GEM 3D MARINE SEISMIC SURVEY

Environment Plan

Rev 1.0

18/09/2019

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APPROVAL

ACTION	NAME	POSITION	INITIALS	DATE
Prepared by	RPS	Consultant	RPS	5-Sep-19
Reviewed by	MC	Senior HSE Specialist	MC	5-Sep-19
Endorsed by	JR	Project Manager	JR	5-Sep-19
Approved by	ZZ	Asset / Country Manager	ZZ	5-Sep-19

REVISION / AMENDMENT RECORD

Rev No:	Date:	Prepared	Reviewed	Endorsed	Approved	Remarks
1.0	5-Sep-2019	RPS	Senior HSE Specialist	Project Manager	Asset /Country Manager	Issued to NOPSEMA for public consultation

EP summary

This Gem 3D MSS Environment Plan (EP) summary has been prepared from material provided in this EP. The summary consists of the following as required by OPGGS(E) Regulation 11(4):

EP Summary material requirement	Relevant section of EP containing EP Summary material
Details of the titleholders nominated liaison person for the activity	**Section 1.2**
Location of the activity	**Section 2.2**
Description of the activity	**Section 2.3**
Description of the receiving environment	**Section 4, Appendix F**
Consultation already undertaken and plans for ongoing consultation	**Section 3, Section 8, Appendix B and Appendix C**
Details of the environmental impacts and risks	**Section 6 and Section 7**
Control measures for the activity	**Section 6 and Section 7**
Arrangements for ongoing monitoring of the titleholders environmental performance	**Section 8**
Response arrangements in the oil pollution emergency plan	**Appendix H**

Abbreviations

Acronym/ Abbreviation	Description
3D	**3-dimensional**
AA	**Acquisition Area (see Glossary for details)**
ABARES	**Australian Bureau of Agricultural and Resource Economics and Sciences**
AFMA	**Australian Fisheries Management Authority**
AFZ	**Australian Fishing Zone**
AHO	**Australian Hydrographic Office**
AIMS	**Australian Institute of Marine Science**
AIS	**Automatic Identification System**

ALARP	As Low as Reasonably Practicable
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
APPEA	Australian Petroleum Production & Exploration Association
ARPA	Automatic radar plotting aid
AS/NZS	Australian Standard/ New Zealand Standard
ASA	Active Source Area (see Glossary for details)
AUSCOAST	Australian Coastguard
BIA	Biologically Important Area
BoM	Bureau of Meteorology
Bonn Convention	Convention on the Conservation of Migratory Species of Wild Animals 1979
BRUV	Baited Remote Underwater Video
CoEP	Code of Environmental Practice
COLREGS	Convention on the International Regulations for Preventing Collisions at Sea 1972
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWR	Department of Agriculture and Water Resources
dB	Decibels
DBCA	Department of Biodiversity, Conservation and Attractions
DoEE	Department of the Environment and Energy
DoT	Department of Transport
DPIRD	Department of Primary Industries and Regional Development
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EEZ	Australia's exclusive economic zone
EIA	Environmental Impact Assessment
EP	Environment plan

EPA	Western Australian Environmental Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPO	Environmental Performance Outcome
EPS	Environmental Performance Standard
ERP	Emergency Response Plan
ESD	Ecologically Sustainable Development
Finder	Finder Exploration Pty Ltd
FishCube	Fish Cube WA - Commercial Wild Catch Component Public Cube
FRDC	Fisheries Research and Development Corporation
g	Gram
GAB	Great Australian Bight
Gem 3D MSS	Gem 3D Marine Seismic Survey
GIP	Good Industry Practice
GIS	Global Information System
HF	High frequency
HSE	Health, Environment and Safety
HSE MS	Health, Environment and Safety Management System
Hz	Hertz
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IMO	Introduced Marine Organism
IMS	Invasive marine species
in^3	Cubic inches
IOGP	International Association of Oil and Gas Producers
ISO	International Standards Organization
JASCO	JASCO Applied Sciences
KEF	Key ecological feature

km	Kilometres
kn	Knots
KPI	Key Performance Indicator
LCS	Legislation, Codes and Standards
LF	Low frequency
m	Metre
MARPOL	International Convention for the Prevention of Pollution from Ships
MD	Mid frequency
MEE	Western Australian State Hazard Plan for Maritime Environmental Emergencies
MFO	Marine Fauna Observer
mm	Millimetre
MNES	Matters of National Environmental Significance
MO	Marine Order
MoC	Management of Change
MOD	Maximum-over-depth
MSL	Mean Sea Level
MSS	Marine seismic survey
MUZ	Multiple use zone
NCVA	National Conservation Values Atlas
NDSMF	Northern Demersal Scalefish Managed Fishery
nm	Nautical mile
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NWMR	North West Marine Region
OA	Operations Area (see Glossary for details)
OBC	Ocean bottom cable

OPEP	Oil Pollution Emergency Plan
OPGGS Act	*Offshore Petroleum and Greenhouse Gas Storage Act 2006*
OPGGS(E) Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2019
OPRC	International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990
OPRC-HNS Protocol	Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances, 2000
OSMP	Oceanic Shoals Marine Park
OSMP	Operational and Scientific Monitoring Program
PJ	Professional Judgement
PK	Zero-to-peak pressure levels
PK-PK	Peak-to-peak pressure levels
PMI	Potential mortal injury
PMST	Protected Matters Search Tool
ppt	Parts per thousand
PTS	Permanent threshold shift
Rms	Root mean squared
ROV	Remotely Operated Vehicle
RPS	RPS Australia West Pty Ltd
SapuraOMV	SapuraOMV Upstream (Western Australia) Pty Ltd
SBT	Southern Bluefin Tuna
Searcher	Searcher Seismic Pty Ltd
SEL	Sound exposure level
SOPEP	Shipboard Oil Pollution Emergency Plan
SPL	Sound pressure level
t	Tonnes
The National Plan	The National Plan for Maritime Environmental Emergencies 2019

TTS	**Temporary threshold shift**
WCDSCF	**West Coast Deep-sea Crustacean Managed Fishery**
WD	**Water depth**

Glossary

Term	Explanation
Acceptable level	**The level of impact or risk to the environment that may be considered broadly acceptable with regard to all relevant considerations listed in Section 5.5.3.1 and compliant with the guidance presented in Environment Plan Content Requirements (NOPSEMA, 2019)**
Acquisition Area	**Area within which the seismic source (airguns) will be operational and seismic data will be acquired**
Active Source Area	**Area in which the airguns are operational at up to full power, including run-outs from the Acquisition Area and run-ins from the Operations Area (required to obtain full fold coverage).**
As Low as Reasonably Practicable	**Reducing impacts and risks based on the concept of reasonable practicability; the weighing up of the magnitude of impact or risk reduction against the cost of that reduction. In this context, a titleholder is required to implement all available control measures where the cost is not grossly disproportionate to the environmental benefit gained from implementing the control measure.**
As Low as Reasonably Practicable assessment	**Process by which SapuraOMV demonstrates, through reasoned and supported arguments, that there are no other practical measures that could reasonably be taken to reduce risks further.**
Consequence	**The outcome of an event. The consequence considers extent, duration, severity and certainty of what would happen should prevention control measures fail.**
Control measure	**A system, an item of equipment, a person or a procedure, that is used as a basis for managing environmental impacts and risks. Control measures maintain and/or modify risk.**
Cost	**The sacrifice required for implementing a control measure, which includes an impost such as the money, time, and/or trouble required to implement a particular control measure. Environmental cost may also be a cost in some circumstances (e.g. dispersant use on an oil spill).**

Environmental aspect	**Element of an organisation's activities or products or services that interacts or can interact with the environment.**
Environmental impact	**Any change to the environment, whether adverse or beneficial, that wholly or partially results from an activity of a titleholder.**
Environmental performance outcome	**An environmental performance outcome is the measurable level of performance required for the management of an environmental aspect of an activity to ensure that environmental impacts and risks will be of an acceptable level.**
Environmental performance standard	**An environmental performance standard is a statement of the performance required of a control measure**
Environmental risk	**Risk is a deviation (positive or negative) from what is expected and reflects the uncertainty associated with unexpected events. A combination of the consequences of an event occurring and the likelihood of its occurrence. Environmental risks result from unplanned events that may occur as a result of the activity.**
Event	**The occurrence or change of a particular set of circumstances. Events can have one or more consequences and causes, can be expected or unexpected, and can be a risk source.**
Indicator Species	**Fisheries management term – term used to describe select fish species that are used to assess the risk to sustainability of all 'like' species susceptible to capture within a fishery resource (Newman et al 2018)**
Likelihood	**The chance that an event or consequence may happen i.e. "likelihood". Both terms have been adopted for this EP. The likelihood may be determined via quantitative means (where data is available), or via qualitative means based on oil and gas industry performance.**
Measurement criteria	**Measurement criteria define how environmental performance will be measured and are used to determine whether the environmental performance outcomes have been met during the activity.**
Operations Area	**Area inclusive of a buffer around the Active Source Area that encompasses activities including streamer deployment and retrieval, maintenance and recovery, and vessel manoeuvring (line turns). Some individual airgun array element testing may occur within the Operations Area during the course of corrective or preventative equipment maintenance.**
Perth Treaty 1997	**Treaty between the Government of Australia and the Government of the Republic of Indonesia establishing an Exclusive Economic Zone Boundary and Certain Seabed Boundaries (signed in Perth, 14 March 1997). This treaty**

	modifies Australia's EEZ in northern waters, including where it crosses the Operational Area. Although not yet in force Australia acts consistently with the treaty arrangements (AFMA Multiple Fishery (Closures) Direction No. 1 2014)
Planning Area	**Area inclusive of a 150 km buffer around the Operations Area encompassing the environment that may be affected by unplanned events associated with planned activities described in this environment plan.**
Predicted impact	**The level of environmental impact associated with planned activities, with control measures implemented.**
Probability	**Probability is a measure of the likelihood that an event will occur and is represented as a number between 0 and 1.**
Residual risk	**The level of environmental risk associated with unplanned events after risk treatment (with control measures implemented).**
Support vessel	**Vessel to remain on standby to direct shipping traffic away from the survey vessel during acquisition activities, scout the area ahead for hazards and support in the event of an emergency.**
Survey vessel	**Vessel undertaking MSS activities under this EP for acquiring survey data.**
The Activity	**Regulation 4 of OPGGS(E) Regulations 2019: Petroleum Activity means any operations or works in an offshore area carried out for the purpose of: a) exercising a right conferred on a petroleum titleholder under the Act by a petroleum title; or b) discharging an obligation imposed on a petroleum titleholder by the Act or a legislative instrument under the Act.**

1 Introduction

1.1 Background

SapuraOMV Upstream (Western Australia) Pty Ltd (SapuraOMV) is titleholder for exploration permit AC/P61 and is subject to permit obligations to explore the hydrocarbon prospectivity of the permit area. Consistent with these obligations, SapuraOMV proposes to undertake a relatively small scale (~410 km^2) 3-dimensional (3D) marine seismic survey (MSS) over the permit and adjacent areas in the Timor Sea, referred to as the Gem 3D MSS.

The activity location lies entirely within Commonwealth waters approximately 250 km offshore of mainland Australia and 650 km from Darwin, with all seismic acquisition occurring outside the area where Australian commercial fishers are permitted to operate (ie beyond the Perth Treaty line). The Gem 3D MSS is scheduled to take place between late Q4 2019 and Q3 2020 and to be completed within 27 days.

1.2 Titleholder

SapuraOMV is a wholly owned subsidiary of SapuraOMV Upstream Sdn. Bhd; a strategic partnership between Sapura Energy Berhad and OMV AG. SapuraOMV is a leading independent oil and gas company with assets in Malaysia and exploration interests in Australia, New Zealand and Mexico.

In 2018, SapuraOMV farmed-in to exploration permit AC/P 61 that was previously held by Finder Exploration Pty Ltd (Finder). SapuraOMV is the registered titleholder of AC/P61 and the operator and owner of this environment plan (EP).

SapuraOMV aims to achieve operational excellence, whilst maintaining the highest levels of environmental and safety compliance standards (e.g. the SapuraOMV Health, Safety and Environmental Policy, see Section 8). SapuraOMV has therefore contracted Searcher Seismic Pty Ltd (Searcher) to assist in the planning, preparation and execution of the seismic survey activity based on Searcher's considerable experience in conducting marine seismic surveys offshore Australia in recent years.

Titleholder	**SapuraOMV Upstream (Western Australia) Pty** **Ltd ABN: 37 629 043 518**
Titleholder Business address	**SapuraOMV Upstream (Western Australia) Pty Ltd** **Level 2, 251 St Georges Terrace** **Perth, WA 6000**
Titleholder Contact	**+61(8) 6118 4990** **Email: gem.australia@sapura-omv.com**
Liaison person	**Paul Miller** **Operations Manager, Searcher Seismic Pty Ltd.**
Liaison person address	**Searcher Seismic Pty Ltd** **Level 1/15 Rheola Street, West Perth, WA 6005**
Liaison person contact	**+61 8 9327 0300** **p.miller@searcherseismic.com**

SapuraOMV will notify the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) in writing in the event of a change of titleholder or nominated liaison person.

1.3 Purpose

The purpose of this EP is to identify the impacts on, and risks to, the receiving environment as a consequence of the Gem 3D MSS (the activity) and to manage impacts and risks to as low as reasonably practicable (ALARP) and acceptable levels. The plan sets out control measures adopted to reduce the identified environmental impacts and risks of the activity and describes how and to what standard of performance those measures will be implemented throughout the life of the activity, including in emergency situations.

In accordance with Regulation 25A of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2019 (OPGGS(E) Regulations), the operation of this EP ends when:

- SapuraOMV notifies NOPSEMA that the activity to which the EP relates has ended,
- SapuraOMV notifies NOPSEMA that all the obligations under the EP have been completed, and
- NOPSEMA accepts the notification.

1.4 Legislative framework

The Gem 3D MSS is located within the Commonwealth Petroleum Jurisdiction Boundary and therefore regulated under Commonwealth legislation; primarily under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) and associated regulations. In accordance with Regulation 13(4) of the OPGGS(E) Regulations, this section describes the Commonwealth legislation, international agreements and other relevant guidelines and codes of practice to the Gem 3D MSS. In the unlikely event of an unplanned hydrocarbon release that migrates into Western Australian (WA) state waters, WA legislation will be triggered. Applicable Commonwealth and state legislation are listed in Appendix A.

1.4.1 Commonwealth legislation

A brief overview of the main Commonwealth legislation and regulations applicable to this EP is outlined below. Appendix A presents a list of Commonwealth legislation relevant to the environmental management of this project.

- *Offshore Petroleum and Greenhouse Gas Storage Act 2006*

The OPGGS Act and the associated OPGGS(E) Regulations specify the requirements to manage the environmental impacts of petroleum activities. The Regulations require that an EP must be accepted by the regulatory authority (NOPSEMA) prior to commencing the proposed activity. NOPSEMA guidelines outline the requirements for the content of EPs.

- *Environment Protection and Biodiversity Conservation Act 1999*

Under Commonwealth government streamlining arrangements, NOPSEMA's assessment of this EP provides an appropriate level of consideration of the impacts to matters of national environmental significance (MNES) protected under Part 3 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This obviates the requirement to refer the project to the Department of the Environment and Energy (DoEE).

- Ecologically Sustainable Development (ESD)

Australia has developed a National Strategy for Ecologically Sustainable Development (ESD), identifying four principles and ways to apply them to a range of industry sectors and issues such as climate change, biodiversity conservation, urban development, employment, and economic activity, diversity and resilience. OPGGS(E) Regulation 3 states that any petroleum activity carried out in an offshore area is carried out in a manner consistent with the principles of ecologically sustainable development as set out in section 3A of the EPBC Act. These are listed below:

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; and e.	Improved valuation, pricing and incentive mechanisms should be promoted.

SapuraOMV has incorporated the principles of ESD into the decision-making framework described in Section 5 and in the development of control measures and environmental performance outcomes proposed in Section 6 and 7. SapuraOMV believes that the commitments made within this EP demonstrate that the environmental management of the activity will be conducted in accordance with the principles of ESD.

1.4.2 International agreements

The Gem 3D MSS overlies the Perth Treaty Area, the 1997 agreement between the Government of Australia and the Government of the Republic of Indonesia establishing an Exclusive Economic Zone (EEZ) boundary and certain seabed boundaries. In effect this gives the Republic of Indonesia rights over the water column and Australia rights under the seabed. The Perth Treaty has not been ratified, however some aspects of management follow direction from the Perth Treaty including the areas of Commonwealth and state commercial fisheries (see Section 4.5.1).

Australia is signatory to several other international environmental protection agreements and conventions which are relevant to the region, including for the protection of wetlands and environmental values. Australia is also a signatory to several international conventions of potential relevance to the activity, including:

- Memorandum of Understanding between the Government of Australia and the Government of the Republic of Indonesia Regarding the Operations of Indonesian Tractional Fishermen in the Areas of the Australian Exclusive Fishing Zone and Continental Shelf 1974,
- Convention on the Conservation of Migratory Species of Wild Animals 1979 (Bonn Convention),
- International Convention on Oil Pollution Preparedness, Response and Co-operation 1990,
- Protocol to International Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter 1996,
- International Convention for the Prevention of Pollution from Ships (MARPOL),
- United Nations Convention on the Law of the Sea 1982.

1.5 Environmental policies, guidelines and codes of practice

1.5.1 Guidelines, policies, standards and Codes of Practice

The following guidelines, policies, standards and codes of practices have been referred to in the preparation of this EP.

Table 1-1: Guidelines, policies, standards and codes of practice

Organisation	Document
Australian Maritime Safety Authority	• **National Plan technical guidelines for preparing contingency plans for marine and coastal facilities 2015** • **National Plan for Maritime Environmental Emergencies 2019**
Australian Petroleum Production & Exploration Association (APPEA)	**SapuraOMV is a full member of APPEA and abides by the APPEA “Principles of Conduct” as set out in their Code of Environmental Practice (CoEP) (2008). These principles provide guidance for activities that are not formally regulated and have evolved from the collective knowledge and experience of the oil and gas industry, both nationally and internationally. The APPEA “Principles of Conduct” covers general environmental objectives for the industry, including planning and design, assessment of environmental risks,**

	emergency response planning, training and inductions, auditing and consultation and communication. For the offshore sector specifically, it covers issues relating to geophysical surveys, drilling and development and production. SapuraOMV applies the APPEA "Principles of Conduct" when planning and managing offshore petroleum exploration activities and are referenced throughout Sections 6 and 7.
Commonwealth of Australia	• National biofouling management guidelines for the petroleum production and exploration industry, 2009 • Interaction between offshore seismic exploration and whales, 2008 • EBPC Act Significant Impact Guidelines 1.1 – Matters of National Environmental Significance, 2013
Department of Agriculture and Water Resources	• Australian Ballast Water Management Requirements Ver. 7, 2017
Department of the Environment and Energy	• National Strategy for Ecologically Sustainable Development 1992 • EBPC Act Policy statement 2.1 – Interaction between offshore seismic exploration and whales, 2008
International Association of Geophysical Contractors (IAGC)	• IAGC Environment Manual for Worldwide Geophysical Operations, 2013
International Association of Oil and Gas Producers (IOGP)	• Environmental Management in Oil and Gas Exploration and Production – IOGP Report 254, 1997
International Standards Organization (ISO)	• 31000:2018 Risk Management – Principles and Guidelines
US National Oceanic and Atmospheric Administration	• Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0), 2008
NOPSEMA	Policies • PL0050 – Assessment – Rev 14 – January 2018 • PL1347 – Environment plan assessment – Rev 7 – April 2019 Guidance notes • GN1343 – Petroleum activity – Rev 2 – April 2016 • GN1344 – Environment plan content requirements – Rev 4 – April 2019

	• GN0166 – ALARP – Rev 6 – June 2015 (this guidance note has been prepared for safety cases but is included here as it provides valuable information for demonstrating As Low As Reasonably Practicable for EPs) • GN1488 – Oil Pollution Risk Management – Rev 2 – February 2018 • GN1735 – Petroleum Activities and Australian Marine Parks – Rev 0 – July 2018 • GN0926 – Notification and reporting of environmental incidents – Rev 4 – February 2014 Guidelines • GL1721 – Environment plan decision making – Rev 5 – June 2018 • GL1566 – Environment plan summaries – Rev 2 – April 2019 • GL1691 – End of the operation of an environment plan – Regulation 25A – Rev 1 – October 2016 • GL1705 – When to submit a proposed revision of an environment plan – Rev 1 – January 2017 • GL1381 – Financial Assurance for Petroleum Titles – Rev 6 – September 2017 • Information papers • IP1349 – Operational and scientific monitoring programs – Rev 2 – March 2016 • IP1411 – Consultation requirements under the OPGGS Environment Regulations 2019 – Rev 2 –December 2014
Standards Australia/ Standards New Zealand	• Handbook on Environmental Risk Management – Principles and Process. Third edition. (HB 203:2006)

1.6 Environmental emergencies

A brief description of the National Plan and Western Australian oil spill response plan is provided below, with details in the Oil Pollution Emergency Plan (OPEP, Appendix H).

1.6.1 National Plan

The National Plan for Maritime Environmental Emergencies 2019 (the National Plan) is managed by the Australian Maritime Safety Authority (AMSA) and sets out national arrangements, policies and principles for the management of maritime environmental emergencies. It gives administrative effect to Australia's emergency response obligations relating to the:

- International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990 (OPRC),
- Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances, 2000 (OPRC-HNS Protocol),
- International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969
- Articles 198 and 221 of the United Nations Convention on the Law of the Sea, 1982.

1.6.2 Western Australian State Emergency Management Plan

The Western Australian State Emergency Plan is managed by the State Emergency Management Committee and provides for the State Hazard Plan for Maritime Environmental Emergencies (MEE).

This plan provides arrangements for managing marine oil pollutions and marine transport emergencies. It contains information on the prevention, preparedness, response and recovery of maritime hazards.

1.7 Demonstration of financial assurance

Under Regulation 5G of the OPGGS(E) Regulations, NOPSEMA must be reasonably satisfied that SapuraOMV is compliant with Section 571(2) of the OPGGS Act and that the compliance is in a form acceptable to NOPSEMA. SapuraOMV will submit a financial assurance declaration (as described in the Financial assurance for petroleum titles guideline Rev 6, 2017) to NOPSEMA. SapuraOMV will review the level of financial assurance in the event of changes in the survey plan or circumstances that affect the insurance risk profile.

SapuraOMV has applied for Access Authorities that may be required for the survey from all relevant permit area titleholders. SapuraOMV will notify NOPSEMA as soon as practicable upon the authorities being granted and provide documentation demonstrating that the appropriate level of financial assurance is in place for these titles. The forms of financial assurance will be kept on record by SapuraOMV throughout the duration of the activity and will be available to NOPSEMA should this be requested.

2 Activity description

The following section contains a description of the proposed activity, including the location, timing, and outline of operational details of the activity, details of vessels to be used, and additional information relevant to consideration of environmental impacts and risks of the activity.

2.1 Activity definition

SapuraOMV is operator of petroleum exploration permit AC/P61 and is intending to conduct a 3-dimensional (3D) marine seismic survey (Gem 3D MSS) over an area of approximately 410 km^2 within the permit area as well as in operated and vacant acreage immediately adjacent to the permit area. SapuraOMV will acquire Access Authorities where appropriate.

The Gem 3D MSS will be conducted within the Operations Area (OA), as described in Section 2.2.3. When vessels are outside the OA (e.g. transiting to or from location or holding position outside the OA) and remain within Australian waters, they come under the regulatory jurisdiction of AMSA and the *Navigation Act 2012*. Accordingly, this EP and associated OPEP does not cover activities performed by the vessels while outside the OA. The EP does cover oil spill response activities outside the OA. At all times, helicopter operations (if they occur due to an unplanned event) come under the regulatory jurisdiction of the Civil Aviation Safety Authority, Civil Aviation Safety Regulations 1998 and the Federal Aviation Regulations.

