as the Rowley Shoals).

The Argo-Rowley Terrace AMP contains habitats, species and ecological communities associated with the Northwest Transition and Timor Province (Director of National Parks 2018). The Northwest Transition is an area of shelf break and continental slope, of which the Rowley Shoals are a key topographic feature. The Timor Province is dominated by warm, nutrient-poor waters. The AMP contains a range of seafloor features such as canyons on the slope between the Argo Abyssal Plain. These geomorphic features are thought to contribute to small, periodic upwellings that results in localised higher levels of biological productivity (Director of National Parks 2018).

The Marine Park supports a range of species including species listed as threatened, migratory, marine or cetacean under the EPBC Act. Biologically important areas within the Marine Park include resting and breeding habitat for seabirds and a migratory pathway for the pygmy blue whale. The Marine Park is thought to be an important area for sharks, which are found in abundance around the Rowley Shoals, and provides important foraging areas for migratory birds and the endangered loggerhead turtle (DoEE n.d).

The Argo-Rowley Terrace Australian Marine Park contains two KEFS: the canyons linking the Argo Abyssal Plain with the Scott Plateau and the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals. The canyons linking the Argo Abyssal Plain with the Scott Plateau KEF is thought to contribute to high productivity and aggregations of marine life through the upwelling of nutrient rich water (DoEE n.d.). The Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF is valued for enhanced productivity, aggregations of marine life and high species richness (DoEE n.d.). These KEFs are further described in Section 4.4.3.

4.4.1.2 Mermaid Reef Australian Marine Park

Mermaid Reef Marine Park is located approximately 69 km from the Operational Area, but within the wider EMBA. The AMP covers an area of approximately 540 km^2 and is listed as a National Park Zone (IUCN II). The AMP is near the edge of Australia's continental slope and is surrounded by waters that extend to a depth of over 500 m. The AMP contains Mermaid Reef, the most north-easterly of three reef systems forming the Rowley Shoals. Mermaid Reef is totally submerged at high tide and therefore falls under Australian Government jurisdiction. The other two reefs of the Rowley Shoals (Clerke Reef and Imperieuse Reef) are managed by the Western Australian Government as part of the Rowley Shoals Marine Park. Mermaid Reef–Rowley Shoals is listed on the Commonwealth Heritage List.

Mermaid Reef AMP contains habitats, species and ecological communities associated with the Northwest Transition (Director of National Parks 2018). The reefs of the Rowley Shoals are one of the few offshore reef systems on the north-west shelf, and are thought to provide ecological stepping stones for reef species originating in Indonesian/Western Pacific waters (Director of National Parks 2018). The Rowley Shoals may also provide a degree of connectivity between these reefs and reefs located further south.

Mermaid Reef is a biodiversity hotspot and key geomorphic feature of the Argo Abyssal Plain (Director of National Parks 2018). Collectively, Mermaid Reef, Clerke Reef and Imperieuse Reef support over 200 species of hard corals and 12 classes of soft corals with coral formations in pristine condition. The shoals are an important area for sharks, including the grey reef shark, the whitetip reef shark and the silvertip whaler; important foraging area for marine turtles; toothed whales; dolphins; tuna and billfish; an important resting and feeding site for migratory seabirds; and a migratory pathway for pygmy blue whales (DoEE n.d.).

The AMP contains the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF, valued for its high species richness, high productivity and aggregations of marine life (DoEE n.d.). The Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF is further described in Section 4.4.3.2. The Marine Park contains one known shipwreck, the *Lively* (wrecked in 1810), which is located to the north-west side of Mermaid Reef. The wreck is listed under the Historic Shipwrecks Act 1976.

4.4.1.3 *Eighty Mile Beach Australian Marine Park*

Eighty Mile Beach AMP is located approximately 72 km south of the Operational Area and outside the wider EMBA, however the AMP is considered relevant to this EP. The AMP is located approximately 74 km north-east of Port Hedland and adjacent to the Western Australian Eighty Mile Beach Marine Park. The Marine Park covers an area of 10,785 km² and a water depth ranges between less than 15 m and 70 m. The entire marine park is zoned as a Multiple Use Zone (IUCN VI).

The Eighty Mile Beach Marine Park consists of shallow shelf habitats, including terrace, banks and shoals. The Marine Park supports a range of species including threatened, migratory, marine and cetacean species. Biologically important areas within the Marine Park include breeding, foraging and resting habitat for seabirds, internesting and nesting habitat for marine turtles, foraging, nursing and pupping habitat for sawfish and a migratory pathway for humpback whales (Director of National Parks 2018).

The Eighty Mile Beach Ramsar site lies adjacent to the AMP and is recognised as one of the most important areas for migratory shorebirds in Australia.

The Marine Park contains three known shipwrecks listed under the Historic Shipwrecks Act 1976: Lorna Doone (wrecked in 1923), Nellie (wrecked in 1908), and Tifera (wrecked in 1923).

Eighty Mile Beach Marine Park also has a range of cultural values for the community. Sea country is valued for Indigenous cultural identity, health and wellbeing. The sea country of the Nyangumarta, Karajarri and Ngarla people extends into Eighty Mile Beach Marine Park (Director of National Parks 2018). Sea country is culturally significant and important to their identity.

4.4.2 State Protected Areas

4.4.2.1 *Rowley Shoals*

The Rowley Shoals are located approximately 48 km from the Operational Area, while the wider EMBA overlaps with the Rowley Shoals Marine Park.

Rowley Shoals consist of three reefs – Mermaid Reef, which is managed under Commonwealth legislation; Clerke Reef which (30km south-west of Mermaid Reef); and Imperieuse Reef (40km south-west of Clerke Reef), which is the largest of the three reefs.

Rowley Shoals is covered by the ‘Rowley Shoals Marine Park Management Plan 2007-2017’, which is still in effect. The boundary of the Argo-Rowley Terrace AMP bounds Rowley Shoals to the north and Mermaid Reef AMP to the east.

Rowley Shoals and surrounding waters are important to the region in supporting high species richness, higher productivity and aggregations of marine life associated with the reefs. The enhanced productivity in Rowley Shoals is facilitated by the breaking of internal waves in the waters surrounding the reef system, therefore, causing mixing and resuspension of nutrients from water depths of 500-700m (DoEE n.d.).

The marine environments within the shoal are typically of clear-water environments and include resident organisms and migrant species (Department of Environment and Conservation 2007). Given the remote location of the reefs, there is no history of disturbance by coral predators, and therefore, creating a diverse number of marine species, including many molluscs, echinoderms and finfish that are not recorded anywhere else in Western Australia and similar habitats in Eastern Australia (DoEE n.d).

The Rowley Shoals contain intertidal and subtidal coral reefs, which support a diverse number of marine fauna and a range of reef biota. Surveys carried out by the Western Australian Museum identified 184 species of corals, primarily Indo-West Pacific species, indicating the strong affinity of the Rowley Shoals communities with Indonesia. In terms of other species, 264 species of molluscs, 82 species of echinoderms and 389 species of finfish were also identified (Department of Environment and Conservation 2007).

As per Section 4.5.1.2, Mermaid Reef has a diverse shark population, which extends to Rowley Shoals. Aside from sharks, reef edges also attract migratory pelagic species such as dolphins, tuna and billfish (DoEE n.d.). Furthermore, Rowley Shoals provides important habitat, feeding, resting and breeding grounds a number of migratory birds, including the red-tailed tropicbird; white-tailed tropicbird and little tern.

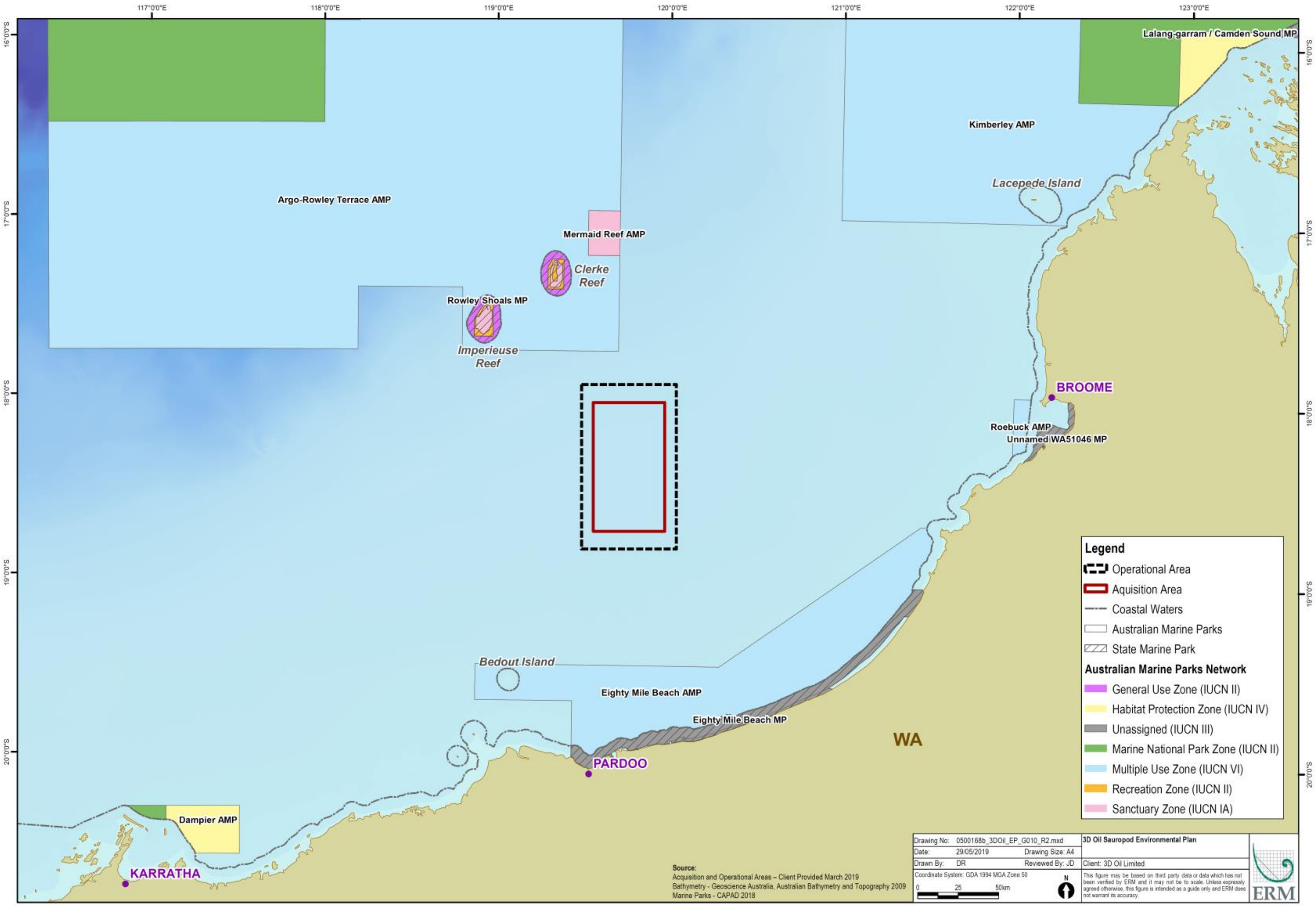


Figure 4-13 Commonwealth and State Protected Areas

4.4.3 Key Ecological Features

Key Ecological Features (KEFs) are the parts of the marine ecosystem that are considered to be of importance for a marine region's biodiversity or ecosystem function and integrity (DoEE n.d.). KEFs have been identified by the Australian Government on the basis of advice from scientists about the ecological processes and characteristics of the area.

One KEF occurs within the Operational Area (the Ancient coastline at 125 m depth contour), and two KEFs occur within the wider EMBA (the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals, and the Continental Slope Demersal Fish Communities) (Figure 4-14). These KEFs are described below.

4.4.3.1 *Ancient coastline t 125 m depth contour*

Several steps and terraces as a result of Holocene sea level changes occur in the region with the most prominent of these features occurring as an escarpment along the NWS and Sahul Shelf at a water depth of 125 m. These steps and terraces form the Ancient coastline at 125 m depth contour KEF, which covers an area of approximately 16,190 km^2. The ancient coastline at 125 m depth contour is defined as a key ecological feature as it is a unique seafloor feature with ecological properties of regional significance. The ancient coastline is not continuous and is fragmented along the 125m depth contour.

Where the ancient submerged coastline provides areas of hard substrate, it may contribute to higher diversity and enhanced species richness relative to soft sediment habitat (DSEWPaC 2012d). Parts of the ancient coastline, represented as rocky escarpment, are considered to provide biologically important habitat in an area predominantly made up of soft sediment.

The topographic complexity of escarpments associated with this feature may facilitate vertical mixing of the water column, providing relatively nutrient-rich localised environments. Migratory pelagic species (e.g. humpback whales and whale sharks) may use this escarpment as a guide.

Although the ancient coastline adds additional habitat types to a representative system, the habitat types are not unique to the coastline as they are widespread on the upper shelf (Falkner et al. 2009).

The Operational Area and the wider EMBA overlap with the ancient coastline at 125 m depth contour. In particular, the Operational Area spatially covers approximately 1,535 km^2 or 9% of the KEF.

4.4.3.2 *Mermaid Reef and Commonwealth Waters Surrounding Rowley Shoals*

Mermaid Reef and Commonwealth waters surrounding Rowley Shoals are regionally important in supporting high species richness, higher productivity and aggregations of marine life associated with the adjoining reefs themselves. The Mermaid Reef and Commonwealth waters surrounding Rowley Shoals are listed as a KEF due to its high productivity and aggregations of marine life.

The Rowley Shoals are a collection of three atoll reefs, Clerke, Imperieuse and Mermaid. Mermaid Reef lies 29 km north of Clerke and Imperieuse reefs and is totally submerged at high tide. Mermaid Reef falls under Commonwealth jurisdiction (DOEE 2019). Clerke and Imperieuse reefs constitute the Rowley Shoals Marine Park, which falls under Western Australian Government jurisdiction (EA 2000).

The reefs provide a distinctive biophysical environment in the Region, with steep and distinct reef slopes, which attract a range of migratory pelagic species and associated fish communities. In evolutionary terms, the reefs may play a role in supplying coral and fish larvae to reefs further south via the southward flowing Indonesian Throughflow. The Rowley Shoals are known to contain 214 coral species and approximately 530 species of fishes, 264 species of molluscs and 82 species of echinoderms (Done et al. 1994; Gilmour et al. 2007).

Rowley Shoals' reefs are different from other reefs in the chain of reefs on the outer shelf of the North-west Marine Region, both in structure and genetic diversity as there is little connectivity between Rowley Shoals and other outer-shelf reefs (Done et al. 1994; Hooper & Ekins 2004; Underwood et al. 2009). An additional difference is that sea snakes do not occur at the Rowley Shoals (Done et al. 1994).

The wider EMBA overlaps with the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals, while the Operational Area is located approximately 46 km north-east away from the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals.

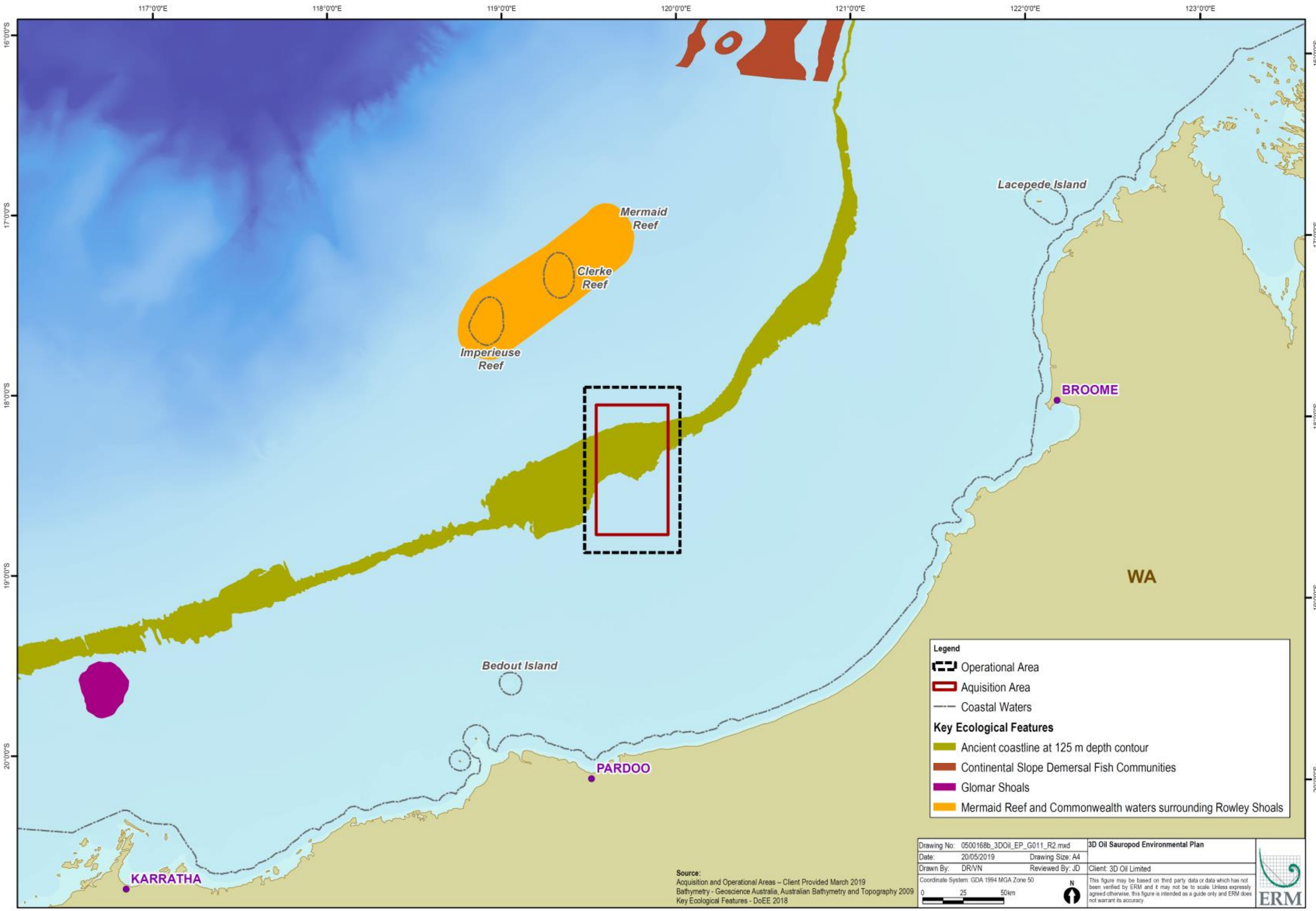


Figure 4-14 Key Ecological Features

4.4.4 Commercial Fisheries

Commercial fishing in Western Australia is comprised of WA State managed fisheries and Commonwealth managed fisheries, and is mainly based on low-volume, high-value products (DPIRD, 2018) The Australian Fisheries Management Authority (AFMA) manages Australian fisheries on behalf of the Commonwealth Government from 3 nm to the edge of the Australian fishing Zone (AFZ). AFMA carry out objectives that are listed in the *Fisheries Administration Act 1991* and the *Fisheries Management Act 1991.* Commonwealth managed fisheries with management boundaries that overlap the Operational Area and EMBA include the:

- Southern Bluefin Tuna Fishery (SBTF)
- Western Tuna and Billfish Fishery (WTBF)
- Western Skipjack Tuna Fishery (WSTF)
- North-West Slope Trawl Fishery (NWSTF)

The Department of Primary Industries and Regional Development (DPIRD) manage fisheries that take place predominantly within the offshore waters of Western Australia and within 3 nm of the coastline. WA State managed fisheries with management boundaries that overlap the Operational Area include the:

- Mackerel Managed Fishery (MMF)
- Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF)
- Pilbara Trap Managed Fishery (PTMF)
- Pilbara Line Fishery (PLF)
- Northern Demersal Scalefish Managed Fishery (NDSMF)
- Nickol Bay Prawn Managed Fishery (NBPMF)
- Beche-de-mer Managed Fishery
- Marine Aquarium Managed Fishery (MAMF)
- Specimen Shell Managed Fishery (SSMF)
- Western Australian North Coast Shark fishery (WASF)

The Commonwealth and WA State managed commercial fisheries with the licence to operate within the Operational Area and/or EMBA are described in Table 4-11.

Table 4-11 Commonwealth and WA State Managed Fisheries

Fishery	Fishery Overlap		Description	Catch/effort potentially within the Operational Area	Relevance to EP
	Operational Area	EMBA			
Commonwealth Managed Fisheries					
Southern Bluefin Tuna Fishery (SBTF)	✓	✓	The SBTF management area covers the entire Australian Fishing Zone overlaps with the Operational Area (Figure 4-15). The fishery targets Southern bluefin tuna (*Thunnus maccoyii*) using purse seine, pelagic longline and some minor line. The SBTF fishing season runs for 12 months, beginning 1 December. In the 2016-17 fishing season, 22 active vessels caught 5,334 tonnes of southern Bluefin tuna (Patterson et al. 2018). Effort is concentrated in the Great Australian Bight and no catch or effort from the SBTF occurs in WA. The only known spawning grounds of the southern bluefin tuna occurs in the Java sea, beyond the wider EMBA.	X	No effort from the SBTF occurs in Western Australia. Therefore, the activities of the SBTF are considered to be outside the scope of this EP.
Western Tuna and Billfish Fishery (WTBF)	✓	✓	The WTBF management area covers western portion of the AFZ from the SA/Victorian border to the Cape York Peninsula, and overlaps with the Operational Area (Figure 4-15). The fishery targets bigeye tuna (*Thunnus obesus*), yellowfin tuna (*Thunnus alacares*), striped marlin (*Kajikia audax*), swordfish (*Xiphias gladius*), and albacore (*Thunnus alalunga*) using pelagic longline, minor line and purse seine. The WTBF fishing season runs for 12 months, beginning 1 February. In the 2016-2017 season, four active vessels caught 322 tonnes of the various target species (Patterson et al. 2018). The WTBF typically fish in Australia's Economic Zone and the high seas of the Indian Ocean. In recent years, effort has been concentrated off south-west Western Australia and South Australia.	X	The Operational Area partially overlaps with the management area of the WTBF; however, the proposed survey is not expected to affect the actual activities of this fishery.
Western Skipjack Tuna Fishery (WSTF)	✓	✓	Australia's Skipjack Tuna Fishery is divided into the Eastern Skipjack Tuna Fishery and the Western Skipjack Tuna Fishery (WSTF). As a whole, the Skipjack Tuna Fishery covers the entire Australian Fishing Zone. The WSTF management area covers western portion of the AFZ from the SA/Victorian border to the Cape York Peninsula, and overlaps with the Operational Area (Figure 4-15). The management boundaries also reflect the two stocks of skipjack tuna in Australia, one on the east coast and the other on the west coast. The fishery targets Indian Ocean skipjack tuna (*Katsuwonus pelamis*) using	X	The Operational Area partially overlaps with the management area of the WTBF; however, the proposed survey is not expected to affect the activities of this fishery

Fishery	Fishery Overlap		Description	Catch/effort potentially within the Operational Area	Relevance to EP
	Operational Area	EMBA			
			purse seine (predominant) and pole-and-line methods. There have been no fishing effort of Western Skipjack tuna since the 2008-2009 season.		since the fishery has been inactive since 2008.
North-West Slope Trawl Fishery (NWSTF)	X	✓	The NWSTF management boundary is located from the coast of the Prince Regent National Park to Exmouth, between the 200m depth contour to the outer limit of the Australian Fishing Zone. The Operational Area is located approximately 10 km south-east of the NWSTF boundary. The fishery targets Scampi (*Metanephrops australienis, Metanephrops boschmai, and Metanephrops velutinus*) using demersal trawl. The NWSTF fishing season runs for 12 months, begging 1 July. In the 2016-2017 season, two active vessels caught 57.8 tonnes of Scampi (Patterson et al. 2018). Effort is concentrated mostly towards the 200m isobaths boundary of the NWSTF from north of the Montebello Islands to Scott Reef.	X	No effort occurs within the Operational Area. However, given the proximity of the Operational Area to the NWSTF boundary and known fished areas, the activities of the NWSTF are considered to be within the scope of the EP.
State Managed Fisheries					
Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF)	✓	✓	This fishery is licenced to fish in the offshore waters of the Pilbara region, subject to specific closure areas (Figure 4-16). The PFTIMF targets red emperor (*Lutjanus sebae*); bluespotted emperor (*Lethrinus punctulatus*); and Rankin cod (*Epinephelus multinotatus*) using demersal trawl techniques. In the 2016 fishing season, 2 vessels reported a total catch of 2,150 tonnes (Newman et al. 2018a). Trawl fishing is permitted in the southern third of the Operational Area. Current DPIRD data indicate that three PTIMF vessels have potentially been active in the south-west corner of the Operational Area between 2013-2017 (DPIRD 2019a). Relatively low catch and effort is recorded within the Operational Area, with significantly higher activity reported in shallower waters adjacent to the Operational Area.	✓	The Operational Area overlaps with the management area of the PFTIMF, and trawl fishers may be active within this overlap. Fishers report low catch and effort within the Operational Area, relative to other areas within the fishery.
Pilbara Trap Managed Fishery (PTMF)	✓	✓	This fishery is licenced to fish in the offshore waters of the Pilbara region, subject to specific closure areas (Figure 4-16). The PTMF targets red emperor (*Lutjanus sebae*); bluespotted emperor (*Lethrinus punctulatus*); and Rankin cod (*Epinephelus multinotatus*) using fish traps. In the 2016 fishing season, 3 vessels reported a total catch of 495 tonnes (Newman et al. 2018a). Current	✓	The Operational Area overlaps with the management area of the PTMF, and trap fishers may be active within this overlap.

Fishery	Fishery Overlap		Description	Catch/effort potentially within the Operational Area	Relevance to EP
	Operational Area	EMBA			
			data indicate that fishers have potentially been active in the Operational Area between 2013-2017 (DPIRD 2019b).		
Pilbara Line Fishery (PLF)	✓	✓	This fishery is licenced to fish in the offshore waters of the Pilbara region and operates as an exemption based fishery. The PLF targets pink snapper (*Pagrus auratus*), red emperor (*Lutjanus sebae*); bluespotted emperor (*Lethrinus punctulatus*); and Rankin cod (*Epinephelus multinotatus*) using pole-and-line techniques. In the 2016 fishing season, 5 vessels reported a total catch of 126 tonnes (Newman et al. 2018a). Current data (2013-2017) indicate that no fishing effort occurs within, or adjacent to the Operational Area (DPIRD 2019b).	X	The Operational Area overlaps with the management area of the PLF, however the proposed survey is not expected to overlap with the actual activities of this fishery.
Northern Demersal Scalefish Managed Fishery (NDSMF)	✓	✓	The Northern Demersal Scalefish Managed Fishery operates off the north-west coast of Western Australia. The NDMSF is divided into an inshore sector (Area 1), and an offshore sector (Area 2). Area 1 occurs between the high water mark and the 30 m isobath where only line fishing is permitted. Area 2 extends from the 30 m isobath the AFZ, and permits handline, dropline and fish traps. Fishing access to the research-fishing zone can only be facilitated through an agreed research Framework. The Operational Area partially overlaps with Area 2 of the NDSF at the far eastern portion of the Operational Area. The fishery targets Goldband snapper (*Pristipomoides mutidens*); and Red emperor (*Lutjanus sebae*) using trap an line techniques. The NDSMF season runs for 12 months from 1 January. In the 2016 fishing season, the fishery reported a total catch of 1,173 tonnes (Newman et al. 2018a). Current data indicate that between 2013-2017, less than three vessels have been active within two of the 10x10 nm CAES blocks that partially overlap with the Operational Area (total overlap of approximately 270 km^2) (DPIRD 2019b).	✓	The Operational Area partially overlaps with the management area of the PDSMF, and trap fishers may be active within this overlap.
Mackerel Managed Fishery (MMF)	✓	✓	The MMF is divided into three management areas, Area 1 (Kimberley), Area 2 (Gascoyne), and Area 3 (Gascoyne-West Coast). Each area has its own management arrangements. The MMF targets Spanish mackerel (*Scomberomorus commerson*) using surface trolling techniques. The MMF is predominately active in the North Coast and Gascoyne Coast Bioregions. The Area 2 (Pilbara) fishing season runs from 1 April to 30 September. In the 2016 season, 276 tonnes of Spanish mackerel were caught across the fishery (Lewis	X	The Operational Area overlaps with the management area of the MMF, however the proposed survey is not expected to overlap with the actual activities of this fishery.

Fishery	Fishery Overlap		Description	Catch/effort potentially within the Operational Area	Relevance to EP
	Operational Area	EMBA			
			and Jones 2018). Current data indicate that no fishing effort has occurred within the Operational Area between 2013-2017 (DPIRD 2019b).		
Beche-de-mer Managed Fishery	✓	✓	The Beche-de-mer Managed Fishery is a nearshore hand-harvest fishery operating from Exmouth Gulf to the Northern Territory Border. The fishery targets Sandfish (*Holothura scabra*); and Redfish (*Actinopyga echinities*) by nearshore diving and wading. In the 2016 fishing season, it was reported that there was a total catch of 93 tonnes. It should be noted, the majority of effect is concentrated around the Kimberley region. However, there have been several years where substantial effort was within the Pilbara region.	X	The Operational Area overlaps with the management area of the Beche-de-mer Managed Fishery. Since the Beche-de-mer Managed Fishery is shore-based, the proposed survey is not expected to overlap with the actual activities of this fishery.
Marine Aquarium Managed Fishery (MAMF)	✓	✓	The Marine Aquarium Managed Fishery is able to operate in all State waters (between the Northern Territory border and South Australia border). The MAMF sources up to 950 species of marine aquarium fishes, as well as coral, live rock, algae, seagrass and invertebrates. The fishery collects species by diving and hand collection. In 2016, the MAMF reported a catch of approximately 15,500 fish, 7,700 kg of corals and 4000 sponges, amongst other marine organisms (Newman et al. 2018b). Typically the fishery is most active in waters south of Broome and the highest amount of effort is generally around the Capes region, Perth, Geraldton, Exmouth and Dampier.	X	The Operational Area overlaps with the management area of the MAMF, however the proposed survey is not expected to overlap with the actual activities of this fishery.
Specimen Shell Managed Fishery (SSMF)	✓	✓	The Specimen Shell Managed Fishery is based on the collection of individual shells for the purposes of display, collection, cataloguing, classification and sale. The fishery covers the entire coastline of Western Australia. The SSMF collects shells by hand by a small group of drivers in shallow waters or wading along coastal beaches. 8,531 shells were collected in the 2016 fishing season. As of 2016, there were 31 license holders in the SSMF. The majority of effort is located adjacent to population centres such as Broome, Exmouth, Perth, Mandurah, the Cape Areas and Albany.	X	The SSMF management boundary overlaps with the Operational Area, however the proposed survey is not expected to impact the activities of this fishery.

Fishery	Fishery Overlap		Description	Catch/effort potentially within the Operational Area	Relevance to EP
	Operational Area	EMBA			
Nickol Bay Prawn Managed Fishery (NBPMF)	✓	✓	The NBPMF operates along the western part of the North-West Shelf between Dampier and the western extend of Eighty Mile Beach. The fishery targets Banana prawns (*Penaeus esculentus*) using high opening otter trawl systems. The Nickol Bay Prawn Managed Fishery season is year-round, with designated nursery areas closed between August and November. In the 2016 fishing season, a total catch of 17 tonnes was reported. Current data indicate that no fishing effort has occurred within, or nearby the Operational Area between 2013-2017 (DPIRD 2019b).	X	The Operational Area partially overlaps with the management area of the NBPMF, however the proposed survey is not expected to impact the activities of this fishery.
Western Australia North Coast Shark Fishery (WASF)	✓	✓	The WASF management area The WANCSF extends from longitude 114°06´ E (North West Cape) to 123°45´ E (Koolan Island), however the area between North-West Cape and 120° E and all waters south of latitude 18° S has been closed indefinitely. The WASF targets dusky whaler, sandbar, gummy and whiskery sharks using demersal gillnets. No fishing activity has been recorded in the WASF since the 2008/09 fishing season.	X	The WASF management boundary partially overlaps with the Operational Area, however the fishery has not been active since 2008. Therefore, the proposed survey is not expected to impact the activities of this fishery.

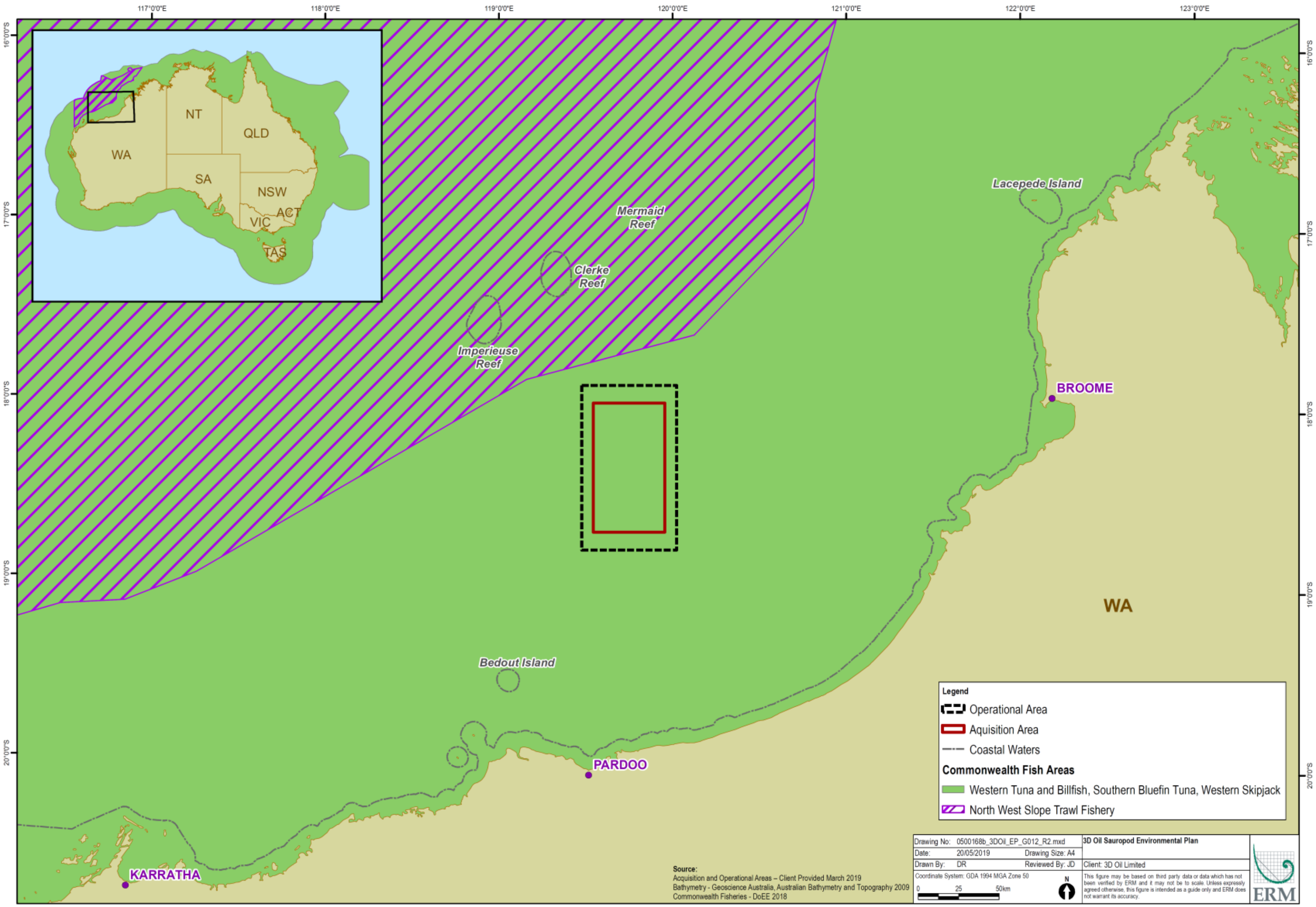


Figure 4-15 Commonwealth Fisheries within the Operational Area and wider EMBA

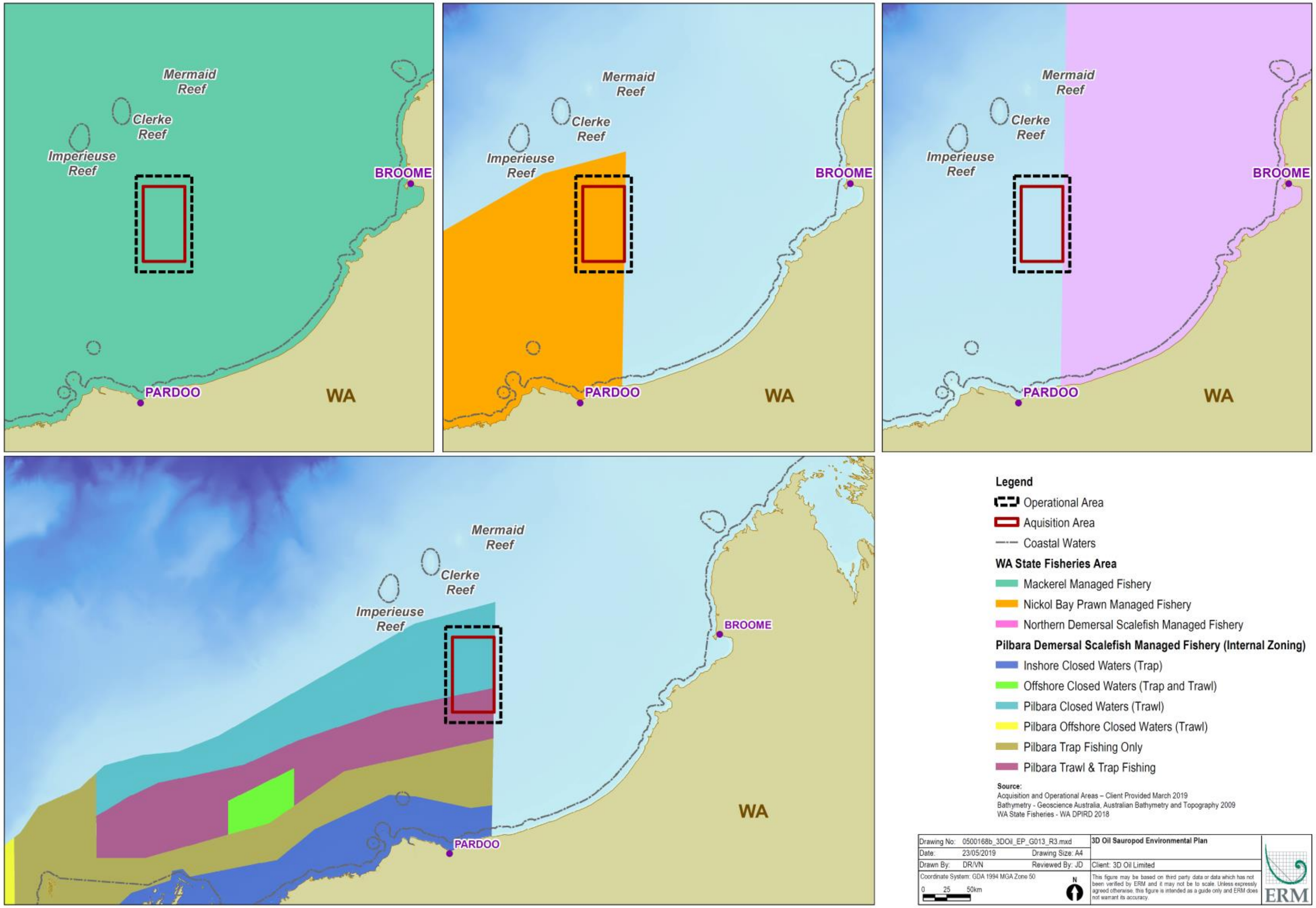


Figure 4-16 WA State Fisheries within the Operational Area

4.4.5 Tourism and Recreation

No tourism activities are known to take place specifically within the Operational Area, however, it is acknowledged that there are growing tourism and recreational sectors in north-west Western Australia. Potential for growth and further expansion in tourism and recreational activities in the Pilbara and Gascoyne regions is recognised, particularly with the development of regional centres and a workforce associated with the resources sector (Gascoyne Development Commission 2012).

Recreational fishing in the NSW bioregion is mainly concentrated on the continental shelf south of the Kimberley and within the North-west Shelf Province, the Central Western Shelf Transition Province and the Central Western Shelf Province. An estimated 640,000 fishers participate in recreational fishing each year (Fletcher & Santoro 2012). Given the depth of waters (95 m – 150 m) and the distance offshore, it is unlikely that recreational fishing occurs within the Operational Area.

Recreational fishing occurs at Rowley Shoals, which are located within the EMBA. However, Mermaid Reef that forms part of Rowley Shoals does not permit recreational fishing. Whilst recreational fishing does occur at Rowley Shoals, it is occasional due to the remote location. Clerke Reef and Imperieuse Reef are also places for tourism, with charter boat operators taking visitors to these remote islands (Department of Environment and Conservation 2007). Scuba diving, snorkelling and other water sports are known to take place at the Rowley Shoals (Department of Environment and Conservation 2007). Boat charter trips of two days or longer regularly visit the Rowley Shoal between September to December when conditions are at their best (Tourism Western Australia 2019).

4.4.6 Oil and Gas Activities

The region currently supports a number of industries including petroleum exploration and production. Petroleum titleholders with titles that are adjacent to the Operational Area are listed in Table 4.9.

There are other potential petroleum exploration activities in the region that may be completed during the scheduled acquisition period of the Sauropod 3D MSS. These are presented in Table 4-13. Table 4-14 identifies previous marine seismic surveys within 150 km of the Operational Area, which will inform the cumulative impact assessment in Section 7 and Section 8.

Table 4-12 Oil and Gas Permits Relevant to the Operational Area

Permit	Permit Type	Operator	Distance from the Operational Area
WA-487-P	Exploration Permit	Pathfinder Energy Pty Ltd	Within Operational Area
WA-436-P	Exploration Permit	Santos WA Northwest Pty Ltd	Within Operational Area
WA-438-P	Exploration Permit	Santos WA Northwest Pty Ltd	Within Operational Area
WA-533-P	Exploration Permit	INPEX Browse E&P Pty Ltd	63 km east
WA-435-P	Exploration Permit	Santos WA Northwest Pty Ltd	51 km west

Table 4-13 Potentially Concurrent Marine Seismic Surveys Within 150 Km Of The Operational Area

Company	Survey Title	Survey Location	EP Status and Survey Timing
PGS Australia Pty Ltd	Rollo Multi-client Marine Seismic Survey	The Sauropod Acquisition Area is located approximately 60 km east of the Beagle Operational Area. There is no spatial overlap with the PGS survey.	The EP was accepted by NOPSEMA on 04/10/2018. Restrictions within the EP allow for a maximum of 25,000 km^2 of seismic acquisition per year for five years. Seismic acquisition has occurred between 22/02/2019 – 08/05/2019. It is not clear whether PGS has completed all seismic acquisition under the accepted EP or whether PGS will return at a later date. The specific commencement dates and durations of individual surveys have not been confirmed.
TGS-NOPEC Geophysical Company Pty Ltd	North West Shelf Renaissance North Multi Client Marine Seismic Survey	The Sauropod 3D Acquisition Area is located approximately 150 km east of the TGS Operational Area. There is no spatial overlap with the PGS survey. Maximum of 25,000 km^2 of seismic acquisition.	The EP was accepted by NOPSEMA on 13/06/2018. The EP is valid for a two-year period. No seismic acquisition has occurred to date under the accepted EP. The specific commencement dates and durations of individual surveys have not been confirmed.

Table 4-14 Marine Seismic Surveys Conducted Within 150 Km of The Operational Area Since 2014

Year	Company	Survey Title	Survey Location	Survey Status and Timing
2014	Titan Multi Client Marine Seismic Survey	PGS Australia Pty Ltd	54 km west	No seismic acquisition occurred under the accepted EP. The EP has since expired.
2016	Nightcap Multi-Client Marine Seismic Surveys	Pathfinder Energy Pty Ltd	Overlaps (approximately 500 km^2)	The EP was accepted by NOPSEMA on 16/11/2016. No seismic acquisition occurred under the accepted EP. The EP has since expired.
2016	TGS-NOPEC	Canning-Northern Carnarvon Multi Client Marine Seismic Survey	Sauropod Acquisition Area overlaps approximately 500 km^2 of the TGS survey area.	Completed between June – September 2016. Exact areas and dates of acquisition areas unknown.

Year	Company	Survey Title	Survey Location	Survey Status and Timing
2016	Search Seismic Pty Ltd	Bilby 2D Phase 3 Multi-client Marine Seismic Survey	Maximum of 55,000 km^2 of 2D seismic acquisition. Sauropod Acquisition Area overlaps with the Bilby survey area.	Completed between June – July 2016. Exact areas and dates of acquisition areas unknown.
2019	Santos Limited	Keraudren Seismic Survey	Maximum of 5,539 km^2 of 3D seismic acquisition with exploration permits WA-435-P, WA-436-P, WA-437-P and WA-438-P. Sauropod Acquisition Area is located approximately 40 km from the Keraudren survey area.	Planned for acquisition between May – July 2019. Maximum of 110 days of acquisition.

4.4.7 World, National and Indigenous Heritage Areas

World heritage sites are natural or man-made sites, areas, or structures recognized as being of outstanding universal value by the United Nations Educational, Scientific and Cultural Organization (UNESCO). There are no World or National Heritage place within the Operational Area.

Australia's National Heritage List contains natural, historic and Indigenous places of significance to the nation and are protected under the EPBC Act (DoEE n.d.). One Commonwealth Heritage listed place occurs within the EMBA, the Mermaid Reef – Rowley Shoals. Mermaid Reef – Rowley Shoals was listed for values meeting Category A, B, C and D of the Commonwealth Heritage List criterion (Commonwealth of Australia n.d.). The significance and values of Mermaid Reef and the Rowley Shoals are described above in Section 4.4.1.2 and Section 4.4.2.1.

There are no known sites of Indigenous cultural heritage significance within the Operational Area or the wider EMBA. The closest recorded sites of Indigenous significance and occur terrestrially, approximately 72 km south-west of Broome and around the Port Hedland area (DPLH 2019).

4.4.8 Ramsar Wetlands

The Ramsar Convention on Wetlands is an intergovernmental treaty that aims to conserve wetlands of international importance. Ramsar wetlands are recognised as a matter of national environmental significance under the EPBC Act (DoEE n.d.). No Ramsar wetlands occur within the Operational Area or EMBA. The closest Ramsar wetlands are located in the coastal waters of Eighty Mile Beach, approximately 113 km south-east of the Operational Area and beyond the wider EMBA.

4.4.9 Marine Archaeology

All shipwrecks more than 75 years old are protected under the *Historic Shipwrecks Act 1976* (DoEE n.d). A search of the National Shipwreck Database (DoEE 2019b) indicated that no known historic shipwrecks occur within the Operational Area. The closet known wreck is the *Koombana* near Bedout Island and is approximately 86 km south-west of the Operational Area. Five other wrecks are situated near the Operational Area (Table 4-15); however none are listed as a Protected Place under the EPBC Act.

Table 4-15 Recorded Shipwrecks Near The Operational Area

Vessel Name	Year Wrecked	Wreck Location	Distance from Operational Area
Koombana	1908	Bedout Island	86 km south-west
Lively	1810	Mermaid Reef	93 km north
Korda	1903	Cape Frezier	98 km east
See Taube	1954	Rowley Shoals	130 km north-east
Pelsart (Pelsaert)	1908	Rowley Shoals	130 km north-east
Alfred	1908	Rowley Shoals	130 km north-east

4.4.10 Commercial Shipping

The Pilbara offshore region facilities high shipping activity associated with mining and oil and gas activities. Port Hedland is the closest major port to the Operational Area, which is also the world's largest bulk export port. Vessels transiting the region during the proposed survey will primarily include oil tankers, bulk carrier ships and general cargo ships.

The Australian Maritime Safety Authority (AMSA) has introduced a network of marine fairways on the NWS of WA to reduce the risk of vessel collisions with offshore infrastructure. None of these fairways intersect with the Operational Area, however one fairway facilitating heavy traffic lies approximately 1 km north-west of the Operational area (Figure 4-17). Consultation with AMSA confirmed that only light traffic occurs within the Operational Area. Moderate to heavy shipping traffic occurs within the wider EMBA, and is generally confined to the AMSA shipping fairways.

4.4.11 Defence Activities

The Department of Defence operate military firing practice and exercise areas at several locations around the Australia. There are no designated defence practice areas within the Operational Area. The closest designated defence practice area is located on the Dampier Peninsula, approximately 127km east of the Operational Area and partially within the wider EMBA. A search of the Department of Defence’s unexploded ordinance (UXO) map confirmed UXO are not known to occur within the Operational Area (PSMA 2019).

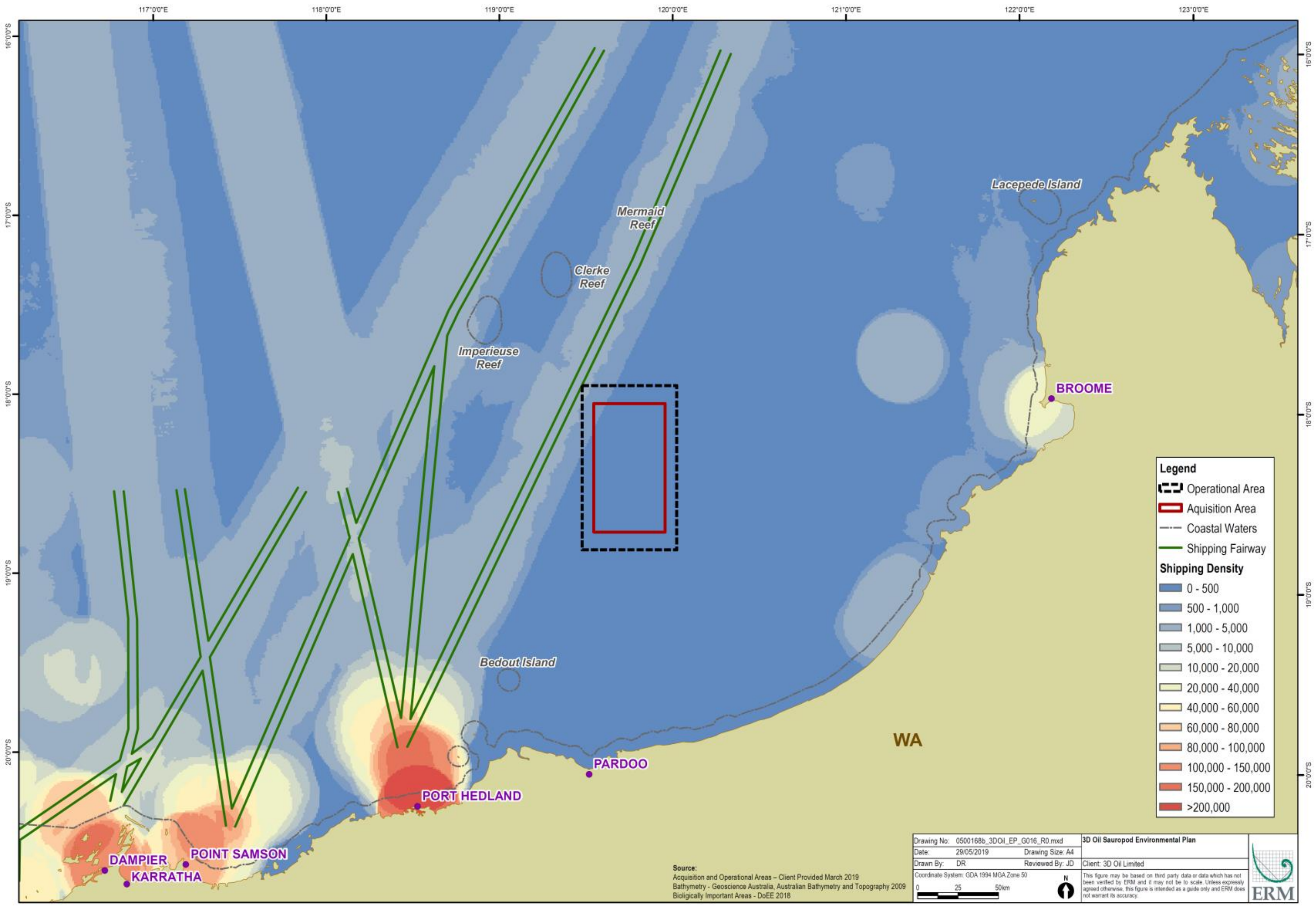


Figure 4-17 Commercial Shipping

5. STAKEHOLDER ENGAGEMENT

For the purpose of this EP, and in accordance with Regulation 11A of the OPGSS (E) Regulations, relevant stakeholders are defined as person(s) whose functions, interests or activities may be affected by the activities to be carried out under the EP. This may include persons who could be affected during emergency conditions.

5.1 Consultation Approach

Consultation has been planned and undertaken with the aim of:

- Informing relevant stakeholders of the 3D seismic survey;
- Gathering information about the stakeholders' interests and activities in the Operational Area during the period over which the survey is proposed to be conducted; and
- Providing stakeholders with the opportunity to raise issues and concerns about the survey.

The consultation approach has been guided by the following:

- NOPSEMA's Information Paper: Consultation Requirements under the OPGGS (E) Regulations 2009;
- WA DMIRS Consultation Guidance Note: For the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009;
- AFMA's Guidelines Form Petroleum Industry Consultation with AFMA (AFMA 2015);
- DoIIS Guidance – Offshore Petroleum and Greenhouse Gas Activities: Consultation with Australian Government agencies with responsibilities in the Commonwealth Marine Area;
- WA DPIRD Fisheries Guidance Statement: Oil and gas industry consultation with the Department (2013) and
- WA DoT Guidance Statement for Marine Oil Pollution: Response and Consultation Arrangements (2018).

5.2 Relevant Stakeholders

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

Relevant stakeholders were identified as:

- Departments and agencies of the Commonwealth and the State of Western Australia to which the activities to be carried out may be relevant;
- Persons and organisations whose functions, interest or activities may be affected by the 3D seismic survey activities to be carried out; and
- Any other person or organisation that 3D Oil consider relevant.

The identified relevant stakeholders are listed in Table 5.1.

Relevant stakeholders were then reviewed to understand how the survey activities may affect the person or the organisation's functions, interest and activities and the most appropriate method of consultation to be utilised.

3D Oil understands that the list of relevant stakeholders is not exhaustive and 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 appropriate information about the survey and invited to make comment. Evidence of additional stakeholder consultation will be documented in the Stakeholder Consultation Log (Appendix B). The Stakeholder Consultation Log is a "living document" which will be updated throughout the survey and will be used during the post-survey review of environmental performance.

Fisheries stakeholders were identified from the AFMA and DPIRD (Fisheries) annual status reports, based on their licence areas of operation and known activities (Section 4). Contact details (postal addresses) of individual licence holders were provided by DPIRD (Fisheries). Email and phone numbers are not publically available, therefore WAFIC as a relevant industry body was also identified in order to maximise communication channels with fishers.

Table 5-1 Identified Relevant Stakeholders

Commonwealth Government	
Australian Border Force	Department of Communications and the Arts
Australian Fisheries Management Authority (AFMA)	Department of Defence
Australian Hydrographic Service (AHS)	Department of Industry, Innovation and Science (DIIS)
Australian Maritime Safety Authority (AMSA)	Director of National Parks
Department of Agriculture and Water Resources (DAWR) – Biosecurity (Marine Pests)	National Native Title Tribunal (NNTT)
Department of Agriculture and Water Resources (DAWR) - Fisheries	
Western Australian Government	
Department of Mines, Industry Regulation and Safety (DMIRS)	Department of Transport - Marine (DoT)
Department of Primary Industries and Regional Development (DPIRD) - Fisheries	
Other Relevant Parties	
Australian Institute of Marine Science	Pearl Producers Association of WA (PPA)
Australian Marine Oil Spill Centre (AMOSC)	Recfishwest
Australian Southern Bluefin Tuna Industry Association (ASBTIA)	Santos WA Northwest Pty Ltd
Commonwealth Fisheries Association (CFA)	Tourism Western Australia
Conservation Council of WA (CCWA)	Western Australian Fishing Industry Council (WAFIC)
CSIRO	Wilderness Society
Kimberley Land Council (KLC)	World Wildlife Fund for Nature (WWF)
Pathfinder Energy Pty Ltd	
WA Commercial Fisheries (*all licence holders*)	
Mackerel Managed Fishery	Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF)
Northern Demersal Scalefish Managed Fishery	Pilbara Trap Managed Fishery (PTMF)

North Coast Prawn - Nickol Bay Prawn	Pilbara Line Fishery (PLF)
North Coast Shark Fishery	

5.3 Consultation Method

Initial stakeholder consultation consisted of an information sheet and map of the Operational and Acquisition Area (refer to the Sensitive Matters Report) distributed by email to relevant stakeholders as listed in Table 5-1 on 15 April 2019. The information presented in the information sheet was a general overview of the survey including location, extent, survey design and environmental setting. Stakeholders were asked to respond and provide initial feedback to a dedicated email address (3DOilSeismic@erm.com) by 17 May 2019. This will be followed by a detailed factsheet with further information on the proposed management measures for those who which to continue receiving information.

The dedicated email address also aided in the tracking and recording of stakeholder and titleholder communication. Some stakeholders were contacted directly regarding information specific to the proposed activity that may potentially impact on the stakeholder.

Where stakeholders could only be contacted via post (e.g. individual State managed fishery license holders) those parties were sent hard copies of a detailed factsheet (refer to the Sensitive Matters Report). The information presented was a general overview of the survey including location, extent, survey design, environmental setting, proposed management measures related to interactions with marine fauna and interactions with other users of the Operational Area.

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

A follow-up email was sent to stakeholders on 27 May 2019 to follow-up on whether stakeholders had any comments or queries. Stakeholders were asked to respond and provide feedback by 7 June 2019.

A progress email and hard copy letter was sent to all stakeholders and individual State managed fishery license holders on 10 June 2019 and 12 June 2019, respectively. This informed stakeholders that 3D Oil had delayed the submission of the EP to NOPSEMA to the end of June 2019, to allow stakeholders additional time to provide feedback and the proposed activity schedule change from the period of November to April 2019/2020 to within the period of January to April 2020, or January to April 2021.

3D Oil has undertaken an assessment of the merit of any objections or claims by stakeholders. 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 about how the issues have been assessed and any relevant controls that will be adopted to reduce the potential impacts and risks to ALARP and acceptable levels.

Consultation will be ongoing throughout the life of the EP, as outlined in Section 9.

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 provided in Appendix B.

Full copies of the consultation records are included in the Sensitive Matters Report.

6. ENVIRONMENTAL RISK ASSESSMENT METHODOLOGY

6.1 Approach

This section describes the environmental impact and risk assessment methodology applied for this EP, in accordance with the 3D Oil Risk Assessment Framework and Toolkit. This framework is consistent with the approach outlined in ISO 14001 (Environmental Management Systems), ISO 31000:2009 (Risk Management) and HB203:2012 (Environmental Risk Management – Principles and Process). Figure 6-1 provides the process adopted for managing impacts and risks associated with the Sauropod 3D MSS.

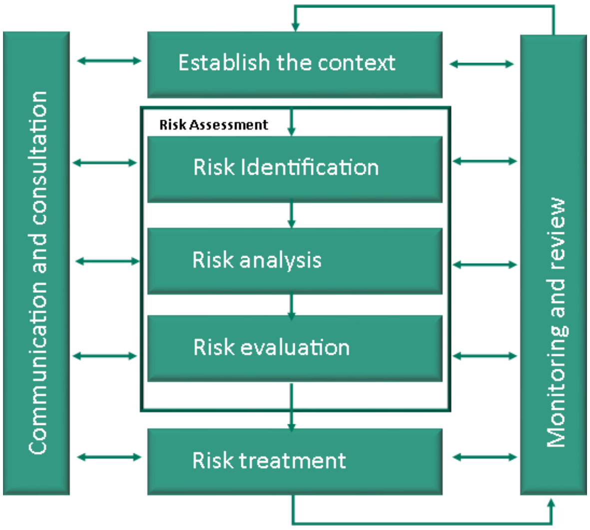


Figure 6-1 AS/NZS ISO 3100 – Risk Management Methodology

The risk assessment process consists of the following steps:

Establish the context of the activity:

- Define the activity and identify aspects that have potential environmental impacts and risks associated with planned activities and credible unplanned incidents (Section 6.2).
- Identify physical, biological, and socio-economic receptors, and environmental values and sensitivities (within and adjacent to the Operational Area) that may be affected by the activity (planned and unplanned events).
- Identify the relevant requirements in the context of legislation, standards and other environmental approval requirements that apply to the activity.

Impact/risk assessment:

- Identify the 'Decision Type' within the Decision Support Framework outlined in Section 6.2.3.
- Identify and evaluate appropriate control measures in relation to the overall context of the activity in accordance with the hierarchy of controls outlined in Section 6.2.2.
- Assess the environmental impacts and risks to determine the potential consequence and likelihood and predict the residual risk using 3D Oil's qualitative risk matrix, taking into consideration the magnitude of the impact or risk and the value and sensitivity of the potentially impacted receptor.

Impact/risk evaluation:

- Impact and risks will be evaluated to determine that they have been reduced to a level that is as low as reasonably practicable (ALARP) and acceptable in accordance with 3D Oil's acceptance criteria (Section 6.2.4);
- Development of environmental performance outcomes, performance standards, and measurement criteria (Section 6.3).

Environmental Hazard Identification

An environmental hazard identification (ENVID) workshop was undertaken in April 2019, to identify and assess the impacts and risks associated with the survey. The workshop was supported by background literature and discussions with relevant seismic operations personnel and environmental specialists. The identification of impacts and risks and the selection of appropriate controls for these risks were also informed by 3D Oil experience in conducting other seismic surveys in Australia.

The ENVID considered the following:

- Activities that will occur during the Sauropod 3D MSS and the equipment and vessels to be utilised in those activities;
- The environmental sensitivity of the receiving environment with respect to species distribution, subsea habitat types and location of environmentally sensitive areas (e.g. breeding, resting, feeding) identified as part of desktop studies; and
- Feedback from marine stakeholders to understand socio-economic activities that may coincide with Sauropod 3D MSS activities via communication and consultation activities.

Within this context, a listing of credible activity-related environmental aspects and possible impacts and risks were identified for the activity. The following sections detail the risk assessment steps.

6.2 Impact and Risk Evaluation

6.2.1 Definitions

The OPGGS (E) Regulations 13(5) & (6) requires the EP to detail and evaluate the environmental impacts and risks for an activity, including control measures used to reduce the impacts and risks of the activity to ALARP and an acceptable level. This must include impacts and risks arising directly or indirectly from all activity operations (i.e., routine) or potential emergency or incident conditions (i.e., incident events).

For this activity, 3D Oil has determined that impacts and risks are defined 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).

6.2.2 Impact and Risk Evaluation Process

The purpose of impact and risk evaluation is to assist in making decisions, based on the outcomes of analysis, about the controls required to reduce an impact or risk to ALARP and acceptable levels. All impacts and risks are subject to this step in the same manner.

1. Calculated the inherent impact or risk for an activity aspect.

    a. Select the consequence (impact) level: Determine the worst-case credible outcome associated with the activity aspect assuming all existing preventative controls have failed. Where more than one impact applies (e.g., environmental and social/cultural), the highest consequence level is recorded (refer Table 6-2);

    b. Select the likelihood level from the description that best fits the chance of the identified consequence occurring (refer Table 6-3); and

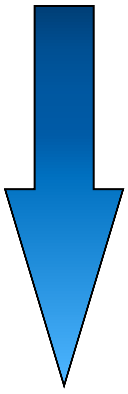
   c. Calculate the inherent risk ranking by comparing the selected consequence and likelihood levels using the qualitative risk matrix in Table 6-4.

2. Identifying Control Measures (i.e. Impact/Risk Treatment)

   a. For each identified impact and risk, control measures are identified to reduce the impact or risk. The hierarchy of controls philosophy is a useful framework to identify and assess controls that are effective (Table 6-1) and is used in this assessment process to determine suitable controls.

   b. Multiple controls selected from this hierarchy provide a depth (number) and breadth (control type) to prevent an impact or risk from occurring. Control types listed in the upper section of the hierarchy are recognised as being more effective in terms of functionality, availability, reliability, survivability, independence and compatibility given their inherent design characteristics.

Table 6-1 Hierarchy of Controls

Control Type	Effectiveness	Example
Eliminate: Complete removal of hazard		Eliminate activity within sensitive timeframes.
Prevent: Prevent hazardous events		Adopt spatial controls to isolate activity from sensitivity
Reduce: Reduce the consequence should the event occur		Adopt shutdown procedures if cetacean is within power-down zone.
Mitigate: Practices to mitigate the consequences once realised.		Implement Shipboard Oil Pollution Emergency Plan (SOPEP) to mitigate spill impacts

3. Calculate the residual impact or risk

With control measures implemented, all inherent impacts and risks are then reassessed for their residual consequence and likelihood according to the 3D Oil Qualitative Risk Matrix (refer Table 6-4). If the residual impact or risk does not meet the tolerability criteria provided in Table 6-6 and Table 6-7, iterations on the assessment process continue until the impact or risk is considered broadly acceptable or additional controls have been identified and/or rejected or accepted via an ALARP demonstration.

Table 6-2 Consequence Definitions

Consequence	Description
5. Critical	■ Safety: Extensive Injuries (Multiple Fatalities). ■ Environment: *Protected Species*: Large population-level impacts. Significant impacts on critical habitats or activities; *Marine Primary Production*: Large-scale, long-term effects. Recovery > 10 years or effects permanent; *Penalty*: Potential revocation of Licence or Permit. ■ Financial:

Consequence	Description
	Extensive Damage (>$25M). ■ Business Reputation: Extreme adverse public, political or media outcry resulting in international media coverage; critical impact on business reputation.
4. Major	■ Safety: Major Injury (Single Fatality). ■ Environment: *Protected Species*: Minor disruption to a significant portion of the population. Minor effects on critical habitats/activities. No threats to population viability. *Marine Primary Production*: Localised but long-term effects; Recovery > 10 years or effects permanent. *Penalty:* Material breach of licence, permit or act. ■ Financial: Major Damage ($10M-$25M). ■ Business Reputation: Significant impact on business reputation and/or national media exposure; local community complaint.
3. Significant	■ Safety: Significant Injury (Lost Time Injury (LTI) or Restricted Work Day Case (RWDC)). ■ Environment: *Protected Species*: Minor disruption to small portion of population. Minor temporary effects on protected species critical habitat or activity. No threats to population viability. *Marine Primary Production*: Localised medium-term effects; Recovery 5-10 years. *Compliance*: Possible administrative fine level. ■ Financial: Significant damage ($5M-$10M). ■ Business Reputation: Serious local adverse public media attention or complaints; local user concern; moderate to small impact on business reputation.
2. Minor	■ Safety: Minor Injury (Medical Treatment Injury) ■ Environment: *Protected Species*: Minor and temporary disruption to small portion of protected species population. No effects of critical habitats or activities. *Marine Primary Production:* Localised short-term effects. Recovery in the timescale of months to < 5 years *Compliance:* Regulatory notification required. ■ Financial: Minor Damage ($1M-$5M). ■ Business Reputation: Public awareness but no public concern beyond local users; Minor impact on business reputation.
1. Negligible	■ Safety: Slight Injury (First Aid Treatment). ■ Environment: *Protected Species*: Incidental effects locally within the environmental setting. *Marine Primary Production*: Recovery in the timescale of days to weeks; *Compliance*: No statutory reporting. ■ Financial:

Consequence	Description
	Slight Damage (0-$1M). ■ Business Reputation: Negligible Impact on Reputation; no public or regulator interest.

Table 6-3 Definition of Likelihood

Likelihood	Description
5. Very likely	Expected to occur in most circumstances
4. Likely	Probably occur in most circumstances
3. Possible	Might occur at some time
2. Unlikely	Could occur at some time
1. Very Unlikely	Only occurs in exceptional circumstances

Table 6-4 3D Oil Qualitative Risk Matrix

		Likelihood				
		1: Very	2: Unlikely	3: Possible	4: Likely	5: Very likely
Consequence	5. Critical					
	4. Major					
	3. Significant					
	2. Minor					
	1. Negligible					

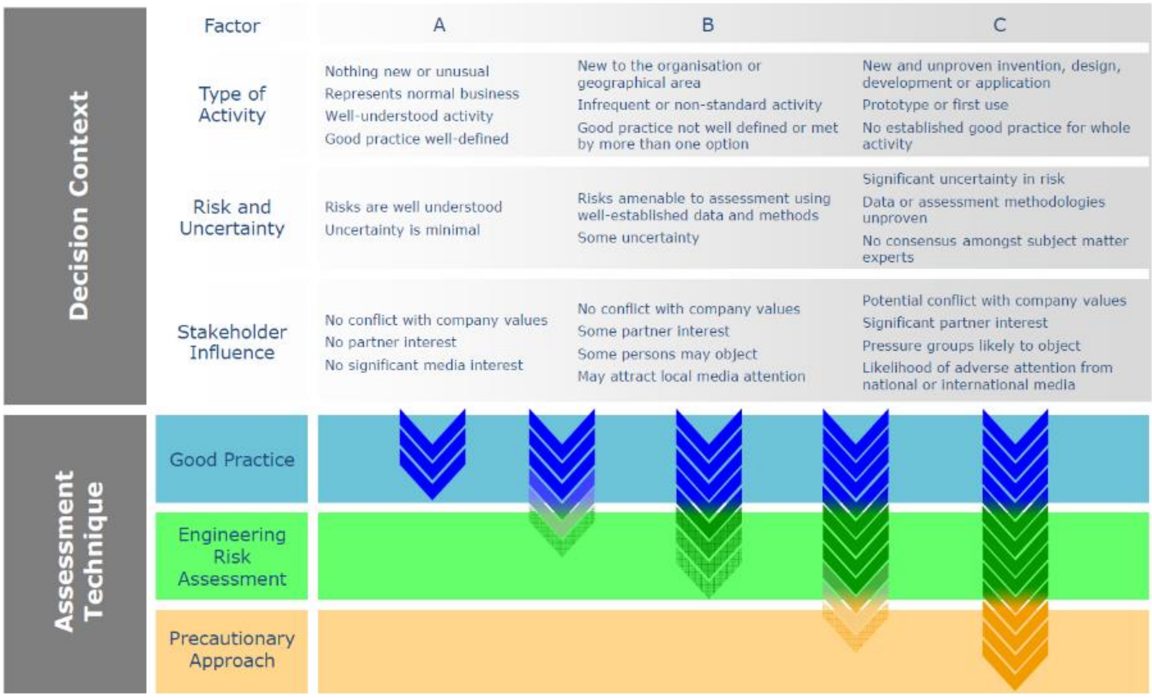
Table 6-5 Definition of Risk and Management Response

Category	Description & Response
High	**High Risk:** Considered intolerable. Work cannot proceed as currently planned. Urgent remedy and resources required for immediate risk reduction. If risk is to be accepted temporarily then approval from the CEO must be obtained and the Board consulted.
Medium	**Medium Risk:** Risk reduction measures need to be implemented in keeping with other priorities. Generally acceptable level of risk where further risk reduction is shown not to be practicable.
Low	**Low Impact/Risk:** Impacts/Risks are sufficiently low to be acceptable (i.e. at ALARP). Manage for continuous improvement by management.

6.2.3 Demonstration of ALARP

This section provides the methodology for determining whether impacts and risks are ALARP and reflects the principles outlined the NOPSEMA Decision-making – Criterion 10(a)(b) ALARP Guideline (GL1721) (Rev 3, May 2017). The EP must demonstrate that impacts and risks to ALARP, which requires that available control measures are implemented where the cost is not grossly disproportionate to the environmental benefit gained from implementing the control measure.

In considering impact and risk-related decision making, 3D Oil utilises the risk-related decision making framework developed by the UK offshore oil and gas (Oil & Gas UK, 2014) to assist with the basis for their decisions. A summary of the framework is shown in Figure 6-2. The framework takes the form of three different decision contexts (A, B & C). Initially the decision context needs to be determined with guidance provided on factors affecting that context (i.e. activity type, risk and uncertainty, and stakeholder influence). The assessment techniques used depend on the selected decision context. Figure 6-2 provides a description of the decision types and the associated assessment techniques utilised to make an ALARP decision.



Source: Oil and Gas UK, 2014

Figure 6-2 Impact and Risk Decision Making Framework

Table 6-6 ALARP Decision-making Methodologies (based upon uncertainty)

Decision Context	Description	Decision Methodologies
A	Risks classified as Decision Type A are well understood with minimal uncertainty and good practice is well-defined, often within legislation, standards and guidelines.	**Legislative Requirements**: Identifies the requirements of legislation, codes and standards that are to be complied with for the activity. **Good Industry Practice**: Identifies further engineering control standards and guidelines that may be applied over and above that required to meet the legislation, codes and standards. **Professional Judgement**: Uses relevant personnel with the knowledge and experience to

Decision Context	Description	Decision Methodologies
		identify alternative controls. When formulating control measures for each environmental impact or risk, the 'Hierarchy of Controls' philosophy, which is a system used in the industry to identify effective controls to minimise or eliminate exposure to impacts or risks, is applied.
B	Risks classified as a Decision Type B are typically in areas of increased environmental sensitivity with some stakeholder concerns. These risks may be associated with infrequent, non-standard activities and have more uncertainty, with good practice less well-defined. Further analysis is required in addition to using the tools described for a Decision Type A.	**Risk-based tools such as cost based analysis or modelling**: Assesses the results of probabilistic analyses such as modelling, quantitative risk assessment and/or cost benefit analysis to support the selection of control measures identified during the risk assessment process. Company values: Identifies values identified in 3D Oil's HSE Policy.
C	Risks classified as a Decision Type C will typically have significant risks related to environmental performance. The risks may be uncertain or result in significant environmental impact; significant project risk/ exposure; or may elicit strong stakeholder awareness and negative perception. For these risks, in addition to Decision Type A and B tools, company and societal values need to be considered by undertaking broader internal and external stakeholder consultation as part of the risk assessment process	**Societal Values:** Identifies the views, concerns and perceptions of relevant stakeholders and addresses relevant stakeholder concerns as gathered through consultation.

In addition to the decision-making framework, for higher level impacts and risks, ALARP assessments shall assess:

- Alternative/substitute controls that may be potentially effective (which lie higher on the hierarchy of controls);
- Additional controls that add to the suite of control measures to reduce the environmental impact; and
- Improvements to already adopted controls that increase their effectiveness.

For risks classified as Decision-Type A, if the inherent risk is determined to be low, 3D Oil considers the control measures adopted to be sufficient to demonstrate that potential impacts and risks are managed to ALARP. However, 3D Oil 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).

All controls considered are documented and the justification for accepting or not adopting the controls is documented as part of the assessment. Assessment of the control includes a comparison of the environmental benefit of adopting the control against the cost of implementation. For higher level impacts and risks, this also includes an assessment of the activity design on a temporal and spatial basis to reduce impacts.

6.2.4 Demonstration of Acceptability

3D Oil considers a range of factors when evaluating the acceptability of environmental impacts or risks associated with its activities. This evaluation is outlined in Table 6-7 and is based on NOPSEMA's Guidance Notes for EP Content Requirements (N-04750-GN1344, Rev 4, April 2019) and guidance issued in Decision-making – Criterion 10A(c) Acceptable Level (GL1721, Rev 5, June 2018.

Impacts and risks are considered acceptable if the level of residual risk is determined to be low or medium and the criteria outlined in Table 6-7 are met.

3D Oil 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, 3D Oil will not undertake the activity until the residual risk rating is reduced to either low or medium. For a high level risk to be accepted temporarily then approval from the CEO would be required and the Board consulted. (Table 6-4). It is noted that all residual impacts and risks in this EP have been determined to be low.

Table 6-7 3D Oil Acceptability Criteria

Context	Factor	Criteria	Demonstration
Internal	3D Oil Policy	Is the proposed management of impact or risk aligned with 3D Oil's HSE Policy?	The impact or risk must be compliant with the objectives of this policy.
	Company Standards/ Systems	Is the proposed management of the impact or risk aligned with the 3D Oil Management System?	Where specific procedures and work instructions are in place for the management of the impact and risk in question, acceptability is demonstrated.
External	Values and Sensitivities of the Natural Environment	Are the values and sensitivities of the environment, including matters protected under Part 3 of the EPBC Act (World Heritage, National Heritage, Wetlands of International Importance, listed threatened species and communities, listed migratory species, Commonwealth marine environment) protected so that no significant impacts result to the environment?	Impacts are risk are demonstrated not to have a significant impact upon protected matters in accordance with EPBC Policy Statement 1.1 – Significance Guidelines.
		Have applicable objectives and actions within relevant species conservation or recovery plans, threat abatement plans, conservation advices, bioregional plans been met?	Compliance with relevant conservation advice, recovery plans and other guidance is demonstrated.
		Have applicable objectives and actions within relevant AMP management plans, been met?	Compliance with relevant AMP management plans is demonstrated.
	Relevant Persons Expectations	Have relevant persons raised any objections or claims about adverse impacts associated with the activity, and if so, have merits of the objection been assessed?	Stakeholder concerns have been assessed, responded to and controls adopted for objections and claims which hold merit.

Context	Factor	Criteria	Demonstration
		For those objections and claims with merit, have measures been put in place to manage those concerns?	
Legislation & Other	Legal Requirements	Is the impact or risk managed in accordance with existing Australian, State and/or international laws/obligations?	Compliance with specific laws/obligations is demonstrated.
Industry Standards	Industry Standards and Best Practices	Do standards adopted reflect best practice guidance (i.e. IAGC Guidelines, IPIECA Guidelines, APPEA Guidelines, IOGP Guidelines)?	Compliance with best practice guidance is demonstrated.
Ecologically Sustainable Development (ESD) (refer below)	ESD Application	Does the proposed risk/impact comply with the APPEA Principles of Conduct (APPEA, 2016), requiring integration of ESD principles into company decision-making, and Government policy frameworks that integrate ESD principles into implementation strategies?	The overall operations are consistent with the APPEA Principles of Conduct and Commonwealth environmental strategy documents.

Ecologically Sustainable Development:

Section 3A of the EPBC Act 1999 defines ESD, which is based on Australia's National Strategy for Ecological Sustainable Development (1992) that defines ESD as 'using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained and the total quality of life, now and in the future, can be increased'.

ESD Principles are outlined below:

- Decision making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations (This principle is inherently met through the EP assessment process. This principal is not considered separately for each acceptability evaluation).
- 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. If there is, the project shall assess whether there is significant uncertainty in the evaluation, and if so, whether the precautionary approach should be applied.
- 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 EP assessment methodology ensures that potential impacts and risks are ALARP, and where the potential impacts and risk are determined to be serious or irreversible the precautionary principle is implemented to ensure the environment is maintained for the benefit of future generations. Consequently, this principal is not considered separately for each acceptability evaluation).
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making (Project to consider if there is the potential to affect biological diversity and ecological integrity).

Improved valuation, pricing and incentive mechanisms should be promoted (Not relevant to this EP).

6.3 Monitoring and Review

Monitoring and review activities are incorporated into the impact and risk management process to ensure that controls are effective and efficient in both design and operation. This is achieved through the environmental performance outcomes, standards and measurement criteria that are described for each environmental impact/risk in Section 7 and 8.

Additional aspects of monitoring and review are described in the Implementation Strategy in Section 9 and include:

- Analysing and lessons learnt from events (including near-misses), changes, trends, successes and failures;
- Detecting changes in the external and internal context, including changes to risk criteria and the risk itself which can require revision of risk treatments and priorities; and
- Identifying emerging risks.

7. ENVIRONMENTAL RISK ASSESSMENT – PLANNED EVENTS

This section presents the evaluation of the environmental impacts and risks completed for planned / routine aspects of the Sauropod 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 7-1.

This section also presents the environmental performance outcomes, performance standards and measurement criteria for each of the identified environmental impacts and risks. 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; and
- Measurement Criteria – defines the measure by which environmental performance will be measured to determine whether the EPO has been met.

Where measurement criteria associated with performance outcomes or performance standards demonstrate that requirements are not met, a recordable incident will be documented and reported to NOPSEMA (refer Section 9).

Table 7-1 Environmental Impact and Risk Ranking Summary

Impact/Risk	EP Section No.	Residual Risk		
		Consequence	Likelihood	Risk Ranking
Noise Emissions: Seismic Source	7.1	Minor (2)	Unlikely (2)	Low
Noise Emissions: Cumulative Seismic Sound	7.2	N/A	N/A	N/A
Noise Emissions: Vessels, Helicopter and Mechanical Equipment	7.3	Negligible (1)	Very Unlikely (1)	Low
Physical Presence: Disruption/Interference with Other Marine Users	7.4	Minor (2)	Unlikely (2)	Low
Discharge: Treated Sewage, Grey Water and Putrescible Waste	7.5	Negligible (1)	Very Unlikely (1)	Low
Discharge: Drains, Deck and Bilge Water	7.6	Negligible (1)	Very Unlikely (1)	Low
Artificial Light Emissions: Vessels	7.7	Negligible (1)	Very Unlikely (1)	Low
Atmospheric Emissions: Vessels and Mechanical Equipment	7.8	Negligible (1)	Very Unlikely (1)	Low

7.1 Noise Emissions: Seismic Source

7.1.1 Source of Impact/Risk

Generation of noise from the seismic source has the potential to cause physical effects and behavioural disturbance to marine fauna.

Acquisition of the Sauropod 3D MSS will involve the use of a seismic source, consisting of an airgun array with a maximum capacity of 3,090 in^3, towed at a water depth of 5-10 m. The source will be used to generate acoustic pulses by periodically discharging compressed air into the water column, at intervals of approximately six seconds as the vessel transits along planned survey lines within the Acquisition Area.

The seismic source will be discharged at or below full capacity (power) within the Operational Area, for the purpose of run-outs, source testing and soft starts during run-ins. This discharge of the source will be sporadic, only occur for short periods of time, and will be limited to relatively short distances (e.g. 4-5 km) from the northern and southern boundaries of the Acquisition Area.

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).

3D Oil commissioned JASCO Applied Sciences to undertake numerical acoustic modelling to predict the source levels and transmission losses from a single seismic pulse and multiple seismic pulses emitted from within the Acquisition Area. The modelling results (Quijano and McPherson 2019; Appendix C) have been used in the following impact and risk evaluation to estimate the potential distances over which different receptors may be affected. The modelling is described in further detail below.

7.1.2 Receptors

The following receptors may potentially be impacted by noise emissions from the seismic source:

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

7.1.3 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 3,090 in^3 seismic source for the Sauropod 3D MSS was modelled by JASCO Applied Sciences (JASCO) to determine acoustic source levels using their Airgun Array Source Model (Quijano and McPherson 2019). The modelling predicted the 3,090 in^3 seismic source to produce far-field[1] source levels up to a maximum of 255 dB re 1 µPa·m (PK) and per-pulse source sound exposure levels (SEL) of 228-231 dB re 1 µPa^{2}m^{2}s (at 0–2,000 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 below.

7.1.3.1 *Sound Source Verification*

In 2018, a measurement program was conducted to validate the source signature predictions of JASCO's Airgun Array Source Model (McPherson et al. 2018). The validation program measured source levels for four airgun arrays including a 3,090 cui array, which is equivalent to the volume that will be used for acquisition of the Sauropod 3D MSS. The measurement program was conducted in 80 m water depth off the northern coast of Australia, with an array passing directly over the recorder on the seafloor. The sound source verification process determined that the maximum measured PK for the 3,090 cui array was 221.7 dB re 1µPa. The measurement study results were used to validate 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 the results showed good agreement with the modelling results (McPherson et al. 2018). This study is therefore considered to provide validation of the modelled source signatures for the 3,090 cui array for this EP.

7.1.4 Acoustic Modelling

To assess the potential magnitude and extent of impacts from underwater noise produced during the Sauropod 3D MSS, 3D Oil commissioned JASCO to model the source levels and sound propagation at four locations that were representative of the different water depths, bathymetry and seabed properties within the Acquisition Area (Quijano and McPherson 2019; Appendix C). The objective of this acoustic modelling study was to evaluate the effects of sound on marine fauna including cetaceans, marine reptiles, fishes, elasmobranchs, benthic invertebrates and zooplankton, and on socio-economic receptors such as commercial fisheries, marine protected areas and tourism and recreational activities. Modelling considered a 3,090 in^3 seismic source, towed at a 5-10 m depth behind the survey 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 defined locations within the Acquisition Area, and accumulated sound exposure fields were predicted for one representative scenario 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), 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 noise effect criteria. Particle motion metrics were predicted at all four

[1] 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 fair-field increases with frequency.

modelled locations. 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 relevant effects thresholds or sound levels were reached.

Contours of the modelled underwater sound fields have been computed, sampled either as the maximum value over all modelled depths (maximum-over-depth: MOD) or at the seafloor for each of the four single-pulse locations, and for the one cumulative SEL_{24h} scenario. The modelled distances for each of the sound exposure thresholds are 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.

The difference between R_{max} and $R_{95\%}$ 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 overestimate the area of the region exposed to such effects. In these instances $R_{95\%}$ is considered more representative. In environments that have bathymetric features that affect sound propagation then the $R_{95\%}$ 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, in order to be conservative.

7.1.5 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 discussed for each receptor in Section 7.1.6. The criteria have been selected on the basis that they include internationally recognised 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 are 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.

Particle Motion

The particle motion component of sound is also relevant to the assessment of potential impacts to marine fauna. Acoustic particle motion refers to the physical motion caused by a sound wave within the water, seabed or other medium. Unlike pressure, particle motion is directional in nature, although the actual to-and-fro particle displacements that constitute sound are extremely small, in the order of nanometres (Popper and Hawkins 2018). Particle motion can be described in terms of particle displacement (m), velocity (m/s), or acceleration (m/s^2) (Popper et al. 2014; Carroll et al. 2017). Alternatively, it is sometimes expressed in dB with respect to a reference value of displacement (dB re 1 pm), velocity (dB re 1 nm/s) or acceleration (dB re 1 $\mu m/s^2$) (Nedelec et al. 2016).

Particle motion is important because marine invertebrates and most fishes are primarily sensitive to particle motion rather than sound pressure and, therefore, particle motion is the most relevant metric for perceiving underwater sound by invertebrates and most fish species (Popper and Hawkins 2019). However, there is currently limited information available to quantify the particle motion sensitivity of fishes and invertebrates. It is complex and challenging to directly measure particle motion compared to sound pressure, hence most research is presented in the context of sound pressure or exposure levels instead of particle motion (Carroll et al. 2017; Popper and Hawkins 2018). Therefore, while the assessment of seismic noise impacts in this EP considers the role of particle motion and its effect on fishes and invertebrates, the acoustic modelling and impact threshold criteria are based upon sound pressure and sound exposure metrics.

It should be noted that particle motion is most relevant close to the source where it is the dominant component of a sound wave, while pressure will dominate a sound wave propagating over distance (Radford et al. 2012; Morley et al. 2014; Nedelec et al. 2016; Popper and Hawkins 2018). Sound pressure levels received at increasing distance from a source do not, therefore, provide a reliable representation of particle motion. Organisms that are sensitive only to particle motion have typically been found to be sensitive only at close range where these particle motions are greatest (Popper et al. 2014; Edmonds et al. 2016; Popper and Hawkins 2018).

7.1.6 Details of Impacts and Risks

7.1.6.1 *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 C). Frequency weighting is also explained in Appendix A.3 of the acoustic modelling report. 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 (SEL_{24h}), 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 Unweighted SPL, SEL24h, 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)	Weighted SEL_{24h} (dB re 1 µPa^2·s)	PK (dB re 1 µPa)	Weighted SEL_{24h} (dB re 1 µPa^2·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.

As described in Section 4.3.6 the humpback whale migration BIA is located approximately 15 km south of the Operational Area. The breeding, nursing and calving BIA for humpback whales along the Kimberley coastline is located 255 km east of the Operational Area. However, the proposed timing for acquisition of the Sauropod 3D MSS (January to April) means that there will be no overlap with either the northbound or southbound migration of humpback whales through the region (June to October; refer Table 4-6). The pygmy blue whale migration and distribution BIAs pass along the shelf edge at depths between 500 m and 1,000 m. The Operational Area overlaps with the distribution BIA, however the migration BIA is located 95 km from the Operational Area. Acquisition of the survey may overlap the commencement of the northbound migration (April), but avoids the southbound migration period for pygmy blue whales in the region (September to November; refer Table 4-6). Hence, there is a possibility of isolated individuals transiting through the Operational Area during the start of the northern migration in the region.

As summarised in Table 4-6, there is the possibility that a number of other cetacean species may be present in the Operational Area during acquisition of the survey (e.g. Bryde's, fin, sei, killer and sperm whales, spotted bottlenose dolphin). 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, and the spatial extent (area) of these zones of potential impact (where relevant), for all modelled scenarios (four single impulse sites and one multiple pulse scenario). The results for the thresholds applied for cetacean PTS and TTS consider both 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 (Frequency Weighted)	R_{max} Distance (Km)
PTS		
LF-cetaceans	219 dB re 1 µPa (PK)	0.03
	183 dB re 1 µPa^2.s (SEL_{24h}) #	0.63
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)	0.06
	168 dB re 1 µPa^2.s (SEL_{24h}) #	15.4
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)	8.36
MF-cetaceans		

The 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) are predicted to experience PTS at a maximum predicted distance of 630 m 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 (such as sperm whales and killer whales) the maximum predicted distance to PTS effects reduces to <20 m, based on the application of the single pulse PK metric (the SEL24h threshold was not exceeded).