2.2 Location

Petroleum exploration permit AC/P61 is located in the Vulcan Sub-basin, western Bonaparte Basin in the Timor Sea, approximately 250 km offshore of mainland Australia and 650 km from Darwin (Figure 2-1).

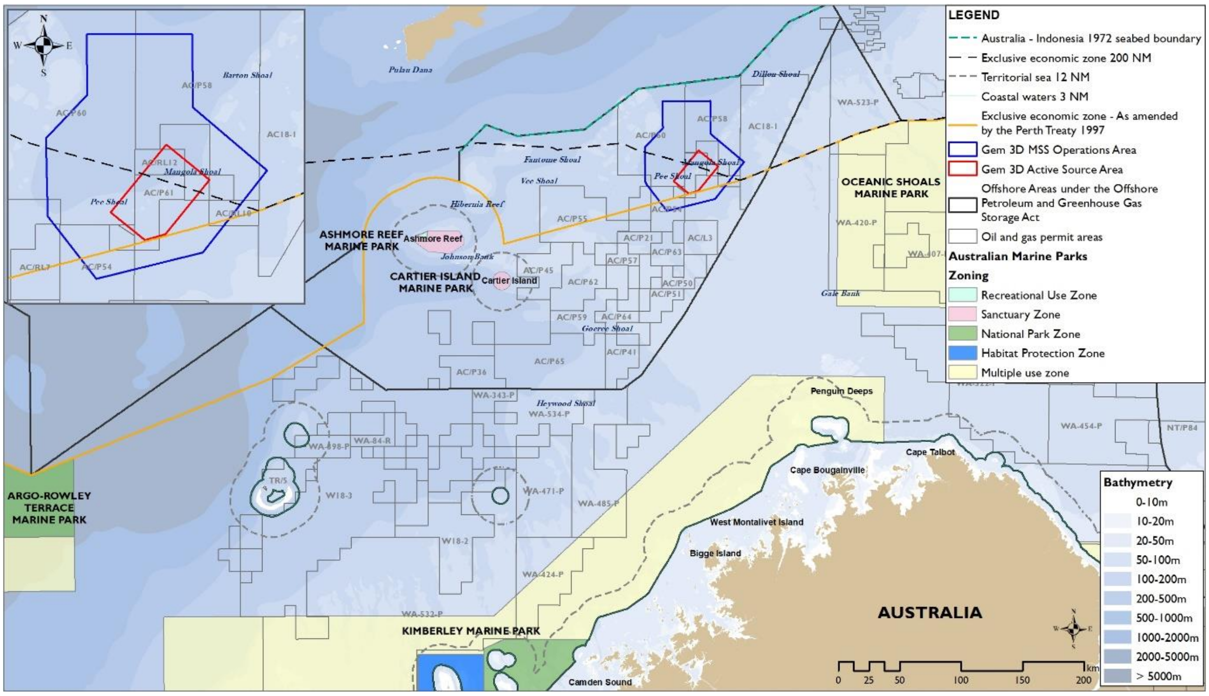


Figure 2-1: Location of the Gem 3D Marine Seismic Survey Area

2.2.1 Acquisition Area

The Gem 3D MSS Acquisition Area (AA) is approximately 410 km^2 and is the focus area in which SapuraOMV needs to better image the subsurface geology to assess the hydrocarbons potential (Figure 2-2). This is the area within which the seismic source (airguns) will be operational and seismic data will be acquired. This area lies within the Perth Treaty 1997 area, which delineates the rights of activities between Indonesia and Australia (see Section 1.4.2).

Table 2-1: Gem 3D MSS Acquisition Area Coordinates (WGS84)

1	125°00'13.9341"E	11°36"04.2271"S
2	**125°08'06.8945"E**	**11°42'18.5073"S**
3	**125°02'03.9806"E**	**11°49'38.8093"S**
4	**124°58'23.9037"E**	**11°50'39.6336"S**
5	**124°52'17.0146"E**	**11°45'.49.1966"S**

2.2.2 Active Source Area

The Gem 3D MSS Active Source Area (ASA) of 647 km^2 is the area within which the seismic energy source (airguns) will be operational for soft start procedures and line runouts (required to obtain full fold coverage) (Figure 2-2). The full seismic source will not be operational outside of the ASA, although small, individual source elements may be tested during maintenance outside the ASA but within the OA.

Table 2-2: Gem 3D MSS Active Source Area Coordinates (WGS84)

1	124°57'08.0910"E	11°52'53.1956"S
2	**124°50'12.5733"E**	**11°47'25.3640"S**

3	**125°01’18.1336”E**	**11°33’52.9273”S**
4	**125°10’07.6716”E**	**11°40’49.4563”S**
5	**125°01’17.4716”E**	**11°51’44.2500”S**

2.2.3 Operations Area

The Gem 3D MSS OA of 4,760 km^2 is inclusive of a buffer around the ASA that encompasses activities including streamer deployment and retrieval, maintenance, recovery, and vessel manoeuvring (line turns) (Figure 2-2) Some individual airgun array element testing may occur within the OA during corrective or preventative equipment maintenance.

Table 2-3: Gem 3D MSS Operations Area Coordinates (WGS84)

1	124°45’05.9122”E	11°12'11.6905"S
2	**125°06'22.5826"E**	**11°11'59.1330"S**
3	**125°06'42.0619"E**	**11°26'29.6840"S**
4	**125°21'41.7489"E**	**11°38'51.9609"S**
5	**125°08’51.1347”E**	**11°55’15.6800”S**
6	**124°47’23.0735”E**	**12°00’42.2586”S**
7	**124°37’32.9137”E**	**11°48’19.2927”S**
8	**124°37’03.4598”E**	**11°32’51.0799”S**
9	**124°45’20.8084”E**	**11°24’05.4636”S**

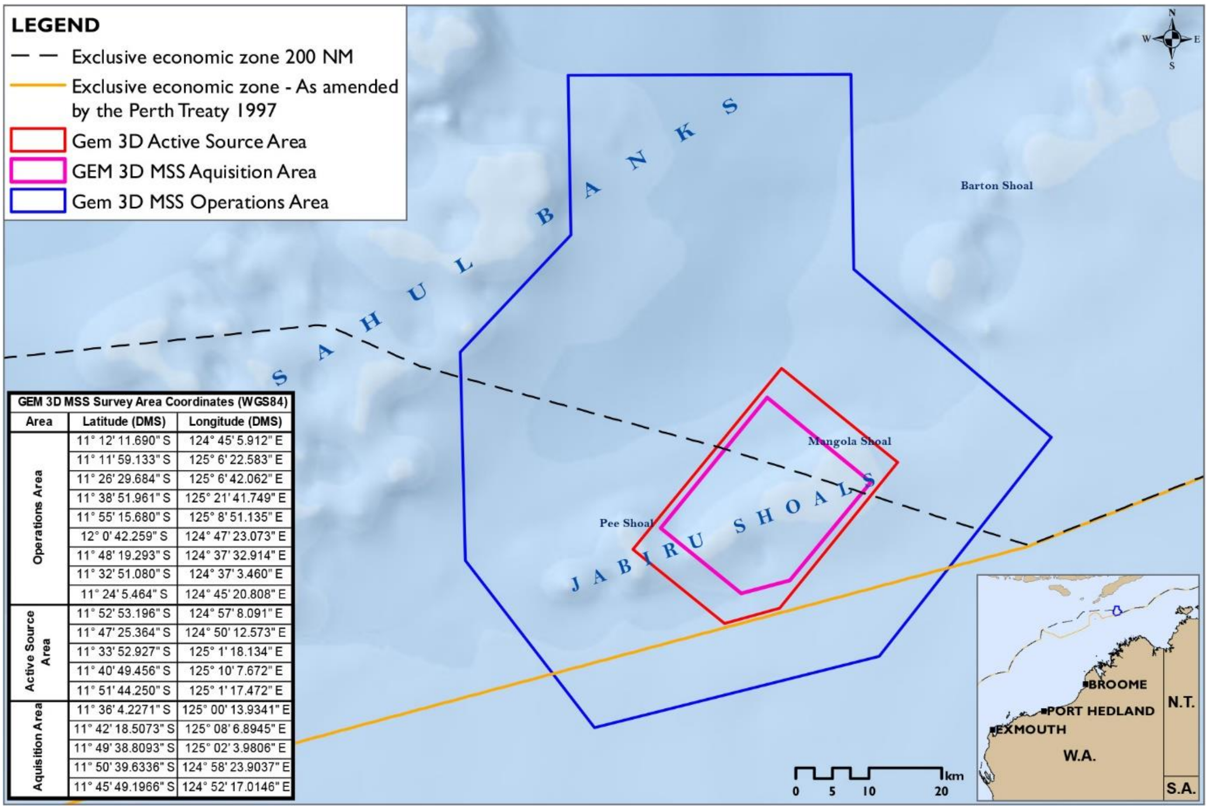


Figure 2-2: Gem 3D MSS survey showing the Acquisition, Active Source and Operations Areas

2.3 Activity overview

The Gem 3D MSS will be undertaken by specialist seismic company Polarcus using a state of the art purpose built seismic survey vessel to acquire 3D seismic data assisted by one support (and possibly one chase) vessel to direct shipping traffic away from the survey vessel during acquisition activities, scout the area ahead for hazards and provide support in the event of an emergency.

The survey vessel will tow an energy source at 5 – 6 metres below the sea surface and a streamer array of up to ten individual streamers, each up to 10 kilometres in length and towed at 9 – 15 metres below the sea surface (water depth dependant).

The survey vessel will tow the seismic array along predefined survey lines in a racetrack pattern within the AA until the full survey area has been covered. Full energy source array activity in the ASA will average less than 3 hours, before silence periods of a similar duration during line turns, prior to commencement of subsequent lines. Occasional reacquisition or “infill” survey lines will be recorded until the AA has been adequately covered to meet the subsurface imaging requirements. The specific survey parameters are listed in Table 2-4.

Table 2-4: Gem 3D MSS survey parameters

Parameter	Gem 3D MSS
Exploration permit AC/P61 area	**335 km^2**
Acquisition Area	**410 km^2**
Active Source Area	**647 km^2**
Operations Area	**4,760 km^2**

Survey timeframe	**December 2019 to Q3 2020**
Survey duration	**≤27 days including downtime**
Airgun array volume (maximum)	**≤2820 cubic inch (2380 cubic inch expected)**
Sound source power output	**Peak to Peak 99.3 bar-m (max)**
Sound source pressure	**2000 psi**
Sound source depth	**5 – 6 m**
Sound source shot point interval	**12.5 m (dual array, flip flop)**
Frequency range of seismic source	**~3-2000 Hz**
Streamer **- number** **- length** **- spacing** **- tow depth** **- composition**	 **Up to 10 streamers** **10 km** **75 m separation** **9-15m tow depth (water depth dependent)** **Solid streamers (Sercel Sentinel)**
Survey line spacing	**375 m**
Minimum water depth	**Charted water depth of <10 m in operations area (Pee Shoal @ 9m) and 13m in Acquisition Area but a minimum safe water depth below the hull for vessel operation will be maintained, as determined by the vessel Master.**
Acquisition speed	**4-5 Kn (over ground speed)**
Daily operation	**Yes, 24 hour operation**

2.4 Seismic source justification

The Gem 3D MSS is intended to acquire modern, high quality broadband 3D seismic data to target Jurassic hydrocarbon prospects that have been identified by legacy 2D and 3D seismic data previously acquired 15 - 20 years ago. The largest of these prospects, the Gem prospect, is approximately 7.5 km^2, but at least ten smaller prospects have been mapped within the ~410 km^2 Gem 3D MSS AA boundaries. The acquisition of new technology 3D data will provide greatly improved imaging of the prospects to help refine potential hydrocarbon reserves.

SapuraOMV commissioned an independent analysis of the minimum airgun array volume required to meet the geological imaging objectives for the Gem 3D MSS. The final analysis report recommended an energy source of between 2098 in^3 and 2820 in^3 in volume (RPS UK 2019). All site-specific sound modelling for this EP, conducted by JASCO, has utilised the 2820 in^3 array design as a worst-case scenario in order to develop controls to minimise risks to environmental receptors to ALARP and acceptable levels.

The smallest recommended array in the RPS UK report, at 2098 in^3, was only considered acceptable for the activity if the shotpoint interval was reduced to make up for the lack of acoustic energy.This was not considered viable and would have increased the 24-hour sound exposure level (SEL) at the site. The airgun array utilised for the activity is expected to have an effective volume of 2380 in^3, well within the RPS report's recommended array volume parameters and consistent with recommendations from the JASCO 2820 in^3 array sound modelling study, and as detailed in Section 6.

2.5 Time frame

The Gem 3D MSS is scheduled to take place between late Q4 2019 and Q3 2020. Within this design envelope the survey is expected to be completed within a 27-day operating envelope, including allowance for expected operational downtime and standby (e.g. due to weather). This duration does not consider unexpected events such as cyclones or vessel breakdown. Should the time frame of the survey alter by more than two weeks the impact and risk assessment, and associated management controls, will be reviewed under the Management of Change process described in Section 8.

2.6 Survey vessels and logistics

The GEM 3D MSS will be undertaken by specialist geophysical company Polarcus using a purpose-built seismic vessel using methods and equipment typical for surveys conducted in Australian waters. No unique or unusual equipment or operations are proposed. The seismic vessel for this survey is expected to be the Polarcus *MV Alima* or similar. Vessel specifications that encompass the Polarcus seismic vessel fleet are provided in Table 2-5. The vessel utilised will fall within the range of key parameters listed in Table 2-5, including fuel type and maximum fuel tank volume. The vessel will comply with the stringent Det Norske Veritas (DNV) CLEAN DESIGN and BWM-T notations, with enhanced environmental performance including a double skinned hull to reduce the potential for collisions to result in spills, advanced ballast and bilge water treatment systems, diesel-electric propulsion and high specification catalytic convertors to minimise emissions.

The seismic vessel will utilise the port of Broome, WA, as the home port for the duration of the survey. One support vessel (possibly plus a chase vessel) will remain on standby to direct shipping traffic away from the survey vessel during acquisition activities. While the specific support vessel(s) for this survey are not yet confirmed, vessel specifications for the typical class of support and chase vessel are provided in Table 2-6.

No reprovisioning or crew transfers at sea will be required during the survey due to the short time frame of the activity. Refuelling is not planned to occur within the OA during the activity due to the short duration of 27 days.

Helicopters will not be used during the activity unless in an emergency or in response to an unplanned hydrocarbon spill. Logistics for hydrocarbon spill response are outlined in Appendix H.

Table 2-5: Seismic survey vessel specifications

Survey vessel class	DNV 1A1, SF, E0, DYNPOS-AUTR, CLEAN DESIGN, COMF-V (3), ICE-1A, WINTERIZED BASIC, NAUT-AW,HELDK, BWM-T, SPS
Length	~90-110 m
Beam	~19-25 m waterline beam

Draft	~6-8 m
Gross tonnage	~6000-8000 t
Total fuel capacity	~1500-2000 m^3
Largest single tank capacity	≤300 m^3 max (<280m^3 expected)
Fuel type (MGO/MDO/HFO)	MGO
Acquisition capability	10 x 10,000 m streamer
Complement (POB)	~ 50-60 berths.
Means and frequency of crew transfers	N/A for this survey due to short duration.

Table 2-6: Support/ chase vessel option specifications

Specification	Support Vessel	Chase vessel
Length	50-60 m	25-30 m
Beam	10-15 m	8-10m m
Draft	<7m	<7m
Gross tonnage	1000-1200 t	~1000
Fuel type (MGO/MDO/HFO)	MGO or MDO	MGO or MDO
Complement (POB)	Max capacity ~50 berths.	Max capacity ~14 berths.
Means and frequency of crew transfers	Not planned for this survey due to short duration.	Not planned for this survey due to short duration.

3 Engagement and consultation

SapuraOMV is committed to engaging with relevant persons, organisations and communities throughout the process of developing this EP and throughout the survey activity in an open and honest manner. SapuraOMV has strived to be transparent during consultation with relevant persons or organisations, sharing information freely to demonstrate a commitment to transparency and has considered all feedback received from relevant persons or organisations for incorporation into this EP.

Consultation with relevant authorities, persons and organisations commenced in May 2019 detailing the characteristics, location, duration and identified risks of the activity such that relevant persons could make an informed assessment of possible consequences of the activity on their functions, interests or activities.

In accordance with the new transparency requirements of the OPGGS(E) Regulations this EP will be published on NOPSEMA's website for public review and comment for a period of 30 days. This process is further described in Section 3.2.

Searcher Seismic Pty Ltd (Searcher) was contracted by SapuraOMV to assist in the regulatory environmental approvals process, including relevant person or organisation consultation and communications related to the survey activity. Searcher facilitated the regulatory consultation process, including communications with relevant persons and responding to relevant person or organisation feedback.

3.1 Purpose

In accordance with Regulation 11A of the OPGGS(E) Regulations this section demonstrates that sufficient information and an appropriate level of consultation was conducted with relevant persons or organisations throughout the course of preparation of the EP and details how SapuraOMV has assessed and responded to any objections or claims made by a relevant person or organisation.

Relevant persons are taken to mean 'a person or organisation that may be affected' by the 'petroleum activity' as defined by regulation 4 of the OPGGS(E) Regulations (as recommended by NOPSEMA Guideline Environment plan decision making June 2018). All relevant persons or organisations were provided with sufficient information such that they could make an informed assessment of how the activity may affect their functions, interests or activities within a reasonable period. Functions, interests or activities were taken to mean as defined by the NOPSEMA Guideline Environment plan decision making June 2018:

- Functions are a person or organisation's power, duty, authority or responsibilities.
- Activities are a thing or things that a person or group does or has done.
- Interests are a person or organisation's rights, advantages, duties, and liabilities; or a group or organisation having a common concern.

3.2 Consultation process

The process undertaken by SapuraOMV to identify and consult with relevant persons or organisations is demonstrated below (Figure 3.1).

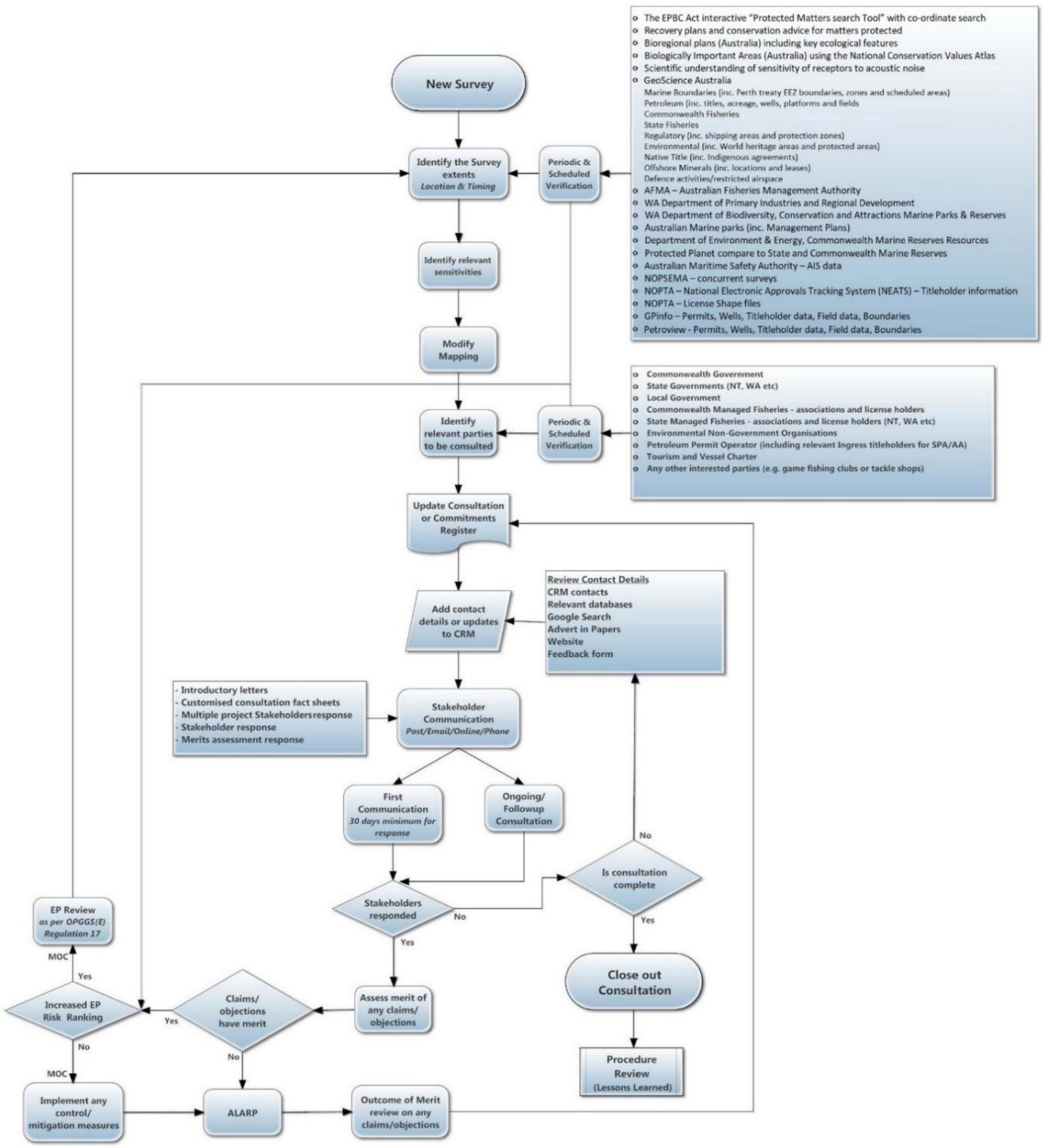


Figure 3-1: Gem 3D MSS consultation process

3.2.1 Identify the survey extents and relevant sensitivities

SapuraOMV assessed the geographic footprint of the activity including underwater noise from seismic activity and unplanned hydrocarbon spills (defined in Section 2 and 4 of this EP). The Planning Area of the activity is the area inclusive of a 150 km buffer around the OA encompassing the environment that may be affected by unplanned events associated with planned activities as described in this EP. The below resources were used to determine relevant sensitivities of the area in order to determine which persons or organisations may be relevant to the Gem 3D MSS:

- Commercial fishery ranges. In addition to the legislated areas of each state and commonwealth fishery that overlap the OA, steps were taken to identify active fishing effort in the OA, given that even though commercial fishers may be permitted to fish in the OA they, in practice, may not fish there regularly or at all.

– AFMA and ABARES catch data to determine which active Commonwealth fisheries areas overlap the OA or those with an interest in the area (i.e. spawning grounds for target species)

– DPIRD catch data to determine which active WA state fisheries areas overlap the OA

– Consultation with fisheries authorities and associations to determine which commercial fishing operators to consult with.

- Recreational fishing groups
- Recreational activity operators and associations
- Organisations with conservation and research interests
- Oil and gas industry operators

The Gem 3D MSS consultation process utilises a method of periodic and scheduled review to be undertaken during the planning and mobilisation phases of the survey to ensure any changes in sensitivities or relevant persons or organisations are identified (Figure 3-1).

3.2.2 Identify relevant persons to be consulted

Regulation 11A of the OPGGS(E) Regulations identifies five groups of relevant persons or organisations who must be consulted in the course of preparing an EP. SapuraOMV carried out the below steps to identify relevant persons to be consulted:

Relevant government departments – Regulation 11A (1) (a), (b), (c)

To ensure that this EP was developed in consultation with each relevant government department and agency SapuraOMV contacted governmental bodies with jurisdiction or authority over any location within the Operations Area. The relevant government departments or agencies contacted are listed in Table B.2 of Appendix B and were provided an opportunity to raise objections or claims. Those departments and agencies that advised SapuraOMV that their jurisdiction does not overlap the activity but requested to remain informed about the Gem 3D MSS are listed in Table B.3 of Appendix B.

Relevant persons or organisations – Regulation 11A (1) (d)

SapuraOMV obtained information from the below sources to ensure that this EP was developed in consultation with each relevant person or organisation in relation to the Gem 3D MSS. Relevant persons or organisations are those whose functions, interests or activities (as defined under NOPEMA's Environment plan decision making guideline 2018) may be affected by both planned and unplanned events. SapuraOMV ensured each relevant person or organisation has been provided with an opportunity to raise objections or claims.

- Commercial fishery licence holders from the identified relevant sensitive fisheries

– AFMA licence data for active Commonwealth fisheries that overlap the Operations Area or those with an interest in the area (i.e. spawning grounds for target species)

– DPIRD licence data for active WA state fisheries that overlap the Operations Area

- Online searches for local businesses and operators who may operate within the Planning Area, and
- Sought and considered the recommendations and referrals of identified relevant persons or organisations regarding which, if any, other persons or organisations should be consulted.

Relevant persons or organisations identified within this regulation and consulted with are listed in Table B.2 of Appendix B. Also summarised is a list of persons or organisations who were engaged for the purposes of planning but identified themselves as not relevant (Table B.3).

Other relevant persons or organisations – Regulation 11A (1) (e)

Regulation 11A (1) (e) covers any other relevant persons or organisations that are not included under regulations 11A (1) (a) – (d). At this time there are no persons or organisations recognised under this category. This EP will be published for public comment under the OPGGS(E) Regulation 11B, during which time SapuraOMV may modify this EP in response to the comments received.

SapuraOMV has maintained a database of all relevant persons identified during the preparation of this EP, which will be kept current through to completion of the activity in accordance with the ongoing consultation process (Section 8). The full list of relevant persons or organisations engaged in the consultation process is provided in Appendix B.

3.2.3 Relevant person or organisation engagement

Formal consultation with relevant persons or organisations was initiated on 29 May 2019 to relevant persons or organisations excluding commercial fishers (DocRef C001, see Appendix B) and on 13 June 2019 to commercial fishers (DocRef C002 and C004, see Appendix B), with the distribution of invitations to comment. Additional relevant persons or organisations identified as a result of the consultation were subsequently contacted by email and/or phone (DocRef C001.3 see Appendix B).

Where no feedback was provided by relevant persons or organisations, SapuraOMV followed up with additional emails and phone calls (where phone numbers could be obtained) to ensure that relevant persons or organisations had received the consultation materials, and to encourage them to respond, or to register that person or organisation as not relevant for the purpose of the Gem 3D MSS.

3.2.3.1 Provision of sufficient information

SapuraOMV provided sufficient information via a variety of communication methods including emails, post, newspaper advertisements and phone calls. The content of written consultation packages (flyers) are provided in Appendix B.

Emails/ post, phone calls

Each email or posted letter provided to relevant persons or organisations included key contact details for Searcher (including postal address) and a flyer. The flyer contained an introduction to SapuraOMV, the proposed activity description including a location map and coordinates, a summary of potential impacts, risks and effects to relevant persons or organisations, control measures to manage the risks and impacts and a description of methods to communicate with SapuraOMV via Searcher. The information provided in flyers has been tailored to the specific interests of relevant persons or organisations. For commercial fishers a summary of the expected interaction with each commercial fishery was included, detailing potential impacts of the Gem 3D MSS survey on their functions, interests and activities e.g. the likelihood of displacement of fishers, entanglement with equipment, and the effects of seismic activity on fish larvae and stocks and within which areas of the survey (including coordinates) this is likely to occur.

Relevant persons or organisations were encouraged to provide feedback via a dedicated project email, contact number, website and a QR code that linked to a registration form/ questionnaire where they could register their interest in the survey and find links to further information (this has been continually updated throughout consultation, DocRefs C001-C001.3). A further QR code linked to an 'opt-out' form where persons or organisations could indicate they are not relevant to the Gem 3D MSS and withdraw from further consultation. Postal address for consultation was made available, however feedback via multiple online methods were offered to provide an efficient and reliable consultation process.

For many commercial fishers only consultation via postal methods has been possible as DPIRD provide only postal contact details. In these instances, efforts have been made to identify alternative contact details (email/ phone), through consultation with fisheries organisations, associations and internet searches. Consultation, where possible, was followed up with phone calls to ensure that relevant persons or organisations had received the consultation materials, and to encourage open dialogue. Phone consultation included requesting feedback to be via a written method to provide a reliable consultation process.

A second flyer (DocRef C001.2 see Appendix B), updated to include modified titleholder details and reduced Acquisition Area and Active Source Area extents that reduce the potential displacement impacts of the Gem 3D MSS on commercial fishers, was sent to relevant persons or organisations on the 1 July 2019.

At the end of July 2019 a flyer (DocRef C005 and C006, see Appendix B) was sent by email or post to relevant persons or organisations that had registered interest in being kept informed of survey updates, had not yet provided feedback or had not responded to “Opt-out” of consultation to date. The flyer noted that SapuraOMV and Searcher had reviewed feedback to date and had undertaken to address any concerns in the planning phase of the Gem 3D MSS. These are detailed in Section 3.2.4 below. The flyer also provided information regarding impact assessments, relevant controls and notification details that had been added to the activity. The flyer encouraged feedback at any time through the abovementioned methods.

A detailed record of all consultation along with feedback received and SapuraOMV’s responses are provided in Appendix B. In accordance with Regulation 16(b)(iv) of the OPGSS(E) Regulations, a complete copy of original responses from all relevant persons or organisations is provided in Appendix C.

Newspaper advertisements

SapuraOMV placed advertisements in a Western Australian newspaper during the initial stages of consultation to ensure that all potentially relevant persons or organisations that may be affected by both planned and unplanned events have been provided with an opportunity to raise objections or claims to SapuraOMV. The following newspaper advert was placed in the Sunday Times, public notices, on Sunday 16 June 2019.

Figure 3-2: Gem 3D MSS WA Sunday Times advert placed 16/6/19

3.2.3.2 Reasonable time

To ensure relevant persons or organisations were allowed adequate opportunity to consider the information provided, relevant persons or organisations (excluding commercial fishers) were asked to respond within 32 days by 30 June 2019. A second flyer (DocRef C001.2 see Appendix B), altered to include updated titleholder details and reduced survey Acquisition Area and Active Source Area extents, was sent to these stakeholders on 1st July 2019, requesting response by 15th July 2019, thus providing an extended response time of 47days.

Commercial fishers were initially asked to respond within 32 days, by 15 July 2019. Fishers, where possible, were followed up via phone calls to ensure that stakeholders had received the consultation materials, taking into consideration the work habits of commercial fishers who may be unavailable for extended periods and to encourage interpersonal open dialogue.

Several relevant persons or organisations did not reply to consultation attempts or replied only to acknowledge receipt of the initial consultation flyer with no feedback on the Gem 3D MSS. In these cases SapuraOMV considers that a reasonable time period for consultation has been provided.

3.2.4 Outcomes

SapuraOMV is satisfied that it has provided sufficient information, time and opportunity to allow relevant persons or organisations to make an informed assessment of the possible impacts of the Gem 3D MSS on their functions, interests or activities. In the context of the nature and scale of the Gem 3D MSS, the environmental sensitivities and values of the area (Section 4), and the outcomes of the impact and risk assessments conducted in Section 6 and 7, SapuraOMV is satisfied that no further attempts to contact relevant persons or organisations to the Gem 3D MSS who have not responded so far is required. Those who have still not responded will be kept informed in the ongoing consultation process through update notifications at key milestones, such as clarification of mobilisation timing, prior to commencement of operations and on completion of the survey, and will be consulted with if they choose to contact SapuraOMV based on information provided through notifications.

Outcomes from relevant person consultation in accordance with the OPGSS(E) Regulations are described in Sections 6 and 7 of this EP, and are detailed in Appendices B and C. SapuraOMV's approach to consultation reporting is as follows:

- Appendix B:

– a summary of each response provided by a relevant person or organisation;

– a list of each objection or claim about the adverse impact of the planned activity to which the environment plan relates;

– an assessment of the merit of each objection or claim about the adverse impact or risk of our planned activity raised by a relevant person;

– a statement of our response, or proposed response, if any, to each objection or claim

– A copy of each consultation round sent to relevant person or organisations

- Appendix C:

– a copy of the full text of consultation conducted with each relevant person or organisation during the development of the EP. This report contains sensitive information and will be provided to NOPSEMA for review but will not be published during the regulatory public consultation process.

3.2.4.1 Measures adopted from consultation with relevant persons or organisations

The following objections or claims emerged from consultation undertaken throughout the development of this EP:

- "Make Good Agreement" – there was no feedback from individual commercial fishers regarding the provision of a "Make Good Agreement" clause, although the peak industry body, WAFIC, requested the inclusion of a "Make Good Agreement" clause in the EP in the event of an incident occurring. SapuraOMV considers that the inclusion of a 'Make Good Agreement" at this stage, with no feedback provided of this nature from specific commercial fishers, is premature, however an agreement can be drafted with individual fishers if requested by that fisher.
- Displacement of fishers – one commercial fisher in the NDSMF expressed concern that the displacement of fishing vessels by seismic surveys in general is an expected occurrence.

SapuraOMV is aware that displacement of commercial fishers is of concern and has reduced the survey area extent inshore of the Perth Treaty line (see Section 1). This means that the ASA and AA of the survey are entirely outside of the permitted fishing grounds for the NDSMF and so displacement of commercial fishers is not expected to occur.

These key themes are the same as those found for other 3D marine seismic surveys of a similar nature and scale. Responses to relevant person or organisation issues and concerns have been provided to those specific issues as indicated in Appendix B and C and have been addressed in Section 6.

3.2.5 Ongoing consultation

SapuraOMV will continue to identify and consult with relevant Commonwealth and state authorities, relevant persons and organisations over the life of the activity. The ongoing consultation plan is described in Section 8.2 with notifications agreed to through consultation with relevant persons or organisations listed in Table 8-3(Section 8.10).

3.2.6 Sensitive information

Appendix B has been redacted prior to publishing to preserve the privacy of those persons or organisations consulted with. This can include the removal personal information (as defined by the *Privacy Act 1988*) and the removal of any information that was provided during consultation where that person has requested for that information not to be published as per OPGGS(E) Regulations subregulation 11(A). SapuraOMV has made reasonable efforts to inform each relevant person consulted that they may request for particular information not to be published during all stages of the consultation.

During the public comment process, NOPSEMA must publish an invitation to give comments on the published plan. This must contain a request in the persons comments that particular information in the comments not be published as described under regulation 11B(1). Comments provided during this process will be responded to within Appendix D and under subregulation 11B(3)(c) will be redacted prior to publishing to preserve the privacy of those persons or organisations consulted with. This can include the removal personal information (as defined by the *Privacy Act 1988*) and the removal of any information that was provided during consultation where that person has requested for that information not to be published as per OPGGS(E) Regulations subregulation 11(B).

3.3 Public comment

After the EP is published on the NOPSEMA website under Regulations 9AB and 11B, the public are invited to comment on the contents of this plan over a period of 30 days.

Any comments that are received during the public review process will be assessed and, if necessary, addressed in survey planning, including revision to the EP if appropriate. The assessment and response to public comments will be detailed within a Statement of Response to Public Comment (Appendix D) and provided to the regulator upon resubmission of the EP, including areas where the EP has been changed as a result of the public comment process. If there are no comments received no response to public comment is required. Within 5 business days of the resubmitted plan being received by the regulator, the Appendix D Statement of Response to Public Comment will be published with the EP on the NOPSEMA website. Only the comments received under Subregulation (2) of Regulation 11B will be considered and no other comments from the public regarding the EP will be addressed.

Sensitive information provided during this process will be dealt with as detailed in Section 3.2.6.

4 Description of the environment

4.1 Overview

The following section of the EP describes the values and sensitivities of the environment (MNES and other physical, biological and socio-economic receptors) that may be affected by the Gem 3D Marine Seismic Survey (Gem 3D MSS), as required by Regulations 4(1), 11(1)(a) and 13(2)(a)(b) of the OPGGS(E) Regulations.

The Gem 3D MSS Operations Area (OA) lies within Commonwealth waters in the Vulcan Sub-basin, western Bonaparte Basin in the Timor Sea, approximately 250 km off the Australian coast and 650 km from Darwin. The nearest point on the Australian mainland from the project area is Cape Bougainville, approximately 250 km to the south-east of the OA. To the north of the OA lies the Indonesian Archipelago, with the closest distance to land, Kupang, being approximately 120 km north-west of the northern OA boundary. Coordinates for the OA are provided in Section 2.

The extent of the existing environment described in this section was determined by considering the nature, timing and comparatively small scale of the Gem 3D MSS and associated environmental risks. The broader spatial extent was determined by the area that may be affected by an unplanned hydrocarbon spill (the Planning Area; Section 4.1.1), as well as within and in the immediate vicinity of the OA where survey activities will occur. The temporal extent was determined by the 27-day window in which the Gem 3D MSS is planned to occur (see Section 2.5).

4.1.1 Planning Area

To determine the potential spatial extent of a worst case accidental release of diesel from a vessel this EP uses Reference Case 2018:1003 – Consequence analysis of an accidental release of diesel (NERA 2018; refer to Section 7.6). The release volumes identified for the Gem 3D MSS do not exceed those used in the Reference Case, and the use of this Reference Case is highly conservative considering the release volumes it is based on are expected to be over double that likely for the Gem 3D MSS. Therefore, this EP has used the 150 km radius boundary around the OA (as determined in Reference Case 2018:1003) to describe the environment that may be affected by an accidental release of diesel. This area is referred to as the Planning Area and shown in Figure 4-5.

4.2 Physical environment

4.2.1 Geomorphology and bathymetry

The Planning Area is situated in the northern region of the Browse Basin, which is a proven hydrocarbon province lying entirely offshore off north-western Australia (Department of Mines and Petroleum 2014). The continental shelf extending from north-western Australia, known as the Sahul Shelf, is broad and relatively shallow, with the shelf break occurring at approximately the 200 m isobath. Bathymetry of the Planning Area is representative of the geomorphic features of the wider region (Figure 4-1). Water depths in the Planning Area range from 10 - 2,600 m.

Shoals and banks in the Planning Area are abrupt geomorphological features extending along the continental shelf edge. Initially the shoals rise steeply from depths of 100 to 200 m or more on the continental shelf and begin to plateau around 40 to 50 m depth (Table 4-1) (PTTEP 2013). The main plateau area of each shoal is typically at depths of 20 - 30 m, with occasional higher ground rising to within 5 to 30 m of the sea surface (Heyward et al. 2010). The geological origin of the shoals on the outer Sahul Shelf is uncertain, however it is suggested that these carbonate features are comprised of biogenic carbonates from scleractinian corals and coralline algae such as *Halimeda* spp. (Collins 2011; Heyward, Pinceratto & Smith 1997).

Within the OA lie approximately 13 banks and shoals that rise to depths of around 10 – 50 m (Figure 4-1). These are collectively referred to as the Jabiru Shoals. A high-resolution bathymetric survey conducted during the RV *Sonne cruise SO 184* revealed that Pee Shoal, which is located within the OA, is an ovate-shaped, dome-like structure in 320 m water depth that has very steep to almost vertical flanks and rises to 21 m from the surface. At the seabed the diameter of this shoal is approximately 2,000 m (Wienberg et al. 2010). A multi-beam echo sounder (MBES) survey conducted by SapuraOMV in July, 2019, over the 7 shoals located within the Acquisition Area (AA), plus Mangola Shoal in the Active Source Area (ASA), revealed a minimum water depth of 13m (lowest astronomical tide) on a single shoal within the AA and at Mangola Shoal, with 15-18m being the shallowest depths encountered on most others surveyed in the AA.

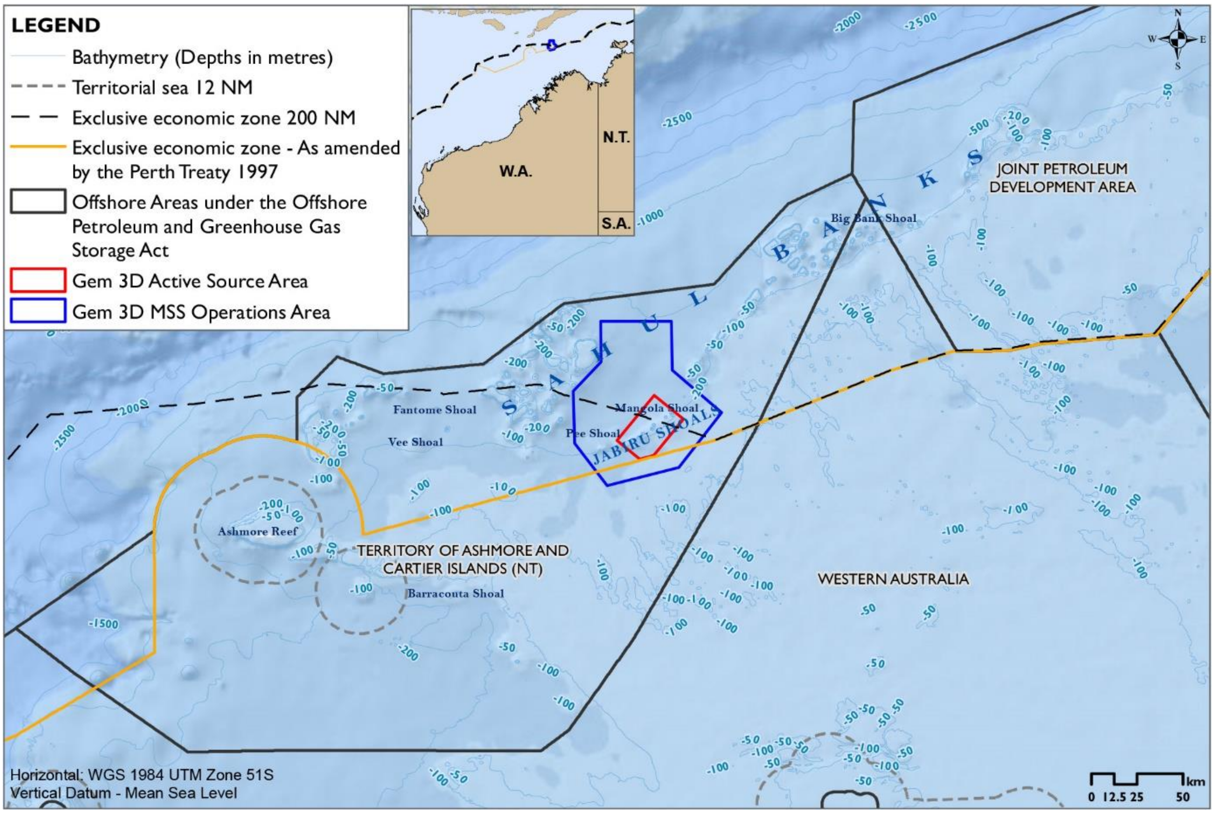


Figure 4-1: Bathymetry of the Planning Area

Table 4-1: Significant banks and shoals within the Planning Area

Bank/Shoals	Within Operations Area	Approximate shallowest depth (m)	Distance from Operations Area (km)	Direction from Operations Area
Barracouta Shoal	**No**	**10.3**	**101**	**Southwest**
Barton Shoal	**No**	**13.7**	**20**	**Northeast**
Big Bank Shoals	**No**	**16**	**124**	**Northeast**
Cartier Island	**No**	**0**	**146**	**Southwest**
Dillon Shoal	**No**	**13.1**	**58**	**Northeast**
Eugene McDermott Shoal	**No**	**15.5**	**119**	**South-southwest**
Fantome Shoal	**No**	**7.6**	**76**	**West**

Gale Bank*	**No**	**22**	**128**	**Southeast**
Goeree Shoal	**No**	**19.6**	**108**	**Southwest**
Hibernia Reef	**No**	**0**	**139**	**West**
Jabiru Shoal	**Yes**	**9.9**	**0**	**N/A**
Karmt Shoal	**No**	**13**	**80**	**Northeast**
Mangola Shoal	**Yes**	**9**	**0**	**N/A**
Pee Shoal	**Yes**	**21**	**(3km from ASA)**	**N/A**
Vee Shoal	**No**	**13.4**	**87**	**West**
Vulcan Shoal	**No**	**9.5**	**104**	**Southwest**
Woodbine Bank	**No**	**11.5**	**139**	**Southwest**

*Part of the carbonate bank and terrace system of the Sahul Shelf KEF

4.2.2 Sedimentology

Surficial sediments of the North West Shelf are predominantly carbonates, with a carbonate component exceeding 90% of samples (Jones 1973). Medium, course and very course-grained calcarenites and lag gravels, consisting mainly of relict organic materials, are spread widely over the shelf (Jones 1971). Dredge samples, grab sampling from the summit (21 m) and upper flank (33 m) of Pee Shoal determined that sediments are dominated by sand and gravel-sized grains, whereas the silt/clay fraction does not exceed 3 wt% of the bulk samples (Wienberg et al. 2010). Plates of the calcareous green alga *Halimeda* spp dominated all analysed surface samples (36-73%) (Wienberg et al. 2010). Coring at Big Bank Shoal (131 km from the OA) revealed that the sediments of those shoals are also composed of an extremely large portion of skeletal material from the green alga *Halimeda* spp whereas terrigenous sediments are absent (Heyward, Pinceratto & Smith 1997). These characteristics are considered to be representative of the OA.

4.2.3 Climate and meteorology

The Timor Sea region experiences a tropical monsoon climate with two distinct seasons – the north-west (summer) monsoon (November to March) and the south-east (winter) monsoon (April to September), with a short transitional period between each season (Pinceratto 1997). Most rainfall is restricted to the summer monsoon period and is associated with storm activity (Commonwealth of Australia 2002).

Troughton Island, located off Cape Bougainville in northern Western Australia, is the nearest meteorological station to the activity. Data collected from 1957 to 2019 shows that mean temperatures range from 22.3°C (July) to 33°C (November) (BoM 2019).

4.2.4 Winds

Winds during the winter monsoon season are typically south-easterlies which originate from over the Australian mainland; while winds during the summer monsoon are typically westerly/north-westerly and humid. A quantitative spatial and seasonal trend analysis of wind variability at a location 45 km north-east of the OA found that wind speed ranged from 9.7 to 29.2 knots during the summer monsoon season to 0 to 29.2 knots during the winter monsoon season (RPS APASA 2014).