The maximum predicted distance to the TTS thresholds for LF-cetaceans is 15.4 km from the nearest survey line, based on application of the multiple-pulse SEL_{24h} threshold. For MF- 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 from the seismic source for 24 hours. This would particularly be the case for an animal migrating through offshore waters that do not 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 and McPherson 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 30–60 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 8.4 km, across all water depths modelled (refer Table 7-3).

Injury (PTS) effects are predicted to occur in LF-cetaceans (such as pygmy blue whales) 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 630 m (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 60 m of the seismic source, based on the application of the single pulse PK metric. Based on the SEL_{24}hr metric, the maximum predicted distance for TTS is 15.4 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 Sauropod 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 timing and 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 pygmy blue whales or any other species of large whale that may be present within or adjacent to the Operational Area.

7.1.6.2 *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, flatback, loggerhead, hawksbill and olive ridley turtles in the North West Shelf, Pilbara and Browse Basin regions (refer Table 4-8).

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 4.3.8, there are several BIAs for turtle species in the region, including those along the coastline and around offshore islands. The closest BIA is at least 15 km from the Operational Area. No foraging, internesting, or nesting BIAs overlap with the Operational Area. The proposed timing for acquisition of the Sauropod 3D MSS (January to April) means that there will be overlap with the nesting and breeding seasons for green, flatback, loggerhead, hawksbill and olive ridley turtles in the region (October to March; refer Table 4-8). Hence, there is a low probability of isolated individuals transiting through the Operational Area during acquisition of the survey.

At least 20 species of sea snake occur within the region, and one threatened sea snake species (the short-nosed seasnake) was identified in the EPBC Act Protected Matters Database search as having the potential to occur in the Operational Area and surrounding waters. No coral reefs or shoals 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 (four single impulse sites and one multiple pulse scenario).

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

Hearing Group	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)*	1.2
	166 dB re 1 µPa (SPL)#	5.1

 # Threshold 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 5 km of the operating array, and the Moein et al. (1995) criterion of 175 dB re 1 µPa (SPL) could be exceeded within 1.2 km of the array.

Summary

As described above, at the closest point, the Operational Area is located at least 20 km from the nearest nesting BIA for turtles (flatback turtle nesting BIA adjacent to Eighty Mile Beach), and at least 105 km from the foraging BIA for green, flatback and loggerhead turtles adjacent to the Dampier Peninsula (refer Figure 4-11). At the closest point, the Operational Area is located at least 57 km from the 'Habitat Critical' for flatback turtles adjacent to Eighty Mile Beach (Figure 4-12). To the north of the Operational Area there are no BIAs or 'Habitat Critical' for marine turtles surrounding the Rowley Shoals.

The potential impacts of noise emissions from the seismic source on marine turtles during acquisition of the Sauropod 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 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 the internesting BIA 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 are thus conservatively assumed to be similar to that of turtles. Seasnakes tend to occur in shallow coastal waters or coral reef habitat 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 not significant.

Seabirds

As described in Section 4.3.9, two threatened, two threatened and migratory, and 13 migratory marine birds were identified by a search of the EPBC Act Protected Matters Database as potentially occurring in the Operational Area. Seabird species that spend the majority of their lives within the region breed at locations along the coast of Australia and at offshore islands, including at the Lacepede Islands and the Rowley Shoals. The Operational Area overlaps a breeding and foraging BIA for the white-tailed tropicbird, and a breeding BIA for the lesser frigate bird.

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 frigate birds and white-tailed tropicbirds will not be displaced from the wider areas of the breeding and foraging BIAs.

7.1.6.3 *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 C).

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 µPa2·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 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

Peak sound level (PK) dB re 1 μPa; SEL_{24h} dB re 1μPa^2·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).

Impact Assessment

As described in Section 4.3, 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, Rankin cod, red emperor, Spanish mackerel and blue-spotted emperor). The Operational Area overlaps the whale shark foraging BIA that extends northwards from North West Cape along the 200 m isobath.

The EPBC Protected Matters Search (refer Section 4.3.3) identified 29 pipefish, 6 seahorse, 4 pipehorse and 1 seadragon species the Operational Area, which are listed marine species. 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 (95-172 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 also overlaps the Ancient coastline at 125 m depth contour key ecological feature (KEF). Parts of this KEF, represented as rocky escarpment, are considered to provide biologically important habitat in an area predominantly made up of soft sediment. These areas of hard substrate may represent habitat for both demersal and benthic fish assemblages, including site-attached fishes.

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/potential mortal injury, recoverable injury and TTS thresholds in fishes in the Operational Area. Data are presented for the both the water column (maximum over depth) and at the seafloor.

Table 7-6 Maximum Predicted Distances (R_{max}) to Mortality/Potential Mortal Injury, Injury and TTS Thresholds for Fish, Fish Eggs and Larvae For Single-Pulse And SEL24h Modelled Scenarios, For Both Water Column and at The Seafloor

Marine Fauna Group	Potential Impact	Sound Exposure Threshold	Water Column (Maximum-Over-Depth)		Seafloor	
			R_{max} (Km)	Area (Km²)	R_{max} (Km)	Area (Km²)
I - Fish: No swim bladder (incl. sharks)	Mortality/potential mortal injury	219 dB re 1 µPa²·s (SEL_{24h})	<0.03	9.75	-	-
		213 dB re 1 µPa (PK)	0.06	NR*	0.08	NR*
	Recoverable injury	216 dB re 1 µPa²·s (SEL_{24h})	<0.03	12.00	-	-
		213 dB re 1 µPa (PK)	0.06	NR*	0.08	NR*
	TTS	186 dB re 1 µPa²·s (SEL_{24h})	2.81	720.12	2.79	715.75
II - Fish: Swim bladder not involved in hearing (particle motion detection)	Mortality/potential mortal injury	210 dB re 1 µPa²·s (SEL_{24h})	<0.03	12.44	-	-
		207 dB re 1 µPa (PK)	0.13	NR*	0.19	NR*
	Recoverable injury	203 dB re 1 µPa²·s (SEL_{24h})	0.04	13.28	-	-
		207 dB re 1 µPa (PK)	0.13	NR*	0.19	NR*

Marine Fauna Group	Potential Impact	Sound Exposure Threshold	Water Column (Maximum-Over-Depth)		Seafloor	
			R_{max} (Km)	Area (Km^2)	R_{max} (Km)	Area (Km^2)
	TTS	186 dB re 1 µPa^2·s (SEL_{24h})	2.81	720.12	2.79	715.75
III - Fish: Swim bladder involved in hearing (primarily pressure detection)	Mortality/potential mortal injury	207 dB re 1 µPa^2·s (SEL_{24h})	0.04	13.28	-	-
		207 dB re 1 µPa (PK)	0.13	NR*	0.19	NR*
	Recoverable injury	203 dB re 1 µPa^2·s (SEL_{24h})	0.04	13.28	-	-
		207 dB re 1 µPa (PK)	0.13	NR*	0.19	NR*
	TTS	186 dB re 1 µPa^2·s (SEL_{24h})	2.81	720.12	2.79	715.75
Fish eggs and larvae	Mortality/potential mortal injury	210 dB re 1 µPa^2·s (SEL_{24h})	<0.03	12.44	-	-
		207 dB re 1 µPa (PK)	0.13	NR*	0.19	NR*
	Injury	Popper et al. (2014) relative risk criteria#	(N) Moderate; (I) Low; (F) Low			
	TTS		N) Moderate; (I) Low; (F) Low			

A dash indicates that the threshold is not reached.
** Not relevant.*
 # 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).

The following fish types have been identified for this assessment:

- Fish assemblages associated with the Ancient coastline at 125 m depth contour;
- 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.

<u>Ancient coastline at 125 m depth contour KEF</u>

As shown in Table 7-6, the maximum predicted R_{max} distances to the mortality/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 80-190 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, and for fish eggs and larvae, is 2.8 km.

The area of overlap between the Ancient coastline at 125 m depth contour KEF and the Acquisition Area for the Sauropod 3D MSS is approximately 1,272 km^2, which represents approximately 8% of the designated area of the KEF. Given the maximum predicted R_{max} distances for mortality/injury and TTS effects of 190 m and 2.8 km, respectively, there is the potential for some fishes at the seafloor to experience mortality/injury and TTS effects. However, as discussed above, the threshold for mortality is considered highly conservative and impacts are considered more likely to be limited to recoverable injury and TTS effects.

Any potential injury or TTS effects to Group I, II and Group III fishes, and to fish eggs and larvae, within the Ancient coastline KEF are not likely to be ecologically significant at a population level for the following reasons:

- Limited spatial and temporal overlap with the KEF - ~8% of the total area of the KEF, and 60 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 review of TTS for the Santos Bethany 3D MSS, which considered similar fish species as present in the 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 North West Shelf region), 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.

As described above, the area of overlap between the Sauropod 3D MSS Acquisition Areas and the KEF is small (1,272 km^2 - ~8%). The SPRAT profile for the Ancient Coastline at 125 m KEF states "*Little is known about fauna associated with the hard substrate of the escarpment, but it is likely to include sponges, corals, crinoids, molluscs, echinoderms and other benthic invertebrates*". There is little published information on the fish communities associated with the KEF but due to the presence of epibenthic communities associated with hard substrate, it was considered that some demersal and site-attached fish species may be present. A recent study by Santos for the portion of the KEF within the Keraudren 3D MSS area indicated that a consistent structurally complex seabed feature that may provide unique habitat for demersal and site-attached fish was not evident (Santos 2019). However, an area of high relief and greater demersal fish abundance and diversity was described in the 95 to 115 m depth range outside of the Keraudren survey area.

Based on 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. Site-attached fish communities at 125 m depth may therefore exhibit some limited behavioural responses to noise emissions from the seismic source.

<u>Demersal Fish Species</u>

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 190 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 130 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, emperor and cod, 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 (~2.8 km in the water column and at the seafloor; refer Table 7-6) 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 ~2.8 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.

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 7-6, 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 130 m (refer Table 7-6). The maximum predicted R_{max} distance to the TTS threshold for all fish hearing groups is ~2.8 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 2.8 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 overlaps the foraging BIA for whale sharks that extends northeast from North West Cape across the North West Shelf (refer Figure 4-10). This BIA is centred on the 200 m isobath and whale sharks are most likely to be present during the annual migration to and from the aggregation area off Ningaloo Reef (March/April and August to November). There may therefore be some limited overlap between acquisition of the Sauropod 3D MSS and movements of whale sharks within this BIA. The Acquisition Area overlaps only 1.6% (3,512 km^2) of this BIA. Hence, it is possible that occasional whale sharks may be present in the Acquisition Area during the Sauropod 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 7-6, the maximum predicted R_{max} distance to the injury threshold in the water column for the hearing group of fishes without swim bladders, is 60 m (refer Table 7-6). The maximum predicted R_{max} distance to the TTS threshold for this fish hearing group is ~2.8 km. Again, it is important to appreciate that individual whale sharks would have to remain within a range of approximately 2.8 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 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 Sauropod 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 60 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 Acquisition Area during the Sauropod 3D MSS.

7.1.6.4 *Benthic Invertebrates*

Species Sensitivity and Sound Exposure Thresholds

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 mollusc ‘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, thus more relevant to effects on crustaceans and molluscs (including bivalves) (Quijano and McPherson 2019).

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. (2016) studies, were applied in the acoustic modelling study. The Payne et al. (2008) 202 dB re 1 µPa PK-PK is considered to be associated with no impacts to benthic crustaceans (such as prawns, scampi and lobsters), whereas the 209-212 re 1 µPa PK-PK thresholds could be associated with some level of sub-lethal effects in these animals (Quijano and McPherson 2019).

A PK sound level of 226 dB re 1 µPa PK was applied for sponges and corals (Heyward et al. 2018).

Impact Assessment

Whilst the silver-lipped pearl oyster (*Pinctada maxima*) has been recorded at maximum water depths of 100 m, adults are mostly found in shallow waters (10-15 m) in inshore, coastal areas, and the species is targeted in the Pearl Oyster Managed Fishery out to water depths of approximately 30-40 m. Consultation between other seismic survey titleholders and the Pearl Producers Association (PPA) has confirmed that there may be pearl oyster brood stock out to a depth of approximately 50 m, but any seismic survey activity in water depths >70 m was of no concern to the PPA with regards to potential impacts on adult shell (Santos 2019). Minimum water depths in the Acquisition Area for the Sauropod 3D MSS are approximately 95 m, and therefore all seismic acquisition will take place in water depths well outside the normal range for pearl oyster broodstock. Potential impacts to adult pearl oyster have, therefore, not been considered as part of this impact assessment for benthic invertebrates.

Accordingly, the following benthic invertebrates have been identified for this assessment:

Crustaceans, sponges and corals associated with the Ancient Coastline at 125 m depth contour KEF.

Sound pressure

As described above, a range of sound exposure thresholds, from 202 dB re 1 µPa PK-PK to 212 dB re 1 µPa PK-PK, were applied in the acoustic modelling study for benthic crustaceans. Sound levels of 209-212 re 1 µPa PK-PK thresholds are potentially associated with some level of sub-lethal effects. As shown in Table 7-7, at a sound exposure threshold of 209 dB re 1 µPa PK-PK, maximum predicted R_{max} distance was 260 m.

The PK sound level at the seafloor directly underneath the seismic source was estimated at all four 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 any of the four sites.

Table 7-7 Maximum Predicted Distances (R_{max}) To Effect Thresholds For Crustaceans At The Seafloor

Sound Exposure Threshold (PK-PK)	R_{max} (M)
213 dB re 1 µPa	156
212 dB re 1 µPa	179
211 dB re 1 µPa	204
210 dB re 1 µPa	234
209 dB re 1 µPa	260
202 dB re 1 µPa	709

As described above, the area of overlap between the Ancient coastline at 125 m depth contour KEF and the Acquisition Area is 1,272 km^2, which represents ~8% of the designated area of the KEF. Given the maximum predicted R_{max} distance for impacts to crustaceans of 260 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 within the Acquisition 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. 2016) 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.

Particle Motion

The acoustic modelling study included predictions of particle motion metrics at all four modelled locations, along the broadside directions, which were associated with the highest levels.

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. (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 (Quijano and McPherson 2019).

As described above, 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.

For bivalves, literature does not present a sound level associated with no impact, and as particle motion is the more relevant metric, particle acceleration from the seismic source has been modelled for comparison with the results of Day et al. (2016). The maximum particle acceleration assessed for scallops was 37.57 ms^{-2} (Quijano and McPherson 2019).

The maximum particle acceleration and velocity for each of the four sites, as a function of horizontal range from the centre of the array in broadside directions (which generate the higher amplitude results) were modelled. The maximum distance to a particle acceleration of 37.57 ms^{-2} is 9.1 m, which occurs at the shallowest site (Site 1, 66 m water depth) (refer Figure 7-1).

Particle acceleration decays rapidly away from the source location within the distance equal to half the water depth. It is then influenced by constructive interference, resulting in an increase in levels at a distance equal to the water depth (66 m at Site 1) before again rapidly decaying by 10 ms^{-2} out to approximately two water depths. Beyond this distance, it exhibits an almost linear decay, apart from constructive interactions at multiples of water depth, with a low point at approximately 10 times the modelling site water depth (Figure 7-1) (Quijano and McPherson 2019).

Particle motion traces generated during the modelling show that vertical particle motion is larger than horizontal particle motion for receivers directly underneath or at short ranges from the array, but at longer ranges the horizontal particle motion dominates. The duration of particle motion also increases with distance as critically-reflected multipath propagation becomes important.

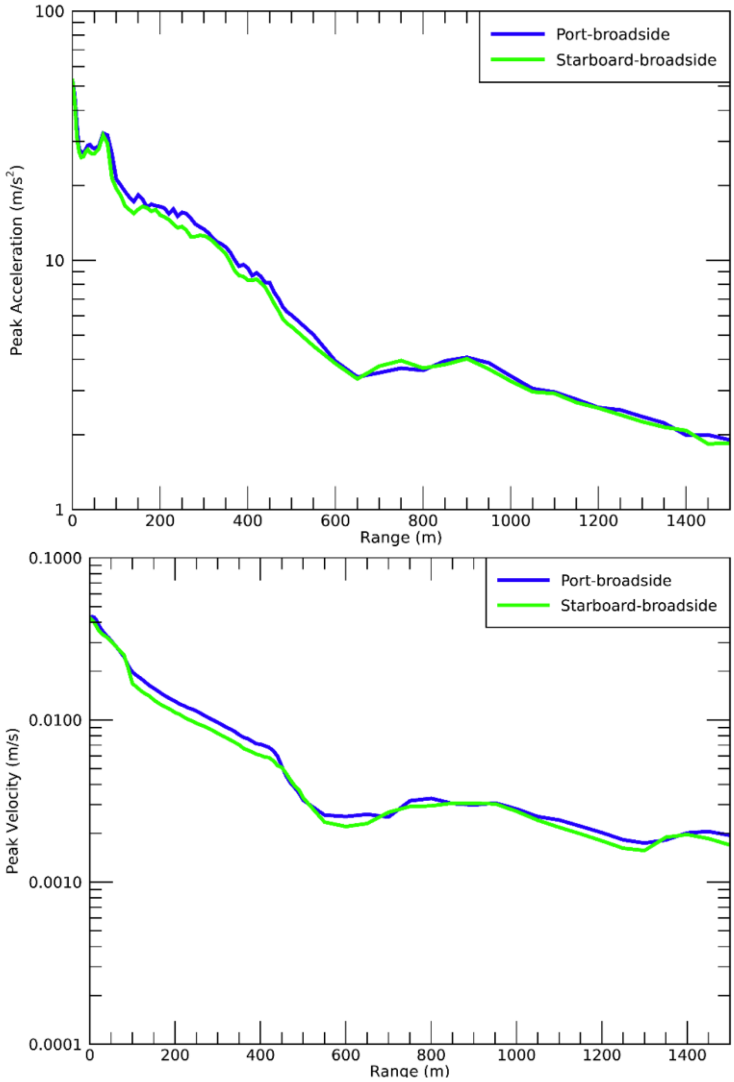


Figure 7-1 Site 1: Maximum particle acceleration (top) and velocity (bottom) at the seafloor as a function of horizontal range from the centre of the 3,090 in3 array along the broadband directions

Day et al. (2016) included a regression of particle acceleration versus range for the single 150 in^3 airgun used in their study (minimum range of 6 m) and showed that acceleration at 10 and 100 m range was typically 26 and 5 ms^{-2}, respectively. Day et al. (2016) also referenced an unpublished maximum particle acceleration measurement of 6.2 ms^{-2} from a 3,130 in^3 airgun array at 477 m range in 36 m of water. In the acoustic modelling study for the Sauropod 3D MSS, modelled peak acceleration at 10 m range was predicted to be between 35 and 19 ms^{-2} depending on the site; corresponding values at 100 m range are between 21 and 12 ms^{-2}. At ~477 m, the modelling predicts an acceleration of between 8.5 and 5.8 ms^{-2} in both the port and starboard broadside directions. This result aligns reasonably with the measurements reported in Day et al. (2016) and thus represents what is likely to occur (Quijano and McPherson 2019).

The maximum distance to a particle acceleration of 37.57 ms^{-2} of 9.1 m is less than that predicted for other studies in the region (Quijano and McPherson 2019), however the difference is likely due to the different airgun array configuration and tow depth, as well as the geology for the respective studies. The seabed geology used for this study, silty carbonate sand to calcarenites, are generally less reflective than seabeds which have thin layers of sand over calcarenite substrate.

Summary

The potential impacts of noise emissions from the seismic source on benthic invertebrates during the Sauropod 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 Acquisition Area.

7.1.6.5 *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. Other studies have also noted limited negative impacts on zooplankton, fish eggs, larvae or fry, and most have reported that impacts occur within a few metres or tens of metres from the source (Kostyuchenko 1973; Dalen & Knutsen 1987; Holliday et al. 1987; Kosheleva 1992 cited in Parry et al*.* 2002; Pearson et al. 1994; Turnpenny & Nedwell 1994; Booman et al. 1996; Payne 2004; Payne et al. 2009). These studies included exposures to sound pressures up to approximately 242 dB re 1 µPa, comparable to those predicted in close range to the Sauropod 3D MSS seismic source.

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 Sauropod 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).

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).

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 7-8).

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 km2 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). The CSIRO modelling was carried out for the Northwest Shelf IMCRA Mesoscale Bioregion and the findings of this study are therefore applicable in determining the potential impacts of the Sauropod 3D MSS on zooplankton communities.

A recent study by Fields et al. (2019) exposed zooplankton (copepods) to seismic pulses at various distances up to 25 m from a seismic source. The source levels produced were estimated to be 221 dB re 1 µPa^2.s and comparable to the far-field source levels predicted for the Sauropod 3D MSS seismic source. The study observed an increase in immediate mortality rates of up to 30% of copepods in samples compared to controls at distances of 5 m or less from the airguns. Mortality one week after exposure was significantly higher by 9% relative to controls in the copepods placed 10 m from the airguns. Fields et al. (2019) also reported that no sublethal effects occurred at any distance greater than 5 m from the seismic source. The findings of the study are consistent with numerous other field studies, as referenced previously, indicating that the potential effects of seismic pulses to zooplankton are limited to within approximately 10 m from the seismic source. Fields et al. (2019) note that the findings of the McCauley et al. (2017) study are difficult to reconcile with the body of other available research. The findings of the McCauley et al. (2017) study may, therefore, provide an overly conservative estimate of the potential effects of seismic pulses to zooplankton.

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 7-8).

Table 7-8 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})	<0.03
207 dB re 1 µPa (PK)	0.13
178 dB re 1 µPa PK-PK	7.93

As shown in Table 7-8, 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 130 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 ~8 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 Sauropod 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 Acquisition Area.

7.1.6.6 *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 key indicator commercial fish species.

Recent information obtained from DPIRD Fisheries (DPIRD 2019c) has defined depth ranges and key spawning periods for a range of key indicator species for the Northern Demersal Scalefish Managed Fishery, Pilbara Demersal Scalefish Fisheries (Pilbara Trawl, Trap and Line) and Mackerel Managed Fishery:

- Red emperor - depth range 10-180 m, spawns Sept-June (bimodal peaks Sept-Nov and Jan-Mar);
- Rankin cod – depth range 10-150 m, spawns June-Dec and Mar (peak Aug-Oct);
- Goldband snapper – depth range 50-200 m, extended peak spawning Oct-May;
- Blue-spotted emperor – depth range 5-110 m, extended peak spawning Jul-Mar;
- Giant ruby snapper – depth range 150-480 m, spawns Dec-Apr (peak Jan-Mar);
- Spanish mackerel - depth range 1 m to at least 50 m, spawns Sept-Dec.

It is believed that all of these species undergo group spawning throughout their range, rather than aggregating at specific locations. The spawning peaks for a number of these species (red emperor, goldband snapper and Spanish mackerel) overlap the timing of the Sauropod 3D MSS.

A spatial analysis has been conducted to determine the overlap between the Acquisition Area and the depth ranges identified above. From this analysis it was determined that the spatial overlap between the Acquisition Area and the depth ranges for each of the key indicator species range from zero (i.e. no overlap) to approximately 3,785 km^2 (i.e. all of the Acquisition Area overlaps the potential spawning range; refer Table 7-9).

Table 7-9 Spatial Overlap Between Depth Ranges For Key Indicator Commercial Fish Species And The Acquisition Area

Fish species	Depth range (m)	Range area (km^2) *	Acquisition Area (3,785 km^2)	
			Overlap (km^2)	%
Red emperor, Pilbara stock	10-180	99,349	3,785	3.8%
Rankin cod, Pilbara stock	10-150	92,575	3,334	3.6%
Goldband snapper, Pilbara stock	50-200	68,748	3,785	5.5%
Blue-spotted emperor, Pilbara stock	5-110	88,121	1,147	1.3%
Giant ruby snapper, Pilbara stock	150-480	43,566	955	2.2%
Spanish mackerel, Pilbara stock	1-50	48,501	0	0.0%

* Stock areas have been estimated based on FRDC (2019) stock assessment data and DPIRD fishery management areas.

As shown in Table 7-9, there is no overlap between the depth range identified by DPIRD Fisheries for Spanish mackerel and the Acquisition Area. There is very minimal overlap (1.3%) between the identified depth range for blue-spotted emperor and the Acquisition Area. The total percentage overlaps with the depth ranges for the demersal key indicator species and the Acquisition Area range from 1.3% (blue-spotted emperor) to 5.5% (goldband snapper) (Table 7-9).

It is highly unlikely that the Sauropod 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 7-6 (130 m from the seismic source);

- short impact ranges for any significant behavioural responses in adult fish (tens or hundreds of metres); and
- the small extent of overlap (1.3 to 5.5%) between the Acquisition Area and the identified depth ranges for the key indicator demersal species.

It should be noted that the spatial overlap presented in Table 7-9 refers to the overall area that may be exposed to sound at some point in time during the entire survey duration. At any point in time when groups of fish may be spawning, the area where fish may be disturbed will be significantly smaller. The effects of sound on spawning fishes will therefore be localised and limited to a small number of groups of fish during times when the species may be spawning. The same groups of fishes will also spawn on multiple other occasions during the respective species' spawning seasons. As the seismic survey vessel moves across the Acquisition Area, there is limited potential for the same groups of fish to be subjected to repeat exposures during another spawning event. There is limited potential for population level (stock) impacts to occur, given each of the species' high fecundity, serial broadcast spawning patterns and high levels of stock connectivity within the region.

For the Pilbara line, trap and trawl fisheries the three key indicator species for assessment and stock status are red emperor, blue-spotted emperor and Rankin cod. The status of ruby snapper is also used as an indicator species for the offshore demersal scalefish resources targeted by the Pilbara Line Fishery (Newman et al. 2018b). A 2016 assessment of these indicator species estimated the spawning biomass of red emperor stock to be currently above the threshold level and the stocks of blue-spotted emperor, Rankin cod and ruby snapper are well above the target spawning biomass levels for the past five years (Newman et al. 2018b), in which time there had been both ongoing commercial fishing and seismic survey activity.

Summary

Based on the timing and duration (up to 60 days) of seismic acquisition, the potential impacts of noise emissions from the seismic source on spawning of key indicator commercial fish species during the Sauropod 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.

7.1.6.7 *Commercial Fisheries*

Impact Assessment

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 in proximity to the Operational Area. 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.

The following WA-managed commercial fisheries that have historic fishing effort within, or in close proximity to, the Operational Area have been identified for this assessment:

- Pilbara Trap Managed Fishery (PTMF);
- Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF);
- Pilbara Line Fishery (PLF)
- Northern Demersal Scalefish Managed Fishery (NDSMF); and
- Mackerel Managed Fishery (MMF) – Area 2 (Pilbara sector).

In addition to commercial fisheries for finfish, the Operational Area overlaps with the Pearl Oyster Fishery Area 2. However, as described in Section 4.4.4 the Pearl Oyster Fishery operates in inshore waters only, with adult pearl oyster shell being harvested by divers out to a maximum water depth of approximately 35 m.

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 (red emperor, Rankin cod, goldband snapper, blue-spotted emperor, ruby snapper and Spanish mackerel) will be limited to distances of a few tens or at most hundreds of metres from the operating seismic source.

An analysis has been conducted to determine the area of overlap between the ‘fishery management area[2]’ and the Acquisition Area and Operational Area. In determining the percentage overlap (shown in Table 7-10), the calculation excludes Areas 3 and 6 for the PFTIMF as these areas are not able to be fished by the fisheries.

Table 7-10 Potential Spatial Overlap With the PTMF, PFTIMF, MMF And NDSMF

Commercial Fishery	Fishable area (km^2)	Operational Area (5,957 km^2)		Acquisition Area (3,785 km^2)	
		Overlap (km^2)	%	Overlap (km^2)	%
Pilbara Trap	86,160	5,247.8	6.1	3,784.2	4.4
Pilbara Trawl	23,155	1,613.4	7.0	1,083.1	4.7
MMF (Area 2)	507,356	5,957.0	1.2	3,785.3	0.8
NDSMF (Licence type B)	396,624	683.0	0.2	0	0

As shown in Table 7-10, the spatial overlap between the Acquisition Area and ‘fishery management areas’ for the PTMF, PFTIMF, MMF and NDSMF range from zero (NDSMF) to a maximum of 4.7% (PTMF).

To provide further assessment of the overlap with the fishing catch and effort of these commercial fisheries, fishing catch and effort (‘FishCube’) data provided by DPIRD was analysed to ascertain the level of fishing effort that occurs in waters overlapped by the Sauropod 3D MSS Acquisition Area. Data was analysed for the most recent 4 years, from 2014 to 2017, based on 60 nm x 60 nm block (PTMF and PLF) or 10 nm x 10 nm FishCube data (PFTIMF; NDSMF and MMF). It has been assumed for the purposes of this analysis that that fishing activity (based on fishing effort data) is also representative of the potential disturbance to target fish species and fisheries’ catch levels. A qualitative assessment of the overlap with commercial catch and effort is presented in Table 7-11.

Table 7-11 Potential Overlap With Fishing Catch And Effort For The PTMF, PFTIMF, PLF PMMF And NDSMF, Based On 2014 – 2017 Fishcube Data

Commercial Fishery	Summary of overlap between the Sauropod 3D MSS Acquisition Area and historical catch and effort (2014 – 2017)
Pilbara trap	Less than 3 vessels from the PTMF fished within a 60 nm x 60 nm block (an area larger than the Operational Area) in each year from 2014 to 2017. Due to confidentiality reasons, catch and effort data was not available as there where less than 3 vessels reporting catch each year. The Operational Area overlaps with approximately 6.1% of the area of effort recorded by the fishery (between 2014 – 2017). Based on this information, the level of fishing effort within the Operational Area is unknown and therefore there is a possibility of interaction with skippers in the PTMF.
Pilbara trawl	The southern part of the Sauropod 3D MSS Acquisition Area overlaps with the eastern edge of the Pilbara trawl zone. Data provided for 10 nm x 10 nm blocks show that blocks were either: ■ fished by less than three vessels during the entire 4-year period 2014-2017; or ■ up to a maximum of 32 days fishing effort has occurred over 4 years (average of 8 days per year) in the most south west corner of the Operational Area.

[2] The fishery management area refers to the total fishery management area (defined by DPIRD Fisheries), minus any closure areas that apply to that specific fishery.

Commercial Fishery	Summary of overlap between the Sauropod 3D MSS Acquisition Area and historical catch and effort (2014 – 2017)
	Greater levels of fishing catch and effort are located to the south and west of the Acquisition Area. The Operational Area overlaps with approximately 7% of the area of effort recorded by the fishery (between 2014 – 2017). Historic fishing catch and effort in the Operational Area is considered low, given greater levels of fishing catch and effort has been recorded outside of the Operational Area. However, there is the potential for interaction with the fishery near the south-west corner of the Operational Area.
Pilbara line	No line fishing occurs in the Sauropod 3D MSS Acquisition Area or Operational Area. The nearest area fished by the PLF in the years 2014-2017 is approximately 20 km south of the Operational Area. Therefore, there is no potential for interaction with the PLF.
MMF (Area 2)	The Sauropod 3D MSS Acquisition Area or Operational Area do not overlap with any areas fished by the MMF in the years 2014-2017. The nearest area fished by the MMF is approximately 20 km south of the Operational Area. Therefore, there is no potential for interactions with the PTMF.
NDSMF	The Acquisition Area does not overlap with any areas fished by the NDSMF. Only the eastern boundary of the Operational Area overlaps with the fishery, comprising 10 nm x 10 nm blocks, where either no fishing catch and effort has occurred or less than three vessels have fished during the entire 4-year period 2014-2017. Due to confidentiality reasons, catch and effort data was not available as there where less than 3 vessels reporting catch each year. The Operational Area overlaps with less than 1% of the area of effort recorded by the fishery (between 2014 – 2017). Based on this information, there is limited potential for interaction with the NDSMF.

Based on the assessment provided in Table 7-11:

- No impacts to the PLF or MMF are expected as a result of the Sauropod 3D MSS;
- There is very limited potential for the Sauropod 3D MSS to interact with the PTMF and NDSMF; and
- There is limited potential for the Sauropod 3D MSS to disturb fish targeted by PFTIMF if both fishing effort and seismic acquisition occur near the southwest corner of the Operational Area at the same time. However, the area where the survey overlaps fishing effort is only a small proportion of the area fished by the fishery (4.7%).

Potential impacts to commercial catch rates are not likely to be significant based on the following:

- 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.
- Large proportions of the 'fishery management areas' for the PTMF, PFTIMF, MMF and NDSMF (>95%) are out of range of the predicted impact thresholds from the Sauropod 3D MSS.
- Fishing catch and effort within the Sauropod 3D MSS Acquisition Area and Operational Area is relatively low (refer to Table 7-11).

- The stock assessment for all key indicator commercial fish species (mackerel, red emperor, blue-spotted emperor and Rankin cod) 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 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 60 days) of seismic acquisition, the potential impacts of underwater noise emissions from the seismic source on commercial catch rates during the Sauropod 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 fish species targeted by commercial fisheries within of adjacent to the Operational Area.

7.1.6.8 *Marine Protected Areas*

Impact Assessment

As shown in Figure 4-13, the northern boundary of the Operational Area is located approximately 21 km from the southern boundary of the Multiple Use Zone (MUZ) of the Argo-Rowley Terrace Marine Park (an AMP) and approximately 60 km from the boundary of the Rowley Shoals Marine Park (State waters) at Imperieuse and Clerke reefs. The Operational Area is located approximately 80 km from the boundary of the Mermaid Reef Marine Park (an AMP).

As described in Section 4.4.1.1, the Argo-Rowley Terrace Marine Park was established to protect a range of natural, cultural and heritage values, including the Canyons linking the Argo Abyssal Plain with the Scott Plateau and the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEFs. The latter KEF overlaps the MUZ of the Argo-Rowley Terrace Marine Park.

Based on the sound level isopleths for modelling Site 3, maximum predicted received sound levels in the water column at the boundaries of these marine protected areas (MPAs) are as follows:

- MUZ of the Argo-Rowley Terrace Marine Park - approximately 134 dB re 1 µPa (SPL);
- Rowley Shoals Marine Park (at Clerke Reef) - approximately 125 dB re 1 µPa (SPL); and
- Mermaid Reef Marine Park – approximately 122 dB re 1 µPa (SPL).

Maximum predicted received sound levels at the boundary of the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF closest to the Operational Area are approximately 127 dB re 1 µPa (SPL).

Consequently, received sound levels in the water column or at the seafloor within the areas of these MPAs closet to the Operational Area will not exceed any of the sound exposure thresholds for injury, TTS or behavioural disturbance in cetaceans, marine reptiles, fishes/elasmobranchs, benthic invertebrates or zooplankton that may be present within the MPAs during acquisition of the Sauropod 3D MSS.

Summary

Based on the timing and duration (up to 60 days) of the Sauropod 3D MSS, and the control measures that will be implemented, predicted noise levels from seismic acquisition are not considered likely to cause any impacts to the natural or cultural heritage values of the any AMP in the region, or to the values of the Rowley Shoals Marine Park (State waters).

7.1.6.9 *Tourism and Recreation*

Impact Assessment

As described in Section 4.4.5, a range of recreational activities take place at Imperieuse and Clerke reefs, within the Rowley Shoals Marine Park (State waters), including scuba diving, snorkelling and fishing charter trips.

The separation minimum distances from the Operational Area and Imperieuse and Clerke reefs are 67 km and 63 km, respectively. At these ranges, received sound levels at the reefs will be well below levels that would result in any effects, including TTS and behavioural disturbance, in fish targeted by recreational fishers. Therefore, acquisition of the Sauropod 3D MSS will not result in any impact to recreational fishing charter trips to the Rowley Shoals.

To assess the potential impacts from operation of the seismic source in the Acquisition Area on divers and snorkellers in the water at Imperieuse and Clerke reefs, a single-impulse sound exposure threshold of 145 dB re 1 µPa (SPL) was applied, which represents a human health assessment threshold for sound exposure to divers and swimmers, derived from Ainslie (2008) and Parvin (2005). This does not imply that this level is associated with the onset of injury. Based on a number of studies examining the potential effects of underwater noise emissions on both military and recreational divers Parvin (2005) suggested 145 dB re 1 µPa (SPL) as a safety criterion for recreational divers and swimmers, within a frequency range between 100 and 500 Hz. Seismic airgun sources are broadband sources, and therefore, for this assessment the most precautionary and conservative diver acoustic impact threshold has been used.

For modelling Site 3, which is the closest of the four single impulse modelling sites to the Rowley Shoals, the maximum predicted R_{max} distance to the 145 dB re 1 µPa (SPL) threshold was 15.8 km, in the endfire direction (i.e. north towards the reefs). Received levels at Imperieuse and Clerke reefs are predicted to be at or below 120 dB re 1 µPa (SPL), which is approaching ambient background noise levels in these offshore atoll environments where SPLs are consistently between 85 – 110 dB increasing at times to in excess of 120 dB re 1 µPa as a result of biological noise, waves and tidal currents.

On this basis, divers and snorkelers at Imperieuse and Clerke reefs will not be exposed to sound levels anywhere close to the 145 dB re 1 µPa (SPL) threshold. If diving and snorkelling activities in these areas were to coincide with acquisition of the Sauropod 3D MSS, it is highly unlikely that individuals in the water would be able to hear individual shots from the seismic source above background ambient noise levels.

Summary

On the basis of the information provided above there will be no impacts from seismic noise emissions during the Sauropod 3D MSS on diving and snorkelling activities at the Rowley Shoals.

7.1.7 Decision Context

The decision context for underwater sound emissions from the seismic source has been assessed as ‘Type A’, given that:

- the Sauropod 3D MSS is not in an area of increased sensitivity for biological of socio-economic receptors;
- the impacts/risks are well understood;
- uncertainty as to the magnitude of impacts determined in this assessment is minimal;
- good practice management of seismic sound impacts is well-defined; and
- 3D Oil has received some, albeit limited, interest from fisheries stakeholders.

7.1.8 Risk Summary

Receptor	Risk Ranking	Consequence	Likelihood	Risk Ranking
Cetaceans	**Inherent Risk**	Minor (2)	Possible (3)	**Medium**
	Residual Risk	Minor (2)	Unlikely (2)	**Low**
Marine reptiles	**Inherent Risk**	Minor (2)	Unlikely (2)	**Low**
	Residual Risk	Minor (2)	Unlikely (2)	**Low**
Seabirds	**Inherent Risk**	Negligible (1)	Very Unlikely (1)	**Low**
	Residual Risk	Negligible (1)	Very Unlikely (1)	**Low**
Fishes and elasmobranchs	**Inherent Risk**	Negligible (1)	Possible (3)	**Low**
	Residual Risk	Negligible (1)	Possible (3)	**Low**
Benthic invertebrates	**Inherent Risk**	Negligible (1)	Unlikely (2)	**Low**
	Residual Risk	Negligible (1)	Unlikely (2)	**Low**
Zooplankton	**Inherent Risk**	Negligible (1)	Possible (3)	**Low**
	Residual Risk	Negligible (1)	Possible (3)	**Low**
Fish spawning	**Inherent Risk**	Minor (2)	Unlikely (2)	**Low**
	Residual Risk	Minor (2)	Unlikely (2)	**Low**
Commercial fisheries	**Inherent Risk**	Minor (2)	Possible (3)	**Medium**
	Residual Risk	Minor (2)	Unlikely (2)	**Low**
Marine protected areas	**Inherent Risk**	Negligible (1)	Very Unlikely (1)	**Low**
	Residual Risk	Negligible (1)	Very Unlikely (1)	**Low**
Tourism and recreation	**Inherent Risk**	Negligible (1)	Very Unlikely (1)	**Low**
	Residual Risk	Negligible (1)	Very Unlikely (1)	**Low**

7.1.9 Identification of Control Measures and Demonstration of ALARP

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Legislative Requirements			
Operation of the seismic source within the Operational Area for the Sauropod 3D MSS will be compliant with EPBC Act Policy Statement 2.1 Part A Standard Management Measures	Yes	Consistent with Part A of EPBC Policy Statement 2.1, the following precaution zones will be applied: ■ Observation zone: 3+ km horizontal radius from the seismic source; ■ Low power zone: 2 km horizontal radius from the seismic source; and ■ Shut-down zone: 500 m horizontal radius from the seismic source. Part A of EPBC Policy Statement 2.1 provides standard management procedures and will be implemented during the Sauropod 3D MSS. Precaution zones will be implemented around the seismic source to allow whale observations to be undertaken and the seismic source to be powered or shut down to reduce the potential for PTS and TTS in the event a whale is observed within the precaution zones.	1.1
		Consistent with Part A of EPBC Policy Statement 2.1, the following procedures will be applied: ■ Pre-Start-up Visual Observations (30 minutes); ■ Start-up Delay Procedures (if sighting); ■ Soft-start Procedures (30 minutes); ■ Operational Shut-down and Low-power Procedures; ■ Night-time and Low Visibility Procedures; ■ Seismic survey vessel crew will be briefed in marine fauna observations, distance estimation and procedures; and ■ Cetacean sighting and compliance reports to be submitted to DOEE within 2 months of survey completion.	
Operation of the seismic source within the Operational Area for the Sauropod 3D MSS will be compliant with EPBC Act Policy Statement 2.1 Part B.1 – Additional Management Measures: Marine Mammal Observers	Yes	Two trained and experienced marine fauna observers (MFOs) will be aboard the seismic survey vessel. The two MFOs (in addition to briefed crew members) will alternate shifts during daylight hours in order to manage fatigue and provide some redundancy in the event one MFO is unavailable. The MFOs will have adequate training and will have >12 months experience in Australian waters.	1.2
Operation of the seismic source within the Operational Area for the Sauropod 3D MSS	Yes	In accordance with criteria outlined in EPBC Policy Statement 2.1, acoustic modelling confirmed that the received sound exposure level from a single seismic pulse will exceed 160 dB re	1.3

Control Measure	Control Adopted	Justification	Performance Standard Ref.
will be compliant with EPBC Act Policy Statement 2.1 Part B.4 - Increased precaution zones and buffer zones.		1µPa^2.s for 95% of pulses at 1 km range. Therefore, instead of a 1 km low power zone, a larger 2 km low power zone will be implemented.	
Good Industry Practice			
The seismic source will not be discharged outside the Operational Area. The seismic source will only be discharged outside of the Acquisition Area for the purpose of run-outs, source testing and soft starts.	Yes	The seismic source will not be discharged outside the Operational Area and will only be discharged outside the Acquisition Area for the purpose of run-outs, source testing and soft starts. Good industry practice, environmental benefit outweighs additional cost.	1.4
3D Oil will engage with proponents identified as having potential concurrent MSS activities prior to commencing the Sauropod 3D MSS and develop a concurrent operations plan for any concurrent surveys identified within 50 km of the Acquisition Area	Yes	Engagement with titleholders for potential concurrent MSS activities prior to acquisition commencing, and development of a concurrent operations plan, which will include the following aspects: ■ Communications protocols; ■ SIMOPS and work programming; ■ Hazard management; and ■ Emergency response. Good industry practice, environmental benefit outweighs additional cost.	1.5
Alternatives/Substitutes Considered			
The source volume used during acquisition of the survey will be equal to or less than the source volume used for the acoustic modelling and impact assessment	Yes	3D Oil has assessed the minimum size source required to fulfil survey data objectives. A maximum source volume of 3,090 in^3 will be used to acquire the survey. This provides confidence in the impact assessment conducted, which was based on modelling results for a 3,090 in^3 array. Good industry practice, no additional cost.	1.6
Additional Controls Considered			
Survey acquisition timed to avoid the migration periods for humpback whales (June to October).	Yes	The survey will be acquired in the period January to April, which will avoid the northbound and southbound migration season for humpback whales in the region (June to October). Good industry practice, environmental benefit outweighs additional cost.	1.7
Survey acquisition timed to avoid the migration periods for pygmy blue whales	No	Not justified. Acquisition of the survey may overlap the commencement of the northbound migration (April), but avoids most of the northbound migration and the entire southbound migration period for pygmy blue whales in the region (September to November). While the	N/A

Control Measure	Control Adopted	Justification	Performance Standard Ref.
		Operational Area overlaps with the pygmy blue whale distribution BIA, the migration BIA is located 95 km from the Operational Area. Only occasional, transient individuals are therefore expected in the area during the proposed acquisition period. The costs of limiting the acquisition window further to avoid the pygmy blue whale migration entirely are grossly disproportionate to any potential environmental benefit gained.	
Survey acquisition timed to avoid turtle internesting periods	No	Not justified. Acquisition of the survey may overlap the nesting and breeding season for a number of turtle species in the region, however the Operational Area is located at least 15 km from the closest BIA or 'Habitat Critical' boundary. The costs are grossly disproportionate to any potential environmental benefit gained.	N/A
EPBC Act Policy Statement 2.1 Part B.2 – Night-time/ Poor Visibility	No	Not justified. 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.	N/A
EPBC Act Policy Statement 2.1 Part B.3 - Use of spotter aircraft and vessels to detect presence of cetaceans	No	Not justified. 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.	N/A
EPBC Act Policy Statement 2.1 Part B.5 - Passive Acoustic Monitoring (PAM) to detect presence of vocalising cetaceans	No	Not justified. 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.	N/A
EPBC Act Policy Statement 2.1 Part B.6 - Adaptive Management Measures	No	Not justified. 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.	N/A

Control Measure	Control Adopted	Justification	Performance Standard Ref.
		The costs are grossly disproportionate to any potential environmental benefit gained.	
Application of EPBC Act Policy Statement 2.1 Part A Standard Management Measures to turtles and whale sharks	No	Not justified. Injury (PTS) effects will only occur within very close ranges (tens of metres) to the operating source. Use of soft start procedures will minimise the risk of an animal being in close proximity to the source operating at full capacity. The Operational Area is located at least 15 km form the closest BIA or 'Habitat Critical' boundary for turtles. Whilst the Operational Area overlaps the whale shark foraging BIA, based on the temporal limits of this BIA (March to November) there is likely to be limited overlap between acquisition of the survey and movements of whale sharks within this BIA with only occasional whale sharks present. The Acquisition Area overlaps only 1.6% of this BIA. Potential effects to whale sharks are expected to be limited to minor and temporary behavioural change such as avoidance. Increased costs would be incurred due to additional shut-downs for turtles and whale sharks, prolonging the survey duration. The costs are grossly disproportionate to any potential environmental benefit gained.	N/A
Survey acquisition timed to avoid or limit temporal overlap with the spawning periods for key indicator species for commercial fisheries	No	Not justified. Combined spawning periods for the key indicator species covers all 12 months of the year. Further constraining the survey window and limiting the overlap of the survey with fish spawning periods would mean that the proposed seismic survey could not be acquired. This would effectively result in 3D Oil missing its work programme commitments under petroleum exploration permit WA-527-P, a cost in the order of millions of dollars. Given the limited predicted risk to fish spawning and fish stocks, the costs are grossly disproportionate to any potential environmental benefit gained.	N/A
No acquisition overlapping the Ancient coastline at 125 m depth contour KEF	No	Not justified. Would result in removal of 1,272 km^2 from the Acquisition Area and 3D Oil would not be able to obtain data for all hydrocarbon prospects being targeted. The area of the KEF potential impact by the survey is small (8%), and the KEF is not expected to support large numbers of site-attached species. Any impacts to individuals are not expected to lead to population or ecosystem level impacts. The costs are grossly disproportionate to any potential environmental benefit gained.	N/A
Reduce survey area to decrease area of overlap with commercial fisheries	No	Not justified. 3D Oil would not be able to obtain data for all hydrocarbon prospects being targeted. There is minimal overlap (0-4.7%) between the Acquisition Area and key fishing areas for the PTMF, PFTIMF, MMF and NDSMF. The costs are grossly disproportionate to any potential environmental benefit gained.	N/A

Control Measure	Control Adopted	Justification	Performance Standard Ref.
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. 3D Oil has determined that compensation for commercial fishers is not an appropriate control or mitigation measure for the Sauropod 3D MSS, given the nature and scale of the activity, and the minimal impacts expected to the commercial fishing industry.	N/A
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)			
No practicable improvements have been identified			N/A
ALARP Statement			
3D Oil considers the adopted control measures appropriate to manage the impacts and risks of underwater sound emissions from the seismic source. As the impact/risk has been classified as 'Type A' and 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.			

7.1.10 Demonstration of Acceptable Levels

Context	Factor	Demonstration
Internal	3D Oil Policy	The impact/risk associated with underwater noise emissions from the seismic source will be managed in accordance with 3D Oil's HSE Policy.
	Company Standards/Systems	The impact/risk associated with underwater noise emissions from the seismic source will be managed in accordance with 3D Oil's Management System.
External	Values and Sensitivities of the Natural Environment	**EPBC Policy Statement 1.1. – Significant guidelines** The residual risk 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.
		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 marine reserve management plans, 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; ■ Whale shark – wildlife management program no. 57 (DPaW 2013); and ■ North-west Marine Parks Management Plan.
		AMP Values, Management Prescriptions and IUCN Reserve Management Principles No impacts are predicted to occur to the natural or cultural heritage values of the Argo-Rowley Terrace Marine Park and Mermaid Marine Park as a result of underwater noise from the seismic source.
	Relevant Persons Expectations	Stakeholder concerns have been assessed, responded to and controls adopted for objections and claims which hold merit.
Legislation & Other Requirements	Legislation & Conventions	The proposed control measures exceed the required standards and control measures set out in Part A of EPBC Policy Statement 2.1.
Industry Standards	Industry Standards & Best Practices	■ The activity will comply with the following applicable industry standards and best practice guidance:

Context	Factor	Demonstration
		■ EPBC Policy Statement 2.1. Part A Standard Management Measures; ■ IOGP Recommended monitoring and mitigation measures for cetaceans during marine seismic survey geophysical operations (March 2017); and ■ IAGC Mitigation Measures For Cetaceans during Geophysical Operations (February 2015).
Ecological Sustainability Development (ESD)	ESD Application	3D Oil has reduced the impact/risk of underwater noise emissions from the seismic source to prevent serious or irreversible ecological damage. Impacts are expected to be have a Negligible or Minor consequence, with likelihoods ranging from Very Unlikely to Possible. 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.
Acceptability Statement		
Based on the criteria above, 3D Oil considers the adopted control measures appropriate to manage the impacts and risks of underwater noise emissions from the seismic source to be of an acceptable level.		

7.1.11 Environmental Performance Outcomes, Standards and Measurement Criteria

Performance Outcomes	Performance Standards	Measurement Criteria
EPO 1 Minimise the impacts from underwater noise emissions from the seismic source to marine fauna	**PS 1.1** Operation of the seismic source within the Operational Area for the Sauropod 3D MSS is compliant with EPBC Act Policy Statement 2.1 Part A Standard Management Measures: ■ 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 (30 minutes); ■ Start-up Delay Procedures (if sighting); ■ Soft-start Procedures (30 minutes); ■ Operational Shut-down and Low-power Procedures; ■ Night-time and Low Visibility Procedures; ■ Seismic survey vessel crew will be briefed in marine fauna observations, distance estimation and procedures; and ■ Cetacean sighting and compliance reports to be submitted to DOEE within 2 months of survey completion.	**MC** Records demonstrate compliance with Policy Statement 2.1 Part A Standard Management Measures.
	PS 1.2 Operation of the seismic source within the Operational Area for the Sauropod 3D MSS is compliant with EPBC Act Policy Statement 2.1 Part B.1 – Additional Management Measures: Marine Mammal Observers. Two trained and experienced MFOs are aboard the seismic survey vessel. The two MFOs (in addition to briefed crew members) alternate shifts during daylight hours in order to manage fatigue and provide some redundancy in the event one MFO is unavailable. The MFOs have adequate training and will have >12 months experience in Australian waters.	**MC** Records demonstrate that two MFOs were aboard the survey vessel for the duration of the survey. MFO sighting records and final report. CVs and training records for the MFOs.

Performance Outcomes	Performance Standards	Measurement Criteria
	PS 1.3 Operation of the seismic source within the Operational Area for the Sauropod 3D MSS is compliant with EPBC Act Policy Statement 2.1 Part B.4 - Increased precaution zones and buffer zones. Acoustic modelling confirmed that the received sound exposure level from a single seismic pulse will exceed 160 dB re 1μPa^2.s for 95% of pulses at 1 km range. Therefore, instead of a 1 km low power zone, a larger 2 km low power zone will be implemented.	**MC** Records demonstrate a 2 km low power zone has been implemented
	PS 1.4 The seismic source is not discharged outside the Operational Area. The seismic source is only discharged outside of the Acquisition Area for the purpose of run-outs, source testing and soft starts.	**MC** Records demonstrate that there has been no discharge of the seismic source outside the Operational Area.
	PS 1.5 3D Oil have engaged with proponents identified as having potential concurrent MSS activities prior to commencing the Sauropod 3D MSS and have developed a concurrent operations plan for any concurrent surveys identified within 50 km of the Acquisition Area.	**MC** Records demonstrate 3D Oil has re-engaged with identified titleholders prior to commencing the Sauropod 3D MSS, and has developed a concurrent operations plan, if required.
	PS 1.6 The source volume used during acquisition of the survey is equal to or less than the source volume used for the acoustic modelling and impact assessment.	**MC** Records confirm that a source with a maximum volume of 3,090 in^3 has been used throughout the survey.
	PS 1.7 Survey acquisition is timed to avoid the migration periods for humpback whales (June to October).	**MC** Records confirm that the survey has been acquired outside the June to October humpback whale migration season.

7.2 Noise Emissions: Cumulative Seismic Sound

7.2.1 Details of Impacts and Risks

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.

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 Sauropod 3D MSS.

This section assesses the potential for cumulative impacts associated with:

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

7.2.1.1 *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 7-12 presents a summary of the marine seismic surveys that have been undertaken in the last five years within approximately 150 km of the Sauropod 3D MSS Operational Area. The footprint of impacts resulting from the Sauropod 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.

Cumulative impacts are not expected to occur as a result of any of the identified previous seismic surveys in the region and the proposed Sauropod 3D MSS. Impacts associated with previous surveys are expected to have recovered well in-advance of the Sauropod 3D MSS commencing. Therefore, cumulative impacts from previous seismic surveys are not assessed further.

Table 7-12 Previous Seismic Surveys Completed Within 150 Km Of The Sauropod 3D MSS In The Last 5 Years

Year	Company	Survey Title	Survey Location	Survey Status and Timing	Comments
2016	TGS-NOPEC	Canning-Northern Carnarvon Multi Client Marine Seismic Survey	Sauropod Acquisition Area overlaps approximately 500 km^2 of the TGS survey area.	Completed between June – September 2016. Exact dates of acquisition are unknown.	There is limited spatial overlap with the survey. The survey was completed at least three years prior to the Sauropod 3D MSS. Therefore, no cumulative impacts are expected.
2016	Searcher Seismic Pty Ltd	Bilby 2D Phase 3 Multi-client Marine Seismic Survey	Maximum of 55,000 km^2 of 2D seismic acquisition. The Sauropod 3D MSS Acquisition Area overlaps with the area acquired by Searcher (i.e. Bilby survey area).	Completed between June – July 2016. Exact dates of acquisition are unknown.	The survey was completed at least three years prior to the Sauropod 3D MSS. Therefore, no cumulative impacts are expected.
2019	Santos Limited	Keraudren Seismic Survey	Maximum of 5,539 km^2 of 3D seismic acquisition with exploration permits WA-435-P, WA-436-P, WA-437-P and WA-438-P. Sauropod Acquisition Area is located approximately 40 km from the Keraudren survey area.	Completed between May – early July 2019. Exact dates of acquisition are unknown.	There is no spatial overlap. The survey was completed six months prior to the earliest possible commencement date of the Sauropod 3D MSS. Therefore, no cumulative impacts are expected.

7.2.1.2 *Concurrent Seismic Surveys*

Over the scheduled period of the Sauropod 3D MSS other seismic surveys are also planned to occur in the region. However, for commercial reasons, it is unlikely that all of the proposed seismic surveys will actually proceed. 3D Oil will endeavour to minimise the potential for interaction between any concurrent seismic surveys to minimise both potential disruptions to operations as well as potential cumulative sound impacts to the marine environment and impacts other marine users.

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 Sauropod 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 Sauropod 3D MSS (Quijano and McPherson 2019) demonstrates that sound levels will be below 145 dB re 1µPa at 20 km from the source (half way between two seismic sources at their minimum separation distance). 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 151 dB re 1µPa, which is below known behavioural response thresholds for marine fauna (e.g. cetaceans).

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

To understand what other known potential seismic surveys may occur near the Sauropod 3D MSS Acquisition Area, Table 7-13 presents the seismic surveys that:

- May occur within 150 km of the Sauropod 3D MSS Acquisition Area;
- May occur within the same EP timeframes; and
- Either have an EP accepted by NOPSEMA or have submitted an EP to NOPSEMA and is currently under assessment.

This section does not assess cumulative impacts from seismic surveys within the area that occur after the Sauropod 3D MSS as it is the responsibility of that titleholder to assess the cumulative impacts.

Table 7-13 Potential Concurrent Seismic Surveys Within 150 Km Of The Sauropod 3D MSS

Company	Survey Title	Survey Location	EP Status and Survey Timing
PGS Australia Pty Ltd	Rollo Multi-client Marine Seismic Survey	The Sauropod Acquisition Area is located approximately 60 km east of the Beagle Operational Area. There is no spatial overlap with the PGS survey.	The EP was accepted by NOPSEMA on 04/10/2018. Restrictions within the EP allow for a maximum of 25,000 km^2 of seismic acquisition per year for five years. Seismic acquisition has occurred between 22/02/2019 – 08/05/2019. It is not clear whether PGS has completed all seismic acquisition under the accepted EP or whether PGS will return at a later date. The specific commencement dates and durations of individual surveys have not been confirmed.
TGS-NOPEC Geophysical Company Pty Ltd	North West Shelf Renaissance North Multi Client Marine Seismic Survey	The Sauropod 3D Acquisition Area is located approximately 150 km east of the TGS Operational Area. There is no spatial overlap with the PGS survey. Maximum of 25,000 km^2 of seismic acquisition.	The EP was accepted by NOPSEMA on 13/06/2018. The EP is valid for a two-year period. No seismic acquisition has occurred to date under the accepted EP. The specific commencement dates and durations of individual surveys have not been confirmed.
INPEX Browse E&P Pty Ltd	2D Seismic Survey WA-532-P, WA-533-P and WA-50-L	The Sauropod 3D Acquisition Area is located approximately 63 km west of the INPEX 2D Seismic Survey Acquisition Area.	The EP was submitted to NOPSEMA on 30/07/2019 and is currently under assessment. The specific commencement date and duration of the survey has not been confirmed.

7.2.2 Evaluation of Impacts

The following section provides a summary of the potential impacts that are predicted to occur from the Sauropod 3D MSS and the other potential concurrent survey identified in Table 7-13.

Marine Fauna

Short-term behavioural impacts are expected to occur up to a maximum of approximately 8 km from the operating seismic source for the most sensitive species of cetacean (depending upon location and water depth) and at lesser distances for other marine fauna (see Section 7.1.6.1). Species are expected to be transient and no changes to migration or other important life stages are expected.

No significant discernible cumulative impacts to marine fauna are expected, given the separation distances between the Rollo Multi-client Marine Seismic Survey (approximately 60 km from the Sauropod Acquisition Area), North West Shelf Renaissance North Multi Client Marine Seismic Survey (approximately 150 km from the Sauropod Operational Area) and the INPEX 2D Seismic Survey (approximately 63 km from the Sauropod Acquisition Area). In addition, taking the proposed 40 km minimum separation into consideration, no cumulative overlap of strong behavioural responses is expected.

The cumulative risk is considered to be Low, given that there is no threat of serious or irreversible environmental damage.

Fish

Behavioural impacts in fish are expected occur at distances of tens or hundreds of metres from the Sauropod 3D MSS acquisition lines, returning to normal within as little as an hour (see Section 7.1.6.3).

No significant discernible cumulative impacts to fish are expected, given the separation distances between the Rollo Multi-client Marine Seismic Survey (approximately 60 km from the Sauropod Acquisition Area), North West Shelf Renaissance North Multi Client Marine Seismic Survey (approximately 150 km from the Sauropod Operational Area) and the INPEX 2D Seismic Survey (approximately 63 km from the Sauropod Acquisition Area). In addition, taking the proposed 40 km minimum separation into consideration, no cumulative overlap of strong behavioural responses is expected. Some mild changes in fish abundance and distribution could occur as a result of exposure from the two operating seismic surveys, but such changes are expected to return to normal within a few hours or days.

The cumulative risk is considered to be Low, given that there is no threat of serious or irreversible environmental damage.

Fish Spawning

The spawning periods for a number of the key indicator species for the Northern Demersal Scalefish Managed Fishery, Pilbara Demersal Scalefish Fisheries (Pilbara Trawl, Trap and Line) and Mackerel Managed Fishery overlap with the timing of the Sauropod 3D MSS.

It is considered credible that the Rollo Multi-client Marine Seismic Survey, North West Shelf Renaissance North Multi Client Marine Seismic Survey and/or the INPEX 2D Seismic Survey may be completed concurrently with the Sauropod 3D MSS, however, the possibility that all surveys will occur at the same time is considered very unlikely. If one or more of the surveys were completed concurrently, it is noted that there may be occasional additional disturbances to different groups of spawning fishes within each of the separate survey areas. However, the effects of sound on spawning fishes in each survey area are expected to be localised and limited to a small number of groups of fish during times when they may be spawning. The same groups of fishes will also spawn on multiple other occasions during the respective species' spawning seasons, and there is limited potential for the same groups of fish to be subjected to repeat exposures during another spawning event. Given the localised disturbances to spawning groups of fishes, there is expected to be limited potential for concurrent surveys to result in discernible population level (stock) impacts, given each species' high fecundity, serial broadcast spawning behaviours, and high levels of stock connectivity across the wider region.

The cumulative risk is considered to be Low, given that there is no threat of serious or irreversible environmental damage.

Plankton, Fish Eggs and Larvae

Based on the maximum worst case mortality exposure suggested by McCauley et al. (2017) and modelling completed by CSIRO (Richardson et al. 2017), impacts to zooplankton are only expected to be significant within a short range (e.g. 15 km) of seismic survey areas. Beyond 22 days of acquisition, CSIRO (Richardson et al. 2017) found that no further relative increase in zooplankton mortality occurs, due to recruitment of zooplankton via currents from adjacent areas, and conditions return to normal within a few days of a survey ceasing. At the regional scale, these impacts are not expected to be significant CSIRO (Richardson et al. 2017). Further, natural mortality rates can be as high as ~60%, and not entirely as a result of predation (see Section 7.1.6.5), therefore, limited impacts are expected relative to the natural variation in zooplankton concentrations and mortality rates.

No significant discernible cumulative impacts to marine fauna are expected, given the separation distances between the Rollo Multi-client Marine Seismic Survey (approximately 60 km from the Sauropod Acquisition Area), North West Shelf Renaissance North Multi Client Marine Seismic Survey (approximately 150 km from the Sauropod Operational Area) and the INPEX 2D Seismic Survey (approximately 63 km from the Sauropod Acquisition Area). In addition, taking the proposed 40 km separation into consideration, the cumulative impacts to plankton are expected to be negligible.

The cumulative risk is considered to be Low, given that there is no threat of serious or irreversible environmental damage.

Benthic Invertebrates

The maximum worst case impacts reported for invertebrates include sub-lethal impacts such as statocyst impairment, temporary reduced immune response function, temporary impaired reflexes, and potentially some chronic effects that lead to mortality of a very small number of sessile benthic invertebrates over and above natural mortality rates. For the Sauropod 3D MSS, such impacts are expected to occur at close range to the seismic source (i.e. <260 m) (see Section 7.1.6.4). In the context of natural mortality, recruitment and recovery rates, the impacts to overall benthic communities are expected to be negligible (see Section 7.1.6.4).

Currently, no other seismic surveys are planned to occur that overlap the planned Sauropod 3D MSS. Should there be some overlap in other future areas, cumulative impacts may only occur if more than one survey occurs within weeks of the preceding survey, which is unlikely to occur.

The cumulative risk is considered to be Low given that there is no threat of serious or irreversible environmental damage.

Commercial Fisheries

Cumulative impacts to commercial fisheries could occur if multiple seismic surveys occur concurrently or in quick succession within an area, resulting in increased avoidance by target fish species. As highlighted in Section 7.1.6.7, the expected range and duration of impacts to fish abundance, distribution and catch rates is relatively small compared to wider areas within which the fisheries operate. It is acknowledged that multiple surveys in a region may result in disruption to fishing activities in multiple locations and an incremental reduction in access to some fishing grounds.

However, the cumulative area that will be subject to seismic acquisition at any one time, remains relatively small compared to the wider areas available for fishing.

3D Oil recognises that clear and regular communication with fisheries stakeholders is required in order to provide timely information on the location and timing of different surveys in order to facilitate better planning and resource sharing. 3D Oil will notify stakeholders prior to the commencement of the survey and will provide regular updates to fishery licence holders during survey operations. The cumulative risk is considered to be Low.

Summary

Based on the assessment presented above and the implementation of the identified controls (Section 7.2.3), the cumulative risk of concurrent seismic surveys is assed as Low.

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

7.2.3 Identification of Control Measures and Demonstration of ALARP

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Legislative Requirements			
No relevant legislation has been identified.	N/A	N/A	N/A
Good Industry Practice			
Issue of marine navigation warnings and Notice to Mariners of survey presence and towed array	Yes	AHS will be contacted four weeks prior to the commencement of the survey for the publication of related Notices 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, environmental benefit outweighs additional cost.	2.1
Pre-survey notification to AMSA JRCC, issue of AUSCOAST warnings	Yes	The AMSA JRCC will be contacted 24-48 hrs before operations commence for issuing of radio-navigation warnings. 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, environmental benefit outweighs additional cost.	2.2
Notification will be provided to fisheries stakeholders, prior to survey commencement and following survey completion.	Yes	Notification will be provided to fisheries stakeholders four weeks prior to commencement of the survey and two weeks following completion of the survey. Implementation of the control will reduce the likelihood of interactions with marine users. Good industry practice, environmental benefit outweighs additional cost.	2.3
3D Oil will engage with proponents identified as having potential concurrent seismic activities prior to commencing the Sauropod survey and develop a concurrent operations plan for any concurrent surveys identified within 50 km of the Acquisition Area.	Yes	Engagement with titleholders for potential concurrent MSS activities prior to acquisition commencing, and development of a concurrent operations plan, which will include the following aspects: ■ Communications protocols; ■ SIMOPS and work programming; ■ Hazard management; and ■ Emergency response. Good industry practice, environmental benefit outweighs additional cost.	1.5

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Alternatives/Substitutes Considered			
No practicable alternative or substitutes to the above controls have been identified.	N/A	N/A	N/A
Additional Controls Considered			
A minimum separation distance of 40 km shall be maintained between the Sauropod 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.	2.4
Survey acquisition timed to avoid spawning periods for key indicator species for commercial fisheries	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.	N/A
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)			
No practicable improvements have been identified.	N/A	N/A	N/A
ALARP Statement			
3D Oil considers the adopted control measures appropriate to manage the risk of cumulative seismic sound impacts. As the risk has been classified as Low and no reasonable additional or alternative controls were identified that would further reduce the risk, without jeopardising the objectives of the survey, the risk is considered to be ALARP.			

7.2.4 Demonstration of Acceptable Levels

Context	*Factor*	*Demonstration*
Internal	3D Oil Policy	The risk management strategy for managing cumulative impacts is compliant with 3D Oil's HSE Policy objectives of proactively identifying hazards, eliminating impacts where possible and where this is not possible managing the risk to ALARP.
	Company Standards/Systems	Section 9 details the relevant management system processes adopted to implement and manage impacts/risks to ALARP: ■ Contractor & Supplier Management (Section 9.7); ■ Notification & Reporting (Section 9.12).
External	Values and Sensitivities of the Natural Environment	**EPBC Policy Statement 1.1. – Significant guidelines** The risk has been assessed as low, and will not have a significant impact upon protected matters in accordance with EPBC Policy Statement 1.1. – Significant guidelines.
		Conservation Advice, Recovery Plans, and Other Guidelines N/A: No advice or guidelines have been identified that specifically address cumulative seismic sound impacts.
		AMP Values, Management Prescriptions and IUCN Reserve Management Principles No impacts are predicted to occur to the natural, cultural and socio-economic values of the Argo-Rowley Terrace Marine Park and Mermaid Marine Park.
	Relevant Persons Expectations	During stakeholder consultation for the Sauropod 3D MSS, WAFIC specifically expressed an interest in the cumulative impacts of multiple seismic surveys and requested that cumulative impact assessment is addressed in the EP. The above assessment has considered the cumulative impacts.
Legislation & Other	Legal Requirements	The controls adopted comply with the *Navigation Act 2012* and *Offshore Petroleum Greenhouse Gas Storage Act 2006*.
Industry Standards	Industry Standards & Best Practices	Compliance with industry standards and best practice is demonstrated.

Context	*Factor*	*Demonstration*
Ecological Sustainability Development (ESD)	ESD Application	There is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecological integrity associated with cumulative seismic sound impacts from the Sauropod 3D MSS.

Acceptability Statement

The adopted controls described in Section 7.2.3, are considered industry best practice and meet legislative requirements. Further opportunities to reduce the risk have been investigated above. 3D Oil considers the adopted control measure to be appropriate to manage the activity to an acceptable level.

7.2.5 Environmental Performance Outcomes, Standards and Measurement Criteria

Performance Outcomes	Performance Standards	Measurement Criteria
EPO 2 Minimise the impacts cumulative noise emissions may have on marine fauna.	**PS 2.1** The AHS is advised four weeks prior to survey commencement to allow for the issue of a Notice to Mariners.	**MC** Records verify that Notice to Mariners issued by AHS prior to survey commencement.
	PS 2.2 AMSA RCC are notified of survey activities 24-48 hours before operations commence, to allow for issue of AUSCOAST warnings, at survey commencement and at completion.	**MC** Available records verify AMSA JRCC notifications have been made, and that AUSCOAST warnings have been issued.
	PS 2.3 Notification is 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.	**MC** Consultation and notification records verify stakeholders have been informed of survey activities throughout the survey period.
	PS (refer to PS 1.5) 3D Oil have engaged with proponents identified as having potential concurrent seismic activities prior to commencing the Sauropod survey and have developed a concurrent operations plan for any concurrent surveys identified within 50 km of the Acquisition Area.	**MC** Records verify that 3D Oil has engaged with proponents prior to acquisition commencement (if relevant), and a concurrent operations plan has been developed.
	PS 2.4 A minimum separation distance of 40 km is maintained between the Sauropod 3D MSS seismic sources and other operating seismic sources.	**MC** Records verify that a minimum separation distance of 40 km has been maintained between the Sauropod 3D MSS seismic sources and other operating seismic sources.

7.3 Noise Emissions: Vessel, Helicopter and Mechanical Equipment

7.3.1 Details of Impacts and Risks

7.3.1.1 *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.

A purpose-built seismic vessel and two support vessels (one supply and one chase) will be employed for the Sauropod 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 Sauropod 3D MSS for the purpose of crew changes. Crew changes are expected to occur every 4-6 weeks. 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 impedance 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.

Potential impacts associated with underwater sound emission from the seismic source is addressed in Section 7.1.

7.3.1.2 *Receptors*

- Cetaceans;
- Marine turtles;
- Whale sharks; and
- Seabirds.

7.3.1.3 *Impact/Risk Evaluation*

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.

The Operational Area is located in water depths ranging from approximately 95 m to 172 m. The 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 areas (Section 4.3.7). The Operational Area overlaps with the pygmy blue whale distribution BIA and whale shark foraging BIA. However, itt is expected low numbers of marine fauna will be present in the Operational Area (refer to Section 4.3.6).

Given there are no high energy impulsive sound sources associated with the routine operation of 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. 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). Permanent injury would be expected to occur at 230 dB re 1 μPa (peak) (Southall et al. 2007) for cetaceans. Noise generated by vessels is unlikely to exceed that level so permanent or temporary injury to protected migratory whale species is 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. Hence, any avoidance or attraction behaviours displayed are expected to be localised and temporary, based on the limited duration of the survey (approximately 60 days). 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 landing helicopters. 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.

Summary

Based on the assessment presented above and the implementation of the identified controls (Section 7.3.4), the consequence of occasional short term and localised disturbance to marine fauna is Negligible (1). The likelihood of this consequence occurring is Very Unlikely (1) and the risk is considered to be *Low*.

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

7.3.2 Decision Context

The decision context for noise from seismic vessel, support vessels and mechanical equipment has been assessed as 'Type A', given the impacts/risks are well understood and uncertainty is minimal, with little or no stakeholder interest.

7.3.3 Risk Summary

Risk Ranking	Consequence	Likelihood	Risk Ranking
Inherent Risk	Negligible (1)	Very Unlikely (1)	**Low**
Residual Risk	Negligible (1)	Very Unlikely (1)	**Low**

7.3.4 Identification of Control Measures and Demonstration of ALARP

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Legislative Requirements			
Vessels will comply, when safe to do so, with the 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 also reduce the risk of engine noise in close proximity to cetaceans. It is a legislative requirement for vessels to comply with the EPBC Act.	3.1
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 Act.	3.2
Good Industry Practice			
No good industry practice measures have been identified	N/A	N/A	N/A
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.	N/A
Additional Controls Considered			

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Vessel engines maintained according to manufacturer's specification.	Yes	This will ensure reliability of equipment to reduce noise impacts. Good industry practice, environmental benefit outweighs additional cost.	3.3
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, 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, 3D Oil has considered extending the prescribed avoidance measures to turtles. Good industry practice, environmental benefit outweighs additional cost.	3.4
Vessels, when safe to do so, 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.	Yes	In addition to implementing the EPBC Regulations 2000 avoidance measures for cetaceans, 3D Oil has extended avoidance measures to whale sharks. Good industry practice, environmental benefit outweighs additional cost.	3.5
Extend the requirements of the EPBC Regulations 2000 - Part 8 Division 8.1 for helicopters to turtles and whale sharks.	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	N/A

Control Measure	Control Adopted	Justification	Performance Standard Ref.
		other fauna is impractical, unnecessary and disproportionate to the limited additional benefit it may provide to reducing the already low level of risk.	

ALARP Statement

The residual risk associated with the generation of noise from seismic vessel, support vessels and mechanical equipment has been determined to be *Low*. 3D Oil considers the adopted control measures appropriate to manage the impacts and risks of noise from seismic vessel, support vessels and mechanical equipment. As the impact/risk has been classified as 'Type A' and 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.

7.3.5 Demonstration of Acceptable Levels

Context	*Factor*	*Demonstration*
Internal	3D Oil Policy	The risk management strategy for managing noise emissions from seismic vessel, support vessels and mechanical equipment operation, is compliant with 3D Oil's HSE Policy objectives of proactively identifying hazards, eliminating impacts where possible and where this is not possible managing the risk to ALARP.
	Company Standards/Systems	Section 9 details the relevant management system processes adopted to implement and manage impacts/risks to ALARP: ■ Contractor & Supplier Management (Section 9.7); ■ Notification & Reporting (Section 9.12).
External	Values and Sensitivities of the Natural Environment	**EPBC Policy Statement 1.1. – Significant guidelines** The residual risk has been assessed as low, and will not have a significant impact upon protected matters in accordance with EPBC Policy Statement 1.1. – Significant guidelines.
		Conservation Advice, Recovery Plans, and Other Guidelines: Proposed control measures and the low residual risk of vessel and mechanical equipment noise are consistent with the various Conservation Advice, Conservation Management Plans and Recovery Plans for whales, whale sharks and turtles.
		AMP Values, Management Prescriptions and IUCN Reserve Management Principles: No impacts are expected to the natural or cultural heritage values of the Argo-Rowley Terrace Marine Park and Mermaid Reef Marine Park.
	Relevant Persons Expectations	No feedback relating specifically to vessel noise has been received during stakeholder consultation. This issue is considered to be addressed and will be managed to acceptable levels.
Legislation & Other	Legal Requirements	The impact/risk will comply with EPBC Regulations 2000 (Part 8 Division 8.1 'Interacting with cetaceans').

Context	*Factor*	*Demonstration*
Industry Standards	Industry Standards & Best Practices	Compliance with best practice guidance is demonstrated.
Ecological Sustainability Development (ESD)	ESD Application	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 seismic vessel, support vessels and mechanical equipment operation during the Sauropod 3D MSS.

Acceptability Statement

The impact assessment has determined that, given the adopted controls, noise disturbance from the seismic vessel, support vessels and mechanical equipment operation are unlikely to result in potential impact greater than localised and temporary disruption to a small proportion of the population. Further opportunities to reduce the impacts and risks have been investigated above.

The adopted controls described in Section 7.3.4 are considered industry best practice and meet legislative requirements. 3D Oil considers the adopted controls appropriate to manage the impacts of noise disturbance from the seismic vessel, support vessels and mechanical equipment operation to be of an acceptable level.

7.3.6 Environmental Performance Outcomes, Standards and Measurement Criteria

Performance Outcomes	Performance Standards	Measurement Criteria
EPO 3 Vessels are operated to minimise noise disturbance to marine fauna during the survey.	**PS 3.1** Marine navigation warnings and Notice to Mariners of survey presence and towed array are issued. Survey is compliant 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).	**MC** MFO records verify interaction between the seismic vessel and marine mammals comply with these requirements where safe to do so. Support vessel observation sheets verify interactions between the vessel and marine mammals comply with these requirements.
	PS 3.2 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 1650 feet within a horizontal radius of 500 metres of a cetacean; and ■ helicopters not to approach a cetacean from head on.	**MC** MFO records verify that helicopter movements comply with these requirements.
	PS 3.3 Vessel engines maintained according to manufacturer's specification.	**MC** Records verify that engines and propulsion system maintenance meet this standard.
	PS 3.4 In addition to the requirements of the EPBC Regulations 2000 - Part 8 Division 8.1 for cetaceans, vessels also, where safe to do so: ■ 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.	**MC** MFO records verify interaction between the seismic vessel and marine turtles comply with these requirements where safe to do so. Support vessel observation sheets verify interactions between the vessel and marine turtles comply with these requirements where safe to do so.
	PS 3.5	**MC**

Performance Outcomes	Performance Standards	Measurement Criteria
	Vessels, when safe to do so, 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.	MFO records verify interaction between the seismic vessel and whale sharks comply with these requirements where safe to do so. Support vessel observation sheets verify interactions between the vessel and whale sharks comply with these requirements where safe to do so.

7.4 Physical Presence: Disruption/Interference with Other Marine Users

7.4.1 Details of Impacts and Risks

7.4.1.1 *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 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 the seismic vessel and other marine users 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.

This section deals with disruption/interference with other marine users. Risk associated with vessel collision/diesel spill is addressed in Section 8.1 and potential underwater sound impacts on commercial fishing is addressed in Section 7.1.

7.4.1.2 *Receptors*

- Commercial fishing;
- Commercial shipping;
- Tourism/recreational activities; and
- Petroleum exploration and production operations.

7.4.1.3 *Impact/Risk Evaluation*

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

- Commercial fishing – WA State commercial fishing licence holders may be encountered during the Sauropod 3D MSS (Section 4.4.4).
- Commercial shipping - Trading vessels may pass through on occasion; however, a relatively low density of shipping is expected in the Operational Area (Section 4.4.10).
- Tourism and recreational operations – Tourism and recreational activities take place to the north of the Operational Area at Rowley Shoals. No activities are known to take place in the Operational Area, however, vessels may traverse the area in low numbers (Section 4.4.5).
- Petroleum exploration and production operations, including associated vessel activities (Section 4.4.6).

The limited manoeuvrability of the seismic vessel means that vessels associated with shipping, commercial fisheries, tourism operations and existing oil and gas operations 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 seismic activities.

<u>*Commercial Fishing*</u>

There are three WA State fisheries that have historically (in the past 5 years) had catch effort within the Operational Area (PTMF, PFTIMF and NDSMF; Section 4.4.4). 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 fishing vessels. There is a possibility that commercial fishing vessels will be displaced from the area, 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 (<5%) of the fishing areas overlapping with the Operational Area (refer Table 7-10).
- Limited fishing effort has occurred in the Operational Area (refer Table 7-11).
- The transient nature of the seismic and support vessels means that any given area is only temporarily unavailable to fishing operations.
- Early notifications to fisheries licence holders, Notice to Mariners and Auscoast warnings, 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.

Commercial Shipping

Some commercial shipping may also need to deviate from intended routes to avoid the seismic vessel, in-water equipment and the support vessels. Consultation with AMSA confirms that only light traffic occurs within the Operational Area. The closest shipping fairway is located to the north-western corner of the Operational Area (Section 4.4.10). The use of the fairways is strongly recommended by AMSA, but is not mandatory and shipping vessels still have to adhere to the International Regulations for Preventing Collisions at Sea 1972 (COLREGS). Based on this and the inherent controls identified above, no significant navigational implications or changes in shipping traffic patterns are expected.

Tourism/Recreational Activities

Tourism/recreational activities are known to take place approximately 62 km north of the Operational Area at Imperieuse and Clerke reefs in the Rowley Shoals Marine Park (State waters), however no tourism/ recreational activities have been identified to take place within the Operational Area. 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.

Petroleum Exploration and Production Operations

Apart from WA-527-P, the Operational Area overlaps three other exploration permits (WA-487-P, WA-436-P and WA-438-P) that are operated by Pathfinder Energy Pty Ltd and Santos WA Northwest Pty Ltd. The potential for concurrent seismic activities has been identified in Section 4.4.6. There are two accepted EPs covering seismic surveys that could be undertaken within the same timeframe as the Sauropod 3D MSS, and potentially occur within 150 km of the Operational Area. Prior to commencement of the Sauropod 3D MSS, 3D Oil will consult with the titleholders/proponents of these EPs to establish whether there is any likelihood of concurrent operations. Concurrent seismic surveys within close proximity to each other (i.e. within tens of kilometres) are routinely managed via CONOPS (concurrent operations plans) and time-sharing arrangements. The potential impact is considered to be slight and short-term. Cumulative impacts from concurrent seismic surveys are described in Section 7.2.

Summary

Based on the assessment presented above and the implementation of the identified controls (Section 7.4.40), it is expected that localised and temporary disruptions to other users and activities will be Minor (2), with fishing vessels and other users able to return to a particular area once the seismic vessel has passed. The likelihood of interaction is considered to be Unlikely (2), resulting in a *Low* residual risk to other users in the Operational Area.

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

7.4.2 Decision Context

The decision context for disruption/interference with other marine users, has been assessed as 'Type A', given the impacts/risks are well understood and uncertainty is minimal, with little or no stakeholder interest.

7.4.3 Risk Summary

Risk Ranking	Consequence	Likelihood	Risk Ranking
Inherent Risk	Minor (2)	Possible (3)	**Medium**
Residual Risk	Minor (2)	Unlikely (2)	**Low**

7.4.4 Identification of Control Measures and Demonstration of ALARP

Control Measure	Control Adopted	Justification	Performance Standard Ref.
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 (SOLAS) as implemented in Commonwealth Waters through the *Navigation Act 2012* and associated Marine Orders 21, 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	Legislative requirement for vessels operating in Commonwealth waters. All vessels associated with the Sauropod 3D MSS are required to comply with the *Navigation Act 2012*.	4.1
Good Industry Practice			
Issue of marine navigation warnings and Notice to Mariners of survey presence and towed array	Yes	AHS will be contacted 4 weeks prior to the commencement of the survey for the publication of related Notices 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, environmental benefit outweighs additional cost.	2.1
Pre-survey notification to AMSA JRCC, issue of AUSCOAST warnings	Yes	The AMSA JRCC will be contacted 24-48 hrs before operations commence for issuing of radio-navigation warnings. 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, environmental benefit outweighs additional cost.	2.2

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Streamers marked with tail buoys.	Yes	Tail buoys will be used to mark ends of the streamers so that they can be detected by other vessels. Good industry practice, environmental benefit outweighs additional cost.	4.2
Notification will be provided to fisheries stakeholders, prior to 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 4 weeks prior to commencement of the survey and 2 weeks following completion of the survey. Implementation of the control will reduce the likelihood of interactions with marine users. Good industry practice, environmental benefit outweighs additional cost.	2.3
A communications protocol will be in place between the survey and support vessels and other users (e.g. known commercial fishing vessels within the Operational Area), to actively manage concurrent activities.	Yes	The survey vessel operator will provide effective 'look-aheads' to commercial fisheries fleet managers and vessel skippers to inform them of the current positions of the survey and support vessels, and of proposed operations for the next 48-72-hour period. Implementation will reduce the likelihood of vessel collision between the survey and/or support vessels and third party vessels.	4.3
At least one additional vessel (support or chase vessel) will accompany the survey vessel when in operation and when safe to do so (e.g. outside of inclement weather periods).	Yes	The chase vessel will conduct advanced scouting when safe to do so (e.g. outside of inclement weather periods) to ensure that other marine users in the area are provided with advance notice of seismic activities. The chase vessel will provide effective communications with other activities and users. Good industry practice, socio-economic benefit outweighs the additional cost.	4.4
3D Oil will engage with proponents identified as having potential concurrent seismic activities prior to commencing the Sauropod survey and develop a concurrent operations plan for any concurrent surveys identified within 50 km of the Acquisition Area.	Yes	Engagement with titleholders for potential concurrent MSS activities prior to acquisition commencing, and development of a concurrent operations plan, which will include the following aspects: • Communications protocols; • SIMOPS and work programming; • Hazard management; and • Emergency response.	1.5

Control Measure	Control Adopted	Justification	Performance Standard Ref.
		Good industry practice, environmental benefit outweighs additional cost.	
Alternatives/Substitutes Considered			
No practicable alternative or substitutes to the acquisition or the good practice controls have been identified	N/A	N/A	N/A
Additional Controls Considered			
No additional controls have been identified	N/A	N/A	N/A
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)			
No practicable improvements have been identified	N/A	N/A	N/A
ALARP Statement			
The residual risk associated with the disruption/interference with marine users has been determined to be *Low*. 3D Oil considers the adopted control measures appropriate to manage the risks of disruption/interference with other marine users. As the risk has been classified as 'Type A' and no reasonable additional or alternative controls were identified that would further reduce the risk, without jeopardising the objectives of the survey, the risk is considered to be ALARP.			

7.4.5 Demonstration of Acceptable Levels

Context	Factor	Demonstration
Internal	3D Oil Policy	The risk management strategy for managing interactions between the seismic vessel, survey equipment, support vessels and other vessels/activities, is compliant with 3D Oil's HSE Policy objectives of proactively identifying hazards, eliminating impacts where possible and where this is not possible, managing the risk to ALARP.
	Company Standards/Systems	Section 9 details the relevant management system processes adopted to implement and manage impacts/risks to ALARP: ■ Contractor & Supplier Management (Section 9.7); ■ Notification & Reporting (Section 9.12).
External	Values and Sensitivities of the Natural Environment	**EPBC Policy Statement 1.1. – Significant guidelines** The residual risk has been assessed as low, and will not have a significant impact upon protected matters in accordance with EPBC Policy Statement 1.1. – Significant guidelines.
		Conservation Advice, Recovery Plans, and Other Guidelines N/A: No advice or guidelines have been identified that are relevant to the disruption/interference with other marine users.
		AMP Values, Management Prescriptions and IUCN Reserve Management Principles No impacts are predicted to occur to the cultural and socio-economic values of the Argo-Rowley Terrace Marine Park and Mermaid Marine Park as a result of disruption/interference with other marine users.
	Relevant Persons Expectations	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 AMSA and AHS.
Legislation & Other	Legal Requirements	All requirements under the *Navigation Act 2012* and associated Marine Orders for navigation, collision, and support vessels are identified as control measures.
Industry Standards	Industry Standards & Best Practices	Compliance with industry standards and best practice is demonstrated.

Context	*Factor*	*Demonstration*
Ecological Sustainability Development (ESD)	ESD Application	There is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecological integrity associated with disruption/interference with other users during the Sauropod 3D MSS.

Acceptability Statement

The impact assessment has determined that, given the adopted controls, the physical presence of the seismic vessel, in-water equipment and support vessels is unlikely to result in potential impact greater than localised and short-term disturbance to other mariner users. Further opportunities to reduce the impacts and risks have been investigated above.

The adopted controls described in Section 7.4.4 are considered industry best practice and meet legislative requirements. 3D Oil considers the adopted controls appropriate to manage the activity to an acceptable level.

7.4.6 Environmental Performance Outcomes, Standards and Measurement Criteria

Performance Outcomes	Performance Standards	Measurement Criteria
EPO 4 Marine users are aware of the survey location, timing and safety navigation zone	**PS 4.1** Adherence with 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, 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.	**MC** 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.
	PS (refer to PS 2.1) The Australian Hydrographic Service (AHS) is advised 4 weeks prior to survey commencement to allow for the issue of a Notice to Mariners.	**MC** Records verify that Notice to Mariners issued by AHO prior to survey commencement.
	PS (refer to PS 2.2) AMSA RCC is notified of survey activities 24-48 hours before operations commence, to allow for issue of AUSCOAST warning, at survey commencement and at completion.	**MC** Records verify AMSA JRCC notifications have been made.
	PS 4.2 Streamers are marked with tail buoys.	**MC** Records confirm tail buoys are fitted to each streamer.
	PS (refer to PS 2.3) Notification has been provided to fisheries stakeholders four weeks prior to commencement of the survey, indicating location and expected timing. Notification has also been provided to fisheries stakeholders within two weeks of cessation of the survey.	**MC** Consultation records confirm that fisheries stakeholders were notified four weeks prior to survey commencement and within two weeks of cessation of activities.
	PS 4.3 A communications protocol is in place between the survey and support vessels and other users (e.g. known commercial fishing	**MC** Records demonstrate that a dedicated chase vessel is employed for the survey

Performance Outcomes	Performance Standards	Measurement Criteria
	vessels within the Operational Area), to actively manage concurrent activities.	
	PS 4.4 At least one chase vessel is employed to assist the seismic vessel to mitigate interference associated with third party vessel operations.	**MC** Records demonstrate that 48-72-hour ‘look-aheads’ have been provided to stakeholders that have requested to receive them.
	PS 1.5 3D Oil have engaged with proponents identified as having potential concurrent seismic activities prior to commencing the Sauropod survey and develop a concurrent operations plan for any concurrent surveys identified within 50 km of the Acquisition Area.	**MC** Records verify that 3D Oil has engaged with proponents prior to acquisition commencement (if relevant), and a concurrent operations plan has been developed.