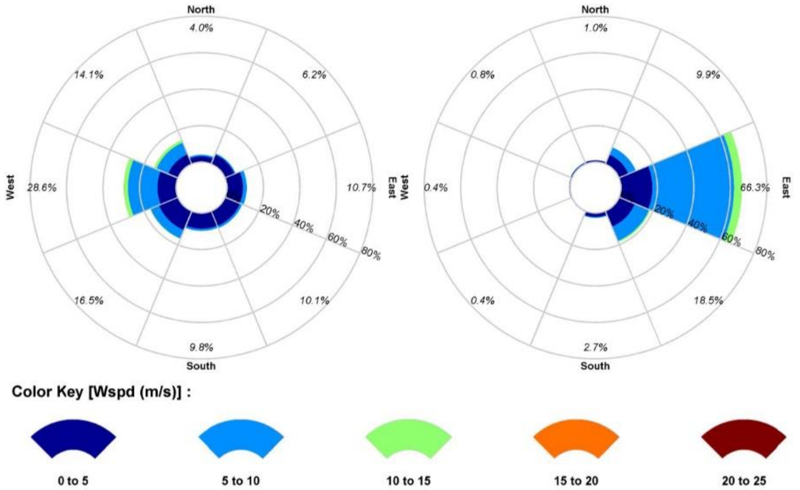


Figure 4-2: Wind field seasonal variability at a location 45 km north-east of the Operations Area (left, Oct – Mar; right, April – Sept)

4.2.5 Currents

Broad-scale ocean circulation of northern Australia is dominated by the Indonesian Throughflow Current system and the Holloway Current which flow south-west and close to the coastline, intensifying during April - July due to increased wind forcing. In the Timor Sea the south-westerly flow of the Holloway Current is slow and broad (0.2 m2; 250 km wide) relative to the Leeuwin Current which it flows into further south (Holloway 1995). This allows seasonal south-west winds to induce a reversal of the current to the north-east in spring and summer (Cresswell et al. 1993).

A quantitative spatial and seasonal trend analysis found that drift current speeds at a location 45 km north-east of the OA range from 0.5 m/s to the west in October-March and >0.6 m/s to the south-west in April-September (Figure 4-3).

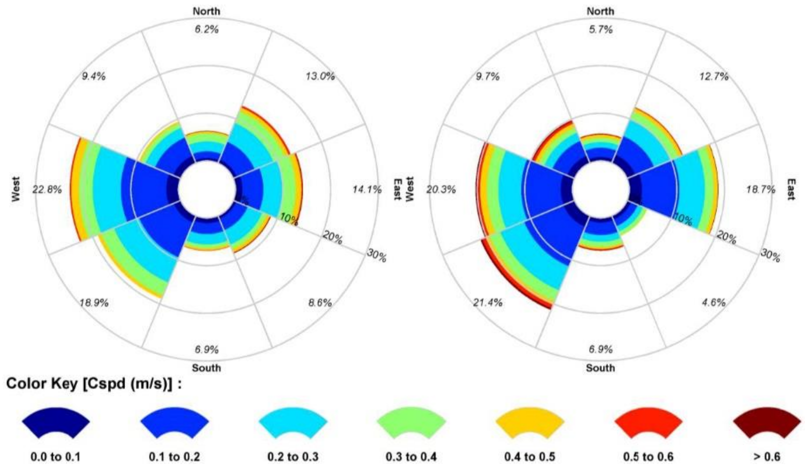


Figure 4-3: Drift current seasonal variability at a location 45 km north-east of the Operations Area (left, Oct – Mar; right, April – Sept)

4.2.6 Tides

The Sahul Shelf and wider region is a tide-dominated meaning that bottom sediments are predominantly mobilised by tidal currents (Porter-Smith et al. 2004). The tides are semidiurnal, with a typical tidal range of 4 m at spring tides and 1.8 m at neap tides (Heyward, Pinceratto & Smith 1997). Tidal currents flow ENE, and ebb currents WSW, in the upper 100 m of the water column and have current velocities on the order of 0.2–0.6 ms1. The tidal currents rotate anticlockwise (Ray, Egbert & Erofeeva 2005).

4.2.7 Waves

The wave climate in the region is influenced by sea and swell waves, as well as the location of storms and the local bathymetric effects. The Sahul Shelf region is characterized by low mean wave heights and short wave periods (Porter-Smith et al. 2004). Ashmore Reef (approximately 200 km away from the OA) has a mean wave height of 1 - 2 m (Glenn & Collins 2005). However, the effect of waves on sediment transport can be temporarily increased due to tropical cyclones that generate prolonged high wind speeds over a large area (Harris & Coleman 1998).

4.2.8 Temperature and salinity

Sea temperatures and salinity in the region are heavily influenced by the warm, low salinity waters of the Indonesian Throughflow Current. In summer, the sea surface temperature is approximately 26 ºC and in winter approximately 22 ºC (DEWHA 2008). Offshore waters are stratified with a distinct thermocline at depths of around 30-50 m in summer and 70-120 m in winter. Lying in the path of the Indonesian Throughflow Current, the salinity of water along the shelf margin is in the 34-35 ppt range (Wilson 2013).

4.2.9 Water quality

Nutrient concentrations are generally low in surface waters of the North West Shelf (Condie & Dunn 2006), especially near the shelf margin where measures of nitrogen and phosphorus are usually around 0.05/12.8 µm and 0.11/0.85 µm respectively (Brewer et al. 2007). Nutrient concentrations below the thermocline are significantly higher and seasonal nutrient enrichment of benthic habitats on the outer and middle shelf may be expected as a result of upwelling. This effect is enhanced in the vicinity of shallow features of the continental slope and outer shelf and greatly influences growth of algae, corals, and other fauna of the shelf-margin reefs and submerged banks (Wilson 2013).

4.3 Ecological environment

The Planning and Operations Areas are situated in the North West Marine Region (NWMR) which covers an area of tropical and sub-tropical waters from shallow continental shelf areas (<200 m deep) to deep abyssal plains in excess of 5,000 m water depth. The NWMR is physically characterised by relatively large tidal amplitudes in the north, cyclones, and warm, oligotrophic surface waters (Baker et al. 2008). The NWMR consists of slope, shelf, and abyssal plain / deep ocean floor and rise geomorphic provinces (Baker et al. 2008) which are managed under the *Marine bioregional plan for the North-west Marine Region* (DSEWPaC 2012).

The NWMR consists of eight provincial bioregions, three of which occur within the Planning Area (Section 4.3.1). Four Key Ecological Features (KEFs) occur within the Planning Area (Section 4.3.2) as well as four Australian Marine Parks (Section 4.3.3).

4.3.1 Marine bioregions

4.3.1.1 Northwest Shelf Province

The Northwest Shelf provincial bioregion is located primarily on the continental shelf between North West Cape and Cape Bougainville, covering an area of 238,759 km^2. It varies in width from about 50 km at Exmouth Gulf to more than 250 km off Cape Leveque. About half of the bioregion has water depths of only 50–100 m and a maximum depth of 200 m. The bioregion is a dynamic oceanographic environment, influenced by strong tides, cyclonic storms, long-period swells and internal tides. Its waters derive from the Indonesian Throughflow Current, are warm and oligotrophic, and circulate throughout the bioregion via branches of the South Equatorial and Eastern Gyral Currents.

Fish communities are diverse and the distribution of benthic and pelagic fish communities appear to be closely associated with depth range. Humpback whales migrate through the bioregion and Exmouth Gulf is an important resting area, particularly for mothers and calves on their southern migration. Several important seabird breeding sites are in the bioregion (but adjacent to Commonwealth waters), including Eighty Mile Beach, the Lacepede Islands, and Montebello and Barrow islands. The bioregion is important for the petroleum industry and the location of commercial fishing operations. The nationally significant ports of Dampier and Port Hedland operate in this bioregion but occur to the south of the Planning Area.

4.3.1.2 Northwest Shelf Transition

The Northwest Shelf transition bioregion straddles the North and North-west Marine Regions, extending from the Tiwi Islands (NT) to Cape Leveque (WA) and covers an area of 305,463 km^2. The Indonesian Throughflow Current is the dominant oceanographic feature and occupies much of the water column. The strength of the Throughflow and its influence in the bioregion varies seasonally in association with the North-west Monsoon season.

Much of the provincial bioregion is located on the continental shelf with water depths from 10–100 m to a maximum of 330 m. The provincial bioregion has complex sea floor topography including submerged terraces, carbonate banks, pinnacles, reefs and sand banks. The carbonate banks and pinnacles of Joseph Bonaparte Gulf are distinctly different in morphology and character to other parts of the Region and are believed to support high biodiversity.

The biological communities of the North-west Shelf Transition are typical of Indo-west Pacific tropical flora and fauna and occur across a range of soft-bottom and harder substrate habitats. The inshore waters off the Kimberley are where the Western Australian population of humpback whales mate and give birth. The Northwest Shelf Transition is important for commercial fisheries, defence, and the petroleum industry.

4.3.1.3 Timor Province

The Timor Province bioregion covers almost 15% of the North-west Marine Region (156,669 km^2), predominantly the continental slope and abyss between Broome and Cape Bougainville. Water depth ranges from 200 m near the shelf break to 5,920 m in the Argo Abyssal Plain. Additional major geomorphic features are Scott Plateau, Ashmore Terrace, part of the Rowley Terrace and Bowers Canyon. Ashmore Reef, Cartier Island, Seringapatam Reef and Scott Reef are important features of the provincial bioregion.

The bioregion is dominated by the warm oligotrophic waters of the Indonesian Throughflow Current. The thermocline is particularly pronounced and is associated with the generation of internal tides, an important oceanographic feature. The variety of geomorphic features in the Timor Province, together with the variation in bathymetry, results in several distinct habitats and biological communities. The reefs and islands of the bioregion are regarded as biodiversity. A high level of endemicity exists in demersal fish communities of the continental slope in the Timor Province. Two distinct communities have been identified – one associated with the upper slope, the other with the mid slope. The Timor Province bioregion is important for the petroleum industry, and several commercial fisheries operate within it.

4.3.2 Key ecological features

There are no Ecological Features (KEFs) within the OA (Figure 4-4). The NWMR bioregional plan (DSEWPaC 2012) lists 13 KEFs, four of which occur within the Planning Area (Table 4-2). The four KEFs within the Planning Area are described below.

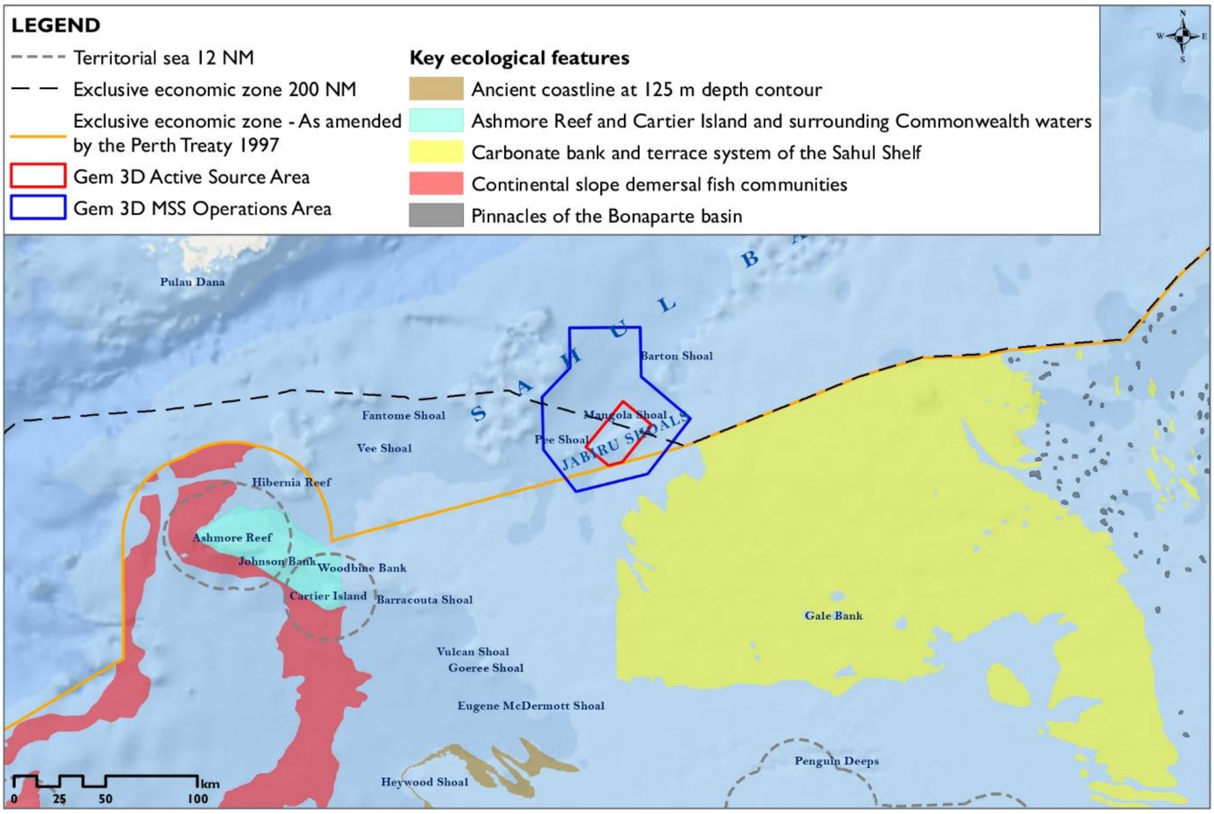


Figure 4-4: Key Ecological Features within the Planning Area

Table 4-2: Key Ecological Features within the Planning Area

Key Ecological Feature	Environmental Values
Ancient coastline at 125 m depth contour	**Unique sea floor feature that provides areas of enhanced biological productivity**
Ashmore Reef and Cartier Island and surrounding Commonwealth waters	**High productivity and aggregations of marine life.** **Regionally important for feeding and breeding aggregations of birds and other marine life, and areas of enhanced primary productivity in an otherwise low-nutrient environment.** **Ashmore Reef supports the highest number of coral species of any reef off the west Australian coast.**
Carbonate bank and terrace system of the Sahul Shelf	**Unique sea floor feature with ecological properties of regional significance**
Continental slope demersal fish communities	**High species diversity and endemism - the most diverse slope bioregion in Australia with over 500 species found with over 64 of those species occurring nowhere else**

Ancient coastline at 125 m depth contour

The Ancient coastline on the 125 m depth contour is managed under the *Marine bioregional plan for the North-west Marine Region* (DSEWPaC 2012). This is recognised for its biodiversity values of unique sea-floor features with ecological properties of regional significance, which apply to both the benthic and pelagic habitats.

The ancient submerged coastline provides areas of hard substrate and therefore may provide sites for higher diversity and enhanced species richness relative to surrounding areas of predominantly soft sediment. 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 representative of hard substrate fauna in the North West Shelf bioregion.

Ashmore Reef and Cartier Island and surrounding Commonwealth waters

The Ashmore Reef and Cartier Island and surrounding Commonwealth waters is managed under the *Marine bioregional plan for the North-west Marine Region* (DSEWPaC 2012). Ashmore Reef is the largest of only three emergent oceanic reefs present in the north-eastern Indian Ocean and is the only oceanic reef in the region with vegetated islands. Ashmore Reef and Cartier Island and the surrounding Commonwealth waters are regionally important for feeding and breeding aggregations of birds and other marine life; they are areas of enhanced primary productivity in an otherwise low-nutrient environment. Ashmore Reef (outside the Planning Area) supports the highest number of coral species of any reef off the West Australian coast.

Carbonate bank and terrace system of the Sahul Shelf

The Carbonate bank and terrace system of the Sahul Shelf is managed under the *Marine bioregional plan for the North-west Marine Region* (DSEWPaC 2012). It is located in the western Joseph Bonaparte Gulf and to the north of Cape Bougainville and Cape Londonderry. The carbonate banks and terraces are part of a larger complex of banks and terraces that occurs on the Van Diemen Rise in the adjacent North Marine Region. The banks consist of a hard substrate and flat tops at depths of 150–300 m. Each bank occupies an area generally less than 10 km^2 and is separated from the next bank by narrow sinuous channels with depths up to 150 m (Brewer et al. 2007). The carbonate banks enhance the biodiversity and productivity of the region by providing hard substrate in an otherwise soft sediment environment. Depths range from 30-80 m, support coral and sponge beds and are known as key foraging areas for marine reptiles and megafauna such as dugongs and humpback whales (Donovan et al. 2008).

The Carbonate banks and terrace system of the Sahul Shelf is defined as a key ecological feature for its role in enhancing biodiversity and local productivity relative to its surrounds as it is a unique sea floor feature supporting relatively high species diversity, making it regionally significant.

Continental slope demersal fish communities

The Continental slope demersal fish communities KEF is managed under the *Marine bioregional plan for the North-west Marine Region* (DSEWPaC 2012). It is recognised as a key ecological feature because of its biodiversity values, including high levels of endemism. The diversity of demersal fish assemblages on the continental slope in the Timor Province, the Northwest Transition and the Northwest Province is high compared to elsewhere along the Australian continental slope.

4.3.3 State and Commonwealth marine parks, reserves and protected areas

No Australian Marine Parks (AMPs) exist within the OA. The Planning Area overlaps three of the 21 AMPs that are managed within the North and North-west Marine Parks Networks (Table 4-3 and Appendix E). A summary of conservation values and management principles for these AMPs is provided in Table 4-3.

Two of the three AMPs overlapped by the Planning Area are part of the North-west Marine Parks Network, which comprises 13 marine parks that are managed in accordance with the North-west Marine Parks Network Management Plan 2018 (DNP 2018a). The third Marine Park is part of the North Marine Parks Network, which comprises eight AMPs off the coast of the Northern Territory and Queensland that are managed in accordance with the North Marine Parks Network Management Plan (DNP 2018b). These management plans provide the rules about what activities can and cannot occur within marine park zones, and petroleum titleholders must ensure that their offshore environment plans are consistent with the zoning and rules that apply to mining operations in marine parks, as described in the management plans. They must also ensure that impacts on the representative values of the parks will be of an acceptable level and managed to As Low As Reasonably Practicable (ALARP) (NOPSEMA 2018).

Under the management plans, planned mining operations are generally allowable in Multiple Use Zones and Special Purpose Zones (IUCN category VI) or “blue zone”, except for Special Purpose (Mining Exclusion) Zones. Mining operations are not allowed to occur in any other zones of the parks (NOPSEMA 2018). In keeping with these requirements, the Gem 3D MSS will not take place within any Australian Marine Park Zone. However, the Planning Area overlaps the Cartier Island Marine Park, Oceanic Shoals Marine Park and a very small part of the Kimberley Marine Park (Table 4-3; Figure 4-5). The management plans allow actions required to respond to unplanned oil pollution incidents including environmental monitoring and remediation to be conducted in all zones without an authorisation issued by the DNP. This is provisional on actions being taken in accordance with an EP that has been accepted by NOPSEMA, and the DNP being notified in the event of oil pollution within a marine park, or where an oil spill response must be taken within a marine park, so far as reasonably practicable prior to response action being taken (NOPSEMA 2018). This requirement is captured in the Implementation Strategy for this EP (Section 8).

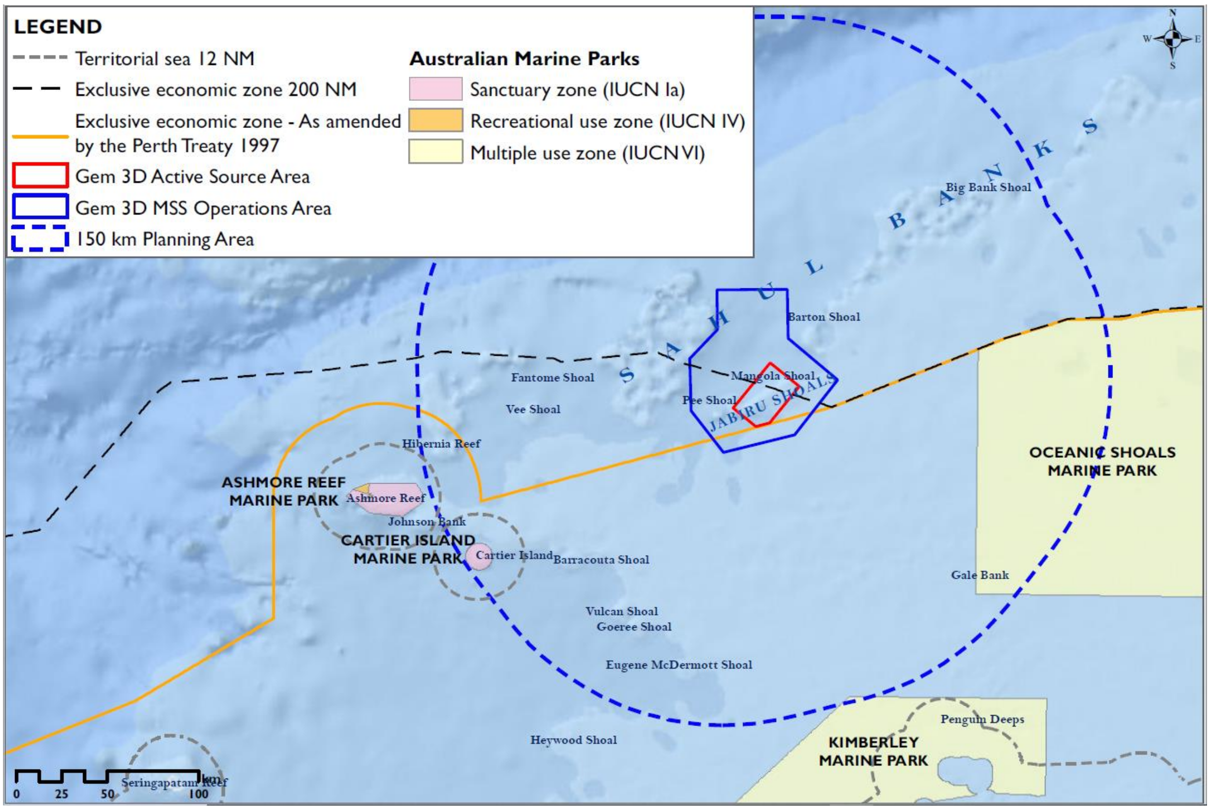


Figure 4-5: Australian Marine Parks within the Gem 3D MSS Planning Area

Table 4-3: Australian Marine Parks within the Planning Area

Protected Area	Major conservation values and environmental sensitivities	Relevant IUCN management principles
Cartier Island Marine Park (172 km^2) **(139 km from OA)**	• **Internationally significant for abundance and diversity of sea snakes** • **Large and significant foraging populations of green, hawksbill, loggerhead turtles** • **Foraging, breeding by seabirds** • **Important seabird rookeries for colonies including bridled terns, common noddies, brown boobies, eastern reef egrets, frigatebirds, tropicbirds, red-footed boobies, roseate terns, crested terns and lesser crested terns** • **Staging points/feeding areas for migratory shorebirds** • **Cultural and heritage site protecting the Ann Millicent historic shipwreck** • **Ecosystems, habitats and communities associated with the North West Shelf, the Timor Province and emergent oceanic reefs**	**Sanctuary Zone - IUCN Category Ia - provides the highest level of protection for birds and other marine life. Petroleum exploration is excluded from this zone, and all vessel activity is prohibited unless approval is obtained from the DNP.**
Kimberley Marine Park (74,469 km^2) **(147 km from OA)**	• **Foraging areas for migratory seabirds, dugong and Indo-Pacific humpback, Indo-Pacific bottlenose and Australian snubfin dolphins** • **Foraging and nesting sites of flatback and green turtles** • **Important migratory pathway and nursery areas for humpback whales** • **Adjacent to important foraging, nursing and pupping areas of freshwater, green and dwarf sawfish** • **Protects communities and habitats offshore of the Kimberley coastline from <15 to 800 m** • **Continental shelf, slope, plateau, pinnacle, terrace, banks and shoals and deep hole/valley sea floor features are all represented in this reserve** • **Examples of communities and sea floor habitats of the North West Shelf Transition, North West Shelf and Timor Provinces along with the Kimberley, Canning, North West Shelf and Oceanic Shoals meso-scale bioregions** • **KEFs represented: ancient coastline and continental slope demersal fish communities**	**Multiple Use Zone – IUCN Category VI– managed to ensure long-term protection and maintenance of biological diversity with a sustainable flow of natural products and services to meet community needs. Some commercial fishing is permissible and petroleum exploration and development is permissible. The south-east corner of the Planning area overlaps minimally with this zone.**

		IUCN zones outside of the Planning Area: **Habitat Protection Zone - IUCN Category IV** **National Park Zone - IUCN Category II**
Oceanic Shoals Marine Park (71,743 km²) **(78 km from OA)**	• **Inter-nesting by flatback and olive ridley turtles** • **Loggerhead and olive ridley turtle foraging** • **Four key ecological features** **- carbonate bank and terrace system of the Van Diemen Rise (unique sea-floor feature)** **- carbonate banks of the Joseph Bonaparte Gulf (enhanced productivity, high biodiversity, unique sea-floor feature)** **- pinnacles of the Bonaparte Basin (enhanced productivity, unique sea-floor feature)** **- shelf break and slope of the Arafura Shelf (unique sea-floor feature)** • **Examples of the ecosystems of the North West Shelf Transition Province and the Timor Transition Province**	**Multiple Use Zone – IUCN Category VI** **IUCN zones outside of the Planning Area:** **Habitat Protection Zone - IUCN Category IV** **National Park Zone - IUCN Category II** **Special Purpose Zone (Trawl) - IUCN Category VI**

4.4 Biological Environment

Assessment of biota in the vicinity of the OA was based on existing information and searches of available databases, with a preference for peer reviewed scientific studies (where available). The suite of taxa listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that may be present in the vicinity of the OA were identified by a search of the Protected Matters Search Tool (PMST) database (Appendix E).

4.4.1 Pelagic habitats

Pelagic habitats within the Planning Area host phytoplankton, zooplankton, and nekton assemblages. Given the oceanography of the OA, pelagic communities in the vicinity of the OA are expected to be broadly represented in the region. Phytoplankton in the region is linked to nutrient availability, with phytoplankton biomass in the Timor Sea higher than deep oceanic conditions in the eastern Indian Ocean, although lower than coastal waters (Hallegraeff & Jeffrey 1984; Susanto, Moore & Marra 2006). Phytoplankton biomass has been shown to vary in phase with the monsoon seasons, likely to be driven by nutrient availability (Hallegraeff & Jeffrey 1984; Susanto, Moore & Marra 2006). Zooplankton in the region is likely to be linked to phytoplankton availability, with zooplankton dynamics linked to food availability (Gusmão & McKinnon 2009). Planktonic biota supports larger pelagic organisms such as fishes (Section 4.5.2), which in turn support fauna such as seabirds (Section 4.5.3).

Chlorophyll-a concentrations are generally used as a proxy for phytoplankton biomass. NASA satellite imagery for the past ten years indicates average chlorophyll concentrations in the OA are relatively low compared to levels immediately surrounding Ashmore Reef and Cartier Islands, which likely reflects localised upwelling around the coral atolls (NASA 2015). Plankton sampling conducted at the Big Bank Shoal, 131 km northeast of the OA, found zooplankton biomass to be in the range of 65-155 mg/m^3 (Smith et al. 1997), which is similar to the 50-100 mg/m^3 found in an upwelling area between the northwest coast of Australia and Indonesia (Tranter 1962). Even though this is the highest level for the Australian Continental Shelf it is still relatively low in a world context.

Nekton assemblages of krill, lanternfish, shrimps and mesopelagic fish support a wide array of pelagic predators and are known to migrate between the pelagic and benthic communities. Island and reef habitats such as Ashmore Reef are known important trophic systems in the region. High trophic productivity results from internal waves mixing waters from 100 m depth up to euphotic waters, stimulating phytoplankton production. In turn zooplankton and nekton assemblage increases (Brewer et al. 2007).

4.4.2 Benthic habitats and communities

The distribution of benthic fauna depends on water depth, the substrate and sediment characteristics, the nature of the substrate and available food. The unconsolidated sandy and muddy substrate that covers most of the OA at 110 -440 m is well represented within the wider region (Pinceratto 1997; Smith et al. 1997). This habitat has little seabed structure and low density of sessile epibenthos, including filter-feeding organisms (e.g. gorgonians, sponges, ascidians and bryozoans) and mobile invertebrates (e.g. echinoderms, prawns and detritus-feeding crabs) (Brewer et al. 2007; DSEWPaC 2012). 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 region.

No platform or fringing coral reef communities are located within the OA. However, there are a number of platform reefs, banks, shoals and shelf edge atolls in the Planning Area, including Cartier Island and Hibernia Reef, and scattered throughout the OA are shoals with shallow, hard substrate supporting more diverse and higher density benthic assemblages of hard and soft corals, gorgonians, encrusting sponges, seagrass and macroalgae. These shoals are noted for their enhanced local productivity relative to surrounding areas and associated fish communities (DSEWPaC 2012; Wienberg et al. 2010). These benthic habitats are discussed in more detail in the following sections.

Tropical cyclones play a significant role in shaping the benthic habitats and communities of the shallower banks and shoals within the Planning and Operations Areas. Cyclones have a particularly destructive impact on *Halimeda* meadows (Wienberg et al. 2010). However, at a frequency of 0.4-0.6 per annum, the area is significantly less impacted than the NW Shelf of Australia (12–20°S), where ten cyclones occur per decade occur on average (Wienberg et al. 2010).

Regeneration following localised mortality events, including tropical cyclones and bleaching events, has been linked to the occurrence and impact of tropical cyclone disturbance. Gilmore et al. (2008) observed community composition changes from dominant branching corals to dominant tabulate and massive corals and sponges on Scott Reef at sites most exposed to the effects of tropical cyclones (which impact largely on branching corals). In the absence of further disturbances, the abundance of branching corals was expected to increase (Gilmore et al. 2008).

Banks and Shoals

There are nine shoals within the ASA that rise to depths of 10 - 50 m (mean sea level). These and other banks and shoals in and adjacent the OA (Table 4-1) form the Jabiru Shoals system that supports diverse benthic communities including numerous species of corals, sponges, seagrasses, crustaceans and fish. Dominant biota varies between shoals and range from macroscopic alga (in particular *Halimeda* spp.) to soft and hard coral communities (Heyward, Pinceratto & Smith 1997).

Shoals in the region may also provide feeding habitats for macrofauna such as marine turtles and dugongs, particularly where the seabed rises to a depth of less than 20 m (Whiting 1999). Banks and shoals in the region that rise to at least 45 m and particularly within 30 m water depth, allow light dependent organisms to thrive and support more biodiversity (NERP 2014; Nichol et al. 2013).

There is adequate light on the deeper shoal plateaus of 50-60 m to support photosynthetic organisms, benthic primary producer habitats, such as algae and reef building corals, and diverse communities (Heyward et al. 2011, 2010, 2013). Shallower shoal plateaus occur in water depths between 20-45 m and curve rapidly at the shoal rim to descend past the 60 m contour, when they slope steeply into deeper water (Heyward et al. 2010, 2011).

Epibenthic communities

Studies of seven shoals located within or adjacent the OA, including Pee Shoal, identified moderate to high densities of live hard coral cover at the shallowest (15 – 20 m) plateaux (ERM 2012). The upper slopes (>20-55 m) of these shoals included a continuation of hard coral dominated benthos (*Porites* dominant and live coral/reef represented by scattered patches of live coral cover/reef amongst sand and rubble substratum) and other light dependent biota, particularly in the depth range of 20-30 m (ERM 2012). Below these depths the density of hard coral cover declined gradually to depths of 40-50 m, with sparse hard coral still evident at depths to 55 m. Beyond these depths the upper slopes were mainly comprised of sand and scattered rubble patches with light-independent filter-feeding biota such as soft corals, sponges, sea fans, sea pens, and sea whips (ERM 2012). The deeper slope substrates were predominantly sand, with some shell and rubble fragments. Benthic assemblages include patches of hydroid seabed matting and scattered filter-feeders between 60- 70 m. The deeper portions of the lower slopes were characterised by sparse and isolated individual filter feeders in large areas of bare sand with rubble (ERM 2012).

Wienberg et al. (2010) conducted a detailed and systematic study on the sediment composition and zonation of Pee Shoal and found similar facies zonation to the broader ERM study (Figure 4-6). The summit region is within water depths of 21-75 m. On the summit plateau (21-35 m), zooxanthellate corals were dominant, including massive Poritidae, encrusting to foliaceous Acroporidae (*Montipora*), and the octocoral *Heliopora coerulea*. Other biota included asteroids, echinoids and crustaceans. Despite no detection of living *Halimeda* plants, which have been reported to dominate knoll structures of the Vulcan Sub-basin (van Andel & Veevers 1967), sediments samples indicate their historic presence. From 35 m the slope angle increased and these upper slopes (35-75 m) were dominated by scattered spherical sponges and small-sized zooxanthellate corals. The second zone (75-210 m) consisted of hard ground outcrops (step-like banks, vertical cliffs) that were mainly colonised by octocorals and sponges. The deepest zone consisted of the lowest banks of the shoal (210-320 m) and comprised soft sediments with scattered debris and scarce sponges, hydrozoans and crinoids.

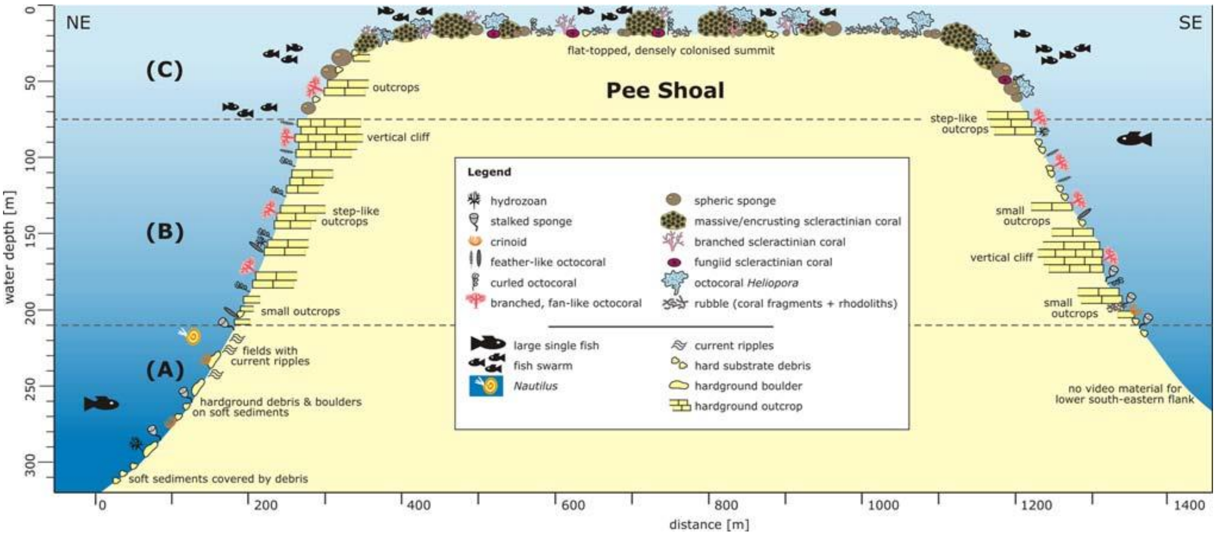


Figure 4-6: Facies of Pee Shoal (Weinberg et al. 2010)

The ecology of Big Bank Shoals, located 124 km northeast of the OA has been studied in detail (Smith et al. 1997). These shoals include Kepiting, Kepah, Sleepy and Tiram Banks (Table 4-1) with summit depths ranging from 15 - 50 m and are dominated by hard coral genera *Porites* and Acropora, and soft octocorals of the Family Alcyoniidae at similar live cover percentages to Pee Shoal. The community structure of the hard-coral ecosystems at Pee Shoal and Big Bank Shoals were also similar to the composition of moderately sheltered, shallow (9-12 m) communities at Scott Reef, approximately 400 km to the southwest (Heyward et al. 1995). This indicates that communities such as the Pee Shoal coral ecosystem may be distributed across a large geographical range along the Sahul Shelf and occupy a range of depths from shallow reef systems to deeper mesophotic habitats.

Fish communities

A recent study by Moore et al. (2017) of fish communities associated with Barracouta, Vulcan, Goree Heywood, Echuca and Eugene McDermott Shoals found that mesophotic coral-reef habitats (20- 80 m) in the western end of the North-west Oceanic Shoals bioregion were a major reservoir of marine biodiversity, including unique and high fish diversity and abundance. The most abundant species were small and large planktivorous fish (Moore et al. 2017). The species richness increased in areas with higher percentage cover of calcareous reef (above ~20%) and shallower depths (>30 m) (Heyward et al. 2013; Moore et al. 2017). In addition, Baited Remote Underwater Video (BRUV) surveys conducted during the study recorded 18 species of conservation interest as listed by the IUCN red list of threatened species. BRUV surveys conducted on upper areas (21-35 m) of shoals within the OA in 2010 showed high diversity and abundance of teleosts (bony fishes) and shark species typical of shallow reef systems (ERM 2012).

Fish communities reflect the changing benthic habitat and exposure to localised mortality events such as tropical cyclones and bleaching events, with the structure of fish communities maintained for the initial 12-18 months after an event, with changes then occurring up to five years. Site attached species abundance varies in accordance to habitat preference, with those species preferring algae most abundant following disturbance events but declining as hard coral cover increase and the subsequent decline in algae. Conversely, the increase in hard coral cover was expected to be followed by an increase in the fish species associated with those habitat types (Gilmore et al. 2008).

Ecological connectivity between shoals

Genetic studies of two species of hard coral showed significant spatial differences in populations from Scott Reef and Rowley Shoals (>100 km), as well as between reefs within these systems (>10 km) and even within reefs (<10 km) (Underwood et al. 2007, 2009). This is consistent with observations made at Scott Reef which showed that 98% of larvae settled within 10 km of their natal reef area (Gilmour, Smith & Brinkman 2009). Nevertheless, the degree of genetic differentiation between Scott Reef and Rowley Shoals indicates that dispersal between these reef systems does occur gradually over multiple generations (Underwood et al. 2013). In addition, several studies have indicated that recruitment from reefs tens to hundreds of kilometres away are important for enhancing recovery following localised mortality events of beaching and tropical cyclones (van Oppen et al. 2008; Underwood et al. 2007; Zvuloni et al. 2008) as these isolated systems must rely on local larval recruitment for regeneration (Gilmore et al. 2008).

Connectivity in fish populations tends to be stronger over wider scales than that of corals (Underwood et al. 2013). This is attributable to the fact that fish larvae spend up to several weeks in the plankton before they settle, are planktotrophic, may be able to delay metamorphosis without energetic costs, and can sense and swim towards reefs, particularly in their later stages (Underwood et al. 2013). Studies of genetic connectivity in the coral reef fish *Chromis margaritife*r among atolls of Scott Reef and the Rowley Shoals found that existing genetic connectivity between these systems is likely maintained by occasional long-distance (~30 km) dispersal of *C. margaritifer* larvae (Underwood, Travers & Gilmour 2012).

4.4.3 EBPC Act Listed species

The EPBC Act PMST (Appendix E) identified 81 listed marine species that are likely to, may, or are known to occur within the Operations and Planning Areas including listed Threatened and listed Migratory species.

Listed threatened species

The EPBC Act PMST (Appendix E) identified 22 Threatened (Vulnerable or Endangered) species that are either likely to, or may occur within the Operations and Planning Areas:

- Four marine mammals (Section 4.4.6)
- Five fish and sharks (Section 4.4.7)
- Five seabird species (Section 4.4.8)
- Eight marine reptile species (Section 4.4.9).

The relevant sections of this EP discuss the likelihood of these species and their biologically important areas occurring within the Operations and Planning Areas.

Listed migratory species

The EPBC Act PMST (Appendix E) identified 33 Listed Migratory species that are likely to, may, or are known to occur within the Operations and Planning Areas. Fourteen of these are also Listed Threatened Species. The Listed Migratory Species include:

- Nine marine mammals (Section 4.4.6)
- Nine fish, sharks, rays (Section 4.4.7)
- Eight marine bird species (Section 4.4.8)
- Seven marine reptiles (Section 4.4.9).

4.4.4 Mammals

The EPBC Act PMST (Appendix E) identified 27 listed marine mammals that are likely to, may, or are known to occur within the Planning Area (Table 4-4). Four of these are also listed Threatened and Migratory species. These are discussed in further detail below. An additional five marine mammal species that are likely to, may, or are known to occur within the Planning Area are listed as Migratory (Table 4-4). Although not identified as a threatened species in the PMST Report, the dugong is also described below because a small population has been recorded at Ashmore Reef (Whiting 1999), just outside the Planning Area. The OA is recognised as an area through which pygmy blue whales migrate (DoEE 2019a). See Section 4.4.6.1.2 for further details on the blue whale.

Table 4-4: EPBC Act listed marine mammals potentially occurring within the Operations and Planning Areas

Scientific name	Common name	EPBC Act status		Presence of species		Presence of BIAs		Relevant EPBC Act legislation
		Threatened	Migratory	Operations Area	Planning Area	Operations Area	Planning Area	
Balaenoptera borealis	**Sei whale**	**Vulnerable**	**Migratory**	**Species or species habitat likely to occur within area.**	**Species or species habitat likely occur within area**			***Balaenoptera borealis* (sei whale) conservation advice (TSSC 2015a)**
Balaenoptera edeni	**Bryde's whale**		**Migratory**	**Species or species habitat may occur within area**	**Species or species habitat likely to occur within area**			
Balaenoptera musculus	**Blue whale**	**Endangered**	**Migratory**	**Species or species habitat likely to occur within area**	**Migration route known to occur within area**	**Yes**	**Yes**	**Blue Whale Conservation Management Plan (DoE 2015a)**
Balaenoptera physalus	**Fin whale**	**Vulnerable**	**Migratory**	**Species or species habitat likely to occur within area**	**Species or species habitat likely occur within area**			***Balaenoptera physalus* (fin whale) conservation advice (TSSC 2015b)**

Delphinus delphis	**Common dolphin**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			
Dugong dugon	**Dugong**		**Migratory**		**Species or species habitat known to occur within area**			
Feresa attenuate	**Pygmy killer whale**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			
Globicephala macrorhynchus	**Short-finned Pilot Whale**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			
Grampus griseus	**Risso's Dolphin**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			
Kogia breviceps	**Pygmy Sperm Whale**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			
Kogia sima	**Dwarf Sperm Whale**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			
Lagenodelphis hosei	**Fraser's Dolphin**				**Species or species habitat may occur within area**			

Megaptera novaeangliae	**Humpback whale**	**Vulnerable**	**Migratory**	**Species or species habitat likely to occur within area**	**Species or species habitat likely occur within area**			***Megaptera novaeangliae*** **(humpback whale) Conservation Advice (TSSC 2015c)**
Mesoplodon densirostris	**Blainville's Beaked Whale**				**Species or species habitat may occur within area**			
Orcaella brevirostris	**Irrawaddy dolphin**				**Species or species habitat may occur within area**			
Orcinus orca	**Killer whale**		**Migratory**		**Species or species habitat may occur within area**			
Peponocephala electra	**Melon-headed Whale**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			
Physeter macrocephalus	**Sperm whale**		**Migratory**	**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			
Pseudorca crassidens	**False Killer Whale**			**Species or species habitat likely to occur within area**	**Species or species habitat likely to occur within area**			

Stenella attenuata	Spotted Dolphin			Species or species habitat may occur within area	Species or species habitat may occur within area			
Stenella coeruleoalba	Striped Dolphin			Species or species habitat may occur within area	Species or species habitat may occur within area			
Stenella longirostris	Long-snouted Spinner Dolphin			Species or species habitat may occur within area	Species or species habitat may occur within area			
Steno bredanensis	Rough-toothed Dolphin			Species or species habitat may occur within area	Species or species habitat may occur within area			
Tursiops aduncus	Indian Ocean Bottlenose Dolphin			Species or species habitat may occur within area	Species or species habitat may occur within area			
Tursiops aduncus (Arafura/ Timor Sea population)	Spotted bottlenose dolphin		Migratory	Species or species habitat may occur within area	Species or species habitat may occur within area			
Tursiops truncatus s. str.	Bottlenose Dolphin			Species or species habitat may occur within area	Species or species habitat may occur within area			
Ziphius cavirostris	Cuvier's Beaked Whale			Species or species habitat may occur within area	Species or species habitat may occur within area			

4.4.4.1 Whales

4.4.4.1.1 Sei whale

The sei whale (*Balaenoptera borealis*) is a baleen species, found in all oceans. The sei whale migratory movements are predominantly north-south with movements observed between Australian waters and Antarctic feeding areas, subantarctic feeding areas, and tropical and subtropical breeding areas. The available information suggests that sei whales are found in deeper water and have the same general pattern of migration as most other baleen whales including blue and fin whales, although the timing is generally later and the current scientific view is that the species does not go to such high latitudes (DEH 2005a; DoE 2015b).

The Conservation Advice for the sei whale (TSSC 2015a) and a search of the EPBC Act database identified that sei whales (classified as Vulnerable and Migratory species) may transit the waters of the Planning and Operations Areas. However, the NCVA (DoEE 2019b) indicates that there are no known BIA (feeding, breeding or resting areas) within the Planning and Operations Areas.

No known migration, aggregation or breeding areas for sei whales are located within the vicinity of the Planning and Operations Areas, and it is unlikely that individuals of this species will occur within these areas during the Gem 3D MSS.

4.4.4.1.2 Blue whale

The blue whale (*Balaenoptera musculus*) is the largest baleen whale, growing to longer than 30 m (Branch et al. 2007). The species is listed as Endangered and Migratory under the EPBC Act and is managed under the Blue Whale Conservation Management Plan (DoE 2015a). The blue whale is divided into three distinct subspecies (DoEE 2019a):

- Pygmy blue whale (*B. musculus brevicauda*)
- Southern blue whale (*B. musculus intermedia*)
- Northern blue whale (*B. musculus musculus*).

Of these subspecies, only the pygmy blue whale (*B. musculus brevicauda*) is expected to potentially occur within the OA as the southern blue whale is generally restricted to waters south of 60°S and the northern blue whale occurs in the Northern Hemisphere (DoEE 2019a).

Pygmy blue whales are known to migrate between warm water (low-latitude) breeding grounds and cold water (high-latitude) feeding grounds. During the northern migratory pathway along the Western Australian coast, pygmy blue whales aggregate in the Perth Canyon to feed from January to May (Rennie et al. 2009), and then move up the coast passing Exmouth in the period April to August, before continuing north (McCauley & Jenner 2010). Studies carried out which tagged pygmy blue whales during their migration recorded individuals offshore between 40 and 100 km (Double et al. 2012). This same study tracked the pygmy blue whale population feeding in the Perth Canyon to their northern destinations in the Banda and Molucca Seas (Indonesia), suggesting these locations are calving areas (Double et al. 2012).