7.5 Discharge: Treated Sewage, Grey Water and Putrescible Waste

7.5.1 Details of Impacts and Risks

7.5.1.1 Source of Impact/Risk

Discharge of treated sewage, grey water and putrescible wastes to the marine environment from the seismic and support vessels has the potential to cause temporary/localised reduction in water quality, and minor/temporary toxicity on marine biota.

The seismic and support vessels employed for the Sauropod 3D MSS will generate liquid wastes (i.e. treated sewage, grey water and putrescible food waste). These vessels will routinely generate/discharge small volumes (up to 15 m^3 per vessel per day) of domestic waste to the marine environment. Routine discharges generated from the survey have the potential to cause temporary and localised reduction in water quality.

Potential impacts associated with the discharge of deck and bilge water from vessels is addressed in Section 7.6.

7.5.1.2 Receptors

- Water quality; and
- Marine biota.

7.5.1.3 Impact/Risk Evaluation

Routine discharges of domestic wastes have 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).

Impacts resulting from the discharge of domestic 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. 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.

Summary

Taking into account the required controls, the consequence of occasional short term and localised disturbance to water quality and marine biota is Negligible (1). The likelihood of this consequence occurring is Very Unlikely (1) and the risk is considered to be *Low*.

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

7.5.2 Decision Context

The decision context for discharge of sewage, grey water and putrescible wastes from the seismic vessel and support vessels to the marine environment has been assessed as 'Type A', given the impacts/risks are well understood and uncertainty is minimal, with little or no stakeholder interest.

7.5.3 Risk Summary

Risk Ranking	Consequence	Likelihood	Risk Ranking
Inherent Risk	Negligible (1)	Very Unlikely (1)	**Low**
Residual Risk	Negligible (1)	Very Unlikely (1)	**Low**

7.5.4 Identification of Control Measures and Demonstration of ALARP

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Legislative Requirements			
Seismic vessel and support vessels will be compliant with Marine Order 96 - pollution prevention – sewage (as appropriate to vessel class): ■ A valid International Sewage Pollution Prevention (ISPP) Certificate, as required by vessel class; ■ 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. It is a legislative requirement for vessels to comply with AMSA Marine Orders.	5.1
Seismic vessel and support vessels will be compliant with Marine Orders 95 – pollution prevention – Garbage (as appropriate to vessel class), specifically: ■ Putrescible waste and food scraps are passed through a macerator so that it is capable of passing through a screen with no opening wider than 25 mm, 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 to ensure adequate dispersion of discharges to reduce the potential for impacts. It is a legislative requirement for vessels to comply with AMSA Marine Orders.	5.2
Good Industry Practice			
No additional good industry practice measures have been identified	N/A	N/A	N/A
Alternatives/Substitutes Considered			
Alternative to the discharge of domestic waste 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:	N/A

Control Measure	Control Adopted	Justification	Performance Standard Ref.
		■ Environmental risks associated with offshore discharge are low given the use of IMO-standard sewage systems and macerator, 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 shore 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.	
Additional Controls Considered			
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 overall cost of the survey, impacting on the commerciality. 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.	N/A
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	N/A
ALARP Statement			
The residual risk associated with the discharge of treated sewage, grey water and putrescible wastes has been determined to be *Low*. 3D Oil considers the adopted control measures appropriate to manage the impacts and risks of discharge of sewage, grey water and putrescible wastes. As the impact has been classified as 'Type A' and no reasonable additional or alternative controls were identified that would further reduce the impacts, without jeopardising the objectives of the survey, the impacts are considered to be ALARP.			

7.5.5 Demonstration of Acceptable Levels

Context	Factor	Demonstration
Internal	3D Oil Policy	The risk management strategy for managing discharge of domestic liquid wastes is compliant with 3D Oil's HSE Policy objectives of proactively identifying hazards, eliminating impacts where possible and where this is not possible managing the risk to ALARP.
	Company Standards/Systems	Section 9 details the relevant management system processes adopted to implement and manage impacts/risks to ALARP: ■ Contractor & Supplier Management (Section 9.7); ■ Environmental Performance Monitoring & Reporting (Section 9.13).
External	Values and Sensitivities of the Natural Environment	**EPBC Policy Statement 1.1. – Significant guidelines** The residual risk has been assessed as low, and will not have a significant impact upon protected matters in accordance with EPBC Policy Statement 1.1. – Significant guidelines.
		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 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 MUZ in the North-west Marine Parks Network Management Plans. Vessel discharges will also not occur in AMP Sanctuary Zones.
	Relevant Persons Expectations	No feedback relating specifically to liquid waste has been received during stakeholder consultation.
Legislation & Other	Legal Requirements	The impact/risk will comply with 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.

Context	*Factor*	*Demonstration*
Industry Standards	Industry Standards & Best Practices	Compliance with best practice is demonstrated.
Ecological Sustainability Development (ESD)	ESD Application	There is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecological integrity associated with discharge of treated sewage, grey water and putrescible wastes from the seismic vessel and support vessels.

Acceptability Statement

The impact assessment has determined that, given the adopted controls, discharge of sewage, grey water and putrescible wastes are unlikely to result in potential impact greater than localised and short-term local concern to water quality and marine biota. Further opportunities to reduce the impacts and risks have been investigated above.

The adopted controls described in Section 7.5.4, are considered industry best practice and meet legislative requirements. 3D Oil considers the adopted control measure to be appropriate to manage the activity to an acceptable level.

7.5.6 Environmental Performance Outcomes, Standards and Measurement Criteria

Performance Outcomes	Performance Standards	Measurement Criteria
EPO 5 No impact to water quality greater than negligible (1) from discharge of sewage, grey water and putrescible waste to the marine environment during the survey.	**PS 5.1** Seismic vessel and support vessels are compliant with Marine Order 96 - pollution prevention – sewage (as appropriate to vessel class): ■ A valid International Sewage Pollution Prevention (ISPP) Certificate, as required by vessel class; ■ 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.	**MC** Records demonstrate seismic vessel and support vessels are compliant with Marine Orders 96 - pollution prevention – sewage (as appropriate to vessel class).
	PS 5.2 Seismic vessel and support vessels are compliant with Marine Orders 95 – pollution prevention – Garbage (as appropriate to vessel class), specifically: ■ Putrescible waste and food scraps are passed through a macerator so that it is capable of passing through a screen with no opening wider than 25 mm.	**MC** Records demonstrate Survey and support vessels are compliant with Marine Orders 95 – pollution prevention (as appropriate to vessel class).

7.6 Discharge: Drains, Deck and Bilge Water

7.6.1 Details of Impacts and Risks

7.6.1.1 *Source of Impact/Risk*

Discharge of deck drainage and oily water to the marine environment from the seismic and support vessels, has the potential to cause temporary/localised reduction in water quality, and minor/temporary toxicity on marine biota.

The seismic and support vessels routinely generate/discharge:

- Relatively small volumes of bilge water. Bilge tanks receive fluids from many parts of the vessel. Bilge water can contain water, oil, detergents, solvents, chemicals, particles and other liquids, solids or chemicals. The amount of bilge wastes accumulated on board is dependent on vessel characteristics, such as size, engine room design, and preventative maintenance schedule.
- Variable volumes of waste from decks directly overboard or via deck drainage systems. Water sources could include rainfall events and/or from deck activities such as cleaning/wash-down of equipment/decks. The volume of drain discharge during the survey is dependent on the amount of rainfall received and the frequency of the deck washing activities. Discharge from open drain areas will be conducted directly overboard.

The discharge of deck drainage and bilge from the seismic and support vessels 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.

Potential impacts associated with the accidental discharge of solid wastes is addressed in Section 8.7.

7.6.1.2 *Receptors*

- Water quality; and
- Marine biota.

7.6.1.3 *Impact/Risk Evaluation*

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 (through an increase in nutrient levels or contaminants such as hydrocarbons), which has the potential to have minor and temporary toxicity impacts on marine biota.

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 either treatment through an oil-in-water separator prior to discharge or disposed of onshore. All vessels > 400 T 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. The bilge stream is treated to reduce hydrocarbon concentrations below 15 ppm prior to discharge overboard. Discharges would rapidly disperse in close proximity to the release location, given the surface currents and the assimilative capacity of the open ocean environment. Given the minor quantities of contaminants expected from the open drains, the expected rapid dispersal of both open drain and treated bilge discharges, and the management measures to be implemented for the bilge waste stream, toxicity impacts to marine biota are not expected.

Summary

Taking into account the required controls, the consequence of occasional short term and localised disturbance to water quality and marine biota is Negligible (1). The likelihood of this consequence occurring is Very Unlikely (1) and the risk is considered to be *Low*.

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

7.6.2 Impact/Risk Evaluation

The decision context for the discharge of deck drainage and bilge water has been assessed as 'Type A', given the impacts/risks are well understood and uncertainty is minimal, with little or no stakeholder interest.

7.6.3 Risk Summary

Risk Ranking	Consequence	Likelihood	Risk Ranking
Inherent Risk	Minor (2)	Very Unlikely (1)	**Low**
Residual Risk	Minor (2)	Very Unlikely (1)	**Low**

7.6.4 Identification of Control Measures and Demonstration of ALARP

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Legislative Requirements			
In accordance with MARPOL Annex 1 and Marine Order 91, vessels >400 gross tonnes 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. 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 on shore disposal.	Yes	Vessels employed for the Sauropod 3D MSS >400 t will hold a current IOPP certificate and have an oil discharge monitoring and control system in accordance with the requirements of MARPOL Annex I and AMSA Marine Order 91. Bilge water discharges will be undertaken in accordance with the requirements of MARPOL Annex I and AMSA Marine Order 91. It is a legislative requirement for vessels to comply with MARPOL and AMSA Marine Orders.	6.1
Good Industry Practice			
No additional good industry practice measures have been identified.	N/A	N/A	N/A
Alternatives/Substitutes Considered			
Seismic and support vessels discharge treated bilge or all contaminated bilge to onshore facilities for treatment and disposal.	No	For the seismic vessel there is substantial additional cost due to onshore treatment and disposal, acquisition downtime, increase in survey duration, increased fuel consumption given the additional transits required by support vessel. Risk of spills and leaks during transfer operations and additional safety risks to personnel during vessel transfer activities. No net benefit observed if treated bilge can be discharged in accordance with MARPOL requirements.	N/A

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Additional Controls Considered			
Oil discharge monitoring and control systems on board the survey 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 to the standard it should be to meet the requirements of MARPOL and associated Marine Orders. The environmental benefit outweighs the additional cost.	6.2
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	N/A
ALARP Statement			
The residual risk associated with the discharge of deck drainage and bilge water has been determined to be *Low*. 3D Oil considers the adopted control measures appropriate to manage the impacts and risks of discharge of deck drainage and bilge water. As the impact/risk has been classified as 'Type A' and 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.			

7.6.5 Demonstration of Acceptable Levels

Context	Factor	Demonstration
Internal	3D Oil Policy	The risk management strategy for managing discharge of deck drainage and bilge water, is compliant with 3D Oil's HSE Policy objectives of proactively identifying hazards, eliminating impacts where possible and where this is not possible, managing the risk to ALARP.
	Company Standards/Systems	Section 9 details the relevant management system processes adopted to implement and manage impacts/risks to ALARP: ■ Contractor & Supplier Management (Section 9.7); ■ Environmental Performance Monitoring & Reporting (Section 9.13).
External	Values and Sensitivities of the Natural Environment	**EPBC Policy Statement 1.1. – Significant guidelines** The residual risk has been assessed as low, and will not have a significant impact upon protected matters in accordance with EPBC Policy Statement 1.1. – Significant guidelines.
		Conservation Advice, Recovery Plans, and Other Guidelines: No species Recovery Plans or Conservation Advice set requirements relating to the management of deck drainage and bilge water discharges.
		AMP Values, Management Prescriptions and IUCN Reserve Management Principles The Operational Area is not located within any AMPs. All vessel discharges will comply with the management prescriptions for AMPs. Vessel discharges will also not occur in AMP Sanctuary Zones.
	Relevant Persons Expectations	No feedback relating specifically to deck drainage and bilge water discharges has been received during stakeholder consultation. This issue is considered to be addressed and will be managed to acceptable levels.
Legislation & Other	Legal 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.

Context	Factor	Demonstration
Industry Standards	Industry Standards & Best Practices	Compliance with best practice guidance is demonstrated.
Ecological Sustainability Development (ESD)	ESD Application	There is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecological integrity associated with discharge of discharge of deck drainage and bilge water from the seismic vessel and support vessels.

Acceptability Statement

The impact assessment has determined that, given the adopted controls, discharge of deck drainage and bilge water are unlikely to result in potential impact greater than localised and short-term local concern to water quality and marine biota. Further opportunities to reduce the impacts and risks have been investigated above.

The adopted controls described in Section 7.6.4, are considered industry best practice and meet legislative requirements. 3D Oil considers the adopted control measure to be appropriate to manage the activity to an acceptable level.

7.6.6 Environmental Performance Outcomes, Standards and Measurement Criteria

Performance Outcomes	Performance Standards	Measurement Criteria
EPO 6 No impact to water quality greater than negligible (1) from discharge of bilge and deck drainage to the marine environment during the survey.	**PS 6.1** Seismic and support vessels are compliant with MARPOL Annex I and AMSA Marine Order 91: ■ A valid IOPP Certificate, as required by vessel class ■ Mandatory measures for the processing of oily water prior to discharge ■ Machinery space bilge/oily water has International Maritime Organisation (IMO) approved oil filtering equipment (oil/water separator) with an on-line monitoring device to measure Oil in Water (OIW) content to be less than 15 ppm prior to discharge ■ IMO approved oil filtering equipment also has an alarm and an automatic stopping device or be capably of recirculating in the event that OIW concentration exceeds 15 ppm ■ In the event that machinery space bilge and deck drainage discharges cannot meet the oil content standard of <15 ppm without dilution or be treated by an IMO approved oil/water separator, they are contained on-board and disposed of onshore ■ 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.	**MC** Records demonstrate compliance with the requirements of MARPOL Annex I and AMSA Marine Order 91.
	PS 6.2 Oil discharge monitoring and control systems on board the survey vessels are maintained and calibrated to ensure monitoring readings are accurate.	**MC** Records demonstrate oil discharge monitoring and control systems have been maintained.

7.7 Artificial Light Emissions: Vessels

7.7.1 Details of Impacts and Risks

7.7.1.1 *Source of Impact/Risk*

Navigational and safety lighting on the seismic and support vessels emit light emissions, which may disrupt normal marine fauna behaviours.

The seismic and support vessels present in the Operational Area will display artificial lighting to meet navigational and safety requirements under the Prevention of Collision Convention (Marine Order 30). 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.

7.7.1.2 *Receptors*

Marine fauna sensitive to artificial lighting (i.e. turtles, fishes and seabirds).

7.7.1.3 *Impact/Risk Evaluation*

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.

Due to the size of the seismic 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.

Turtles

Artificial light has the potential to disrupt critical behaviours in turtles, particularly in relation to nesting at the shoreline. Light has been shown to affect how turtles choose nesting sites, how they return to the sea after nesting and how hatchlings find the sea following emergence from nests (Witherington and Martin 2003). Artificial lighting may affect the location that turtles emerge to the beach, the success of nest construction, whether nesting is abandoned, and even the seaward return of adults (Salmon et al. 1995). However, the Operational Area is approximately 115 km away from the closest known turtle nesting beach (Eighty Mile Beach), and impacts to nesting turtles are therefore not anticipated (Section 4.3.8.1).

Adult turtles that may be present within the Operational Area may be attracted to the survey and support 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);
- the limited distance of visible light from the seismic vessel; and
- the Operational Area being located outside of any turtle internesting or foraging BIAs.

In addition, during acquisition, sound emissions from the survey and support vessels, and from the seismic source, are expected to act as a localised and temporary deterrent to approaching adult turtles (refer to Section 7.1).

Fishes

Light emissions from the vessels in the Operational Area may result in localised aggregation of fishes 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). These aggregations of fishes are considered localised and temporary and any long-term changes to fish species composition or abundance is considered highly unlikely.

Light emission impact to fishes 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 survey and support vessels and light use being limited to night-time operations. Sound emissions from the survey and support vessels, and from the seismic source, are also expected to act as a localised and temporary deterrent to fishes (refer to Section 7.1).

Seabirds

Studies conducted in the North Sea indicate that migratory birds may be attracted to offshore lights when travelling within a radius of 3 to 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 through and those foraging within the lesser frigatebird foraging BIA and the white-tailed tropicbird breeding/foraging BIAs) are expected to be localised and temporary based on the transient nature of the survey and limited distance of visible light from the survey and support vessels. 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 migration or behavioural patterns.

Summary

Given the transient nature of the survey, the limited number of vessels operating in the Operational Area, together with the short duration of the survey (60 days) and the predominantly open oceanic and offshore location of the Operational Area, 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 Negligible (1). The likelihood of this consequence occurring is Very Unlikely (1) 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.

7.7.2 Decision Context

The decision context for artificial light emissions has been assessed as ‘Type A’, given the impacts/risks are well understood and uncertainty is minimal, with little or no stakeholder interest.

7.7.3 Risk Summary

Risk Ranking	Consequence	Likelihood	Risk Ranking
Inherent Risk	Negligible (1)	Very Unlikely (1)	**Low**
Residual Risk	Negligible (1)	Very Unlikely (1)	**Low**

7.7.4 Identification of Control Measures and Demonstration of ALARP

Control Measure	Control Adopted	Justification	Performance Standard Ref.
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 (SOLAS) as implemented in Commonwealth Waters through the *Navigation Act 2012* and associated Marine Orders 21, 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	Legislative requirement for vessels operating in Commonwealth waters. All vessels associated with the Sauropod 3D MSS are required to comply with the *Navigation Act 2012*.	4.1
Good Industry Practice			
No additional good industry practice measures have been identified.	N/A	N/A	N/A
Alternatives/Substitutes Considered			
No practicable alternative or substitutes to the above controls have been identified	N/A	N/A	N/A
Additional Controls Considered			
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.	N/A

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Survey crews shall be instructed to minimise unnecessary external lighting where practicable during the activity.	Yes	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. The environmental benefit outweighs the additional cost.	7.1
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	N/A
ALARP Statement			
The residual risk associated with the artificial light emissions has been determined to be *Low*. 3D Oil considers the adopted control measures appropriate to manage the impacts and risks of artificial light emissions. As the impact/risk has been classified as 'Type A' and 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.			

7.7.5 Demonstration of Acceptable Levels

Context	Factor	Demonstration
Internal	3D Oil Policy	The risk management strategy for managing artificial light emissions, is compliant with 3D Oil's HSE Policy objectives of proactively identifying hazards, eliminating impacts where possible and where this is not possible managing the risk to ALARP.
	Company Standards/Systems	Section 9 details the relevant management system processes adopted to implement and manage impacts/risks to ALARP: ■ Contractor & Supplier Management (Section 9.7); ■ Environmental Performance Monitoring & Reporting (Section 9.13).
External	Values and Sensitivities of the Natural Environment	**EPBC Policy Statement 1.1. – Significant guidelines** The residual risk has been assessed as low, and will not have a significant impact upon protected matters in accordance with EPBC Policy Statement 1.1. – Significant guidelines.
		Conservation Advice, Recovery Plans, and Other Guidelines: 3D Oil 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 Principles 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.
	Relevant Persons Expectations	No specific concerns have been raised by stakeholders relating to artificial light emissions.

Context	Factor	Demonstration
Legislation & Other	Legal Requirements	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.
Industry Standards	Industry Standards & Best Practices	No industry standards and best practice have been identified that relate to artificial light emissions.
Ecological Sustainability Development (ESD)	ESD Application	There is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecological integrity associated with artificial light emissions during the Sauropod 3D MSS.

Acceptability Statement

The impact assessment has determined that, given the adopted controls, artificial light emissions are unlikely to result in potential impact greater than localised and short-term local concern to marine fauna. Further opportunities to reduce the impacts and risks have been investigated above.

The adopted controls described in Section 7.7.4, are considered industry best practice and meet legislative requirements. 3D Oil considers the adopted control measure to be appropriate to manage the activity to an acceptable level.

7.7.6 Environmental Performance Outcomes, Standards and Measurement Criteria

Performance Outcomes	Performance Standards	Measurement Criteria
EPO 7 Lighting reduced to levels required for navigational and safety purposes, so as to not disrupt behaviour patterns of marine fauna	**PS (refer to PS 4.1)** Vessels will comply with *Navigation Act 2012* and associated Marine Orders 21, 30, 58 - safety and emergency arrangements, prevention of collisions, safe management of vessels, including: ■ Appropriate lighting, navigation and communication to inform other users; and ■ Use of radar and 24/7 watch.	**MC** 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.
	PS 7.1 Survey crews are instructed to minimise unnecessary external lighting where practicable during the activity (note that lighting for the purpose of safety or navigation purposes is necessary).	**MC** Survey crew induction materials include a summary of the requirements to minimise artificial lighting. Survey induction attended by all crew as demonstrated by induction records.

7.8 Atmospheric Emissions: Vessels and Mechanical Equipment

7.8.1 Details of Impacts and Risks

7.8.1.1 Source of Impact/Risk

Atmospheric emissions from the seismic and support vessels during the survey may result in a temporary and localised reduction in air quality.

The seismic survey vessel and support vessels present in the Operational Area will generate atmospheric emissions from power generation equipment, engine exhaust and waste incinerators. Atmospheric emissions generated from internal combustion engines of seismic vessel and support vessels and machinery used during the survey will include SO2, NOX, ozone depleting substances, CO2, particulates and Volatile Organic Compounds (VOCs).

7.8.1.2 Receptors

- Air quality in the immediate vicinity of the vessel exhaust.
- Contribution of greenhouse gases (GHG) to the atmosphere.

7.8.1.3 Impact/Risk Evaluation

The seismic survey vessel and support 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 GHG 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 (60 days). Given the location of the Operational Area offshore is approximately 120 km from the mainland coastline, any emissions are expected to disperse rapidly in the open oceanic conditions and 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 and decreasing 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.

Summary

The consequence of occasional short term and localised disturbance to air quality is Negligible (1). The likelihood of this consequence occurring is Very Unlikely (1) and the risk is considered to be Low.

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

7.8.2 Decision Context

The decision context for atmospheric emissions has been assessed as ‘Type A’, given the impacts/risks are well understood and uncertainty is minimal, with little or no stakeholder interest.

7.8.3 Risk Summary

Risk Ranking	Consequence	Likelihood	Risk Ranking
Inherent Risk	Negligible (1)	Very Unlikely (1)	**Low**
Residual Risk	Negligible (1)	Very Unlikely (1)	**Low**

7.8.4 Identification of Control Measures and Demonstration of ALARP

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Legislative Requirements			
In accordance with MARPOL 73/78 Annex VI (Prevention of Air Pollution) and Marine Order 97, vessels to have a valid IAPP Certificate (International air pollution prevention certificate) confirming: ■ Incinerators are certified to meet prescribed emissions standards ■ Diesel engines >130 kW are 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.	8.1
Vessels will use MGO or MDO grade fuel during the survey, which will have low sulphur content.	Yes	Vessels will use low sulphur Marine Gas Oil (MGO) or Marine Diesel Oil (MDO) 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.	8.2
Good Industry Practice			
Vessel engines 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.	3.3
Vessel incinerators maintained according to manufacturer's specification.	Yes	Vessel incinerators 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.	8.3

Control Measure	Control Adopted	Justification	Performance Standard Ref.
		Good industry practice, environmental benefit outweighs additional cost.	
Alternatives/Substitutes Considered			
No practical alternative or substitute to the above controls have been identified.	N/A	N/A	N/A
Additional Controls Considered			
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.	N/A
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.	N/A
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	N/A
ALARP Statement			
The residual risk associated with atmospheric emissions has been determined to be *Low*. 3D Oil considers the adopted control measures appropriate to manage the impacts and risks of atmospheric emissions. As the impact/risk has been classified as 'Type A' and 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.			

7.8.5 Demonstration of Acceptable Levels

Context	Factor	Demonstration
Internal	3D Oil Policy	The risk management strategy for atmospheric emissions, is compliant with 3D Oil's HSE Policy objectives of proactively identifying hazards, eliminating impacts where possible and where this is not possible managing the risk to ALARP.
	Company Standards/Systems	Section 9 details the relevant management system processes adopted to implement and manage impacts/risks to ALARP: ▪ Contractor & Supplier Management (Section 9.7); ▪ Environmental Performance Monitoring & Reporting (Section 9.13).
External	Values and Sensitivities of the Natural Environment	**EPBC Policy Statement 1.1. – Significant guidelines** The residual risk has been assessed as low, and will not have a significant impact upon protected matters in accordance with EPBC Policy Statement 1.1. – Significant guidelines.
		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 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.
	Relevant Persons Expectations	No specific concerns have been raised by stakeholders relating to atmospheric emissions.
Legislation & Other	Legal 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.

Context	Factor	Demonstration
Industry Standards	Industry Standards & Best Practices	No industry standards and best practice have been identified that relate to atmospheric emissions.
Ecological Sustainability Development (ESD)	ESD Application	There is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecological integrity associated with atmospheric emissions during the Sauropod 3D MSS.

Acceptability Statement

The impact assessment has determined that, given the adopted controls, atmospheric emissions are unlikely to result in potential impact greater than localised and short-term local concern to air quality. Further opportunities to reduce the impacts and risks have been investigated above.

The adopted controls described in Section 7.8.4, are considered industry best practice and meet legislative requirements. 3D Oil considers the adopted control measure to be appropriate to manage the activity to an acceptable level.

7.8.6 Environmental Performance Outcomes, Standards and Measurement Criteria

Performance Outcomes	Performance Standards	Measurement Criteria
EPO 8 Atmospheric emissions to meet or exceed the requirements of MARPOL Annex VI and AMSA Marine Order 97	**PS 8.1** in accordance with MARPOL 73/78 Annex VI (Prevention of Air Pollution) and Marine Order 97, vessels have a valid IAPP Certificate confirming: ▪ Incinerators certified to meet prescribed emissions standards; and ▪ Diesel engines >130 kW certified to meet prescribed emission standards.	**MC** Records of the pre-survey environmental checklist confirm that current IAPP certificate is sighted on board vessel.
	PS 8.2 Vessels use MGO or MDO with a low sulphur content of ≤3.5% by mass (m/m). If the survey is completed after 1 January 2020 sulphur content is not to exceed 0.50% m/m.	**MC** Records / oil log book confirm MGO or MDO grade fuel is used and fuel data sheet confirms sulphur content.
	PS (refer to PS 3.3) Vessel engines are maintained according to manufacturer's specifications.	**MC** Records verify that engines and propulsion system maintenance meet this standard.
	PS 8.3 Incinerators are certified and maintained according to manufacturer's specifications.	**MC** Records confirm that the incinerator's MARPOL 73/78 certification is current and sighted, and maintained as per maintenance records.

8. ENVIRONMENTAL RISK ASSESSMENT – UNPLANNED EVENTS

This section presents the evaluation of environmental impacts and risks completed for unplanned events associated with the Sauropod 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 Collision	8.2	Minor (2)	Very Unlikely (1)	Low
Hydrocarbon Spill – Bunkering	8.3	Negligible (1)	Very Unlikely (1)	Low
Chemical Spill – Single Point Failure	8.4	Negligible (1)	Very Unlikely (1)	Low
Physical Presence: Entanglement / Collision with Marine Fauna	8.5	Significant (3)	Very Unlikely (1)	Low
Physical Presence: Loss of Equipment	8.6	Minor (2)	Very Unlikely (1)	Low
Discharge: Loss of Hazardous or Non-Hazardous Solid Waste	8.7	Minor (2)	Very Unlikely (1)	Low
Introduction of Invasive Marine Species: Ballast Water and Biofouling	8.8	Significant (3)	Very Unlikely (1)	Low

8.1 Hydrocarbon and Chemical Spills

8.1.1 Hydrocarbon and Chemical Properties

The following types of hydrocarbons and chemicals are likely to be present on the seismic vessel and support vessels in varying quantities during the survey:

- Marine diesel (Marine Gas Oil [MGO] or Marine Diesel Oil [MDO]) used to fuel the vessels;
- Hydraulic fluids such as engine and synthetic oils required for equipment and engine use; and
- Chemicals for cleaning and maintenance purposes.

8.1.2 Credible Spill Scenarios

Credible hydrocarbon and chemical spill scenarios were identified during the environmental risk assessment undertaken for this EP, 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 Credible Hydrocarbon And Chemical Spill Scenarios

Scenario	Spilt material and volume	Description
Vessel fuel tank rupture	280 m^3 of marine diesel	A collision between the survey 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 (2013) guidelines), which is 280 m^3 of marine diesel. This scenario was modelled.
Vessel refuelling failure	1.2 m^3 to 25 m^3 of marine diesel	Vessel refuelling failure may result in the release of marine diesel to the marine environment. 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 marine diesel transferred within a 15 minute period (AMSA 2013a), which represent 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.
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.

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 was already captured through the assessment of the selected scenarios for consideration in this EP.

To understand the fate and trajectory of a potential spill, hydrocarbon spill modelling was undertaken on the identified worst case credible scenario. Given the volumes involved, impacts and risks associated with a single point failure or a vessel refuelling spill would be expected to be considerably less than those described for a vessel collision scenario.

8.1.3 Spill Modelling Methodology

3D Oil commissioned RPS to undertake quantitative hydrocarbon spill modelling for the Sauropod 3D MSS, using a three-dimensional hydrocarbon spill trajectory and weathering model, SIMAP (Spill Impact Mapping and Analysis Program) (RPS 2019). 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.

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 summary of all 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 locations	One – northern boundary of Operational Area
Spill volume	280 m^3
Hydrocarbon type	MDO
Release type	Surface
Spill duration	6 hours
Simulation duration	30 days
No. of simulations	100 randomly selected trajectories modelled per season (3) using a range of wind and current conditions. 300 simulations in total
Modelled seasons	Summer (December to February) Transitional (March, October and November) Winter (April to September)

8.1.3.1 *Release Location Selection*

The release location selected for the spill modelling is the closest point on the northern boundary of the Operational Area to the Argo-Rowley Terrace Marine Park, the Rowley Shoals Marine Park (State waters) and the Mermaid Reef Marine Park, which represent the nearest sensitive environmental receptors. The specific location is detailed in Table 8-4.

Table 8-4 Location of the Spill Release Site

Latitude	Longitude	Water Depth (m)
-17°56"17.0'	119°30"14.8'	160

8.1.3.2 *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 100 spill trajectories per season were modelled, resulting in a total of possible 300 spill trajectories.

8.1.3.3 *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 8-5, with further detail provided below.

Table 8-5 Hydrocarbon Exposure Thresholds

Exposure Type	Hydrocarbon Concentration	Potential Level of Exposure
Surface Exposure (g/m^2)	1	Low
	10	Moderate
	25	High
Shoreline Contact (g/m^2)	10	Low
	100	Moderate
	1,000	High
Dissolved Hydrocarbon Concentration (ppb)#	6	Low
	50	Moderate
	400	High
Entrained Concentration (ppb)#	10	Low
	100	Moderate
	1,000	High

#These threshold values refer to a) instantaneous concentrations (i.e. exposure over a 1-hour period) and b) time-averaged exposure over a 48-hour window. Both exposure durations are considered in the presentation of results below.

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.

8.1.3.4 *Hydrocarbon Characteristics*

MDO is a light-persistent fuel oil used in the maritime industry. It has a density of 829.1 kg/m^3 (API of 37.6) and a low pour point (-14°C). The low viscosity (4 cP) indicates that this oil will spread quickly when released and will form a thin to low thickness film on the sea surface, increasing the rate of evaporation. Approximately, 5% (by mass) of the oil is categorised as a group II oil (light-persistent) based on categorisation and classification derived from AMSA (2015) guidelines. The classification is based on the specific gravity of hydrocarbons in combination with relevant boiling point ranges.

Table 8-6 details the physical properties of MDO, while Table 8-7 presents the boiling point ranges of the MDO used in the modelling study.

Table 8-6 Physical Properties of MDO

Characteristic	Value
Density (kg/m^3)	829.1
API	37.6
Dynamic viscosity (cP)	4
Pour point (ºC)	-14
Wax content (%)	1
Hydrocarbon property category	Group II
Hydrocarbon property classification	Light - Persistent

Table 8-7 Boiling Point Ranges of MDO

Characteristic	Not Persistent			Persistent
	Volatile	Semi-volatile	Low volatility	Residual
Boiling point (ºC)	<180	180-265	265-380	>380
Percent	6.0	34.6	54.4	5.0

Figure 8-1 shows weathering graphs for a 280 m^3 release of MDO over 6 hours (tracked for 30 days) during three static wind conditions. The prevailing weather conditions will influence the weathering and fate of the MDO. Under lower wind-speeds (5 knots), the MDO will remain on the surface longer, spread quicker, and in turn increase the evaporative process. Conversely, sustained stronger winds (>15 knots) will generate breaking waves at the surface, causing a higher amount of MDO to be entrained into the water column and reducing the amount available to evaporate.

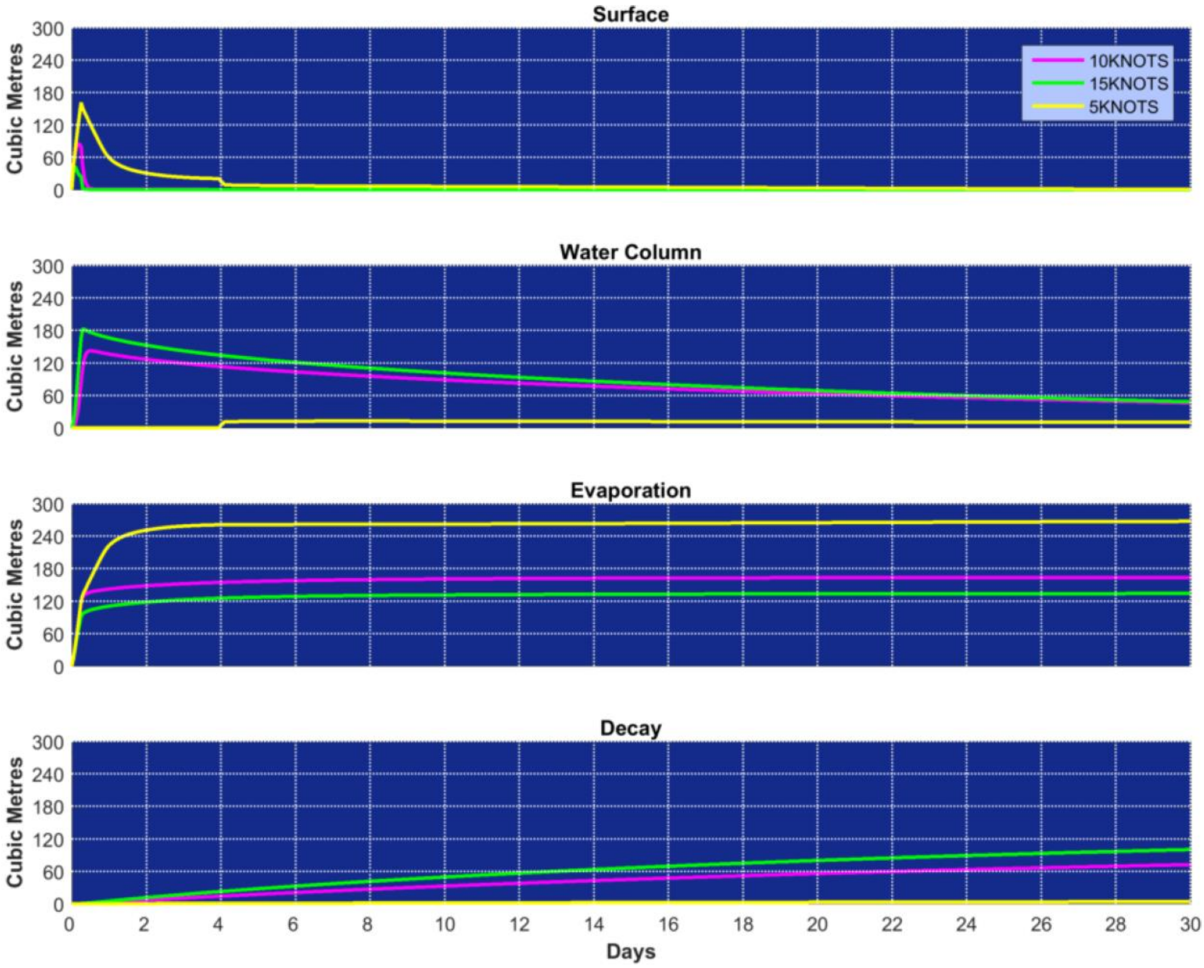


Figure 8-1 Weathering of MDO under three static wind conditions (5, 10 and 15 knots). The results are based on a 280m^3 surface release of MDO over 6 hours, tracked for 30 days

8.2 Hydrocarbon Spill – Vessel Collision

8.2.1 Details of Impacts and Risks

8.2.1.1 *Source of Impact/Risk*

Accidental hydrocarbon release to the marine environment due to a vessel collision, with the potential hazards of 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 two support vessels utilised throughout the Sauropod 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 a vessel occurred, the worst case credible scenario would be the loss of the largest single fuel tank volume (consistent with AMSA (2013) guidelines), which is 280 m^3 of marine diesel.

8.2.1.2 *Receptors*

- Marine fauna;
  - cetaceans, marine reptiles, seabirds, fishes/elasmobranchs, planktonic communities;
- Water quality;
- Marine protected areas; and
- Commercial fisheries.

8.2.1.3 *Impact/Risk Evaluation*

Spill Modelling Results

<u>Surface Hydrocarbons</u>

Modelling indicated that, in the event of a 280 m^3 spill of MDO, sea surface hydrocarbons at low (1 g/m^2), moderate (10 g/m^2) and high (25 g/m^2) exposure levels may occur up to a maximum of approximately 66 km, 14 km and 7 km from the spill release locations, respectively (Table 8-8 and Figure 8-2). This result does not indicate a continuous slick, but that patches of the surface slick may exceed thresholds out to these distances from the spill release location. The evaporative nature of MDO and environmental conditions in the area result in short-lived surface hydrocarbon exposures, with surface exposures reduced to less than 10 g/m^2 after approximately 24-48 hours (RPS 2019). Generally, sea surface hydrocarbon volumes were negligible after approximately 10-15 days and did not persist beyond 17 days.

The area of potential instantaneous exposure to surface hydrocarbons for the low, moderate and high thresholds during the transitional season is presented in Figure 8-2. It is important to note that the area presented is based on 100 hypothetical spill trajectories and does not represent the predicted outcome of a single spill event. This area falls within the predicted annualised EMBA for entrained hydrocarbons, and hence no separate EMBA for surface hydrocarbons has been defined.

No sensitive receptors were predicted to be exposed to surface oil at the moderate and high thresholds. The Argo-Rowley Terrace Marine Park is the only sensitive receptor showing potential exposure to surface oil at the low threshold, with a low likelihood of 1-2% (during the summer and winter seasons only) (Table 8-8).

Table 8-8 Summary of Spill Modelling Results For Surface Hydrocarbons, Including Sensitive Receptors With Predicted Exposure Above Threshold Concentrations

Season	Distance and direction	Areas of potential sea surface exposure		
		>1 g/m^2	>10 g/m^2	>25 g/m^2
Summer	Maximum distance from release site (km)	31	11	4
	Direction	N	SSE	NW
	Probability of oil exposure to Argo-Rowley Terrace Marine Park (%)	2	-	-
	Minimum time before oil exposure to Argo-Rowley Terrace AMP (hrs)	1	-	-
Transitional	Maximum distance from release site (km)	66	14	7
	Direction	WSW	SSE	SE
	Probability of oil exposure to Argo-Rowley Terrace AMP (%)	-	-	-
	Minimum time before oil exposure to Argo-Rowley Terrace AMP (hrs)	-	-	-
Winter	Maximum distance from release site (km)	31	12	6
	Direction	NNE	WNW	NW
	Probability of oil exposure to Argo-Rowley Terrace AMP (%)	1	-	-
	Minimum time before oil exposure to Argo-Rowley Terrace AMP (hrs)	1	-	-

A dash indicates that the threshold was not reached. The results were calculated from 300 possible spill trajectories and do not represent a single spill event.

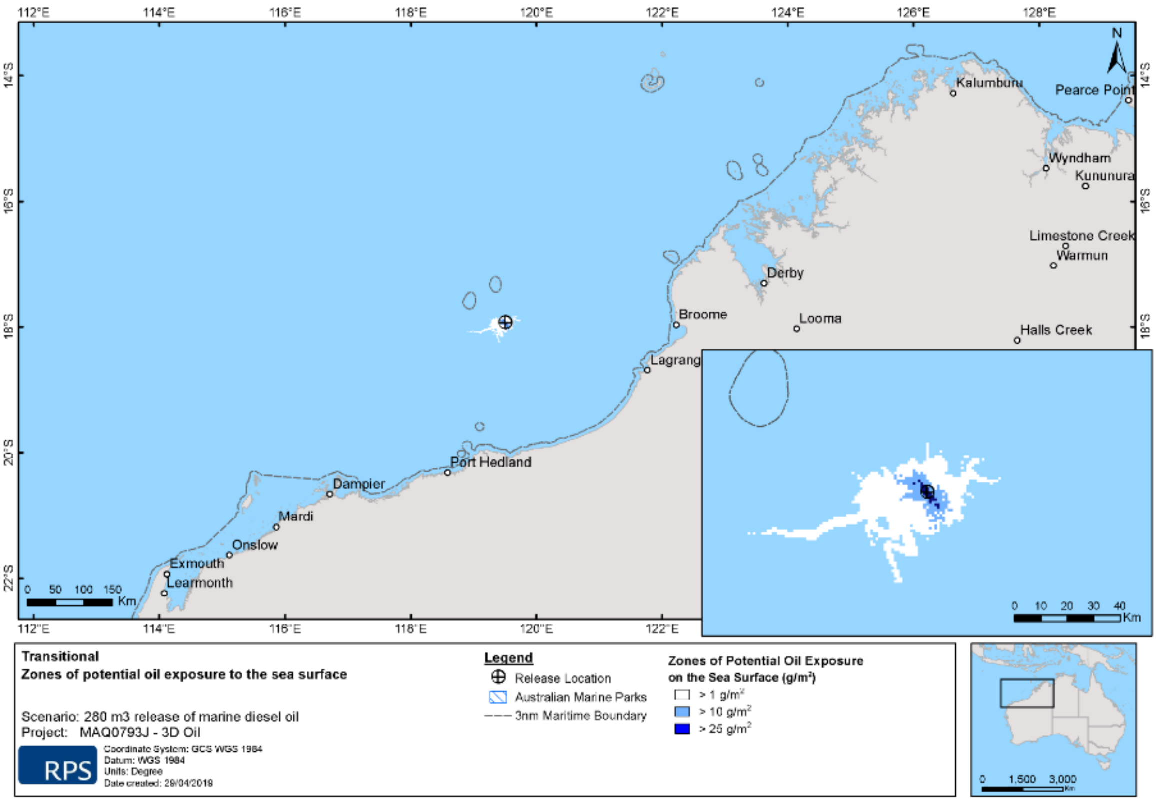


Figure 8-2 Zones of Potential Oil Exposure On The Sea Surface, In The Event of an 280 m^3 MDO Spill Within The Operational Area During The Transitional Season

Shoreline Accumulation

No shoreline contact above the exposure thresholds was predicted by the modelling at any location. It is acknowledged that modelling was only conducted at a single location along the northern boundary of the Operational Area. Given the extent of the predicted EMBA (refer Figure 8-4) no shoreline contact at any mainland location is predicted to occur for a 280 m^3 marine diesel spill anywhere within the Operational Area, including at the southeast corner, which is closest to the coast.

Entrained Hydrocarbons

Modelling of entrained hydrocarbons considered exposure to receptors at 0-10 m water depth at or above the exposure thresholds discussed in Section 8.1.3.3. The maximum entrained hydrocarbon exposure was considered against the thresholds for both instantaneous exposure concentrations and time-averaged exposure concentrations over a 48-hour period.

The maximum time-averaged exposure to entrained hydrocarbons over 48 hours ranged from 402 ppb to 499 ppb for the transitional and summer seasons respectively. The maximum instantaneous exposure to entrained hydrocarbons ranged from 3,251 ppb to 6,287 ppb for the transitional and summer seasons respectively (Table 8-9)

The zone of potential instantaneous entrained hydrocarbon exposure at 0–10 m below the sea surface in the event of a 280 m^3 of surface release of MDO is presented in Figure 8-3 for the summer season. The predicted annualised (i.e. all seasons) EMBA for entrained hydrocarbons above the moderate threshold (100 ppb), based on instantaneous exposures, is presented in Figure 8-4. It is important to note that the area presented is based on 300 hypothetical spill trajectories (100 per season) and does not represent the predicted outcome of a single spill event. The EMBA for the north-west corner of the Operational Area was also extrapolated to the three other corners to encompass all environmental values and sensitivities that could potentially be affected in the event of a spill Figure 8-4.

No sensitive receptors were predicted to be impacted by entrained hydrocarbons above the high threshold (1,000 ppb). Sensitive receptors potentially impacted above the low and moderate thresholds (10 ppb and 100 ppb respectively) are summarised in Table 8-9.

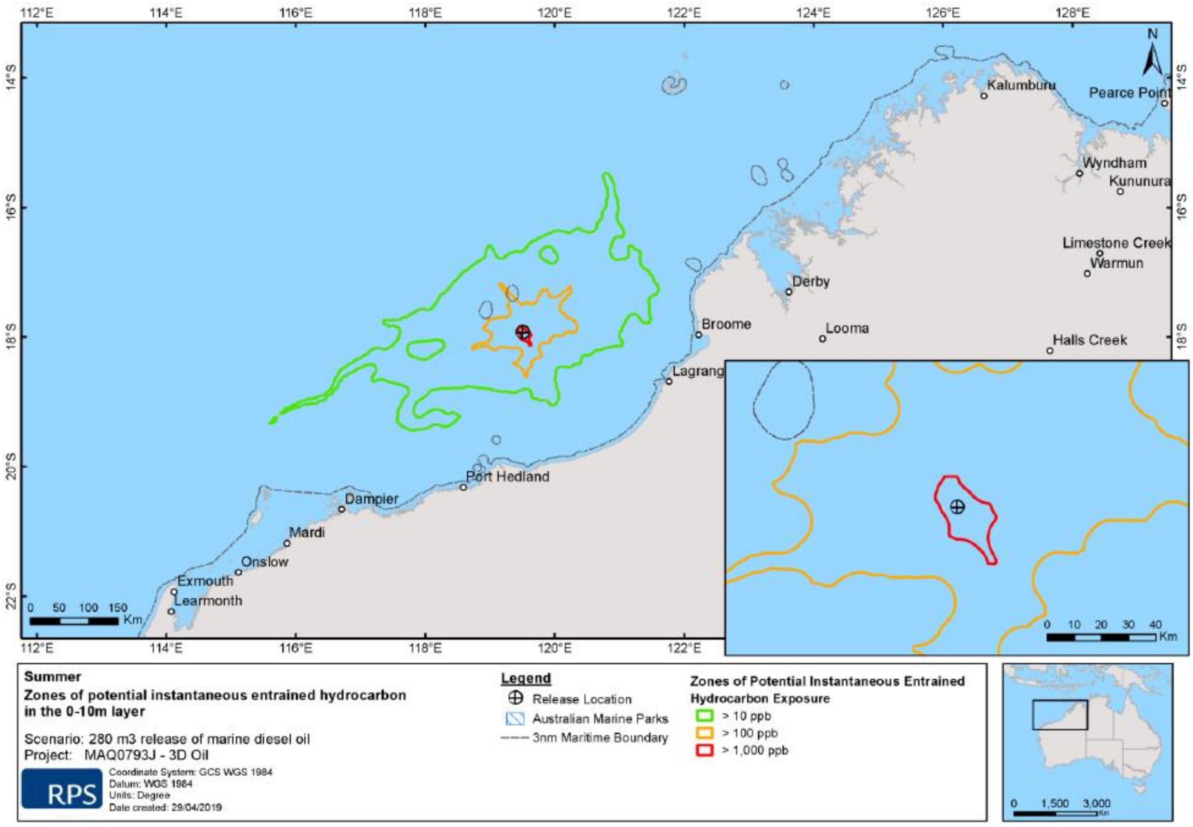


Figure 8-3 Zones of Potential Instantaneous Entrained Oil Exposure at 1-10 m Below The Sea Surface, In The Event of an 280m^3 MDO Spill Within The Operational Area During The Summer Season

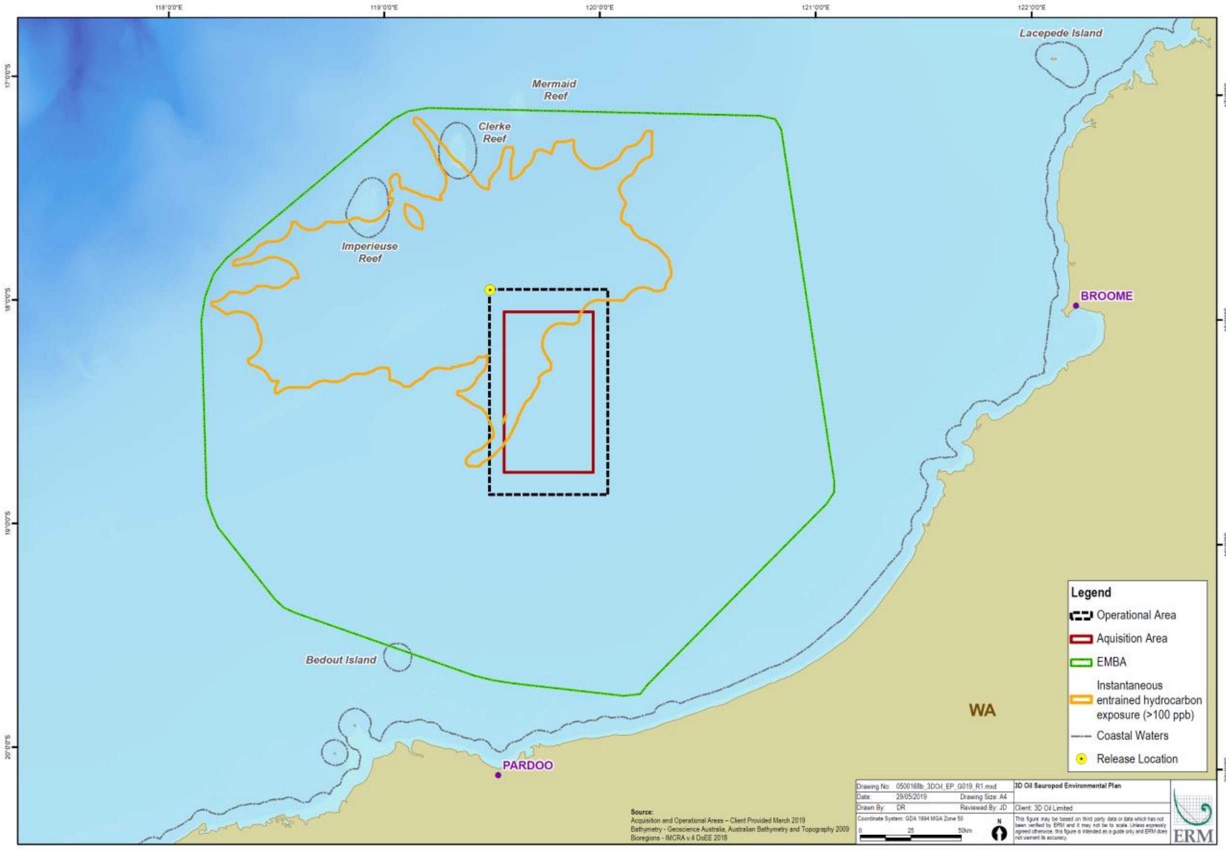


Figure 8-4 Predicted Annualised EMBA for Entrained Hydrocarbons Above 100 ppb Resulting From a 280 m^3 MDO Spill Within The Operational Area

Table 8-9 Summary of Spill Modelling Results For Entrained Hydrocarbons, Including Sensitive Receptors With Predicted Exposure Above Threshold Concentrations

Season	Receptor	Time-averaged (48-hr) entrained hydrocarbon exposure			Instantaneous entrained hydrocarbon exposure		
		Maximum concentration (ppb)	Probability of exposure (%) at >10 ppb	Probability of exposure (%) at >100 ppb	Maximum concentration (ppb)	Probability of exposure (%) at >10 ppb	Probability of exposure (%) at >100 ppb
Summer	Argo-Rowley Terrace AMP	114	11	2	607	23	8
	Mermaid Reef AMP	21	2	-	66	3	-
	Rowley Shoals MP	49	5	-	185	8	2
	Imperieuse Reef	33	4	-	59	7	-
	Clerke Reef	40	2	-	158	7	1
	Mermaid Reef	20	1	-	55	2	-
	Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF	49	5	-	213	12	2
	North West Shelf	402	66	14	6,287	89	74
Transitional	Argo-Rowley Terrace AMP	89	14	-	401	21	6
	Mermaid Reef AMP	26	5	-	76	10	-
	Rowley Shoals MP	30	7	-	94	14	-
	Imperieuse Reef	26	3	-	89	8	-
	Clerke Reef	26	6	-	84	14	-
	Mermaid Reef	8	-	-	28	3	-

Season	Receptor	Time-averaged (48-hr) entrained hydrocarbon exposure			Instantaneous entrained hydrocarbon exposure		
		Maximum concentration (ppb)	Probability of exposure (%) at >10 ppb	Probability of exposure (%) at >100 ppb	Maximum concentration (ppb)	Probability of exposure (%) at >10 ppb	Probability of exposure (%) at >100 ppb
	Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF	73	9	-	177	16	2
	North West Shelf	499	49	16	3,251	79	54
Winter	Argo-Rowley Terrace AMP	95	13	-	338	17	6
	Mermaid Reef AMP	18	1	-	100	6	1
	Rowley Shoals MP	57	8	-	207	17	2
	Imperieuse Reef	42	4	-	105	11	1
	Clerke Reef	7	-	-	27	2	-
	Mermaid Reef	8	-	-	57	3	-
	Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF	57	13	-	261	18	6
	North West Shelf	398	64	21	4,355	84	70

A dash indicates that the threshold was not reached. The results were calculated from 300 spill trajectories and do not represent a single spill event.

Dissolved Hydrocarbons

Modelling of dissolved hydrocarbons considered exposure to receptors at 0-10 m water depth at or above the exposure thresholds discussed in Section 8.1.3.3. The maximum dissolved hydrocarbon exposure was considered against the thresholds for both instantaneous exposure concentrations and time-averaged exposure concentrations over a 48-hour period.

The maximum time-averaged exposure to dissolved hydrocarbons over 48 hours remained below the low threshold value of 6 ppb for all modelled seasons. The maximum instantaneous exposure to dissolved hydrocarbons ranged from 6 ppb to 73 ppb for the transitional and summer seasons respectively (Table 8-10).

The area of potential instantaneous exposure to dissolved hydrocarbons for the low and moderate thresholds during the winter season is presented in Figure 8-5 (the high threshold was not exceeded). It is important to note that the area presented is based on 100 hypothetical spill trajectories and does not represent the predicted outcome of a single spill event. This area falls within the predicted annualised EMBA for entrained hydrocarbons (Figure 8-4), and hence no separate EMBA for dissolved hydrocarbons has been defined.

No sensitive receptors were predicted to be exposed above the low threshold of 6 ppb to dissolved hydrocarbons over a time-averaged period of 48 hours (Table 8-10).

No sensitive receptors were predicted to be exposed instantaneously to dissolved hydrocarbons at the moderate threshold (50 ppb). The Argo-Rowley Terrace Marine Park, Rowley Shoals Marine Park, Mermaid Reef Marine Park and Commonwealth waters KEF showed potential instantaneous exposure to dissolved hydrocarbons at or above the low threshold (6 ppb), with a low likelihood of 1-2% (during the summer and winter seasons only, refer to Table 8-10).

Table 8-10 Summary of Spill Modelling Results For Dissolved Hydrocarbons, Including Sensitive Receptors With Predicted Exposure Above Threshold Concentrations

Season	Receptor	Time-averaged (48-hr) dissolved hydrocarbon exposure		Instantaneous dissolved hydrocarbon exposure	
		Maximum concentration (ppb)	Probability of exposure (%) at >6 ppb	Maximum concentration (ppb)	Probability of exposure (%) at >6 ppb
	Argo-Rowley Terrace AMP	1	-	8	1
	North West Shelf	4	-	73	21
	Argo-Rowley Terrace AMP	<1	-	6	1
	North West Shelf	3	-	37	16
	Argo-Rowley Terrace AMP	1	-	19	2
	Rowley Shoals	<1	-	13	1
	Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF	<1	-	14	1
	North West Shelf	4	-	48	36

The results were calculated from 300 spill trajectories and do not represent a single spill event.

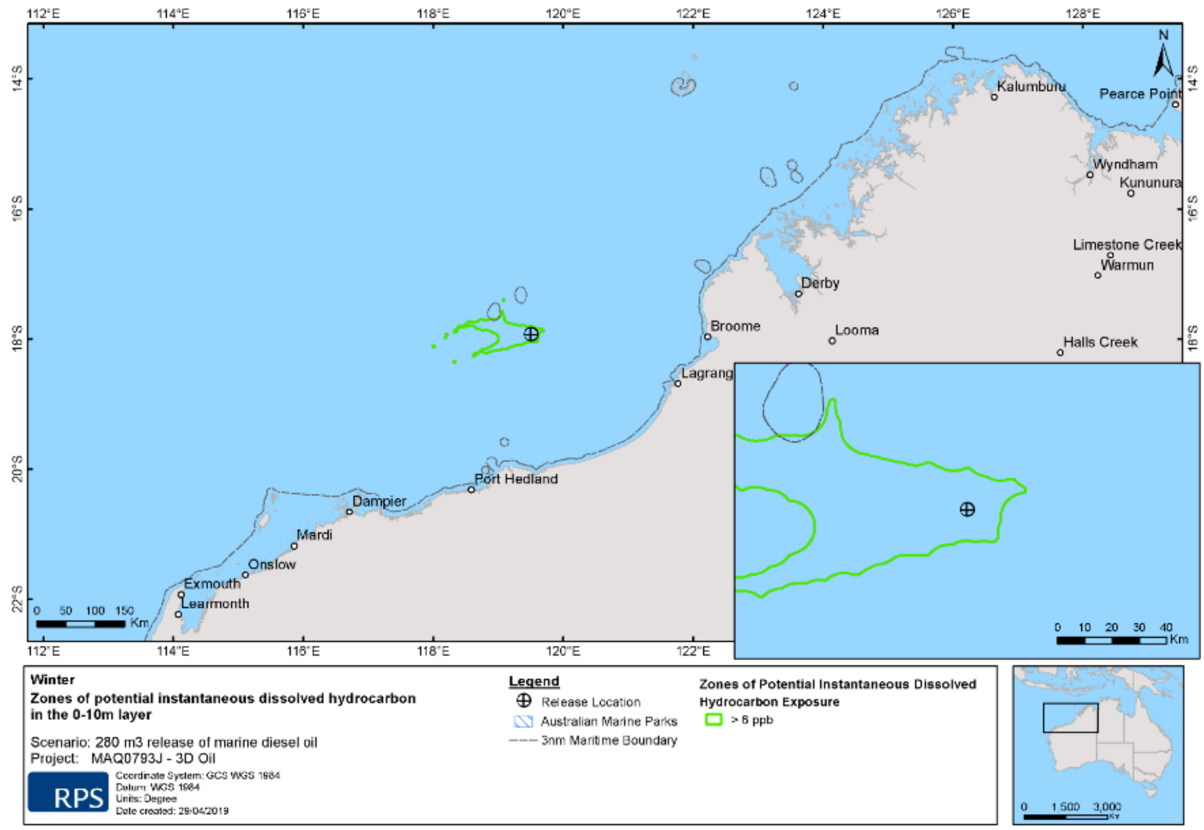


Figure 8-5 Zones Of Potential Instantaneous Dissolved Hydrocarbon Exposure At 0–10 M Below The Sea Surface In The Event Of An 280 M^3 Within The Operational Area During Winter

Summary of Modelling Results

- No shoreline contact above the low (1 g/m^2) surface oil threshold was predicted for the modelled scenario, for any season.
- Modelling results demonstrated that surface oil at low (1 g/m^2), moderate (10 g/m^2) and high (25 g/m^2) exposure levels could potentially travel greater distances during the transitional period, compared to the summer and winter periods. The maximum distance travelled by surface oil during the transitional season for the low, moderate and high threshold was 66 km, 14 km and 7 km, respectively.
- The modelling results demonstrated a low probability (1-2%) of surface oil exposure at the low threshold to the Argo-Rowley Terrace Marine Park and zero probability of surface oil exposure (at any threshold) to the Rowley Shoal Marine Park and the Mermaid Reef Marine Park.
- The maximum time-averaged exposure to entrained hydrocarbons ranged from 4 ppb to 499 ppb for the transitional and winter seasons respectively. The maximum instantaneous exposure to entrained hydrocarbons ranged from 3,251 ppb to 6,287 ppb for the transitional and summer seasons respectively.
- The maximum time-averaged exposure to dissolved hydrocarbon at the depths of 0-10 m remained less than 1 ppb for the winter and transitional seasons while reaching 4 ppb for the summer and winter seasons for various receptors. The maximum instantaneous exposure to dissolved hydrocarbons ranged from 6 ppb to 73 ppb for the transitional and summer seasons, respectively.

- There were no zones of potential time-averaged exposure to dissolved hydrocarbons above the low exposure threshold (6 ppb).

Potential Impacts to Environmental Values

Protected Species

As identified in Section 4.3.5, 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.

Cetaceans

No critical habitats or aggregation areas (feeding, breeding, resting) for cetaceans have been identified within the EMBA for a 280 m^3 diesel spill within the Operational Area and it is therefore considered that any cetacean species that are present will be in low numbers and transient, as they traverse the area. The humpback whale migration BIA is located approximately 15 km south of the Operational Area. The breeding, nursing and calving BIA for humpback whales along the Kimberley coastline is located 255 km east of the Operational Area.

The entrained hydrocarbons EMBA partially overlaps the humpback whale migration BIA (refer Figure 4-9). However, the proposed timing for acquisition of the Sauropod 3D MSS (January to April) means that there will be no overlap with either the northbound or southbound migration of humpback whales through the region (June to October). The pygmy blue whale migration and distribution BIAs pass along the shelf edge at depths between 500 m and 1,000 m. The Operational Area overlaps with the distribution BIA, and the migration BIA is located approximately 72 km from the Operational Area. The entrained hydrocarbons EMBA partially overlaps the pygmy whale migration BIA (refer Figure 4-8). Hence, there is a low probability of isolated individuals transiting through the entrained hydrocarbons EMBA during the beginning of their northbound migration (April to July). The proposed acquisition period avoids the southbound migration of pygmy blue whales in the region (September to November).

As summarised in Table 4-6, there is the possibility that a number of other cetacean species may be present in the Operational Area and surrounding waters during acquisition of the survey (e.g. Bryde's, fin, sei, killer and sperm whales, spotted bottlenose dolphin). 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.

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; IPIECA 1995). 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 come into contact with surface slicks.

Marine Reptiles

At the closest point, the Operational Area is located at least 20 km from the nearest nesting BIA for turtles (flatback turtle nesting BIA adjacent to Eighty Mile Beach), and at least 105 km from the foraging BIA for green, flatback and loggerhead turtles adjacent to the Dampier Peninsula. At the closest point, the Operational Area is located at least 57 km from the 'Habitat Critical' for flatback turtles adjacent to Eighty Mile Beach. To the north of the Operational Area, there are no BIAs or 'Habitat Critical' for turtles surrounding the Rowley Shoals.

There is partial overlap between the entrained hydrocarbons EMBA and the flatback turtle 'Habitat Critical' adjacent to Eighty Mile Beach (Figure 4-12). The entrained hydrocarbon EMBA also partially overlaps the flatback turtle internesting buffer BIA adjacent to Eighty Mile Beach (Figure 4-11).

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 (95 - 172 m), the Operational Area is highly unlikely to represent important habitat for marine turtles. The 280 m^3 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 seasnakes 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, seasnakes 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.

Seabirds

There is overlap between the zone of surface hydrocarbons at low, moderate and high exposure thresholds and the breeding and foraging BIA for the white-tailed tropicbird around the Rowley Shoals. There is no overlap between the zone of surface hydrocarbons (at any threshold) and the breeding BIA for the lesser frigatebird around Bedout Island.

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 seabird 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).

Therefore, a diesel spill may result in impacts on individuals within the white-tailed tropicbird breeding/foraging BIA and potentially disruption to a significant portion of the habitat, however this is not expected to result in a threat to the overall population viability of seabirds, due to the relatively small EMBA and the rapid dispersion of marine diesel.

Fishes and Elasmobranchs

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.

Whale sharks located in open offshore waters are most likely transiting the region. The Operational Area overlaps the whale shark foraging BIA that extends north from North West Cape across the North West Shelf (Figure 4-10), however the survey does not overlap with the foraging season which occurs from August - November for the region (see Table 4-7 for details on seasonality). If individuals are present in the Operational Area, their abundance is not expected to be high. The zone of surface hydrocarbons (all thresholds) and the entrained hydrocarbon EMBA overlap the whale shark foraging BIA (Figure 4-10).

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 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.

Planktonic Communities

Planktonic communities within the entrained hydrocarbons EMBA for a 280 m^3 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 Sauropod 3D MSS has the potential to overlap spawning periods for some fish species.

The entrained hydrocarbons EMBA for all seasons partially overlaps Imperieuse and Clerke reefs, and the proposed acquisition period for the survey (January to April) means that the activity could potentially overlap the main spawning episode for corals in the region (March-April). The reproductive cycles of the broadcast spawning species at the Rowley Shoals have been described, with mass spawning occurring biannually in spring (October) and autumn (March) (Gilmour et al. 2016). The entrained hydrocarbons EMBA for the transitional period (which includes March) does not overlap either Imperieuse or Clerke reefs.

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 duration of fish spawning periods, lack of suitable habitat for fish spawning aggregating near the surface, combined with the quick evaporation and dispersion of marine diesel, impacts to fish eggs and larvae are not expected to be significant.

Any planktonic communities impacted 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.

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.

Marine Protected Areas

Argo-Rowley Terrace Marine Park

There is a small overlap between the zone of surface hydrocarbons at the low exposure threshold (>1 g/m^2) and the Multiple Use Zone (MUZ) of the Argo-Rowley Terrace Marine Park. Additionally, the entrained hydrocarbons EMBA overlaps the MUZ and the Special Purpose Zone (Trawl) of this AMP (Figure 4-13).

The designated natural values of this AMP include a range of species (including species listed as threatened, migratory, marine or cetacean under the EPBC Act), foraging and breeding BIAs for seabirds and a migratory BIA for the pygmy blue whale. Potential impacts to these values from a 280 m^3 marine diesel spill within the Operational Area are assessed in the sub-sections above.

Potential impacts to commercial fisheries occurring within the MUZ of this AMP are assessed below.

Mermaid Reef Marine Park

There is no overlap between the zone of surface hydrocarbons at the low exposure threshold (>1 g/m^2) and the Mermaid Reef Marine Park. There is a very small overlap between the entrained hydrocarbons EMBA and this AMP (winter season only). Maximum instantaneous entrained hydrocarbon concentrations within the Mermaid Reef Marine Park are predicted to range from 30 ppb (summer) to 100 ppb (winter). The area within the marine park predicted to be exposed to entrained hydrocarbons in the 0-10 m upper layer of the water column is restricted to a small patch approximately 2.5 km east of the reef edge. Hence, no seabed habitats or communities of the submerged reef itself are likely to be exposed to entrained hydrocarbons resulting from a marine diesel release within the Operational Area.

Rowley Shoals Marine Park

There is no overlap between the zone of surface hydrocarbons at the low exposure threshold (>1 g/m^2) and the waters or islands within the Rowley Shoals Marine Park (State waters). Hence, there will be no shoreline contact or hydrocarbon accumulation within the marine park. As no surface sheens or slicks are likely to occur within the waters of the Rowley Shoals Marine Park, it is highly unlikely that there will be any impacts to socio-economic values of the marine park (i.e. tourism and recreation activities, including fishing and diving/snorkelling charters).

There is overlap between the entrained hydrocarbons EMBA and the Rowley Shoals Marine Park, including exposure to small areas of both Imperieuse and Clerke reefs. Maximum instantaneous entrained hydrocarbon concentrations at Imperieuse and Clerke reefs are predicted to range from 18 ppb (winter) to 158 ppb (summer). Thus, some benthic habitats and communities in the upper layer of the water column (0-10 m) could be exposed to instantaneous concentrations of entrained hydrocarbons >100 ppb, which could result in some sub-lethal effects (e.g. bioaccumulation of hydrocarbons).

Commercial Fisheries

A 280 m^3 marine diesel spill in the Operational Area is considered unlikely to cause significant direct impacts on the target species fished by the North West Slope Trawl Fishery (NWSTF), the Pilbara Trawl and Trap fisheries (PTMF, PFTIMF), and the Northern Demersal Scalefish Managed Fishery (NDSMF). The target species for these fisheries (demersal finfish and crustaceans) inhabit water depths in the range of >60-200 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) 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.

Summary

Based on the assessment presented above and the implementation of the identified controls (Section 8.2.4), it is expected that the consequence associated with an accidental hydrocarbon release to the marine environment due to a vessel collision will be Minor (2). The likelihood of impacts occurring is considered to be Very Unlikely (1), resulting in a *Low* residual risk to sensitive receptors within and adjacent to the Operational Area.

8.2.2 Decision Context

The decision context for accidental hydrocarbon release to the marine environment due to a vessel collision has been assessed as ‘Type A’, given the impacts/risks are well understood, uncertainty is minimal and little or no stakeholder interest.

8.2.3 Risk Summary

Risk Ranking	Consequence	Likelihood	Risk Ranking
Inherent Risk	Minor (2)	Unlikely (2)	**Low**
Residual Risk	Minor (2)	Very Unlikely (1)	**Low**

8.2.4 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Justification	Performance Standard Ref.
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 (SOLAS) as implemented in Commonwealth Waters through the *Navigation Act 2012* and associated Marine Orders 21, 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 Commonwealth waters and will be implemented by all vessels. Adherence to these requirements will reduce the likelihood of vessel collision between the survey and/or support vessels and third party vessels.	4.1
Issue of marine navigation warnings and Notice to Mariners of survey presence and towed array	Yes	The Australian Hydrographic Service (AHS) will be contacted four weeks prior to the commencement of the survey for the publication of related Notices 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 vessel collision between the survey and/or support vessels and third party vessels.	2.1
Pre-survey notification to AMSA JRCC, issue of AUSCOAST warnings	Yes	The AMSA JRCC will be contacted 24-48 hrs before operations commence for issuing of AUSCOAST warnings. 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 vessel collision between the survey and/or support vessels and third party vessels.	2.2
Good Industry Practice			
Notification will be provided to fisheries stakeholders, prior to commencement of the survey, indicating location and expected	Yes	Notification will be provided to fisheries stakeholders, four weeks prior to commencement of the survey, indicating location and expected timing.	2.3

Control Measure	Control Adopted	Justification	Performance Standard Ref.
timing. Notification will also be provided to fisheries stakeholders upon completion of the survey.		Notification will also be provided to fisheries stakeholders within two weeks of completion of the survey. 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 vessel collision between the survey and/or support vessels and third party vessels.	
A communications protocol will be in place between the survey and support vessels and other users (e.g. known commercial fishing vessels within the Operational Area), to actively manage concurrent activities.	Yes	The survey vessel operator will provide effective 'look-aheads' to commercial fisheries fleet managers and vessel skippers to inform them of the current positions of the survey and support vessels, and of proposed operations for the next 48-72-hour period. Implementation will reduce the likelihood of vessel collision between the survey and/or support vessels and third party vessels.	4.3
At least one additional vessel (support or chase vessel) will accompany the survey vessel when in operation and when safe to do so (e.g. outside of inclement weather periods).	Yes	The support and/or chase vessel will conduct advanced scouting to ensure that other activities in the area are provided with advance notice to move away from the path of the survey vessel. Use of two vessels will mean that one vessel can remain with the survey vessel at all times, allowing the other vessel to return to port when necessary. Implementation will reduce the likelihood of vessel collision between the survey and/or support vessels and third party vessels.	4.4
Alternatives/Substitutes Considered			
No practicable alternative or substitutes to the acquisition or the inherent controls have been identified.	N/A	N/A	N/A
Additional Controls Considered			
No additional controls have been identified.	N/A	N/A	N/A
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)			
No practicable improvements have been identified	N/A	N/A	N/A

Control Measure	Control Adopted	Justification	Performance Standard Ref.
ALARP Statement			
3D Oil considers the adopted control measures appropriate to manage the impacts and risks of accidental hydrocarbon release to the marine environment due to a vessel collision. As the impact/risk has been classified as 'Type A' and 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.			

8.2.5 *Demonstration of Acceptable Levels*

Context	Factor	Demonstration
Internal	3D Oil Policy	The risk management strategy for managing the impacts and risks of accidental hydrocarbon release to the marine environment due to a vessel collision, is compliant with 3D Oil's HSE Policy objectives of proactively identifying hazards, eliminating impacts where possible and where this is not possible managing the risk to ALARP.
	Company Standards/Systems	Section 9 details the relevant management system processes adopted to implement and manage impacts/risks to ALARP: ▪ Contractor & Supplier Management (Section 9.7); and ▪ Notification & Reporting (Section 9.12).
External	Values and Sensitivities of the Natural Environment	**EPBC Policy Statement 1.1. – Significant guidelines** The residual risk has been assessed as low, and will not have a significant impact upon protected matters in accordance with EPBC Policy Statement 1.1. – Significant guidelines.
		Conservation Advice, Recovery Plans, and Other Guidelines No advice or guidelines have been identified that specifically address potential impacts to protected species resulting from accidental hydrocarbon release.
		AMP Values, Management Prescriptions and IUCN Reserve Management Principles No significant impacts are predicted to occur to the natural, cultural and socio-economic values of the Argo-Rowley Terrace Marine Park and the Mermaid Reef Marine Park.
	Relevant Persons Expectations	No specific concerns have been raised by stakeholders relating to the impacts and risks of accidental hydrocarbon release to the marine environment due to a vessel collision.
Legislation & Other	Legislation & Conventions	All requirements under the Navigation Act and associated Marine Orders for navigation, collision, and support vessels are identified as control measures.
Industry Standards	Industry Standards & Best Practices	Compliance with industry standards and best practice is demonstrated.

Context	Factor	Demonstration
Ecological Sustainability Development (ESD)	ESD Application	There is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecological integrity associated with accidental hydrocarbon release from a vessel collision during the Sauropod 3D MSS.

Acceptability Statement

The impact assessment has determined that, given the adopted controls, accidental hydrocarbon release to the marine environment due to a vessel collision is unlikely to result in potential impact greater than localised and short-term effects to marine fauna, water quality, marine protected areas and commercial fisheries. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls described in Section 8.2.4 are considered industry best practice and meet requirements of the Australian Marine Orders, and expectations of AMSA and the AHS. The potential impacts and risks are considered to be of an acceptable level if the adopted controls are implemented. Therefore, 3D Oil considers the adopted controls appropriate to manage the impacts accidental hydrocarbon release to the marine environment due to a vessel collision to be of an acceptable level.

8.2.6 Environmental Performance Outcomes, Standards and Measurement Criteria

Performance Outcomes	Performance Standards	Measurement Criteria
EPO 9 No release of hydrocarbons to the marine environment due to a vessel collision associated with the activity.	**PS (refer to PS 4.1)** Adherence with 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, 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.	**MC** No incidents 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.
	PS (refer to PS 2.1) The AHS is advised four weeks prior to survey commencement to allow for the issue of a Notice to Mariners.	**MC** Records verify that Notice to Mariners issued by AHS prior to survey commencement.
	PS (refer to PS 2.2) AMSA RCC is notified of survey activities 24-48 hours before operations commence, to allow for issue of AUSCOAST warnings, at survey commencement and at completion.	**MC** Available records verify AMSA JRCC notifications have been made, and that AUSCOAST warnings have been issued.
	PS (refer to PS 2.3) Notification is 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.	**MC** Consultation and notification records verify stakeholders have been informed of survey activities throughout the survey period.
	PS (refer to PS 4.3) A communications protocol is in place between the survey and support vessels and other users (e.g. known commercial fishing vessels within the Operational Area), to actively manage concurrent activities.	**MC** Records demonstrate that 48-72-hour 'look-aheads' have been provided to stakeholders that have requested to receive them.
	PS (refer to PS 4.4) At least one chase vessel is employed to assist the seismic vessel to mitigate interference associated with third party vessel operations.	**MC** Records demonstrate that one vessel (support or chase vessel) has remained with the survey vessel throughout the entire duration of the survey.

8.3 Hydrocarbon Spill – Bunkering

8.3.1 Details of Impacts and Risks

8.3.1.1 *Source of Impact/Risk*

Accidental hydrocarbon release to the marine environment due to bunkering of the survey vessel at sea, with the potential hazards of temporary and localised reduction in water quality and temporary toxicity effects to marine biota.

Bunkering of marine diesel between the support vessel and the survey vessel may occur within the Operational Area or surrounding waters for the Sauropod 3D MSS. Bunkering of the survey vessel is expected to be required approximately every 5-6 weeks during the survey.

Two credible scenarios for the loss of containment of marine diesel during bunkering operations were identified:

- Partial or total failure of a bulk transfer hose or fittings during bunkering, due to operational stress or other integrity issues could spill marine diesel to the deck and/or into the marine environment. This would be in the order of less than 200 L, based on the likely volume of a bulk transfer hose (assuming a failure of the dry break coupling and complete loss of hose volume); and

Partial or total failure of a bulk transfer hose or fittings during bunkering, combined with a failure in procedure to shutoff fuel pumps, for a period of up to five minutes, resulting in approximately 1.2 to 25 m^3 marine diesel loss to the deck and/or into the marine environment.

8.3.1.2 *Receptors*

- Marine fauna;
  - cetaceans, marine reptiles, seabirds, fishes/elasmobranchs, planktonic communities; and
- Water quality.

8.3.1.3 *Impact/Risk Evaluation*

Based on the modelling conducted for the 280 m^3 marine diesel spill within the Operational Area the exposure to surface hydrocarbons above the moderate 10 g/m^2 threshold is limited to the immediate vicinity of the release site, with little potential to extend beyond distances of 1 km or less. Therefore, it is considered that exposure to thresholds concentrations from a 25 m^3 surface spill from bunkering operations would be well within the surface hydrocarbon extent or 'footprint' for the vessel collision scenario in the Operational Area (refer to **Figure 6-2**), detailed in Section 8.1.3. Given this, specific modelling for a 25 m^3 marine diesel release was not undertaken for the Sauropod 3D MSS.

Based on the modelling results presented in Section 8.1.3, it is considered that there is no potential for contact with any marine protected areas, shallow waters or shorelines above low threshold concentrations (surface hydrocarbons 1 g/m^2; entrained hydrocarbons 10 ppb; or dissolved hydrocarbons 6 ppb) from a 25 m^3 or 200 L spill of marine diesel within the Operational Area during the survey.

The potential biological and ecological impacts to marine fauna and water quality associated with a much larger hydrocarbon spill are presented in Section 8.2. The biological consequences of such small volume releases of marine diesel on identified open water sensitive receptors relate to the potential for minor impacts to cetaceans, marine reptiles, seabirds, fishes/elasmobranchs and planktonic communities (surface and water column biota) that are within the spill affected area. The potential impacts are considered to be very localised and short-term.

No impacts to commercial fisheries are expected to occur.

<u>Summary</u>

Based on the assessment presented above and the implementation of the identified controls (Section 8.3.4), it is expected that the consequence associated with an accidental hydrocarbon release to the marine environment due to bunkering of the survey vessel at sea will be Negligible (1). The likelihood of impacts occurring is considered to be Very Unlikely (1), resulting in a *Low* residual risk to sensitive receptors within the Operational Area.

8.3.2 Decision Context

The decision context for accidental hydrocarbon release to the marine environment due to due to bunkering of the survey vessel at sea has been assessed as 'Type A', given the impacts/risks are well understood, uncertainty is minimal and little or no stakeholder interest.

8.3.3 Risk Summary

Risk Ranking	Consequence	Likelihood	Risk Ranking
Inherent Risk	Negligible (1)	Very Unlikely (1)	**Low**
Residual Risk	Negligible (1)	Very Unlikely (1)	**Low**

8.3.4 Identification of Control Measures and Demonstration of ALARP

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Legislative Requirements			
Adherence with requirements of Marine Order 91: Marine pollution prevention – oil.	Yes	By ensuring a SOPEP is in place for the vessel, the likelihood of a spill entering the marine environment is reduced.	10.1
Good Industry Practice			
Bunkering equipment controls: ■ All bulk transfer hoses tested for integrity before use; ■ Dry-break couplings and flotation installed on refuelling hoses. ■ Adequate number of appropriately stocked, located and maintained spill kits aboard both survey and support vessels.	Yes	By ensuring the appropriate equipment is in place, tested and maintained appropriately, the likelihood of a spill occurring is reduced. By ensuring spill kits are in place, the likelihood of a spill entering the marine environment is reduced. Good industry practice, environmental benefit outweighs additional cost.	10.2
Survey vessel contractor procedures include requirements to be implemented during bunkering/refuelling operations, including: ■ A completed Permit to Work (PTW) and / or Job Safety Analysis (JSA) implemented for bunkering operations. ■ Visual monitoring of gauges, hoses, fittings and sea surface during bunkering operations. ■ Hose checks prior to commencement. ■ Bunkering commences only in daylight hours. If transfer is to continue into night-time, JSA risk assessment must	Yes	By ensuring the appropriate bunkering procedures are implemented, the likelihood of a spill occurring is reduced, and the likelihood of a spill entering the marine environment is also educed. Good industry practice, environmental benefit outweighs additional cost.	10.3

Control Measure	Control Adopted	Justification	Performance Standard Ref.
consider lighting and ability to determine if a spill has occurred. ■ Bunkering not to occur in marginal weather conditions.			
Bunkering operations will be undertaken within the Operational Area (unless as required in an emergency situation).	Yes	The Operational Area does not overlap with any AMPs, therefore bunkering within the Operational Area is consistent with the management prescriptions of the AMPs. Good industry practice, environmental benefit outweighs additional cost.	10.4
Alternatives/Substitutes Considered			
Survey vessel bunkering only occurs in port.	No	The survey vessel would have to recover the towed array, leave the Operational Area and return to port for bunkering. This would increase the survey duration, and the overall cost. Eliminates the hydrocarbon spill risk from the Operational Area, but transfers it to coastal waters. The costs are grossly disproportionate to any potential environmental benefit gained.	N/A
Additional Controls Considered			
No additional controls have been identified.	N/A	N/A	N/A
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)			
No practicable improvements have been identified	N/A	N/A	N/A
ALARP Statement			
3D Oil considers the adopted control measures appropriate to manage the impacts and risks of accidental hydrocarbon release to the marine environment due to bunkering of the survey vessel at sea. As the impact/risk has been classified as 'Type A' and 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.			

8.3.5 Demonstration of Acceptable Levels

Context	Factor	Demonstration
Internal	3D Oil Policy	The risk management strategy for managing the impacts and risks of accidental hydrocarbon release to the marine environment due to bunkering of the survey vessel at sea, is compliant with 3D Oil's HSE Policy objectives of proactively identifying hazards, eliminating impacts where possible and where this is not possible managing the risk to ALARP.
	Company Standards/Systems	Section 9 details the relevant management system processes adopted to implement and manage impacts/risks to ALARP: ■ Contractor & Supplier Management (Section 9.7); and ■ Notification & Reporting (Section 9.12).
External	Values and Sensitivities of the Natural Environment	**EPBC Policy Statement 1.1. – Significant guidelines** The residual risk has been assessed as low, and will not have a significant impact upon protected matters in accordance with EPBC Policy Statement 1.1. – Significant guidelines.
		Conservation Advice, Recovery Plans, and Other Guidelines N/A: No advice or guidelines have been identified that specifically address potential impacts to protected species resulting from accidental hydrocarbon release.
		AMP Values, Management Prescriptions and IUCN Reserve Management Principles No significant impacts are predicted to occur to the natural, cultural and socio-economic values of the Argo-Rowley Terrace Marine Park and the Mermaid Reef Marine Park.
	Relevant Persons Expectations	No specific concerns have been raised by stakeholders relating to the impacts and risks of accidental hydrocarbon release to the marine environment due to bunkering of the survey vessel at sea.
Legislation & Other	Legislation & Conventions	All requirements under the Navigation Act and associated Marine Orders for prevention of pollution from oil are identified as control measures.

Context	Factor	Demonstration
Industry Standards	Industry Standards & Best Practices	Compliance with industry standards and best practice is demonstrated.
Ecological Sustainability Development (ESD)	ESD Application	There is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecological integrity associated with accidental hydrocarbon release from bunkering during the Sauropod 3D MSS.

Acceptability Statement

The impact assessment has determined that, given the adopted controls, accidental hydrocarbon release to the marine environment due to bunkering of the survey vessel at sea is unlikely to result in potential impact greater than very localised and short-term effects to marine fauna and water quality. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls described in Section 8.3.4 are considered industry best practice and meet requirements of the Australian Marine Orders. The potential impacts and risks are considered to be of an acceptable level if the adopted controls are implemented. Therefore, 3D Oil considers the adopted controls appropriate to manage the impacts accidental hydrocarbon release to the marine environment due to bunkering of the survey vessel at sea to be of an acceptable level.

8.3.6 Environmental Performance Outcomes, Standards and Measurement Criteria

Performance Outcomes	Performance Standards	Measurement Criteria
EPO 10 No unplanned loss of hydrocarbons to the marine environment from bunkering of the survey vessel at sea during the activity	**PS 10.1** A SOPEP is available onboard the survey and support vessels (as appropriate to vessel class), as required by Marine Order 91 (Marine pollution prevention – oil).	**MC** Marine Assurance inspection records demonstrate a SOPEP is available onboard the survey and support vessels in compliance with Marine Order 91.
	PS 10.2 Bunkering equipment controls are implemented: ■ All bulk transfer hoses tested for integrity before use; ■ Dry-break couplings and flotation installed on refuelling hoses. ■ Adequate number of appropriately stocked, located and maintained spill kits aboard both survey and support vessels.	**MC** Records confirm the vessel bunkering equipment is subject to systematic integrity checks, has dry-break couplings and flotation installed on refuelling hoses, and there are an adequate number of appropriately stocked, located and maintained spill kits aboard both survey and support vessels.
	PS 10.3 At sea bunkering procedures are followed, including: ■ A completed PTW and / or JSA implemented for bunkering operations. ■ Visual monitoring of gauges, hoses, fittings and sea surface during bunkering operations. ■ Hose checks prior to commencement. ■ Bunkering commences only in daylight hours. If transfer is to continue into night-time, JSA risk assessment must consider lighting and ability to determine if a spill has occurred. ■ Bunkering not to occur in marginal weather conditions.	**MC** Records demonstrate bunkering / refuelling undertaken in accordance with contractor bunkering procedures.
	PS 10.4 Bunkering operations are undertaken within the Operational Area (unless as required in an emergency situation).	**MC** Records demonstrate that no bunkering operations have been undertaken outside of the Operational Area.

8.4 Chemical Spill: Single Point Failure

8.4.1 Details of Impacts and Risks

8.4.1.1 *Source of Impact/Risk*

Accidental spills of up to 1 m^3 of hydraulic fluids or chemicals may result in a localised and short-term reduction in water quality with the potential to result in toxic effects on marine fauna.

8.4.1.2 *Receptors*

- Marine fauna;
  - cetaceans, marine reptiles, seabirds, fishes/elasmobranchs, planktonic communities; and
- Water quality.

8.4.1.3 *Impact/Risk Evaluation*

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.

Based on the assessment presented above and the implementation of the identified controls (Section 8.3.4), it is expected that the consequence associated of a single point failure resulting in a reduction in water quality and toxicity to marine fauna and fish will be Negligible (1). The likelihood of impacts occurring is considered to be Very Unlikely (1), resulting in a *Low* residual risk to sensitive receptors within the Operational Area

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

8.4.2 Decision Context

The decision context for a release of hydraulic fluids or chemicals to the marine environment from a single point failure has been assessed as 'Type A', given the impacts/risks are well understood, uncertainty is minimal and little or no stakeholder interest.

8.4.3 Risk Summary

Risk Ranking	Consequence	Likelihood	Risk Ranking
Inherent Risk	Negligible (1)	Very Unlikely (1)	**Low**
Residual Risk	Negligible (1)	Very Unlikely (1)	**Low**

8.4.4 Identification of Control Measures and Demonstration of ALARP

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Legislative Requirements			
Adherence with requirements of Marine Order 91: Marine pollution prevention – oil.	Yes	By ensuring a SOPEP is in place for the vessel, the likelihood of a spill entering the marine environment is reduced.	10.1
Good Industry Practice			
Hydraulic fluids and chemicals will be selected in accordance with the 3D Oil 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 3D Oil Chemical Control Procedure ensuring the use of chemicals with the lowest environmental toxicity possible meeting technical specifications. Good industry practice.	11.1
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.	11.2
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.	11.3
Spills will be reported through the 3D Oil Incident Reporting Procedure and waste materials managed in accordance with the vessel Waste/Garbage Management Plan.	Yes	All spills during the Sauropod 3D MSS will be reported through the 3D Oil Incident Reporting Procedure. Waste materials will be managed in accordance with the vessel Waste/Garbage Management Plan. Good industry practice.	11.4
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 3D Oil Chemical Control Procedure ensuring the	N/A

Control Measure	Control Adopted	Justification	Performance Standard Ref.
		use of chemicals with the lowest environmental toxicity possible meeting technical specifications.	
Additional Controls Considered			
No additional control measures have been identified	N/A	N/A	N/A
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)			
No practicable improvements have been identified	N/A	N/A	N/A
ALARP Statement			
3D Oil considers the adopted control measures appropriate to manage the impacts and risks of accidental chemical release to the marine environment from a single point failure. As the impact/risk has been classified as ‘Type A’ and 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.			

8.4.5 Demonstration of Acceptable Levels

Context	Factor	Demonstration
Internal	3D Oil Policy	The risk management strategy for managing the impacts and risks of accidental chemical release to the marine environment from a single point failure is compliant with 3D Oil's HSE Policy objectives of proactively identifying hazards, eliminating impacts where possible and where this is not possible managing the risk to ALARP.
	Company Standards/Systems	Section 9 details the relevant management system processes adopted to implement and manage impacts/risks to ALARP: ■ Contractor & Supplier Management (Section 9.7); and ■ Notification & Reporting (Section 9.12).
External	Values and Sensitivities of the Natural Environment	**EPBC Policy Statement 1.1. – Significant guidelines** The residual risk has been assessed as low, and will not have a significant impact upon protected matters in accordance with EPBC Policy Statement 1.1. – Significant guidelines.
		Conservation Advice, Recovery Plans, and Other Guidelines N/A: No advice or guidelines have been identified that specifically address potential impacts to protected species resulting from accidental chemical release.
		AMP Values, Management Prescriptions and IUCN Reserve Management Principles No significant impacts are predicted to occur to the natural, cultural and socio-economic values of the Argo-Rowley Terrace Marine Park and the Mermaid Reef Marine Park.
	Relevant Persons Expectations	No specific concerns have been raised by stakeholders relating to the impacts and risks of accidental chemical release to the marine environment due to bunkering of the survey vessel at sea.
Legislation & Other	Legislation & Conventions	All requirements under the Navigation Act and associated Marine Orders for prevention of pollution are identified as control measures.
Industry Standards	Industry Standards & Best Practices	Compliance with industry standards and best practice is demonstrated.

Context	Factor	Demonstration
Ecological Sustainability Development (ESD)	ESD Application	There is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecological integrity associated with accidental chemical release to the marine environment from a single point failure during the Sauropod 3D MSS.
Acceptability Statement		
The impact assessment has determined that, given the adopted controls, accidental chemical release to the marine environment from a single point failure is unlikely to result in potential impact greater than very localised and short-term effects to marine fauna and water quality. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls described in Section 8.4.4 are considered industry best practice and meet requirements of the Australian Marine Orders. The potential impacts and risks are considered to be of an acceptable level if the adopted controls are implemented. Therefore, 3D Oil considers the adopted controls appropriate to manage the impacts accidental chemical release to the marine environment from a single point failure to be of an acceptable level.		

8.4.6 Environmental Performance Outcomes, Standards and Measurement Criteria

Performance Outcomes	Performance Standards	Measurement Criteria
EPO 11 No unplanned loss of hydraulic fluids or chemicals to the marine environment from a single point failure during the activity	**PS (refer to PS 10.1)** A SOPEP is available onboard the survey and support vessels (as appropriate to vessel class), as required by Marine Order 91 (Marine pollution prevention – oil).	**MC** Marine Assurance inspection records demonstrate a SOPEP is available onboard the survey and support vessels in compliance with Marine Order 91.
	PS 11.1 Hydraulic fluids and chemicals are selected in accordance with the 3D Oil Chemical Control Procedure and will be selected to have the lowest environmental toxicity possible whilst meeting operational performance requirements.	**MC** Records of pre-survey environmental checklist and compliance audit during the survey (Section 9.13) confirm that only chemicals approved via the 3D Oil Chemical Control Procedure are carried on the vessel.
	PS 11.2 Storage, handling and use of hazardous substances (including hydraulic fluids and chemicals) are in accordance with the product's Safety Data Sheet (SDS).	**MC** Records demonstrate survey inductions 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 available on board and storage, handling and/or use is in accordance with the SDS.
	PS 11.3 Spill kits and scupper plugs are available on board the seismic vessel and crew are trained in their use.	**MC** Record of pre-survey environmental checklist (Section 9.13) 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..
	PS 11.4 Spills are reported through the 3D Oil Incident Reporting Procedure and waste materials managed in accordance with the vessel Waste/Garbage Management Plan.	**MC** If a spill has occurred during the survey, 3D Oil 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.

8.5 Physical Presence: Entanglement / Collision with Marine Fauna

8.5.1 Details of Impacts and Risks

8.5.1.1 *Source of Impact/Risk*

The physical presence of the survey and support vessels and towed equipment within the Operational Area provides a risk of potential entanglement/collision with marine fauna.

The survey and support vessels operating in the Operational Area, and the towed seismic equipment, may represent a potential entanglement / collision risk to cetaceans and other protected marine fauna, such as whale sharks and marine turtles.

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 12). 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 (8 km/hr), until the required coverage is completed (up to 60 days). The survey vessel will be accompanied by two support vessels.

This section deals with the risk of entanglement or collision with marine fauna from the physical presence of vessels and in-water equipment (streamers and seismic source) in the Operational Area. Risks associated with the disruption/interference with other marine users are addressed in Section 7.4, and potential underwater acoustic impacts on marine fauna are addressed in Sections 7.1 to 7.2.

8.5.1.2 *Receptors*

- EPBC listed marine fauna, including threatened and migratory cetaceans, marine turtles and whale sharks.

8.5.1.3 *Impact/Risk Evaluation*

The risk of a vessel collision or entanglement is limited to the footprint of the vessels, which is temporary in nature at any one position, as the vessels transits within the Operational Area for a maximum of 60 days.

As the survey vessel transits at low speeds (4-5 knots), with MFO observers on-board, the likelihood of a vessel-strike and associated injury to megafauna is considered very unlikely. Support vessels generally travel at higher speeds within the Operational Area and are considered to have a slightly higher potential for collision and damage with megafauna, relative to the survey vessel.

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. Anecdotally, there have been no reported cases of marine fauna becoming entangled in seismic equipment in Australian waters.

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. The Operational Area overlaps with the pygmy blue whale distribution BIA, with the migration BIA located 95 km from the Operational Area. Occasional individuals may therefore pass through the Operational Area and surrounds during the annual migration. Acquisition of the survey may overlap the commencement of the northbound migration (April), but avoids the southbound migration period for pygmy blue whales in the region (September to November). However, overall cetacean numbers within the Operational Area are expected to be very low during the proposed timing of the Sauropod 3D MSS (January to April). Given the low number of cetaceans expected in the Operational Area, presence of two MFOs on board the seismic survey vessel, and the low operating speeds of vessels, the risk of entanglement or collision is considered low.

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 is considered to be significant for supporting large feeding and nesting turtle populations. Six threatened and migratory marine turtle species have the potential to occur in the Operational Area, however, the Operational Area does not overlap with any BIAs for marine turtle species. The closest foraging BIA for the flatback turtle is 55 km from the Operational Area. In addition, the closest 'habitat critical to the survival of a species' BIA for the flatback turtle is located approximately 55 km from the Operational Area. The marine turtle numbers within the Operational Area are expected to be low during the proposed Sauropod 3D MSS. Given the low number of marine turtles expected in the Operational Area and the low operating speeds of vessels, the risk of entanglement or collision is considered low.

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 offshore North West Shelf waters in the Operational Area during their migrations to and from Ningaloo Reef. The Operational Area does overlap with a foraging BIA for whale sharks which extends northwards from Ningaloo Reef along the

200 m isobath. The foraging BIA is used from August to November and does not overlap with the proposed acquisition period. Whale sharks are a highly migratory species, which are known to migrate between Christmas Island and Ningaloo Reef. Migration is expected to occur between January and March. 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. Given the low number of whale sharks expected in the Operational Area and the low operating speeds of vessels, the risk of entanglement or collision is considered low.

<u>*Summary*</u>

Based on the assessment presented above and the implementation of the identified controls (Section 8.5.4), it is expected that in the event of entanglement or collision with marine fauna, the consequence would be Significant (3), as collision/entanglement of marine fauna could result in serious injury or death. The likelihood of interaction is considered Very Unlikely (1), given the low presence of transiting individuals, avoidance behaviour of marine fauna and the low operating speed of vessels. The residual risk of entanglement/collision with marine fauna has been assessed as *Low*.

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

8.5.2 Decision Context

The decision context for the risk of potential entanglement or collision with marine fauna, has been assessed as ‘Type A’, given the risks are well understood and uncertainty is minimal, with little or no stakeholder interest.

8.5.3 Risk Summary

Risk Ranking	Consequence	Likelihood	Risk Ranking
Inherent Risk	Significant (3)	Possible (3)	**Medium**
Residual Risk	Significant (3)	Very Unlikely (1)	**Low**

8.5.4 *Identification of Control Measures and Demonstration of ALARP*

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Legislative Requirements			
Vessels will comply, when safe to do so, with the 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. MSS. For safety reasons, the distance requirements are not applied for vessels with limited manoeuvrability. It is a legislative requirement for vessels to comply with the EPBC Act and EPBC Regulations.	3.1
Good Industry Practice			
Operation of the seismic source within the Operational Area for the Sauropod 3D MSS is compliant with EPBC Act Policy Statement 2.1 Part B.1 – Additional Management Measures: Marine Mammal Observers.	Yes	Two trained and experienced marine fauna observers (MFOs) will be aboard the survey vessel. The two MFOs (in addition to briefed crew members) will alternate shifts during daylight hours (during operation of the seismic source) in order to manage fatigue and provide some redundancy in the event one MFO is unavailable. The MFOs will have adequate training and will have >12 months experience in Australian waters. Good industry practice, environmental benefit outweighs additional cost.	1.2
Any vessel strike incident to marine mammals shall be reported as soon as possible via the National Vessel Strike Database at https://data.marinemammals.gov.au/report/shi , within 72hr of collision.	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. Good industry practice, environmental benefit outweighs additional cost.	12.1
Turtle guards installed on tail buoys or tail buoys are of a design that does not represent an entrapment risk to turtles.	Yes	A tail buoy will be fitted to the end of each streamer. Tail buoys are brightly coloured and contain a radar reflector and strobe light to be visible to other	12.2

Control Measure	Control Adopted	Justification	Performance Standard Ref.
		marine users. If the tail buoys are not of a design that does not represent an entrapment risk to turtles, they will be fitted with guards to prevent accidental entrapment of turtles. Good industry practice, environmental benefit outweighs additional cost.	
All vessel crews have completed an environmental induction covering the requirements for cetacean vessel interactions consistent with EPBC Regulations 2000 – Part 8 Division 8.1.	Yes	Environmental inductions will be included as part of the crew induction package, including cetacean vessel interactions, consistent with EPBC Regulations 2000 – Part 8 Division 8.1. Good industry practice, environmental benefit outweighs additional cost.	12.3
Alternatives/Substitutes Considered			
Use ocean bottom nodes (OBN – receivers) 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. However, this was considered impractical for the following reasons: ■ Environmentally, OBNs 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, OBNs can result in unnecessary seabed disturbance particularly in areas of shallow benthic habitat. ■ OBNs cannot be placed securely on steep sloping seabed, making acquisition in some areas of the Operational Area difficult or impossible to implement. ■ OBNs 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. ■ 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.	N/A
Additional Controls Considered			

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Marine fauna entangled within the in-water equipment will be returned to sea (where possible and safe to do so).	Yes	If safe and practicable to do so, marine fauna found to be entangled in towed equipment shall be recovered to reduce the risk of mortality. The environmental benefit outweighs the additional cost.	12.4
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 due 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 survey vessel.	N/A
Survey acquisition timed to avoid turtle internesting periods	No	Not justified. Acquisition of the survey may overlap the nesting and breeding season for a number of turtle species in the region, however the Operational Area is located approximately 55 km from the closest BIA boundary. The costs are grossly disproportionate to any potential environmental benefit gained.	N/A
Survey acquisition timed to avoid the migration periods for humpback whales	Yes	The survey will be acquired in the period January to April, which will avoid the northbound and southbound migration season for humpback whales in the region (June to October). The environmental benefit outweighs the additional cost.	1.7
Survey acquisition timed to avoid the migration periods for pygmy blue whales	No	Not justified. Acquisition of the survey may overlap the commencement of the northbound migration (April), but avoids the either the southbound migration period for pygmy blue whales in the region (September to November). While the Operational Area overlaps with the pygmy blue whale distribution BIA, the migration BIA is located 95 km from the Operational Area. Only occasional, transient individuals are therefore expected in the area during the proposed acquisition period. The costs are grossly disproportionate to any potential environmental benefit gained.	N/A
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)			

Control Measure	Control Adopted	Justification	Performance Standard Ref.
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, 3D Oil has considered extending the prescribed avoidance measures to turtles. For safety reasons, the distance requirements are not applied for vessels with limited manoeuvrability. The environmental benefit outweighs the additional cost.	3.4
Vessels, when safe to do so, will also adopt 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.	Yes	In addition to implementing the EPBC Regulations 2000 avoidance measures for cetaceans, 3D Oil has extended avoidance measures to whale sharks. For safety reasons, the distance requirements are not applied for vessels with limited manoeuvrability. The environmental benefit outweighs the additional cost.	3.5

ALARP Statement

3D Oil considers the adopted control measures appropriate to manage the risks of entanglement or collision with marine fauna. As the risk has been classified as ‘Type A’ and 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.

8.5.5 Demonstration of Acceptable Levels

Context	Factor	Demonstration
Internal	3D Oil Policy	The risk management strategy for managing the physical presence of vessels and towed equipment, reflects 3D Oil's HSE Policy goals of proactively identifying hazards, eliminating impacts where possible and where this is not possible managing the risk to ALARP.
	Company Standards/Systems	Section 9 details the relevant management system processes adopted to implement and manage impacts/risks to ALARP: ■ Contractor & Supplier Management (Section 9.7); ■ Environmental Performance Monitoring & Reporting (Section 9.13).
External	Natural Environment	**EPBC Policy Statement 1.1. – Significant guidelines** The residual risk has been assessed as low, and will not have a significant impact upon protected matters in accordance with EPBC Policy Statement 1.1. – Significant guidelines.
		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, Recovery Plans and other Guidelines for whales, sharks and turtles: • 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; and • Whale shark – wildlife management program no. 57 (DPaW 2013) • National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna (DoEE 2017)
		AMP Values, Management Prescriptions and IUCN Reserve Management Principles No impacts are expected to the natural and cultural heritage values of the Argo-Rowley Terrace Marine Park and Mermaid Reef Marine Park.
	Relevant Persons Expectations	No specific concerns have been raised by stakeholders relating to the risk of entanglement/collision with marine fauna from the physical presence of vessels and in-water equipment.

Context	Factor	Demonstration
Legislation & Other	Legislation	The controls adopted will comply with the *Navigation Act 2012*, *Offshore Petroleum and Greenhouse Gas Storage Act 2006* and the *Environment Protection and Biodiversity Conservation Act 1999*.
Industry Standards	Industry Standards & Best Practices	Compliance with industry standards and best practices (where applicable).
Ecological Sustainability Development (ESD)	ESD Application	If an incident resulting in entanglement/collision with marine fauna was to occur, it would be expected to be limited to an isolated individual. There is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecology integrity associated with the risk of entanglement/collision with marine fauna from the physical presence of vessels and in-water equipment during the Sauropod 3D MSS.

Acceptability Statement

The impact assessment has determined that, given the adopted controls, physical presence of vessels and in-water equipment is very unlikely to result in potential impact to marine fauna. Further opportunities to reduce the risk have been investigated above.

The adopted controls described in Section 8.5.4, are considered industry best practice and meet legislative requirements. 3D Oil considers the adopted control measure to be appropriate to manage the activity to an acceptable level.

8.5.6 Environmental Performance Outcomes, Standards and Measurement Criteria

Performance Outcomes	Performance Standards	Measurement Criteria
EPO 12 No injury or death to marine fauna as a result of vessel collision or entanglement with in-water equipment during the Sauropod 3D MSS.	**PS (refer to PS 3.1)** Seismic vessels 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 whale (300 m).	**MC** MFO Master Data Sheet verifies interaction between the MSS vessel and marine mammals comply with these requirements. Support vessel observations sheet verified interactions between the vessel and marine mammals comply with these requirements.
	PS (refer to PS 1.2) Operation of the seismic source within the Operational Area for the Sauropod 3D MSS is compliant with EPBC Act Policy Statement 2.1 Part B.1 – Additional Management Measures: Marine Mammal Observers. Two trained and experienced MFOs are aboard the seismic survey vessel. The two MFOs (in addition to briefed crew members) alternate shifts during daylight hours in order to manage fatigue and provide some redundancy in the event one MFO is unavailable. The MFOs have adequate training and will have >12 months experience in Australian waters.	**MC** Records demonstrate that two MFOs were aboard the survey vessel for the duration of the survey. MFO sighting records and final report. CVs and training records for the MFOs.
	PS 12.1 Any vessel strike incident to marine mammals is reported as soon as possible via the National Vessel Strike Database at https://data.marinemammals.gov.au/report/shi, within 72 hr of collision.	**MC** Records verify incident has been reported via the National Vessel Strike Database.
	PS 12.2 Turtle guards are installed on tail buoys or tail buoys are of a design that does not represent an entrapment risk to turtles.	**MC** Inspection records verify turtle guards are installed on header buoys and tail buoys (or buoys have been designed to not represent an entanglement risk to turtles).

Performance Outcomes	Performance Standards	Measurement Criteria
	PS 12.3 All vessel crews have completed an environmental induction covering the requirements for cetacean vessel interactions consistent with EPBC Regulations 2000 – Part 8 Division 8.1.	**MC** Induction records verify that all crews have completed an environmental induction.
	PS 12.4 Marine fauna entangled within the in-water equipment are returned to sea (where possible and safe to do so).	**MC** MFO records verify that any marine fauna entangled within the in-water equipment are returned to sea (where possible and safe to do so).
	PS (refer to PS 1.7) Survey acquisition is timed to avoid the migration periods for humpback whales (June to October).	**MC** Records confirm that the survey has been acquired outside the June to October humpback whale migration season.
	PS (refer to PS 3.4) In addition to the requirements of the EPBC Regulations 2000 - Part 8 Division 8.1 for cetaceans, vessels (where 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.	**MC** MFO Master Data Sheet verifies interaction between the MSS vessel and marine mammals comply with these requirements. Support vessel observations sheet verified interactions between the vessel and marine mammals comply with these requirements.
	PS (refer to PS 3.5) Vessels, when safe to do so, also adopt will measures consistent with the Whale shark – wildlife management program no. 57 (DPaW 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.	**MC** MFO Master Data Sheet verifies interaction between the MSS vessel and marine mammals comply with these requirements. Support vessel observations sheet verified interactions between the vessel and marine mammals comply with these requirements.

8.6 Physical Presence: Loss of Equipment

8.6.1 Details of Impacts and Risks

8.6.1.1 *Source of Impact/Risk*

The risk of physical loss of equipment (e.g. seismic streamers and/or source) in the Operational Area could result in localised seabed disturbance and disruptions to other marine users.

Equipment associated with the Sauropod 3D MSS has the potential to be lost within the Operational Area, as a result of a breakage in cables or a failure in lifting equipment. The survey will be undertaken by a purpose-built seismic survey vessel towing an underwater seismic source (at a depth of 5-10m) and a series of hydrophone streamers (up to 12). These streamers will be towed at a depth of approximately 15 m below the surface. Loss of this equipment has the potential to cause localised seabed disturbance, localised damage to benthic habitats, and disruptions to other marine users. Loss of equipment during petroleum activities is uncommon; however, it has been recorded within the industry.

Impacts associated with the unplanned loss of solid wastes (hazardous or non-hazardous) are assessed in Section 8.7.

8.6.1.2 *Receptors*

- Marine users: commercial fishing and commercial shipping; and
- Benthic habitats and communities.

8.6.1.3 *Impact/Risk Evaluation*

Marine users (e.g. commercial fishing and shipping)

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.

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.

The Ancient coastline at 125 m depth contour KEF overlaps with a small portion of the Operational Area. Parts of the ancient coastline are represented as rocky escarpment, which are considered to provide significant habitat in an area predominantly made up of soft sediment (Section 4.3.2).

The Operational Area is expected to consist primarily of soft, fine unconsolidated sediments, which are typical of the broader NWMR (Section 4.2.4). As such physical impacts to the seabed are expected to be short-term and highly localised. Due to the presence of soft sediments and lack of hard substrate, the seabed is likely to be inhabited by a low abundance and patchy distributions of filter feeders and other epifauna, characteristic of the wider NWMR (Brewer et al. 2007). Impacts to benthic habitats such as shelf and slope habitats, pinnacle and terrace seabed features and the Ancient coastline KEF are not expected.

Summary

Based on the assessment presented above and the implementation of the identified controls (Section 8.6.4), it is expected that localised seabed disturbance, impact to benthic habitats and localised disturbance to marine users will be Minor (2). The likelihood of this consequence occurring is Very Unlikely (1) and the residual risk is considered to be *Low*.

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

8.6.2 Decision Context

The decision context for loss of equipment has been assessed as ‘Type A’, given the impacts/risks are well understood and uncertainty is minimal with little or no stakeholder interest.

8.6.3 Risk Summary

Risk Ranking	Consequence	Likelihood	Risk Ranking
Inherent Risk	Minor (2)	Unlikely (2)	**Low**
Residual Risk	Minor (2)	Very Unlikely (1)	**Low**

8.6.4 Identification of Control Measures and Demonstration of ALARP

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Legislative Requirements and Good Industry Practice			
No relevant legislation has been identified.	N/A	N/A	N/A
Good Industry Practice			
Solid streamers will be used for the survey.	Yes	Solid streamers are used as a standard to prevent any possibility of discharges that could otherwise occur if fluid-filled streamers were used and became damaged. Good industry practice, environmental benefit outweighs additional cost.	13.1
The seismic vessel will operate under approved procedures for streamer deployment/retrieval and these procedures are adhered to at all times.	Yes	The procedure ensures all personnel involved in the deployment/retrieval of in-water equipment, are doing so in a safe and consistent manner. The environmental benefit outweighs the additional cost.	13.2
Streamer equipment are routinely maintained and inspected for wear and tear to ensure the equipment is fit-for-purpose.	Yes	In-water equipment is routinely checked to confirm the integrity of the equipment, and to ensure the equipment is fit-for-purpose. The environmental benefit outweighs the additional cost.	13.3
Streamers will be fitted with the following equipment: ■ Streamer recovery devices (self-inflating SRDs) ■ Surface marker buoys ■ Secondary retaining devices ■ Tail buoys	Yes	Streamers are fitted with equipment to allow for the ease in deployment and retrieval of in-water equipment. The environmental benefit outweighs the additional cost.	13.4
Support vessels will search for and retrieve lost in-water equipment (where possible and safe to do so).	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.	13.5
Marine stakeholders will be notified (VHF Channel 16) in the event of a loss of in-water equipment.	Yes	Notification to other marine users (i.e. commercial fishing and shipping) to alert them of the navigational hazard (if applicable). This is considered good industry practice.	13.6

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Loss of equipment will be reported to AMSA, as soon as possible.	Yes	Notification to AMSA to alert them of the navigational hazard. This is considered good industry practice.	13.7
Alternatives/Substitutes Considered			
No practicable alternative or substitutes to the above controls have been identified.	N/A	N/A	N/A
Additional Controls Considered			
No additional controls have been identified.	N/A	N/A	N/A
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)			
No practicable improvements have been identified	N/A	N/A	N/A
ALARP Statement			
3D Oil considers the adopted control measures appropriate to manage the risk of a loss of equipment. The residual risk has been assessed as Low. As the risk has been classified as 'Type A' and 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.			

8.6.5 Demonstration of Acceptable Levels

Context	Factor	Demonstration
Internal	3D Oil Policy	The risk management strategy for managing loss of equipment to the marine environment, reflects 3D Oil's HSE Policy goals of proactively identifying hazards, eliminating impacts where possible and where this is not possible managing the risk to ALARP.
	Company Standards/Systems	Section 9 details the relevant management system processes adopted to implement and manage impacts/risks to ALARP: ■ Contractor & Supplier Management (Section 9.7); ■ Environmental Performance Monitoring & Reporting (Section 9.13).
External	Natural Environment	**EPBC Policy Statement 1.1. – Significant Guidelines** The residual risk has been assessed as low, and will not have a significant impact upon protected matters in accordance with EPBC Policy Statement 1.1. – Significant guidelines.
		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. 3D Oil 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 Reserve Management Principles Although the Operational Area is not located within any AMPs, management of loss of equipment is consistent with the management prescriptions of North and North-west Management Plans for AMPS. No impacts are predicted to occur to the cultural and socio-economic values of the AMPs.
	Relevant Persons Expectations	No specific concerns have been raised by stakeholders relating to the loss of equipment during the Sauropod 3D MSS.

Context	Factor	Demonstration
Legislation & Other	Legislation	The controls adopted for the loss of equipment to the marine environment will comply with the *Navigation Act 2012*, *Offshore Petroleum and Greenhouse Gas Storage Act 2006* and the *Environment Protection and Biodiversity Conservation Act 1999*.
Industry Standards	Industry Standards & Best Practices	Compliance with industry standards and best practices (where applicable).
Ecological Sustainability Development (ESD)	ESD Application	There is no threat of serious or irreversible ecological damage from the loss of equipment to the marine environment during the Sauropod 3D MSS.

Acceptability Statement

The impact assessment has determined that, given the adopted controls, loss of equipment is very unlikely to result in to result in potential impact greater than localised seabed disturbance, and short-term disruption to marine users. Further opportunities to reduce the risk have been investigated above.

The adopted controls described in Section 8.6.4, are considered industry best practice and meet legislative requirements. 3D Oil considers the adopted control measure to be appropriate to manage the activity to an acceptable level.

8.6.6 Environmental Performance Outcomes, Standards and Measurement Criteria

Performance Outcomes	Performance Standards	Measurement Criteria
EPO 13 No loss of equipment to the marine environment during the survey.	**PS 13.1** Solid streamers are used for the survey.	**MC** Inspection records verify solid streamers are used.
	PS 13.2 The survey vessel operates under approved procedures for streamer deployment/retrieval and these procedures are adhered to at all times.	**MC** Approved procedures are available and used on-board all vessels.
	PS 13.3 Streamer equipment are routinely maintained and inspected for wear and tear to ensure the equipment is fit-for-purpose.	**MC** Inspection records verify streamers are fit-for-purpose.
	PS 13.4 Streamers are fitted with the following equipment: ■ SRDs ■ Surface marker buoys ■ Secondary retaining devices ■ Tail buoys	**MC** Equipment deployed meets minimum specification requirements.
	PS 13.5 Support vessels search for and retrieve lost in-water equipment (where possible and safe to do so).	**MC** Dropped objects recorded in incident report and vessel log.
	PS 13.6 Marine stakeholders are notified (VHF Channel 16) in the event of a loss of in-water equipment.	**MC** Vessel log records notification on loss of equipment.
	PS 13.7 Loss of equipment is reported to AMSA, as soon as possible.	**MC** Incident report/notification to AMSA.

8.7 Discharge: Loss of Hazardous or Non-Hazardous Solid Waste

8.7.1 Details of Impacts and Risks

Entanglement with, or ingestion by marine fauna may occur as a result of the unplanned loss of solid wastes (hazardous and non-hazardous waste) from the seismic and support vessels. Loss of solid waste also has the potential to cause a temporary/localised reduction in water quality and minor/temporary toxicity in marine biota.

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.

Loss of solid wastes excludes scenarios involving detachment of operational equipment (i.e. streamers and the survey array), which is assessed in Section 8.6. Impacts associated with the discharge of putrescible wastes is assessed in Section 7.5.

8.7.1.1 *Source of Impact/Risk*

- Water quality;
- Ancient coastline at the 125 m depth contour KEF.
- Marine biota; and
- Marine fauna.

8.7.1.2 *Impact/Risk Evaluation*

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.

Discharge of solid wastes 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.

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.

Marine Fauna

The risk associated with the loss of solid wastes to marine fauna involves direct interaction between the waste and organism, which may result in fauna mortality or injury through ingestion or entanglement.

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).

Solid wastes will not be discharged to sea but rather will be stored on board the seismic vessel and support 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.

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 (Section 4.3.2). 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.

Summary

Taking into account the required controls, the consequence resulting from the risk of occasional short term and localised disturbance to marine fauna and benthic habitat from the unplanned discharge of hazardous and non-hazardous solid waste is Minor (2). The likelihood of this consequence occurring is Very Unlikely (1) and the risk is considered to be *Low*.

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

8.7.2 Decision Context

The decision context for loss of solid wastes has been assessed as ‘Type A’, given the impacts/risks are well understood, uncertainty is minimal and little or no stakeholder interest.

8.7.3 Risk Summary

Risk Ranking	Consequence	Likelihood	Risk Ranking
Inherent Risk	Minor (2)	Very Unlikely (1)	**Low**
Residual Risk	Minor (2)	Very Unlikely (1)	**Low**

8.7.4 Identification of Control Measures and Demonstration of ALARP

Control Measure	Control Adopted	Justification	Performance Standard Ref.
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 engaged 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.	14.1
Marine Order 94 – packaged harmful substances, which requires: ■ Vessels carrying harmful substances in packaged form must comply with regulations 2 to 5 of MARPOL Annex III, with respect to stowage requirements; A vessel Master may only wash a substance overboard if: ■ The physical, chemical and biological properties of the substance have been considered; and ■ Washing overboard is considered the most appropriate manner of disposal; and ■ The vessel Master has authorised the washing overboard.	Yes	Vessels used for the survey will comply with regulations 2 to 5 of MARPOL Annex III and the vessel Master will comply with Marine Oder 94. It is a legislative requirement for vessels to comply with AMSA Marine Orders.	14.2
Good Industry Practice			
Bins available for the segregation of waste as per the vessel Waste Management Plan, and bins for potentially wind-blown waste are covered (e.g. using lids or netting).	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.	14.3

Control Measure	Control Adopted	Justification	Performance Standard Ref.
		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.	
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.	14.4
Alternatives/Substitutes Considered			
No practicable alternative or substitutes to the above the controls have been identified	N/A	N/A	N/A
Additional Controls Considered			
No practicable alternative or substitutes to the above the controls have been identified	N/A	N/A	N/A
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)			
No practicable alternative or substitutes to the above the controls have been identified	N/A	N/A	N/A
ALARP Statement			
The residual risk associated with the unplanned loss of solid waste has been determined to be *Low*. 3D Oil considers the adopted control measures appropriate to manage the risks of a loss of solid waste. As the risk has been classified as ‘Type A’ and no reasonable additional or alternative controls were identified that would further reduce the impacts and risks, without jeopardising the objectives of the survey, the risk is considered to be ALARP.			

8.7.5 Demonstration of Acceptable Levels

Context	Factor	Demonstration
Internal	3D Oil Policy	The risk management strategy for managing the loss of soil waste, reflects 3D Oil's HSE Policy goals of proactively identifying hazards, eliminating impacts where possible and where this is not possible managing the risk to ALARP.
	Company Standards/Systems	Section 9 details the relevant management system processes adopted to implement and manage impacts/risks to ALARP: ■ Contractor & Supplier Management (Section 9.7); ■ Environmental Performance Monitoring & Reporting (Section 9.13).
External	Natural Environment	**EPBC Policy Statement 1.1. – Significant guidelines** The residual risk has been assessed as low, and will not have a significant impact upon protected matters in accordance with EPBC Policy Statement 1.1. – Significant guidelines.
		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. 3D Oil 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 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 and North-west Management Plans for AMPs. Unplanned loss of solid waste will not occur in AMPs.
	Relevant Persons Expectations	No specific concerns have been raised by stakeholders relating to loss of solid waste.
Legislation & Other	Legislation	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.
Industry Standards	Industry Standards & Best Practices	The impact/risk will comply with industry standards and good practice by using bins to segregate wastes on vessels in accordance with the vessel Waste Management Plan. Covered bins with tight lids will be used to prevent windblown waste.
Ecological Sustainability Development (ESD)	ESD Application	There is no threat of serious or irreversible ecological damage from the loss of solid waste to the marine environment during the Sauropod 3D MSS.

Acceptability Statement

The impact assessment has determined that, given the adopted controls, loss of solid waste is unlikely to result in potential impact greater than localised and short term local concern to water quality and marine biota. Further opportunities to reduce the impacts and risks have been investigated above.

The adopted controls described in Section 8.6.4, are considered industry best practice and meet legislative requirements. 3D Oil considers the adopted control measure to be appropriate to manage the activity to an acceptable level.

8.7.6 Environmental Performance Outcomes, Standards and Measurement Criteria

Performance Outcomes	Performance Standards	Measurement Criteria
EPO 14 No releases of solid hazardous or non-hazardous waste to the marine environment during the survey.	**PS 14.1** Seismic vessel and support vessels are compliant with Marine Order 95 – pollution prevention – Garbage: ■ 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	**MC** Records demonstrate any non-compliance with Marine Orders is documented.
	PS 14.2 Seismic vessel and support vessels are compliant with Marine Orders 94 – packaged harmful substances which provides information about preventing harmful substances carried by regulated Australian vessels, from entering the marine environment, which requires: ■ Vessels carrying harmful substances in packaged form must comply with regulations 2 to 5 of MARPOL Annex III, with respect to stowage requirements; ■ A vessel Master may only wash a substance overboard if: ■ The physical, chemical and biological properties of the substance have been considered; and ■ Washing overboard is considered the most appropriate manner of disposal; and ■ The vessel Master has authorised the washing overboard.	**MC** Records demonstrate any non-compliance with Marine Orders is documented.
	PS 14.3 Hazardous and non-hazardous waste will be managed in accordance with the vessel Waste Management Plan, which requires: ■ Dedicated waste segregation bins. ■ Records of all waste to be disposed, treated or recycled. ■ Waste streams shall be handled and managed according to their hazard and recyclability class.	**MC** Pre-Mobilisation Inspection Report confirms that a vessel Waste Management Plan is on the vessel **MC** Documented evidence that the vessel Waste Management Plan is included in induction content

Performance Outcomes	Performance Standards	Measurement Criteria
		MC Records demonstrate compliance against vessel Waste Management Plan.
	PS 14.4 Non-hazardous solid waste is recycled or re-used where possible.	**MC** Records demonstrate compliance against vessel Waste Management Plan.

8.8 Introduction of Invasive Marine Species: Ballast Water and Biofouling

8.8.1 Details of Impacts and Risks

8.8.1.1 *Source of Impact/Risk*

Potential introduction of invasive marine species (IMS) via unmanaged vessel biofouling or the discharge of ballast water from vessels within the Operational Area.

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 survey and support vessels will operate out of an Australian port (likely Port Hedland). Should a survey or support vessel arrive in Australia from overseas, it will enter Australian territory via an Australian port prior to mobilising to the Operational Area.

8.8.1.2 *Receptors*

- Marine ecological communities; and
- Ancient coastline at the 125 m depth contour KEF.

8.8.1.3 *Impact/Risk Evaluation*

IMS are widely recognised as a potentially significant threats to marine ecosystems worldwide. Shallow coastal marine environments in particular, are thought to be amongst the ecosystems most susceptible to the establishment of IMS, which largely reflects the accidental transport of IMS by international shipping to marinas and ports (Commonwealth of Australia 2009; Wells et al. 2009). The availability of suitable habitat, such as hard substrate or artificial structures are also conducive to the settlement and establishment of IMS (Glasby et al. 2007; Dafforn et al. 2009a, 2009b; Wells et al. 2009).

Not all organisms that are translocated to an area outside of their natural range will survive to establish as IMS, with the majority of introduced species failing to establish (Williamson and Fitter 1996; Paulay et al. 2002). The successful survival and subsequent establishment of an IMS is dependent on a number of factors, including:

- Presence and potential for uptake of organisms at a point of origin prior to translocation, such as a port, harbour or within coastal waters;
- Activities undertaken by the vessel (both at origin and destination) that favour successful establishment of the IMS, such as low speed or stationary vessel activities in shallow water locations; and,
- Environmental conditions during transit and at destination compared with the point of origin, such as water temperature, salinity and light availability; and
- Availability of suitable habitat on which to settle, grow, reproduce and establish a population.

Once introduced, IMS may be irreversible and can have significant impacts on the marine ecosystem. Invasive organisms may have few or no predators or natural competition, resulting in IMS potentially outcompeting native species for food or habitat, preying on native species, or changing the nature of the environment. This may result in an alteration to the structure (species biodiversity and abundance) and the functioning of ecological communities. Introduction of IMS also has the potential to introduce pathogens to the marine environment, which can be detrimental to native organisms.

During the Sauropod 3D MSS, vessels will be moving for the majority of the time and will not be stationary for prolonged periods and so are less conducive to the translocation of IMS than stationary vessels. The water depths in the Operational Area range from approximately 95 m to 172 m. The bathymetry within the Operational Area is predominately characterised by relatively flat seabed and no shallow bathymetric features are present. In addition, the substrate is predominantly calcareous gravel, sand and silt, which supports relatively little seabed structure or sessile epibenthos. Areas of hard substrate and topographic relief supporting filter feeder communities may occur in association with the Ancient coastline at the 125 m depth contour KEF. Therefore, given the nature of the survey activities, the relatively deep water location and limited availability of suitable habitat provides relatively unfavourable environmental conditions for most IMS to become established and spread. However, in the unlikely event that IMS were introduced to the Operational Area by the survey and support vessels and were successful in establishing on substrates associated with the Ancient coastline at the 125 m depth contour KEF, this could result in long term-impacts to the these regionally significant ecological communities. Changes to ecological communities may also impact upon socio-economic receptors such as commercial fisheries, by effecting target fish stocks or through food chain related impacts.

Summary

Given the unfavourable water depths, environmental conditions (i.e. low light penetration at the seabed), and the limited availability of suitable habitat in the Operational Area, establishment of IMS is not expected to occur. However, any localised introduction of IMS in the Operational Area, including the Ancient coastline at the 125 m depth contour KEF, may result in long-term changes to ecological communities in the form of decreased ecological diversity or ecosystem health, and potential for indirect to commercial fisheries. If unmanaged, the potential consequence of localised but medium-term impacts is assessed as Significant (3).

Given the environmental conditions in the Operational Area, the mobile nature of the survey and support vessels and the implementation of the identified controls (Section 8.8.4), the consequence is considered to be Significant (3) and the likelihood of IMS being introduced and subsequently becoming established is reduced to Very Unlikely (1), resulting in a *Low* level of residual risk.

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

8.8.2 Decision Context

The decision context for the potential introduction of IMS has been assessed as ‘Type A’, given the impacts/risks are well understood, good practice is well defined, the conditions in the Operational Area is of limited environmental sensitivity with respect to IMS, and there is little or no stakeholder interest.

8.8.3 Risk Summary

Risk Ranking	Consequence	Likelihood	Risk Ranking
Inherent Risk	Significant (3)	Unlikely (2)	**Medium**
Residual Risk	Significant (3)	Very Unlikely (1)	**Low**

8.8.4 Identification of Control Measures and Demonstration of ALARP

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Legislative Requirements and Good Industry Practice			
Seismic vessel and support vessels will have Department of Agriculture and Water Resources biosecurity clearance prior to mobilising to the Operational Area.	Yes	Vessels are required to submit a pre-arrival report prior to entering Australian territorial waters, and obtain Department of Agriculture and Water Resources (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.	15.1
Vessels will also have an anti-fouling system that is compliant with the prescriptions of 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.	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.	15.2
Compliant with the Australian Ballast Water Management Requirements, vessels will manage ballast water exchange/discharge using one of the following approved methods of management including:	Yes	Once in the Operational Area, vessels are not anticipated to exchange/discharge ballast water. Any requirement to do so will comply with the Australian Ballast Water Management Requirements, which are consistent with international good practice and the Ballast Water Management Convention.	15.3

Control Measure	Control Adopted	Justification	Performance Standard Ref.
■ an approved ballast water management system ■ ballast water exchange conducted in an acceptable area * ■ use of low risk ballast water (e.g. fresh potable water, water taken up on the high seas, water taken up and discharged within the same place) ■ retention of high-risk ballast water on board the vessel ■ discharge to an approved ballast water reception facility *Acceptable area is as defined in the *Biosecurity (Ballast Water and Sediment) Determination 2017*.		Management of ballast water reduces the likelihood of IMS being introduced to the Operational Area by preventing the exchange of high risk ballast water.	
Vessels will have an approved Ballast Water Management Plan (BWMP) and valid Ballast Water Management Certificate (BWMC), unless an exemption applies or is obtained from DWAR.	Yes	In accordance with the Australian Ballast Water Management Requirements, vessels will have a BWMP that details the approved ballast water management method. A BWMC verifies the vessel has been surveyed to a standard compliant with the Ballast Water Convention. Management of ballast water reduces the likelihood of IMS being introduced to the Operational Area by preventing the exchange of high risk ballast water.	15.4
Vessels will maintain complete and accurate records of ballast water exchange that complies with Section B, Regulation B.2. of the Annex to the Ballast Water Convention.	Yes	Records identify when ballast water is taken on board; circulated or treated for ballast water management purposes; and discharged to the sea or a reception facility; and accidental or other exceptional discharges of ballast water. Ballast water records will be used to confirm that ballast water management is undertaken in accordance with the Australian Ballast Water Management Requirements, as detailed above.	15.5

Control Measure	Control Adopted	Justification	Performance Standard Ref.
Biofouling risk assessment	Yes	A biofouling risk assessment will be completed for each vessel mobilised from overseas or from other regions in Australia prior to mobilising to the Operational Area. 3D Oil will use the Biofouling Risk Assessment Tool 'Vessel Check' developed by the WA DPIRD (or equivalent). The assessment will consider hulls, niche areas, seawater systems and immersible equipment. Mitigation will be implemented that is commensurate to the level of risk, as appropriate to ensure the vessel and equipment poses a low risk of introducing IMS. For vessels determined to have a LOW biofouling risk, the vessel is deemed suitable for use in the Sauropod 3D MSS without corrective actions. For vessels determined to have a MEDIUM or HIGH risk, the vessel contractor will need to engage a qualified independent third-party marine pest inspector to determine the corrective actions to reduce the vessel IMS risk to low. The vessel contractor must demonstrate to 3D Oil that all corrective actions have been implemented and reassessment of the vessel prior to mobilisation determines the risk to be low. This control and implementation of any associated corrective actions will reduce the likelihood of IMS translocation and establishment from biofouling.	15.6
Alternatives/Substitutes Considered			
No discharge of ballast water from vessels.	No	Although, ballast water exchange is not expected to occur during routine survey activities, the possibility of discharge or exchange cannot be ruled out completely. Ballast water exchange and uptake may be required in unexpected circumstances where the safety of persons on board the vessel is a necessity. Ballast water will already be managed in accordance with the Australian Ballast Water Management Requirements and the likelihood of introducing IMS via ballast water is highly unlikely. The control is not practicable to implement and is	N/A

Control Measure	Control Adopted	Justification	Performance Standard Ref.
		grossly disproportionate to the limited environmental benefit that would be gained in addition to existing controls.	
Additional Controls Considered			
Hull cleaning and/or new antifouling coat application to vessel hull and niche areas on every occasion prior to entry into the NWMR.	No	Given the existing control measure to undertake a biofouling risk assessment, this control measure may not be commensurate to the level of risk. Should the risk assessment determine a vessel to have a medium or high IMS risk from biofouling, further inspections or cleaning may be implemented. However, the cost of undertaking inspections and hull cleaning could range from tens to hundreds of thousands of dollars. This is not practicable to implement in all cases and is disproportionate to the level of risk if the existing risk profile for a vessel is already low.	N/A
All towed seismic equipment (source and streamers) has been removed from the water, inspected and cleaned (where required) prior to deployment in the NWMR.	Yes	Transfer of immersible equipment will result in equipment being stored out of water, which reduces the potential for marine fouling to survive transport. Equipment will also be inspected and cleaned prior to deployment in Australian waters, which reduces the risk of introducing IMS and also increases performance of the equipment.	15.7
Improvements Considered to Effectiveness of Controls (functionality, availability, reliability, survivability, independence and compatibility)			
No further improvements have been identified that can practicably reduce the level of risk.	N/A	N/A	N/A
ALARP Statement			
3D Oil considers the adopted control measures appropriate to manage the impacts and risks of IMS. As the impact/risk has been classified as 'Type A', all legislative and good practice controls, as well as additional controls have been identified that further reduce the impacts and risks, without jeopardising the objectives of the survey, the impacts and risks are considered to be ALARP.			

8.8.5 Demonstration of Acceptable Levels

Context	Factor	Demonstration
Internal	3D Oil Policy	The risk management strategy for managing the potential to introduce IMS, reflects 3D Oil's HSE Policy goals of proactively identifying hazards, eliminating impacts where possible and, where this is not possible, managing the risk to ALARP.
	Company Standards/Systems	Section 9 details the relevant management system processes adopted to implement and manage impacts/risks to ALARP: ■ Contractor & Supplier Management (Section 9.7); ■ Environmental Performance Monitoring & Reporting (Section 9.13).
External	Natural Environment	**Natural environmental setting of the Sauropod 3D MSS** The water depths and environmental conditions within the Sauropod 3D MSS Operational Area present limited potential for the introduction and establishment of IMS and the residual risk is low.
		EPBC Policy Statement 1.1. – Significant guidelines The residual risk has been assessed as low, and will not have a significant impact upon protected matters in accordance with EPBC Policy Statement 1.1. – Significant guidelines.
		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 No IMS impacts are predicted to occur to the natural values within the AMPs.
	Relevant Persons Expectations	The Department of Agriculture and Water Resources responded during stakeholder consultation and outlined the need to comply with the requirements of the *Biosecurity Act 2016* and Australian Ballast Water Management Requirements. The Department also provided information on biofouling management. The control measures adopted meet the requirements of the *Biosecurity Act 2016*, the Australian Ballast Water Management Requirements and are consistent with the National Biofouling Management Guidelines.

Context	Factor	Demonstration
Legislation & Other	Legislation	The controls adopted will comply with the *Biosecurity Act 2016*, and the Australian Ballast Water Management Requirements.
Industry Standards	Industry Standards & Best Practices	The controls adopted with regards to anti-fouling coatings, biofouling risk assessment and corrective actions are consistent with the National Biofouling Management Guidelines.
Ecological Sustainability Development (ESD)	ESD Application	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 Sauropod 3D MSS.

Acceptability Statement

The impact assessment has determined that, given the adopted controls, the Sauropod 3D MSS is highly unlikely to result in the introduction of IMS. Further opportunities to reduce the risk have been investigated above.

The adopted controls described in Section 8.8.4, are considered industry best practice and meet legislative requirements. 3D Oil considers the adopted control measure to be appropriate to manage the activity to an acceptable level.

8.8.6 Environmental Performance Outcomes, Standards and Measurement Criteria

Performance Outcomes	Performance Standards	Measurement Criteria
EPO 15 Prevent the introduction and establishment of IMS in the marine environment as a result of the Sauropod 3D MSS	**PS 15.1** 3D Oil verify that vessel contractors comply with pre-arrival reporting obligations defined in the *Biosecurity Act 2015* and that biosecurity clearance / low risk status is obtained from DWAR prior to mobilisation to the Operational Area.	**MC** Pre-mobilisation vessel audit confirms vessels have received ddocumentation of DAWR release from biosecurity control or low risk status.
	PS 15.2 All vessels have an anti-fouling system that complies with the requirements of Annex 1 of 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.	**MC** Pre-mobilisation vessel audit confirms vessels have current anti-fouling certification that complies with the stated convention, Act and Marine Order.
	PS 15.3 Vessels operating within Australian seas manage ballast water discharge in accordance with the Australian Ballast Water Management Requirements using one of the following approved methods of management including: ■ an approved ballast water management system; ■ ballast water exchange conducted in an acceptable area*; ■ use of low risk ballast water; ■ retention of high-risk ballast water on board the vessel; ■ discharge to an approved ballast water reception facility; *Acceptable area is as defined in the *Biosecurity (Ballast Water and Sediment) Determination 2017*.	**MC** Pre-mobilisation vessel audit confirms vessels have a BWMC and BWMP that provides for ballast water management in accordance with the Australian Ballast Water Management Requirements. Ballast water records confirm that ballast water management was undertaken in accordance with the Australian Ballast Water Management Requirements.
	PS 15.4	**MC** Vessels have a BWMP and BWMC on board.

Performance Outcomes	Performance Standards	Measurement Criteria
	Vessels have an approved BWMP and valid BWMC, unless an exemption applies or is obtained from DWAR.	
	PS 15.5 Vessels maintain complete and accurate records of ballast water exchange that complies with Section B, Regulation B.2. of the Annex to the Ballast Water Convention.	**MC** Records demonstrate the ballast water exchange records are maintained.
	PS 15.6 A biofouling risk assessment, in accordance with WA DPIRD 'Vessel Check' (or equivalent) is completed for all MSS vessels mobilising from overseas or from other bioregions of Australia, prior to arrival within the NWMR. Where required, mitigation measures commensurate to the risk are implemented to ensure the vessel risk profile is reduced to 'Low' in accordance with WA DPIRD 'Vessel Check' (or equivalent).	**MC** Vessel-specific biofouling risk assessment (WA DPIRD 'Vessel Check' or equivalent) confirming the vessel presents a low risk and records of mitigation measures implemented (if required).
	PS 15.7 The seismic source and towed streamers have been removed from the water, inspected and cleaned (where required) prior to deployment in the NWMR.	**MC** Pre-mobilisation vessel audit confirms seismic source and towed streamers have been removed from the water, inspected and cleaned (where required).

9. IMPLEMENTATION STRATEGY

9.1 Environmental Management System

9.1.1 Management System Arrangements

The design and execution of the Sauropod 3D MSS will be conducted under the framework of the 3D Oil HSE Policy (refer to Appendix E). As part of contract award, 3D Oil will review the management system of the seismic/vessel contractor against ISO14001 requirements as it relates to the implementation of EP commitments for the Sauropod 3D MSS (i.e. a gap assessment). Key components of the system, which will be assessed will include:

- Planning:
  - Contractor HSE Policy;
  - Contractor organisation including roles, responsibilities and resourcing levels (particularly with respect to EP control measure implementation);
  - Environmental hazard & risk assessment process; and
  - Emergency response (including oil spill) preparedness and response arrangements.
- Implementation:
  - Operational procedures available to support environmental management of hazards (including equipment specifications and preventative maintenance system);
  - Management of change procedures;
  - Crew training needs analysis requirements and training records[3];
  - Vessel induction requirements; and
  - Work activity assessment and management (e.g. Permit-to-Work, Toolbox Meeting, standard operating procedures).
- Monitoring and measuring:
  - Incident reporting, investigation and corrective action management process;
  - HSE Inspection and corrective action management process; and
  - Emission/discharge monitoring process.
- Review:
  - Audit procedures/schedule and corrective action management; and
  - HSE review and continuous improvement action items.

Both marine and seismic crews operate under a campaign-specific HSEQ Plan, which details the relevant procedures addressing environmental management elements detailed above. 3D Oil recognises that due to the short duration of the Sauropod 3D MSS and the crew familiarity with the ship-based systems, contractor processes should be utilised wherever possible. However, to ensure that the specific requirements of the Sauropod 3D MSS EP are integrated and implemented into contractor systems, gaps identified during the assessment of the contractor's management system, will be documented and implemented via the Sauropod 3D MSS Project Specific HSEQ Plan, which will function as a bridging document. This document will define the agreed procedures and additional/supplemental requirements to be adopted within the contractor system during the Sauropod

[3] Particular emphasis will be placed on those positions responsible for implementing critical control measures to manage environmental impact/risk (e.g. MFOs).

3D MSS. The document will be agreed and endorsed by 3D Oil and the seismic/vessel contractor. Particular attention will be given in the bridging document to:

- The utilisation of 3D Oil's Risk Management Framework as provided in Section 6 for the assessment of environmental risks[4] by 3D Oil, and the use of this EP's Environmental Risk Register for the Sauropod 3D MSS;
- Identification of crew positions responsible/accountable for the implementation of control measures identified within this EP (i.e. control measure 'custodians'). Information provided to these positions will include the required control measure performance standard, recording and notification requirements if standards are not maintained/met[5] and delivery of records to verify performance (and effectiveness);
- Identification of 'reportable incidents' to be observed for the Sauropod 3D MSS. This will include the required internal notification/reporting requirements to meet regulatory notification and reporting timeframes and incident investigation requirements;
- Identification of vessel inspection programs included as a 'control measure' in this EP, ensuring the scope of the inspection addresses the relevant performance standard requirement;
- Identification of EPSs for the Sauropod 3D MSS and the required recording and reporting, via the vessel's incident management process, where EPSs are not achieved;
- Identification of crew positions who maintain records (e.g. oil record book, incident records) to quantify emissions and discharges (during normal and incident/emergency events) during the Sauropod 3D MSS and the requirement to provide these records to the 3D Oil Offshore Representative;
- Ensuring all corrective actions/opportunities for improvement arising from incidents, audits, inspections, monitoring events are documented in the Vessel's on-board Vessel Action Tracking System and monitored for closure by the Party Chief and 3D Oil Offshore Representative in accordance with the vessel's corrective action close-out procedure;
- Events associated with the survey which may result in a change in the activity scope and may trigger a revision to the NOPSEMA accepted EP (refer Section 9.10);
- Oil spill response arrangement for the Sauropod 3D MSS, which must be observed (refer Section 9.6) and the pre-survey activities to be conducted.

9.1.2 Implementation Strategy Methodology

3D Oil shall adopt the following methodology to ensure compliance with this EP:

- **Pre-survey audits:** Pre-survey audits and information provision from the seismic contractor will determine 'hardware' and procedural compliance of the seismic contractor and vessels engaged to the EP requirements prior to survey;
- **Sauropod 3D MSS Project-Specific HSEQ Plan:** The vessel contractor management systems will be bridged with project-specific Sauropod 3D MSS EP requirements. Control measure 'custodians' will be identified for relevant control measure implementation and a daily report provided to the 3D Oil Offshore Representative on compliance and effectiveness (as relevant);
- **Environmental inductions:** An environmental induction program will advise all survey personnel of relevant environmental sensitivities; identified environmental impacts and risks, their EPOs/EPSs and relevant incident reporting requirements if not achieved; and 'reportable incidents' (refer to Section 9.12);

[4] Safety and health aspects of the project will be assessed in accordance with the Contractor's risk framework.

[5] Crew position will be advised that this is a 'recordable incident' with required notification to the 3D Oil Offshore Representative.

- **Daily performance reviews:** During the Sauropod 3D MSS, the 3D Oil Offshore Representative shall collate daily environmental parameters (e.g. waste streams, maritime compliance, cetacean mitigation and incident reporting outcomes) to determine EPO/EPS attainment and control measure implementation;
- **Compliance audit and review:** The 3D Oil Offshore Representative will undertake an EP Compliance Audit and an EP implementation review against the Sauropod 3D MSS Project Specific HSE Plan to determine the effectiveness of the 'bridged' 3D Oil requirements into the Contractor's management system;
- **Environmental performance reporting:** The 3D Oil Offshore Representative will obtain all relevant records to provide verification of discharges, incidents, etc. at the completion of the survey to be reported in the Sauropod 3D MSS Environmental Performance Report and submitted to NOPSEMA three months after the completion of the Sauropod 3D MSS.

A Master Listing of Commitments will be generated from this EP on acceptance and refined as part of the review of the selected Contractor's management system, identifying the responsible person for implementing the requirement; when the requirement shall be implemented or information obtained; and whether the requirement requires ongoing monitoring by the 3D Oil Offshore Representative during the survey. Ongoing monitoring tasks will form the basis of a daily checklist for collation by the 3D Oil Offshore Representative.

9.2 Organisation Structure

3D Oil is responsible for ensuring that the proposed Sauropod 3D MSS is managed in accordance with this EP. The selected seismic/vessel contractor will undertake the seismic survey under contractual arrangement with 3D Oil and is required to implement and comply with all environmental commitments contained within this EP.

The organisation reporting structure for the survey is provided in Figure 9-1.

The Vessel Master (or a delegated Officer of the Watch) on-board the seismic vessel is responsible for maintaining control of all vessel operations (including support and chase vessels) associated with the Sauropod 3D MSS and for establishing/maintaining communication with other vessels and marine traffic during the survey.

The support vessels shall abide by all instruction from the seismic vessel and communicate with other marine traffic during the Sauropod 3D MSS.

All vessels will be capable of communicating and operating on both dedicated UHF working channels and maritime VHF working channels.

9.3 Roles and Responsibilities

Roles and responsibilities relating to the implementation of this EP are provided in Table 9-1.

Roles and responsibilities as they relate specifically to Oil Spill Response are detailed in the Sauropod 3D MSS Oil Pollution Emergency Plan (OPEP).

During contract award and on evaluation of the Contractor's management system, specific on-board positions will be identified who are responsible for specific control measure implementation.

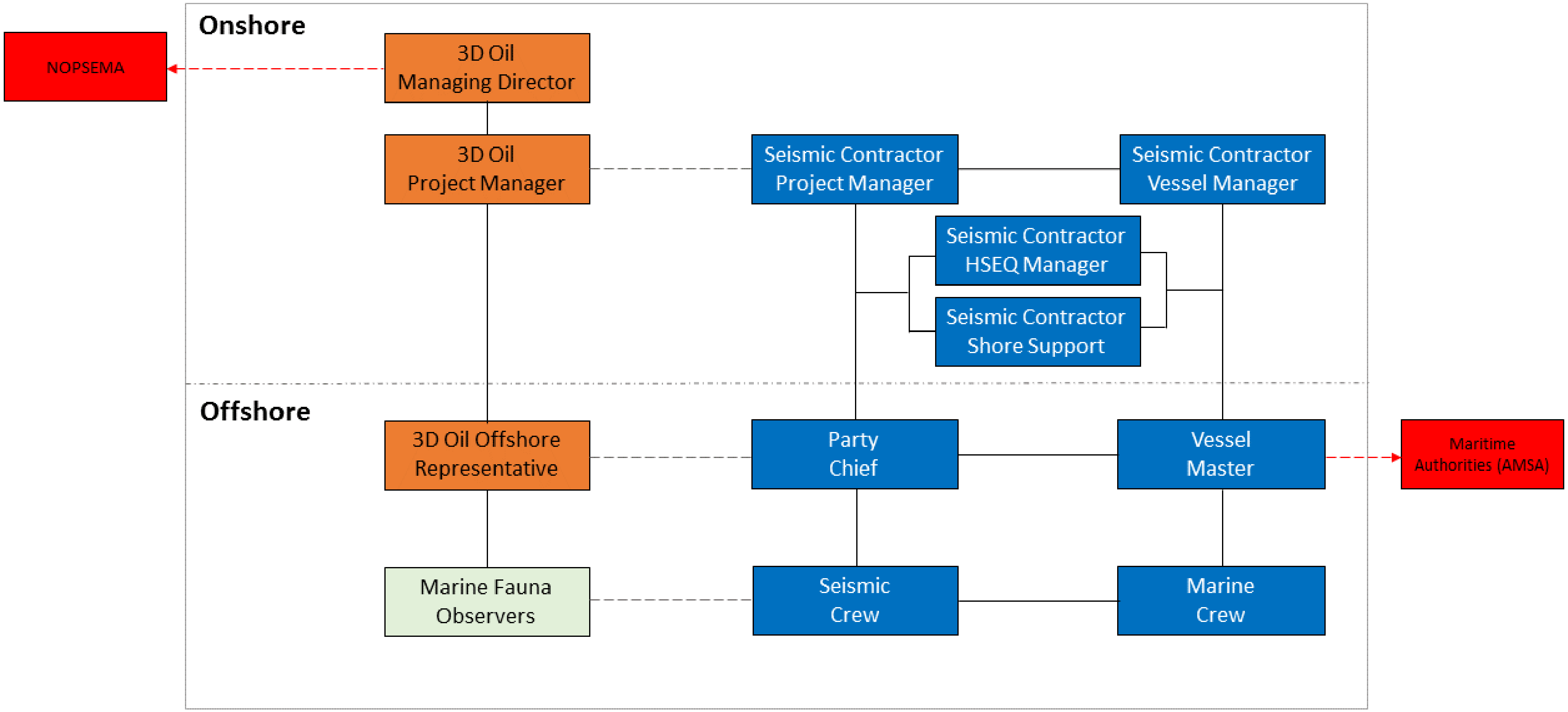


Figure 9-1 Sauropod 3D MSS Organisation Structure

Table 9-1 Roles and Responsibilities

Role	Responsibilities
3D Oil	
3D Oil Managing Director	The 3D Oil Managing Director (MD) has overall accountability for the implementation of this Sauropod 3D EP and the delivery of environmental performance outcomes for the survey. This person is accountable for the: ■ Seismic contractor and vessel selections, which meets the requirements of this EP; ■ All statutory approvals have been obtained for the activity; and ■ All relevant reporting and notification activities are undertaken for the Sauropod 3D MSS.
3D Oil Project Manager	The 3D Oil Project Manager oversees the routine operation of the vessel, including the operations of the contractors and has overall responsibility for ensuring that all policies/procedures are implemented and the scope of the seismic survey is completed. This position ensures that: ■ Regulatory approvals obtained for this activity are distributed to appropriate project personnel and relevant authorities (as identified in this EP); ■ The petroleum activity is monitored for change, which may trigger an Environment Plan revision; ■ Appropriately qualified and experienced MFOs are engaged for the activity; ■ All seismic activity incident notification(s) and associated reports to NOPSEMA, NOPTA, DMIRS and Director of National Parks (DNP) (including reportable environmental incidents and environmental performance close-out report) are fulfilled; ■ Provision of weekly seismic activity reports to NOPTA; ■ A full briefing and induction of project personnel is undertaken to ensure an understanding of the environmental sensitivities of the survey area, the environmental management procedures and commitments detailed in the EP and individual responsibilities; ■ Consultation activities associated with the seismic program to relevant government agencies and marine stakeholders in advance of operations commencing, during and after the completion of the survey; ■ All necessary program-specific procedures are developed and implemented prior to the commencement of the survey; ■ Monitors for legislative or environmental change which affects the impact and risk assessment associated with the Sauropod 3D MSS; ■ Coordinates necessary management of change activities and associated risk assessments; ■ Ensures a pre-mobilisation vessel inspection, oil spill response exercise and oil spill response capability audit is undertaken prior to survey commencement; ■ Implements a monitoring program (scientific) (as necessary) to monitor oil impacts to environmental sensitivities (wildlife, water quality) in the event of a Level 2 spill if oil

Role	Responsibilities
	is detected at levels which may cause environmental impact to the particular sensitivity; and ■ Undertakes HSE review at the completion of the program and develops a 'lessons-learnt' listing.
3D Oil Offshore Representative	The 3D Oil Offshore Representative will be located on-board the seismic vessel and is responsible for the oversight and reporting on the day-to-day conduct of the program by the seismic contractor. The 3D Oil Offshore Representative verifies that the seismic contractor is undertaking operations in a manner consistent with the performance outcomes and environmental management procedures detailed in this EP. This position ensures that: ■ Day-to-day activities are monitored for compliance against this EP and the outcomes reported to the 3D Oil Project Manager; ■ The 3D Oil Project Manager is immediately alerted to any changes in operations, which could impact negatively on environmental performance or for changes in operation which alter the environmental risk profile of the activity; ■ Maintains full awareness of ongoing operations, including status of EPOs/EPSs and control measure performance providing the necessary reports to the 3D Oil Project Manager; ■ Data and records are collected for the Environmental Performance Close-out Report; ■ Monitors for control measure implementation and associated 'performance standard' compliance; ■ Collates information for monthly recordable incident report and provides information to the 3D Oil Project Manager; ■ All on-board personnel have had a program environmental induction; ■ All reportable incidents are reported to the 3D Oil Project Manager; ■ An EP compliance audit is conducted during the survey; ■ A review of the effectiveness of the 'bridged' Contractor management system with Sauropod 3D MSS Environment Plan requirements (i.e. delivering EPOs and environmental performance standards) identifying opportunities for improvement.
Marine Fauna Observer(s)	Marine Fauna Observer(s) (MFOs) act as 3D Oil's environmental representatives on-board the vessel with respect to marine fauna interactions. This includes: ■ Ensures approval requirements outlined in this EP with regard to minimising disturbance to fauna are adhered to on-board the vessel; ■ Communicates directly with the Vessel Master and Seismic Crew regarding fauna sightings and required mitigation procedures (e.g. seismic source shut down); and ■ Submitting daily fauna sighting and mitigation reports to the 3D Oil Project Manager.
Seismic Contractor	
Project Manager	The seismic contractor's Project Manager is responsible for the overall coordination and implementation of the survey in accordance with the scope of the Sauropod 3D MSS. This person is the seismic contractor's principle point of contact for 3D Oil. In communication with the Vessel Manager and Party Chief, and with support from the

Role	Responsibilities
	HSEQ Manager and Shore Support team, their key responsibilities in relation to the EP include: ■ Supporting the 3D Oil Project Manager in the implementation and communication of the Sauropod 3D MSS EP and Project-Specific HSEQ Plan; ■ Ensure latest copies of all survey-related documentation are available and on-board all vessels involved in the survey, including support/chase vessel; and ■ Ensure all offshore personnel are available for project inductions and are signed-off accordingly.
Vessel Manager	The Vessel Manager is responsible for coordinating the seismic vessel and support vessels for the survey, including: ■ Vessel compliance to HSEQ plan, ISM code, local, flag state, port state and class requirements for assigned vessels; ■ Vessel pre-arrival reporting and biosecurity/port/customs clearances prior to mobilisation of the vessels to the Operational Area; ■ Assessment and management of vessel biofouling risk; and ■ Investigate maritime incidents and ensure that corrective actions are identified and implemented.
Party Chief	The Party Chief is responsible for strict observance of the Health, Safety and Environmental Management System (HSEMS) on-board the vessel and supports the Master in the following aspects of the operation: ■ Implements the vessel HSEMS on-board; ■ Reports all incidents and near-misses, recording the details and taking initial actions to render the situation safe; ■ Ensures the procedures and work instructions required for seismic operations are known, understood and followed; ■ Ensures tool-box meetings area carried out; ■ Ensures new employees receive inductions, training and are appropriately supervised; ■ Ensures HSE inspections are undertaken; ■ Ensures that all working codes and practices are implemented for all survey operations in accordance with recognised standards; ■ Ensures that prompt action is taken in order to rectify any deficiencies in working practices or conditions; ■ Ensures active participation in HSE meetings by survey crew; ■ Communicates all deficiencies of operation with the 3D Oil Offshore Representative; and ■ Investigates all incidents along with the Safety Officer, Master and 3D Oil Offshore Representative.
Vessel Master	The Seismic Vessel's Master has ultimate responsibility for the safe execution of all vessel operations including:

Role	Responsibilities
	■ Conduct vessel operations in accordance with this EP; ■ Compliance of the vessel with all regulatory (international and local) requirements; ■ Notification of vessel movements to AMSA JRCC; ■ AMSA notifications associated with vessel or streamer (loss) incidents; ■ Ensure safety critical equipment and spill kits on board the vessel are maintained and compliant with regulatory requirements; ■ Implement the vessel's SOPEP in an emergency; ■ Notifications to other marine users associated with incidents; ■ All vessel-related emergency drills and training are undertaken; ■ Auditing is undertaken as required by vessel procedures; ■ Equipment is maintained to statutory requirements or better; ■ All statutory records (oil record book, garbage record book, ODS Book, BWM records, etc.) are maintained; ■ All HSE related procedures and work instructions are known, understood and followed; ■ All new employees are provided with induction, job familiarisation and specific obligations with respect to HSE participation; ■ All marine crew have minimum HSE training and are competent in marine activities; and ■ Safe working codes and practices are implemented for all vessel operations in accordance with recognised standards and policies.
Seismic Crew	The Seismic Crew operate the survey equipment. They are responsible for: ■ The deployment and recovery of all seismic equipment: ■ Operate the seismic source and record seismic data during the survey. ■ Planned and continued maintenance of all towed equipment to ensure there is minimum risk of electrical/mechanical failure, which might result in the loss of equipment during deployment, acquisition and recovery; ■ The seismic crew also form the small workboat crew[6] to conduct the in-water maintenance on the streamer spread and the streamer depth control, steering, position and emergency recovery units, also clearing any debris entanglements with the streamers. The seismic crew consists of four departments: ■ Navigation: Responsible for the surface and sub-surface positioning of equipment, survey planning and execution. They are the communication hub during all operations for acquisition, deployment, recovery, in water maintenance or emergency. The department minimises the amount of time in acquiring survey data;

[6] All workboat operations are conducted during appropriate weather conditions; have appropriate lighting; and the boat complies with all international requirements for small boat operations for safety, navigation and lighting. The small workboat, when not utilised for these operations is located on-board the seismic vessel.

Role	Responsibilities
	■ Recording: Responsible for the safe deployment and recovery of the streamer spread and all streamer units controlling depth, steering, positioning and emergency recovery. This department is also responsible for the streamer and towing harness integrity and the planned maintenance of these items; ■ Source: Responsible for the safe deployment, recovery, planned maintenance and operation of the acoustic source. This department maintains, deploys and recovers the barovanes used to separate the streamers and assists with the operation during the deployment and recovery of streamers; and ■ Processing: Responsible for the quality control of the seismic data acquired and are able to quantify in near real-time whether the data is achieving the objective negating the need for additional work in the same area.
Marine Crew	The Marine Crew operate the vessel, performing duties in the engine room, galley and accommodation services, internal/external decks, small boats and bridge. ■ The bridge watch offices and crew are responsible for: ■ Safe navigation, including 360˚ watch/lookout, radar monitoring and AIS monitoring; ■ On-the water communication with other vessels via radio and telephone; and ■ Monitoring of all vessel internal communications, integrated safety and emergency alarm systems and indicators.

9.4 Training and Awareness

The seismic contractor will be experienced with regard to the proposed seismic activity and their suitability to undertake the proposed works will be evaluated as part of the project planning phase (contract award).

9.4.1 Induction

In addition to the vessel induction, all personnel on-board the survey vessels will be made aware of relevant environmental matters to achieve the required Sauropod 3D MSS EPOs via an environmental induction prior to commencement on the survey. Induction material will include:

3D Oil HSE Policy;

- Importance of conforming with the EP and associated regulatory requirements;
- The location of environmentally sensitive areas in proximity to the Operational Area;
- Potential environmental hazards and required controls to minimise impacts associated with the survey;
- Environmental performance outcomes, performance standards, measurement criteria and requirements contained within this EP;
- Reportable and recordable incidents associated with the Sauropod 3D MSS;
- Personnel roles and responsibilities with respect to implementation of nominated controls in this EP; and
- The emergency and oil spill response arrangements for the Sauropod 3D MSS.

A record of inductions will be maintained with endorsement of personnel who attended. These records shall be provided to 3D Oil Offshore Representative as soon as possible after induction activities.

Note support vessel crews will be provided with awareness training particularly with respect to their role and requirements outlined in this EP.

9.4.2 Competency and Ongoing Awareness

3D Oil will ensure that all MFOs engaged for the survey have appropriate qualifications and experience to undertake reliable marine mammal observation activities.

The Seismic Contractor will provide offshore personnel that are trained and competent to undertake their respective activities on-board the seismic vessel. All marine personnel will be qualified, as required, in accordance with the International Convention on Standards of Training Certification and Watch Keeping for Seafarers (STCW95).

All seismic contractor employees will be inducted into the Vessel's HSEMS and specific responsibilities will be detailed in position job descriptions. Appropriate training is provided to individuals with specific environmental responsibilities).

The following ongoing activities serve to reinforce environmental awareness during the seismic program:

- **Project Kick-off Meeting** which is held at the start of each project and reviews the contractual and HSE specifications for the activity, scope of work, Sauropod 3D MSS HSE/Project Plan, survey hazards and risks. This meeting is attended by the 3D Oil Project Manager, 3D Oil Offshore Representative, contractors and sub-contractor's representatives, Vessel Master, Party Chief and marine/survey crews;
- **On-board Daily Meeting** which reviews all survey operations and reviews incidents of the previous day. This meeting is attended by the 3D Oil Offshore Representative, Party Chief, Vessel master and relevant marine/survey crews;
- **On-board HSE Committee Meetings** attended by all on-board management positions and held each five weeks. In addition, two full crew safety meetings and one departmental meeting (per department) is held within this period. These meetings review all HSE issues against plan requirements, review the Action Point list arising from incidents and inspections and prepare, in close liaison with all relevant parties, an action plan to facilitate continuous improvement in performance;
- **Toolbox Meetings** attended by all personnel involved in a specific operation's (before mobilisation, operations involving major hazards and operations involving more than one person). This meeting reviews the activity and reinforces appropriate measures to be adopted to prevent environmental and safety impacts.

Records are produced for each of these meetings.

9.5 Communication and Consultation

9.5.1 Internal Communications

The Seismic Contractor will be responsible for keeping its workforce informed about environmental issues. The Party Chief acts as a focal point for personnel to raise environmental issues, and consults/involves all personnel in the following:

- Issues associated with the implementation of the EP;
- Any proposed changes to equipment, systems, or methods of operation of plant, where these may have environmental implications; and
- Any proposals associated with continuous improvement of environmental protection, including the setting of environmental objectives and training schemes.

Regular HSE meetings will be held on the seismic vessel. The issues discussed and actions taken will be recorded. The minutes of each meeting, including action items from the meetings, will be made available to all personnel.

Other forms of internal communication include toolbox meetings, which occur before every critical or unfamiliar job. This meeting includes all personnel involved in the task and will include aspects such as spill prevention requirements, etc.

9.5.2 Ongoing Stakeholder Consultation

Stakeholder consultation will be ongoing during the planning and activity stages of the Sauropod 3D MSS. Consultation previously undertaken with relevant stakeholders is summarised in Section 5.4.

9.5.2.1 *Review of Relevant Stakeholders*

3D Oil will continue to identify relevant persons, consistent with the relevance categories outlined in Section 5.2, after acceptance of the EP. A review of relevant stakeholders will be undertaken during routine reviews of information relevant to the EP, as outlined in Section 9.8.

9.5.2.2 *Stakeholder Notifications*

In addition, 3D Oil will keep relevant persons up-to-date with activity status by sending periodic notifications to relevant stakeholders. Key milestones that trigger a notification include:

- EP public comment period;
- EP acceptance by NOPSEMA;
- Prior to survey commencement;
- Upon survey completion;
- In the event of a significant incidents (e.g. large fuel spill);
- If there is a change to the MSS activity scope that may affect the stakeholder interests, activities or functions;
- If a new or significant increase in potential impact or risk is identified that (after identification of additional control measures to manage those impacts or risks) may affect the stakeholder interests, activities or functions.

All notifications will include the relevant details of the activity including the activity title, location and contact details of the nominated EP liaison person.

Further details on specific notifications and timing are provided in Section 9.12.3.

9.5.2.3 *Assessment and Management of New Objections or Claims*

3D Oil shall assess the merits of any new claims or objections made by a relevant stakeholder whereby they believe the activity will have an adverse impact on their interests, activities or functions. If the claim has merit, where appropriate, 3D Oil may modify the management of the activity. The assessment will be done using the methodology detailed in this EP as detailed in Section 5.

If a change to the activity or controls adopted during the MSS occurs as a result of stakeholder consultation, the change will be managed in accordance with 3D Oil's Management of Change process (refer Section 9.10).

3D Oil shall endeavour to finalise the merits of any claim or objection received during the survey within one week of receipt and undertake any resulting management of change actions as soon as practicable, but preferably within the same timeframe.

The assessment of merit and any resulting management of change actions will be shared with the concerned stakeholder.

For objections and claims that do not hold merit, 3D Oil will respond to stakeholders providing reasoning and supporting information (as relevant) to support 3D Oil's conclusions.

9.6 Emergency Response

9.6.1 General Arrangements

Prior to the commencement of the Sauropod 3D MSS, 3D Oil and the Vessel Contractor shall develop the Sauropod 3D MSS (campaign-based) HSEQ Plan, which will review and bridge the emergency response arrangements between the Vessel Contractor and 3D Oil. The Sauropod 3D MSS HSEQ Plan contains instructions for vessel emergency, medical emergency, search and rescue, reportable incidents, incident notification and contact information.

In the event of an emergency of any type the survey vessel Master will assume overall onsite command and act as the Emergency Response Team (ERT) Coordinator (ERC). All persons aboard the vessel/s will be required to act under the ERC's directions. The survey vessel will maintain communications with the Vessel Manager and/or other emergency services in the event of an emergency. Emergency response support will be provided by the contracted Vessel Manager if requested by the ERC.

In any incident, the:

- Party Chief will notify the contracted Vessel Manager of any vessel-based incidents. The vessel contractors' ERG Leader (typically the shore-based Vessel Manager) will make an initial assessment and take actions in accordance with the vessel's Emergency Response Plan (ERP). The ERG Leader will notify the contractor organisation (as required), take appropriate action to control the situation and activate the ERG to provide emergency support (as required) to the vessel.
- 3D Oil Offshore Representative will contact the 3D Oil Project Manager, who will make contact with the contracted Vessel Manager, to confirm situational awareness and actions being taken to manage the emergency. 3D Oil will provide support to the shore-based contractor ERG where required.
- The Vessel Master is responsible for notifying maritime safety authorities (i.e. AMSA) in the event of a maritime safety/environmental emergency (e.g. oil spill). The 3D Oil Project Manager is responsible for notifying NOPSEMA, NOPTA, DMIRS and DNP of any reportable environmental incidents.

9.6.2 Oil Pollution Emergency Plan (OPEP)

The Sauropod 3D MSS OPEP, considering the nature and scale of the activity and the potential spill risks involved (refer Section 8), consists of the following:

- Survey vessel(s) SOPEP (for vessels over 400 GRT involved in the survey or equivalent for lesser tonnage vessels) that manage the environmental impacts of a spill and vessel-based operational monitoring; and
- 3D Oil Sauropod 3D MSS OPEP, which supports the individual vessel-based SOPEPs, details the interaction between contractor-related spill response plans and 3D Oil response arrangements.
- These response arrangements are consistent with, and supported by, the:
- National Plan for Maritime Environmental Emergencies (NATPLAN): Australian Maritime Safety Authority (AMSA) – has jurisdiction and is the Control Agency for vessel spills which affect Commonwealth waters.

- State Hazard Plan for Maritime Environmental Emergencies (State Hazard Plan): The WA Department of Transport (DoT) is the Control Agency for marine oil spills in WA state waters.

The seismic and support vessels (if > 400 GRT) IMO-accepted SOPEPs, prepared in accordance with IMO guidelines for the development of shipboard oil pollution emergency plans (resolution MEPC.54 (32) as amended by resolution MEPC.86 (44)), include oil spill response arrangements and provisions for testing the SOPEP (oil pollution emergency drills), as required under Regulations 14(8AA), 14(8A) and 14(8B) to 14(8E) of the OPGGER. Typical oil spill response actions for shipboard oil spills are contained in the Sauropod 3D MSS OPEP.

3D Oil will ensure that support vessels <400 GRT (that are not obligated legislatively to have a SOPEP), do have vessel-specific spill response plans (to an equivalent standard) that cover spill response arrangements. The SOPEP is designed to ensure a rapid and appropriate response to any oil spill and provide practical information required to undertake a rapid, effective response; and reporting procedures in the event of a spill.

Initial actions undertaken by a vessel in the event of a spill to limit environmental impacts, are detailed in the Sauropod 3D MSS OPEP.

9.6.3 Drills and Training (OPEP/SOPEP)

The OPEP will be tested:

- Prior to the survey commencing; and
- Following any significant amendment of the arrangements; and
- If and when a new vessel is engaged for the activity; and
- Not later than 12 months after the most recent test.

These arrangements for testing the OPEP are commensurate with the nature and scale of the worst-case oil spill scenario and the short duration of the survey.

Vessel-based SOPEP tests are undertaken by vessels routinely as per MARPOL Annex I (Regulation 15) requirements, and drill outcomes reviewed as part of the ongoing monitoring and improvement of emergency response control measures.

A desktop drill of the Sauropod 3D MSS OPEP, including the vessel SOPEP, will be conducted to assess the effectiveness of the arrangements, taking into account the nature and scale of the risk of a hydrocarbon prior to survey commencement. Specifically, the drill will test the following:

- Roles and responsibilities of those involved in oil spill response are clear and understood;
- Communication sequence from the vessel master to vessel-contractor onshore management and the Control Agency, including notification of the AMSA JRCC is adequate, current and includes all relevant details;
- Communication between the 3D Oil Offshore Representative and 3D Oil Project Manager and subsequent notification authorities is adequate and timely;
- Ensures Type 1 operational monitoring such as spill surveillance and tracking is appropriate, understood and practiced; and
- Equipment and procedures intended for source control on-board the vessels are available for use as outlined in the vessel SOPEP.

The outcomes of the Sauropod 3D MSS OPEP drill will be documented, reviewed and improvements identified (as needed). Should any inadequacies, altered contractual arrangements or improvements to arrangements be identified via testing, these corrective actions will be registered as a non-conformance (refer to Section 9.9) and the EP/OPEP will be amended for these items via a Management of Change process (refer Section 9.10). This is the responsibility of the 3D Oil Project

Manager. The 3D Oil Project Manager is responsible for assessing any changes to the OPEP against the criteria in OPGGS (E) Regulations - Regulation 17 (refer Section 9.11) and where necessary, the EP/OPEP submitted to NOPSEMA as a formal revision.

9.6.4 Maintaining Currency

3D Oil will monitor AMSA and DoT's published plans and should the plans change, 3D Oil will assess the implications of any changes on the OPEP arrangements as described in this EP.

Any change to the activity itself, or the potential and risks associated with it, will result in a review of the EP (including the OPEP) to ensure the measures in place remain suitable and there is not a significant increase in impact or risk (refer Section 9.9 and 9.10).

9.7 Contractor and Supplier Management

Seismic contractors considered for the Sauropod 3D MSS will be assessed against, and meet the following criteria:

- Compliance with all statutory requirements;
- Have an acceptable HSEC performance record in undertaking seismic activities;
- Provide evidence of resources and competency in the services to be provided;
- Services, procedures and vessel hardware comply with the requirements of this EP; and
- Any equipment to be used in the provision of survey services meets regulatory requirements, is fit-for-purpose and has all equipment, testing and verification certificates.

Specific requirements, which need to be assessed at tender evaluation stage includes:

- The acoustic source is confirmed to be 3,090 in^3 or less.

Specific requirements which needs to be assessed prior to vessel mobilisation to the Operational Area include:

- All vessels transiting from outside of the NWMR must be assessed for biofouling risk and have the relevant biosecurity clearance from DWAR (refer Section 8.8).

EP implementation activities with the selected seismic contractor have been described in Section 9.1.

9.8 Maintaining Environmental and Legislative Knowledge

9.8.1 Quarterly Review

Changes to the external environment will be identified by the 3D Oil Project Manager (or delegate) by:

- Subscribing to environmental websites such as the DoEE to obtain regular updates of Commonwealth environmental information (e.g. species listings, threat abatement/management plan issue and policy updates via RSS news feeds[7]); and
- Monitoring other key research websites on a quarterly basis to establish research, which may provide additional information on the Sauropod 3D MSS environment, or new science on species present, which might affect this EP assessment.

9.8.2 Prior to Survey

At least eight weeks prior to the survey, the 3D Oil Project Manager shall undertake pre-survey planning that will review and consider the following at a minimum:

- Stakeholder notification requirements as per Section 9.12;

[7] DoEE provides an RSS feed which lets people know when a certain website or part of a website is updated with new content.

- New issues or concerns raised by stakeholders;
- Changes to relevant legislation or regulatory guidelines;
- Existing information in relation to any component of the receiving environment described in Section 4 (including BIAs, AMPs);
- Search the NOPSEMA website and consult with geophysical companies and/or titleholders to determine the presence of other seismic operations overlapping the proposed Sauropod 3D MSS;
- Changes to commercial fishery license areas, fishery status, current fishing effort and licence holders overlapping the Sauropod 3D MSS area based on:
  - Status reports and available data sources such as FRDC, IMAS for fisheries and aquatic resources;
  - Information provided directly by fishers, WA DPIRD, and AFMA through the stakeholder consultation process;
  - Fishing locations; and
  - Spawning information relevant to key indicator species.
- Newly-available scientific literature;
- New acoustic source technology and justification for or against its implementation;
- Confirmation of emergency (oil spill) contacts.

If new information regarding the receiving environment relevant to the Sauropod 3D MSS area is present, then an internal risk assessment will be conducted as described in Section 9.9.

9.9 Impact and Risk Management

The 3D Oil Project Manager (as per Section 9.3) will ensure an internal risk assessment is conducted for the following trigger events associated with the Sauropod 3D MSS:

- Non-conformances suggest the specified control measures no longer adequately demonstrate that the environmental impact/risk of the activity is managed to ALARP;
- New developments in the scientific understanding of impacts and risks suggest the impacts and risks are no longer acceptable;
- New information regarding the receiving environment relevant to the Sauropod 3D MSS identifies a potential new or increase in potential impact or risk;
- New stakeholder objections or claims received that are assessed to have merit;
- EP changes as identified in Section 9.10.

Participants in the risk assessment workshop will be determined by the 3D Oil Project Manager based upon the scope of the review. The risk assessment methodology outlined in Section 6 of this EP will be adopted for risk assessment activities. This methodology includes the steps to identify, analyse and evaluate the risks and impacts of the activities being undertaken within the Sauropod 3D MSS Operational Area. The decision-making framework is designed to ensure that activities do not pose an unacceptable environmental risk and are ALARP and acceptable in accordance with AS/ANZ ISO 31000 Risk Management (Principles and Guidelines) and Oil and Gas UK Guidance on Risk Related Decision Making (2014). The process for identifying additional controls will follow the risk assessment methodology outlined in Section 6. Any opportunities for improvement identified in the internal risk assessment (i.e. new controls to be adopted) will be amended via Management of Change (refer Section 9.10).

All environmental impacts and risk assessments must include an ALARP and acceptability assessment against 3D Oil criteria.

Risk assessments will be documented and approved by the 3D Oil Project Manager.

9.10 Management of Change

For the Sauropod 3D MSS, the following activities will trigger a Management of Change (MoC) process:

- A new scope (e.g. timing, location or changes to operational details such as vessel type, equipment, processes or procedures), which has the potential to impact on the environment not assessed for environmental impact previously or authorised in existing management plans and procedures (responsibility of the 3D Oil Project Manager);
- Change to the existing activity, scope, equipment, process or procedures which have the potential to impact on the environment or interface with an environmental receptor (responsibility of the 3D Oil Project Manager);
- Changes in the external environment managed and monitored by the 3D Oil Project Manager (or delegate):
  - Provision of new information that differs to that included in this EP (such as potential changes in science surrounding impacts and risks from seismic activities or new environmental sensitivities within or adjacent to the survey area);
  - Issue of new regulatory requirements (i.e. AMP Management Plans);
  - Identification of KEFs, threatened or migratory species or critical habitats/BIAs not identified in the EP;
  - Identification of new stakeholder objections or claims that are assessed to have merit (refer Section 9.5.2).
- Non-conformances (audits, inspections, etc.) which identify control measures may no longer manage environmental impact/risk to ALARP or acceptable criteria. Non-conformances are monitored by the 3D Oil Offshore representative;
- Incidents which identify new or increased impacts and risks arising from activities not previously identified in the accepted EP. Incidents are monitored by the 3D Oil Offshore representative.

Any change to the Sauropod 3D MSS shall be directed to the 3D Oil Offshore Representative and the 3D Oil Project Manager for initial assessment. The change shall be assessed for environmental impact/risk in accordance with the 3D Oil risk methodology and any implications determined for the environment and associated regulatory document revisions.

A risk assessment will accompany any MoC with identified environmental impacts/risks in accordance with the 3D Oil Risk Management Process (refer Section 9.9).

For changes (e.g. additional controls, etc.) identified in the risk assessment process, if stakeholder interests, activities or functions are affected by the change, stakeholders will be advised and feedback invited on the proposed change.

Additional controls identified as part of the MoC shall be effective in reducing the environmental impact and risk to a level which is ALARP and acceptable; and meet the nominated EPOs and EPSs set out in the accepted EP for the activity. Note: Existing EPOs and EPSs cannot be altered from those set out in the accepted EP. If EPOs/EPSs cannot be met, a recordable or reportable incident will be registered for the activity.

9.11 EP Revision and Resubmission

Any new information, changes or updates considered via the MoC process (refer Section 9.10) will also 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 include the following:

17(1) New Activity, defined as a change to the extent that the regulatory levy category applied to the Sauropod 3D MSS would change.

17(5) Significant modification of the Sauropod 3D MSS activity or to how the activity is being managed and conducted. Modification to the activity or management system that 3D Oil consider to be significant include but are not limited to:

- The total acoustic source volume and dB output is increased beyond that defined in this EP; or
- The vessel fuel type changes from that described in this EP; or
- The 3D Oil Environmental Management System (Section 9.1) is altered to the degree that the overall activity or a potential impact or risk of the activity can no longer be managed to ALARP or acceptable levels or in accordance with relevant EPOs and EPSs.