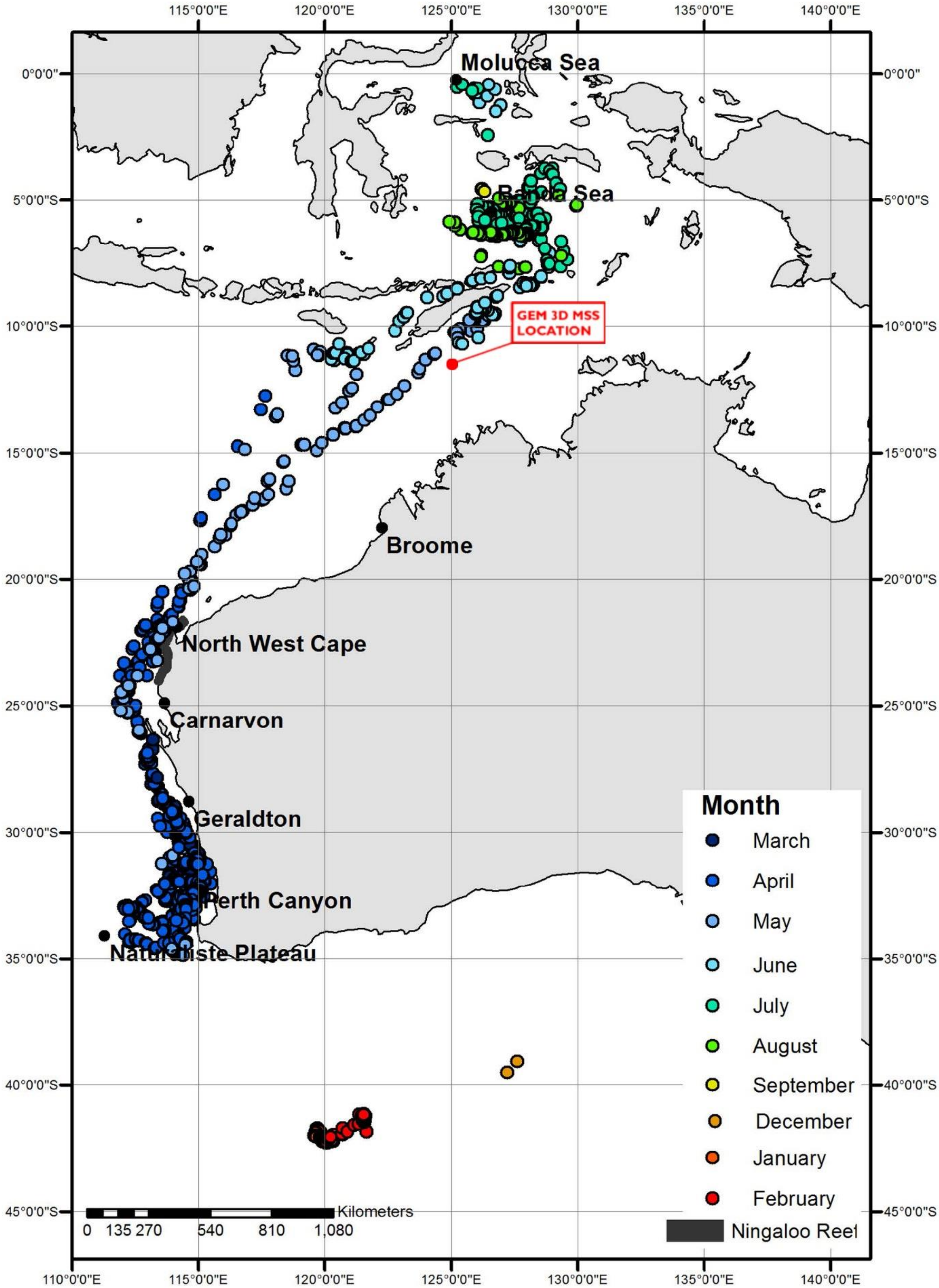
During their northern migration, tagged pygmy blue whales were recorded between 40 and 100 km from the coastline in March and April. From the North West Cape, tagged individuals continued to travel northwards and further offshore (238.0 ±13.9 km) in May towards the Savu and Timor seas (Double et al. 2014). The tagging study conducted by Double et al. (2014) identified that northbound whales spend more time in four areas: Perth Canyon–Naturaliste Plateau region, North West Cape–Ningaloo Reef region, Indonesian waters and the subtropical frontal zone (Figure 4-7 and Figure 4-8).

The southern migration down the Western Australian coast occurs between September and late December (McCauley and Jenner 2010, Double et al. 2014). Individuals have been recorded passing along the shelf edge at depths of 500 to 1,000 m, moving faster on the southern migration to reach feeding grounds and coming in close to the coast in the Exmouth to the Montebello Islands area (McCauley and Jenner 2010).

The Conservation Management Plan for the blue whale (2015 - 2025) (Commonwealth of Australia 2015) identifies two BIAs within the Planning Area, the foraging area and migratory pathway, which encompasses the northern and southern migration. The OA overlaps an area where pygmy blue whales are known to be present (Commonwealth of Australia 2015). The Gem 3D MSS timing and the OA overlap with the BIAs for whales migrating south from Indonesia (Table 4-5, Figure 4-9). Key threats identified in the Conservation Management Plan relevant to the proposed activity include; noise interference and vessel disturbance (i.e. vessel presence or collision), as well as ocean acidification (from the combustion of fossil fuels) and marine debris. These potential threats are addressed in Section 6 of this EP. No known feeding aggregation or breeding areas are located within the vicinity of the Planning and Operations Areas. Therefore, this species is unlikely to be encountered during the survey except for rare encounters with individual pygmy blue whales, particularly transiting through the northern part of the OA during the southern migration.

Table 4-5: Migrating periods for pygmy blue whales from south west Western Australia to Indonesia

Migration route	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern Migration (SW WA to Indonesia)												
Southern Migration (Indonesia to SW WA)												



(Source Double et al. 2014)

Figure 4-7: Filtered satellite tag derived locations of pygmy blue whales (n=11) by month

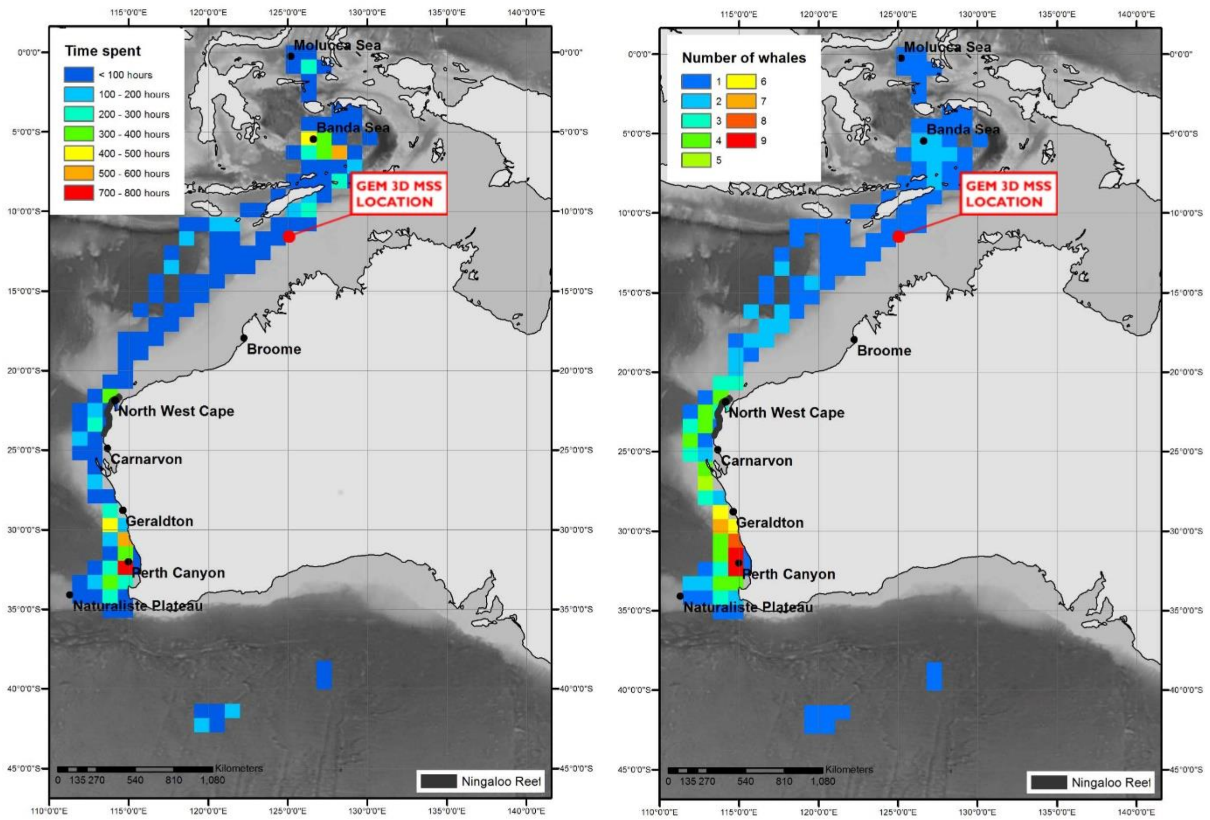


Figure 4-8: Gridded measures of time spent and occupancy for satellite tagged pygmy blue whales (n=11) a) total time spent b) number of whales

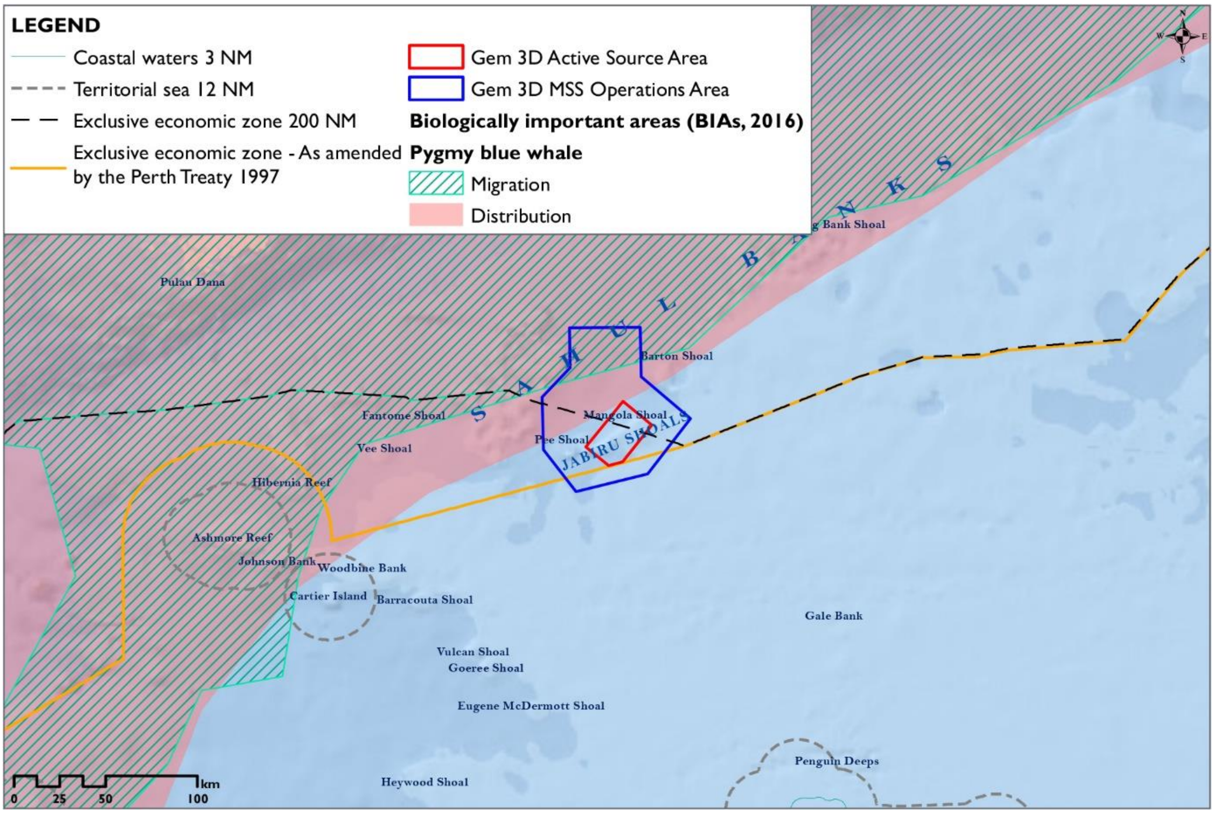


Figure 4-9: Biologically important areas of migrating pygmy blue whales

4.4.4.1.3 Fin whale

The fin whale (*Balaenoptera physalus*) is a baleen whale that occurs from polar to tropical waters. Although widely distributed in both hemispheres, the biology and life history of the species is poorly understood (TSSC 2015b). The Conservation Advice for the fin whale (TSSC 2015b) and a search of the EPBC Act database identified that fin whales (classified as Vulnerable and Migratory species) may transit the waters of the Planning and Operations Areas. However, the NCVA (DoEE 2019c) indicates that there are no known BIAs (feeding, breeding or resting areas) within the Planning and Operations Areas. The key threats identified in the Conservation Advice that are relevant to the proposed activity include anthropogenic noise and acoustic disturbance, habitat degradation including pollution, pollution from persistent toxic pollutants and vessel strike, all of which are identified as having a 'minor' consequence rating. These potential threats are addressed in this EP.

No known migration, aggregation or breeding areas for fin whales are located within the vicinity of the Planning and Operations Areas (DoEE 2019c) and it is unlikely that individuals of this species will occur within these areas during the Gem 3D MSS.

4.4.4.1.4 Humpback whale

The humpback whale (*Megaptera novaeangliae*) is listed as Vulnerable and Migratory under the EPBC Act and is managed under the *Megaptera novaeangliae* (humpback whale) Conservation Advice (TSSC 2015c). The species has a cosmopolitan distribution in temperate waters, with whales off Western Australia undertaking an annual migration between feeding grounds in the Southern Ocean and calving and breeding areas off northern Western Australia, notably Camden Sound which lies over 300 km south of the OA (Jenner et al. 2001). Given the northern extent of the humpback whale migration is generally regarded as Camden Sound, with the highest abundance between July and September (Jenner et al. 2001), they are not expected to occur within the Planning and Operations Areas during the Gem 3D MSS.

4.4.4.1.5 Dugong

The dugong (*Dugong dugon*) is associated with shallow benthic seagrass and macroalgal habitats across northern Australia. The main dugong populations in Western Australia inhabit nearshore and coastal marine habitats in Shark Bay, Ningaloo Marine Park and Exmouth Gulf, and between Exmouth Gulf and the De Grey River (Gales et al. 2004; Marsh et al. 2002). A small population has been recorded at Ashmore Reef and appears to be genetically distinct from the mainland populations (Whiting 1999). This population was observed to have a close affinity with seagrass habitat on the Sahul Banks. Dugongs are generally solitary but may travel in pairs or in association with small groups (three to six individuals). Given that the benthic habitat of the OA consists mostly of unconsolidated sandy and muddy substrate at depths of 110 - 440 m and the shallower shoals are dominated by coral communities and the coralline algae *Halimeda* spp., dugongs are very unlikely to occur in the OA.

4.4.5 Fish and sharks

The EPBC Act PMST search identified 30 listed teleost fish species that are likely to, may, or are known to occur within the Operations and Planning Areas. These are described in further detail in Section 4.4.5.1. Commercial species and site-attached reef species are described in Sections 4.4.5.3 and 4.4.5.4, respectively. The EPBC Act PMST (Appendix E) also identified ten listed sharks and rays that are likely to, may, or are known to occur within the Planning Area (Table 4-6). These are described in the table below and discussed in further detail in Section 4.4.5.2.

Table 4-6: EPBC Act listed sharks and rays potentially occurring within the Operations and Planning Areas

Scientific name	Common name	EPBC Act status		Presence of species		Presence of BIAs		Relevant EPBC Act legislation
		Threatened	Migratory	Operations Area	Planning Area	Operations Area	Planning Area	
Anoxypristis cuspidate	**Narrow sawfish**		**Migratory**		**Species or species habitat may occur within area**			
Carcharodon carcharias	**Great white shark**	**Vulnerable**	**Migratory**	**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			**Recovery plan for the White Shark (*Carcharodon carcharias*) 2013**
Glyphis garricki	**Northern river shark**	**Endangered**		**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			**Approved Conservation Advice for *Glyphis garricki* (northern river shark) (DoE 2014)** **Sawfish and River Sharks Multispecies Recovery Plan (Commonwealth of Australia 2015)**
Isurus oxyrinchus	**Shortfin mako**		**Migratory**		**Species or species habitat may occur within area**			
Isurus paucus	**Longfin mako**		**Migratory**		**Species or species habitat may occur within area**			

Manta alfredi	**Reef manta ray**		**Migratory**		**Species or species habitat may occur within area**			
Manta birostris	**Giant manta ray**		**Migratory**		**Species or species habitat may occur within area**			
Pristis pristis	**Freshwater sawfish**	**Vulnerable**	**Migratory**	**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			**Approved Conservation Advice for *Pristis pristis* (largetooth sawfish) (TSSC 2014)** **Sawfish and River Sharks Multispecies Recovery Plan (Commonwealth of Australia 2015)**
Pristis zijsron	**Green sawfish**	**Vulnerable**	**Migratory**	**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			**Approved Conservation Advice for Green Sawfish (TSSC 2008a)** **Sawfish and River Sharks Multispecies Recovery Plan (Commonwealth of Australia 2015)**
Rhincodon typus	**Whale shark**	**Vulnerable**	**Migratory**	**Foraging, feeding or related behaviour known to**	**Foraging, feeding or related behaviour known to occur within area**	**Yes**	**Yes**	**Conservation Advice *Rhincodon typus* whale shark (TSSC 2015f)**

				occur within area				

4.4.5.1 Demersal and pelagic fish

A search of the EPBC Act PMST indicated that 30 listed teleost fish may occur within the vicinity of the OA. All 30 of these species are within the family Syngnathidae (seahorses and pipefish), none of which are listed as Threatened or Migratory under the EPBC Act. Species within this family typically are generally site-attached and associated with shallow reef habitats 0-60 m depth (Allen & Steene 1988; Dawson 1985; Fricke, Kulbicki & Wantiez 2011; Kuiter & Tonozuka 2001; Lourie, Vincent & Hall 1999; Myers 1999). Seahorses and pipefish are distributed widely in similar shallow reef habitats throughout the Sahul Shelf region, including Ashmore Reef, Cartier Island and Hibernia Reef (Geoscience Australia 2018). However, species in the Halicampus genus, of which four species are PMST listed species, commonly occur as adults in estuarine environments and the terminal reaches of coastal streams and mangroves rather than on coral reefs or in the open sea (Dawson 1985) and so are unlikely to be found within the OA.

4.4.5.2 Sharks, rays

The EPBC Act PMST (Appendix E) identified 10 listed sharks and rays that are likely to, may, or are known to occur within the Planning Area (Table 4-6). Five are listed as Threatened, with four of these also listed as Migratory species and a further four listed as Migratory (Table 4-6). The Threatened species are further described below.

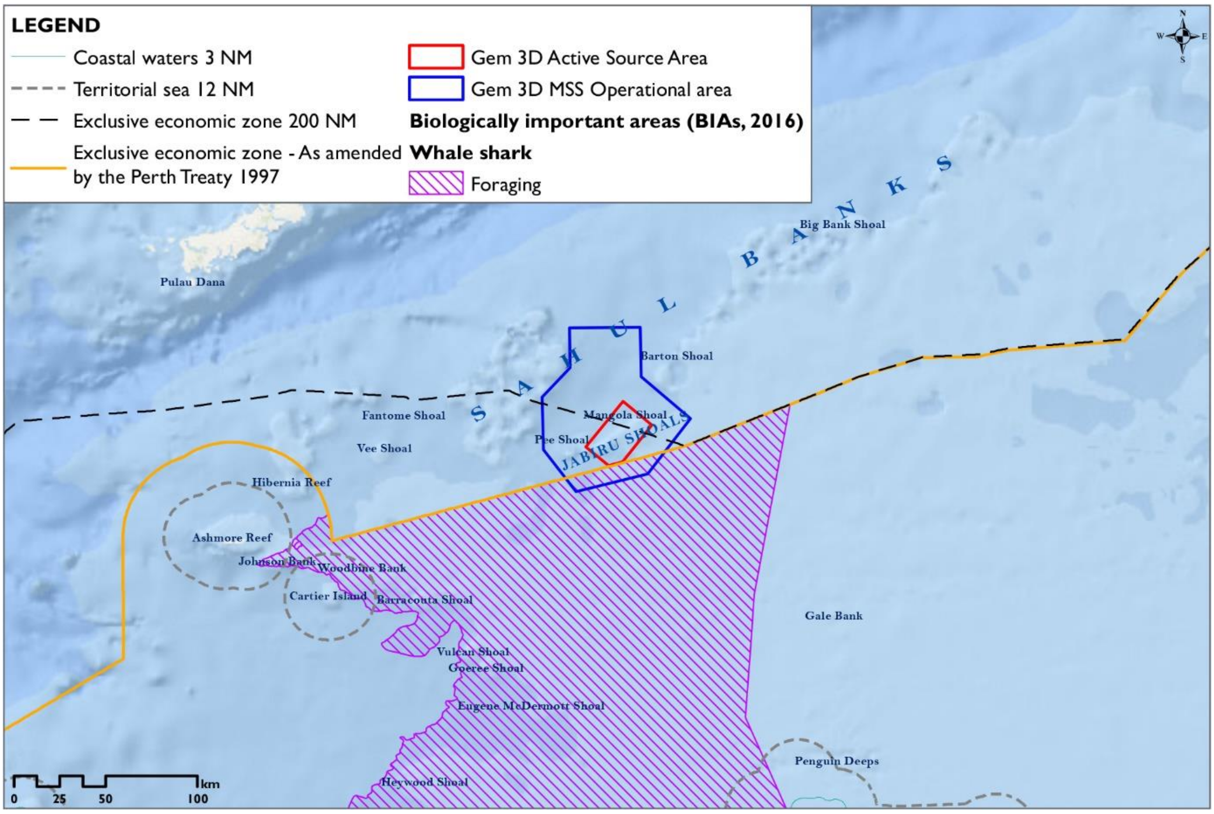


Figure 4-10: Biologically important areas of sharks in the Gem 3D MSS Planning Area

4.4.5.2.1 Great white shark

The great white shark (*Carcharodon carcharias*) is listed as vulnerable and migratory under the EPBC Act and appears under the CITES Appendix II and CMS Appendix I and II. Great white sharks are widely but sparsely distributed in all seas including cold temperate waters in both hemispheres. This species is most frequently observed and captured in coastal temperate and subtropical regions. Additionally they have been observed in tropical areas such as the Coral Sea, Papua New Guinea, the central Pacific, northern Brazil and the tropical south-west Indian Ocean (DoEE 2019d).

The Recovery Plan for the great white shark identifies high density foraging sites, mostly around seal and sea lion colonies, and juvenile aggregation sites (DSEWPaC 2013). No BIAs have been identified for this species in the vicinity of the Planning and Operations Areas. No key threats are identified relevant to the proposed activity. Given the Planning and Operations Areas are at the northern limit of the known distribution of this species in Western Australia (DoEE 2019d), they are unlikely to occur within the OA during the period of the Gem 3D MSS.

4.4.5.2.2 Northern river shark

The northern river shark (*Glyphis garricki*) is listed as endangered under the EPBC Act and is managed under the Sawfish and River Sharks Multispecies Recovery Plan (Commonwealth of Australia 2015). The northern river shark is capable of living in and moving between freshwater and seawater, with the species utilizing rivers, tidal sections of large tropical estuarine systems, microtidal embayments, inshore and offshore marine habitats (DoE 2014). Neonates, juveniles and subadults have been recorded in freshwater, estuarine and marine environments, whereas adults have only been recorded in the marine environment (DoE 2014). The presence of animals well offshore suggests northern river sharks undertake movements away from rivers and estuaries and therefore likely to move between river systems, however, the extent to which this occurs and the distances moved is unknown (DoE 2014). Northern river sharks are believed to be endemic to Australia and southern New Guinea, and outside of Australia, the species is known from only a few specimens from the Fly River in Papua New Guinea (DoE 2014). The global population size of northern river sharks is unknown and the relationship between the Australian and global populations is poorly understood (DoE 2014). Given the Planning and Operations Areas are located a considerable distance from any critical habitats identified for northern river sharks the available evidence suggests that the species is unlikely to occur within the Planning and Operations Areas, with the possible exception of mature individuals transiting through the area.