17(5) New stage of the activity, defined as either:

- A change to the spatial limits of the activity (an increase in the geographical extent of the Sauropod 3D MSS Operational Area); or
- A change to the temporal limits of the activity (an extension to the acquisition timeframe or EP timeframe specified in this EP).

17(6) New or increased environmental impact or risk. Only significant new or significant increased impacts or risks (following identification of additional control measures) require resubmission of the EP to NOPSEMA.

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).

Minor revisions to the Sauropod 3D MSS EP that do not require resubmission to NOPSEMA will be made when:

- Minor administrative changes are identified that do not impact on the environment (e.g. document references, contact details, etc.
- A review of the activity/change and the environmental impacts and risks of the activity/change do not trigger a requirement for revision under the OPGGS (E) Regulations (Regulation 17 and Regulation 18).

Where amendments are made to the accepted EP/OPEP via the 3D Oil MoC process, revisions made will be justified, tracked and a comprehensive record of the revision made for each change. This includes all risk assessments associated with MoC activities.

9.12 Notifications and Reporting

9.12.1 Internal Incident Notifications and Reporting

9.12.1.1 *Activity Reports and Key Performance Indicators:*

The Daily Seismic Survey Report is distributed to 3D Oil by the seismic contractor.

The Weekly Seismic Survey Report will be submitted to NOPTA at reporting@nopta.gov.au by the 3D Oil Project Manager.

The 3D Oil Offshore Representative and the MFOs will be responsible for recording compliance against this EP and for sending daily HSE reports to 3D Oil outlining the status of the survey as well as information against environmental performance as covered in this EP.

9.12.1.2 *Incident Reporting & Investigation*

All environmental incidents (including any environmental incident and near miss) on-board the seismic or support vessels are reported and investigated in accordance with the vessel's Incident Reporting and Investigation Procedure. The Party Chief is responsible for forwarding any incident to the 3D Oil Offshore Representative on-board. All environmental incidents, including non-compliances with the EPOs and EPSs, will be communicated immediately to 3D Oil's Project Manager to confirm external notification requirements.

Incident investigations will be undertaken commensurate with the significance of the incident. Incident investigations are initiated and closed-out in a timely manner; and learnings associated with incidents communicated to all parties on-board. The Party Chief and 3D Oil Offshore Representative (or delegate) will lead incident investigation activities into the cause of the incident/non-compliance.

All corrective actions arising from incidents, audits and inspections are recorded on the seismic vessel's on-board action tracking system and monitored for closure by the Party Chief and 3D Oil Offshore Representative. Corrective and preventative actions taken to eliminate the cause of potential incidents will be commensurate with the magnitude of the environmental risks. 3D Oil will carry forward the identified corrective/preventative actions from incidents for consideration in future seismic 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 MSS operations.

9.12.2 External Incident Notification and Reporting

9.12.2.1 *Recordable and Reportable Incidents*

The Commonwealth OPGGS (E) Regulations - Regulation 4 defines the following incident types:

- **Recordable incident:** An incident arising from the activity that breaches an EPO or EPS in the EP that applies to the activity that is not a reportable incident;
- **Reportable incident:** An incident arising from the activity that has caused, or has the potential to cause, moderate to significant environmental damage.

The requirements for notifying environmental incidents to external agencies are listed in Table 9-2. These will be reported to the regulator by the 3D Oil Project Manager.

Table 9-2 External Notifications and Reporting Requirements

Requirement	Timing	Contact
Recordable Incidents		
As a minimum, the written monthly recordable incident report must include a description of: ■ All recordable incidents which occurred during the calendar month; ■ All material facts and circumstances concerning the incidents that the	As soon as possible but before the 15th day of the following calendar month.	NOPSEMA - submissions@nopsema.gov.au

Requirement	Timing	Contact
operator knows or is able to reasonably find out. ■ Any actions taken to avoid or mitigate any adverse environmental impacts of the incident; and ■ Corrective actions that have been taken, or may be taken, to prevent a repeat of similar incidents occurring.		
Reportable Incidents		
Verbal Notifications		
Vessel-sourced spill in Commonwealth waters.	Within 1 hour	Joint Rescue Co-ordination Centre Australia (JRCC Australia): Phone: +61 2 6230 6811 or 1800 641 792 Facsimile: 1800 622 153
Reportable incidents include, but are not limited to, those that have been identified through the risk assessment process as having an inherent impact consequence of 'significant', 'major' or 'critical'; or at a minimum, the following incidents: ■ A level 2 spill incident; ■ Vessel strike / entrapment or entanglement with a cetacean or marine turtle; ■ IMS Introduction. ■ The notification must contain: ■ All material fact and circumstances concerning the incident; ■ Any action taken to avoid or mitigate the adverse environmental impact of the incident; and ■ The corrective action that has been taken or is proposed to be taken to stop control or remedy the reportable incident. This must be followed by a written record of notification ASAP after notification. This written notification must also be supplied to the NOPTA and DMIRS for Commonwealth water incidents.	Within 2 hours	Verbal: NOPSEMA – Phone 08 6461 7090. DMIRS - 0419 960 621 Written Notification: NOPSEMA - submissions@nopsema.gov.au NOPTA – reporting@nopta.gov.au DMIRS - petroleum.environment@dmirs.wa.gov.au
If an oil pollution incident occurs within or approaches an AMP, or where an oil spill response action must be taken within an AMP, the Director of National Parks (DNP) must be contacted immediately.	As soon as possible and prior to response action being taken, so	Verbal: Director of Marine Parks – 0419 293 465 (24hr Marine Compliance Officer)

Requirement	Timing	Contact
Information which must be provided within that notification includes: ■ Titleholder details; ■ Time and location of the incident (including AMP likely to be affected) ■ Proposed response arrangements as per OPEP; and ■ Contact details of the emergency coordinator.	far as reasonably practicable	
Notify DoEE of any death or injury of a listed threatened species; all cetacean species; listed migratory species or listed marine species.	Within 7 days	Phone: +61 2 6274 111 Email: EPBC.Permits@environment.gov.au
Written Incident Reports		
Verbal notification of a reportable incident to NOPSEMA (Commonwealth waters) must be followed by a written report. As a minimum, the written incident report will include: ■ The incident and all material facts and circumstances concerning the incident; ■ Actions taken to avoid or mitigate any adverse environmental impacts; ■ The corrective actions that have been taken, or may be taken, to prevent a recurrence of the incident; ■ The action that has been taken or is proposed to be taken to prevent a similar incident occurring in the future.	Within 3 days of notification of incident (NOPSEMA) Within 7 days' after submission to NOPSEMA (NOPTA).	NOPSEMA - submissions@nopsema.gov.au NOPTA – reporting@nopta.gov.au
Vessel strike with cetacean is reported to the DoEE.	Within 72 hours of incident.	Upload information to: https://data.marinemammals.gov.au/report/shipstrike

9.12.3 External Routine Notification and Reporting Requirements

Review of statutory and stakeholder requirements with respect to routine external notification and reporting is provided inTable 9-3. These actions are the responsibility of the 3D Oil Project Manager (or delegate).

Table 9-3 External Routine Notification and Reporting Requirements

Requirement	Timing	Contact
Routine Performance Reporting		
OPGGS (E) Regulations - Regulation 26C	Within 3-months of survey completion.	NOPSEMA - submissions@nopsema.gov.au

Requirement	Timing	Contact
Submit an EP Performance/Compliance Report to NOPSEMA. This reports compliance against each of the EPOs and EPSs as outlined in this EP.		
Provide cetacean observation data to the DoEE. This report will include: ■ The location, date and start-up time of the survey; ■ Name, qualifications and experience of MFOs involved in the survey; ■ The location, times and reasons when observations were hampered by poor visibility or high winds; ■ The location and time of any start-up delays, shut-downs or stop-work procedures instigated as a result of whale sightings; ■ The location, time and distance of any cetacean sightings; and ■ The date and time of completion of the survey.	Within 2 months of activity completion.	Upload information to: https://data.marinemammals.gov.au/csa
Activity Notifications		
EP Public Comment Period Open		
Notification to all relevant stakeholders advising of public comment period.	Within 2 days after the date public comment period is open.	All relevant stakeholders listed in the Consultation Log.
EP Accepted & Activity Update		
Notification to all relevant stakeholder advising of EP acceptance and provide an update on survey commencement.	Within 10 days of the date the EP has been accepted.	All relevant stakeholders listed in the Consultation Log.
Provision of OPEP to DoT and AMSA following EP acceptance and prior to survey commencement.	Prior to survey commencement.	Contact details listed in Consultation Log.
Survey Commencement		
Notify AHS for Notice to Mariners.	At least 4 weeks prior to commencement.	AHS - datacentre@hydro.gov.au
Notify fisheries stakeholders of survey commencement. The notification shall include: ■ Survey location;	At least 4 weeks prior to commencement.	Fisheries stakeholders listed in Consultation Log.

Requirement	Timing	Contact
▪ Timeframe (anticipated start date and likely duration); ▪ Vessel details (vessel names, call signs, IMO vessel numbers, radio and satellite phone communication details); ▪ Website details for 48 hr look-aheads; and ▪ Telephone and email contact details for claims, objections, queries or concerns.		
Notify DMIRS of survey commencement.	At least 10 days prior to commencement.	DMIRS - petroleum.environment@dmirs.wa.gov.au.
Notify NOPSEMA of survey commencement.	At least 10 days prior to commencement.	NOPSEMA - submissions@nopsema.gov.au
Notify AMSA for Auscoast Warnings	At least 24 hours prior to survey commencement.	JRCC - rccaus@amsa.gov.au Ph: 1800 641 792 or +61 2 6230 6811
Survey Cessation		
Notify AMSA to cease Auscoast Warnings	Upon vessel demobilisation.	JRCC - rccaus@amsa.gov.au Ph: 1800 641 792 or +61 2 6230 6811
Notify NOPSEMA with survey completion date	Within 10 days of survey completion.	NOPSEMA - submissions@nopsema.gov.au
Notify DMIRS with survey completion date	Within 10 days of survey completion.	DMIRS - petroleum.environment@dmirs.wa.gov.au.
Notify fisheries stakeholders of survey cessation	Within 10 days of survey completion.	Fisheries stakeholders listed in the Consultation Log.
End of EP		
Notification of EP completion to NOPSEMA.	End of EP operation.	NOPSEMA - submissions@nopsema.gov.au

9.13 Environmental Performance Monitoring, Inspection, Audit and Reporting

The objective of the monitoring, audit and review program for the Sauropod 3D MSS is to ensure that the survey EPOs/EPSs are observed, verified and measured; EP controls are implemented and performance standards verified; environmental emissions/discharges are recorded and overall environmental performance assessed and the EP implementation strategy is assessed for effectiveness. These activities assist 3D Oil to review environmental performance with a view to continuous improvement of environmental management and implementation strategies.

Collation of information provided by control measure ‘custodians’, EPO incident records and emissions/discharge records allows the 3D Oil Offshore Representative to assess environmental performance against nominated EPOs and standards as outlined in Section 7 and Section 8.

All breaches of EPO and EPSs in this EP are considered non-compliances and a recordable incident (refer to Section 9.12.2). Non-compliances may be identified during an audit, inspection, general observation or as a consequence of an incident.

9.13.1 Pre-mobilisation Inspection and Audit

Prior to mobilisation, the 3D Oil Project Manager (or delegate) will undertake:

- A vessel audit to confirm that the vessel and seismic contractor management system meets with the environmental constraints detailed in this EP. The activity will be documented and any corrective actions rectified prior to mobilisation.
- An audit of the on-board spill response capability of the vessels against SOPEPs will be made prior to survey mobilisation to verify spill preparedness for the Sauropod 3D MSS.

Additionally, during the survey activity the 3D Oil Offshore Representative will also:

- Conduct an EP compliance audit against EP requirements during the Sauropod 3D MSS. This will target the following:
  - Compliance with regulatory requirements detailed in this EP;
  - Independent verification that all EPOs and control measure performance standards have been monitored, measured and correctly evaluated;
  - Emissions and discharges are being correctly monitored, measured and documented; and
  - Management strategies and procedures to achieve the EPOs are in place and being implemented effectively.
- Any required remedial actions will be followed up immediately. A copy of the environmental audit can be forwarded to NOPSEMA upon request.
- Conduct an EP implementation review against the Sauropod 3D MSS Project Specific HSEQ Plan to determine the effectiveness of the ‘bridged’ 3D Oil requirements into the Contractor’s management system.

Non-conformances and opportunities for improvement will be identified and corrective actions will be tracked to completion utilising the seismic vessel’s on-board action tracking system. Corrective actions will specify the remedial action required to fix the breach and prevent its reoccurrence and is delegated to the person deemed most appropriate to fulfil the action. Where more immediacy is required, non-compliances will be communicated to relevant personnel immediately and responded to as soon as possible. 3D Oil will carry forward any areas of non-conformance identified during the Sauropod 3D MSS for consideration in future seismic campaigns to assist with continuous improvement in environmental management controls and performance outcomes.

9.13.2 Emission/Discharge Monitoring, Quantification & Reporting

3D Oil will maintain a quantitative record of emissions and discharges as required by OPGGS (E) Regulations - Regulation 16(7). For vessel-based records, the 3D Oil Offshore Representative is responsible for collecting the data.

A summary of these results will be reported in the Sauropod 3D MSS Environmental Performance Report to be submitted to NOPSEMA 3 months after the completion of the Sauropod 3D MSS.

Parameters detailed in Table 9-4 provide a summary of the emission, discharge and interaction parameters, which will be monitored for the Sauropod 3D MSS.

Table 9-4 Operational Monitoring Program

Discharge / Incident	Parameters	Record	Responsibilities
Atmospheric Emissions			
Engine Exhaust	Quantities of marine diesel used by the vessel(s)	Daily Fuel Use Log	Vessel Master(s)
Incinerated Waste	Volume of waste incinerated.	Garbage Record Book	Vessel Master(s)
Ozone Depleting Substances	Volume released	OSD Record Book	Vessel Master(s)
Discharge to Sea			
Oily Water Discharges	Volume of oil water discharge from vessel(s)	Oil Record Book	Vessel Master(s)
Food-scraps	Volume of food-scraps discharged from vessel(s)	Garbage Record Book	Vessel Master(s)
Sewage/Grey Water Discharge	Volume of potable water consumed	Water Use Records	Vessel Master(s)
Disposal of Wastes			
Hazardous Waste	Volume of hazardous waste transferred onshore	Garbage Record Book / Oil Record Book	Vessel Master(s)
Solid Non-biodegradable Wastes	Volume of non-hazardous waste transferred onshore	Garbage Record Book	Vessel Master(s)
Food-scraps	The volume of food-scraps transferred onshore	Garbage Record Book	Vessel Master(s)
Marine Fauna Interactions			
Cetacean Sightings	Details required on the DoEE Cetacean Sighting Reports	MFO Records	MFO
	Record of soft start procedures, shut-downs and visual checks prior to commencement	MFO Records	MFO
	Daily log of seismic acquisition by Party Manager	Daily Seismic Report	MFO
Marine User Interactions			
Vessel Interaction	Communications with other vessels.	Incident Records Consultation Records	Vessel Master(s)
Spill / Release Incidents			

Discharge / Incident	Parameters	Record	Responsibilities
Spill/release Incidents from Vessel(s)	Location, volume, duration and type. Response actions.	Oil Pollution Reports (POLREPs) & Situation reports (SITREPs) Incident Records	Vessel Master(s)
Equipment Release Incident	Location, equipment type and duration. Response actions.	Incident Records	Vessel Master(s)
Cetacean Collision Incidents	Location, time, species and expected injury. Response actions.	Incident Records	MFO / Vessel Master
Operational / Scientific Monitoring			
Operational / Scientific Monitoring Results	As per content of OSMP	OSMP Records	3D Oil Project Manager

9.13.3 Oil Spill – Operational and Scientific Monitoring

AMSA (2003) recommends that monitoring programs reflect the scale and potential effects of a 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 3D Oil 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.

In the event of a Level 2 MDO spill, the following monitoring will be required:

- Operational monitoring (Type 1) to inform spill response activities; and
- Scientific monitoring (Type 2) to quantify the nature of the extent, severity and persistence of environmental impacts and inform appropriate remediation activities.

9.13.3.1 *Type I Operational Monitoring*

In the event of an MDO 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 (refer Section 9.6). Operational monitoring may include spill surveillance and tracking to validate oil spill trajectory modelling. 3D Oil 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 3D Oil 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.

3D Oil 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.

9.13.3.2 *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, 3D Oil 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 9-5. As described previously, in the event of a spill, 3D Oil 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 9-5, a detailed monitoring plan will be developed as per the template in Table 9-6. 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. Information resulting from scientific (Type II) monitoring will be directed to the relevant Commonwealth and State environmental authorities as it becomes available.

If deemed necessary, following consultation with the Combat Agency and relevant stakeholders (e.g. DoT, DoEE and/or DBCA), 3D Oil will contract 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 OSMP support.

3D Oil will keep ERM informed of the progress of the Sauropod 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 9.12, should a hydrocarbon spill occur, the 3D Oil Project Manager 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.

Monitoring studies will include detail monitoring performance outcomes, standards, monitoring methodology, sampling and analysis plan (including laboratory QA/QC where applicable), available baseline information (sites, sampling frequency, baseline data-sets, baseline custodian), impacts assessment approach (e.g. reference site comparison, BACI or beyond BACI), competencies, responsibilities and reporting requirements (refer to Table 9-6). It is to be noted that monitoring parameters and methodologies selected will observe the requirements of conservation management plans with respect to individual species (where monitoring parameters are available). Also, where available, management plans provide details of relevant 'umbrella species' which are monitored over time which measure the area's long-term health and meet objectives of management plans (e.g. water quality indicators, inter-tidal reef indicators). Relevant management plans for protected species, marine parks, etc. will be consulted in the preparation of studies to identify these indicators.

Consultation: 3D Oil will consult with relevant Commonwealth and State authorities prior to the implementation of any Type 2 monitoring studies to ensure that scientific monitoring is undertaken to the satisfaction of the Commonwealth and Western Australia. These authorities include:

- For Commonwealth waters:
  - Marine Research Organisations (AIMS, CSIRO);
  - Director of National Parks;
  - AMSA;
  - Department of the Environment & Energy (DoEE);
  - Australian Fisheries Management Authority (AFMA); and
  - Other relevant parties that have an interest in the affected area.
- Western Australian State Waters:
  - Marine Research Organisations (WAMSI);
  - Department of Biodiversity Conservation and Attractions (DBCA);

- Department of Primary Industries and Regional Development (Fisheries);
- Department of Transport (DoT); and
- Other relevant parties that have an interest in the affected area.

3D Oil will notify these authorities on a Level 2 spill incident and provide available operational data. 3D Oil will consult with these authorities on the content of Type 2 studies (e.g. baseline, location of reference and control sites and confirmation of monitoring parameters) and obtain spill specific feedback, which may be incorporated into the Type 2 study design to ensure monitoring is to the satisfaction of the Commonwealth and State authorities.

Table 9-5 3D Oil Scientific Monitoring Studies

Scientific Monitoring Study	Rationale	Monitoring Performance Outcomes	Initiation Triggers	Termination Criteria
SSM1: Marine Water Quality	Monitor hydrocarbons in marine waters at sub-tidal and inter-tidal sensitive locations and reference sites to support assessment of environmental impact and recovery.	Monitor hydrocarbons in marine waters at sub-tidal and intertidal sensitive locations, commercial fishery areas and reference sites to support the assessment of environmental impacts and recovery. This will be used to: ■ Detect and monitor for the presence, quantity and behaviour of surface and in-water hydrocarbons; and verify predictions made in modelling about the extent and presence of hydrocarbon contamination; ■ Identify sensitivities at risk of hydrocarbon exposure, inform the NEBA and identify which sensitivities require scientific monitoring; and ■ Provide data to validate hind-cast modelling confidence in the fate and transport of hydrocarbons.	■ A Level 2 hydrocarbon spill results from the seismic survey; and ■ Agreement with relevant stakeholders that meaningful results can be provided by the study.	The 3D Oil Project Manager (or delegate) will terminate the study when, in consultation with DoEE, DoT, DNP and NOPSEMA, the following criteria has been met: ■ The spill has ceased; and ■ No visible sheens are present and no further sheens are predicted from modelling. ■ Water monitoring data relating to observations, measurements of hydrocarbons in-water have been compiled, analysed and reported.
SSM2: Marine and Inter-tidal Sediment	Monitor hydrocarbons in marine sediments at sub-tidal and inter-tidal sensitive locations and reference sites to support assessment of	Monitor hydrocarbons in marine waters at sub-tidal and intertidal sensitive locations, commercial fishery areas and reference sites to support the assessment of	■ A Level 2 hydrocarbon spill results from the seismic survey and where operational monitoring results indicate that inter-tidal	The 3D Oil Project Manager (or delegate) will terminate the study when, in consultation with DoEE, DoT and NOPSEMA, the following criteria has been met:

Scientific Monitoring Study	Rationale	Monitoring Performance Outcomes	Initiation Triggers	Termination Criteria
	environmental impact and recovery.	environmental impacts and recovery. This will be used to: ■ Detect and determine the extent, severity and persistence of hydrocarbons in marine sediments across selected sites where hydrocarbons have been observed, recorded or predicted; ■ Provide information which can be used to interpret possible cause and effect drivers for environmental impacts of sensitive receptors monitored under SMPs; ■ Provide data to validate hind-cast modelling confidence in the fate and transport of hydrocarbons.	or sub-tidal areas have been exposed to surface oil levels of 1 g/m^2 (visible sheen); 100 ppb (entrained phase) or 100 g/m^2 (shoreline residue). ■ Agreement with relevant stakeholders that meaningful results can be provided by the study.	■ Concentrations of hydrocarbons in sediment samples are below ANZG 2018 ISQG low-trigger values for biological disturbance or hydrocarbon levels in sediments are within natural variability of baseline condition no longer posing a risk to environmental receptors; and ■ The extent, severity and persistence of hydrocarbons from concentrations recorded in sediments have been documented.
SSM3: Sub-tidal and Intertidal Benthos	Hydrocarbon contact with shorelines may lead to contamination of inter-tidal and sub-tidal (coastal) habitats. On sandy beaches this can lead to impacts on inter-tidal invertebrates with subsequent impacts to shoreline bird populations and may affect productivity in sub-tidal areas leading to	Monitor sub-tidal habitats (e.g., reef habitats) and inter-tidal habitats (e.g. sandy shorelines) at priority sensitive locations and one reference site to support the assessment of environmental impacts and recovery. This will be used to: ■ Quantify the distribution, abundance and community composition of marine organisms in soft sediment and hard substrate environments;	■ A Level 2 hydrocarbon spill results from the seismic survey and where operational monitoring results indicate that inter-tidal or sub-tidal areas have been exposed to surface oil levels of 1 g/m^2 (visible sheen); 100 ppb (entrained phase) or 100 g/m^2 (shoreline residue).	The 3D Oil Project Manager (or delegate) will terminate the module when, in consultation with DoEE, DoT, and NOPSEMA, the following criteria has been met: ■ Overall impacts to inter-tidal and sub-tidal benthic habitats from hydrocarbon

Scientific Monitoring Study	Rationale	Monitoring Performance Outcomes	Initiation Triggers	Termination Criteria
	effects on other trophic levels. Categories of inter-tidal and sub-tidal habitat that may be monitored includes rocky reefs, gastropods, site-attached fish, macroalgal communities and invertebrate (sandy beaches) communities.	■ Quantify the level of exposure to affected communities; and ■ Determine the impact and recovery of the hydrocarbon release on those habitats.	■ Agreement with relevant stakeholders that meaningful results can be provided by the study.	exposure have been quantified; ■ Recovery of impacted benthic habitats have been evaluated; ■ Agreement with relevant stakeholders and regulators, based upon the nature and scale of the spill impacts are no longer attributable to the spill.
SSM4: Marine Fauna Monitoring	Oil spills have the potential for long-term impacts to marine fauna (includes whales, dolphins, turtles). Hydrocarbon contact with marine and shoreline fauna due to surface oil may have the potential to impart lethal and sub-lethal impacts to individual and populations of species. This may include behavioural (e.g. migratory deviation, foraging displacement); physiological (digestion disruption) and/or physical effects.	Monitor marine fauna to: ■ Determine the impact of the oil spill on marine fauna throughout the response at locations contacted by hydrocarbons to inform spill response activities (including documentation of dead individuals). ■ Utilising data collected (mortality, stranding or oiling of mobile marine species), via population analysis determine (infer) potential impacts to marine fauna species populations.	■ A Level 2 hydrocarbon spill results from the seismic survey; and ■ Agreement with relevant stakeholders that meaningful results can be provided by the study.	The 3D Oil Project Manager (or delegate) will terminate the study when, in consultation with DoEE, DoT, DNP and NOPSEMA, the following criteria has been met: ■ The spill has ceased; and ■ No visible sheens are present and no further sheens are predicted from modelling.

Scientific Monitoring Study	Rationale	Monitoring Performance Outcomes	Initiation Triggers	Termination Criteria
SSM5: Marine Bird Population Monitoring	Oil spills have the potential for long-term impacts to seabird/shorebird populations. Hydrocarbon contact with avifauna may impart lethal or sub-lethal impacts to individual birds and populations of species through direct contact with oiled surfaces; transfer of oil to eggs from contaminated plumage or ingestion during foraging or ingesting contaminated prey.	Monitor shorebird and seabird populations to assess potential impacts to, and subsequent recovery following a hydrocarbon release. ■ Operational Monitoring: - Provide oiled bird data during spill incident to inform response (remedial) activities; - Assess any impacts to shorebirds/seabirds as a result of response operations; ■ Scientific Monitoring: - Quantify the level of exposure and impact to affected bird populations; - Determine the recovery of affected populations after spill.	Operational Monitoring will be initiated in a Level 2 spill incident. Scientific Monitoring will be implemented in a level 2 spill event if: ■ Dead, oiled or injured bird species are recorded as part of the spill response activity; or ■ Operational monitoring identifies shoreline contact of surface hydrocarbons above 1 g/m^2 or shoreline residue > 100 g/m^2 at sensitive shoreline colony locations.	The 3D Oil Project Manager (or delegate) will terminate the study when, in consultation with DoEE, DoT, AMSA and NOPSEMA: ■ Impacts to seabird and shorebird populations from hydrocarbon exposure have been quantified; ■ Recovery of impacted seabird and shorebird populations has been evaluated and is reasonably satisfied; and ■ Agreement with relevant stakeholders and regulators, based upon the nature and scale of the spill impacts are no longer attributable to the spill.
SSM6: Fish Species Monitoring	Oil spills have the potential to impact on commercial fisheries via a number of pathways such as physical contamination (e.g. tainting); toxic effects (i.e. fish health) and by disrupting business activity.	Monitor for hydrocarbons in representative commercial fish species (including shellfish) to assess the physiological impacts to fisheries; seafood quality/safety and the fisheries recovery following a hydrocarbon spill.	■ A Level 2 hydrocarbon spill results from the seismic survey; and ■ Agreement with relevant stakeholders that meaningful results can be provided by the study.	The 3D Oil Project Manager (or delegate) will terminate the study when, in consultation with AFMA, NOPSEMA, DPIRD Fisheries, DoEE and DoT: ■ The hydrocarbon spill has ceased;

Scientific Monitoring Study	Rationale	Monitoring Performance Outcomes	Initiation Triggers	Termination Criteria
	Fish exposed to hydrocarbons may not be killed but may suffer sub-lethal impacts which may impact upon the saleability of fish.			■ Impacts to the quality/safety of fish species from hydrocarbon exposure have been quantified and information provided to relevant stakeholders and regulators for the management of any affected fisheries; and ■ Recovery of affected commercial fish from hydrocarbon has been assessed and the hydrocarbon levels in representative commercial fish tissue are below relevant seafood standards for marine waters and pose a minimal risk.
SSM7: Hindcast Modelling	This study aims are to: ■ Conduct hind-cast simulations of a hydrocarbon spill, validated with information / data from other OSMP studies to refine post-incident impact assessment and to inform long-term scientific monitoring specifications (as required); and ■ To support assessments of the impacts and recovery of environmental sensitivities.		The study will be initiated immediately after the cessation of Operational Forecast Modelling by the 3D Oil Project manager (or delegate).	The 3D Oil Project Manager (or delegate) approves Hind-cast Modelling Impact Assessment Modelling Report submitted by RPS and a Hind-cast Modelling Impact Assessment Workshop is conducted.

Table 9-6 Scientific Monitoring Plan Template

Section	Content Description
Initiation criteria	Criteria to initiate the monitoring study
Termination criteria	Criteria for terminating the study
Monitoring rationale, objectives and performance outcomes	Study-specific objectives and critical success factors
Monitoring Performance Standard	Performance(s) required of the monitoring study elements (systems, equipment, personnel and/or procedures) that are used as the basis to manage achievement of the monitoring performance outcome
Methodology	Approach, techniques and standards to be implemented
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
Sample storage and transport requirements (if applicable)	Sample holding times, storage requirements and chain of custody procedures
Personnel resources	Number of personnel required, qualifications and skill level
HSE Planning	HSE Risk Assessment and Management Plan (e.g. Job Hazard Analysis)
Subcontractor requirements	Required accreditations (e.g. NATA accredited laboratories) if applicable
Permits	Permit requirements/exemptions
Quality Control	QA/QC requirements for data and reporting
Reporting	Report format and communication of results to relevant stakeholders

9.13.4 Review

An end of survey HSE Review will be jointly conducted by 3D Oil and the seismic contractor during the Post Survey Meeting.

This activity will enable the review of management and mitigation strategies implemented during the survey and, including reviews of performance, incident investigations, audits and field activity identify actions for future seismic surveys, which can be implemented on a continuous improvement basis. The seismic survey close-out report will include a ‘Lessons Learnt’ section to facilitate incorporation of any recommended improvement actions in future seismic activities.

9.13.5 Record Management

In accordance with the Commonwealth OPGGS (E) Regulations - Regulation 27, 3D Oil will store and maintain documents or records relevant to the EP implementation for a period of 5 years in a way that makes retrieval reasonably practicable.

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APPENDIX A PROTECTED MATTERS SEARCH TOOL

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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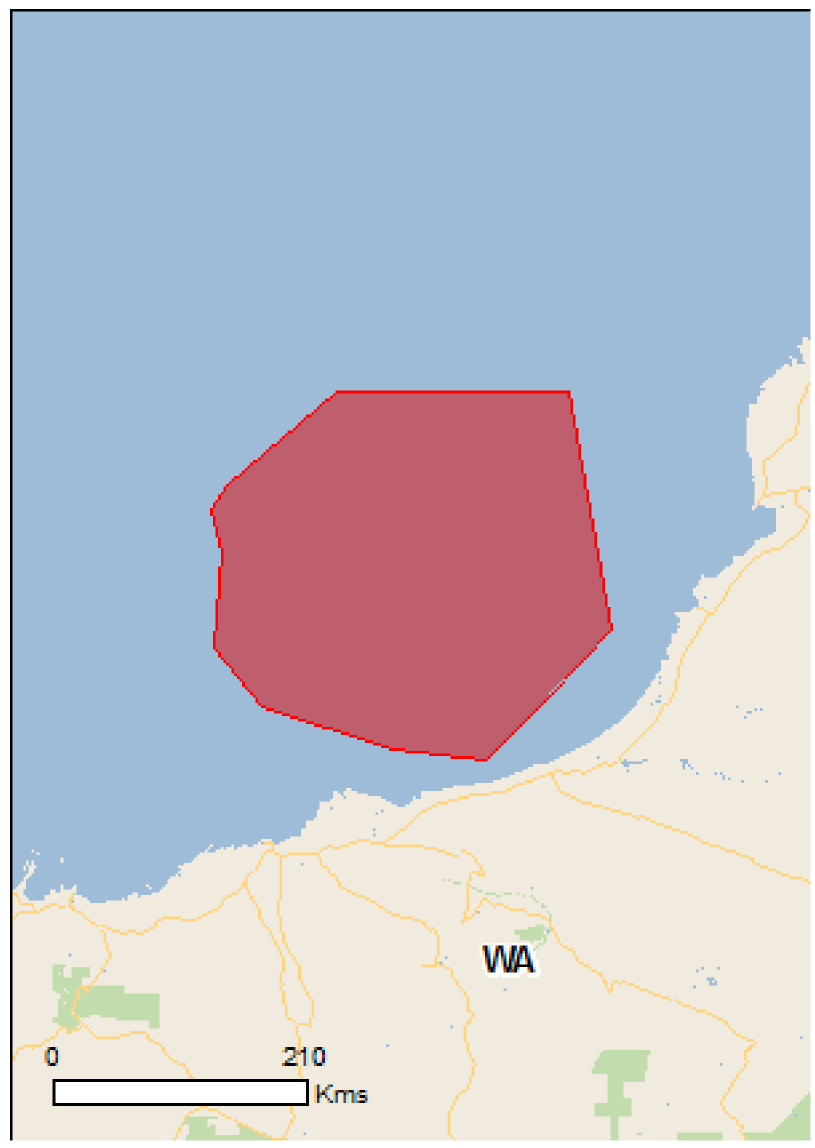
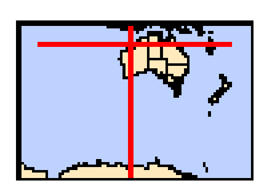


Coordinates

Buffer: 1.0Km



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:	44

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:	1
Listed Marine Species:	85
Whales and Other Cetaceans:	26
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	4

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)	2

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-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
Papasula abbotti		
Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Reptiles		
Aipysurus apraefrontalis		
Short-nosed Seasnake [1115]	Critically Endangered	Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Sharks		
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Pristis clavata		
Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding 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	Breeding known to occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to 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
Phaethon lepturus		
White-tailed Tropicbird [1014]		Breeding likely to occur within area
Phaethon rubricauda		
Red-tailed Tropicbird [994]		Breeding known to occur within area
Sterna dougallii		
Roseate Tern [817]		Breeding likely to occur within area

Name	Threatened	Type of Presence
Sternula albifrons		
Little Tern [82849]		Breeding known to occur within area
Sula leucogaster		
Brown Booby [1022]		Breeding known to occur within area
Migratory Marine Species		
Anoxypristis cuspidata		
Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni		
Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Species or species habitat likely to 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 known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour 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 known 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
Manta alfredi		
Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known 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 known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to

Name	Threatened	Type of Presence
		occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding 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	Breeding known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to 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 Terrestrial Species		
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		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
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Commonwealth Heritage Places		[Resource Information]
Name	State	Status
Natural		
Mermaid Reef - Rowley Shoals	WA	Listed place

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 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
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		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
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding likely to occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Sterna albifrons Little Tern [813]		Breeding known to occur within area
Sterna bengalensis Lesser Crested Tern [815]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding likely to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Fish		
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		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 latispinosus Muiron Island Pipefish [66196]		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

Name	Threatened	Type of Presence
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
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		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 nitidus Glittering Pipefish [66224]		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 angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		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

Name	Threatened	Type of Presence
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		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 apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat likely to 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
Aipysurus tenuis Brown-lined Seasnake [1121]		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 known to occur

Name	Threatened	Type of Presence
		within area
[Chelonia mydas](#) Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
[Dermochelys coriacea](#) Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour 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
[Emydocephalus annulatus](#) Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
[Ephalophis greyi](#) North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
[Eretmochelys imbricata](#) Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
[Hydrelaps darwiniensis](#) Black-ringed Seasnake [1100]		Species or species habitat may occur within area
[Hydrophis czeblukovi](#) Fine-spined Seasnake [59233]		Species or species habitat may occur within area
[Hydrophis elegans](#) Elegant Seasnake [1104]		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
[Lapemis hardwickii](#) Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
[Natator depressus](#) Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to 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 likely to occur within area
[Balaenoptera edeni](#) Bryde's Whale [35]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		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
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species

Name	Status	Type of Presence
		habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to 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
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Australian Marine Parks [Resource Information]

Name	Label
Argo-Rowley Terrace	Multiple Use Zone (IUCN VI)
Argo-Rowley Terrace	Special Purpose Zone (Trawl) (IUCN VI)
Eighty Mile Beach	Multiple Use Zone (IUCN VI)
Mermaid Reef	National Park Zone (IUCN II)

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
Ancient coastline at 125 m depth contour	North-west
Mermaid Reef and Commonwealth waters	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

-17.1559 120.8212,-17.1457 119.1159,-17.8143 118.2949,-17.9826 118.1763,-18.2909 118.2615,-18.9529 118.1922,-19.3736 118.5484,-19.6713 119.5193,-19.7482 120.2186,-18.8224 121.144,-17.1559 120.8212

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

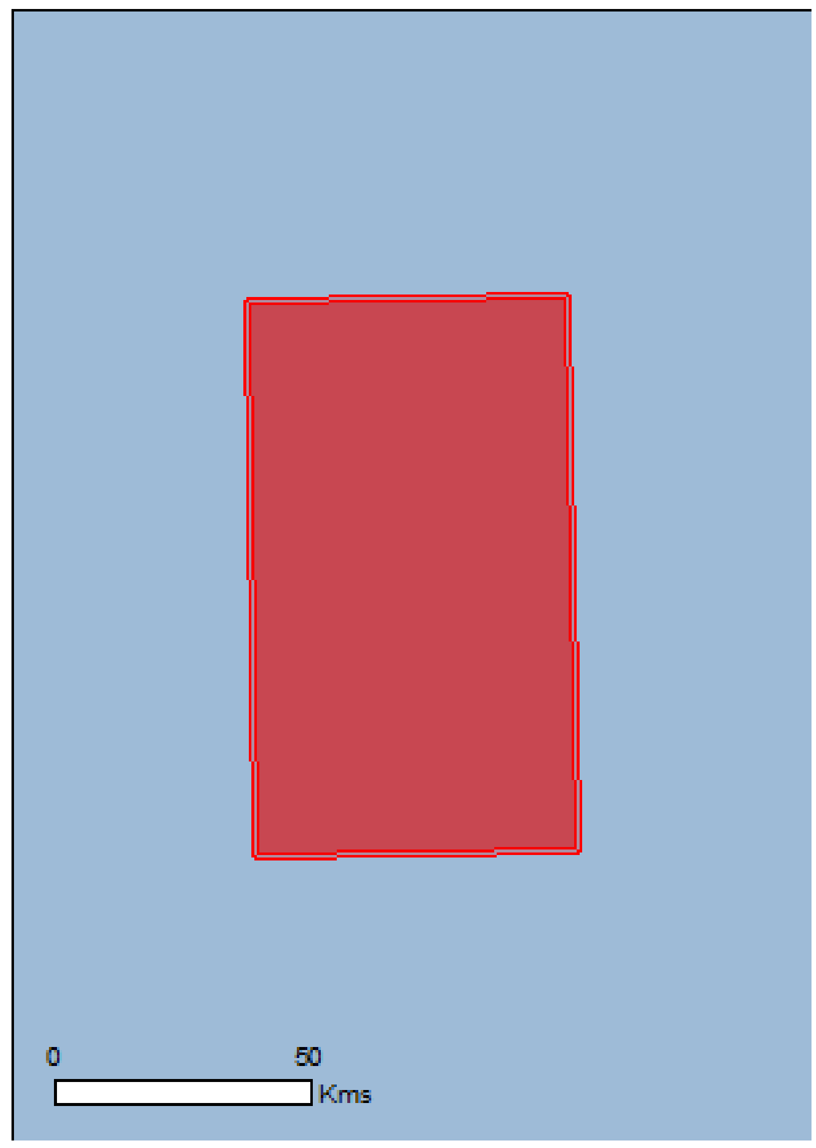
EPBC Act Protected Matters Report

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.

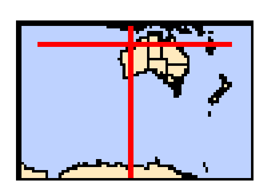
Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 27/03/19 15:55:31



Coordinates

Buffer: 1.0Km



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:	16
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:	56
Whales and Other Cetaceans:	25
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

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-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
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Papasula abbotti		
Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Species or species habitat likely to 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 likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat known 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
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area
Sharks		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	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	Foraging, feeding or related behaviour known to 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
Phaethon lepturus White-tailed Tropicbird [1014]		Foraging, feeding or related behaviour likely to 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 likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
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 likely to 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
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
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 known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		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	Foraging, feeding or related behaviour known to occur within area

Name	Threatened	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
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 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 melanotos		
Pectoral Sandpiper [858]		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

Name	Threatened	Type of Presence
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
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Foraging, feeding or related behaviour likely to occur within area
Fish		
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 flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		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 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

Name	Threatened	Type of Presence
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		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
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
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
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
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
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Hydrophis elegans Elegant Seasnake [1104]		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
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to 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 likely to 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 likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area

Name	Status	Type of Presence
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		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
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		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 may occur within area

Name	Status	Type of Presence
Tursiops truncatus s. str.		
Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris		
Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

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
Ancient coastline at 125 m depth contour	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

-18.8544 119.5174,-18.846 120.0729,-17.93 120.0567,-17.9379 119.5041,-18.8544 119.5174

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 B STAKEHOLDER CONSULTATION LOG

Stakeholder	Appendix #	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit
Australian Border Force	2.1.1	15/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.1.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.1.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Australian Fisheries Management Authority (AFMA)	2.2.1	15/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.2.2	15/04/2019	Email/Letter from stakeholder	AFMA would like to be included throughout the consultation process.		N/A - Advice / request for further information only. No objection or claim made.
	2.2.3	10/05/2019	Email/Letter to stakeholder	Thanked AFMA and attached the detailed factsheet which includes information on the potential environmental hazards and control measures.	Yes - Detailed Factsheet	N/A
	2.2.4	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
	2.2.5	23/07/2019	Email/Letter to stakeholder	Advised the Sauropod 3D MSS EP has been published by NOPSEMA for public comment and review. Provided the review period and the direct link to the dedicated submission portal on the NOPSEMA website.		N/A
Australian Hydrographic Service (AHS)	2.3.1	15/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.3.2	15/04/2019	Email/Letter from stakeholder	Automated Response received.		N/A
	2.3.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
	2.3.4	11/06/2019	Email/Letter from stakeholder	Automated Response received.		N/A
Australian Institute of Marine Science	2.4.1	15/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.4.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.4.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January		N/A

Stakeholder	Appendix #	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit
				to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		
Australian Marine Oil Spill Centre (AMOSC)	2.5.1	15/04/2019	Email/Letter from stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.5.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.5.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Australian Maritime Safety Authority (AMSA)	2.6.1	15/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.6.2	18/04/2019	Email/Letter from 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	N/A - Advice / request for further information only. No objection or claim made.
	2.6.3	29/04/2019	Email/Letter to stakeholder	Thanked AMSA for the vessel traffic plot. Advised AMSA that 3D Oil will notify AMSA's Joint Rescue Coordination Centre 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.		N/A
	2.6.4	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
	2.6.5	13/06/2019	Email/Letter from stakeholder	Email from AMSA thanking 3D Oil for the email update.		N/A
	2.6.6	23/07/2019	Email/Letter to stakeholder	Advised the Sauropod 3D MSS EP has been published by NOPSEMA for public comment and review. Provided the review period and the direct link to the dedicated submission portal on the NOPSEMA website.		N/A
Australian Southern Bluefin Tuna Industry Association (ASBTIA)	2.7.1	15/04/2019	Email/Letter from stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.7.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.7.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Commonwealth Fisheries Association (CFA)	2.8.1	15/04/2019	Email/Letter from stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken;	Yes - Initial Notification	N/A

Stakeholder	Appendix #	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit
				· types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.		
	2.8.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.8.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Conservation Council of WA (CCWA)	2.9.1	15/04/2019	Email/Letter from stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.9.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.9.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
CSIRO	2.10.1	15/04/2019	Email/Letter from stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.10.2	18/04/2019	Email/Letter from stakeholder	Provided correct contacts for the relevant scientists and stated that the email sent by 3D Oil had been forwarded to the correct person.		N/A
	2.10.3	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.10.4	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Department of Agriculture and Water Resources (DAWR) – Biosecurity (Marine Pests)	2.11.1	15/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.11.2	30/04/2019	Email/Letter from stakeholder	DAWR would like to receive the detailed fact sheet. Their interests are specifically in relation to how the seismic vessel will be managing the biosecurity risk of ballast water and biofouling. DAWR, went on to provide further information: To comply with Australia's ballast water regulations, you must meet the requirements detailed in the Australia's Ballast Water Management Requirements. Further information on biofouling management and biosecurity requirements can be found at http://www.marinepests.gov.au/commercial/offshore-infrastructure.		N/A - Advice / request for further information only. No objection or claim made.

Stakeholder	Appendix #	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit
	2.11.3	10/05/2019	Email/Letter to stakeholder	Thanked DAWR for the advice and iterated that 3D Oil will comply with DAWR's requirements and the Australian Ballast Water Management Requirements, and IMO requirements. Attached the detailed factsheet which includes information on the potential environmental hazards and control measures.	Yes - Detailed Factsheet	N/A
	2.11.4	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
	2.11.5	23/07/2019	Email/Letter to stakeholder	Advised the Sauropod 3D MSS EP has been published by NOPSEMA for public comment and review. Provided the review period and the direct link to the dedicated submission portal on the NOPSEMA website.		N/A
Department of Agriculture and Water Resources (DAWR) - Fisheries	2.12.1	15/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.12.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.12.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Department of Communications and the Arts	2.13.1	15/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.13.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.13.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Department of Defence	2.14.1	15/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.14.2	20/05/2019	Email/Letter from stakeholder	Defence responded and mentioned, the information 3D Oil sent has been reviewed and Defence has no objections to the proposed activities. Defence went on to mention that 3D Oil have to contact the AHS three weeks prior to commencement on the Survey.		N/A - Advice / request for further information only. No objection or claim made.
	2.14.3	27/05/2019	Email/Letter to stakeholder	Thanked Defence for the advice and iterated that 3D Oil will notify the AHS three weeks before commencement of the survey.		N/A
	2.14.4	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A

Stakeholder	Appendix #	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit
	2.14.5	23/07/2019	Email/Letter to stakeholder	Advised the Sauropod 3D MSS EP has been published by NOPSEMA for public comment and review. Provided the review period and the direct link to the dedicated submission portal on the NOPSEMA website.		N/A
Department of Industry, Innovation and Science (DIIS)	2.15.1	15/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.15.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.15.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Director of National Parks	2.16.1	15/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.16.2	09/05/2019	Email/Letter from stakeholder	Marine Parks noted that the seismic survey does not overlap with any Australian Marine Parks. Marine Parks went on to provide links to the guidance note completed by Parks Australia and NOPSEMA that outlines what titleholders need to consider and evaluate while preparing an EP. Marine Parks confirmed they do not require any further information from 3D Oil unless there are changes to the activity that may result in an overlap with a marine park, a new impact or for emergency responses. In the event of emergency responses: The DNP should be made aware of oil/gas pollution incidences which occur within a marine park or are likely to impact on a marine park as soon as possible. Notification should be provided to the 24 hour Marine Compliance Duty Officer on 0419 293 465. 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 Plan (e.g. dispersant, containment, etc.) - confirmation of providing access to relevant monitoring and evaluation reports when available; and - contact details for the response coordinator.		N/A - Advice / request for further information only. No objection or claim made.
	2.16.3	10/05/2019	Email/Letter to stakeholder	Thanked Marine Parks for the advice and iterated that 3D Oil will notify Marine Parks on any change in activity that may result in an overlap with a marine park or result in the identification of a new impact. In regards to an emergency response, 3D Oil will notify DNP, ensure notification is provided to the 24 hour Marine Compliance Duty Officer and include the required information.		N/A
	2.16.4	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
	2.16.5	23/07/2019	Email/Letter to stakeholder	Advised the Sauropod 3D MSS EP has been published by NOPSEMA for public comment and review. Provided the review period and the direct link to the dedicated submission portal on the NOPSEMA website.		N/A
Kimberley Land Council (KLC)	2.17.1	15/04/2019	Email/Letter from stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A

Stakeholder	Appendix #	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit
	2.17.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.17.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
National Native Title Tribunal (NNTT)	2.18.1	15/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.18.2	15/04/2019	Email/Letter from stakeholder	Automated Response received.		N/A
	2.18.3	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.18.4	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Pathfinder Energy Pty Ltd	2.19.1	15/04/2019	Email/Letter from stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.19.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.19.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Pearl Producers Association of WA (PPA)	2.20.1	15/04/2019	Email/Letter from stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.20.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.20.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Recfishwest	2.21.1	15/04/2019	Email/Letter from stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A

Stakeholder	Appendix #	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit
	2.21.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.21.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Santos WA Northwest Pty Ltd	2.22.1	17/04/2019	Email/Letter from stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.22.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.22.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Tourism Western Australia	2.23.1	15/04/2019	Email/Letter from stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.23.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.23.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
WA Department of Mines, Industry Regulation and Safety (DMIRS)	2.24.1	15/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.24.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.24.3	23/05/2019	Email/Letter from stakeholder	DMIRS acknowledges receipt of the information sent by 3D Oil. DMIRS notes that the proposed activity will be assessed under the OPGGS (E) Regulations 2009 and regulated by the NOPSEMA. DMIRS does not require any further information at this stage. DMIRS has requested 3D Oil provide pre-start notification confirming the start date of the proposed activity and a cessation notification to inform DMIRS upon completion of the activity. DMIRS also provided a link to the Consultation Guidance Note for information pertaining to the reporting of incidents that could potentially impact on any land or water under State jurisdiction.		N/A - Advice / request for further information only. No objection or claim made.
	2.24.4	27/05/2019	Email/Letter to stakeholder	Thanked DMIRS for their response and iterated that 3D Oil will provide DMIRS with a prestart notification stating the start date of the proposed activity and a		N/A

Stakeholder	Appendix #	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit
				cessation notification to inform DMIRS of completion of the activity. In the instance there are incidents that will impact any land or water under WA Jurisdictions, 3D Oil will notify DMIRS as soon as practicable.		
	2.24.5	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
	2.24.6	23/07/2019	Email/Letter to stakeholder	Advised the Sauropod 3D MSS EP has been published by NOPSEMA for public comment and review. Provided the review period and the direct link to the dedicated submission portal on the NOPSEMA website.		N/A
WA Department of Primary Industries and Regional Development (DPIRD) - Fisheries	2.25.1	08/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Meeting request for 18th April 2019		N/A
		09/04/2019	Phone call to stakeholder	Discussed the meeting that 3D Oil requested and confirmed a time.		N/A
	2.25.2	10/04/2019	Email/Letter to stakeholder	Follow on email to confirm meeting request. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; · Environmental hazards and proposed control measures. Attached supplementary fisheries information provided. This includes a summary of our understanding in the area of the activity.	Yes Detailed Factsheet Supplementary Fisheries Information	N/A
	2.25.3	10/04/2019	Email/Letter from stakeholder	Response from DPIRD - formal response can be provided based on the information given to DPIRD. A meeting can then be organised if needed to discuss DPIRD's response further.		N/A
	2.25.4	13/05/2019	Phone call from stakeholder	Phone call with DPIRD to confirm information sent via email was received. Also confirmed that peak spawning information will also be provided to 3D Oil. DPIRD confirmed, information from 3D Oil was received and spawning information will be provided.		N/A
	2.25.5	16/05/2019	Email/Letter from stakeholder	Email from DPIRD stating that most current spawning information will be provided to 3D Oil as soon as it is available.		N/A
	2.25.6	17/05/2019	Email/Letter to stakeholder	Response to DPIRD, thanking them for that update.		N/A
		23/05/2019	Phone call to stakeholder	Attempted a call with DPIRD to discuss outstanding fish spawning information and any potential comments DPIRD may have. DPIRD was unavailable to take the call.		N/A
		27/05/2019	Phone call to stakeholder	Asked about spawning information, DPIRD responded the info was still with principal scientist for review. Asked if DPIRD had any comments on the survey, DPIRD said they have comments but were waiting for spawning information. 3D Oil requested the comments on the survey are received as we wait on the spawning information to ensure we have ample time to respond to DPIRD's query.		N/A

Stakeholder	Appendix #	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit
	2.25.7	30/05/2019	Email/Letter from stakeholder	Response from DPIRD - DPIRD provided a list of representative bodies that have been identified as appropriate to the proposed survey and should be consulted: • Western Australian Fishing Industry Council (WAFIC); • Pearl Producers Association of WA; • Recfishwest; and • Relevant Traditional Owner groups. DPIRD went on to request that individual commercial fishers and charter operators are to be consulted and provided the avenues to use to obtain contact details - http://www.fish.wa.gov.au/Documents/commercial_fishing/r-1_application.pdf. DPIRD described the use of fishcube data to understand fish stock in the proposed area. the relevant website links were provided, as well as the relevant data to be used when making the request for fishcube data. DPIRD expects that the following information has considered and incorporated in the EP: the recommendations published by NOPSEMA on the Acoustic Impact evaluation and management guidance to ensure environmental impacts and detailing how those impacts will be managed to ensure they are ALARP and the Risk Assessment of the potential impacts of seismic air gun surveys on marine finfish and invertebrates in Western Australia, June 2018. All website links where provided. DPIRD provided document on Ecosystem-based Fisheries Management Risk Assessment for the Pearling Industry (attached), which specifically addresses the Oil and Gas Industry and also expects this to be considered and incorporate the outcomes in the EP DPIRD went on to state, Based on the water depth for the proposed 3D Oil survey ranging between 95m to 172m with a volume sound source of 3090 cubic inch and given the location of the survey (in an area which contains pearl stock) the Department does not support any proposed seismic survey where the risk is severe or high, in particular for immobile and mobile invertebrates and demersal finfish, unless scientific peer reviewed literature (location and species specific) demonstrates there is no impact. DPIRD requests that no seismic survey acquisition occurs during spawning periods for key species. Management controls to mitigate any risk to fish stock, if spawning time can't be avoided, should be undertaken and provided to relevant stakeholders for comment. Updated spawning information, based on the most current science will be provided once confirmed from relevant scientists.	Yes Ecosystem-Based Fisheries Management (EBFM) Risk Assessment of the Western Australian Sliver-Lipped Pearl Oyster (Pinctada maxima) Industry.	Stakeholder objection / claim / concern is to be addressed in the EP. Stakeholder is to be advised of outcome.
		04/06/2019	Phone call to stakeholder	Attempted a call with DPIRD to discuss outstanding fish spawning information DPIRD was unavailable to take the call.		N/A
		06/06/2019	Phone call to stakeholder	Call with DPIRD to discuss outstanding fish spawning information. DPIRD advised that information would be provided on 07/06/2019		N/A
	2.25.8	07/06/2019	Email/Letter from stakeholder	Email from DPIRD with the updated spawning information. DPIRD advised that fishers and WAFIC have also received this information	Yes - Finfish Spawning Data	N/A
	2.25.9	07/06/2019	Email/Letter to stakeholder	Email to DPIRD thanking them for the spawning information and advised the 3D Oil would provide a formal response early next week.		N/A
	2.25.10	19/06/2019	Email/Letter to stakeholder	Thanked DPIRD for the comments and advice provided. 3D Oil responded to DPIRD's queries. 3D oil also informed DPIRD the change in EP submission to end of June 2019 and the change in acquisition timing to either a period in Jan to April 2020 or Jan to April 2021.		
	2.25.11	23/07/2019	Email/Letter to stakeholder	Advised the Sauropod 3D MSS EP has been published by NOPSEMA for public comment and review. Provided the review period and the direct link to the dedicated submission portal on the NOPSEMA website.		N/A
WA Department of Transport - Marine (DoTWA)	2.26.1	15/04/2019	Email/Letter to stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A

Stakeholder	Appendix #	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit
	2.26.2	18/04/2019	Email/Letter from stakeholder	DoTWA advised that if there is a risk of a spill impacting State waters from the activity, to ensure that the Department of Transport is consulted as outlined in the Department of Transport Offshore Petroleum Industry Guidance Note – Marine Oil Pollution: Response and Consultation Arrangements (September 2018)		N/A - Advice / request for further information only. No objection or claim made.
		13/05/2019	Phone call to stakeholder	3D Oil had a phone call with DoTWA to confirm the level of information in regards to spill required from 3D Oil.		N/A
	2.26.3	7/06/2019	Email/Letter to stakeholder	Email response to DPIRD with the oil spill risk assessment and draft Oil Pollution Emergency Plan (OPEP). 3D Oil responded to the requested information in Appendix 6 of the Department of Transport Offshore Petroleum Industry Guidance Note – Marine Oil Pollution: Response and Consultation Arrangements.	Yes Spill Modelling Report EMBA Figure Draft EP Oil Spill Risk Assessment OPEP Draft Location Figure	N/A
	2.26.4	10/06/2019	Email/Letter from stakeholder	Automated Response received.		N/A
		17/06/2019	Phone call to stakeholder	Attempted a call with DoT to ensure they received the information provided on 7/06/2019. DoT was unavailable to take the call.		N/A
	2.26.5	18/06/2019	Email/Letter to stakeholder	Email to DPIRD to confirm 3D Oil's email was received.		N/A
	2.26.6	18/06/2019	Email/Letter from stakeholder	Automated Response received.		N/A
		21/06/2019	Phone call to stakeholder	Attempted a call with DoT to ensure they received the information provided on 7/06/2019. DoT was unavailable to take the call.		N/A
		26/06/2019	Phone call from stakeholder	Attempted a call with DoT to ensure they received the information provided on 7/06/2019. DoT was unavailable to take the call.		N/A
	2.26.7	02/07/2019	Email/Letter to stakeholder	Advised DOT of the submission date to NOPSEMA. Requested that any DOT comments to provided before submission		N/A
	2.26.8	02/07/2019	Email/Letter from stakeholder	Automated Response received.		N/A
		03/07/2019	Phone call from stakeholder	DoT thanked 3D Oil for the additional information and apologised for the delay. DoT confirmed all attachments had been received. 3D Oil confirmed that the risk of a spill into State waters was low. DoT mentioned that a review of 3D Oil's documents will be reviewed and a formal response provided.		N/A
	2.26.9	03/07/2019	Email/Letter from stakeholder	DoT thanked 3D Oil for the additional information and apologised for the delay. DoT confirmed a full review of the OPEP has not been deemed necessary as the risk of a spill into State waters was low. DoT requested an accepted version of the OPEP to be provided.		N/A
	2.26.10	03/07/2019	Email/Letter to stakeholder	3D Oil thanked DoT for the response and iterated that a copy of the approved OPEP will be provided.		N/A
	2.26.11	23/07/2019	Email/Letter to stakeholder	Advised the Sauropod 3D MSS EP has been published by NOPSEMA for public comment and review. Provided the review period and the direct link to the dedicated submission portal on the NOPSEMA website.		N/A
Western Australian Fishing Industry Council (WAFIC)	2.27.1	08/04/2019	Email/Letter from stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Meeting request for 18th April 2019		N/A
	2.27.2	08/04/2019	Email/Letter to stakeholder	Response from WAFIC declining the request for meeting. WAFIC provided a list of additional information they require prior to any formal meeting		N/A - Advice / request for further information only. No objection or claim made.
	2.27.3	09/04/2019	Email/Letter to stakeholder	Response to WAFIC advising that a factsheet is in prepartion, which will also include detailed fisheries information. Request for meeting for 18th April 2019.		N/A
	2.27.4	09/04/2019	Email/Letter from stakeholder	Response from WAFIC declining meeting invite and explained why.		
		10/04/2019	Phone call from stakeholder	Call from WAFIC further iterating the reason the meeting request was declined and the reasoning for the information WAFIC is requesting.		N/A

Stakeholder	Appendix #	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit
	2.27.5	11/04/2019	Email/Letter to stakeholder	Response to WAFIC's request for further information. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; · Environmental hazards and proposed control measures. Additional information attached includes: Supplementary fisheries information provided. This includes a summary of our understanding in the area of the activity. Relevant Fishery Activity in the Ops Area has been attached to provide additional information on the query on key fishers in the area. This includes fish cube data, identified key indicator species and a brief preliminary assessment. A draft matrix taking into consideration both biological and socio-economic activities within the activity area.	Yes Fisheries Factsheet Supplementary Fisheries Information Relevant Fishery Activity in the Ops Area Draft Matrix	N/A
		21/05/2019	Phone call to stakeholder	Attempted a call with WAFIC to discuss outstanding fish spawning information. WAFIC was unavailable to take the call.		N/A
	2.27.6	21/05/2019	Email/Letter from stakeholder	Email from WAFIC, stating they received the missed call and are unavailable until Tuesday 28 May 2019		N/A
		28/05/2019	Phone call to stakeholder	Phone call with WAFIC to discuss outstanding fish spawning information and potential next steps. 3D Oil informed WAFIC that we are currently waiting to receive upto date information from DPIRD. WAFIC confirmed they are also waiting for that information. WAFIC went on to mention that they would not review the information 3D Oil provides without the up to date fish spawning information.		N/A
	2.27.7	07/06/2019	Email/Letter to stakeholder	A response to the outstanding information requested by WAFIC. This included information on: Identification of Relevant Commercial Fisheries Risk Assessments: Physical Presence of Vessels and Equipment – Commercial Fisheries, Noise Emissions - Commercial Fisheries, Noise Emissions - Fish Spawning and Noise Emissions - Cumulative Impacts EP Submission & Acquisition Timing	Yes Identification of relevant commerical fisheries Key sensitivities Matrix Cumulative assessment.	N/A
	2.27.8	07/06/2019	Email/Letter from stakeholder	Email from WAFIC requesting clarification on the comment made on "fishable areas". Did 3D Oil mean the area of the actual fishery of the areas within the fishery that are actually fished?		N/A - Advice / request for further information only. No objection or claim made.
	2.27.9	10/06/2019	Email/Letter from stakeholder	Email from WAFIC responding to 3D Oil's information provided on 07/06/2019.		Stakeholder objection / claim / concern is to be addressed in the EP. Stakeholder is to be advised of outcome.
	2.27.10	19/06/2019	Email/Letter to stakeholder	Thanked WAFIC for the comments and advice provided. 3D Oil responded to WAFIC's queries.		N/A
	2.27.11	23/07/2019	Email/Letter to stakeholder	Advised the Sauropod 3D MSS EP has been published by NOPSEMA for public comment and review. Provided the review period and the direct link to the dedicated submission portal on the NOPSEMA website.		N/A
	2.27.12	04/09/2019	Email/Letter to stakeholder	Provided WAFIC with response to the recent public comment submission in relation to the 3D Oil Sauropod 3D Marine Seismic Survey (MSS) Environment Plan (EP).		N/A
Wilderness Society	2.28.1	15/04/2019	Email/Letter from stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.28.2	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A

Stakeholder	Appendix #	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit
	2.28.3	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
World Wildlife Fund for Nature (WWF)	2.29.1	15/04/2019	Email/Letter from stakeholder	Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 17 May 2019.	Yes - Initial Notification	N/A
	2.29.2	15/04/2019	Email/Letter from stakeholder	Automated Response received.		N/A
	2.29.3	23/05/2019	Email/Letter to stakeholder	Follow up email sent. 'Advised of proposal to undertake the 3D Sauropod 3D MSS. Attached factsheet provides information on: · the location, schedule and description of activities to be undertaken; · types of vessels to be used and logistical arrangements, as known; Requested any feedback be provided prior to 7 June 2019.	Yes - Initial Notification	N/A
	2.29.4	23/05/2019	Email/Letter from stakeholder	Automated Response received.		N/A
	2.29.5	10/06/2019	Email/Letter to stakeholder	Follow up email sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
	2.29.6	10/06/2019	Email/Letter from stakeholder	Automated Response received.		N/A
WA Fisheries						
Mackerel Managed Fishery (All License Holders)		12/04/2019	Email/Letter to stakeholder	Letter sent out by 3D Oil. 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; · Environmental hazards and proposed control measures. Requested feedback be provided prior to 17 May 2019. Attached supplementary fisheries information provided. This includes a summary of our understanding in the area of the activity.	Yes Fisheries Factsheet Supplementary Fisheries Information	N/A
		12/06/2019	Email/Letter to stakeholder	Follow up letter sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Northern Demersal Scalefish Managed Fishery (All License Holders)		12/04/2019	Email/Letter to stakeholder	Letter sent out by 3D Oil. 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; · Environmental hazards and proposed control measures. Requested feedback be provided prior to 17 May 2019. Attached supplementary fisheries information provided. This includes a summary of our understanding in the area of the activity.	Yes Fisheries Factsheet Supplementary Fisheries Information	N/A
		12/06/2019	Email/Letter to stakeholder	Follow up letter sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
North Coast Prawn - Nickol Bay Prawn (All License Holders)		12/04/2019	Email/Letter to stakeholder	Letter sent out by 3D Oil. 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; · Environmental hazards and proposed control measures. Requested feedback be provided prior to 17 May 2019. Attached supplementary fisheries information provided. This includes a summary of our understanding in the area of the activity.	Yes Fisheries Factsheet Supplementary Fisheries Information	N/A

Stakeholder	Appendix #	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit
		12/06/2019	Email/Letter to stakeholder	Follow up letter sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
North Coast Shark Fishery (All License Holders)		12/04/2019	Email/Letter to stakeholder	Letter sent out by 3D Oil. 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; · Environmental hazards and proposed control measures. Requested feedback be provided prior to 17 May 2019. Attached supplementary fisheries information provided. This includes a summary of our understanding in the area of the activity.	Yes Fisheries Factsheet Supplementary Fisheries Information	N/A
		12/06/2019	Email/Letter to stakeholder	Follow up letter sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Pilbara Demersal - Trawl (All License Holders)		12/04/2019	Email/Letter to stakeholder	Letter sent out by 3D Oil. 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; · Environmental hazards and proposed control measures. Requested feedback be provided prior to 17 May 2019. Attached supplementary fisheries information provided. This includes a summary of our understanding in the area of the activity.	Yes Fisheries Factsheet Supplementary Fisheries Information	N/A
		12/06/2019	Email/Letter to stakeholder	Follow up letter sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Pilbara Demersal - Trap (All License Holders)		12/04/2019	Email/Letter to stakeholder	Letter sent out by 3D Oil. 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; · Environmental hazards and proposed control measures. Requested feedback be provided prior to 17 May 2019. Attached supplementary fisheries information provided. This includes a summary of our understanding in the area of the activity.	Yes Fisheries Factsheet Supplementary Fisheries Information	N/A
		12/06/2019	Email/Letter to stakeholder	Follow up letter sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A
Brown Dog Fishing - Pilbara Demersal License Holder	2.30.1	22/04/2019	Email/Letter from stakeholder	Email received from Brown Dog Fishing stating they have vessels operating in the Pilbara Demersal and Northern Demersal trap fisheries and have operations from time to time within and adjacent to your survey area. Brown Dog Fishing went to explain they do not support seismic activities in areas over and around their fishing grounds on account of the unknown effects the noise signals may have on the trophic food chain and our target fish behaviour. Gold Band Snapper, school up to spawn every November and December in, and adjacent to the area on the eastern side of the survey area. Brown Dog Fishing believe that no seismic activity should be permitted at this time due to the risk it poses to this spawning activity. Brown Dog Fishing went on to explain that they would not be ready to bear the cost of avoidance by ceasing their activities during the seismic survey and believe that 'make good" process should be considered.		Stakeholder objection / claim / concern is to be addressed in the EP. Stakeholder is to be advised of outcome.

Stakeholder	Appendix #	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit
	2.30.2	07/06/2019	Email/Letter to stakeholder	3D Oil provided Brown Dog Fishing with a summary of the relevant impact assessments (i.e. impacts to commercial fisheries and fishing spawning): Physical Presence of Vessels and Equipment, Noise Emissions. 3D Oil also provided information on the Make Good Process and provided an updated on the EP submission date and the acquisition timing.		N/A
	2.30.3	23/07/2019	Email/Letter to stakeholder	Advised the Sauropod 3D MSS EP has been published by NOPSEMA for public comment and review. Provided the review period and the direct link to the dedicated submission portal on the NOPSEMA website.		N/A
Pilbara Demersal - Line (All License Holders)		12/04/2019	Email/Letter to stakeholder	Letter sent out by 3D Oil. 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; · Environmental hazards and proposed control measures. Requested feedback be provided prior to 17 May 2019. Attached supplementary fisheries information provided. This includes a summary of our understanding in the area of the activity.	Yes Fisheries Factsheet Supplementary Fisheries Information	N/A
		12/06/2019	Email/Letter to stakeholder	Follow up letter sent advising stakeholder of change in activity schedule: The Sauropod 3D MSS is now expected to be undertaken within the period of January to April 2020, or January to April 2021. Also notified the stakeholder that the EP is to be submitted at the end of June.		N/A

APPENDIX C JASCO ACOUSTIC MODELLING REPORT

3D Oil Sauropod 3-D Marine Seismic Survey

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

Submitted to:

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Environmental Resources Management

Authors:

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Craig McPherson

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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:

Quijano, J.E. and C.R. McPherson. 2019. *3D Oil Sauropod 3-D Marine Seismic Survey: Acoustic Modelling for Assessing Marine Fauna Sound Exposures*. Document 01781, Version 1.0. Technical report by JASCO Applied Sciences for Environmental Resources Management.

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Executive Summary

JASCO Applied Sciences performed a numerical estimation study of underwater sound levels associated with the planned 3D Oil Sauropod 3-D Marine Seismic Survey (MSS) to assist in understanding the potential acoustic impact on key regional receptors including fish, cetaceans, turtles, benthic invertebrates, and plankton. Modelling considered a 3090 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 defined locations within the Acquisition Area, and accumulated sound exposure fields were predicted for one representative scenario 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. Particle motion metrics were predicted at four modelled sites. 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) marine mammal behavioural response criterion of 160 dB re 1 µPa (SPL) could be exceeded varied between 6.47 and 8.36 km (Site 2 and Site 1, water depths of 125 66 m respectively).
- The results for the criteria applied for marine mammal 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 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)
Low-frequency cetaceans	SEL_{24h}†	0.63
Mid-frequency cetaceans	PK	<0.02
High-frequency cetaceans	PK	0.23

† 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 array is not a point source (approximately 14 × 8 m), the actual ranges from the edge of the airgun array is small.

- The distances to where the NMFS criterion (NSF 2011) 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)	
	Min	Max
175†	1.00	1.20
166‡	3.28	5.10

† Threshold for turtle behavioural response to impulsive noise (Moein et al. 1995).
‡ Threshold for turtle behavioural response to impulsive noise (NSF 2011).

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)
Fish: No swim bladder	Injury	PK	0.06	PK	0.08
	TTS	SEL_{24h}	2.81	SEL_{24h}	2.79
Fish: Swim bladder not involved in hearing Swim bladder involved in hearing	Injury	PK	0.13	PK	0.19
	TTS	SEL_{24h}	2.81	SEL_{24h}	2.79
Fish eggs, and larvae	Injury	PK	0.13	PK	0.19

Crustaceans and Bivalves, 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 468 and 709 m depending on the modelled site.
- Bivalves: the distance where a particle acceleration of 37.57 ms^{-2} at the seafloor could occur was determined for comparing to results presented in Day et al. (2016a). The maximum horizontal distance to this particle acceleration level was 9.1 m.
- 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 four considered sites.
- 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 5.32 km to 7.93 km.

1. Introduction

JASCO Applied Sciences (JASCO) performed a numerical estimation study of underwater sound levels associated with the planned 3D Oil Sauropod 3-D Marine Seismic Survey (MSS) in permit WA-527-P to assist in understanding the potential acoustic impact on key regional receptors including fish, cetaceans, benthic invertebrates, plankton, and turtles. Modelling considered a 3090 in^3 seismic source in a flip-flap-flop configuration, towed at a 6 m depth behind a single vessel.

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 one representative scenario 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. Particle motion metrics were predicted at the modelled locations along the broadside directions associated with the highest levels.

2. Modelling Scenarios

Four standalone single impulse sites and one likely scenario for survey operations over 24 hours to assess accumulated SEL were defined. The locations of all 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. The considered survey acquisition lines took ~10.18 h (each) to traverse with ~5.2 h of turn time required between the lines, accounted for 13280 impulses. During line turns the seismic source was not in operation.

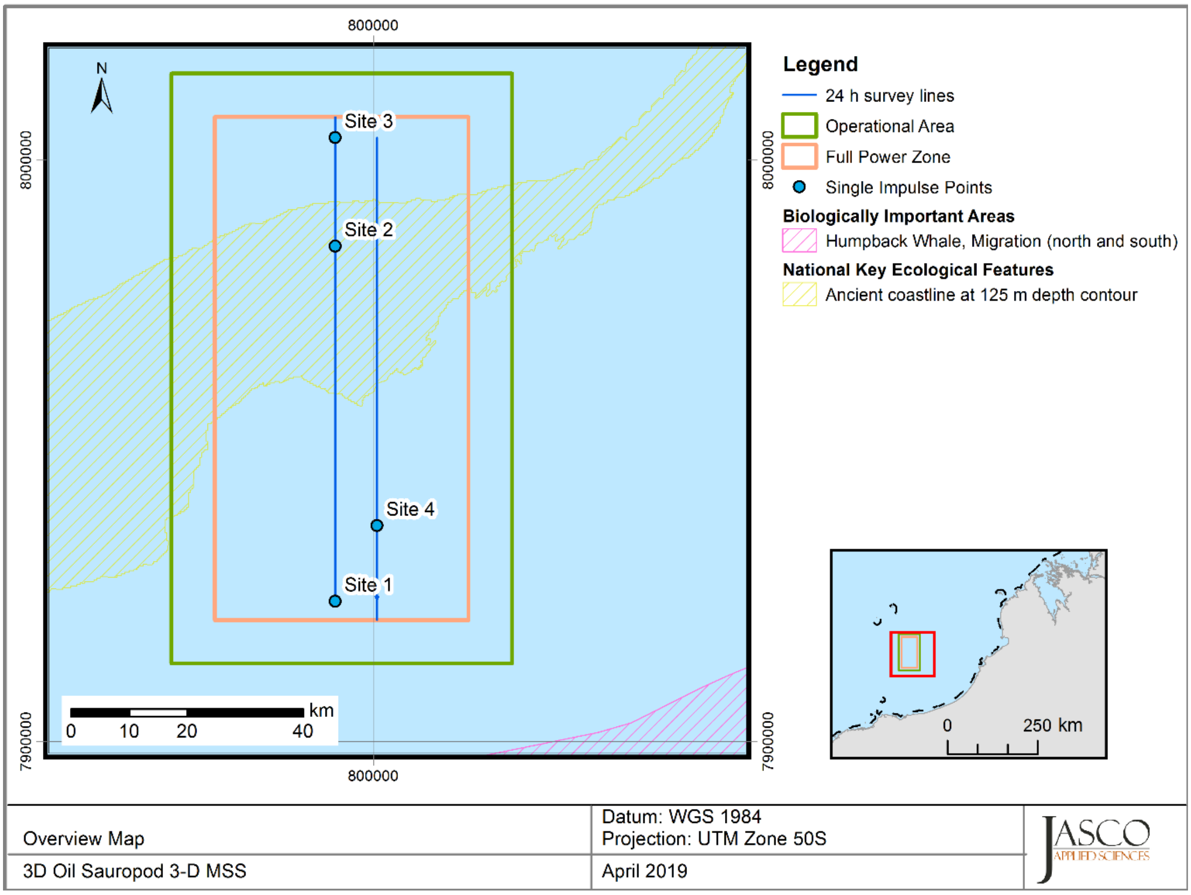

Figure 1. Overview of the modelling sites, acquisition lines, and features for the 3-DSauropod 3-D MSS modelling.

Table 4. Location details for the modelling sites.

Site	Latitude (S)	Longitude (E)	UTM (WGS1984) Zone 50S		Water depth (m)	Representative tow direction (°)
			X (m)	*Y* (m)		
1	18° 45' 14.3694"	119° 46' 58.6168"	793425	7924100	66	0 & 180
2	18° 12' 08.6755"	119° 46' 26.6060"	793425	7985200	125	
3	18° 02' 00.9264"	119° 46' 17.0335"	793425	8003900	161	
4	18° 38' 07.1558"	119° 50' 57.1375"	800625	7937133	107	

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 (2017a).

Whether acoustic exposure levels might injure or disturb marine mammals 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 (Sections 3.1–3.2 and Appendix A):

1. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from the U.S. National Oceanic and Atmospheric Administration (NOAA) Technical Guidance (NMFS 2018) for the onset of Permanent Threshold Shift (PTS) in marine mammals.
2. Marine mammal 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 2011), 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. 2000b, McCauley et al. 2000a, NSF 2011).
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; $L_{pk\text{-}pk}$) and particle acceleration at the seafloor to help assess effects of noise on crustaceans and bivalves, through comparing to results in Day et al. (2016a) and Payne et al. (2008).
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 (2014)	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 µPa²·s)	PK (L_{pk}; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·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 µPa²s.
Subscripts indicate the designated marine mammal auditory weighting.

3.1.1. Behavioural response

Southall et al. (2007) extensively reviewed marine mammal behavioural responses to sounds. Their review found that most marine mammals 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 marine mammal. 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, to help assess the potential for injuries to cetaceans. 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 marine mammals 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 1µPa^2·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. (2000b) 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 2011). 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 2011). 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 (2011) 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 µPa^2·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, seabed material 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 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 the 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 included.

For bivalves, literature does not present a sound level associated with no impact, and as particle motion is the more relevant metric, particle acceleration from the seismic source has been presented for comparing the results in Table 7 and Day et al. (2016a). The maximum particle acceleration assessed for scallops was 37.57 ms^{-2}.

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 3090 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. VSTACK was also used to compute estimates of particle acceleration and velocity at all modelling sites.

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 3090 in^3 seismic source arrays consisting of two strings each were modelled in a flip-flop-flap configuration. The three arrays considered were towed at a depth of 6 m, and the lateral distance between the arrays was 25 m. A single sound speed profile for May 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 a succession from soft to hard sediments (silty carbonate sand to calcarenites) (Table D-1).

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.

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 3000 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 2.5 to 25 kHz. The MONM and Bellhop results were combined to produce results for the full frequency range of interest.

FWRAM was run to 100 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 3090 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 µPa²m²s)	
		10–2000 Hz	2000–25000 Hz
Broadside	249.4	225.1	184.5
Endfire	245.7	223.2	187.8
Vertical	255.0	228.2	195.0
Vertical (surface affected source level)	255.0	230.6	198.0

5.2. Per-pulse Sound Fields

5.2.1. Tabulated results

Per-pulse results for the 3090 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 3090 in³ array to modelled maximum-over-depth unweighted per-pulse SEL isopleths from the four modelled single impulse sites.

Per-pulse SEL (L_E; dB re 1 µPa²·s)	Site 1 (66 m)		Site 2 (125 m)		Site 3 (161 m)		Site 4 (107 m)	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
180	0.16	0.14	0.16	0.14	0.16	0.13	0.16	0.14
170	0.72	0.59	0.74	0.67	0.78	0.69	0.70	0.63
160†	3.10	2.35	2.44	1.99	2.24	1.76	2.42	2.00
150	9.27	7.82	7.90	6.43	7.95	6.42	7.45	6.26
140	25.2	19.2	18.2	14.9	19.1	16.0	17.1	14.0
130	50.5	40.7	36.1	30.9	37.8	32.1	33.7	27.8
120	86.3	71.2	73.4	60.0	67.2	59.1	61.1	51.3

† Low power zone assessment criteria DEWHA (2008).

Table 9. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 3090 in³ array to modelled maximum-over-depth SPL isopleths from the four modelled single impulse sites.

SPL (L_p; dB re 1 µPa)	Site 1 (66 m)		Site 2 (125 m)		Site 3 (161 m)		Site 4 (107 m)	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
190	0.14	0.12	0.13	0.12	0.12	0.12	0.13	0.12
180	0.58	0.50	0.70	0.62	0.54	0.48	0.66	0.60
175#	1.20	0.99	1.01	0.85	1.00	0.84	1.14	0.85
170	2.48	2.09	2.04	1.66	1.80	1.49	2.02	1.72
166†	5.10	3.60	3.32	2.85	3.28	2.68	3.64	2.87
160‡	8.36	6.76	6.47	5.58	6.58	5.65	7.18	5.50
150	20.5	16.3	15.7	13.1	16.5	13.8	14.7	12.2
140	43.6	34.9	30.9	26.2	32.9	27.7	28.5	23.9
130	78.5	64.6	64.5	52.0	60.8	51.0	53.5	44.9

Threshold for turtle behavioural response to impulsive noise (Moein et al. 1995).
† Threshold for turtle behavioural response to impulsive noise (NSF 2011).
‡ Marine mammal behavioural threshold for impulsive sound sources (NMFS 2014).

Table 10. Maximum (R_{max}) horizontal distances (km) from the 3090 in3 array to modelled maximum-over-depth peak pressure level (PK) thresholds based on the NOAA Technical Guidance (NMFS 2018) for marine mammals, 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 (66 m)	Site 2 (125 m)	Site 3 (161 m)	Site 4 (107 m)
Low-frequency cetaceans (PTS)	219	0.03	0.03	0.03	0.03
Low-frequency cetaceans (TTS)	213	0.06	0.06	0.06	0.06
Mid-frequency cetaceans (PTS)	230	<0.02	<0.02	<0.02	<0.02
Mid-frequency cetaceans (TTS)	224	<0.02	<0.02	<0.02	<0.02
High-frequency cetaceans (PTS)	202	0.21	0.21	0.22	0.23
High-frequency cetaceans (TTS)	196	0.68	0.41	0.6	0.7
Fish: No swim bladder (also applied to sharks)	213	0.06	0.06	0.06	0.06
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	0.11	0.12	0.13	0.12
Turtles (PTS)	232	<0.02	<0.02	<0.02	<0.02
Turtles (TTS)	226	<0.02	<0.02	<0.02	<0.02

Table 11. Maximum (R_{max}) horizontal distances (in km) from the 3090 in^3 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 (66 m)	Site 2 (125 m)	Site 3 (161 m)	Site 4 (107 m)
178	7.93	5.76	6.38	5.32

5.2.1.2. Seafloor

Table 12. Maximum (R_{max}) horizontal distances (in m) from the 3090 in^3 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 (66 m)	Site 2 (125 m)	Site 3 (161 m)	Site 4 (107 m)
Sound levels for sponges and corals†	226	—	—	—	—
Fish: No swim bladder (also applied to sharks)	213	80	52	32	60
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	187	158	145	150

† Heyward et al. (2018)
A dash indicates the level was not reached.

Table 13. Maximum (R_{max}) horizontal distances (in m) from the 3090 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 ($L_{pk\text{-}pk}$; dB re 1 µPa)	Distance R_{max} (m)			
	Site 1 (66 m)	Site 2 (125 m)	Site 3 (161 m)	Site 4 (107 m)
213	156	150	130	146
212	179	165	156	164
211	204	182	186	188
210	234	209	210	215
209	260	240	229	247
202	468	635	709	591

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 2–09.

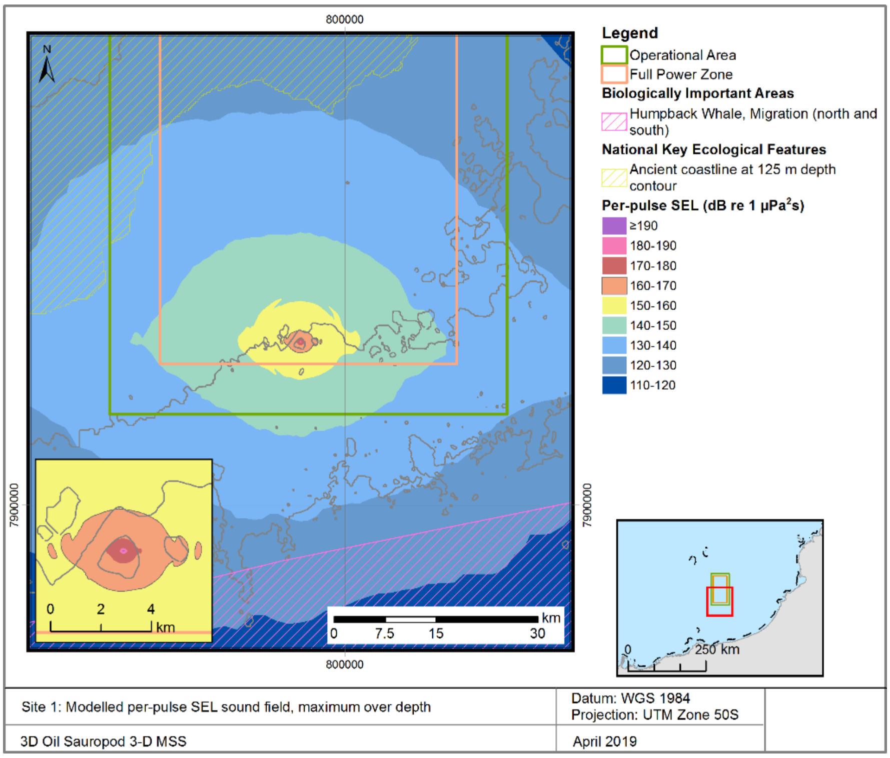

Figure 2. *Site 1, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth results.

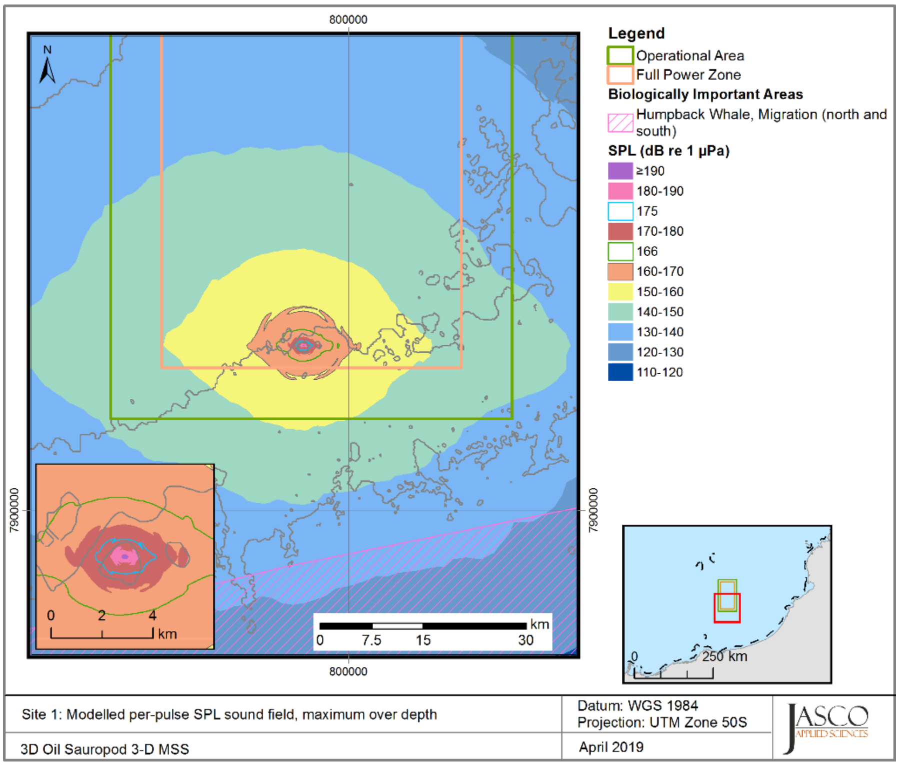

Figure 3. *Site 1, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

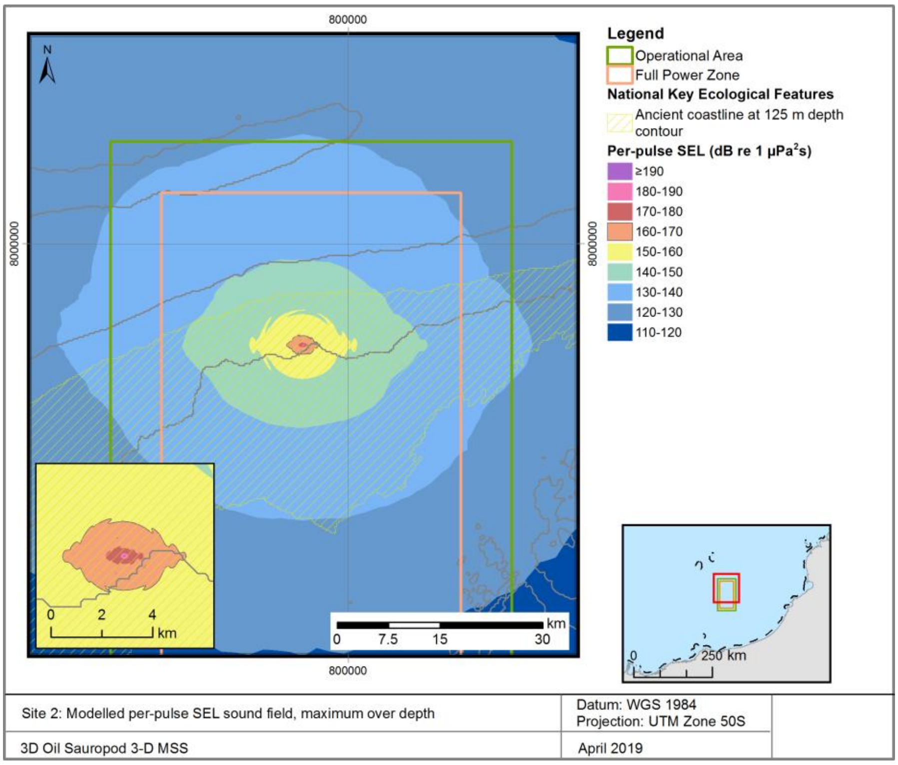

Figure 4. *Site 2, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth results.

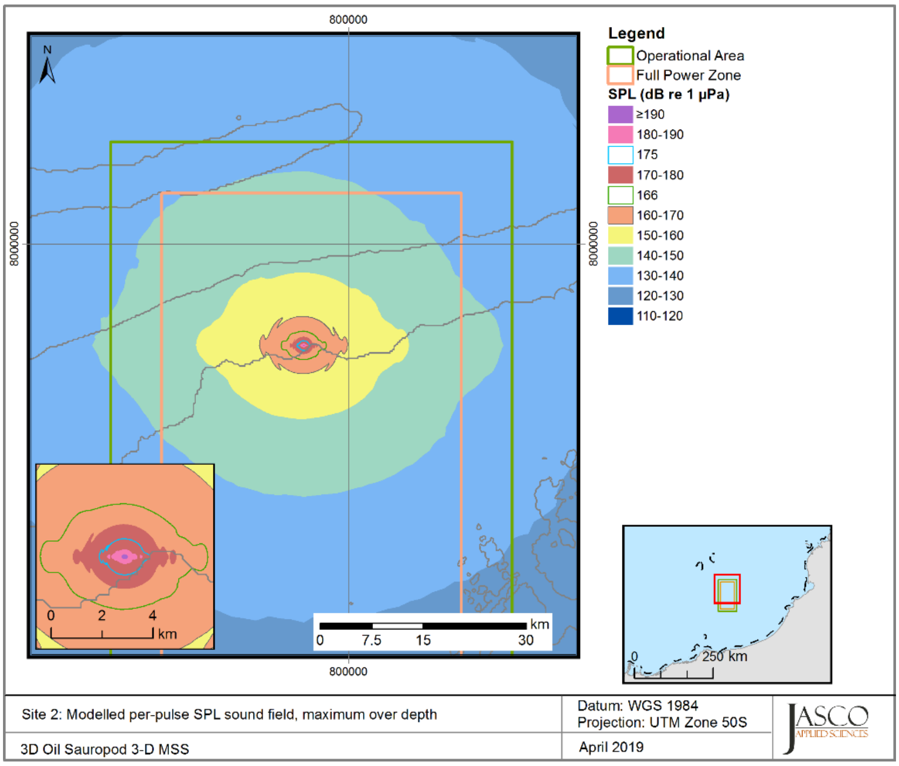

Figure 5. *Site 2, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

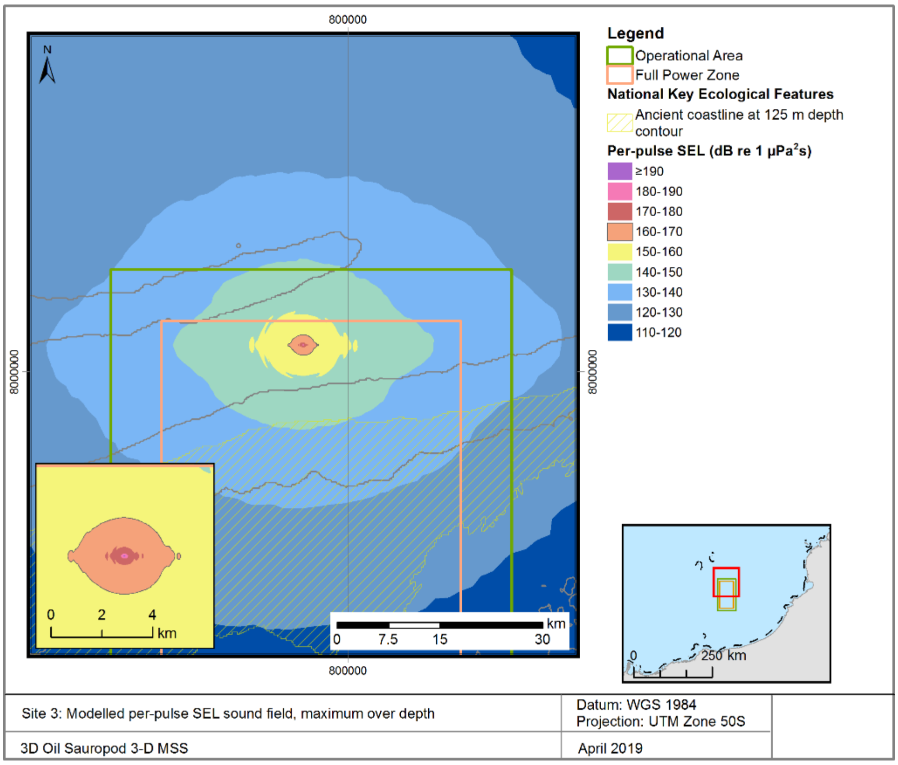

Figure 6. *Site 3, per-pulse SEL*: Sound level contour map showing unweighted maximum-over-depth results.

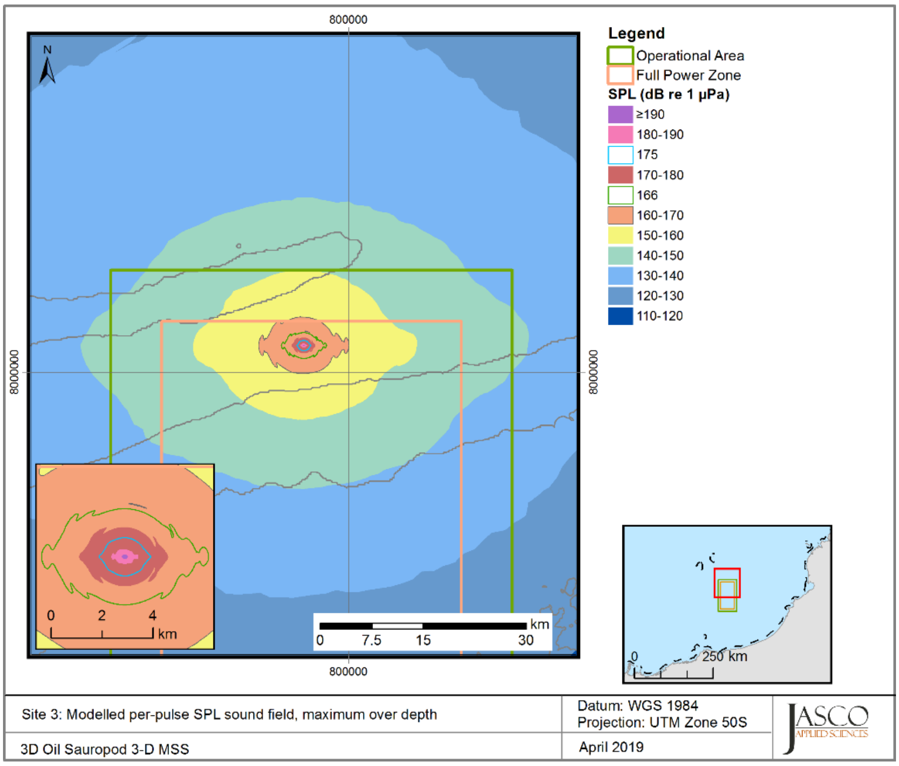

Figure 7. *Site 3, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

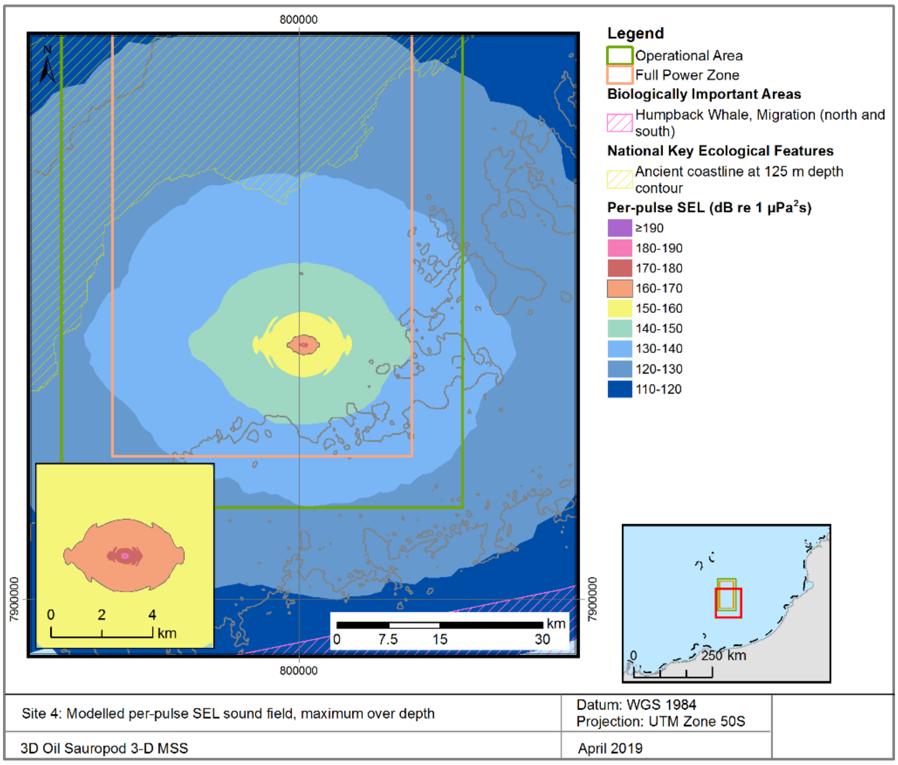

Figure 8. *Site 4, per-pulse SEL*: Sound level contour map showing unweighted maximum-over-depth results.

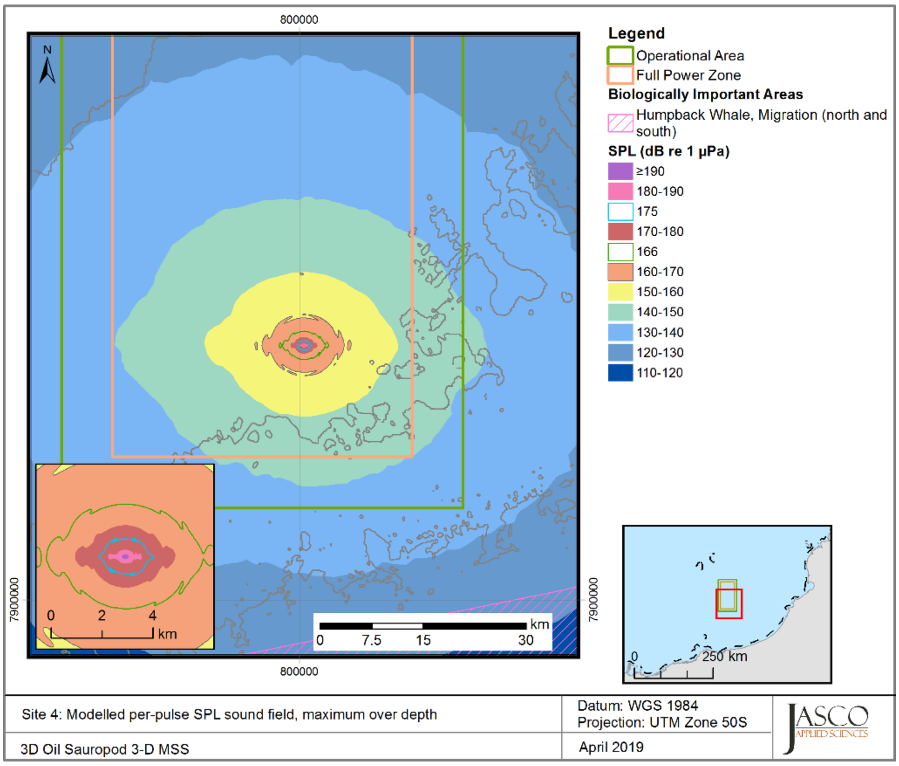

Figure 9. *Site 4, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

5.2.2.2. Vertical slices of modelled sound fields

Vertical slices of the SPL sound fields for the 3090 in^3 airgun array are shown in Figures 10–13.

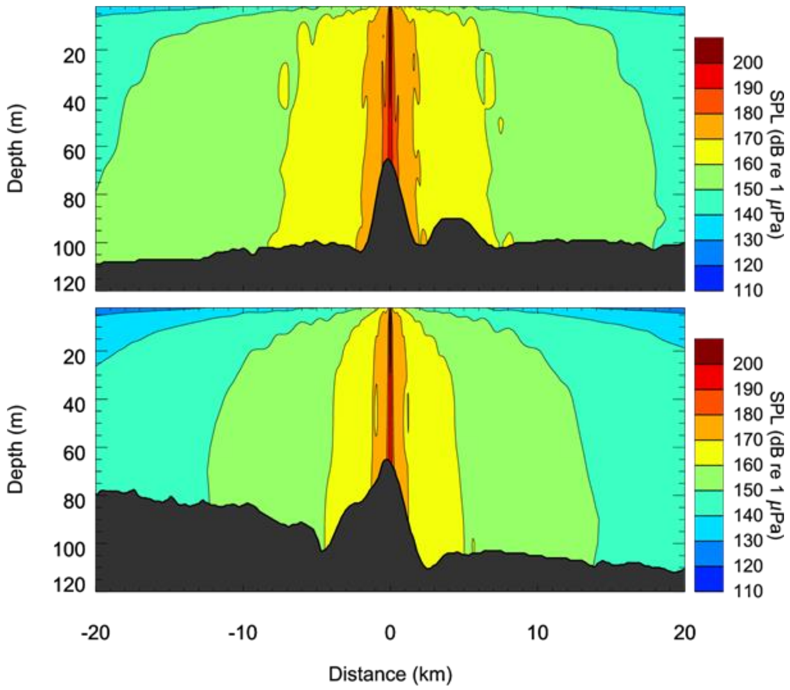

Figure 10. *Site 1, SPL*: Vertical slice of the predicted SPL for the 3090 in^3 array. Levels are shown along the broadside (top) and endfire (bottom) directions.

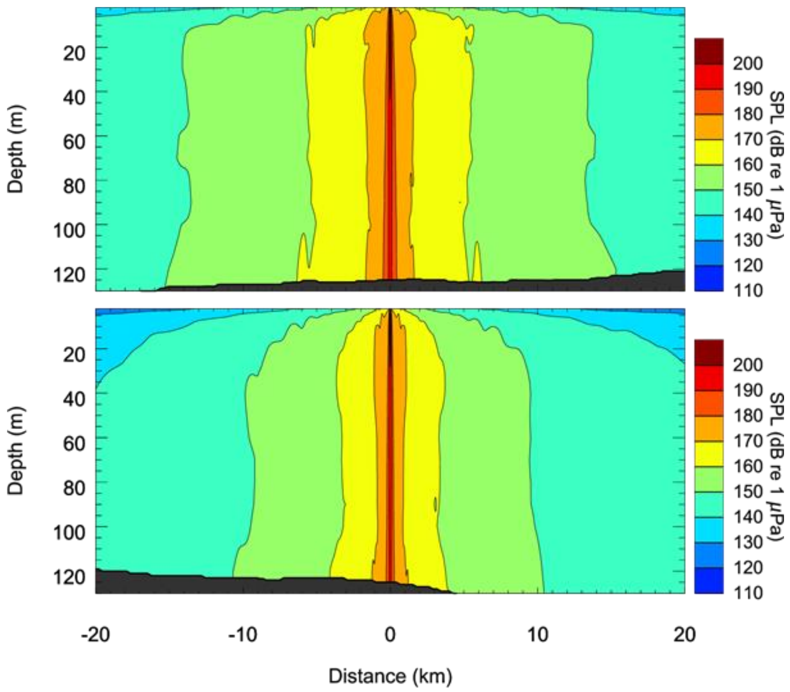

Figure 11. *Site 2, SPL*: Vertical slice of the predicted SPL for the 3090 in^3 array. Levels are shown along the broadside (top) and endfire (bottom) directions.

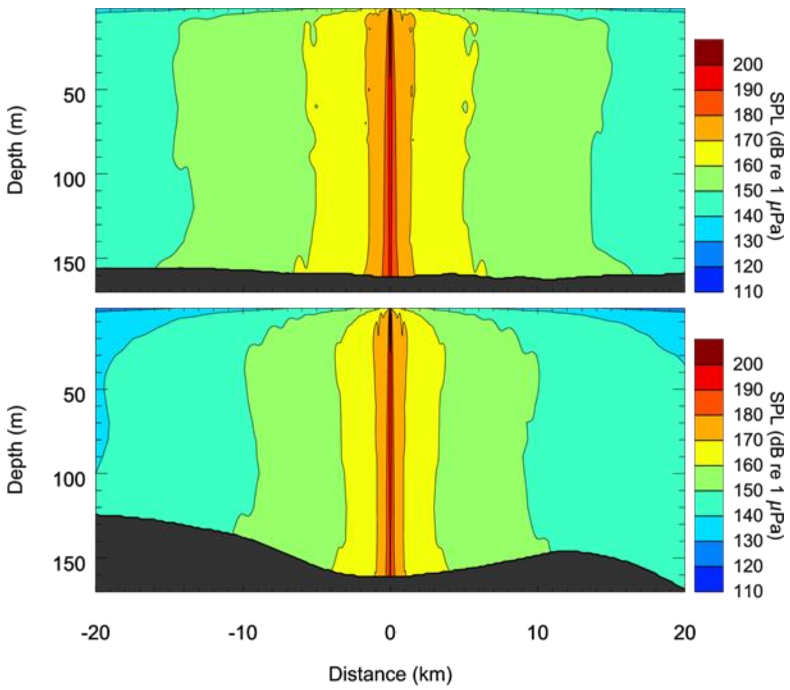

Figure 12. *Site 3, SPL*: Vertical slice of the predicted SPL for the 3090 in^3 array. Levels are shown along the broadside (top) and endfire (bottom) directions.

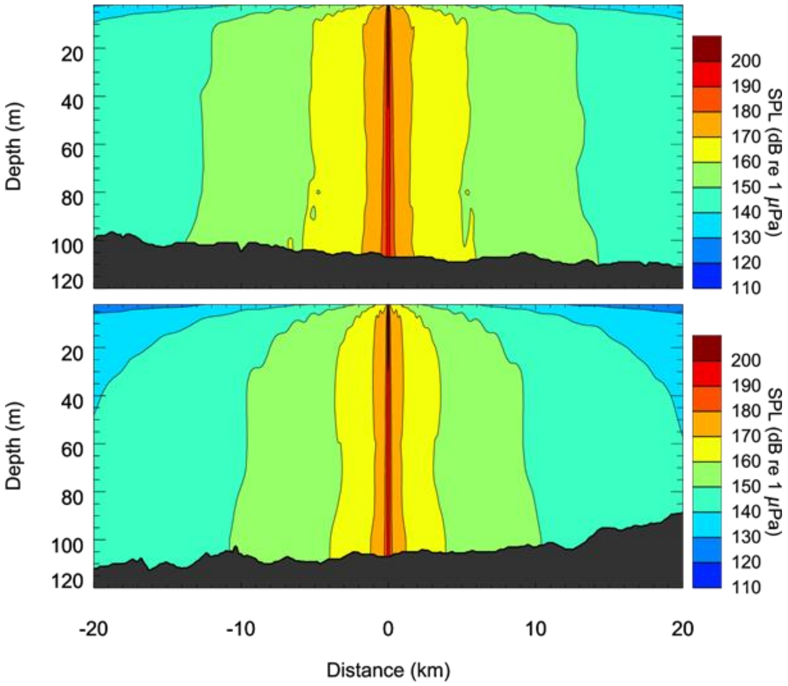

Figure 13. *Site 4, SPL*: Vertical slice of the predicted SPL for the 3090 in^3 array. Levels are shown along the broadside (top) and endfire (bottom) directions.

5.2.3. Particle motion

Particle acceleration and velocity was modelled for seafloor receivers at each site. Modelling was performed in the broadside directions because particle motion was highest along those azimuths. From the modelled 3-D particle motion traces, the peak acceleration and velocity were computed as a function of horizontal range from the centre of the array. The maximum horizontal distance to a peak particle acceleration of 37.57 ms^{-2} (Section 3.3; Day et al. (2016b) is3.3; (Day et al. 2016a)) was 9.1 m, which occurred at the shallowest site, Site 1, Figure 14. The results for Sites 2–4 are shown in Appendix E.1, Figures E-1 to E-3.

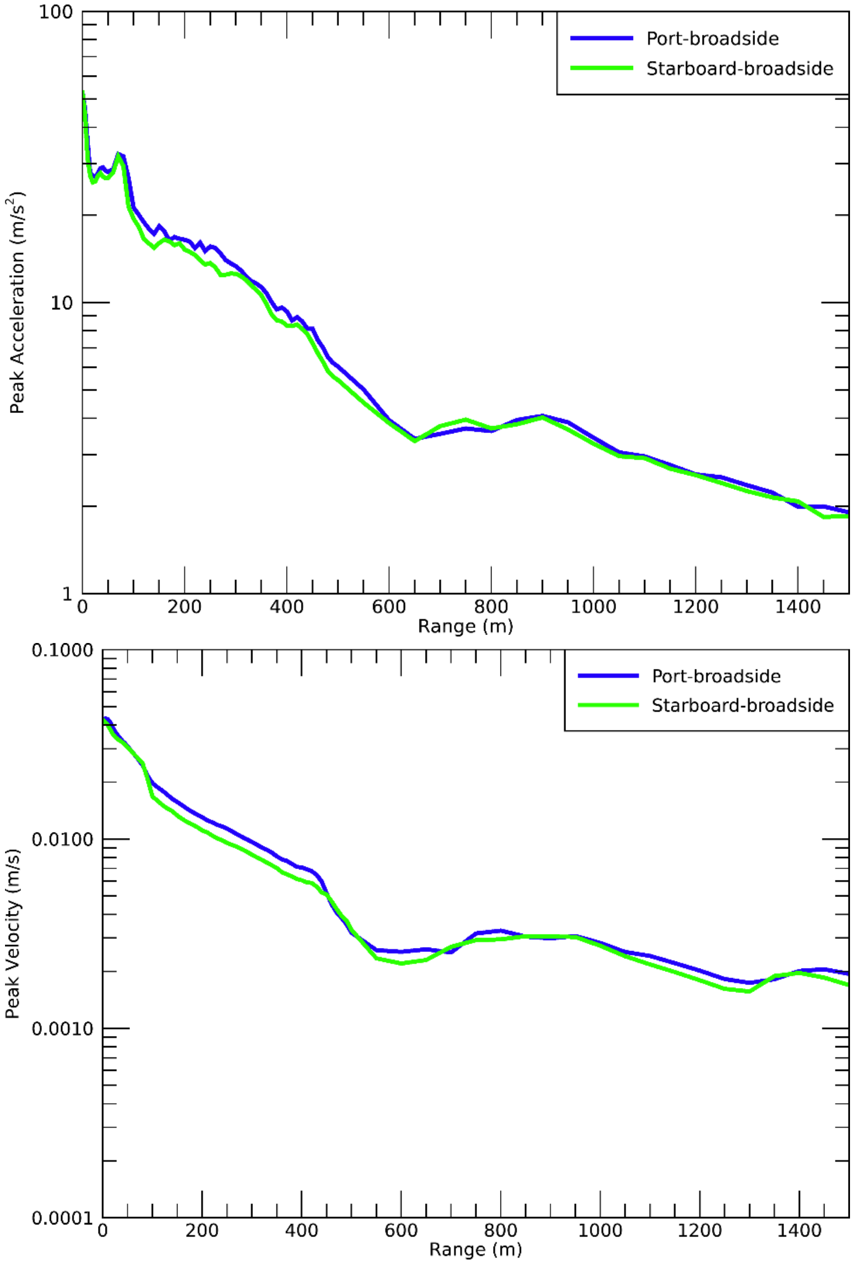

Figure 14. Site 1: Maximum particle acceleration (top) and velocity (bottom) at the seafloor as a function of horizontal range from the centre of a single 3090 in^3 seismic source along the broadband directions.

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 and 15 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 Figure 15, while estimates of the sound field at the seafloor and threshold contours relevant to fish are presented in Figure 16.

Table 14. Maximum-over-depth distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018).

Hearing group	PTS		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	183	0.63	147.93
Mid-frequency cetaceans	185	—	—
High-frequency cetaceans	155	0.03	8.99
Hearing group	**TTS**		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	168	15.4	2974.8
Mid-frequency cetaceans	170	—	—
High-frequency cetaceans	140	0.23	78.2

A dash indicates the threshold is not reached.

Table 15. Distances to SEL_{24h} based fish criteria.

Marine fauna group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	Maximum-over-depth		Seafloor	
		R_{max} (km)	Area (km²)	R_{max} (km)	Area (km²)
Mortality and potential mortal injury					
I	219	<0.03	9.75	—	—
II, Fish eggs and fish larvae	210	<0.03	12.44	—	—
III	207	0.04	13.28	—	—
Fish recoverable injury					
I	216	<0.03	12.00	—	—
II, III	203	0.04	13.28	—	—
Fish TTS					
I, II, III	186	2.81	720.12	2.79	715.75

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.

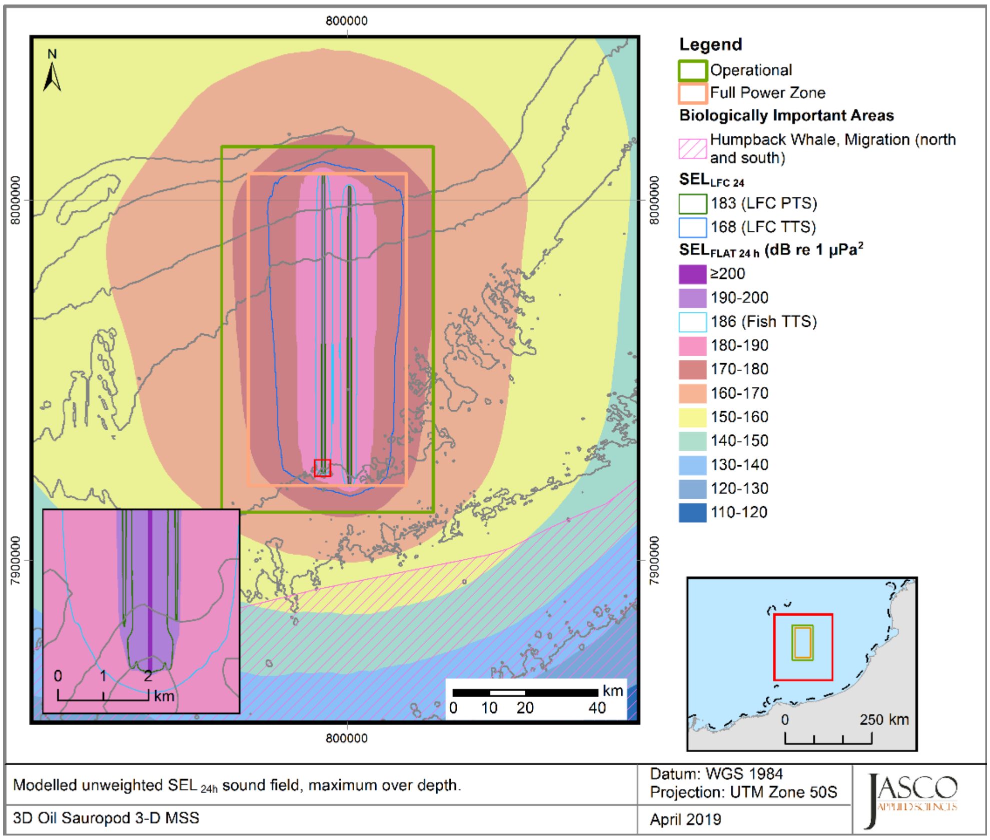

Figure 15. Sound level contour map showing maximum-over-depth SEL_{24h} results.

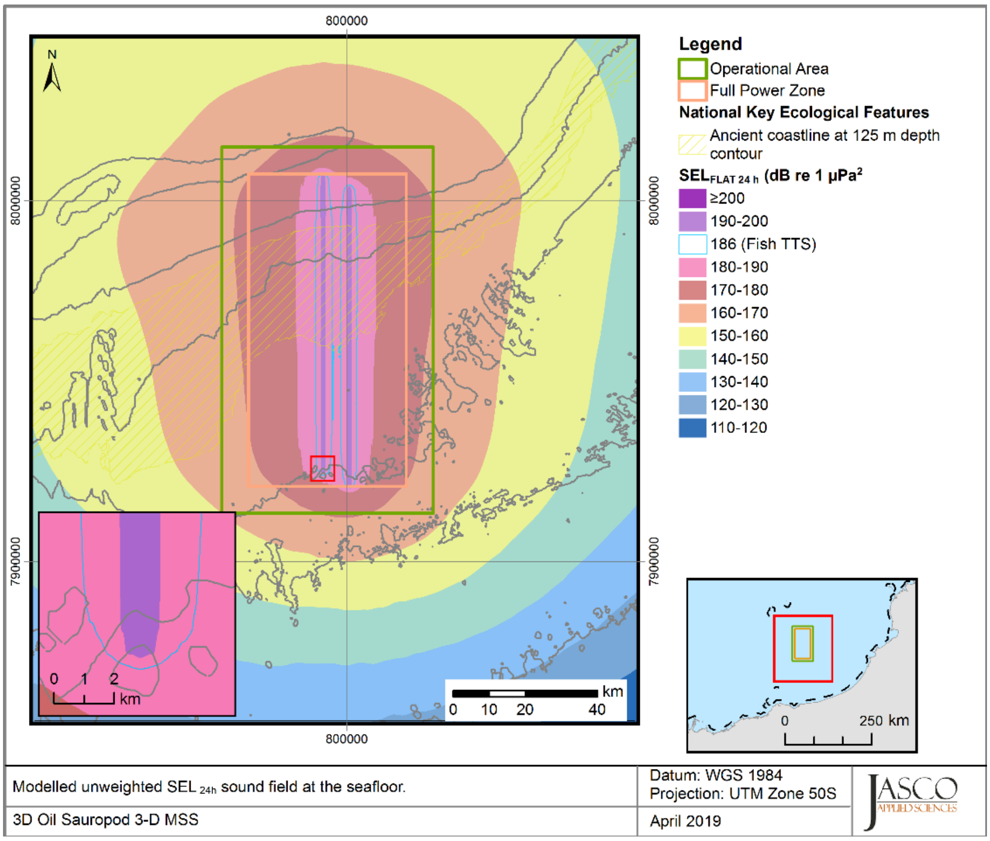

Figure 16. Sound level contour map showing seafloor SEL_{24h} results.

6. Discussion

6.1. Overview and Source Levels

This modelling study predicted underwater sound levels associated with the planned Sauropod 3-D MSS. The underwater sound field was modelled for a 3090 in^3 seismic source (Appendix B) with a water column sound speed profile for May. 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 source is output at lower frequencies, in the tens to hundreds of hertz. The array had a pronounced broadside directivity for 1/3-octave-bands between approximately 158 to about 316 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 3090 in^3 array operating at 6 m depth was 225.1 dB 1 μPa^{2}m^{2}s in the broadside direction and 223.3 dB 1 μPa^{2}m^{2}s in the endfire direction. The peak pressure level in the same directions was 249.4 and 245.7 dB re 1 μPa m, respectively, these results are presented in Table 7.

6.2. Per-Pulse Sound Fields

At all sites, 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; this is due to the directionality of the array. The acoustic footprints were not substantially influenced by changes in water depth because changes in bathymetry within the modelling area was marginal and gradual (Figure D-3). The shallowest site, Site 1 (66 m) had the farthest distance to almost all isopleths, with the distances at the other three modelling sites being more similar. The combination of the geology, water depth, local and bathymetry support longer range propagation at this site when compared to the three other sites in deeper water. This difference is noticeable in both the close range seafloor modelling results (Table 12) and the maximum-over-depth results at greater distances (Table 8). The vertical slice plot for Site 1 (Figure 10) shows that this site is located on a localised shallow point surrounded by deeper water, which contributes to the way the sound is reflected both from and within the seafloor at this site. The other vertical slice plots (Section 5.2.2.2) demonstrate the difference between the broadside and endfire directions within the water column but also the similarity of the footprints for each respective direction at Sites 2–4.

The distances to PK based potential injury criteria (Section 3.2 and 3.3) for fish and benthic crustaceans at the seafloor decreased with increasing depth, apart from the distance to the 202 dB re 1 μPa (PK-PK) relevant to crustaceans, which increased with increasing depth. The distances to these criteria did not always consistently change with increasing depth, phenomena related to complex patterns of surface and bottom reflections that affect sound propagation in shallow water; the distances could be greater for depths even slightly shallower or deeper. However, the number of modelling sites considered within the Acquisition Area, representing the variations in bathymetry, provides a good representation of potential variability.

6.3. Particle Motion

Section 3.3 discuss the relevance of particle motion (acceleration and velocity) to benthic invertebrates. Peak particle acceleration and velocity decayed rapidly with horizontal distance from the centre of the array (Figure 14). There was little difference in particle motion between the two modelled broadside directions.

Particle motion traces generated during the modelling showed that vertical particle motion was larger than horizontal particle motion for receivers directly underneath or at short ranges from the array, but at longer ranges the horizontal particle motion dominated. The duration of particle motion also increased with distance as critically reflected multipath propagation becomes important.

Day et al. (2016a) included an empirical regression of particle acceleration versus range for the single 150 in^3 airgun used in their study (minimum range of 6 m) and showed that acceleration between 10 and 100 m range was typically between 26 and 5 ms^{-2}, respectively. Day et al. (2016a) also referenced an unpublished maximum particle acceleration measurement of 6.2 ms^{-2} from a 3130 in^3 airgun array at 477 m range in 36 m of water. In our study, modelled peak acceleration at 10 m range was predicted to be between 35 and 19 ms^{-2} depending on the site; corresponding values at 100 m range are between 21 and 12 ms^{-2}. At approximately 477 m, our study predicts an acceleration of between 8.5 and 5.8 ms^{-2} in both the port and starboard broadside directions. This result aligns reasonably with the measurements reported in Day et al. (2016a).

The maximum distance to peak particle acceleration of 37.57 ms^{-2}, determined for comparing literature (Section 3.3; (Day et al. 2016a), Day et al. (2016b)) is 9.1 m (Figure 14). This distance is less than that predicted for other studies in the region (Quijano et al. 2018); however, the difference is likely due to the different airgun array configuration and tow depth, as well as the geology for the respective studies. The geology for this study, silty carbonate sand to calcarenites (Appendix D.3.3), is less reflective than seabeds that have thin layers of sand over calcarenite substrate.

6.4. Multiple Pulse Sound Fields

The accumulated SEL over 24 hours of seismic operation was modelled considering a realistic acquisition pattern 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). The footprint of the accumulated SEL (Figures 15 and 16) showed a slight widening of the contours at the deeper end of the survey lines. The single impulse modelling site, Site 1, was only representative of a small portion of the survey lines; therefore, despite having the largest single impulse footprints, the influence on the 24 h footprints was not noticeable.

The extents of isopleths associated with criteria for cetaceans and fish was relatively uniform along the survey lines, with the maximum distances being reached only a few kilometres to the side of each modelled survey line, as shown in the insert maps in Figures 15 and 16. The distance to the maximum-over-depth SEL_{24h} of 219 dB re 1 µPa²·s for fish (<30 m) was determined by the lateral distance between the airgun arrays (25 m), with the three arrays operated in a flip-flop-flap configuration. The 219 dB re 1 µPa²·s 24-hour contour extended a short distance beyond the outer arrays.

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.

6.5. 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) marine mammal behavioural response criterion of 160 dB re 1 µPa (SPL) could be exceeded varied between 6.47 and 8.36 km (Site 2, 125 m and Site 1, 66 m), Table 9.
- The results for the criteria applied for marine mammal 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. Table 16 summarises the maximum distances for PTS, along with the relevant metric and the location of the results within this report.

Table 16. Summary of maximum cetacean PTS onset distances for SEL_{24h} modelled scenarios (PK values from Table 10 and SEL_{24h} values from Table 14)

Relevant hearing group	Metric associated with longest distance to PTS onset	R_{max} (km)
Low-frequency cetaceans†	SEL_{24h}	0.63
Mid-frequency cetaceans	PK	<0.02
High-frequency cetaceans	PK	0.23

† The model does not account for shutdowns.

- 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 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 location for 24 hours.

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 2011) 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 17.

Table 17. Distances to turtle behavioural response criteria (from Table 9).

SPL (L_p; dB re 1 µPa)	Distance (km)	
	Min	Max
175†	1.00	1.20
166‡	3.28	5.10

† Threshold for turtle behavioural response to impulsive noise (Moein et al. 1995).
‡ Threshold for turtle behavioural response to impulsive noise (NSF 2011).

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 (seafloor and water column) and SEL_{24h} (water column only) 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 18 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 18. 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 Table 15).

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)
Fish: No swim bladder	Injury	PK	0.06	PK	0.08
	TTS	SEL_{24h}	2.81	SEL_{24h}	2.79
Fish: Swim bladder not involved in hearing Swim bladder involved in hearing	Injury	PK	0.13	PK	0.19
	TTS	SEL_{24h}	2.81	SEL_{24h}	2.79
Fish eggs, and larvae	Injury	PK	0.13	PK	0.19

Crustaceans and Bivalves, 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 468 and 709 m depending on the modelled site (Table 13).
- Bivalves: the distance where a particle acceleration of 37.57 ms^{-2} at the seafloor could occur was determined for comparing to results presented in Day et al. (2016a). The maximum distance to this particle acceleration level was 9.1 m, Section 5.2.3.
- 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 four 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 5.32 km to 7.93 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 2017b).

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 marine mammals 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 marine mammal 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 $\mu Pa^2 \cdot s \cdot m^2$ (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 marine mammal 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:

$$L_{E,N} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}}\right). \quad \text{(A-5)}$$

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 marine mammals 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 marine mammal 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 marine mammal 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 marine mammal 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. Marine mammal 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 marine mammals 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 marine mammals (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

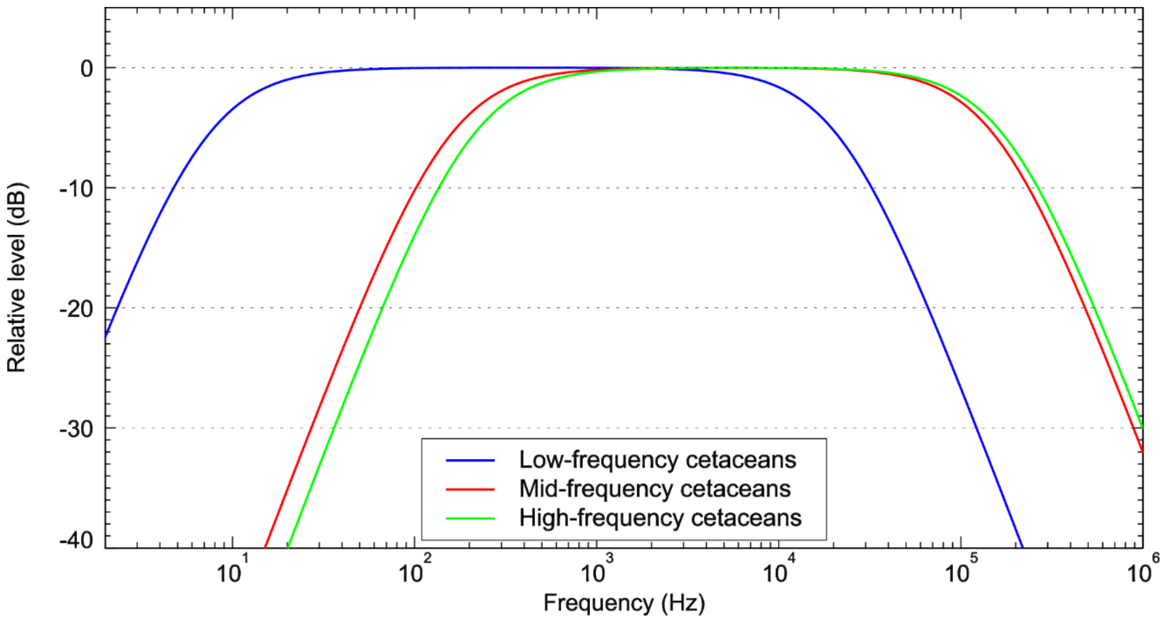

Figure A-1. Auditory weighting functions for functional marine mammal hearing groups used in this project as recommended by NMFS (2018).

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:

$$R_{nf} < \frac{l^2}{4\lambda} \tag{B-1}$$

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 3090 in³ 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.

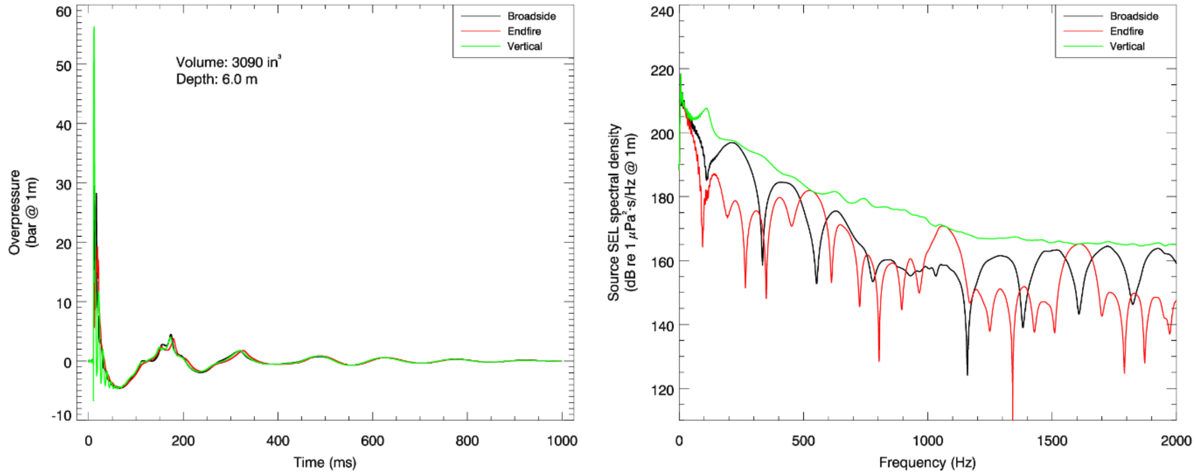

Figure B-1. Predicted source level details for the 3090 in³ array at a 6 m towed depth. (Left) the overpressure signature and (right) the power spectrum for in-plane horizontal (broadside), perpendicular (endfire), and vertical directions.

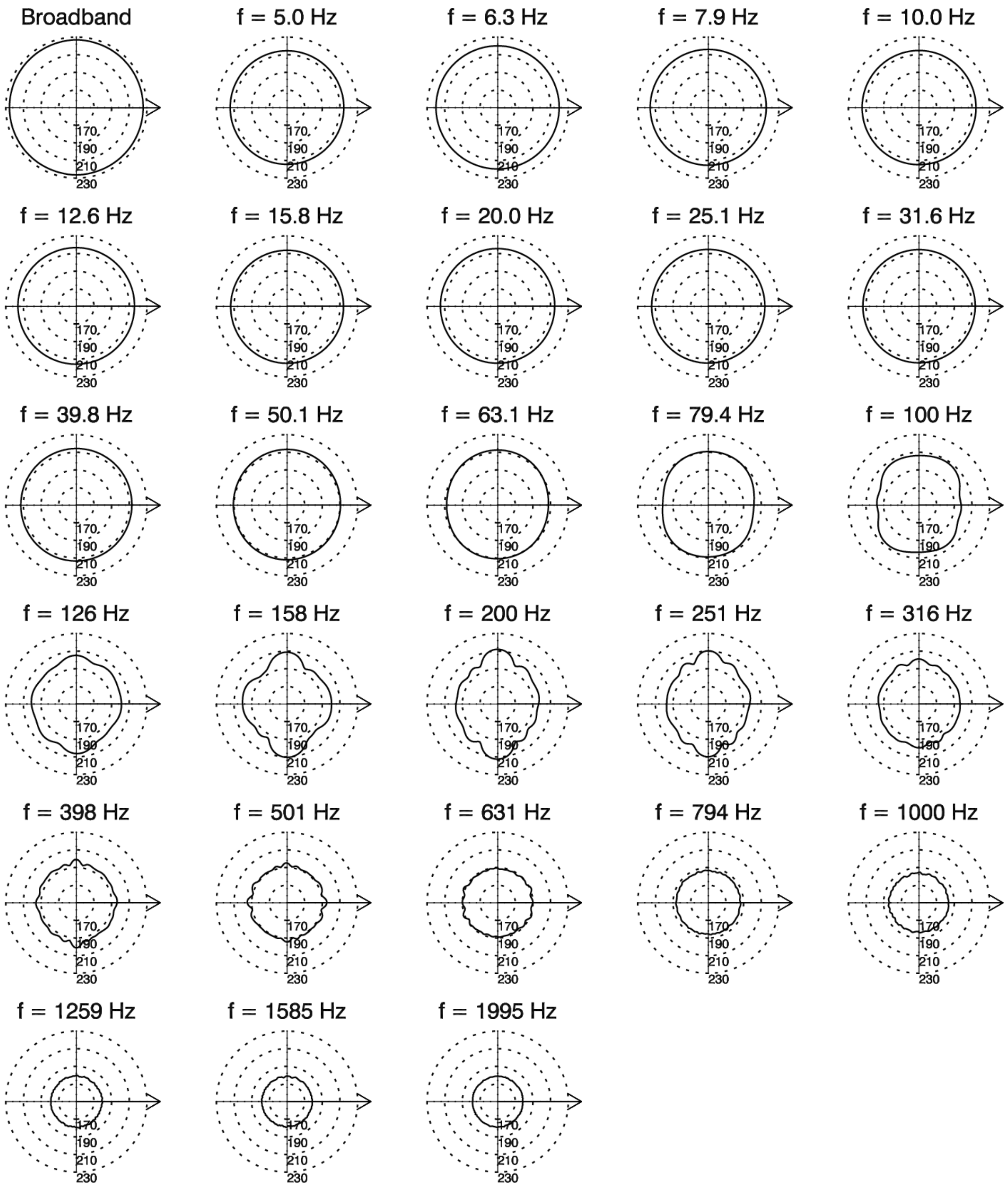

Figure B-2. Directionality of the predicted horizontal source levels for the 3090 in^3 seismic source array, 10 Hz to 2 kHz. Source levels (in dB re 1 $\mu Pa^2 \cdot s\ m^2$) are shown as a function of azimuth for the centre frequencies of the 1/3-octave-bands modelled; frequencies are shown above the 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).

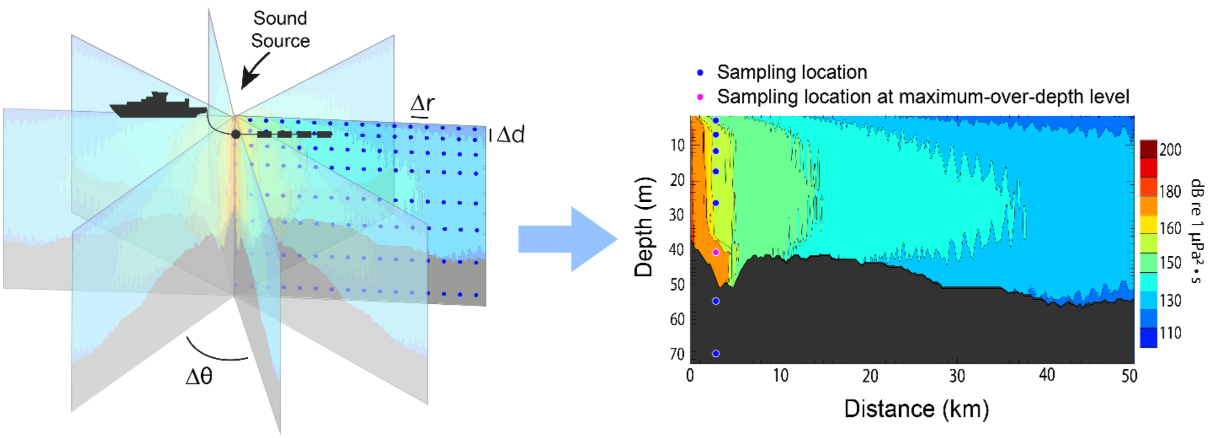

Figure C-1. The N×2-D and maximum-over-depth modelling approach used by MONM.

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 marine mammals. 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).

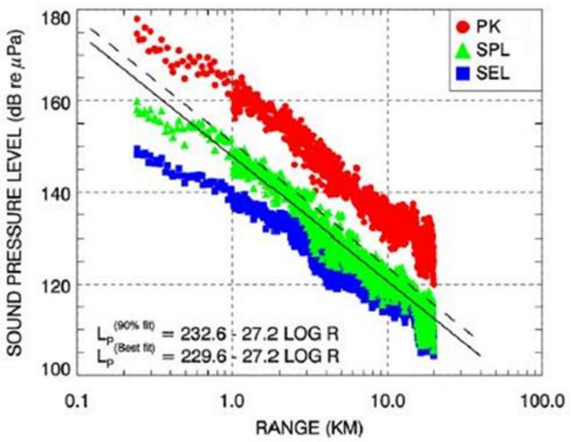

Figure C-2. PK and SPL and per-pulse SEL versus range from a 20 in^3 seismic source. Solid line is the least squares best fit to SPL. Dashed line is the best fit line increased by 3.0 dB to exceed 90% of all SPL values (90th percentile fit) (Ireland et al. 2009, Figure 10).

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.

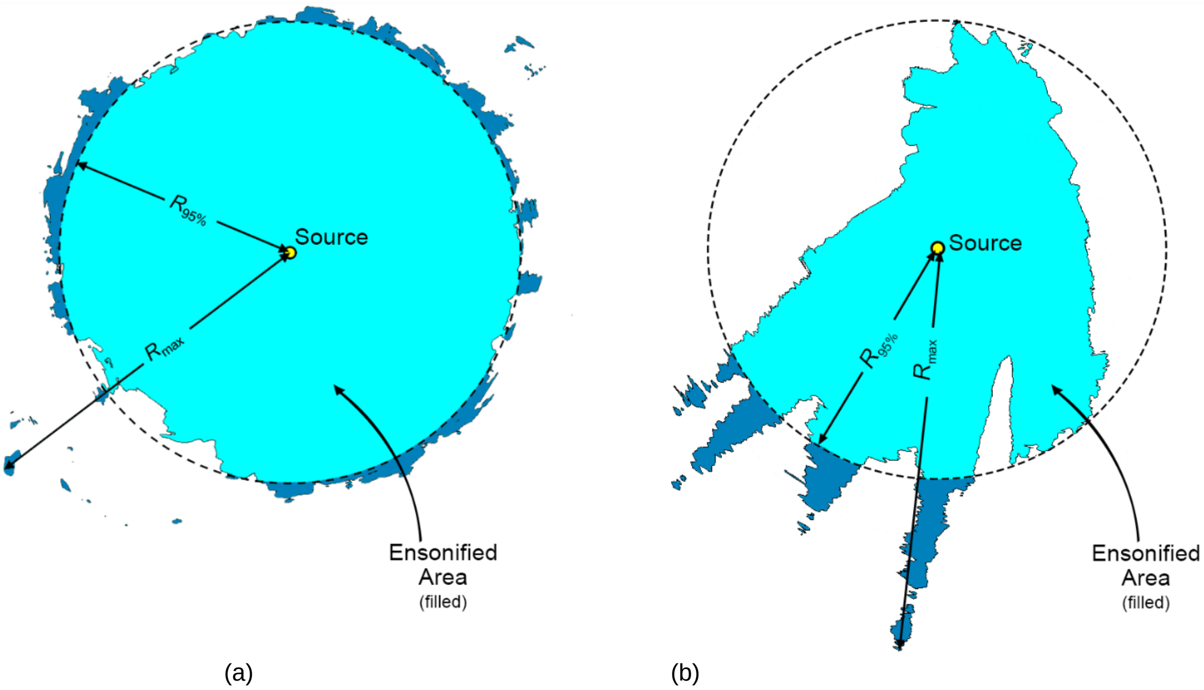

Figure D-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified 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 all four sites.

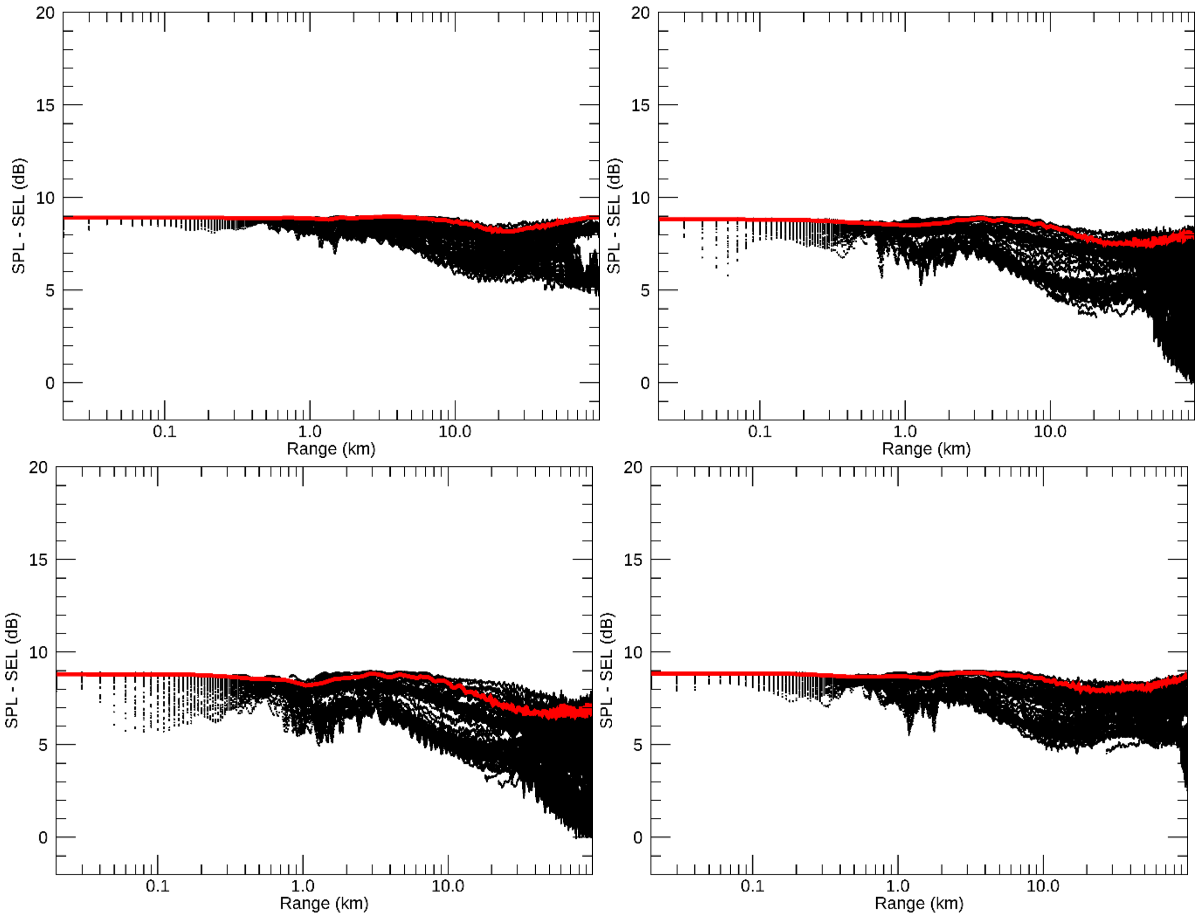

Figure D-2. Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Slices are shown for the 3090 in^3 modelled Site 1 (top left), Site 2 (top right), Site 3 (bottom left), and Site 4 (bottom right). Black lines are the modelled differences between SEL and SPL across 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 50 S) with a regular grid spacing of 100 × 100 m to generate the bathymetry in Figure D-3.

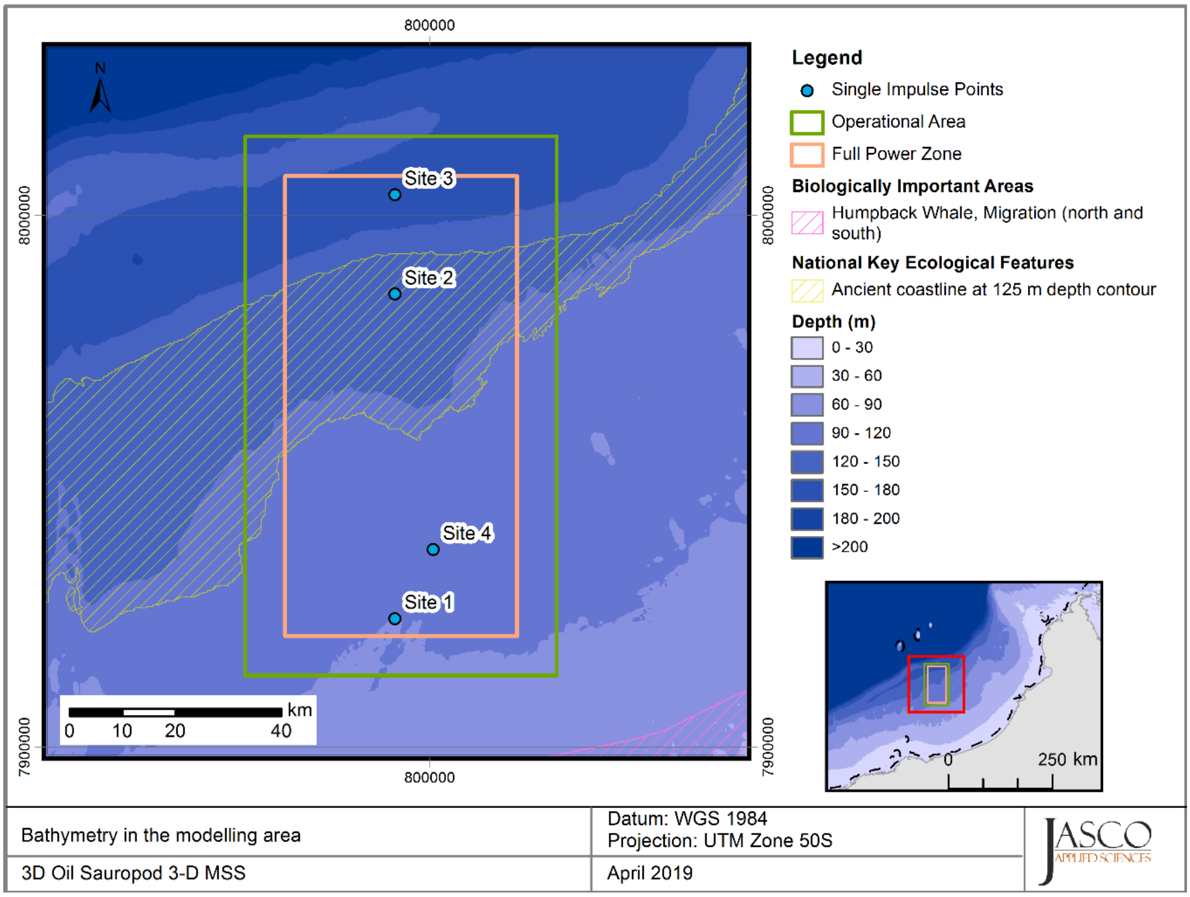

Figure D-3. Bathymetry map of the modelling area.

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 (December to May) were derived from the GDEM profiles within a 200 km box radius encompassing all modelling sites. The May sound speed profile is expected to be most favourable to longer-range sound propagation across the entire year. As such, May 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.

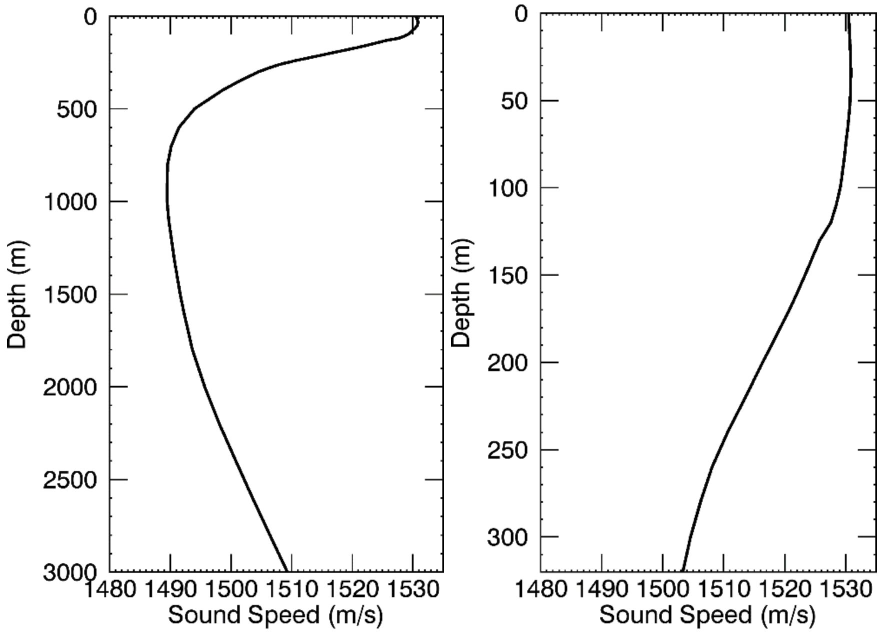

Figure D-4. The final sound speed profile (May) used for the modelling showing the entire water column (left) and the top 300 m within the profile (right). Profiles are calculated from temperature and salinity profiles from GDEM V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

D.3.3. Geoacoustics

Geoacoustic parameters were derived from sedimentary grain size measurements from various locations off the coast of Western Australia. Most samples were taken on or near the seafloor, although a smaller number were from depths of up to 6 m. The geoacoustic parameters used for numeric modelling listed in Table D-1 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)	Predicted lithology	Density (g/cm^3)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed (m/s)	Attenuation (dB/λ)
0–26	Silty carbonate sand to interbedded sandy carbonated mud and sand	1.78	1523–1674	0.05-0.67		
26–42	Carbonated sandy silt to muddy, sandy carbonate silt/silty mud	1.80	1685–1716	0.68–0.79		
42–72	Carbonate silty sand with occasional poorly cemented calcarenite layers	1.78	1704–1745	0.77–0.91	180	0.1
72–108	Silty sandy poorly cemented calcarenite	2.32–2.37	2121–2181	0.32–0.33		
108–188	High strength calcarenite zone, locally sandy	2.87–2.96	2781–2909	0.53–0.55		

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.

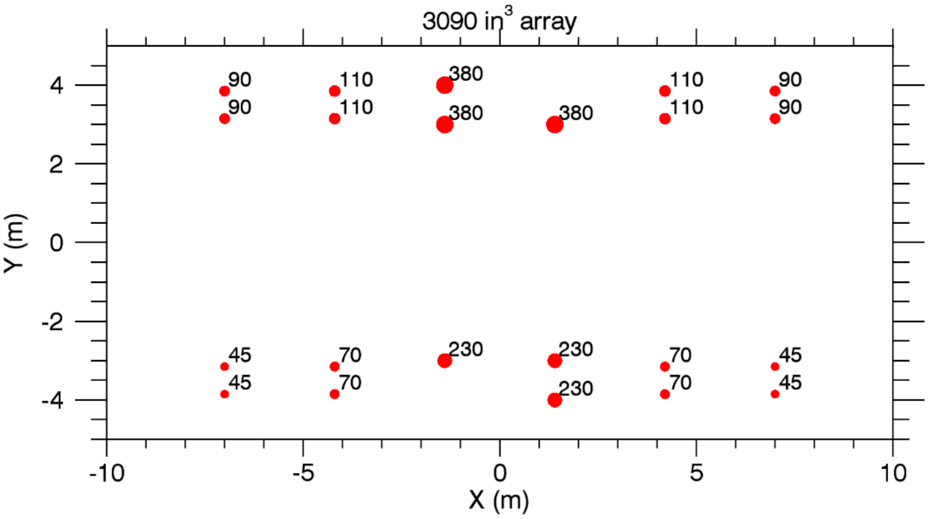

Figure D-5. Layout of the modelled 3090 in^3 seismic source array. Tow depth is 6 m. The labels indicate the firing volume (in cubic inches) for each airgun. Also see Table D-2.

Table D-2. Layout of the modelled 3090 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	7.00	−3.85	6.00	45	12	7.00	3.15	6.00	90
2	7.00	−3.15	6.00	45	13	7.00	3.85	6.00	90
3	4.20	−3.85	6.00	70	14	4.20	3.15	6.00	110
4	4.20	−3.15	6.00	70	15	4.20	3.85	6.00	110
5	1.40	−4.00	6.00	230	16	1.40	3.00	6.00	380
6	1.40	−3.00	6.00	230	17	−1.40	3.00	6.00	380
7	−1.40	−3.00	6.00	230	18	−1.40	4.00	6.00	380
8	−4.20	−3.85	6.00	70	19	−4.20	3.15	6.00	110
9	−4.20	−3.15	6.00	70	20	−4.20	3.85	6.00	110
10	−7.00	−3.85	6.00	45	21	−7.00	3.15	6.00	90
10	−7.00	−3.15	6.00	45	22	−7.00	3.85	6.00	90

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 E. Additional Results

E.1. Particle Motion

Figures E-1 to E-3 show the maximum particle acceleration and velocity for Sites 2–4, as a function of horizontal range from the centre of the array in broadside directions, which generate the higher amplitude results, results for Site 1 are shown in Figure 14.

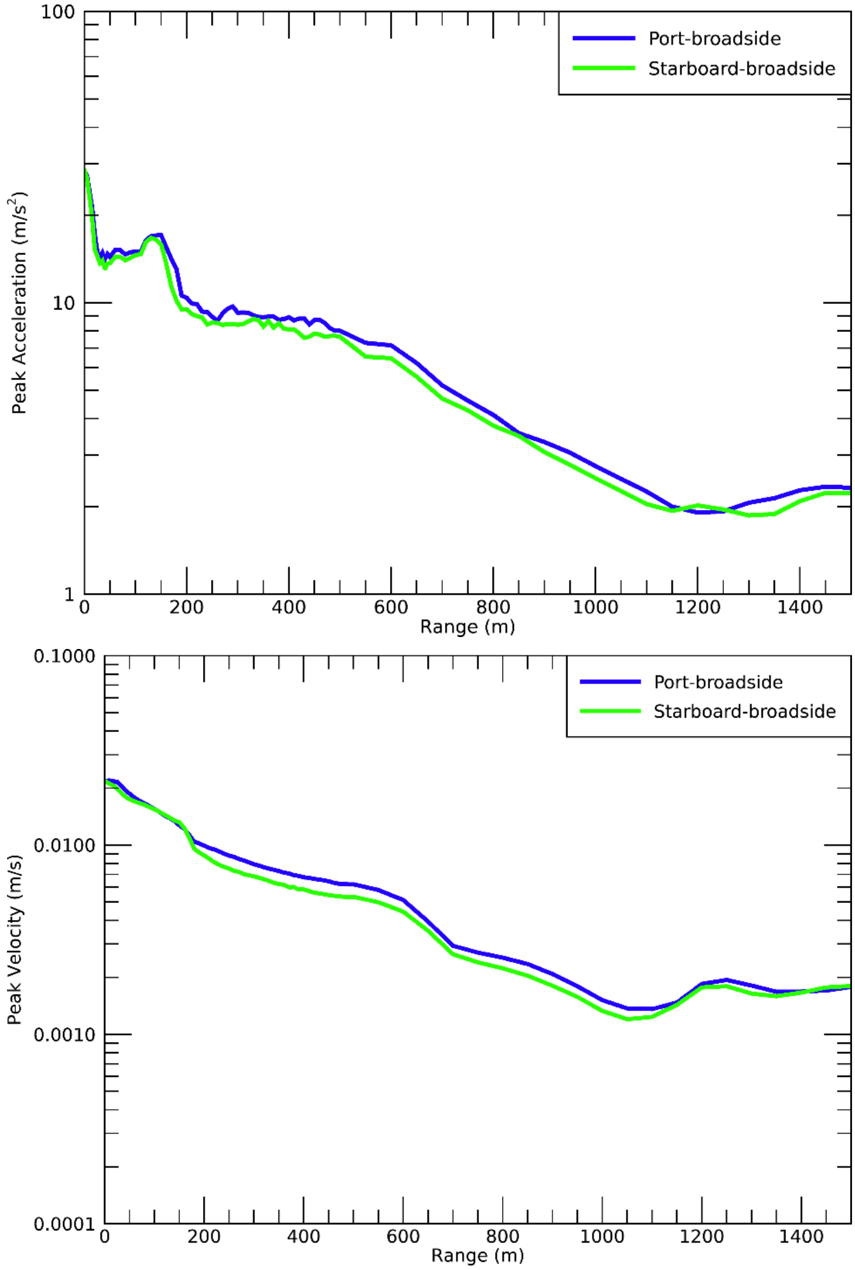

Figure E-1. Site 2: Maximum particle acceleration (top) and velocity (bottom) at the seafloor as a function of horizontal range from the centre of a single 3090 in^3 seismic source along the broadband directions.

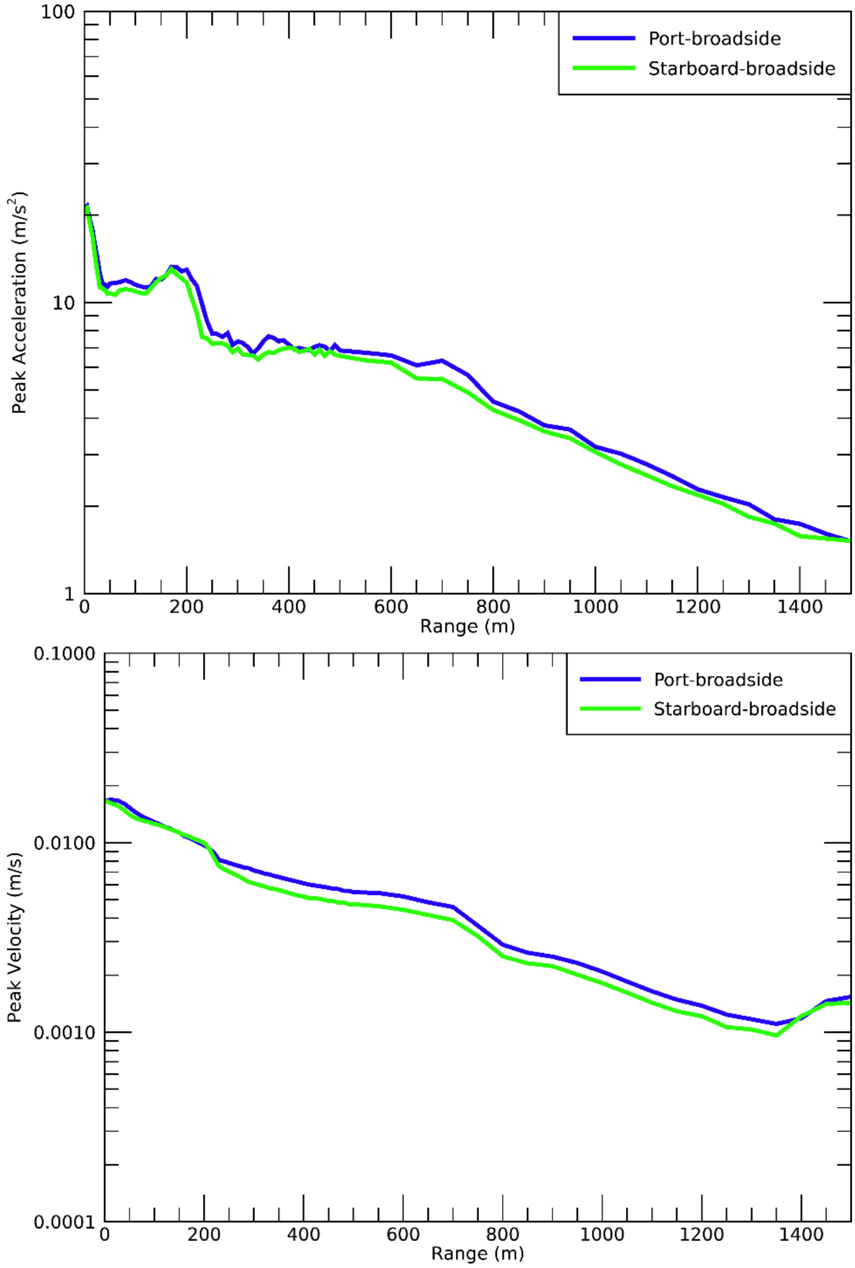

Figure E-2. Site 3: Maximum particle acceleration (top) and velocity (bottom) at the seafloor as a function of horizontal range from the centre of a single 3090 in^3 seismic source along the broadband directions.

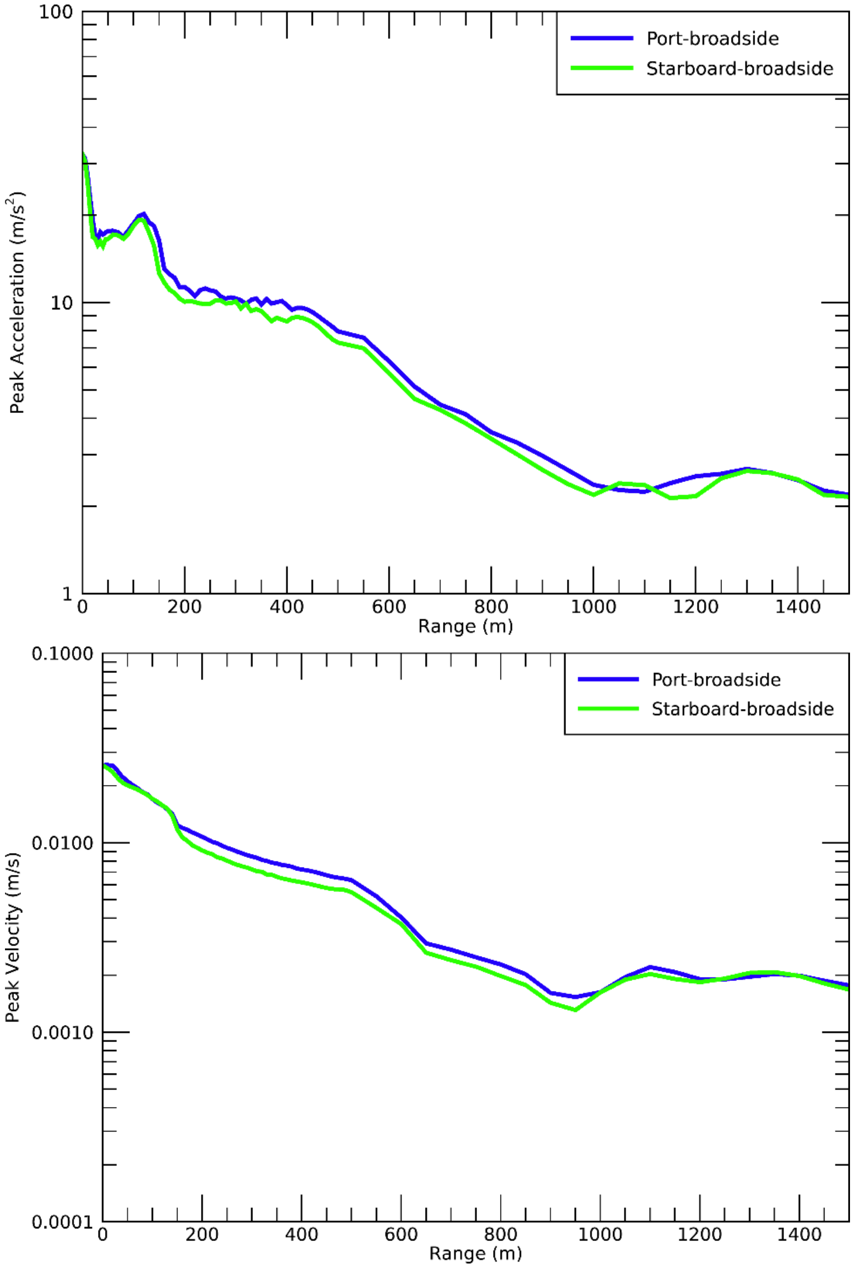

Figure E-3. Site 4: Maximum particle acceleration (top) and velocity (bottom) at the seafloor as a function of horizontal range from the centre of a single 3090 in^3 seismic source along the broadband directions.

APPENDIX D RPS SPILL MODELLING REPORT

Report

RPS

29 MAY 2019

3D Oil WA-527-P

Oil Spill Modelling

RPS

Document status

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Approval for issue

Name	Signature	Date
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Reviewed: Nathan Benfer
Approved: Nathan Benfer
No.: MAQ0793J
Version: Rev1
Date: 29 May 2019

RPS

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Terms and Abbreviations

°	Degrees
‘	Minutes
“	Seconds
Actionable oil	Oil which is thick enough for effective use of mitigation strategies, such as mechanical clean up (e.g. skimmers), booms, dispersed, or burned
AMP	Australian marine parks
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment and Conservation Council
API	American Petroleum Institute gravity (A measure of how heavy or light a petroleum liquid in comparison to water)
ASTM	American Society for Testing and Materials
Bonn Agreement Oil Appearance Code	An agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances, 1983, includes: Governments of the Kingdom of Belgium, the Kingdom of Denmark, the French Republic, the Federal Republic of Germany, the Republic of Ireland, the Kingdom of the Netherlands, the Kingdom of Norway, the Kingdom of Sweden, the United Kingdom of Great Britain and Northern Ireland and the European Union
°C	Degree Celsius (unit of temperature)
cP	Centipoise (unit of viscosity)
CFSR	Climate Forecast System Reanalysis
cm	Centimetre (unit of length)
Decay	The process where oil components are changed either chemically or biologically (biodegradation) to another compound. It includes breakdown to simpler organic carbon compounds by bacteria and other organisms, photo-oxidation by solar energy, and other chemical reactions
Dissolved aromatic hydrocarbons	Dissolved hydrocarbons within the water column with alternating double and single bonds between carbon atoms forming rings, containing at least one six-membered benzene ring
g/m^2	Grams per square meter (unit of surface or area density)
EIA	Environmental impact assessment
Entrained oil	Droplets or globules of oil that are physically mixed (but not dissolved) into the water column. Physical entrainment can occur either during pressurised release from a subsurface location, or through the action of breaking waves (>12 knots)
EP	Environmental plan
EEZ	Exclusive Economic Zone
Evaporation	The process whereby components of the oil mixture are transferred from the sea-surface to the atmosphere
GODAE	Global Ocean Data Assimilation Experiment
HYCOM	Hybrid Coordinate Ocean Model is a data-assimilative, three-dimensional ocean model
HYDROMAP	Advanced ocean/coastal tidal model used to predict tidal water levels, current speed and current direction
IOA	Index of Agreement gives a non-dimensional measure of model accuracy or performance
IBRA	Interim Biogeographic Regionalisation for Australia
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
Isopycnal layers	Water column layers with corresponding water densities

ITOPF	The International Tanker Owners Pollution Federation
KEF	Key Ecological Feature
km	Kilometre (unit of length)
km^2	Square Kilometres (unit of area)
KEF	Key ecological feature
Knot	unit of wind speed (1 knot = 0.514 m/s)
LC_{50}	Median lethal dose. The dose required for mortality of 50% of a tested population after a specified test duration
LGA	Local Government Area
m	Meters (unit of length)
m^2	Meters squared (unit of area)
m^3	Meters cubed (unit of volume)
m/s	Meters per Second (unit of speed)
MAE	Mean Absolute Error is the average of the absolute values of the difference between model predicted and observed data (e.g. surface elevations)
MB	Marine boundary
MNP	Marine National Park
MS	Marine Sanctuary
NASA	National Aeronautics and Space Administration
NCEP	National Centres for Environmental Prediction
NOAA	National Oceanic and Atmospheric Administration
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
nm	nautical mile (unit of distance; 1 nm = 1.852 km)
NP	National Parks
Ocean current	Large scale and continuous movement of seawater generated by forces such as breaking waves, wind, the Coriolis effect, and temperature and salinity gradients. It is the main flow of ocean waters
OECD	Organisation for Economic Co-operation and Development
P&A	Plug and abandon
PFW	Produced formation water
PNEC	Predicted no-effect concentration
ppb	Parts per billion (concentration)
ppb.hrs	ppb multiplied for hours (concentration x time)
PSU	Practical salinity units
Ramsar site	A wetland site designated of international importance under the Ramsar Convention
RAMSAR Convention	The Convention on Wetlands, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.
Sea surface exposure	Floating oil on the sea surface equal to or above reporting threshold (e.g. 0.5 g/m^2)
Shoreline contact	Stranded oil on the shoreline equal to or above reporting threshold (e.g. 10 g/m^2)
SIMAP	Spill Impact Mapping Analysis Program
US EPA	United States Environmental Protection Agency
Visible oil	Floating oil on the sea surface equal to or above reporting threshold (e.g. 0.5 g/m^2)

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EXECUTIVE SUMMARY

Background

3D Oil is seeking approval to undertake a work program consisting of the acquisition and processing of 3-dimensional seismic survey data in permit area WA-527-P, in the offshore Roebuck Basin. In order to obtain environmental approvals for the planned marine seismic survey operations, ERM Australia (ERM) commissioned RPS, on behalf of 3D Oil to undertake a comprehensive oil spill modelling study.

The study considered the following hypothetical, yet plausible scenario:

- A 280 m^3 release of marine diesel oil resulting from a vessel collision incident at the closest point of the operational area to the Rowley Shoals.

SIMAP's stochastic model was used to quantify the probability of exposure to the sea surface and in the water column as well as the probability of shoreline contact from hypothetical spill scenarios. The SIMAP system, the methods and analysis presented herein use modelling algorithms which have been anonymously peer reviewed and published in international journals. Further, RPS warrants that this work meets and exceeds the ASTM Standard F2067-13 "*Standard Practice for Development and Use of Oil Spill Models*".

Methodology

The modelling study was carried out in several stages. Firstly, a five-year current dataset (2008–2012) that includes the combined influence of three-dimensional ocean and tidal currents was developed. Secondly, the currents, spatial winds and then detailed hydrocarbon properties were used as inputs in the oil spill model to simulate the drift, spread, weathering, entrainment and fate of the spilled hydrocarbons.

As spills can occur during any set of wind and current conditions, a total of 100 spill trajectories for the scenario described above and per season (e.g. summer, transitional and winter) were initiated at random times within a 5-year period (2008–2012) to enable a robust statistical analysis.

Each simulation was configurated with the same spill information (i.e. spill volume, duration and oil type) except for the start time and date which in turn, ensures that the predicted transport and weathering of an oil slick is subject to a wide range of current and wind conditions.

Oil Properties

For this oil spill modelling study, a marine diesel oil (MDO) was used to represent the containment loss from a vessel collision scenario. This oil has a density of 829.1 kg/m^3 (API of 37.6), a pour point (-14^oC) and a viscosity of 4cP which indicate that this oil will spread quickly when released on the sea surface and will form a thin to low thickness film, increasing the rate of evaporation. The oil is categorised as a group II oil (light-persistent) based on categorisation and classification derived from AMSA (2015a) guidelines.

Key Findings

Scenario: Containment loss from a vessel collision

- No shoreline contact above the low (10 g/m^2) threshold was predicted for the scenario;
- Modelling results demonstrated that surface oil at low (1 g/m^2), moderate (10 g/m^2) and high (25 g/m^2) exposure levels could potentially travel greater distances during the transitional period, compared to the summer and winter periods. The maximum distance travelled by surface oil for the low, moderate and high threshold was 66 km, 14 km and 7km, respectively.
- While the low exposure surface oil was predicted to travel in any directions from the release site, surface oil above the moderate and high exposure levels remained along the northwest to southeast axis across all seasons.

- The evaporative nature of MDO and environmental conditions in the area resulted in short-lived surface hydrocarbon exposure, with surface exposure reduced to less than 10 g/m^2 after approximately 12-24 hours.
- The modelling results demonstrated a low likelihood (1-2%) of low surface oil exposure to the Argo-Rowley Terrace Australian Marine Park.
- The maximum time-averaged exposure to dissolved hydrocarbon over 48 hours remained less than 1 ppb for the winter and transitional seasons while reaching 4 ppb for the summer and winter seasons for various receptors. These concentrations are below the defined low threshold for dissolved hydrocarbons.
- The maximum instantaneous exposure to dissolved hydrocarbons ranged from 6 ppb to 73 ppb for the transitional and summer seasons, respectively. None of the receptors was exposed at the moderate (50 ppb) or high (400 ppb) thresholds or above for instantaneous exposure with the exception of the IMCRA – North West Shelf. This receptor had a 1 % probability of exposure to instantaneous dissolved hydrocarbon during the summer season.
- The maximum time-averaged exposure over 48 hours to entrained hydrocarbons ranged from 4 ppb to 499 ppb for the transitional and winter seasons respectively.
- The maximum instantaneous exposure to entrained hydrocarbon was 6,287 ppb for the Northwest Shelf IMCRA during the summer.

1 INTRODUCTION

3D Oil is seeking approval to undertake a work program consisting of the acquisition and processing of 3-dimensional seismic survey data in permit area WA-527-P, in the offshore Roebuck Basin (Figure 1). In order to obtain environmental approvals for the planned marine seismic survey operations, ERM Australia (ERM) commissioned RPS, on behalf of 3D Oil to undertake a comprehensive oil spill modelling study.

The study considered the following hypothetical, yet plausible scenario:

- A 280 m^3 release of marine diesel oil resulting from a vessel collision incident at the closest point of the operational area to the Rowley Shoals.

Table 1 Location of the release site.

Release site	Latitude	Longitude	Water Depth (m)
Release site	-17°56"17.0'	119°30"14.8'	160

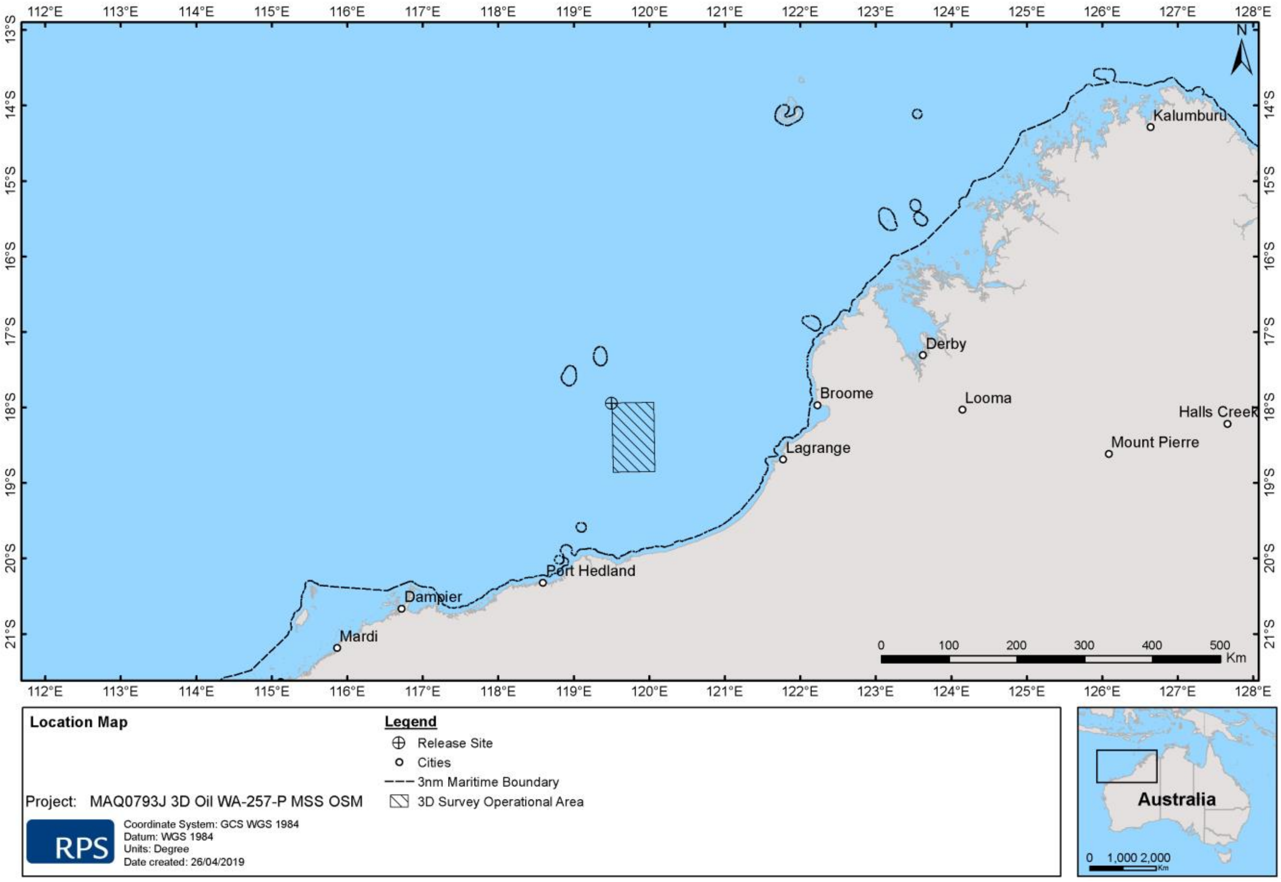

Figure 1 Locality map

2 SCOPE OF WORK

The scope of work will include the following components:

- Generate tidal current patterns of the region using the ocean/coastal model, HYDROMAP;
- Use HYCOM (Hybrid Coordinate Ocean Model) ocean currents combined with HYDROMAP tidal currents over a 5-year period (2008 to 2012) to account for large scale flows offshore and tidal flows nearshore;
- Use 5 years of high-resolution wind, aggregated current data and site-specific oil characteristics as input into the 3-dimensional oil spill model to represent the movement, spreading, entrainment, weathering of the oil over time;
- Use SIMAP's stochastic model (also known as a probability model) to calculate exposure to surrounding waters (sea surface and water column) and shorelines. This will involve running 100 randomly selected single trajectory simulations for each season, with each simulation having the same spill information (spill volume, duration and composition of hydrocarbons) but varying start times. This will ensure that each spill trajectory is subjected to unique wind and current conditions.