4.4.5.2.3 Freshwater sawfish

The freshwater sawfish (*Pristis pristis*) is listed as vulnerable and migratory under the EPBC Act and is managed under the Sawfish and River Sharks Multispecies Recovery Plan (Commonwealth of Australia 2015). Mainly confined to the main channels of large rivers, the freshwater sawfish potentially occur in all large rivers of northern Australia from the Fitzroy river in Western Australia over to the western side of Cape York Peninsular, Queensland (DoEE 2019e). The freshwater sawfish is a marine/estuarine species that spends its first three to four years in freshwater with juveniles and sub adult individuals predominantly found in rivers and estuaries, while larger mature animals tend to occur in coastal and offshore waters up to 25m in depth (DoEE 2019e). A study on the movement patterns of other sawfish species 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 (DoEE 2019e). Given the Planning and Operations Areas are located a considerable distance from any critical habitats identified for freshwater sawfish the available evidence suggests that the species is unlikely to occur within the Planning and Operations Areas.

4.4.5.2.4 Green sawfish

The green sawfish is listed as vulnerable and migratory under the EPBC Act and is managed under the Sawfish and River Sharks Multispecies Recovery Plan (Commonwealth of Australia 2015). Green sawfish are currently distributed from about the Whitsundays in Queensland across northern Australian waters to Shark Bay in Western Australia (Commonwealth of Australia 2015). Green sawfish have been recorded in inshore marine waters, estuaries, river mouths, embankments and along sandy and muddy beaches (Commonwealth of Australia 2015). Green sawfish have been recorded in very shallow water (<1 m) to offshore trawl grounds in over 70 m of water (Commonwealth of Australia 2015). The majority of records for green sawfish in Australia are of juvenile and sub-adult animals from rivers (Commonwealth of Australia 2015). The nearest green sawfish BIAs are located approximately 1000 km south-west of the Planning and Operations Areas and comprise a pupping, nursing and foraging ground that runs east from Cape Keraudren along 80 Mile Beach for around 250 km but is restricted to within 25 km from shore (TSSC 2008a).

Given the Planning and Operations Areas are located 1000 km from any critical habitats identified for green sawfish the species is unlikely to occur within the Planning and Operations Areas, with the possible exception of mature individuals.

4.4.5.2.5 Whale shark

The whale shark (*Rhincodon typus*) is listed as vulnerable and migratory under the EPBC Act, vulnerable on the IUCN Red List, and is managed under the EPBC Act Conservation Advice *Rhincodon typus* whale shark (TSSC 2015d). The whale shark was identified as potentially occurring within the Planning Area. This species is broadly distributed in tropical and temperate seas worldwide, feeding on phytoplankton, macroalgae, plankton, krill and small squid or vertebrates (DoEE 2019g). Whale sharks aggregate annually off the Western Australian coast at Ningaloo Reef between March and May. Sharks tagged at this aggregation have been shown to migrate northwards into the Timor Sea (Meekan & Radford 2010). It is known that the 200 m isobath is an important migratory route for the species, with migration occurring between July and November.

The south-eastern portion of the OA for the Gem 3D MSS overlaps a very small extent of the whale shark foraging BIA, which extends northwards across the North West Shelf and the Browse Basin along the 200 m isobath (Figure 4-13). However, it is possible that individual whale sharks may transit through the OA. The underwater noise generated by the operating seismic vessel is considered likely to cause localised avoidance behaviour in whale sharks as described in Section 6, reducing the potential for physical interactions.

The recovery plan for whale sharks ceased to be in effect in 2015, however the EPBC Act still provides conservation advice due to the decline in the single global population of the species. Internationally, threats to the whale shark include intentional and unintentional mortality due to fishing, however in Australia most concern is regarding boat strike and habitat disruption from exploration (TSSC 2015d).

Whale sharks may occur at low densities within the Planning and Operations Areas.

4.4.5.3 Commercial species

Consultation with DPIRD and AFMA indicated several species of demersal and pelagic fish that are targeted commercially within the OA (Appendix C). These include 15 teleost fish species from the families Lutjanidae (snappers and seaperches), Lethrinidae (emperors) and Epinephelinae (cods and groupers). Of these species, red emperor and goldband snapper are considered to be ‘indicator species’ for the Kimberley region (Newman et al. 2018). Indicator species are used to assess the risk to sustainability of all ‘like’ species susceptible to capture within a fishery resource. They are determined via information on their inherent vulnerability (e.g. biological attributes); risk to sustainability (e.g. stock status); and management importance (e.g. commercial prominence, social and/or cultural amenity value of the resource) (Newman et al. 2018).

Table 4-7 describes the indicator species of commercially important fisheries within the OA. Two other species captured within the OA, rankin cod and bluespotted emperor, are also described in Table 4-7 as they are identified as indicator species for the Pilbara region and enable description of all commercial taxa caught in the area.

*Table 4-7: Indicator species for commercially important fisheries that overlap the Operations Area**

Species	Red emperor (*Lutjaunus sebae*)	Goldband snapper (*Pristipomoides multidens*)	Rankin cod (*Epinephelus multinotatus*)	Bluespotted emperor (*Lethrinus puntulatus*)	Southern Bluefin Tuna (*Thunnus maccoyii*)	Other demersal species
Family	**Lutjanidae**	**Lutjanidae**	**Epinephelinae**	**Lethrinidae**	**Scombridae**	**N/A**
Stock status	**Sustainable**	**Sustainable**	**Sustainable**	**Sustainable**	**Overfished**	**Sustainable**
Distribution	**Indo-West Pacific** **WA: Widely distributed across Western Australia – as far south as Rottnest Island to the NT border**	**Restricted Indo-Pacific** **WA: From the Abrolhos Islands northwards to the NT border**	**Indian Ocean** **WA: Abrolhos Islands north to Cape Leveque**	**Endemic - Exmouth to Darwin** **WA: along the northwest coast from the Abrolhos Islands to the NT**	**Throughout the Atlantic, Pacific and Indian Oceans**	**Variable**
Depth range	**10-180 m**	**50-200 m** **80-140 m****	**10-150 m**	**5-110 m**	**Up to 500 m**	**Variable**
Habitat	**Demersal** **Rocky or coral reefs and rubble seabeds**	**Demersal** **Deep coastal waters, rocky or rubble seabed on the edge of the continental shelf**	**Demersal** **Inshore coral reefs and deeper offshore waters**	**Coral reefs, sand and rubble as well as seagrass beds**	**Pelagic**	**Demersal** **Variable**
Diet	**Small invertebrates and fish**	**Small invertebrates and fish**	**Small invertebrates and fish**	**Small invertebrates and fish**	**Fish, cephalopods, crustaceans**	**Variable**

Reproduction mode	**Gonochoristic**	**Gonochoristic**	**Protogynous**	**Functionally Gonochoristic**	**Gonochoristic**	**Variable**
Spawning season	**Sept-June (bimodal peaks Sept-Nov and Jan-Mar)**	**Kimberley: Nov-May (extended peak period)**	**June-Dec and Mar (peak Aug-Oct)**	**Jul-Mar (extended peak spawning period)**	**September-October and February -March**	**Typically peak spawning Oct-May**
Spawning Area	**No specific area – spawns throughout range**	**No specific area – spawns throughout range**	**No specific area – spawns throughout range**	**No specific area – spawns throughout range**	**North-eastern Indian Ocean, south of Java**	**No specific area – spawns throughout range**

*(Evans et al. 2012; Rome & Newman 2010); DPIRD Principal Scientist, pers. comm. 23/5/2019.

**(80-140 m is the principal goldband snapper depth range (ERM 2019).

Consultation with DPIRD and AMFA indicated the Planning Area may also overlap the spawning and migration grounds of southern bluefin tuna which is targeted by commercial fishers in SE Australia (see Section 4.5.1) but spawns 150 km from the OA (Appendix C). Spawning occurs in peaks in September/ October and February/ March, however mature individuals have been sighted in the area annually (Evans et al. 2012).

The spawning periods for key indicator species of commercial fisheries identified in Table 4-7 are summarised below in Table 4-8.

Table 4-8: Spawning periods of commercial fishery key indicator species within the Gem 3D MSS Operations Area

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Red emperor (*Lutjanus sebae*)												
Goldband snapper (*Pristipomoides multidens*)												
Rankin cod (*Epinephelus multinotatus*)												
Bluespotted emperor (*Lethrinus punctulatus*)												
Bluespotted emperor (*Lethrinus punctulatus*)												
Other demersal species												

Key: grey= spawning expected; dark grey = peak spawning time (DPIRD Principal Scientist, pers comm. 23/5/2019)

4.4.5.4 Site-attached fish species

BRUV surveys conducted on upper areas (21-35 m) of shoals within the OA in 2010 showed a high diversity and abundance of teleost (bony fishes) and shark species typical of shallow reef systems (Table 4-9). These included species from families Pomacentridae (damselfishes) and Labridae (wrasses). Because body size is positively related to home-range area in reef fish (Nash et al. 2015), these smaller-sized species are expected to have small home ranges (tens of metres in size) compared to larger species such as those in the families Serranidae and Lethrinidae which may regularly move hundreds or even thousands of metres (Chapman and Kramer 2000). Damselfishes are highly territorial species that dwell on reef slopes and passages at 5-40 m. Wrasses are highly diverse and represent the second largest family of reef fishes occurring over rubble, weed or coral reef structure. Smaller to mid-sized species of wrasse are found at 5-50 m, protect themselves by hiding within reef structure and can exhibit territorial behaviours (Allen 2009). Larger-sized species, such as the humphead Maori wrasse (*Cheilinus undulates*) can extend to 100 m (Edgar 2008). These larger-sized species may move across or around shoals whilst remaining in their preferred depth range but are unlikely to move across open water to other shoals (Chapman and Kramer 2000).

Spawning seasons for site-attached reef fish families are not well documented globally, however it is accepted most reef fishes have a distinct spawning season over summer months and that reproductive behaviour will peak at some point during this time (Cowen, Hare & Fahay 1993; Davis & West 1993; Johannes 1978; Thresher 1984). Therefore, it is expected that spawning of site-attached fish found throughout the OA will occur throughout the year, and peak in the summer months.

Table 4-9: Species list for fishes recorded by BRUVs during the 2010 wet season survey of shoals within the Operations Area (ERM 2012)

Family	Species	Reef-associated	Australian Waters	Indo-Pacific
Acanthuridae	***Acanthurus nigricans***	X	X	X
	Ctenochaetus striatus	X	X	X
Balistidae	***Melichthys niger***	X	X	X
	Melichthys vidua	X	X	X
	Sufflamen chrysopterum	X	X	X
Chaetodontidae	***Chaetodon trifascialis***	X	X	X
Labridae	***Halichoeres hortulanus***	X	X	X
	Halichoeres prosopeion	X	X	X
	Labroides bicolor	X	X	X
	Labroides dimidiatus	X	X	X
Lethrinidae	***Lethrinus microdon***	X	X	X
Mullidae	***Parupeneus multifasciatus***	X	X	
Pinguipedidae	***Parapercis clathrata***	X	X	X
Pomacanthidae	***Centropyge bicolor***	X	X	
	Centropyge tibicen	X	X	
	Centropyge vrolikii	X	X	X
Pomacentridae	***Chromis fumea***	X	X	X
	Pomacentrus coelestis	X	X	X
Scaridae	***Chlorurus microrhinos***	X	X	
	Scarus species	X	X	
Serranidae	***Variola louti***	X	X	X

Note: Reef-associated and fish distribution (in Australian waters and the wider Indo-Pacific) were confirmed using Fishbase.

4.4.6 Birds

The EPBC Act PMST (Appendix E) identified 17 listed seabirds and shorebirds that are likely to, may, or are known to occur within the Planning Area (Table 4-10). Five of the species identified are listed as Threatened and eight are listed as Migratory under the EPBC Act. These are discussed in further detail below (see Section 4.4.6.1)

Table 4-10: EPBC Act listed seabirds and shorebirds potentially occurring within the Operations and Planning Areas

Scientific name	Common name	EPBC Act status		Presence of species		Presence of BIAs		Relevant EPBC Act legislation
		Threatened	**Migratory**	**Operations Area**	**Planning Area**	**Operations Area**	**Planning Area**	
Actitis hypoleucos	**Common sandpiper**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			
Anous stolidus	**Common noddy**		**Migratory**	**Species or species habitat may occur within area**	**Foraging, feeding or related behaviour known to occur within area**			
Anous tenuirostris melanops	**Australian lesser noddy**	**Vulnerable**		**Species or species habitat may occur within area**	**Foraging, feeding or related behaviour known to occur within area**			**Conservation Advice *Anous tenuirostris melanops* Australian lesser noddy (TSSC 2015g)**
Calidris acuminate	**Sharp-tailed sandpiper**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			

Calidris canutus	Red Knot, Knot	Endangered		Species or species habitat may occur within area	Species or species habitat may occur within area			Conservation Advice *Calidris canutus* Red knot (TSSC 2016a)
Calidris furruginea	Curlew sandpiper	Critically endangered		Species or species habitat may occur within area	Species or species habitat may occur within area			Conservation Advice *Calidris ferruginea* curlew sandpiper (TSSC 2015h)
Calidris melanotos	Pectoral sandpiper			Species or species habitat may occur within area	Species or species habitat may occur within area			
Calonectris leucomelas	Streaked shearwater		Migratory	Species or species habitat may occur within area	Species or species habitat likely to occur within area			
Fregata airel	Lesser frigatebird		Migratory	Species or species habitat likely to occur within area	Breeding likely to occur within area		Yes	
Fregata minor	Greater frigatebird		Migratory	Species or species habitat may occur within area	Foraging, feeding or related behaviour likely to occur within area		Yes	

Numenius madagascariensis	**Eastern curlew, Far eastern curlew**	**Critically endangered**		**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			**Conservation Advice *Numenius madagascariensis* eastern curlew (TSSC 2015i)**
Papasula abbotti	**Abbott's booby**	**Endangered**			**Species or species habitat may occur within area**			**Conservation Advice *Papasula abbotti* Abbott's booby (TSSC 2015j)**
Phaethon lepturus	**White-tailed tropicbird**		**Migratory**		**Foraging, feeding or related behaviour likely to occur within area**		**Yes**	
Sterna bengalensis	**Lesser crested tern**				**Breeding known to occur within area**		**Yes**	
Sterna dougallii	**Roseate tern**		**Migratory**		**Foraging, feeding or related behaviour likely to occur within area**		**Yes**	
Sula leucogaster	**Brown booby**		**Migratory**		**Breeding known to occur within area**		**Yes**	
Sula sula	**Red - footed booby**		**Migratory**		**Breeding known to occur within area**		**Yes**	

4.4.6.1 Threatened seabirds and shorebirds

There are no BIAs for seabirds or shorebirds in or near the Operations Area. Several species have been recorded from Ashmore Reef and Cartier Island areas. Both Ashmore Reef (outside the Planning Area) and Cartier Island are considered important habitat for a number of seabirds and shorebirds (Clarke 2010; Commonwealth of Australia 2002a).

The EPBC Act PMST did not list the wedge-tailed shearwater (*Puffinus pacificus,* also known as *Ardenna pacifica*) as potentially present; however, this species has a breeding and foraging BIA that overlaps a portion of the Planning Area (Figure 4-11). It is likely to be encountered occasionally in the Planning Area.

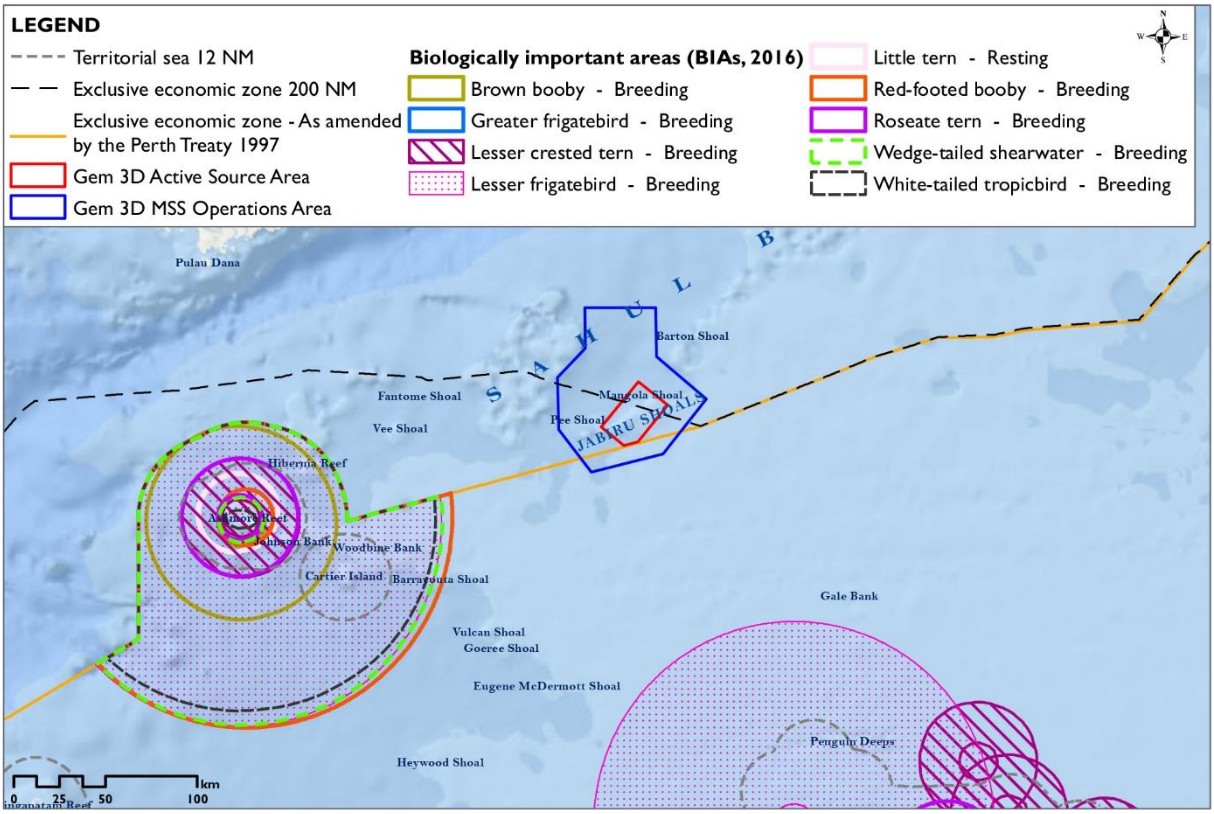


Figure 4-11: Biologically important areas of seabirds and shorebirds within the Gem 3D MSS Planning Area

4.4.6.1.1 Australian lesser noddy

The Australian lesser noddy (*Anous tenuirostris melanops*) is listed as vulnerable under the EPBC Act and managed under the Conservation Advice *Anous tenuirostris melanops* Australian lesser noddy (TSSC 2015e). The species is a small seabird with a wingspan of approximately 60 cm. The species is known to breed on the Houtman Abrolhos islands off the mid-west coast of Western Australia (DoEE 2019h). The species may also breed on Ashmore Reef (Stokes & Hinchey 1990); however this has not been confirmed conclusively. The species was not observed by Clarke (Clarke 2010) on Ashmore Reef or Cartier Island, although the closely related lesser noddy (*Anous tenuirostris*) was recorded as present. There are no BIAs within the Planning and Operations Areas, however the species may occur in the vicinity of these Areas.

4.4.6.1.2 Red knot

The red knot (*Calidris canutus*) is listed as endangered under the EPBC Act and managed under the Conservation Advice *Calidris canutus* Red knot (TSSC 2016). The species is a small seabird with a wingspan of approximately 45-54cm (DoEE 2019i). The red knot mainly inhabit intertidal mudflats, sandflats and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbours;

sometimes on sandy ocean beaches or shallow pools on exposed wave-cut rock platforms or coral reefs (DoEE 2019i). The red knot usually forages in soft substrate near the edge of water on intertidal mudflats or sandflats exposed by low tide (DoEE 2019i). Red knots have also been recorded foraging on beds of eelgrass on tidal sandflats, on a thick algal mat in shallow waters, and in shallow pools on crest of coral reef (DoEE 2019i). The red knot roosts on sandy beaches, spits and islets, and mudflats; also in shallow saline ponds of saltworks (DoEE 2019i). There are no BIAs within the Planning and Operations Areas, however the species may occur in the vicinity of these Areas.

4.4.6.1.3 Curlew sandpiper

The curlew sandpiper (*Calidris ferruginea*) is listed as critically endangered under the EPBC Act and managed under the Conservation Advice *Calidris ferruginea* curlew sandpiper (DoE 2015d). There are no BIAs for this species within the Planning and Operations Areas. The species is a small, slim sandpiper with a wingspan of approximately 38-41cm (DoEE 2019j). The curlew sandpiper’s distribution is around the coasts and are also quite widespread inland, though in smaller numbers (DoEE 2019j). Curlew sandpipers mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms (DoEE 2019j). The species rarely forages on exposed reefs (DoEE 2019j), and hence is unlikely to be encountered in the Planning and Operations Areas, however, may transit through the areas.

4.4.6.1.4 Eastern curlew

The eastern curlew (*Numenius madagascariensis*) is listed as critically endangered under the EPBC Act and managed under the Conservation Advice *Numenius madagascariensis* eastern curlew (DoE 2015e). The species is the largest migratory shorebird in the world with a wingspan of approximately 110cm (TSSC 2015g). The eastern curlew has a primarily coastal distribution, rarely being recorded inland (DoE 2015e). 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 (DoE 2015e). The eastern curlew does not breed in Australia (DoE 2015e). The eastern curlew mainly forages on soft sheltered intertidal sandflats or mudflats, open and without vegetation or covered with seagrass, often near mangroves, on saltflats and in saltmarsh, rockpools and among rubble on coral reefs, and on ocean beaches near the tideline (DoE 2015e). There are no BIAs for this species within the Planning and Operations Areas, however the species may occur in the vicinity of these Areas.

4.4.6.1.5 Abbotts booby

The Abbott’s booby (*Papasula abbotti*) is listed as endangered under the EPBC Act and managed under the Conservation Advice *Papasula abbotti* Abbott's booby (TSSC 2015h). Currently the species is only known to breed on Christmas Island and to forage in the waters surrounding the island (DoEE 2019k). The species is a marine species, spending most of its time at sea, but comes ashore to breed (DoEE 2019k). Abbott’s booby feeds on squid and fish, and are known to go on long fishing trips in a north-west direction, towards one of the major upwellings (DoEE 2019k). It is thought the species can travel up to 400 km to feeding grounds when they area breeding (DoEE 2019k). There are no BIAs for this species within the Planning and Operations Areas, however the species may occur in the vicinity of these areas.

4.4.6.2 Migratory species

The nine migratory seabird species likely to occur in the region of the OA, including the eight species known to nest on Ashmore Reef (Table 4-10), are highly mobile and are all expected to range throughout the Planning and Operations Areas. All of these species forage widely over the waters surrounding emergent roosting sites and nesting sites. Different species nest in different seasons and nesting birds may be present during both wet and the dry seasons.

4.4.7 Marine reptiles

The EPBC Act PMST (Appendix E) identified 27 listed marine reptiles that are likely to, may, or are known to occur within the Operations and Planning Areas (Table 4-11). Eight of the species identified are listed as Threatened and seven are listed as Migratory under the EPBC Act. These are discussed in further detail below. There are no BIAs for any marine reptiles in the Operations Area.