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3 REGIONAL CURRENTS

The permit area is located within the offshore Roebuck Basin, on the central North West Shelf, a shallow (generally <100 m) waterbody bordered by the Indian Ocean and Timor Sea. The North West Shelf is characterised by complex geomorphological features such as shoals, valleys and terraces and is dominated by high-amplitude tides and seasonally-dependant wind driven currents (DEWHA, 2007).

Although the Indonesian Throughflow and Holloway current generate south-westerly flows all year-round, warm and less saline waters originating from the tropics can generate internal gyres that typically migrate through the area and result in large variation in the speed and direction of local currents. The Holloway current generally intensifies during April to July due to increased wind forcing.

A comprehensive description of the circulation patterns of the Northwest Shelf and Bonaparte Gulf is provided in a review by Condie and Andrewartha (2008) and a schematic of the ocean currents along the Northwest Australian continental shelf is shown in Figure 2.

While, tidal currents are generally weaker in the deeper waters, its influence is greatest along the near shore and around islands. Therefore, to accurately account for the movement of an oil spill, which can move between the offshore and near shore region, ocean and tidal currents were combined as part of the study.

Figure 3 and Figure 4 present summer and winter current trends within the Roebuck Basin and the southern section of the North West Shelf.

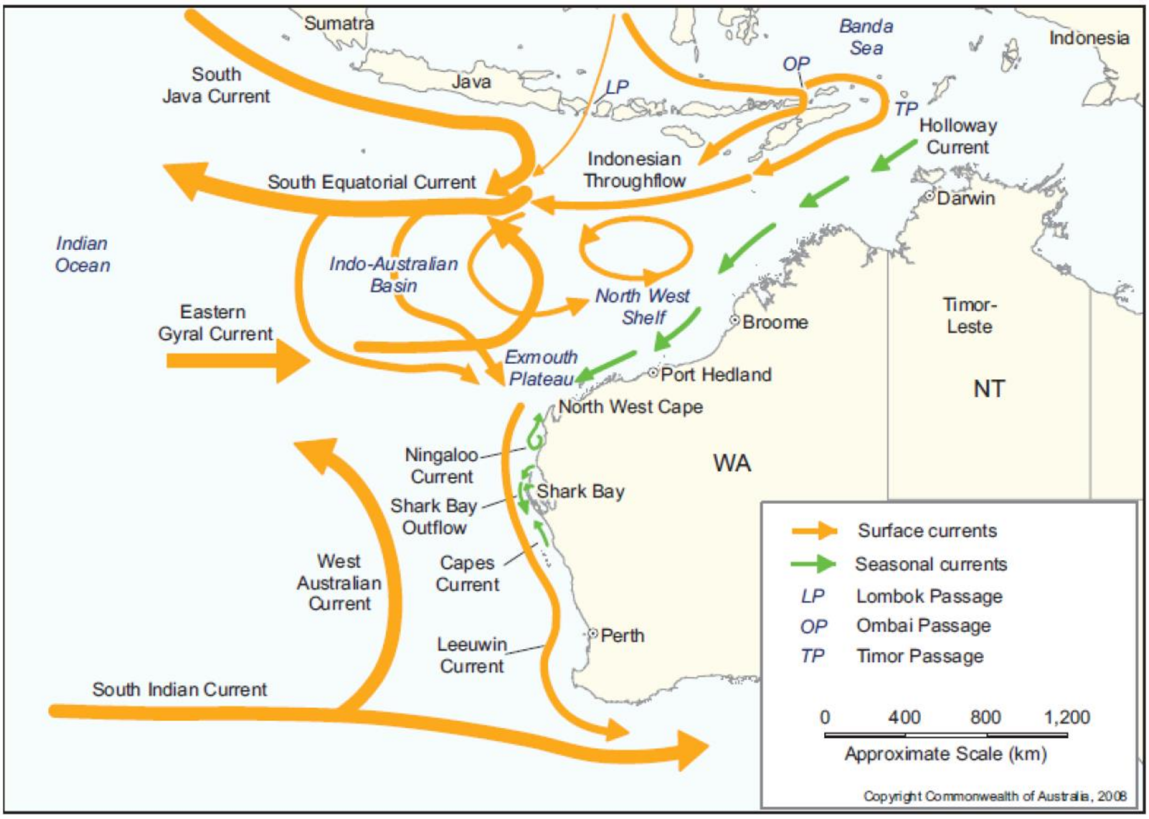

Figure 2 Schematic of ocean currents along the Northwest Australian continental shelf. Image adapted from DEWHA (2008).

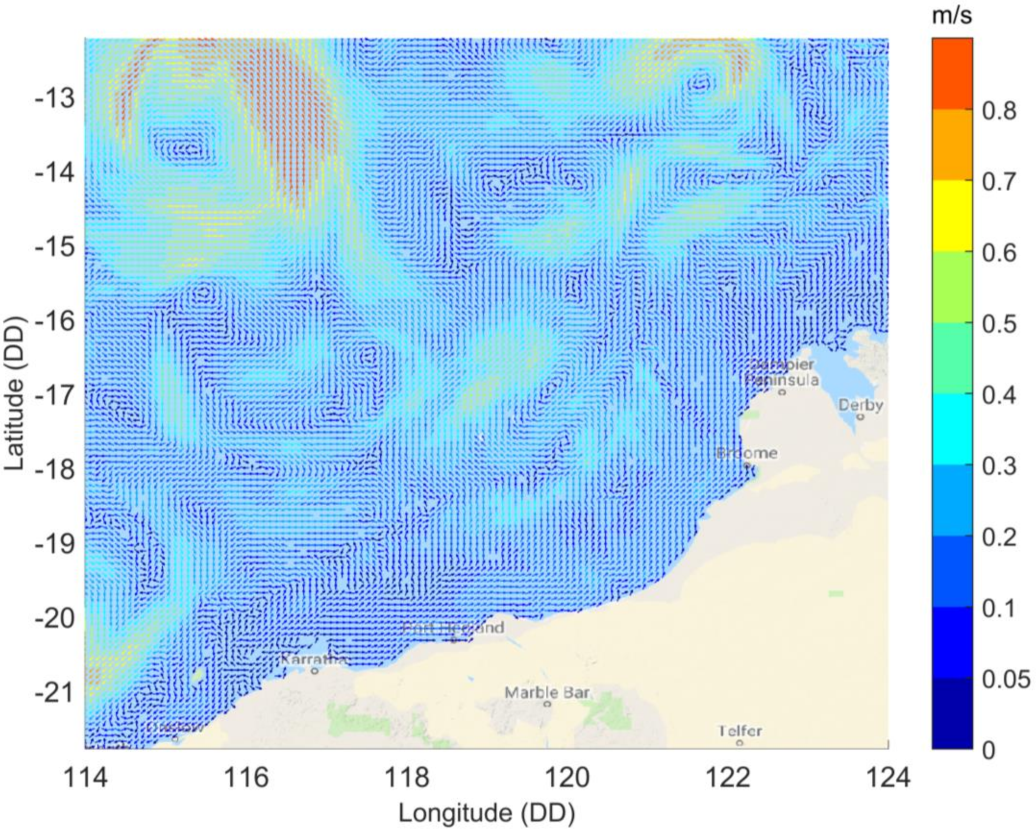

Figure 3 Typical ocean current circulation pattern during the summer months.

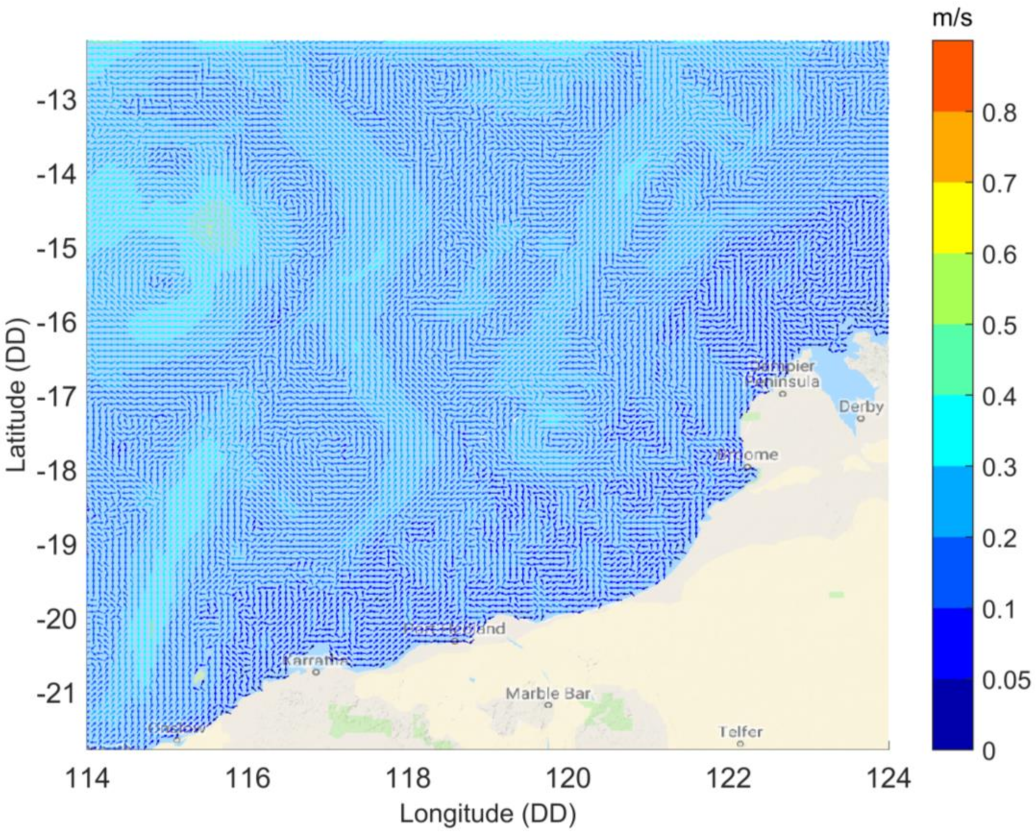

Figure 4 Typical ocean current circulation pattern during the winter months.

3.1 Tidal Currents

Tidal current data was generated using RPS's advanced ocean/coastal model, HYDROMAP. The HYDROMAP model has been thoroughly tested and verified through field measurements throughout the world over the past 32 years (Isaji & Spaulding, 1984; Isaji, et al., 2001; Zigic, et al., 2003). HYDROMAP tidal current data has been used as input to forecast (in the future) and hindcast (in the past) pollutant spills in Australian waters and forms part of the Australian National Oil Spill Emergency Response System operated by AMSA (Australian Maritime Safety Authority).

HYDROMAP employs a sophisticated sub-gridding strategy, which supports up to six levels of spatial resolution, halving the grid cell size as each level of resolution is employed. The sub-gridding allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, and/or of particular interest to a study.

The numerical solution methodology follows that of Davies (1977a and 1977b) with further developments for model efficiency by Owen (1980) and Gordon (1982). A more detailed presentation of the model can be found in Isaji and Spaulding (1984) and Isaji et al. (2001).

3.1.1 Grid Setup

RPS has a seamless global tidal model calibrated to modelled and measured (when available) tidal data around the world. The tidal domains are sub-gridded to a resolution of 500 m for shallow and coastal regions, starting from an offshore (or deep water) resolution of 8 km. The finer grids were allocated in a step-wise fashion to more accurately resolve flows along the coastline, around islands and over regions with more complex bathymetry. Figure 5 shows the tidal model grid covering the study domain.

A range of datasets were sourced and merged to describe the shape of the seabed within the grid domain. These included spot depths and contours which were digitised from nautical charts released by the hydrographic offices as well as Geoscience Australia database and depths extracted from the Shuttle Radar Topography Mission (SRTM30_PLUS) Plus dataset (see Becker et al., 2009).

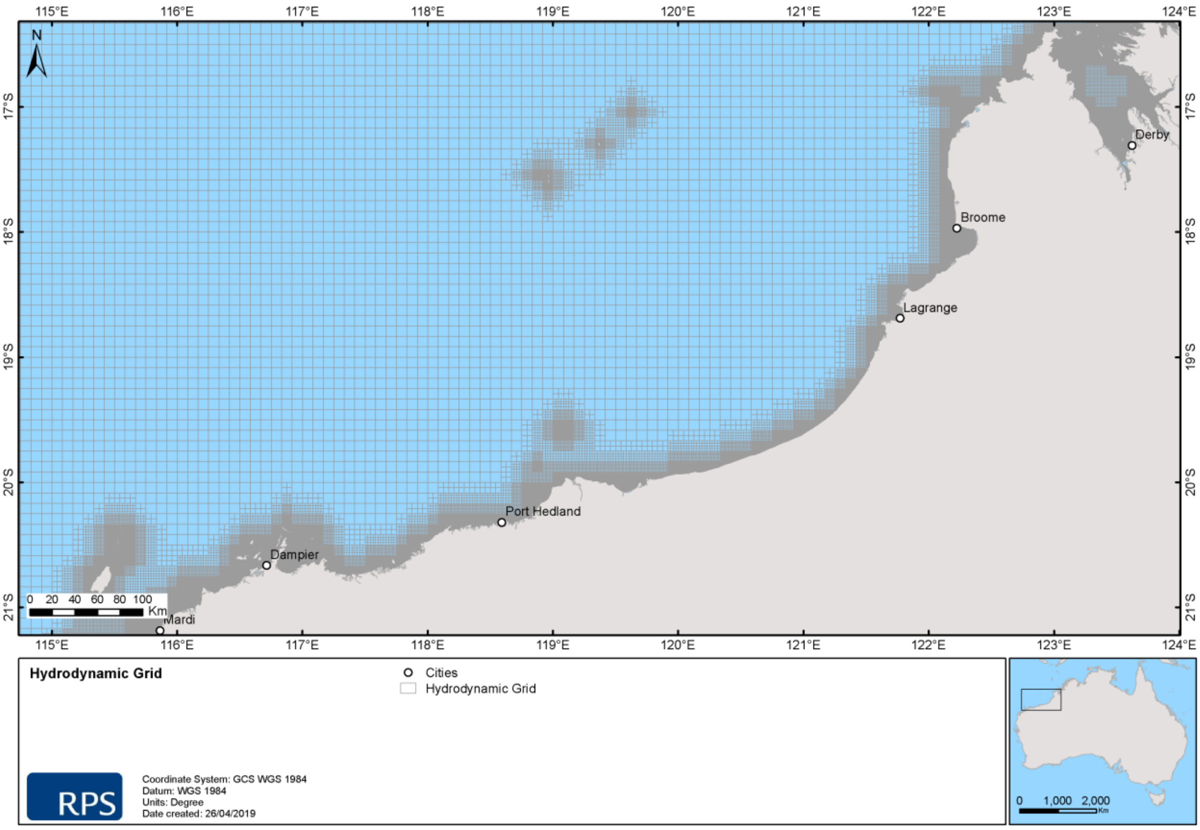

Figure 5 Map showing the regions of sub-gridding for the study area.

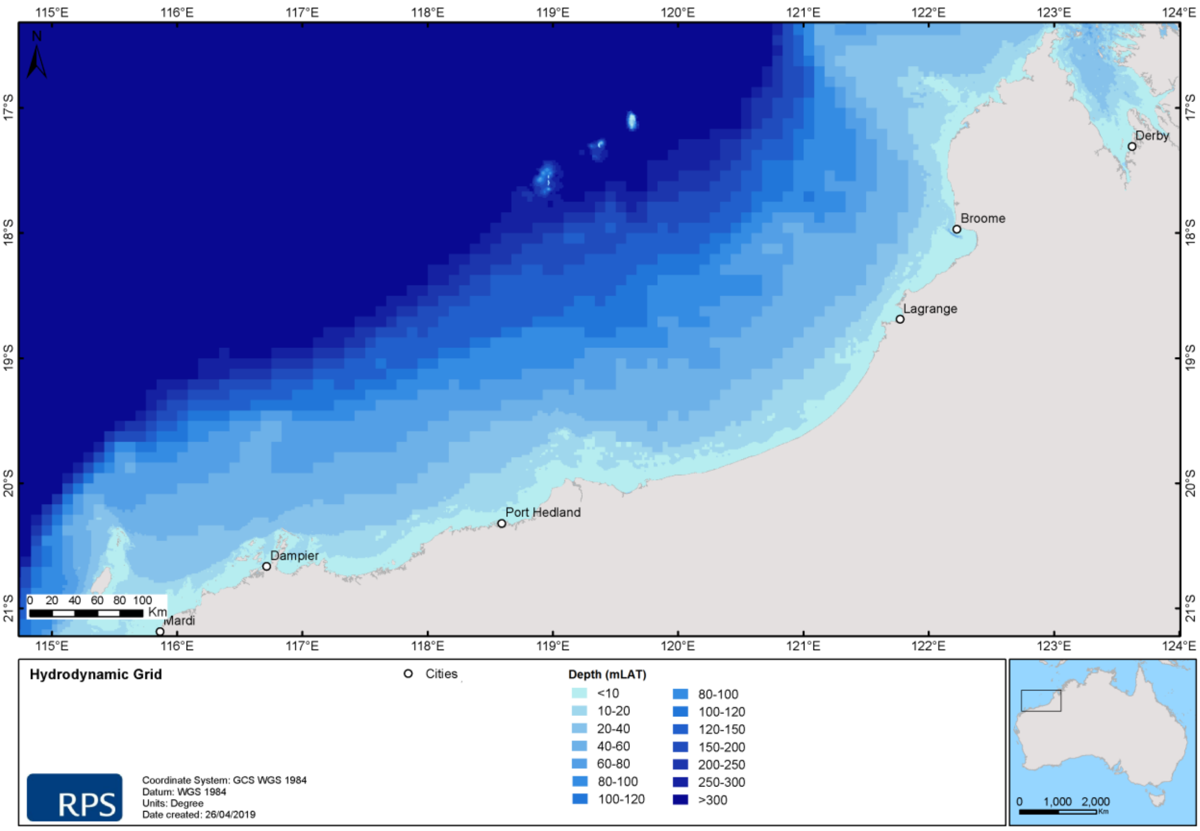

Figure 6 Bathymetry defined throughout the tidal model domain.

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3.1.2 Tidal 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. Using the tidal data, surface heights were firstly calculated along the open boundaries, at each time step in the model.

The TOPEX/Poseidon satellite data has a global resolution of 0.25 degrees and is produced and quality controlled by NASA (National Aeronautics and Space Administration). The satellites equipped with two highly accurate altimeters and capable of taking sea level measurements with an accuracy of ± 5 cm measured oceanic surface elevations (and the resultant tides) for over 13 years (1992–2005). In total, these satellites carried out 62,000 orbits of the planet.

The TOPEX/Poseidon tidal data has been widely used amongst the oceanographic community, being included in more than 2,100 research publications (e.g. Andersen, 1995; Ludicone et al., 1998; Matsumoto et al., 2000; Kostianoy et al., 2003; Yaremchuk and Tangdong, 2004; Qiu and Chen 2010). As such the TOPEX/Poseidon tidal data is considered suitably accurate for this study.

3.1.3 Surface Elevation Validation

To ensure that tidal predictions were accurate, predicted surface elevations were compared to data observed at eight locations (see Figure 7).

To provide a statistical measure of the model performance, the Index of Agreement (IOA - Willmott (1981)) and the Mean Absolute Error (MAE - Willmott (1982) and Willmott and Matsuura (2005)) were used.

The MAE (Eq.1) is simply the average of the absolute values of the difference between the model-predicted (P) and observed (O) variables. It is a more natural measure of the average error (Willmott and Matsuura, 2005) and more readily understood. The MAE is determined by:

$$MAE = N^{-1} \sum_{i=1}^{N} |P_i - O_i| \quad \text{Eq.1}$$

Where: N = Number of observations

P_i = Model predicted surface elevation

O_i = Observed surface elevation

The Index of Agreement (IOA; Eq. 2) in contrast, gives a non-dimensional measure of model accuracy or performance. A perfect agreement between the model predicted and observed surface elevations exists if the index gives an agreement value of 1, and complete disagreement between model and observed surface elevations will produce an index measure of 0 (Wilmott, 1981). Willmott et al (1985) also suggests that values larger than 0.5 may represent good model performance. The IOA is determined by:

$$IOA = 1 - \frac{\sum |X_{model} - X_{obs}|^2}{\sum (|X_{model} - \overline{X_{obs}}| + |X_{obs} - \overline{X_{obs}}|)^2} \quad \text{Eq.2}$$

Where: X_{model} = Model predicted surface elevation

X_{obs} = Observed surface elevation

Clearly, a greater IOA and lower MAE represent a better model performance.

Figure 8 and Figure 9 illustrate a comparison of the predicted and observed surface elevations for each location for January 2014. As shown on the graph, the model accurately reproduced the phase and amplitudes throughout the spring and neap tidal cycles.

Table 2 Statistical comparison between the observed and predicted surface elevations.

Tide Station	IOA	MAE (m)
Broome	0.90	1.11
Lagrange Bay	0.96	0.71
Lynher Bank	0.98	0.31
Port Hedland	0.98	0.33
Port Walcott	0.99	0.20
Red Bluff	0.98	0.46

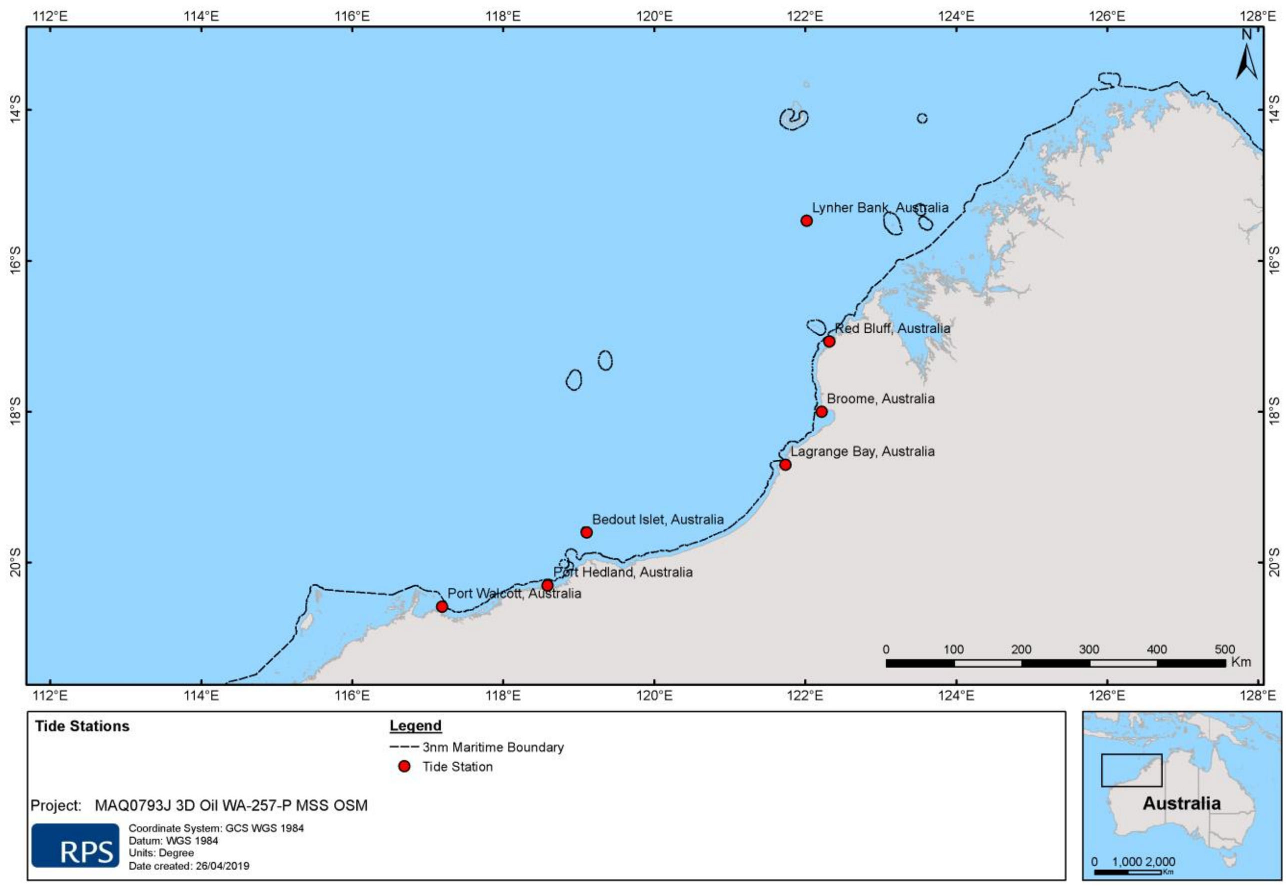

Figure 7 Tide stations used to calibrate surface elevation within the model.

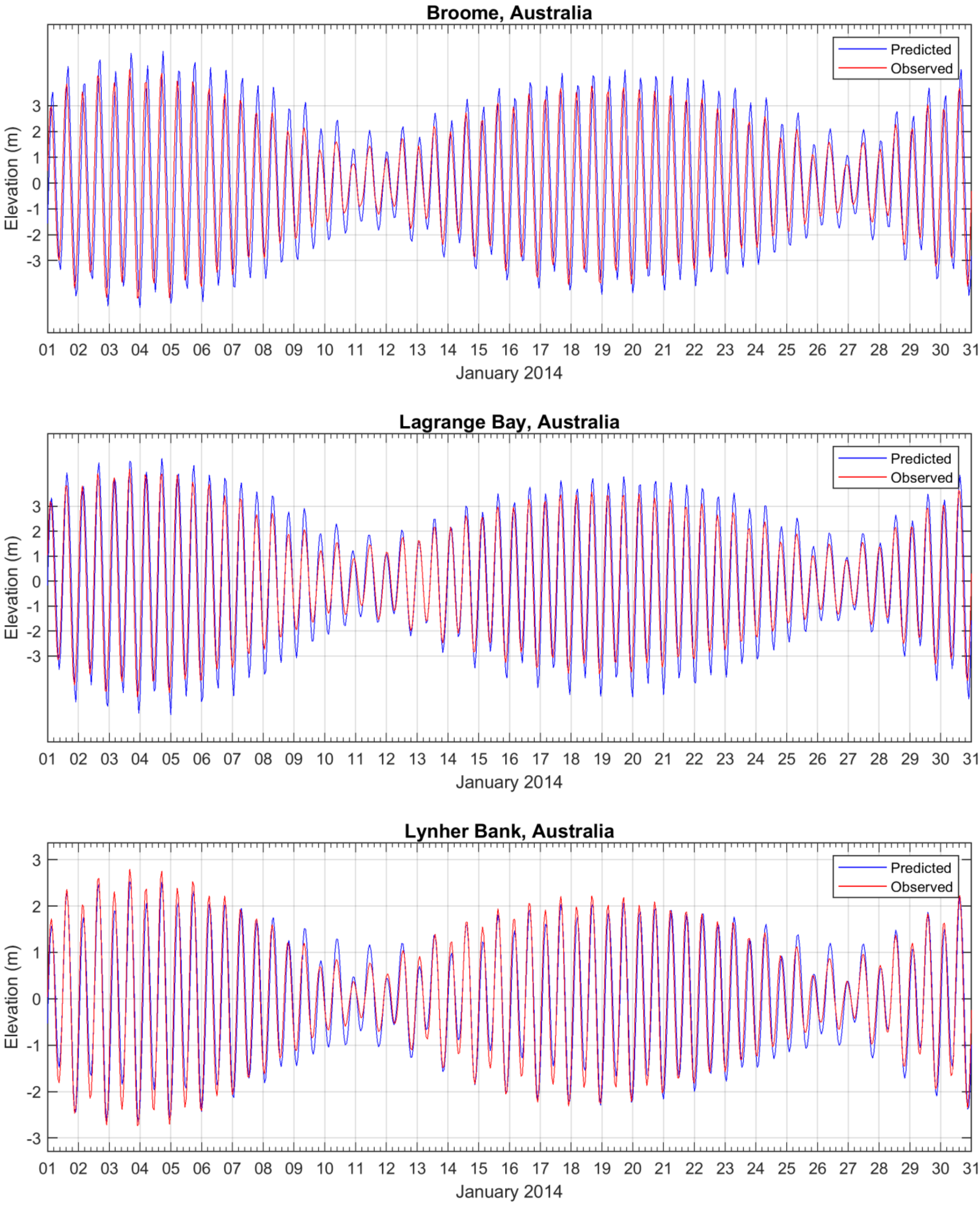

Figure 8 Comparison between HYDROMAP predicted (blue line) and observed (red line) surface elevation.

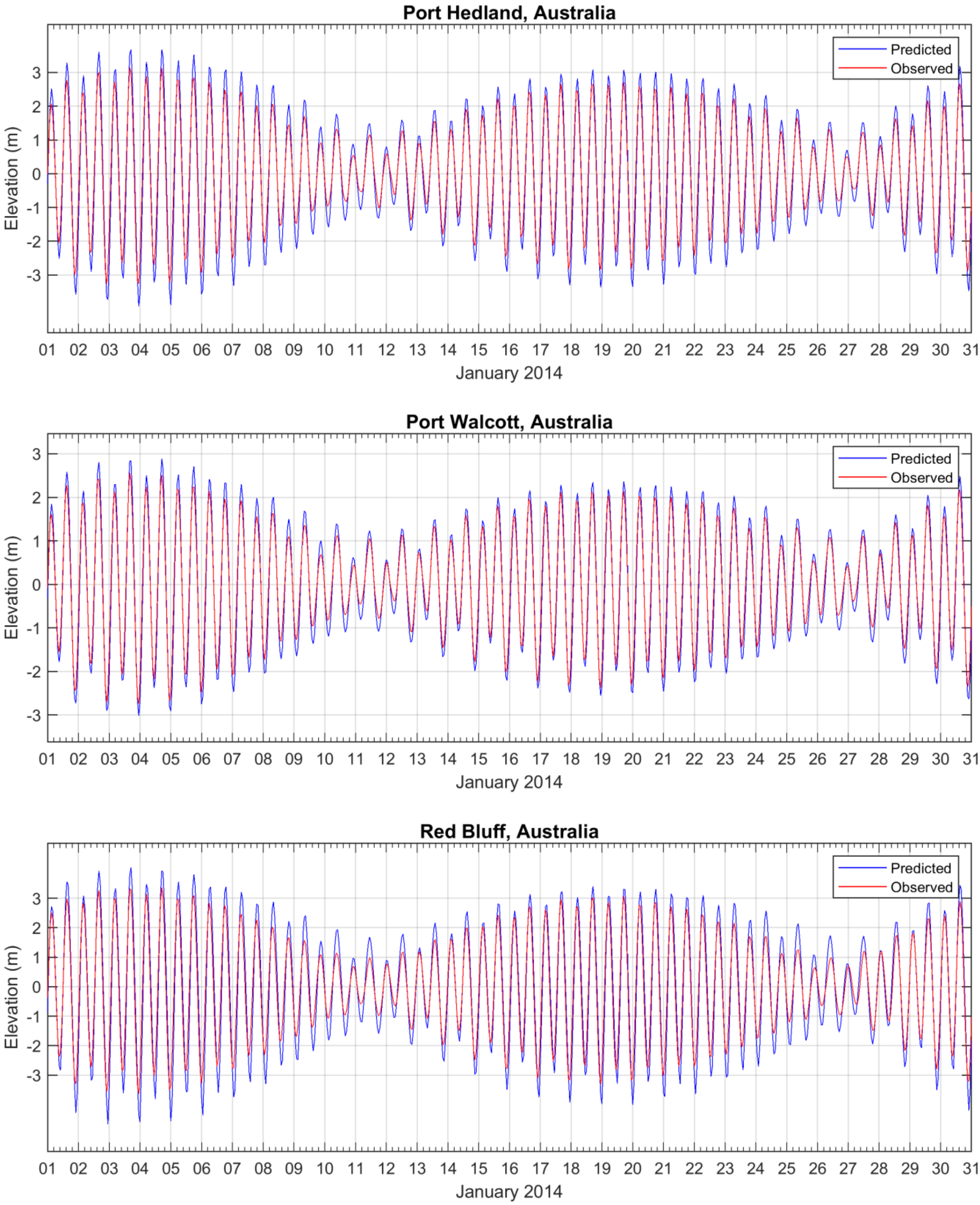

Figure 9 Comparison between HYDROMAP predicted (blue line) and observed (red line) surface elevation.

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3.2 Ocean Currents

Data describing the flow of ocean currents was obtained from HYCOM (Hybrid Coordinate Ocean Model, (Chassignet et al., 2007), which is operated by the HYCOM Consortium, sponsored by the Global Ocean Data Assimilation Experiment (GODAE). HYCOM is a data-assimilative, three-dimensional ocean model that is run as a hindcast (for a past period), assimilating time-varying observations of sea surface height, sea surface temperature and in-situ temperature and salinity measurements (Chassignet et al., 2009). The HYCOM predictions for drift currents are produced at a horizontal spatial resolution of approximately 8.25 km (1/12th of a degree) over the region, at a frequency of once per day. HYCOM uses isopycnal layers in the open, stratified ocean, but uses the layered continuity equation to make a dynamically smooth transition to a terrain following coordinate in shallow coastal regions, and to z-level coordinates in the mixed layer and/or unstratified seas.

For this study, the HYCOM reanalysis hindcast currents were obtained for the years 2008 to 2012 (inclusive).

3.3 Surface Currents at the release site

Table 3 displays the predicted average and maximum surface current speed near the release site. Figure 10 illustrates the monthly current rose distributions (2008-2012 inclusive) derived from combining HYCOM ocean current data and HYDROMAP tidal data.

Note the convention for defining current direction is the direction the current flows towards, which is used to reference current direction throughout this report. Each branch of the rose represents the currents flowing to that direction, with north to the top of the diagram. Sixteen bins of 22.5° each are used to describe the current direction. The branches are divided into segments of different colour, which represent the current speed ranges for each direction. Speed intervals of 0.1 m/s are predominantly used in these current roses. The length of each coloured segment is relative to the proportion of currents flowing within the corresponding speed and direction.

The combined current data (ocean plus tides) demonstrated that the release site is situated in a dynamic environment, with waters flowing along a predominant northwest to southeast axis all year-round. Monthly average surface current speed ranged between 0.30 m/s (December) and 0.38 m/s (March, May and September) while maximum surface current speed peaked at 1.26 m/s in February.

Table 3 Predicted monthly average and maximum surface current speeds adjacent to the release location. Data derived by combining the HYCOM ocean data and HYDROMAP high resolution tidal data from 2008-2012 (inclusive).

Month	Average current speed (m/s)	Maximum current speed (m/s)	General direction (towards)
January	0.34	0.95	NNW – SE
February	0.36	1.26	NNW – SE
March	0.38	1.24	NW – SSE
April	0.37	0.95	NW – SSE
May	0.38	1.15	WNW – SSE
June	0.32	0.80	WNW – SSE
July	0.35	0.93	NW – SW
August	0.36	1.03	NW – SE
September	0.38	1.04	NW – SE
October	0.35	1.06	NW – SE
November	0.32	0.84	NNW – SE
December	0.30	0.87	NW – SE
Minimum	**0.30**	**0.80**	
Maximum	**0.38**	**1.26**	

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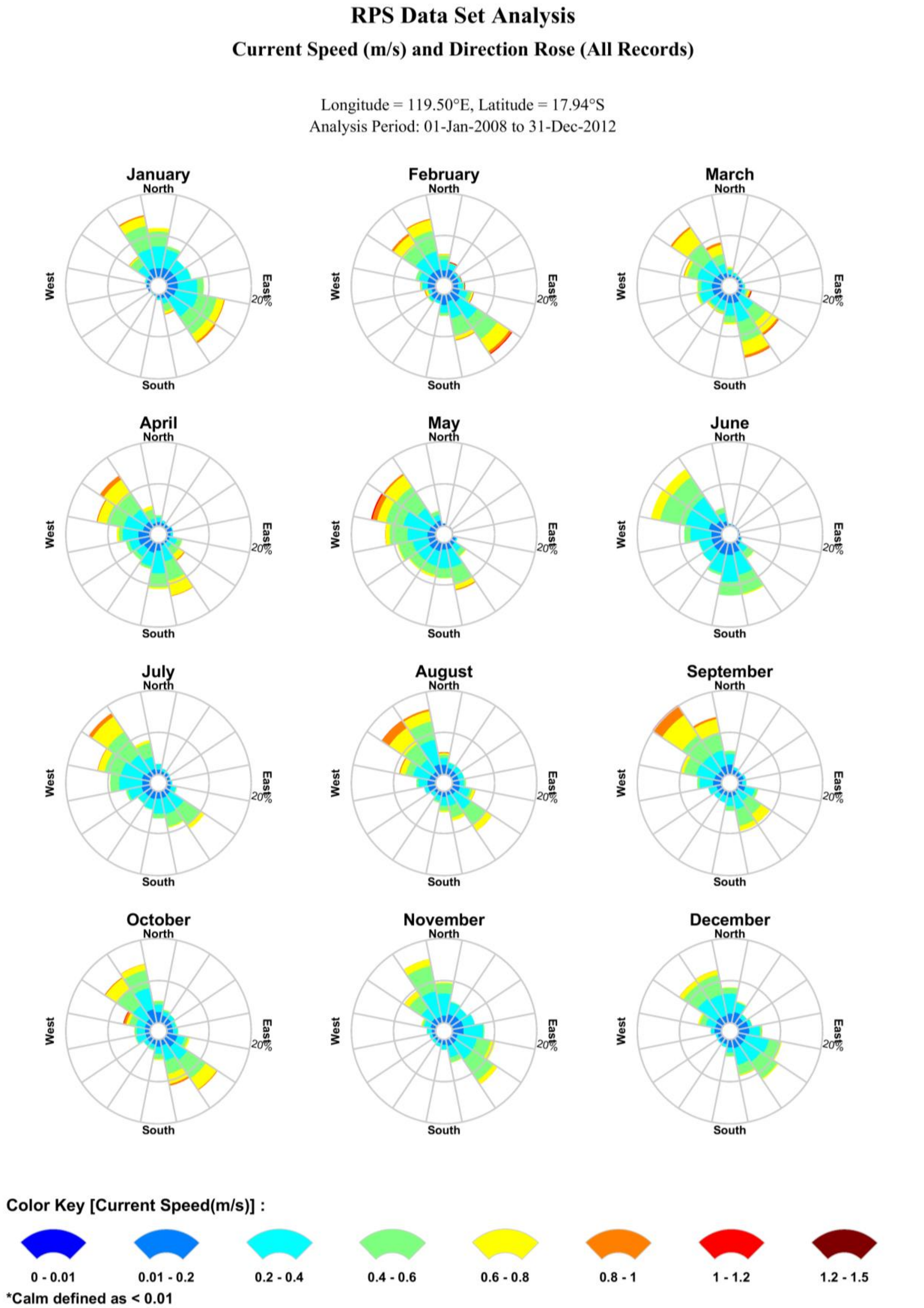

Figure 10 Monthly surface current rose plots near the release location (derived by combining the HYDROMAP tidal currents and HYCOM ocean currents for 2008 – 2012 inclusive).

4 WIND DATA

High resolution wind data was sourced from the National Centre for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR; see Saha et al., 2010) from 2008 to 2012 (inclusive).The CFSR wind model includes observations from many data sources; surface observations, upper-atmosphere air balloon observations, aircraft observations and satellite observations and is capable of accurately representing the interaction between the earth's oceans, land and atmosphere. The gridded wind data output is available at ¼ of a degree resolution (~33 km) and 1-hourly time intervals. Figure 11 shows the spatial resolution of the wind field used as input into the oil spill model. Table 4 shows the monthly average and maximum winds derived from the CFSR node located adjacent to the release site. Figure 12 to Figure 14 show the monthly, seasonal and annual wind rose distributions, respectively.

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. Sixteen bins of 22.5° each are used to describe the wind direction. The branches are divided into segments of different colour, which represent wind speed ranges from that direction. Speed ranges of 3 knot intervals, excluding the calm and near calm conditions are used in these wind roses. The length of each segment within a branch is proportional to the frequency of winds blowing within the corresponding range of speeds from that direction.

Table 4 illustrates predicted average and maximum wind velocities as well as general direction for each month. The data indicated that winds are generally stronger during the summer months as a result of easterly trade winds, reaching a maximum of 58 knots in March. Monthly average wind velocities oscillated between 8 knots (April) and 13 knots (July).

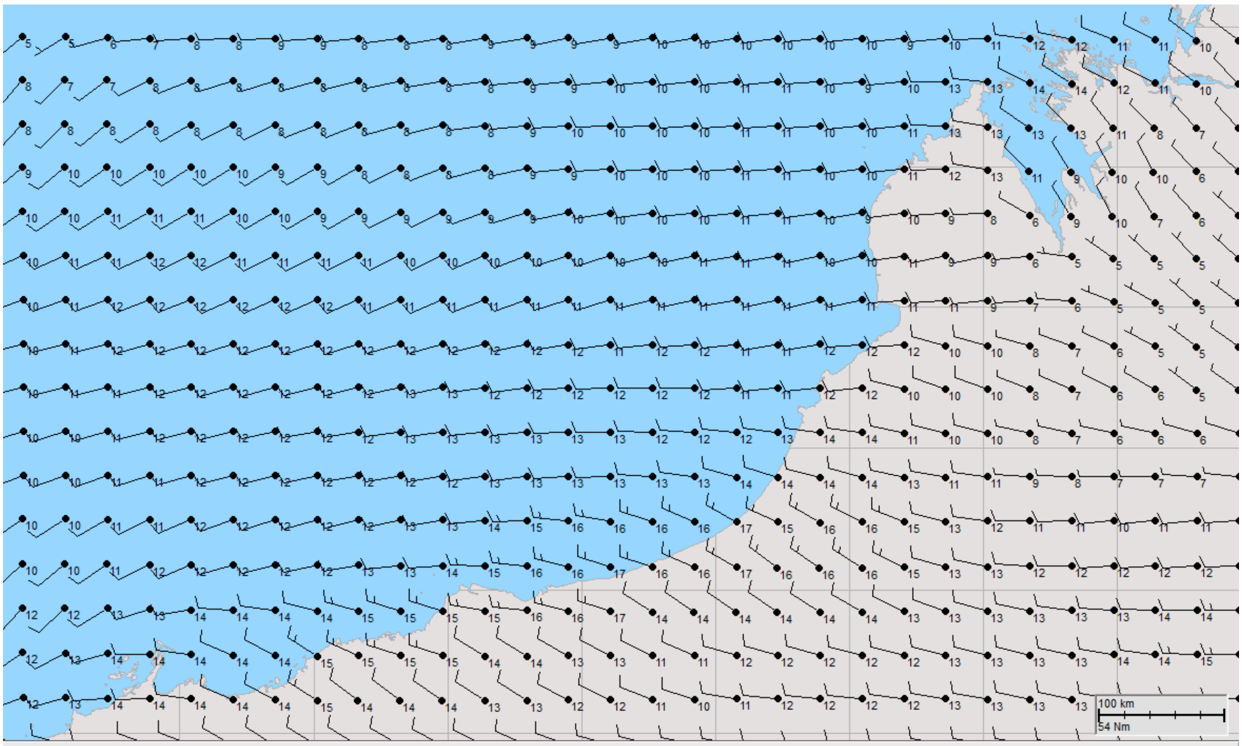

Figure 11 Sample of the CFSR modelled wind data

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Table 4 Predicted monthly average and maximum winds for the wind node adjacent to the release location. Data derived from CFSR hindcast model from 2008-2012 (inclusive).

Month	Average wind (knots)	Maximum wind (knots)	General direction (from)
January	11	35	W
February	11	47	W
March	9	58	Variable
April	8	27	Variable
May	13	32	ESE
June	13	30	ESE
July	13	29	ESE
August	11	29	ESE
September	11	31	Variable
October	10	25	WSW
November	10	27	WSW
December	11	36	W
Minimum	**8**	**25**	
Maximum	**13**	**58**	

RPS

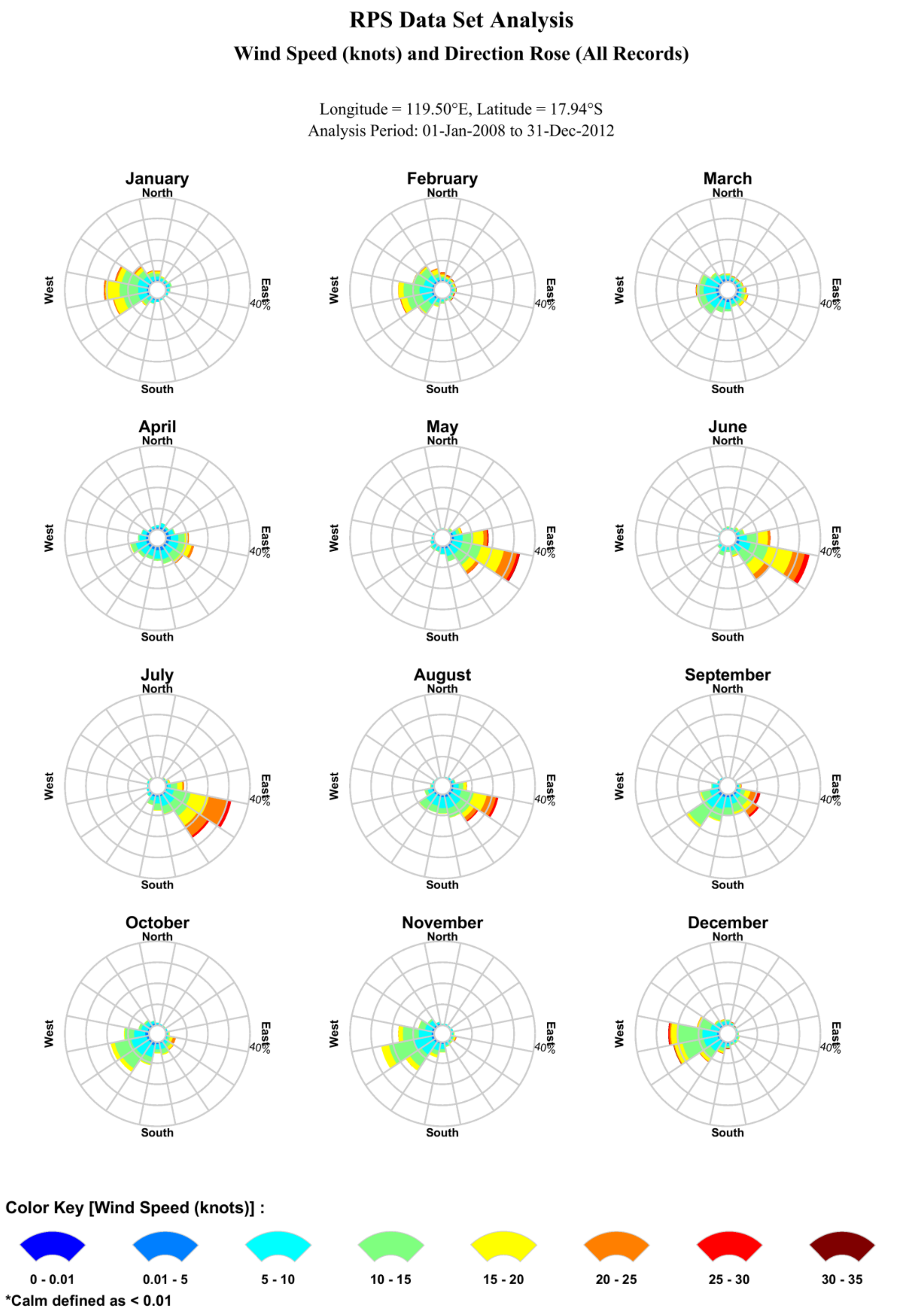

Figure 12 Monthly wind rose distributions derived from the CFSR model from 2008–2012 (inclusive), for the nearest wind node to the release site.

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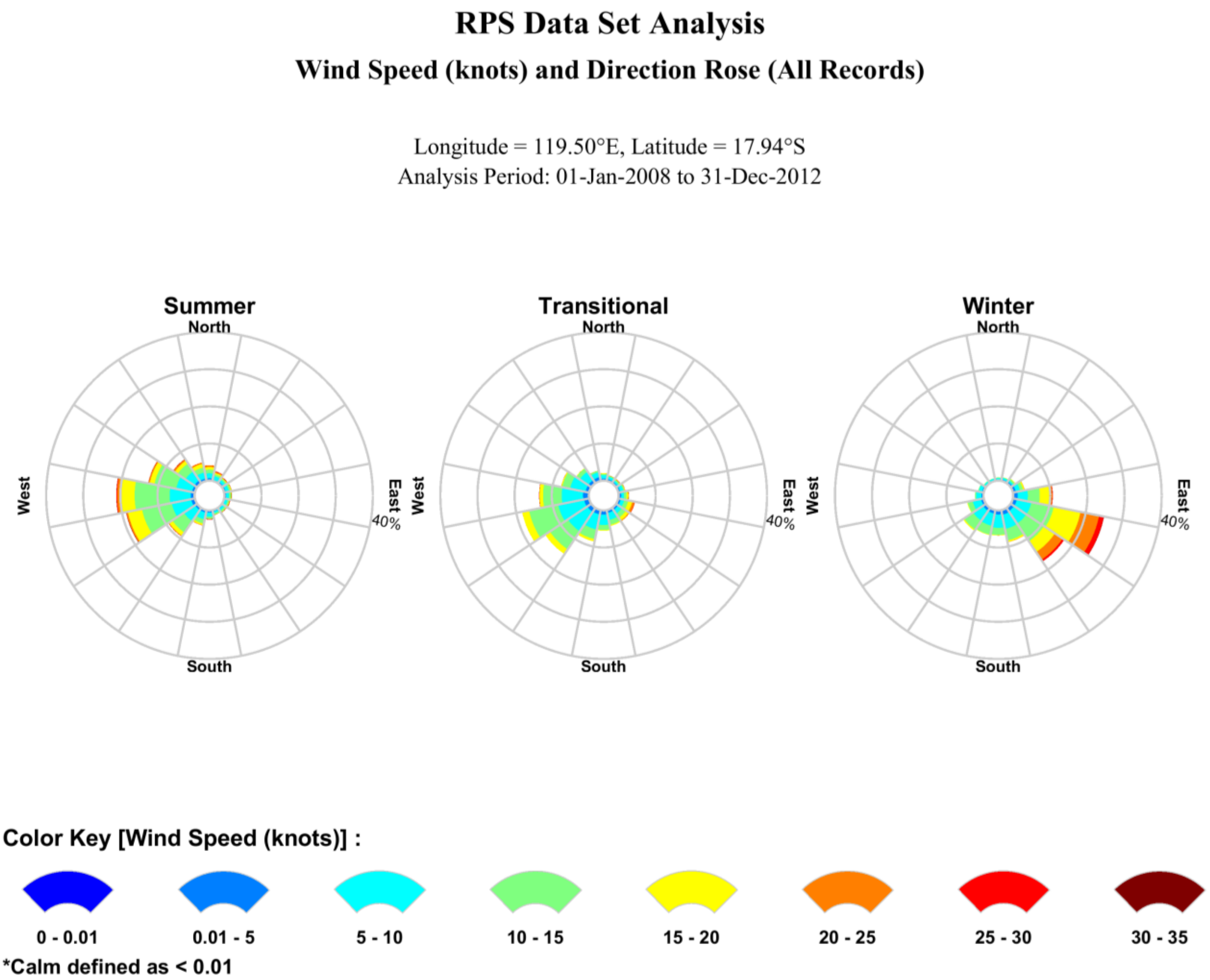

Figure 13 Seasonal wind rose distributions derived from the CFSR model from 2008–2012 (inclusive), for the nearest wind node to the release site.

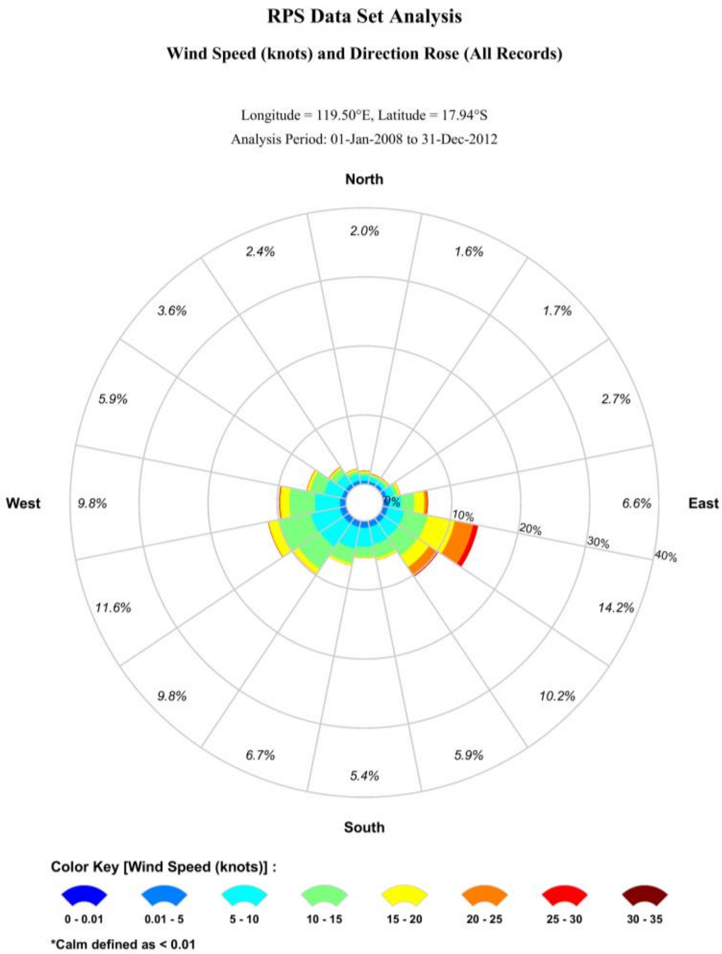

Figure 14 **Annual wind rose distributions derived from the CFSR model from 2008–2012 (inclusive), for the nearest wind node to the release site.**

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5 WATER TEMPERATURE AND SALINITY

The monthly sea temperature and salinity profiles of the water column adjacent to the release site was obtained from the World Ocean Atlas 2013 (WOA13) produced by the National Oceanographic Data Centre (National Oceanic and Atmospheric Administration) (see Levitus et al., 2013).

To account for depth-varying sea temperature and salinity the modelling used monthly average sea temperature and salinity profiles at 5 m intervals through the water column (refer to Figure 15).

Table 5 details the monthly average sea surface temperatures and salinity (0-5 m depth layer). Monthly average sea surface temperatures were shown to range from 25.2°C (September) and 30.2°C (March). Salinity remained consistent throughout the year ranging from 34.3 to 35.0 psu.

Table 5 Monthly average sea surface temperature and salinity in the 0–5 m depth layer near the release site

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (°C)	30.0	29.9	30.2	29.5	27.7	28.1	25.4	25.3	25.2	26.7	28.1	28.8
Salinity (psu)	34.8	34.6	34.6	34.8	34.5	34.8	34.3	34.7	34.6	34.7	35.0	34.9

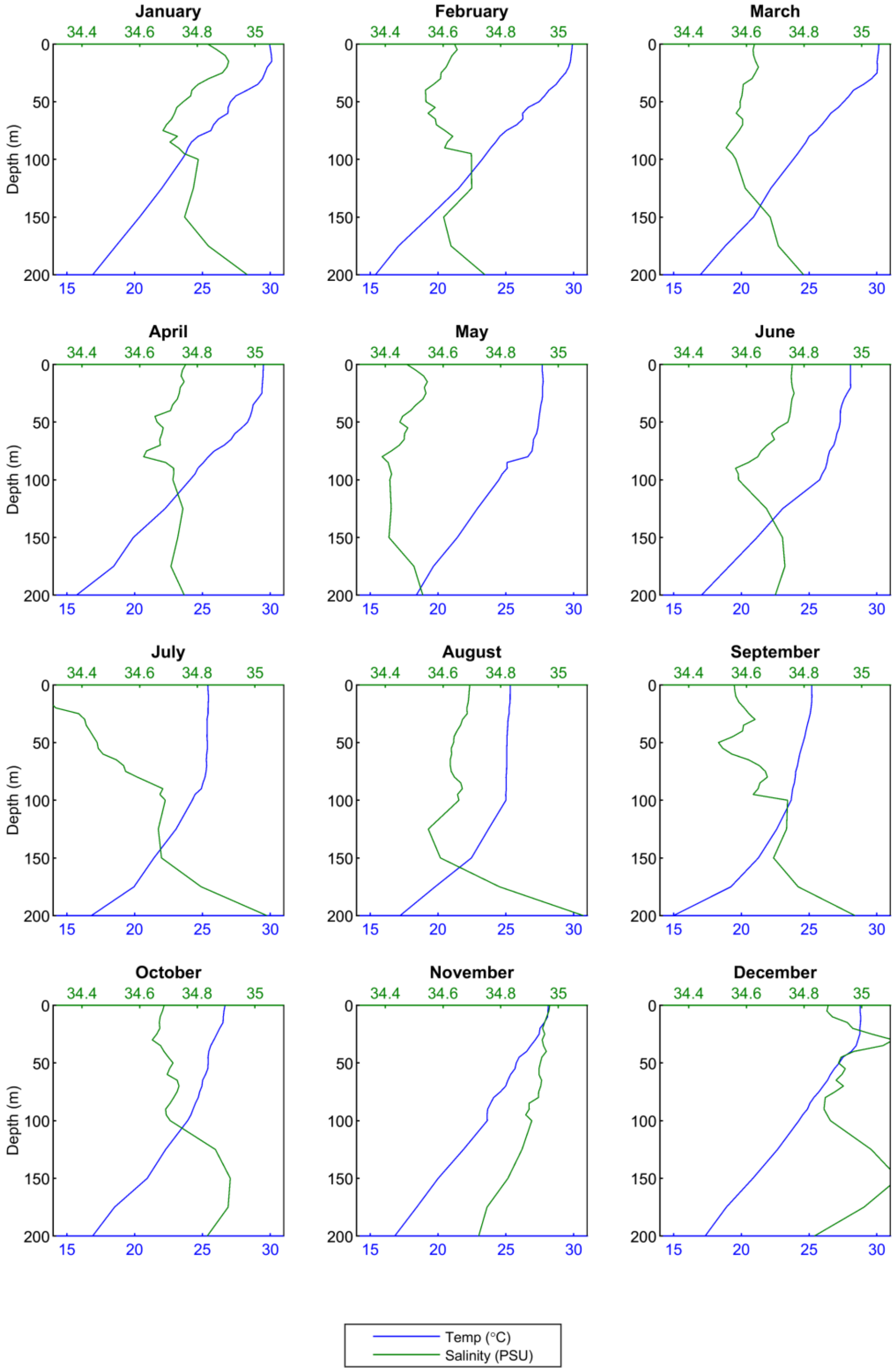

Figure 15 Monthly water temperature and salinity profiles near the release site.

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6 OIL SPILL MODEL – SIMAP

The oil spill modelling was performed using SIMAP. 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 hydrocarbon), (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.

6.1 Stochastic Modelling

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 hypothetical spill scenarios.

As spills can occur during any set of wind and current conditions, a total of 100 spill per season (e.g. summer, transitional and winter) were initiated at random times within a 5-year period (2008–2012) to enable a robust statistical analysis.

Each simulation was configurated 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 summary of all trajectories run for the scenario.

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6.2 Sea surface, Shoreline and In-Water Exposure Thresholds

The sea surface, shoreline and in-water exposure thresholds used to assess the oil spill modelling results and generate statistical tables and spatial maps were communicated by the client and are summarised in Table 6.

Table 6 Exposure threshold values requested by ERM

Exposure level	Sea Surface Exposure (g/m^2)	Shoreline Contact (g/m^2)	Dissolved Hydrocarbon Concentration (ppb)#	Entrained Hydrocarbon Concentrations (ppb)#
Low	1	10	6	10
Moderate	10	100	50	100
High	25	1,000	400	1,000

#These threshold values refer to a) instantaneous concentrations (i.e. exposure over a 1-hour timestep) and b) time-averaged exposure over a 48-hour window. Both sets of results are provided in the Result Section(s).

6.3 Oil Properties

6.3.1 Marine Diesel Oil

Marine Diesel Oil (MDO) is a light-persistent fuel oil used in the maritime industry. It has a density of 829.1 kg/m^3 (API of 37.6) and a low pour point (-14^{o}C). The low viscosity (4cP) indicates that this oil will spread quickly when released and will form a thin to low thickness film on the sea surface, increasing the rate of evaporation. The oil is categorised as a group II oil (light-persistent) based on categorisation and classification derived from AMSA (2015a) guidelines. The classification is based on the specific gravity of hydrocarbons in combination with relevant boiling point ranges.

Table 7 details the physical properties of MDO, while Table 8 presents the boiling point ranges of the MDO used in this study.

Figure 16 shows weathering graphs for a 280 m^3 release of MDO over 6 hours (tracked for 30 days) during three static wind conditions.

The prevailing weather conditions will influence the weathering and fate of the MDO. Under lower wind-speeds (5 knots), the MDO will remain on the surface longer, spread quicker, and in turn increase the evaporative process. Conversely, sustained stronger winds (>15 knots) will generate breaking waves at the surface, causing a higher amount of MDO to be entrained into the water column and reducing the amount available to evaporate.

Table 7 Physical properties of Marine Diesel Oil

Characteristic	Marine Diesel Oil (MDO)
Density (kg/m^3)	829.1
API	37.6
Dynamic viscosity (cP)	4
Pour Point (ºC)	-14
Wax content (%)	1
Hydrocarbon property category	Group II
Hydrocarbon property classification	Light - Persistent

Table 8 Boiling point ranges of Marine Diesel Oil

Characteristic	Not Persistent			Persistent
	Volatile	Semi-volatile	Low volatility	Residual
Boiling point (ºC)	< 180	180 - 265	265 - 380	>380
Marine Diesel Oil	*6.0*	*34.6*	*54.4*	*5.0*

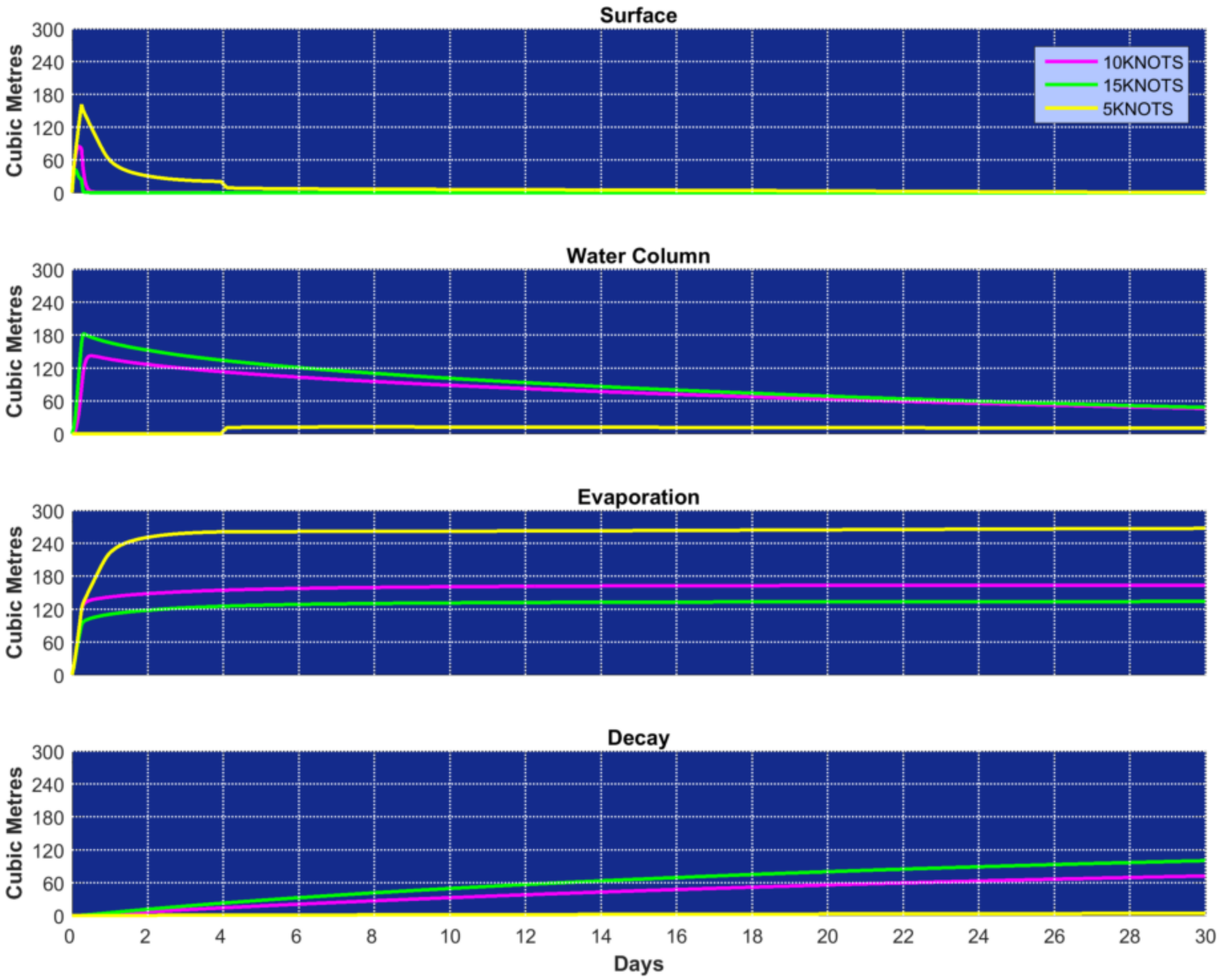

Figure 16 Weathering of MDO under three static winds conditions (5, 10 and 15 knots). The results are based on a 280 m^3 surface release of MDO over 6 hours and tracked for 30 days.

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6.4 Model Settings

This oil spill modelling study quantified the seasonal risk and potential exposure to the surrounding waters and shorelines for a plausible, yet hypothetical scenario:

- 280 m^3 surface release of MDO over 6 hours resulting from a vessel collision incident at the closest point of the operational area to the Rowley Shoals.

Table 9 provides a summary of the oil spill model settings.

Table 9 Summary of the oil spill model settings

Parameter	Oil Spill Scenario
Scenario description	Vessel Collision
Model period	Summer (December to February) Transitional (March, October and November) Winter (April to September)
Number of randomly selected spill start times and locations per season	100
Oil type	MDO
Spill volume (m^3)	280
Release type	Surface
Release duration	6 hr
Simulation length (days)	30
Surface oil concentration thresholds	1 g/m^2, 10 g/m^2, >25 g/m^2
Shoreline load threshold	10 g/m^2, 100 g/m^2, >1,000 g/m^2
Dissolved aromatic exposure to assess the potential exposure (ppb)	6 ppb, potential low exposure 50 ppb, potential moderate exposure 400 ppb, potential high exposure
Entrained oil exposure to assess the potential exposure (ppb)	10 ppb, potential low exposure 100 ppb, potential moderate exposure 1,000 ppb, potential high exposure
In-water exposure duration	Instantaneous and 48 hr exposure

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7 PRESENTAITON AND INTERPRETATION OF MODEL RESULTS

The results from the modelling study are presented in a number of tables and figures, which aim to provide a comprehensive understanding of the predicted sea-surface and in-water (subsurface) exposure and shoreline contact (if predicted).

7.1 Seasonal Analysis

7.1.1 Figures

The figures are based on the following principles:

- *The* ***potential zones of exposure (surface oil, entrained hydrocarbons and dissolved aromatics)*** – is determined by identifying the maximum loading (surface) or dosage (subsea) within a grid cell and is then classified according to identified surface or subsea thresholds.
- The ***minimum time before oil exposure on the sea surface*** **–** is determined by recording the elapsed time before sea surface exposure to a grid cell, at a specified threshold.
- The ***probability of exposure/contact (surface oil, shoreline oil, entrained hydrocarbon or dissolved aromatic)*** **–** is calculated by dividing the number of spill trajectories passing over that given cell (surface, shoreline or subsea) by the total number of spill trajectories, above the specified threshold value.
- The **Maximum potential shoreline loading –** is determined by identifying the maximum loading within a shoreline cell and is then classified according to the identified thresholds (i.e. 10, 100 g/m^2 and 1,000 g/m^2).

7.1.2 Statistics

The statistics are based on the following principles:

- The ***greatest distance travelled by a spill trajectory*** **–** is determined by a) recording the maximum distance travelled by a single trajectory, within a scenario, from the release location to the identified exposure thresholds.
- The ***probability of shoreline contact*** – is determined by recording the number of spill trajectories to contact the shoreline, at a specific threshold, divided by the total number of spill trajectories within that scenario.
- The ***minimum time before oil exposure*** – is determined by recording the minimum time for a grid cell to record exposure, at a specific threshold.
- The ***average volume of oil ashore for a single spill*** – is determined by calculating the average volume of the all the single spill trajectories which were predicted to make shoreline contact within a scenario.
- The ***maximum volume of oil ashore from a single spill trajectory*** – is determined by identifying the single spill trajectory within a scenario/season, that recorded the maximum volume of oil to come ashore and presenting that value.
- The ***average length of shoreline contacted by oil*** – is determined by calculating the average of the length of shoreline (measured as grid cells) contacted by oil above a specified threshold.
- The ***maximum length of shoreline contacted by oil*** – is determined by recording the maximum length of shoreline (measured as grid cells) contacted by oil above a specified threshold.
- The ***probability of oil exposure to a receptor*** **–** is determined by recording the number of spill

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trajectories to reach a specified sea surface or subsea threshold within a receptor polygon, divided by the total number of spill trajectories within that scenario.

- The ***minimum time before oil exposure to a receptor*****–** is determined by ranking the elapsed time before sea surface exposure, at a specified threshold, to grid cells within a receptor polygon and recording the minimum value.
- The ***probability of oil contact to a receptor*** **–** is determined by recording the number of spill trajectories to reach a specified shoreline contact threshold within a receptor polygon, divided by the total number of spill trajectories within that scenario.
- The ***minimum time before shoreline contact to a receptor*** **–** is determined by ranking the elapsed time before shoreline contact, at a specified threshold, to grid cells within a receptor polygon and recording the minimum value.
- The ***average potential oil loading within a receptor*** – is determined taking the average of the maximum loading to any grid cell within a polygon, for all simulations within a scenario/season, that recorded shoreline.
- The ***maximum potential oil loading within a receptor*** – is determined by identifying the maximum loading to any grid cell within a receptor polygon, for a scenario.
- The ***average volume of oil ashore within a receptor*** – is determined by calculating the average volume of oil to come ashore within a receptor polygon, from all the single spill trajectories which were predicted to make shoreline contact within a scenario.
- The ***maximum volume of oil ashore within a receptor*** – is determined by recording the maximum volume of oil to come ashore within a receptor polygon, from all the single spill trajectories which were predicted to make shoreline contact within a scenario.
- The ***average length of shoreline contacted within a receptor*** – is determined by calculating the average of the length of shoreline (measured as grid cells) contacted by oil within a receptor polygon, at a specified threshold, from all the single spill trajectories which were predicted to make shoreline contact within a scenario.
- The ***maximum length of shoreline contacted by oil*** – is determined by recording the maximum length of shoreline (measured as grid cells) contacted by oil within a receptor polygon, at a specified threshold, from all the single spill trajectories which were predicted to make shoreline contact within a scenario.

7.2 Receptors Assessed

A range of environmental receptors summarised in Table 10 and illustrated in Figure 17 to Figure 21 were assessed for sea surface exposure, shoreline contact and water column exposure as part of the study.

Table 10 Summary of receptors used to assess surface, shoreline and in-water exposure to hydrocarbons

Receptor Category	Acronym	Hydrocarbon Exposure Reported for		
		Water column	Sea Surface	Shoreline
Marine National Park (including Australian Marine Parks and Marine Parks)	MNP, AMP, MP	✓	✓	✗
Integrated Marine and Coastal Regionalisation of Australia	IMCRA	✓	✓	✗
Interim Biogeographic Regionalisation of Australia	IBRA	✓	✓	✓
Key Ecological Feature	KEF	✓	✓	✗
Reefs, Shoals and Banks	RSB	✓	✓	✗

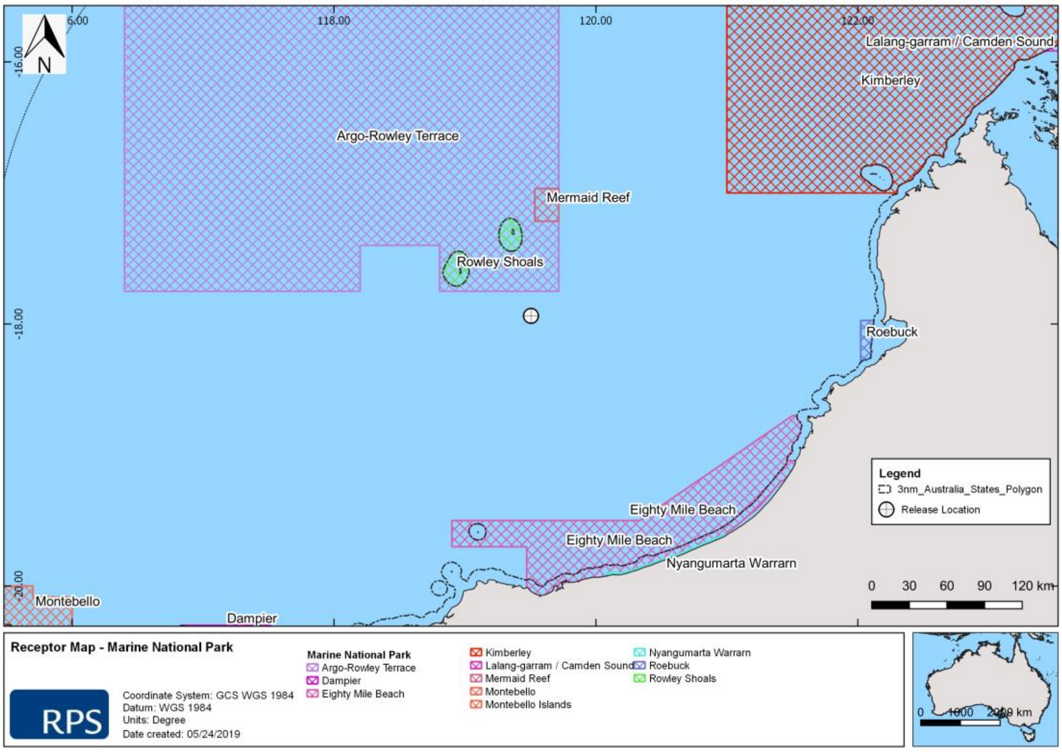

Figure 17 Receptor map illustrating Marine Parks

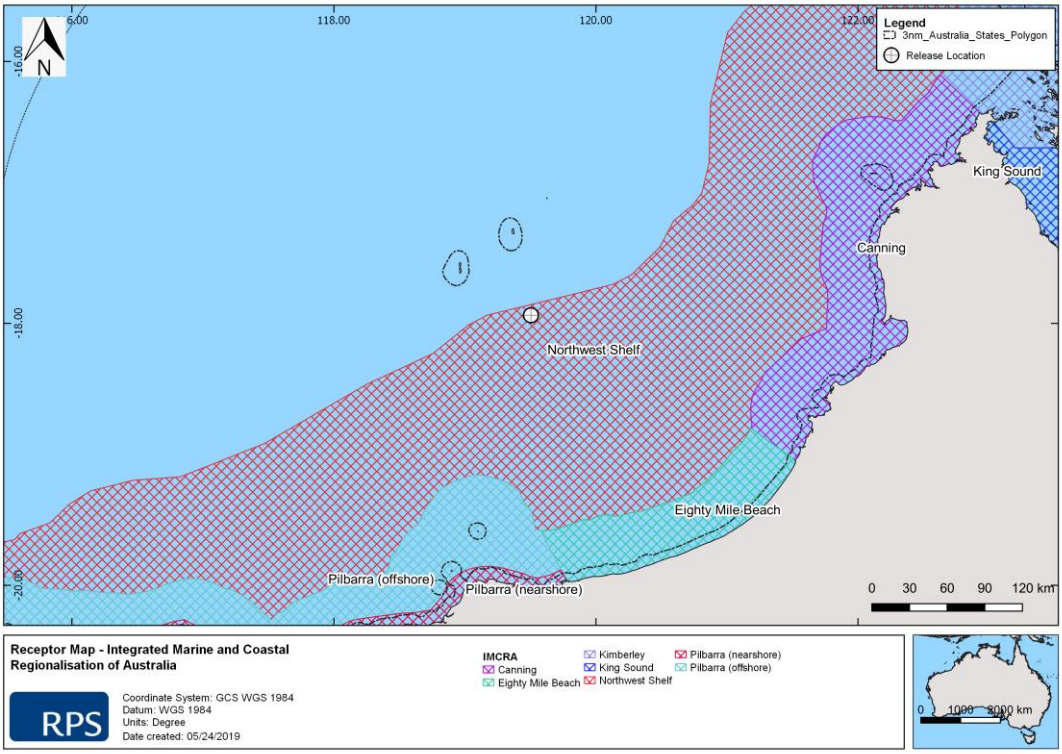

Figure 18 Receptor map illustrating the Integrated Marine and Coastal Regionalisation of Australia (IMCRA)

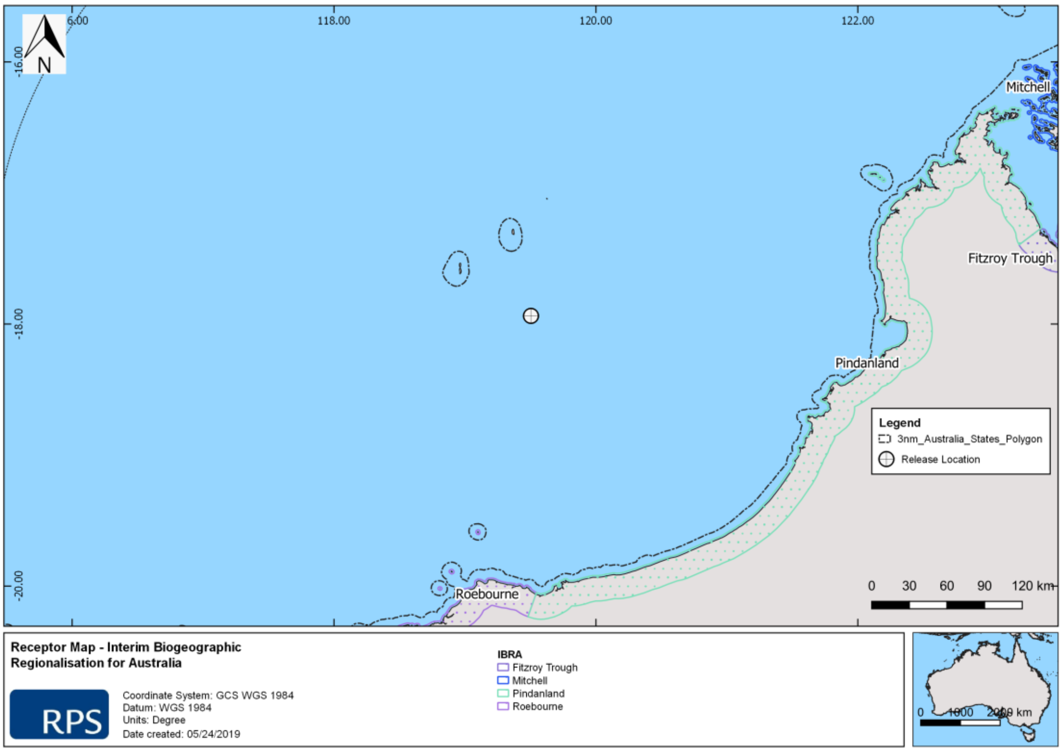

Figure 19 Receptor map illustrating the Interim Biogeographic Regionalisation for Australia (IBRA)

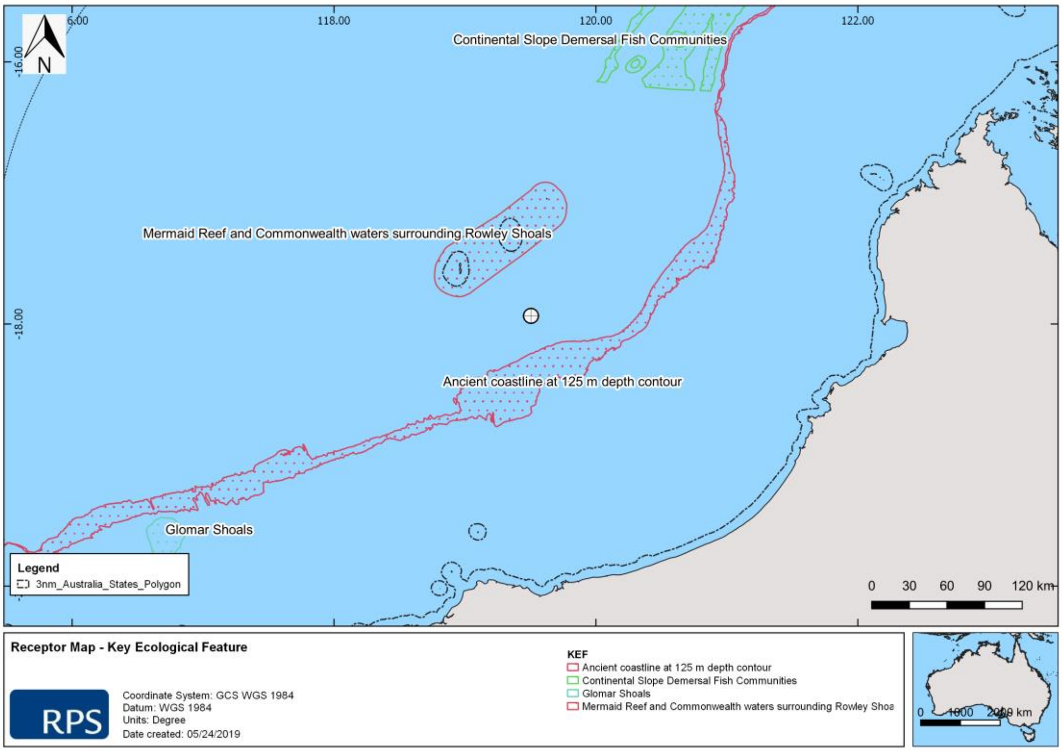

Figure 20 Receptor map illustrating Key Ecological Features (KEF)

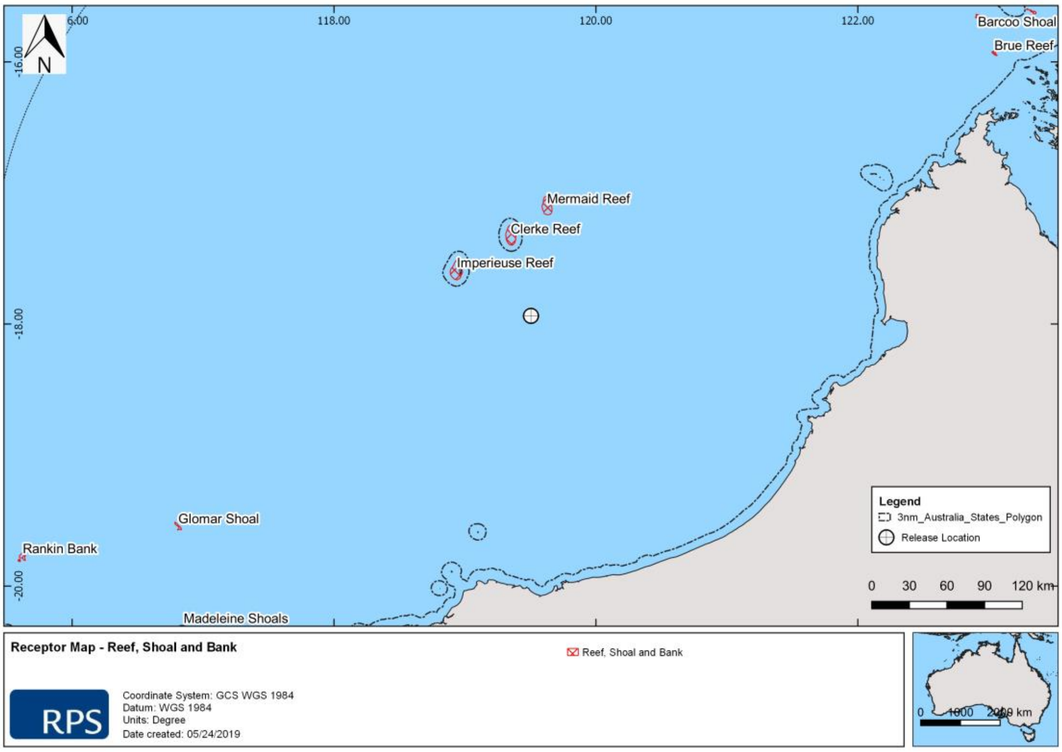

Figure 21 Receptor map illustrating the Reefs, Shoals and Banks

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8 RESULTS: 280 M^3 SURFACE RELEASE OF MARINE DIESEL OIL

The scenario examined a 280 m^3 release of MDO over 6 hours, tracked for 30 days. A total of 100 spill trajectories were simulated for each of the seasons, summer, transitional and winter.

Section 8.1 presents stochastic results. Note, no shoreline contact was predicted for this scenario.

8.1 Stochastic Analysis

For the modelling study each spill trajectory was tracked to the following minimum thresholds:

- Sea surface oil – 1 g/m^2
- Shoreline contact – 10 g/m^2
- Dissolved aromatics – 6 ppb (instantaneous and over a 48-hour exposure window)
- Entrained hydrocarbons – 10 ppb (instantaneous and over a 48-hour exposure window)

8.1.1 Sea Surface Exposure

Table 11 presents a summary of the maximum distance and direction travelled by oil on the sea surface at the low (1 g/m^2), moderate (10 g/m^2) and high (>25 g/m^2) exposure thresholds for each of the three seasons considered, summer, transitional and winter. Modelling results suggested that surface oil at low, moderate and high exposure levels could potentially travel greater distances during the transitional period. The maximum distance travelled by surface oil for the low, moderate and high threshold was 66 km, 14 km and 7 km, respectively.

Figure 22 to Figure 24 show zones of sea surface exposure for the summer, transitional and winter seasons respectively. While the low exposure surface oil was predicted to travel in any directions from the release site, the moderate and high exposure levels remained along the northwest-southeast axis across all seasons.

Figure 25 to Figure 33 show minimum time to surface exposure at the low, moderate and high thresholds for the summer, transitional and winter seasons respectively. As depicted on these figures, the evaporative nature of MDO and environmental conditions in the area resulted in short-lived surface hydrocarbon exposure, with surface exposure reduced to less than 10 g/m^2 after approximately 12-24 hours.

The weathering plot illustrated in Figure 16 indicates that surface hydrocarbon would drop to negligible volumes between 1 to 4 days depending on the wind conditions.

Table 12 presents the potential sea surface exposure to individual receptors. The results demonstrated a 100% predicted probability of sea surface exposure at the low threshold (1 g/m^2) for Northwest Shelf (IMCRA). As shown in Section 7.2, the release location is situated within this area. No sensitive receptors were predicted to be exposed to surface oil at the moderate and high threshold. Argo-Rowley Terrace (AMP) was the only sensitive receptor showing potential exposure to surface oil at the low threshold, with a low likelihood of 1-2 % (during the summer and winter seasons only).

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Table 11 Maximum distance and direction travelled on the sea surface by a single trajectory from the release location to oil exposure thresholds.

Season	Distance and direction	Zones of potential sea surface exposure		
		>1 g/m^2	>10 g/m^2	>25 g/m^2
Summer	Max. distance from release site (km)	31	11	4
	Max distance from release site (km) (99th percentile)	28	11	4
	Direction	N	SSE	NW
Transitional	Max. distance from release site (km)	66	14	7
	Max distance from release site (km) (99th percentile)	56	13	7
	Direction	WSW	SSE	SE
Winter	Max. distance from release site (km)	31	12	6
	Max distance from release site (km) (99th percentile)	28	11	6
	Direction	NNE	WNW	NW

Table 12 Summary of the potential sea surface exposure to receptors

			Probability of oil exposure on the sea surface (%)			Minimum time before oil exposure on the sea surface (hours)		
Season	Receptor		>1 g/m^2	>10 g/m^2	>25 g/m^2	>1 g/m^2	>10 g/m^2	>25 g/m^2
Summer	IMCRA	Northwest Shelf	100	99	56	-	-	-
	AMP	Argo-Rowley Terrace	2	-	-	1	-	-
Transitional	IMCRA	Northwest Shelf	100	100	58	-	-	-
Winter	IMCRA	Northwest Shelf	100	97	45	-	-	-
	AMP	Argo-Rowley Terrace	1	-	-	1	-	-

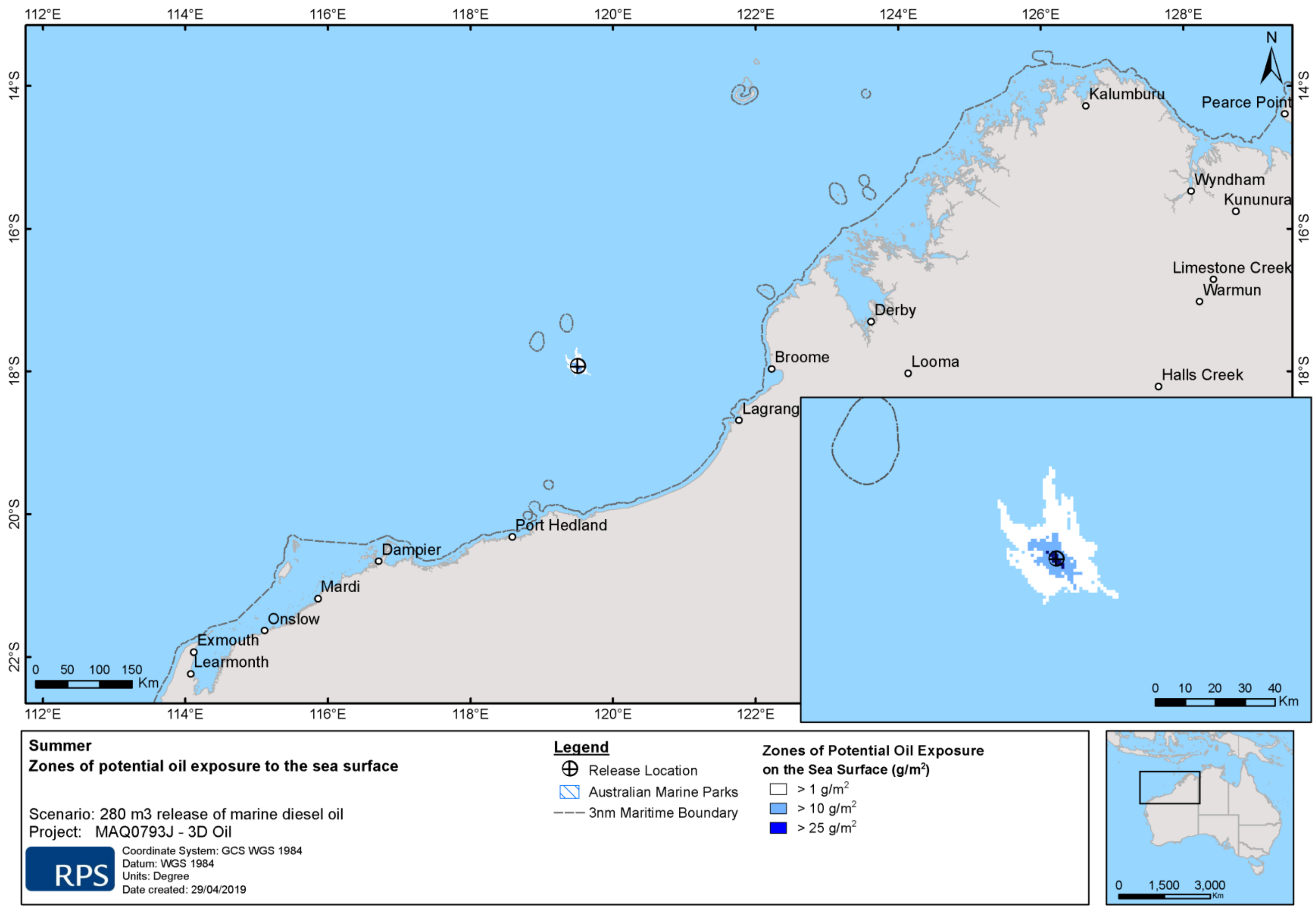

Figure 22 Zones of potential oil exposure on the sea surface, in the event of a 280 m^3 surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during summer wind and current conditions.

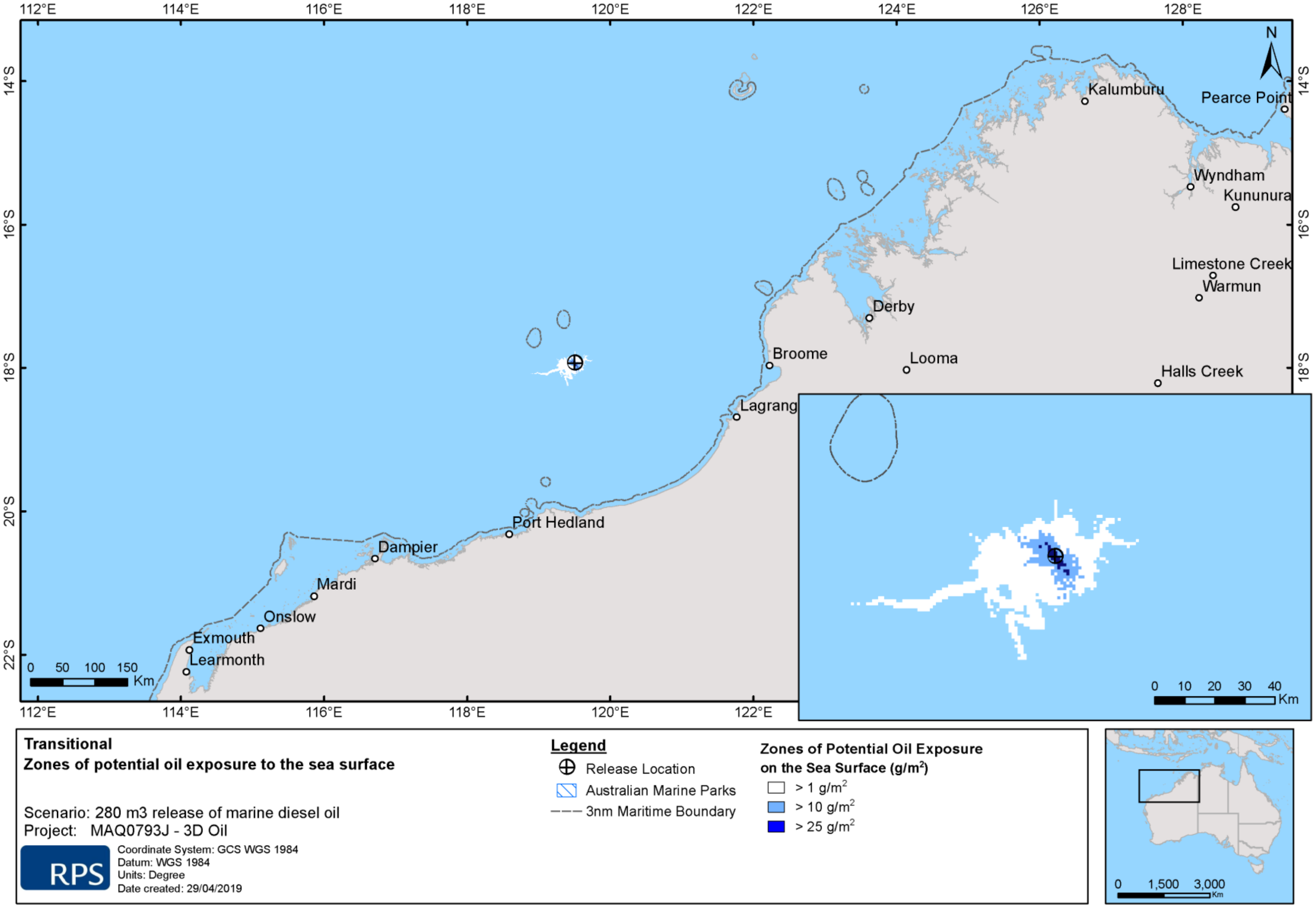

Figure 23 Zones of potential oil exposure on the sea surface, in the event of a 280 m^3 surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during transitional period wind and current conditions.

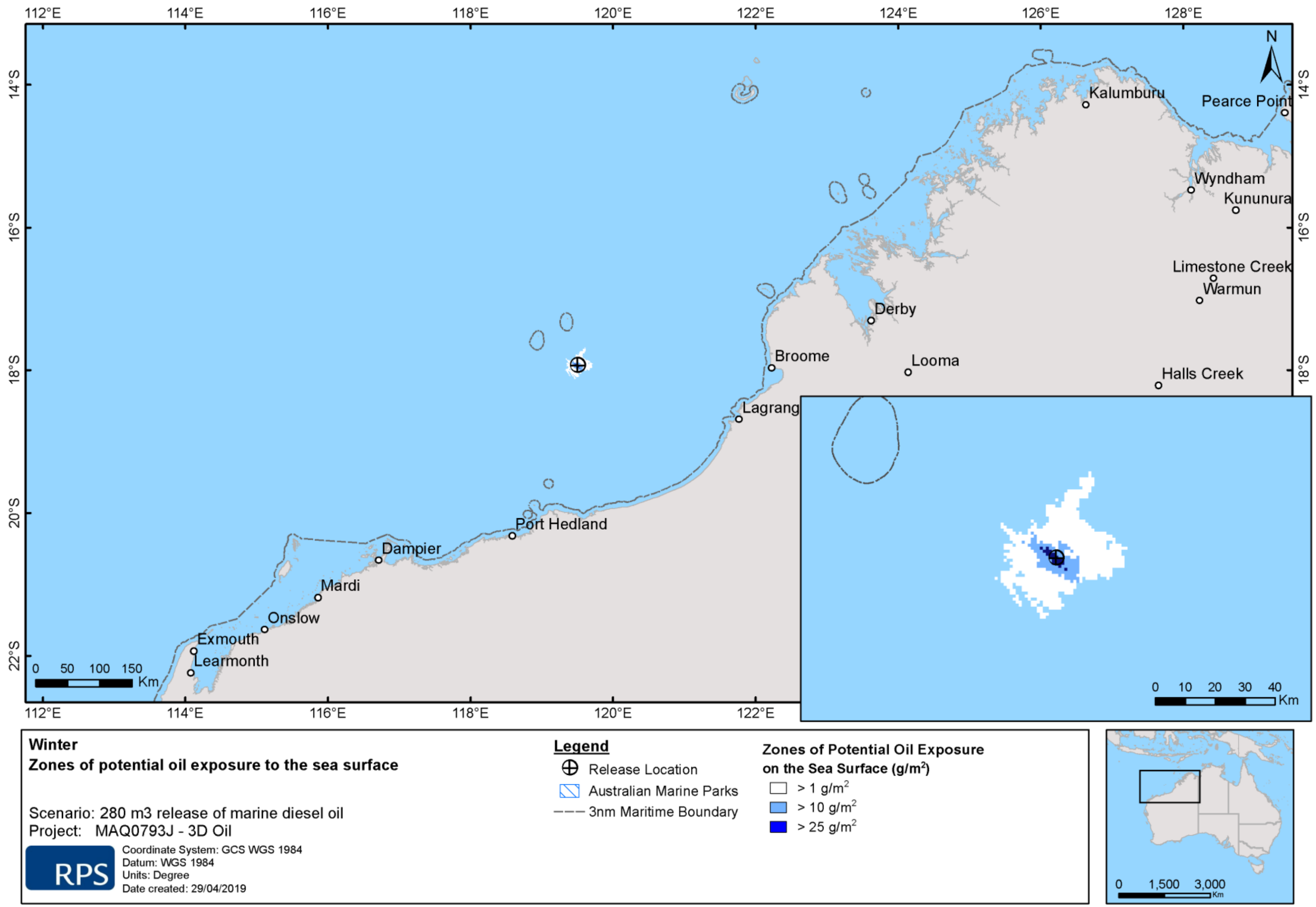

Figure 24 Zones of potential oil exposure on the sea surface, in the event of a 280 m^3 surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during winter wind and current conditions.

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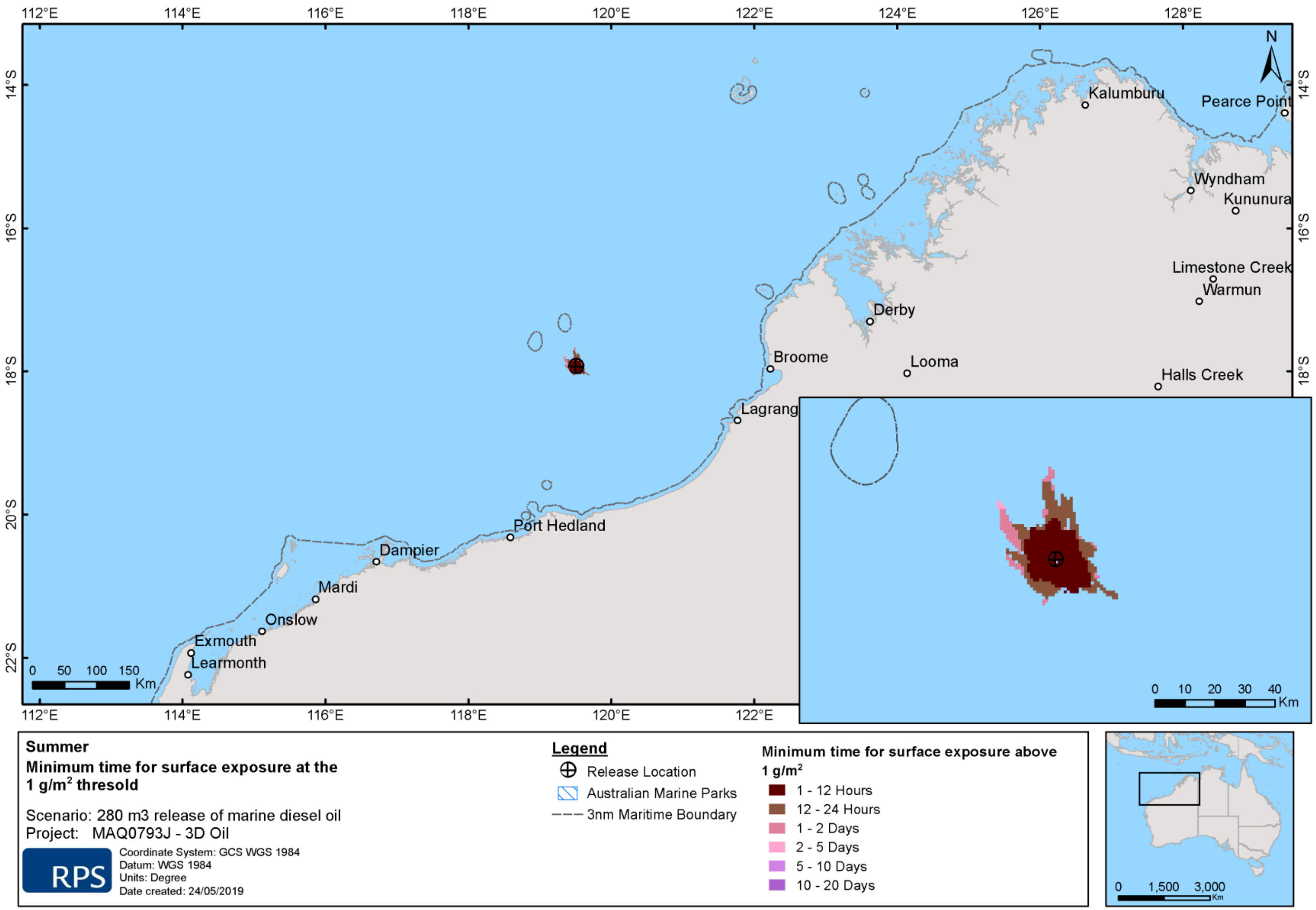

Figure 25 Minimum time for oil exposure on the sea surface at the low (1 g/m^2) threshold, in the event of a 280 m^3 surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during summer conditions.

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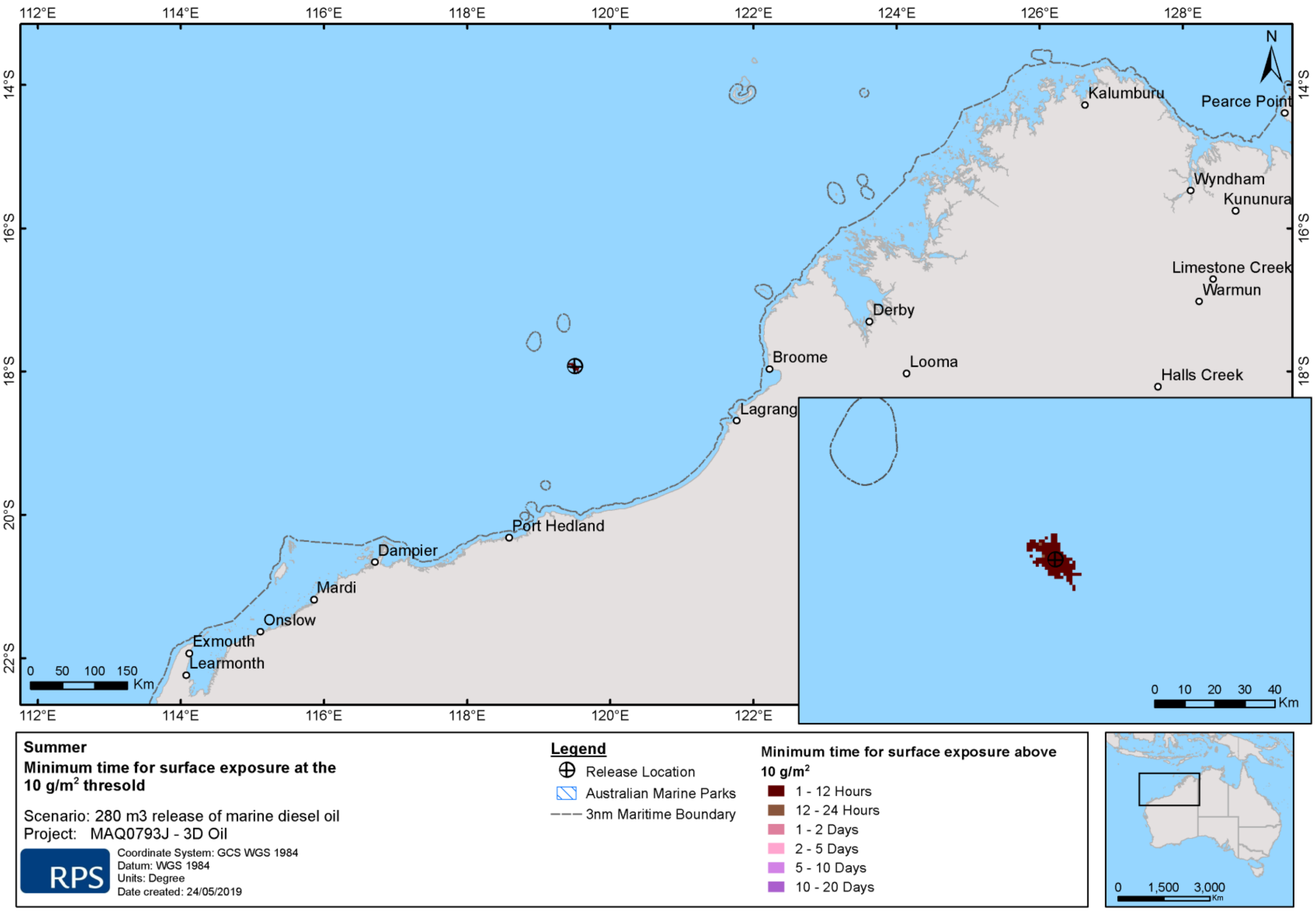

Figure 26 Minimum time for oil exposure on the sea surface at the moderate (10g/m^2) threshold, in the event of a 280 m^3 surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during summer conditions.

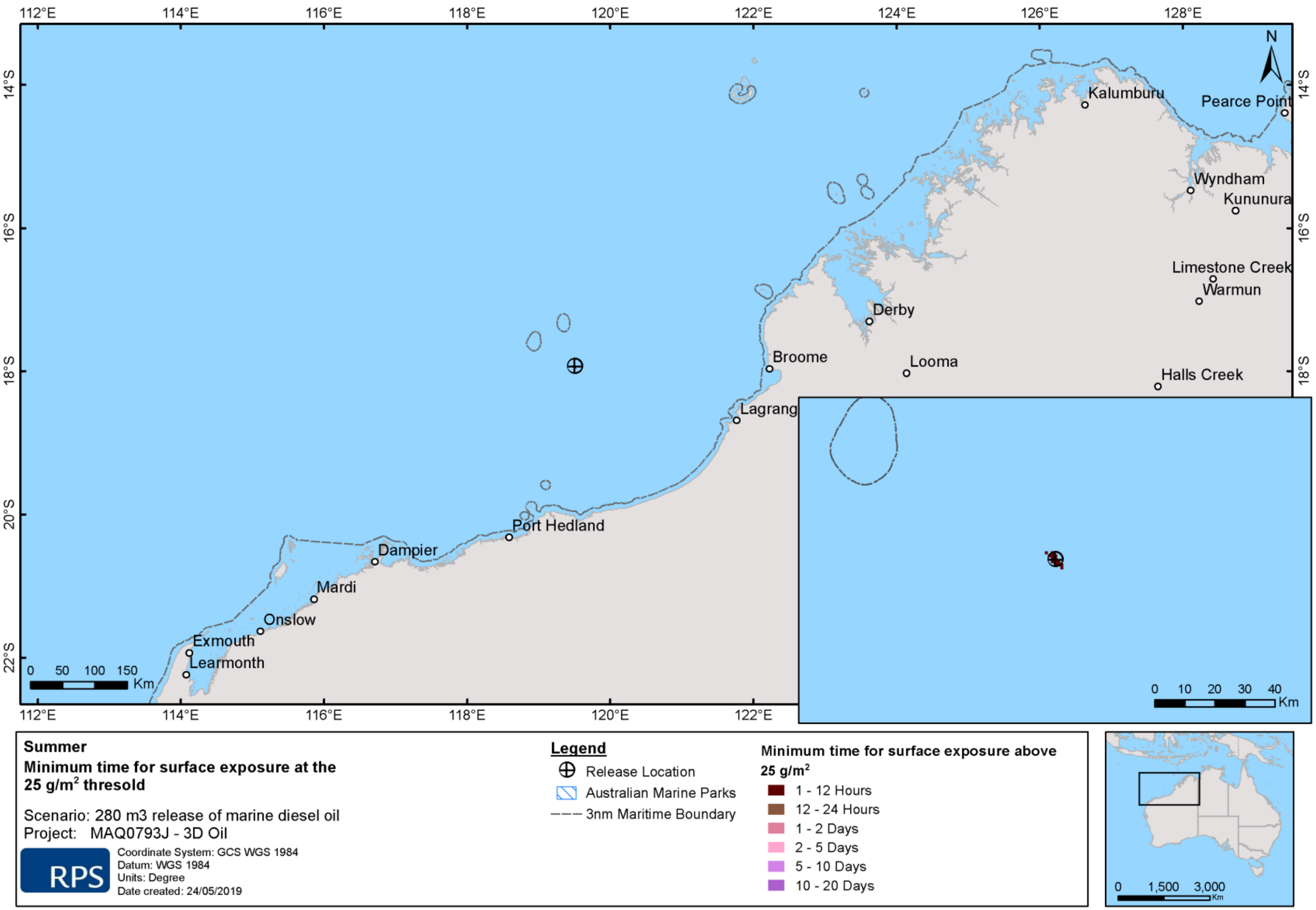

Figure 27 Minimum time for oil exposure on the sea surface at the high (25 g/m^2) threshold, in the event of a 280 m^3 surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during summer conditions.

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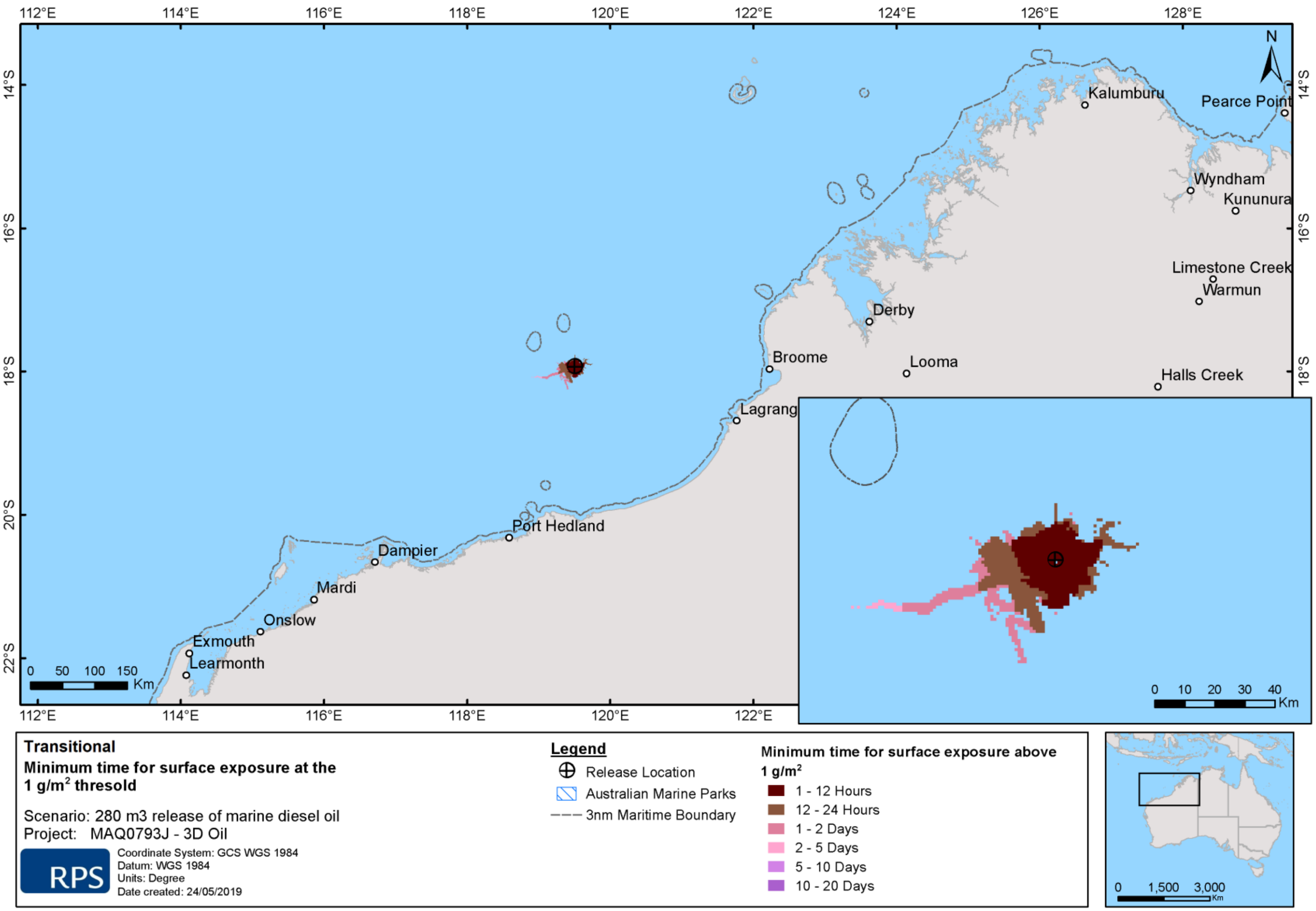

Figure 28 **Minimum time for oil exposure on the sea surface at the low (1 g/m²) threshold, in the event of a 280 m³ surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during transitional period conditions.**

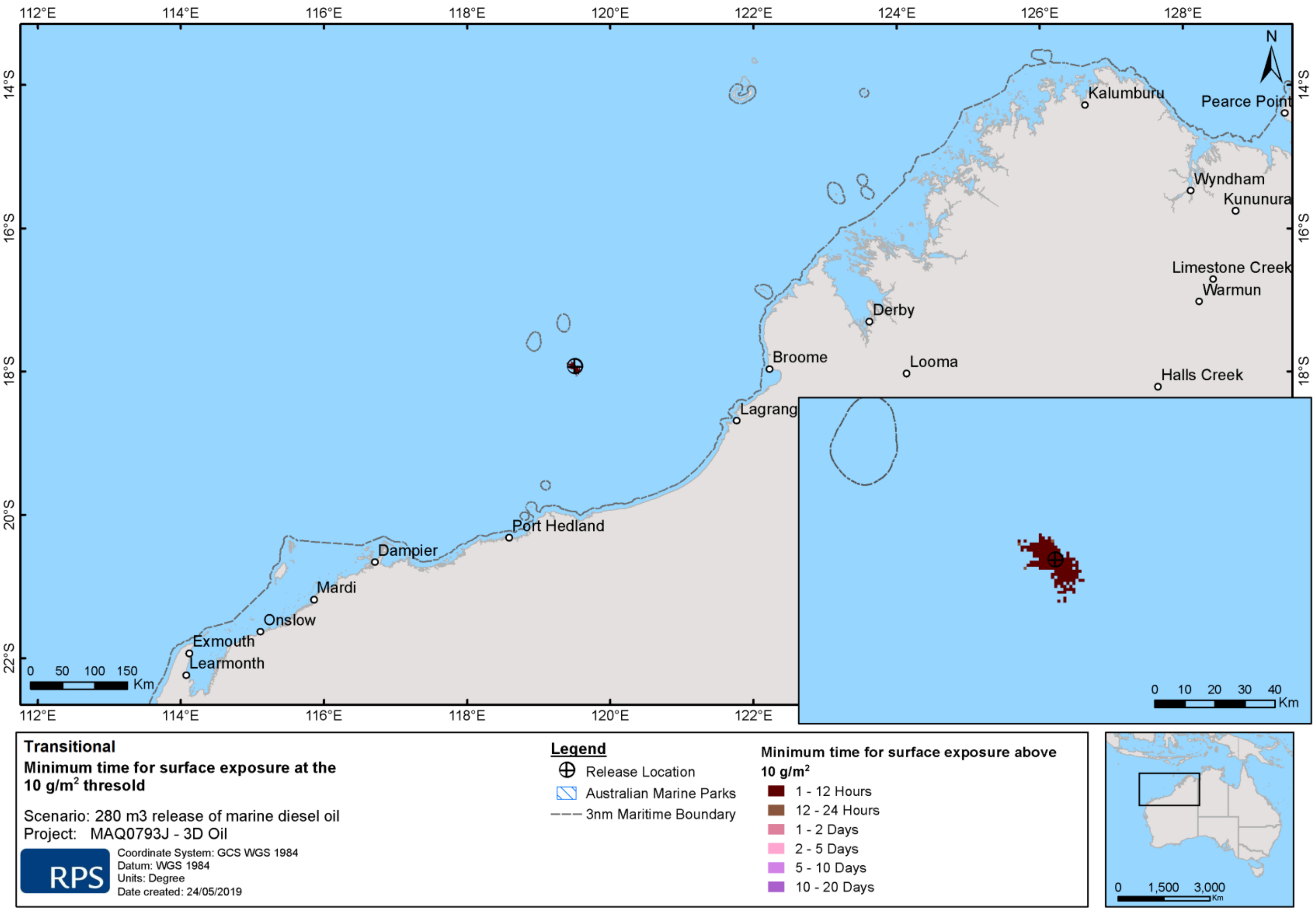

Figure 29 **Minimum time for oil exposure on the sea surface at the moderate (10 g/m^2) threshold, in the event of a 280 m^3 surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during transitional period conditions.**

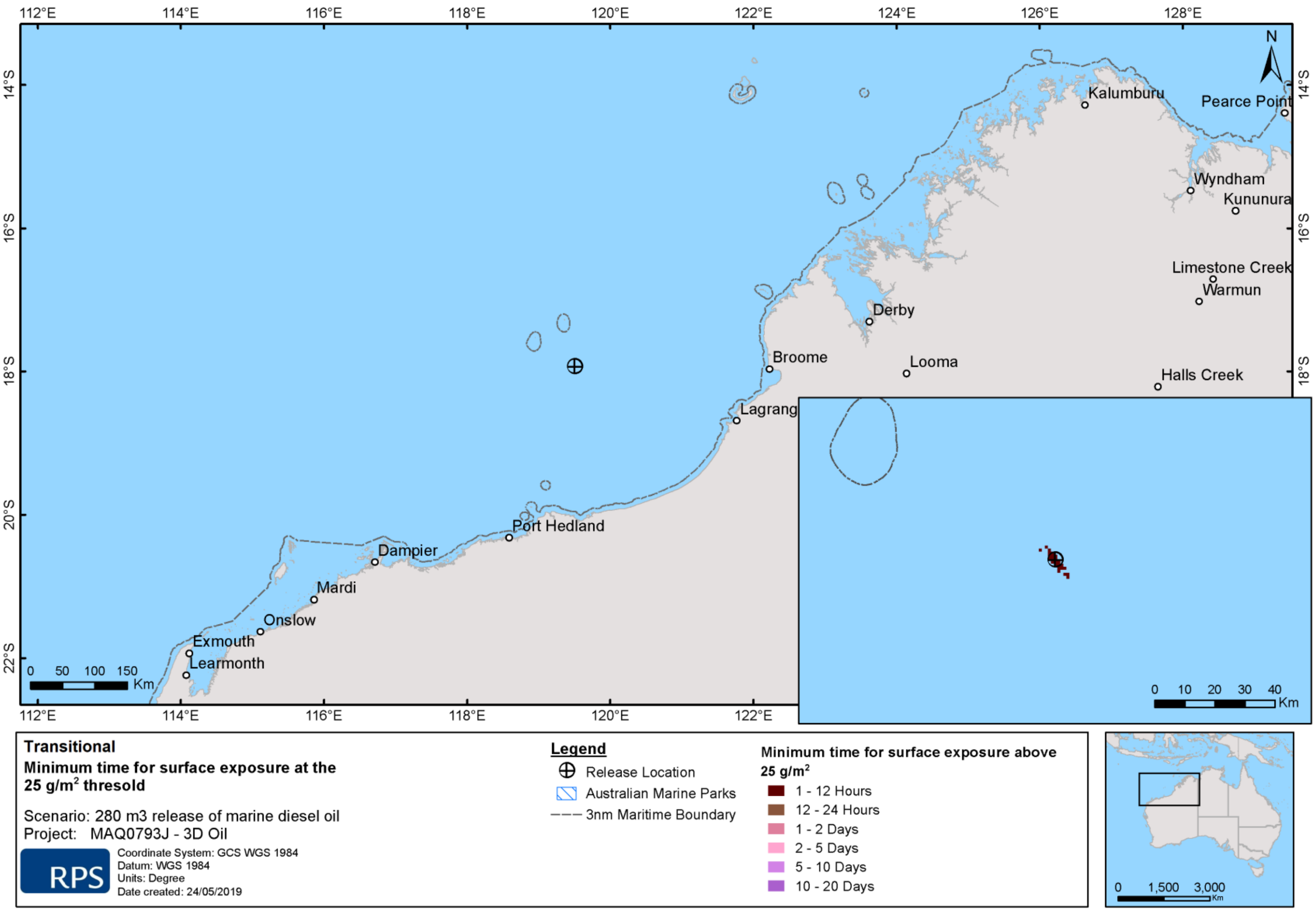

Figure 30 **Minimum time for oil exposure on the sea surface at the high (25 g/m²) threshold, in the event of a 280 m³ surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during transitional period conditions.**

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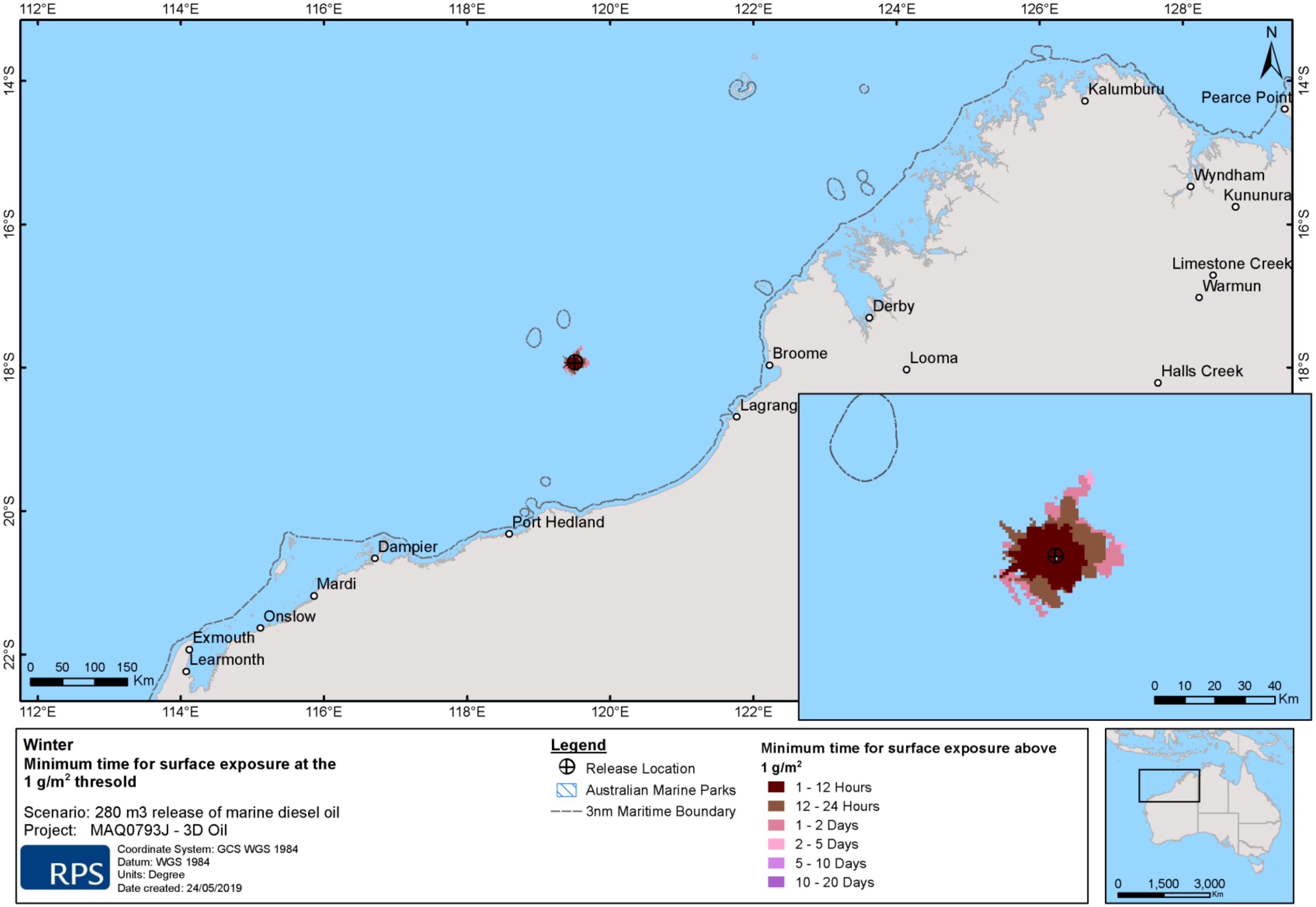

Figure 31 Minimum time for oil exposure on the sea surface at the low (1 g/m²) threshold, in the event of a 280 m³ surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during conditions.

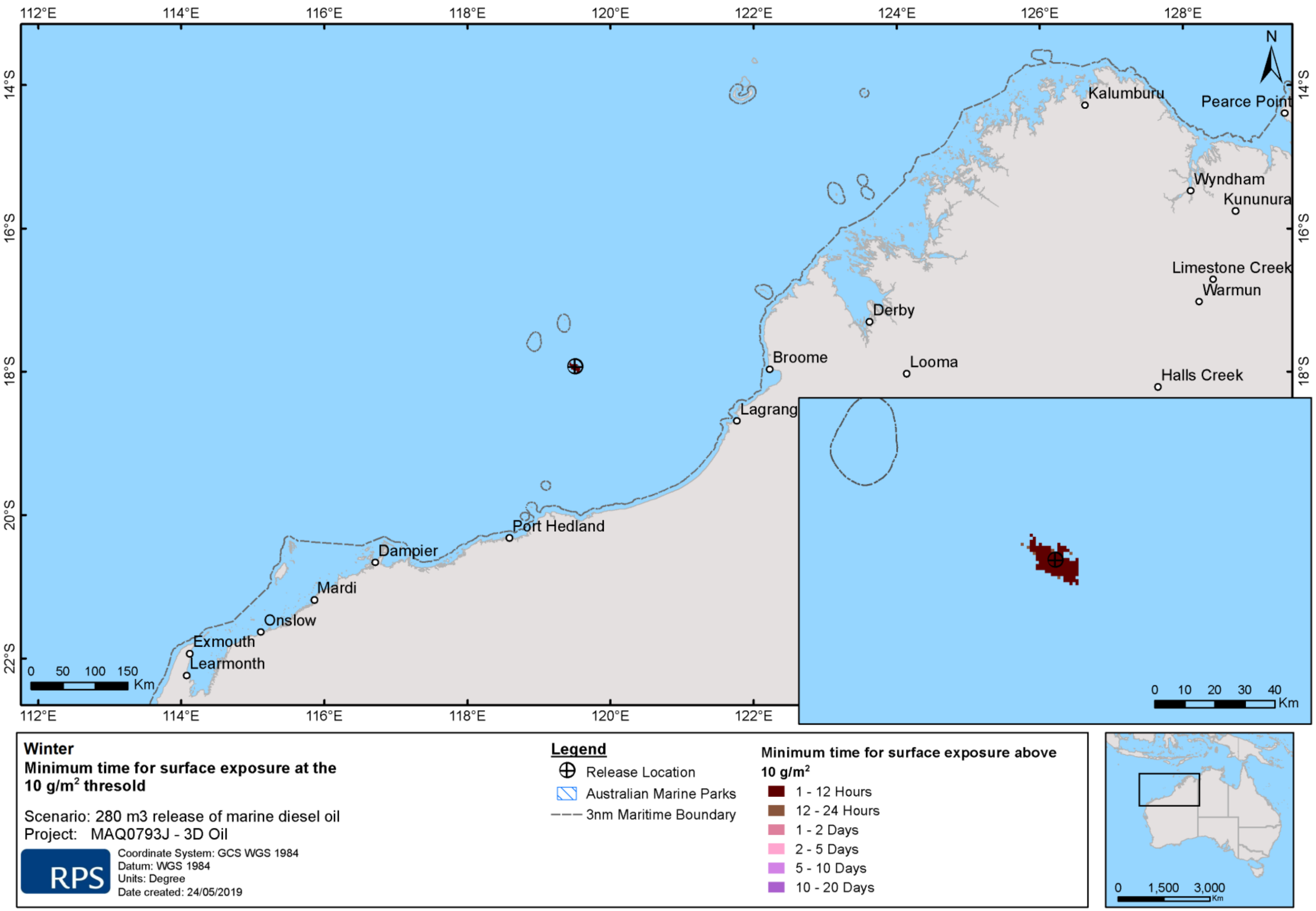

Figure 32 Minimum time for oil exposure on the sea surface at the moderate (10 g/m^2) threshold, in the event of a 280 m^3 surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during conditions.

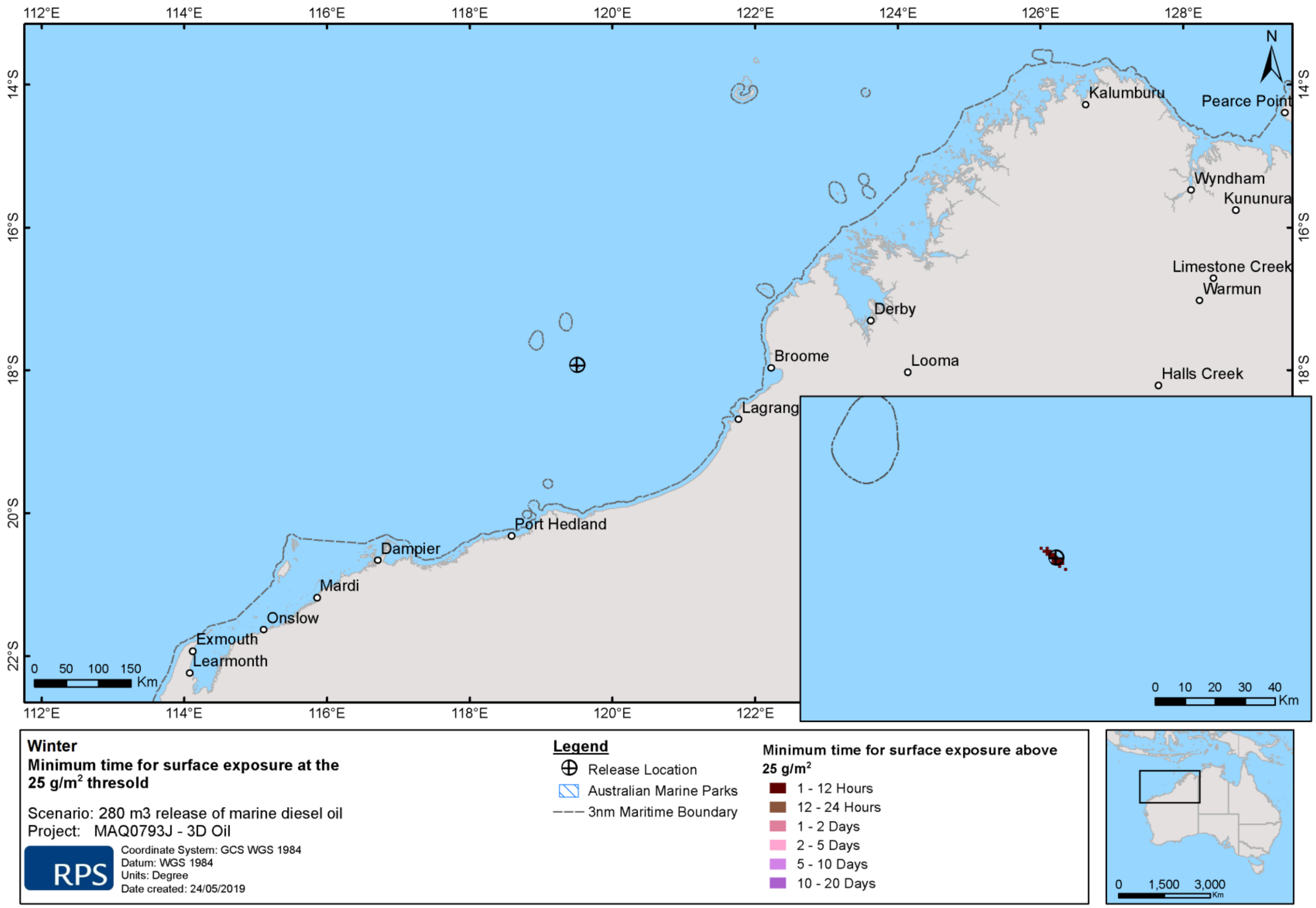

Figure 33 Minimum time for oil exposure on the sea surface at the high (25 g/m^2) threshold, in the event of a 280 m^3 surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during conditions.

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8.2 Water Column Exposure

8.2.1 Dissolved Hydrocarbons

Table 13 summarises the maximum dissolved hydrocarbon exposure (time-averaged and instantaneous) to receptors in the 0–10 m depth layer at or above the exposure thresholds discussed in Section 6.2 over the seasonal assessments.

At the depths of 0-10 m, the maximum time-averaged exposure to dissolved hydrocarbon over 48 hours remained less than 1 ppb for the winter and transitional seasons while reaching 4 ppb for the summer and winter seasons for various receptors. These concentrations are below the defined low threshold for dissolved hydrocarbons. The maximum instantaneous exposure to dissolved hydrocarbons ranged from 6 ppb to 73 ppb for the transitional and summer seasons respectively. None of the receptors was exposed at the moderate (50 ppb) or high (400 ppb) thresholds or above for instantaneous exposure with the exception of the IMCRA – North West Shelf. This receptor had a 1 % probability of exposure to instantaneous dissolved hydrocarbon during the summer season.

Zones of potential dissolved hydrocarbon for instantaneous exposure are presented for each season in Figure 34 to Figure 36.

There were no zones of potential exposure above the exposure thresholds for the time-averaged exposure discussed in Section 6.2, therefore there are no figures provided in this section.

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Table 13 Predicted maximum instantaneous and time-averaged (48 hr) dissolved hydrocarbon exposure to receptors in the 0–10 m depth layer. Results are based on a 280 m³ surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories per season.

Season	Receptor		Maximum time-averaged dissolved hydrocarbon exposure (ppb)	Probability of time-averaged dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure (ppb)	Probability of instantaneous dissolved hydrocarbon exposure		
				>6 ppb	>50 ppb	>400 ppb		>6 ppb	>50 ppb	>400 ppb
Summer	IMCRA	Northwest Shelf	4	0	0	0	73	21	1	0
	AMP	Argo-Rowley Terrace	1	0	0	0	8	1	0	0
Transitional	IMCRA	Northwest Shelf	3	0	0	0	37	16	0	0
	AMP	Argo-Rowley Terrace	<1	0	0	0	6	1	0	0
Winter	IMCRA	Northwest Shelf	4	0	0	0	48	36	0	0
	AMP	Argo-Rowley Terrace	1	0	0	0	19	2	0	0
	MP	Rowley Shoals	<1	0	0	0	13	1	0	0
	KEF	Mermaid Reef and Commonwealth waters surrounding Rowley Shoals	<1	0	0	0	14	1	0	0

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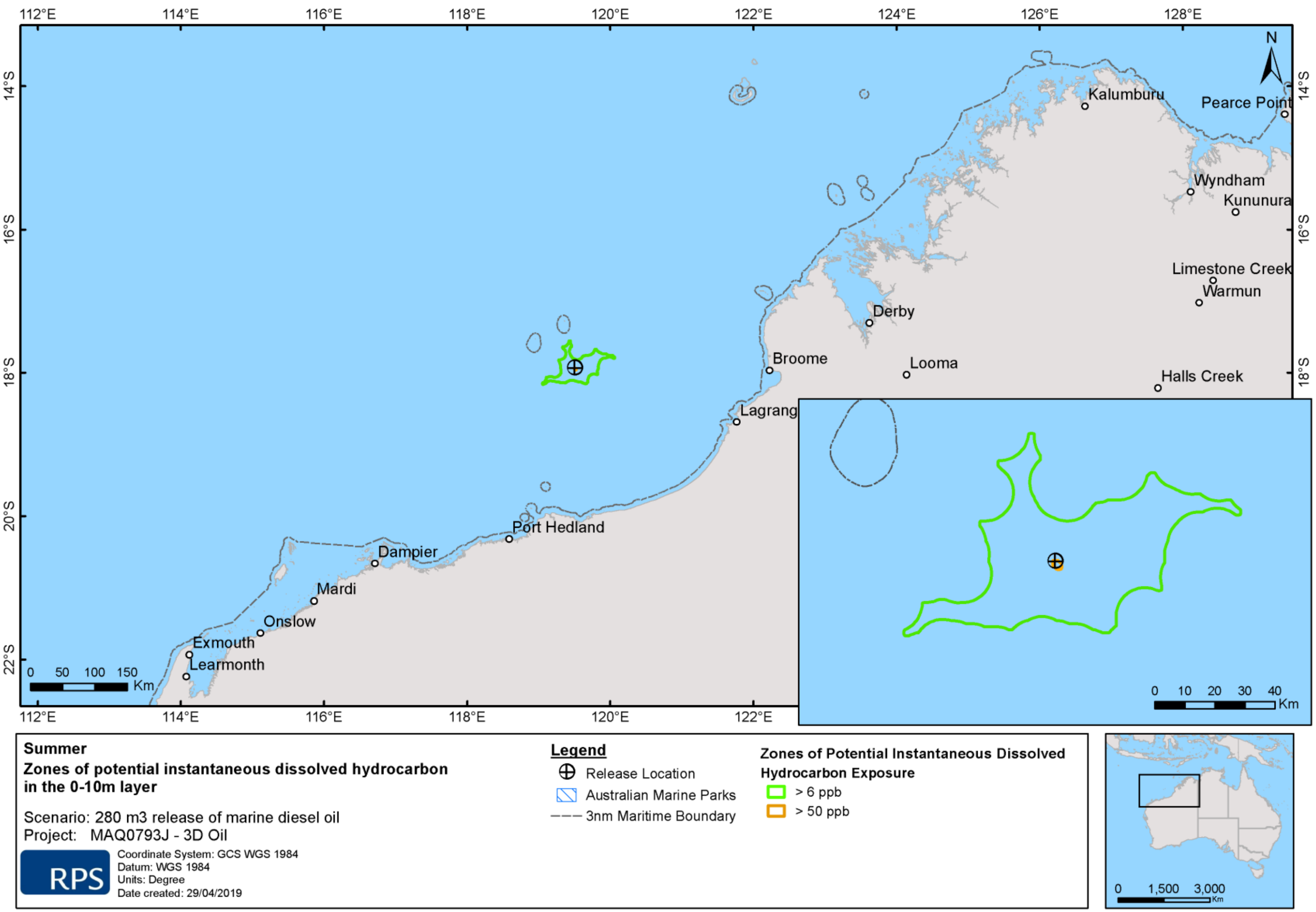

Figure 34 Zones of potential instantaneous dissolved hydrocarbon exposure at 0–10 m below the sea surface in the event of a 280 m^3 of surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during summer wind and current conditions.

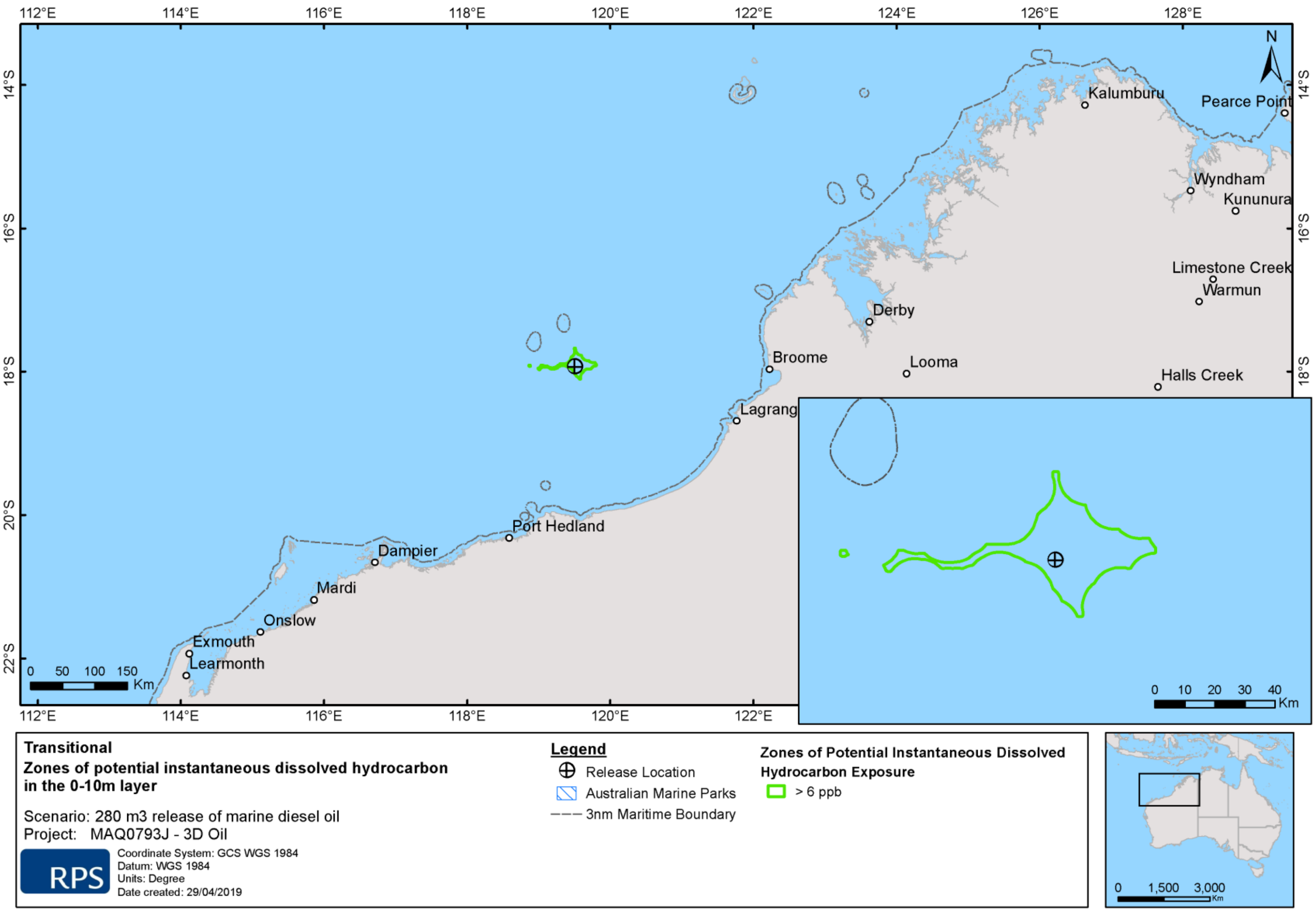

Figure 35 Zones of potential instantaneous dissolved hydrocarbon exposure at 0–10 m below the sea surface in the event of a 280 m^3 of surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during transitional period wind and current conditions.

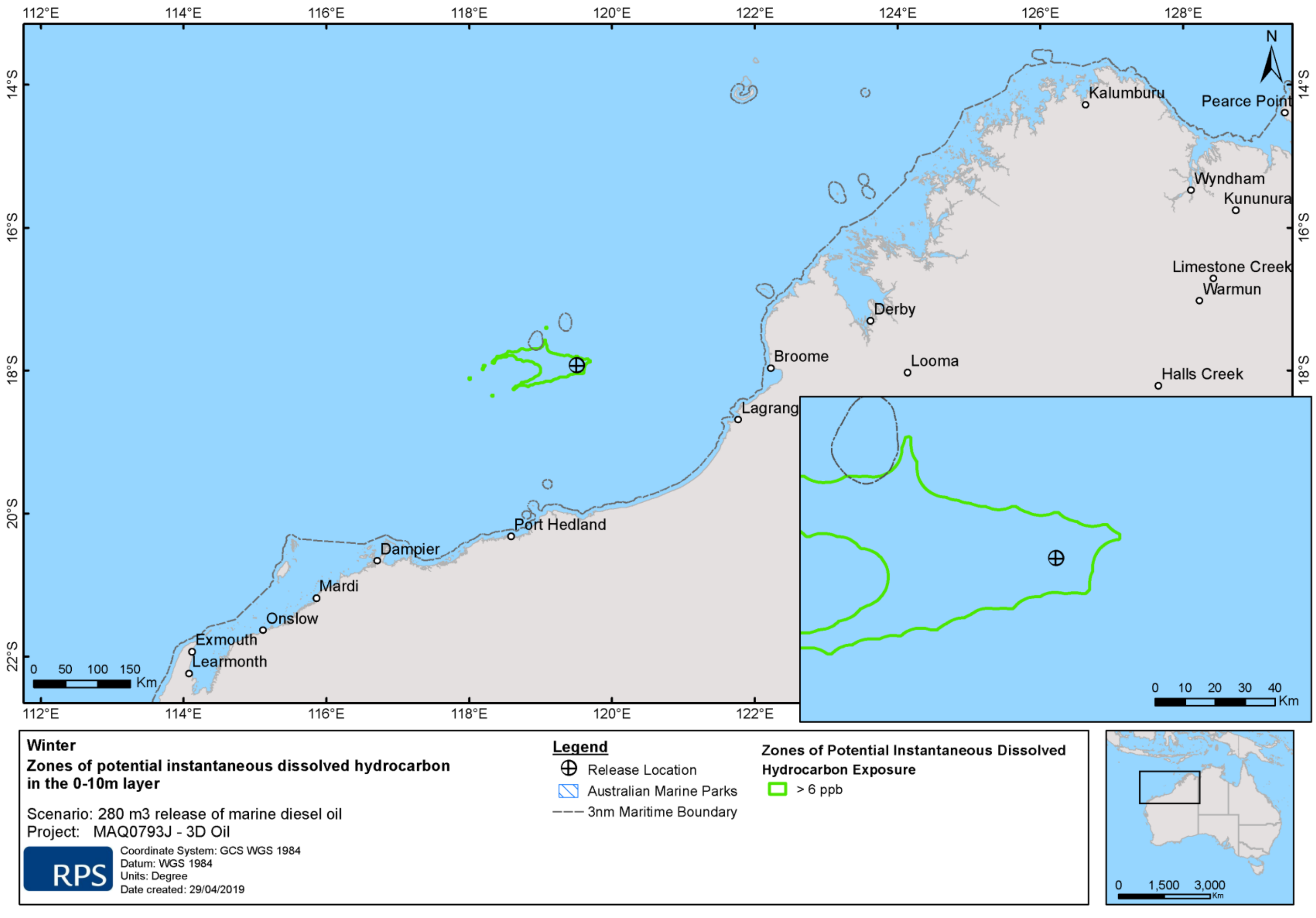

Figure 36 Zones of potential instantaneous dissolved hydrocarbon exposure at 0–10 m below the sea surface in the event of a 280 m^3 of surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during winter wind and current conditions.

8.2.2 Entrained Hydrocarbons

Table 14 summarises the maximum entrained hydrocarbon exposure (time-averaged and instantaneous) to receptors in the 0–10 m depth layer at, or above the exposure thresholds discussed in Section 6.2 over the seasonal assessment.

The maximum time-averaged exposure over 48 hours to entrained hydrocarbons ranged from 4 ppb to 499 ppb for the transitional and winter seasons respectively. The maximum instantaneous exposure to entrained hydrocarbon was 6,287 ppb for the Northwest Shelf IMCRA during the summer. The IMCRA – North West Shelf was the only receptor exposed at the high threshold (1,000 ppb) or above for instantaneous exposure. Several receptors were exposed and the moderate threshold (100 ppb) or above for instantaneous exposure (i.e. AMP – Argo-Rowley Terrace, AMP – Mermaid Reef, MP – Rowley Shoals, KEF – Mermaid Reef and Commonwealth waters surrounding Rowley Shoals, KEF – Ancient coastline at 125 m depth contour and the RSB – Imperieuse Reef) during different seasons as specified in Table 14

The zone of potential time-averaged entrained hydrocarbon exposure is presented in Figure 37 to Figure 39, while Figure 40 to Figure 42 illustrate the zones of potential instantaneous entrained hydrocarbon exposure for each season.

RPS

Table 14 Predicted maximum instantaneous and time-averaged (48 hr) entrained hydrocarbon exposure to receptors in the 0–10 m depth layer. Results are based on a 280 m^3 surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories per season.

Season	Receptor		Maximum time-averaged entrained hydrocarbon exposure (ppb)	Probability of time-averaged entrained hydrocarbon exposure			Maximum instantaneous entrained hydrocarbon exposure (ppb)	Probability of instantaneous entrained hydrocarbon exposure		
				>10 ppb	>100 ppb	>1,000 ppb		>10 ppb	>100 ppb	>1,000 ppb
Summer	SHORE	Imperieuse Reef	27	4	0	0	57	5	0	0
		Cunningham Island	28	3	0	0	61	7	0	0
		Clerke Reef	14	2	0	0	31	6	0	0
		Mermaid Reef	10	0	0	0	30	1	0	0
	IMCRA	Northwest Shelf	402	66	14	0	6,287	89	74	17
	AMP	Argo-Rowley Terrace	114	11	2	0	607	23	8	0
		Kimberley	10	1	0	0	32	4	0	0
		Mermaid Reef	21	2	0	0	66	3	0	0
	MP	Rowley Shoals	49	5	0	0	185	8	2	0
	RSB	Mermaid Reef	20	1	0	0	55	2	0	0
		Imperieuse Reef	33	4	0	0	59	7	0	0
		Clerke Reef	40	2	0	0	158	7	1	0
	KEF	Mermaid Reef and Commonwealth waters surrounding Rowley Shoals	49	5	0	0	213	12	2	0
		Ancient coastline at 125 m depth contour	109	6	1	0	646	11	5	0
Transitional	SHORE	Imperieuse Reef	9	0	0	0	36	6	0	0
		Cunningham Island	27	3	0	0	89	6	0	0
		Clerke Reef	25	6	0	0	81	12	0	0
	IMCRA	Northwest Shelf	499	49	16	0	3,251	79	54	14
	AMP	Argo-Rowley Terrace	89	14	0	0	401	21	6	0
		Kimberley	6	0	0	0	11	2	0	0
		Mermaid Reef	26	5	0	0	76	10	0	0

	MP	Rowley Shoals	30	7	0	0	94	14	0	0
	RSB	Mermaid Reef	8	0	0	0	28	3	0	0
		Imperieuse Reef	26	3	0	0	89	8	0	0
		Clerke Reef	26	6	0	0	84	14	0	0
	KEF	Mermaid Reef and Commonwealth waters surrounding Rowley Shoals	73	9	0	0	177	16	2	0
		Ancient coastline at 125 m depth contour	72	6	0		229	7	2	0
Winter	SHORE	Imperieuse Reef	23	4	0	0	76	7	0	0
		Cunningham Island	23	3	0	0	74	5	0	0
		Clerke Reef	6	0	0	0	18	1	0	0
		Mermaid Reef	4	0	0	0	11	2	0	0
	IMCRA	Northwest Shelf	398	64	21	0	4,355	84	70	29
	AMP	Argo-Rowley Terrace	95	13	0	0	338	17	6	0
		Mermaid Reef	18	1	0	0	100	6	1	0
	MP	Rowley Shoals	57	8	0	0	207	17	2	0
	RSB	Mermaid Reef	8	0	0	0	57	3	0	0
		Imperieuse Reef	42	4	0	0	105	11	1	0
		Clerke Reef	7	0	0	0	27	2	0	0
	KEF	Mermaid Reef and Commonwealth waters surrounding Rowley Shoals	57	13	0	0	261	18	6	0
		Ancient coastline at 125 m depth contour	56	2	0	0	111	4	1	0
		Continental Slope Demersal Fish Communities	11	1	0	0	16	1	0	0

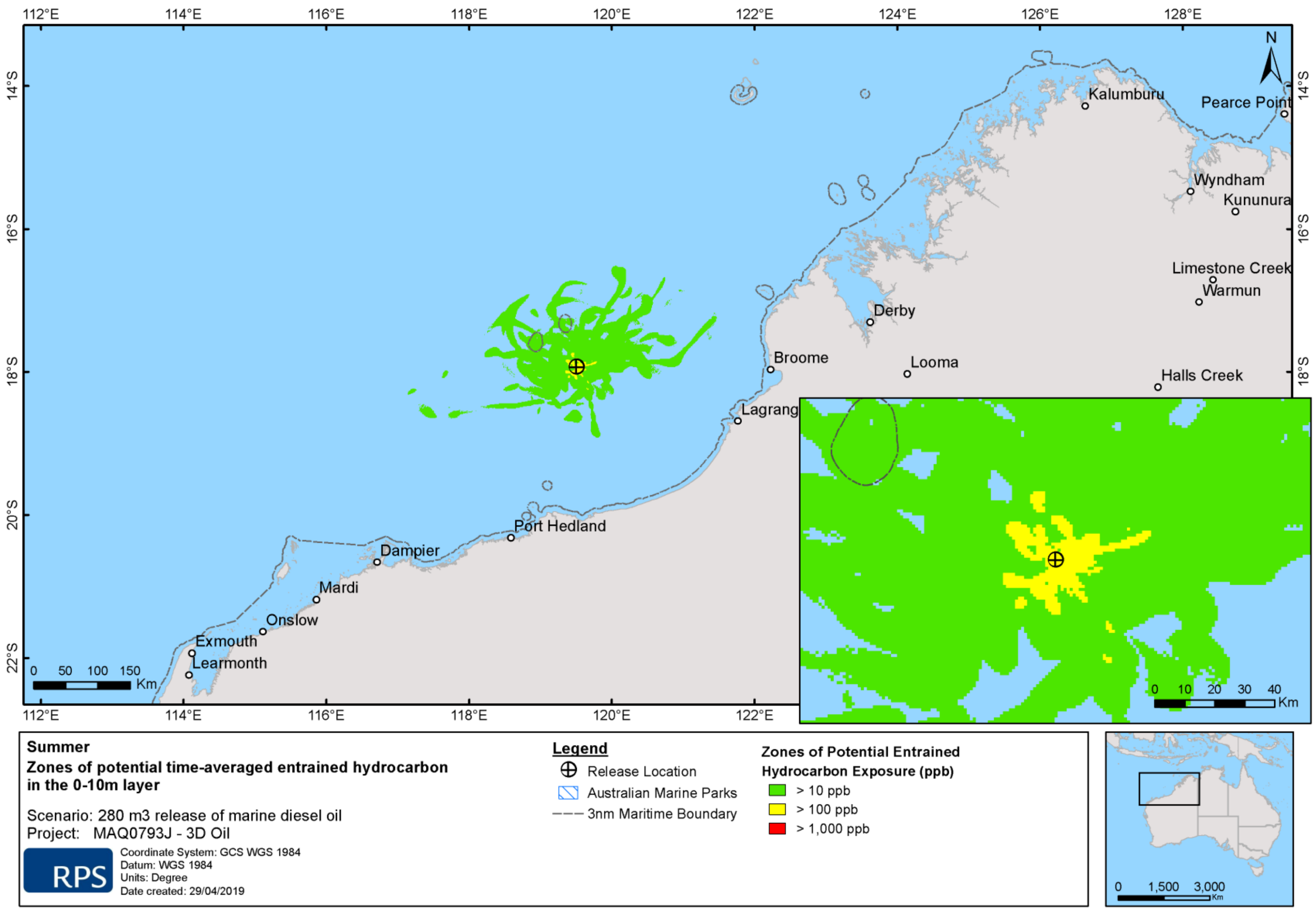

Figure 37 Zone of potential time-averaged entrained hydrocarbon exposure at 0–10 m below the sea surface in the event of a 280 m^3 of surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during summer wind and current conditions.

RPS

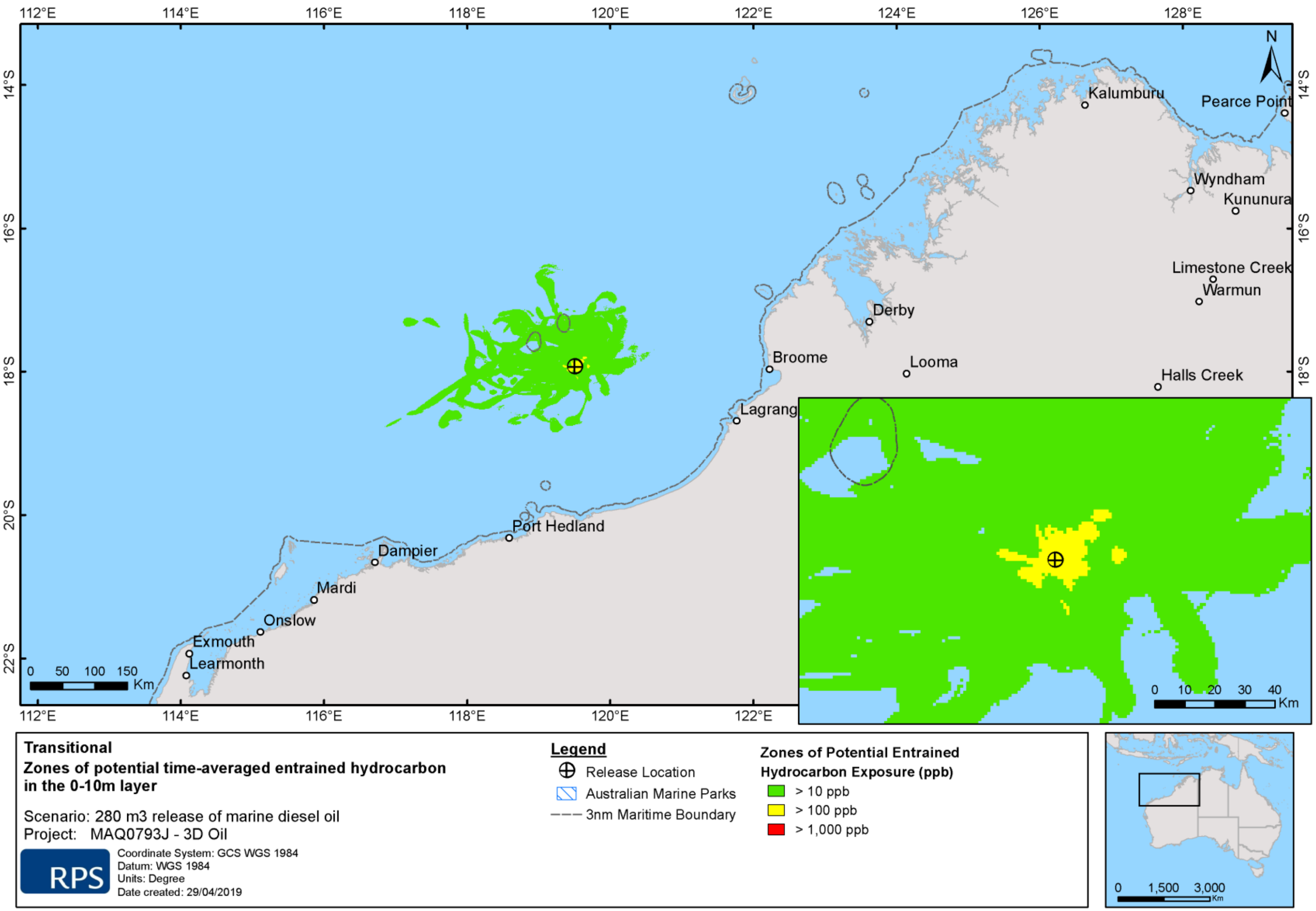

Figure 38 Zone of potential time-averaged entrained hydrocarbon exposure at 0–10 m below the sea surface in the event of a 280 m^3 of surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during transitional period wind and current conditions.

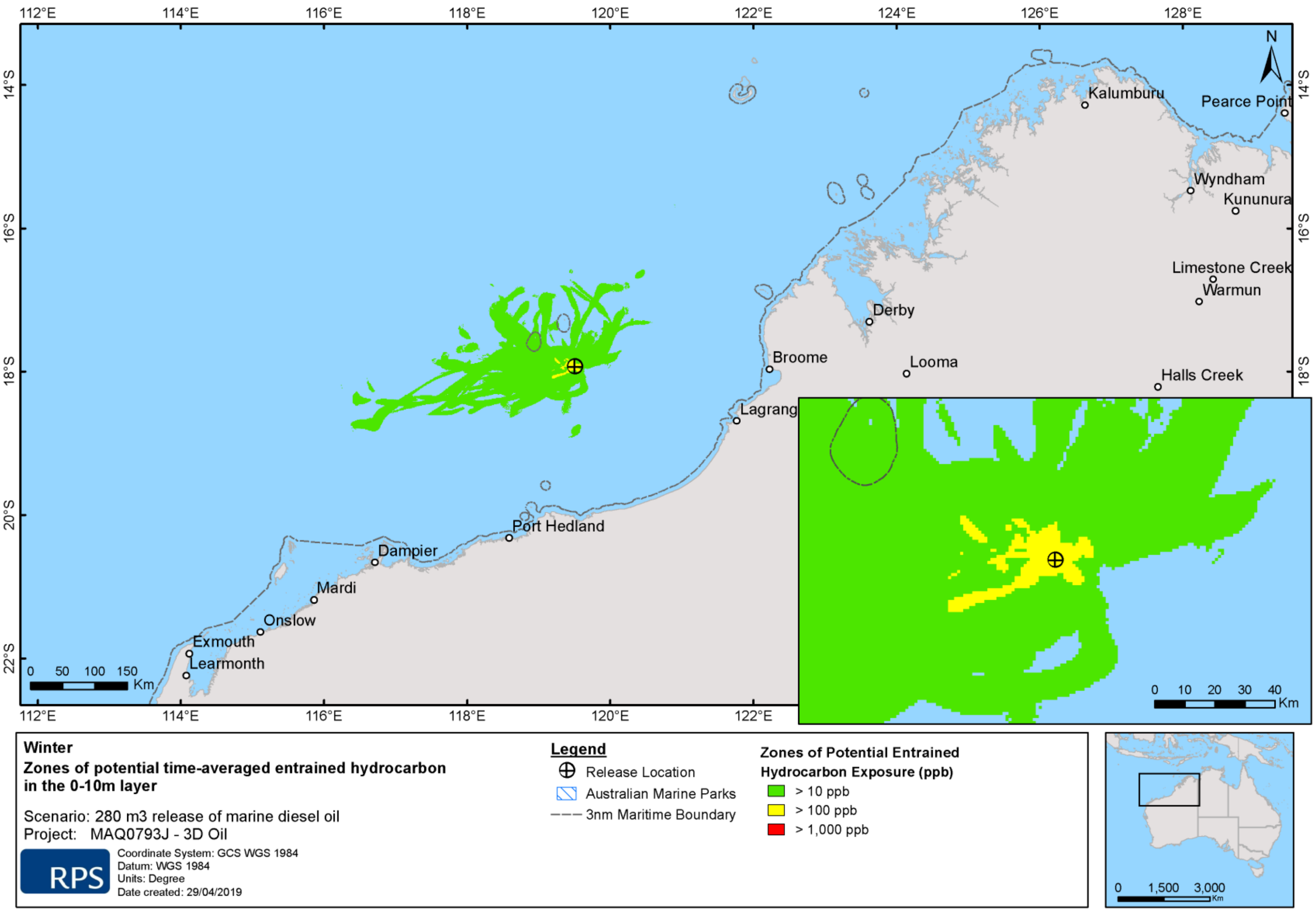

Figure 39 Zone of potential time-averaged entrained hydrocarbon exposure at 0–10 m below the sea surface in the event of a 280 m^3 of surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during winter wind and current conditions.

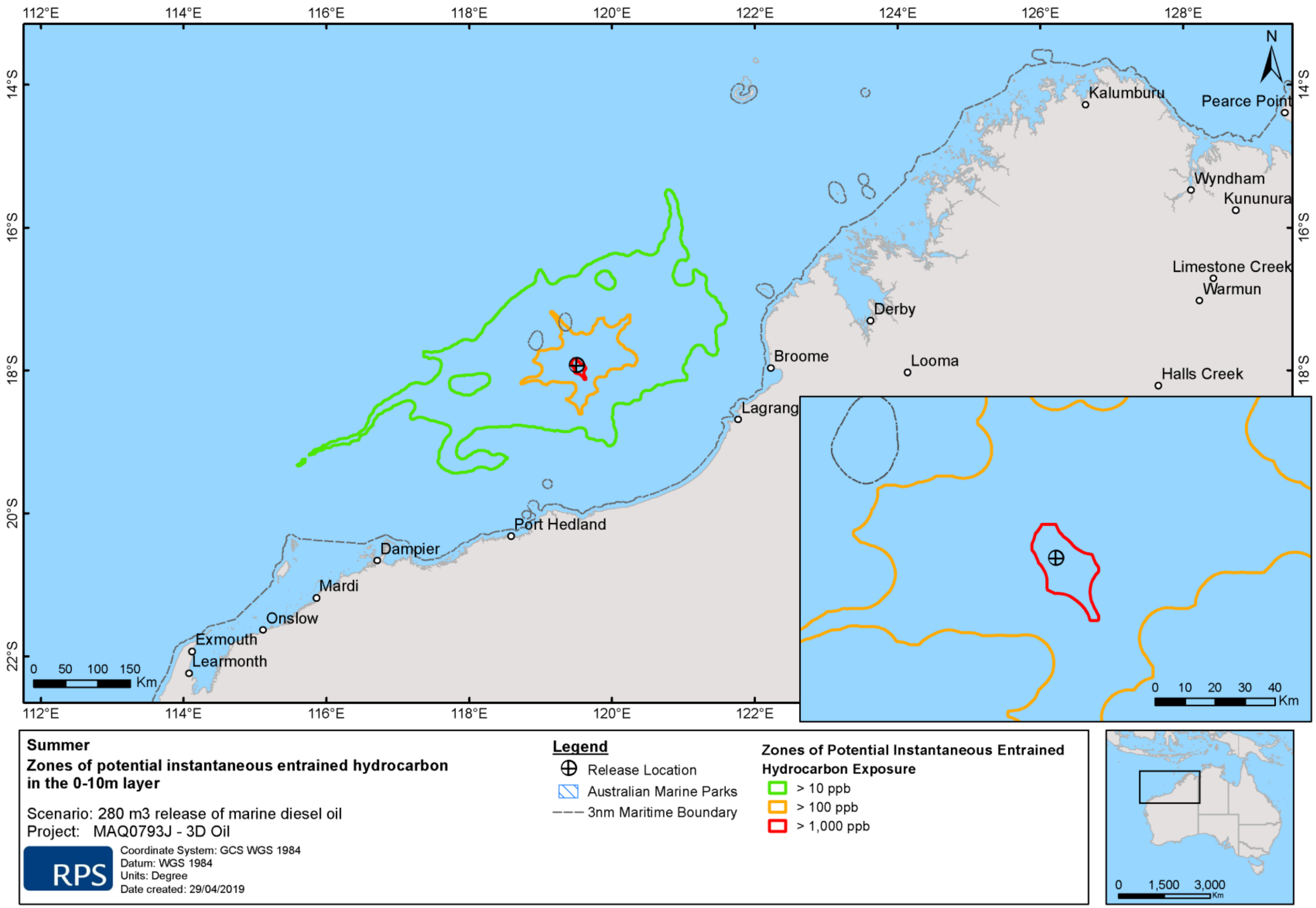

Figure 40 Zone of potential instantaneous entrained hydrocarbon exposure at 0–10 m below the sea surface in the event of a 280 m^3 of surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during summer wind and current conditions.

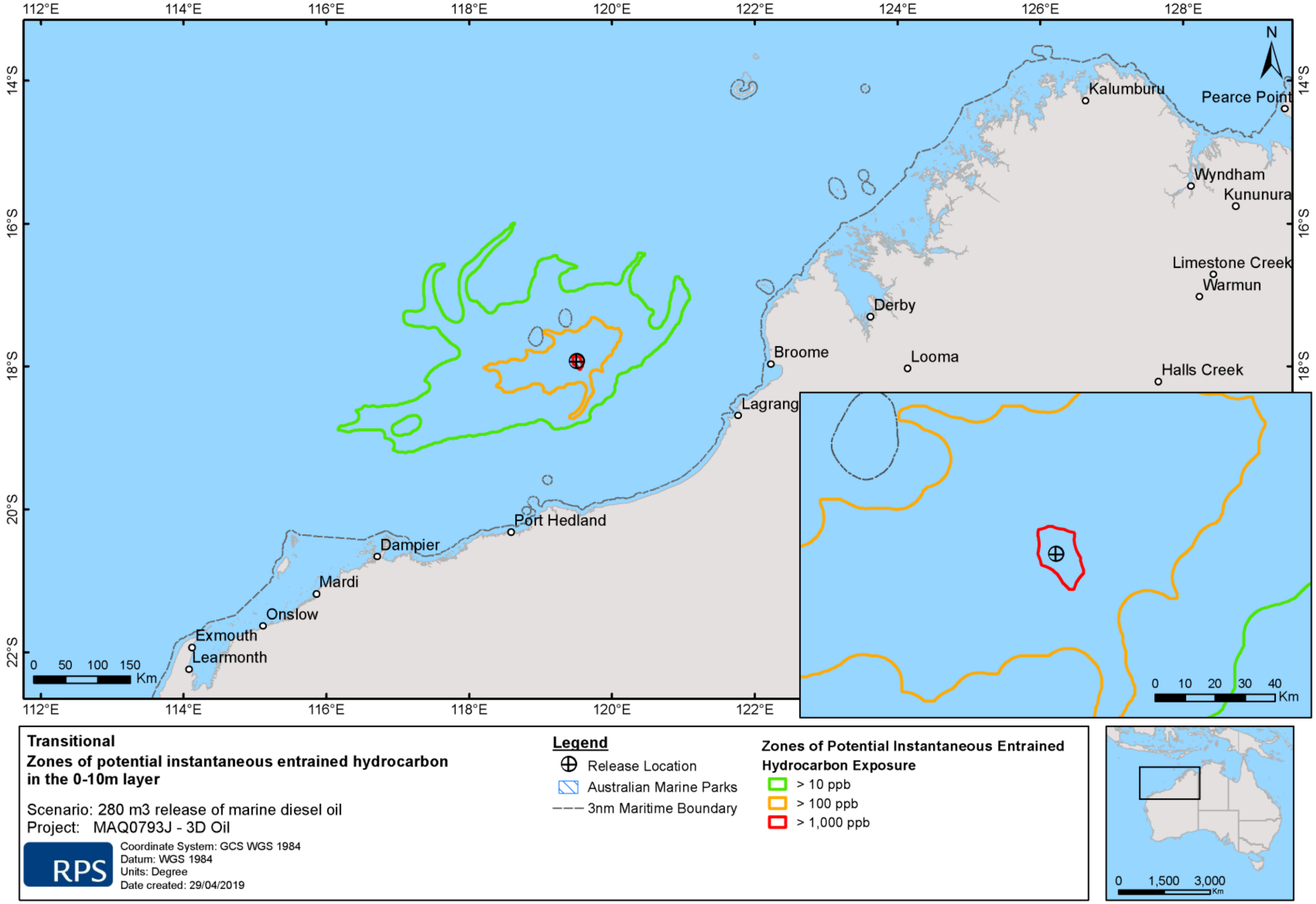

Figure 41 Zone of potential instantaneous entrained hydrocarbon exposure at 0–10 m below the sea surface in the event of a 280 m^3 of surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during transitional period wind and current conditions.

RPS

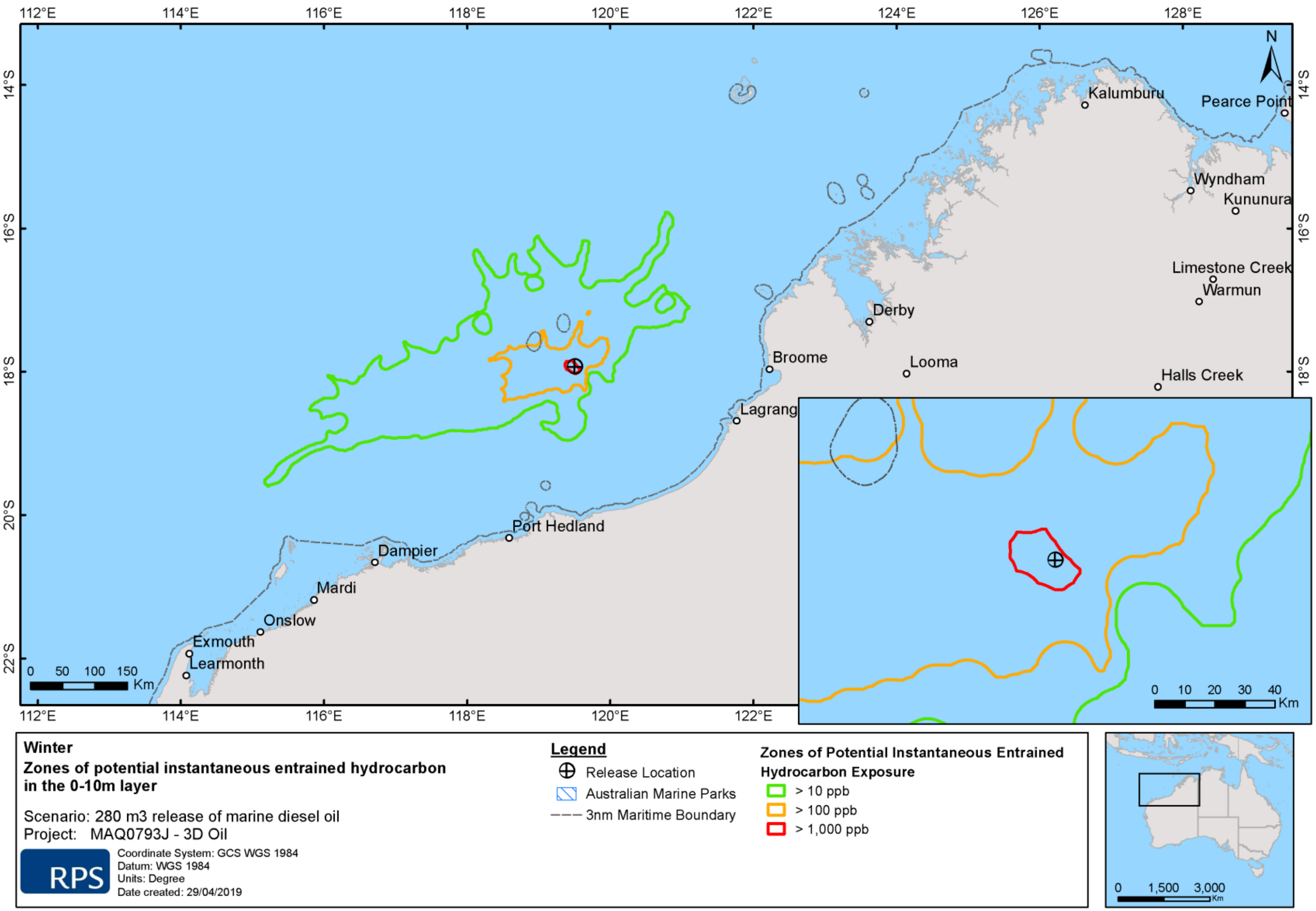

Figure 42 Zone of potential instantaneous entrained hydrocarbon exposure at 0–10 m below the sea surface in the event of a 280 m^3 of surface release of MDO over 6 hours, tracked for 30 days. The results were calculated from 100 spill trajectories simulated during winter wind and current conditions.

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APPENDIX E 3D OIL HSE POLICY

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Health, Safety & Environment Policy

3D Oil Limited is committed to hydrocarbon development which maximizes shareholder value and delivers Health, Safety & Environmental (HSE) outcomes which:

- Minimize environmental and community impacts;
- Maximize resource utilization; and
- Provides a safe and healthy workplace for all 3D Oil personnel.

To achieve these outcomes, 3D Oil will implement and maintain effective management systems which will:

- Systematically identify HSE hazards and where possible, eliminate the hazard or implement controls to manage the risk to as low as reasonably practicable (ALARP);
- Comply with all applicable legislation and apply responsible standards where legislated standards do not exist;
- Implement HSE monitoring programs and measure progress through program HSE targets and objectives;
- Continuously improve HSE outcomes through incident management, inspection, audit and review processes;
- Provide necessary resources, information and training to allow 3D Oil personnel to fulfill their HSE responsibilities;
- Consult openly with all relevant internal and external stakeholders who have an interest in 3D Oil's activities;
- Engage service contract organizations who manage HSE performance in a manner consistent with this policy;
- Develop, maintain and test 3D Oil's ability to respond effectively to emergencies; and
- Foster a corporate culture of respect, open communication and engagement between all personnel to achieve our HSE outcomes.

This policy applies to all 3D Oil personnel, including contractors, engaged on 3D Oil activities.

Primary responsibility for implementation of the HSE Policy lies with 3D Oil's Managing Director and management team.

Delivery of HSE outcomes is both an individual and shared responsibility of all 3D Oil personnel within the workplace.

Noel Newell
Managing Director – 3D Oil
January 2018

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