Table 4-11: EPBC Act listed marine reptiles potentially occurring within the Operations and Planning Areas

Scientific name	Common name	EPBC Act status		Presence of species		Presence of BIAs		Relevant EPBC Act legislation
		Threatened	**Migratory**	**Operations area**	**Planning Area**	**Operations area**	**Planning Area**	
Acalyptophis peronii	**Horned Seasnake**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			
Aipysurus apraefrontalis	**Short-nose seasnake**	**Critically endangered**			**Species or species habitat known to occur within area**			**Approved Conservation Advice for *Aipysurus apraefrontalis* (Short-nosed Sea Snake) (TSSC 2011a)**
Aipysurus duboisii	**Dubois' Seasnake**				**Species or species habitat may occur within area**			
Aipysurus eydouxii	**Spine-tailed seasnake**				**Species or species habitat may occur within area**			

Aipysurus foliosquama	Leaf-scaled Seasnake	Critically endangered		Species or species habitat may occur within area	Species or species habitat known to occur within area			Approved Conservation Advice for *Aipysurus foliosquama* (Leaf-scaled Sea Snake) (TSSC 2011b)
Aipysurus fuscus	Dusky Seasnake				Species or species habitat known to occur within area			
Aipysurus laevis	Olive Seasnake			Species or species habitat may occur within area	Species or species habitat may occur within area			
Astrotia stokesii	Stokes' Seasnake			Species or species habitat may occur within area	Species or species habitat may occur within area			
Caretta caretta	Loggerhead turtle	Endangered	Migratory	Foraging, feeding or related behaviour likely to occur within area	Foraging, feeding or related behaviour known to occur within area		Yes	Recovery Plan for Marine Turtles in Australia (DoEE 2017)

Chelonia mydas	**Green turtle**	**Vulnerable**	**Migratory**	**Foraging, feeding or related behaviour known to occur within area**	**Foraging, feeding or related behaviour known to occur within area**		**Yes**	**Recovery Plan for Marine Turtles in Australia (DoEE 2017)**
Crocodylus porosus	**Salt-water crocodile**		**Migratory**		**Species or species habitat likely to occur within area**			
Dermochelys coriacea	**Leatherback turtle**	**Endangered**	**Migratory**	**Foraging, feeding or related behaviour likely to occur within area**	**Foraging, feeding or related behaviour likely to occur within area**			**Approved Conservation Advice for *Dermochelys coriacea* (Leatherback Turtle) (TSSC 2008b)** **Recovery Plan for Marine Turtles in Australia (DoEE 2017)**
Disteira kingii	**Spectacled Seasnake**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			
Disteira major	**Olive-head Seasnake**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			

Emydocephalus annulatus	**Turtle-headed Seasnake**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			
Enhydrina schistosa	**Beaked Seasnake**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			
Eretmochelys imbricata	**Hawksbill turtle**	**Vulnerable**	**Migratory**	**Foraging, feeding or related behaviour likely to occur within area**	**Foraging, feeding or related behaviour known to occur within area**		**Yes**	**Recovery Plan for Marine Turtles in Australia (DoEE 2017)**
Hydrelaps darwiniensis	**Black-ringed seasnake**				**Species or species habitat may occur in area**			
Hydrophis atriceps	**Black-headed seasnake**				**Species or species habitat may occur within area**			
Hydrophis coggeri	**Slender-necked Seasnake**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			

Hydrophis elegans	Elegant Seasnake			Species or species habitat may occur within area	Species or species habitat may occur within area			
Hydrophis macdowelli	Small-headed seasnake				Species or species habitat may occur within area			
Hydrophis ornatus	Spotted seasnake			Species or species habitat may occur within area	Species or species habitat may occur within area			
Lapemis hardwickii	Spine-bellied seasnake			Species or species habitat may occur within area	Species or species habitat may occur within area			
Lepidochelys olivacea	Olive Ridley Turtle	Endangered	Migratory	Foraging, feeding or related behaviour likely to occur within area	Foraging, feeding or related behaviour known to occur within area		Yes	Recovery Plan for Marine Turtles in Australia (DoEE 2017)
Natator depressus	Flatback turtle	Vulnerable	Migratory	Foraging, feeding or related behaviour likely to occur within area	Foraging, feeding or related behaviour known to occur within area		Yes	Recovery Plan for Marine Turtles in Australia (DoEE 2017)

Pelamis platurus	**Yellow-bellied seasnake**			**Species or species habitat may occur within area**	**Species or species habitat may occur within area**			

4.4.7.1.1 Short-nosed seasnake

The short-nosed seasnake (*Aipysurus apraefrontalis*) is listed as critically endangered under the EPBC Act and is managed under the Approved Conservation Advice for *Aipysurus apraefrontalis* (Short-nosed Sea Snake) (TSSC 2011a). The species occurs within the Planning Area and has been recorded from Hibernia Reef (TSSC 2011a). The species typically occurs in shallow water (<10 m) in the protected parts of the reef flat (TSSC 2011a) and as such is unlikely to be encountered by the survey vessel during acquisition but might be present if/where the vessel transits between the shallower shoals.

4.4.7.1.2 Leaf-scaled seasnake

The leaf-scaled seasnake (*Aipysurus foliosquama*) is listed as critically endangered under the EPBC Act and is managed under the Approved Conservation Advice for *Aipysurus foliosquama* (Leaf-scaled Sea Snake) (TSSC 2011b). The species is a small, slender seasnake endemic to reef complexes in the Sahul Shelf region. The species has historically been recorded at Hibernia reef in the Planning Area, but has not been recorded at these locations during recent surveys (DoEE 2019l). The species typically inhabits the same habitat and at the same water depths as the short-nosed sea snake (see Section 4.4.9.1.1), and as such is also unlikely to be encountered in any numbers during the activity.

4.4.7.1.3 Loggerhead turtle

The loggerhead turtle (*Caretta caretta*) is listed as endangered and migratory under the EPBC Act and is managed under the Recovery Plan for Marine Turtles in Australia (DoEE 2017). The loggerhead turtle is distributed throughout tropical, subtropical and temperate waters globally (DoEE 2019m). The species nests on sandy beaches, with most Australian rookeries recorded in Queensland and Western Australia and little evidence of inter-breeding between the two stocks (DoEE 2019m). In Western Australia, most documented nesting occurs between Shark Bay and North West Cape (DoEE 2019m). One individual loggerhead turtle has been recorded nesting at Ashmore Reef (DoEE 2019m) just outside the Planning Area; however the reef is not regarded as being key nesting habitat for the species. Transiting individuals may be encountered during the activity.

4.4.7.1.4 Green turtle

The green turtle (*Chelonia mydas*) is listed as vulnerable and migratory under the EPBC Act and is managed under the Recovery Plan for Marine Turtles in Australia (DoEE 2017). The green turtle is a widely distributed species which nests, forages and migrates throughout northern Australia. Nesting occurs on sandy beaches throughout, with Western Australia supporting one of the largest green turtle populations in the world, estimated at tens of thousands of individuals (DoEE 2019n). The species has been documented as nesting at Ashmore Reef, with the number of individuals nesting there thought to be in the hundreds (DoEE 2019t; Limpus 2008a) (see Figure 4-12). Peak nesting season is mid-summer (Table 4-12), although sporadic nesting may occur in the region year-round. During nesting activities, female green turtles are thought to stay within 5-10 km of their nesting beach. Outside nesting season green turtles may forage up to 2,600 km (DoEE 2019n). Transiting individuals are likely to be encountered during the activity.

4.4.7.1.5 Leatherback turtle

The leatherback turtle (*Dermochelys coriacea*) is listed as endangered and migratory under the EPBC Act and is managed under the Recovery Plan for Marine Turtles in Australia (DoEE 2017). It is the largest of all turtle species, reaching up to 1.6 m carapace length. This species can utilise colder waters than others due to physiological adaptations and is regularly observed in temperate as well as tropical waters around Australia (DoEE 2019o). Nesting has rarely been observed in Australia (only within the Northern Territory and Queensland), with no mating or major documented nesting sites known (Limpus 2009a). This species is unlikely to be encountered during the activity.

4.4.7.1.6 Hawksbill turtle

The hawksbill turtle (*Eretmochelys imbricata*), which has a widespread tropical distribution, is listed as vulnerable and migratory under the EPBC Act and is managed under the Recovery Plan for Marine Turtles in Australia (DoEE 2017). The population in Australia utilises a number of significant nesting beaches (DoEE 2019p), however Ashmore Reef and Cartier Island are not recognised as being critical rookeries. The hawksbill turtles observed at Ashmore Reef and Cartier Island may be animals from an Indonesian population separate to that of northern Australia (Limpus 2009b). Nesting and breeding in northern Western Australia occurs primarily during October to January (Table 4-12) (Limpus 2009b), although may occur year round at some locations. Transiting individuals are likely to be encountered during the activity.

4.4.7.1.7 Olive Ridley turtle

The olive ridley turtle (*Lepidochelis olivacea*) is listed as endangered and migratory under the EPBC Act and is managed under the Recovery Plan for Marine Turtles in Australia (DoEE 2017). The species has a circumtropical distribution, with nesting recorded in the Northern Territory and Queensland. No nesting has been recorded in Western Australia (DoEE 2019q; Limpus 2008). Breeding occurs year-round in northern Australia with a peak April to June (Table 4-12) (Limpus 2008b). Given the lack of nesting habitat in the Planning Area, foraging or migrating olive ridley turtles are not expected to be encountered in any significant numbers during the activity.

4.4.7.1.8 Flatback turtle

The flatback turtle (*Natator depressus*) is listed as vulnerable and migratory under the EPBC Act and is managed under the Recovery Plan for Marine Turtles in Australia (DoEE 2017). The species is only found in tropical waters of northern Australia, Papua New Guinea and Irian Jaya, with nesting confined to Australia (DoEE 2019x). Key rookeries have been identified in Queensland, the Northern Territory and Western Australia (Limpus 2007). No major rookeries are known within the area of the OA or Planning Area, although some nesting on Ashmore Reef (outside the Planning Area) may occur (Figure 4-12) (DoEE 2019r). Nesting in the western Northern Territory stock has been documented year-round, with peak nesting occurring in July (Table 4-12) (Limpus 2007). It is not expected that significant numbers of flatback turtles would be encountered in the OA during the survey.

Table 4-12: Critical Periods for Marine Turtle Stocks in Waters of the North West Shelf (Source: Commonwealth of Australia 2017)

Species	Stock	Event	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Loggerhead turtle	**Western Australia**	**Mating**												
		Nesting												
		Hatching												
Green turtle	**North West Shelf**	**Mating**												
		Nesting												
		Hatching												
Hawksbill turtle	**Western Australia**	**Mating**												
		Nesting												
		Hatching												
Flatback turtle	**Pilbara**	**Mating**												
		Nesting												

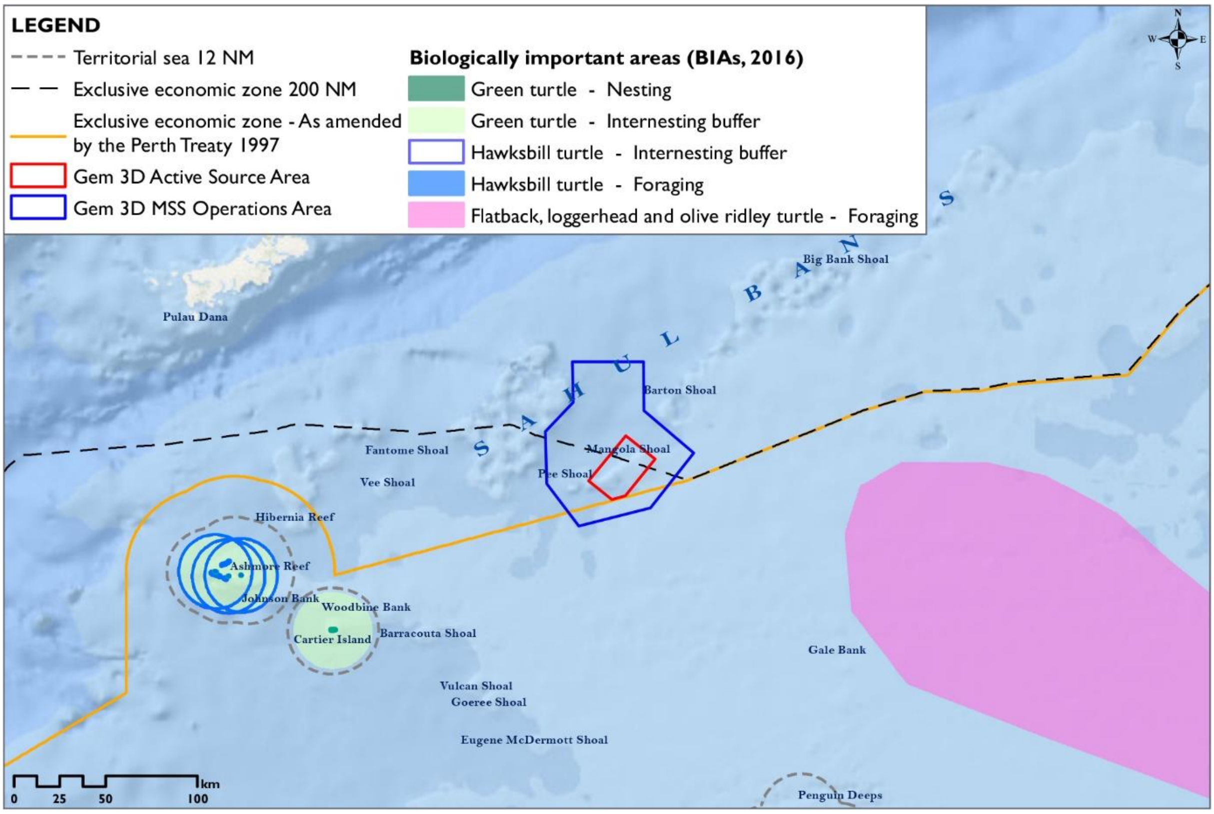


Figure 4-12: Biologically important areas of marine reptiles in the Gem 3D MSS Planning Area

4.5 Socio economic environment

4.5.1 Other marine users

4.5.1.1 Commercial fisheries

The area of proposed seismic acquisition is outside the areas where Australian commercial fishers are permitted to operate. The area of three Commonwealth and eleven WA state fisheries overlap the OA (Table 4-13). However, the outer limit of these jurisdictions is aligned with Australia's Exclusive Economic Zone, including where this has been modified by the Treaty between the Government of Australia and the Government of the Republic of Indonesia establishing an Exclusive Economic Zone Boundary and Certain Seabed Boundaries (Perth, 14 March 1997) (Perth Treaty) (Delimitation Treaties Infobase 2002). Although not yet in force, Australia acts consistently with the arrangements of this treaty (AFMA 2014). This treaty line passes through the OA. It also coincides with the Provisional Fisheries Surveillance and Enforcement Line (PFSEL), which is based on an agreement made between the governments of Indonesia and Australia in 1981 and prohibits Australian fishing vessels equipped to fish for swimming species (including licensed NDSMF vessels) moving north of the line unless their gear is stowed and secured (DoFWA 2016). As such, operators in state and Commonwealth fisheries described in Table 4.13 are not able to fish and are not expected to be present in the ASA as it is offshore of the Perth Treaty line, as shown in Figure 4-13.

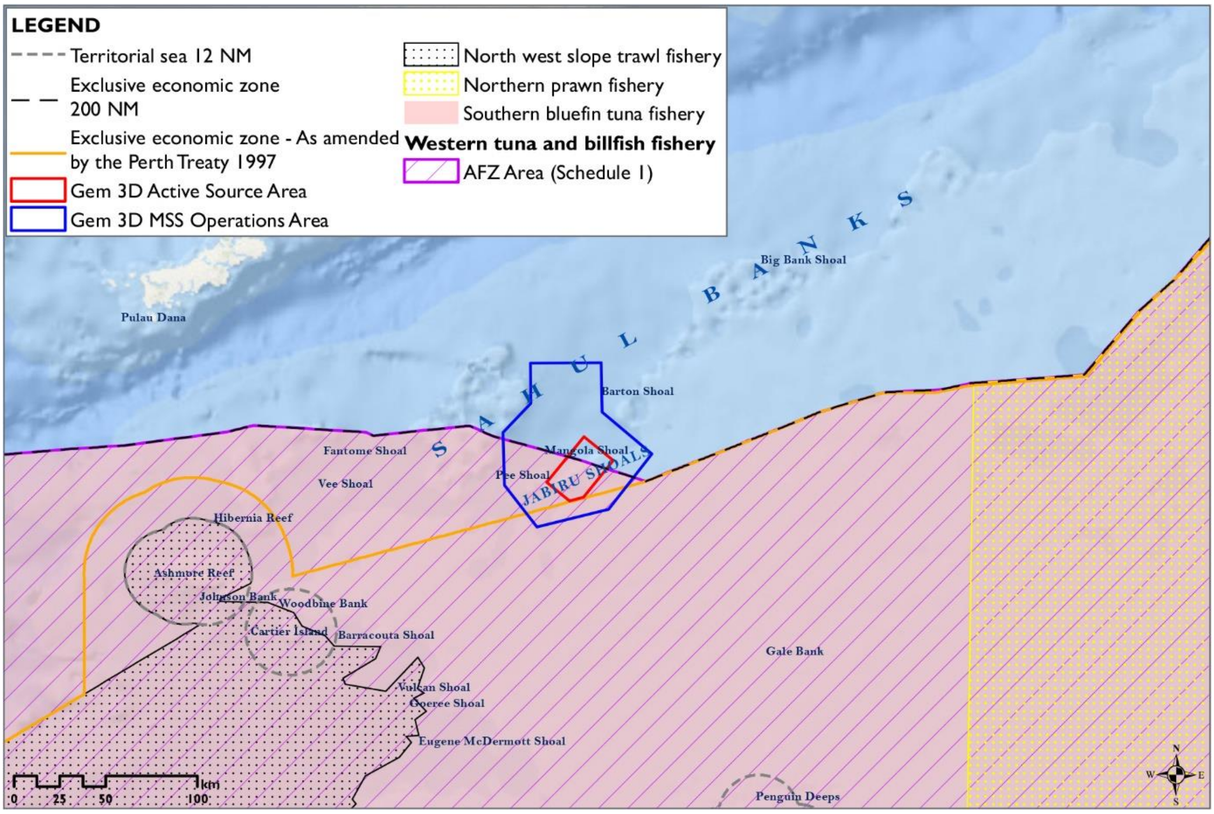


Figure 4-13: Commonwealth-managed fisheries that overlap the Operations Area

Table 4-13: Commercial fishery areas that overlap the Gem 3D MSS Operations Area

Fishery	Activity in the OA
Commonwealth Managed	
Southern Bluefin Tuna Fishery	**No**
Western Tuna and Billfish Fishery	**No**
Western Skipjack Tuna Fishery	**No**
State Managed	
Northern Demersal Scalefish Managed Fishery	**Yes**
South-west Coast Salmon Managed Fishery	**No**
Abalone Managed Fishery	**No**
Kimberley Prawn Managed Fishery	**No**
Northern Shark Fisheries	**No**
Mackerel Managed Fishery	**No**
Marine Aquarium Fish Managed Fishery	**No**
Pearl Oyster Managed Fishery	**No**
Specimen Shell Managed Fishery	**No**
West Coast Deep-sea Crustacean Managed Fishery	**No**
Kimberley Crab Managed Fishery	**No**

4.5.1.1.1 Commonwealth managed commercial fisheries

The Australian Fisheries Management Authority manages all Commonwealth fisheries under the *Fisheries Management Act 1991*. Three Commonwealth-managed commercial fisheries intersect the OA and the jurisdictional area of each fishery is shown in Figure 4-13. The areas fished and relative catch levels of the three Commonwealth-managed fisheries in 2016–2017 are presented in Figure 4-14 and Table 4-14.

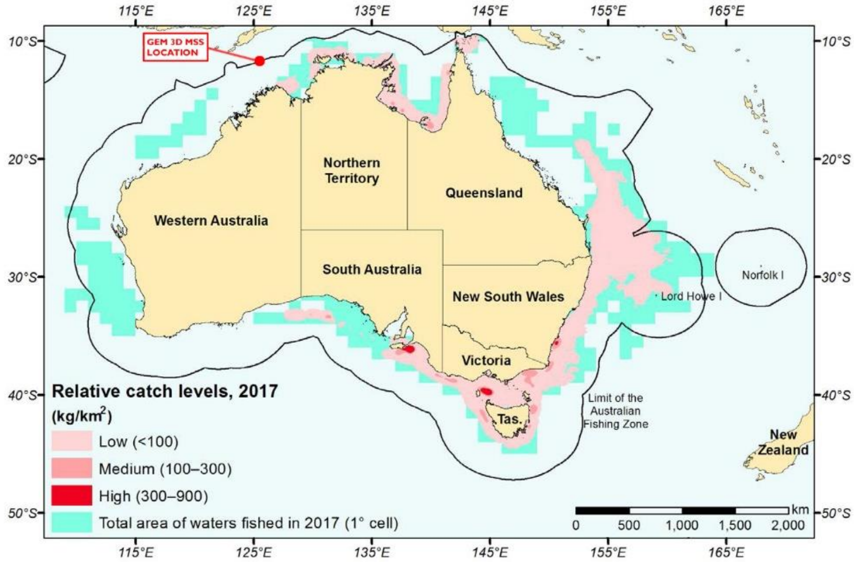


Figure 4-14: Relative catch levels of all Australian Government-managed fisheries, 2017 (ABARES 2018)

Table 4-14: Commonwealth-managed fisheries which overlap the Operations Area

Fishery	Geographic extent	Target species	Season	Method	Catch and value	Fishing occurs within the Operations Area?
Southern Bluefin Tuna Fishery	**All AFZ waters (3–200 nm). Most of the Australian catch is taken in the Great Australian Bight (GAB), with small amounts taken off south-east Australia.**	**Juvenile southern bluefin tuna (2–5 years)**	**Fishing occurs from the start of Dec to the end of Mar. After feeding in the grow-out cages, fish are generally harvested in Aug**	**Purse seine (in the GAB), pole and line, longline and trolling (off south-east Australia)**	**5,697 t valued at $38.57 million in 2016-17 season**	**Unlikely- fishing effort is concentrated in the GAB and off south-east Australia.**
Western Tuna and Billfish Fishery	**All AFZ waters (3–200 nm) from Cape York (QLD) to the VIC–SA border. In recent years, effort has concentrated off south-west WA and SA**	**Yellowfin tuna, bigeye tuna, skipjack tuna, albacore, billfish**	**Year-round**	**Pole and line, purse seine, pelagic longline, troll, rod and reel, handline**	**2016-2017 ranged from 320- 322 tonnes. Value not reported.**	**Unlikely- Effort data shows fishing effort is concentrated offshore of the 200 m isobath and to the south of the OA**
Western Skipjack Tuna Fishery	**All external Commonwealth and state waters out to 200 nm**	**Skipjack tuna**	**Year-round**	**Purse seine and pole**	**Not active**	**No – licence holders have not participated in the fishery since 2008-09**

4.5.1.1.1.1 Southern Bluefin Tuna Fishery

The Southern Bluefin Tuna Fishery targets southern bluefin tuna (*Thunnus maccoyii*) under the Southern Bluefin Tuna Fishery Management Plan 1995. Effort in this fishery is concentrated in the Great Australian Bight, several thousand kilometres from the location of the proposed activity (Figure 4-15), with this trend demonstrated historically from 2014 to 2018 (ABARES 2018, 2017a, 2016a, 2015a, 2014a). SBT catch in 2016 represented 10.68% of all Commonwealth fisheries catch for that year (AFMA 2018a). Southern bluefin tuna spawn in the North West Shelf region of Western Australia between September and March, approximately 150 km west from the OA (see inset map Figure 4-15). The larvae may be seasonally abundant in surface waters of the broader region during these months and migrating adult tuna may transit through the region. Due to the large distance between the actively fished area and the location of the activity, vessels participating in this fishery are not expected to be encountered during the activity.

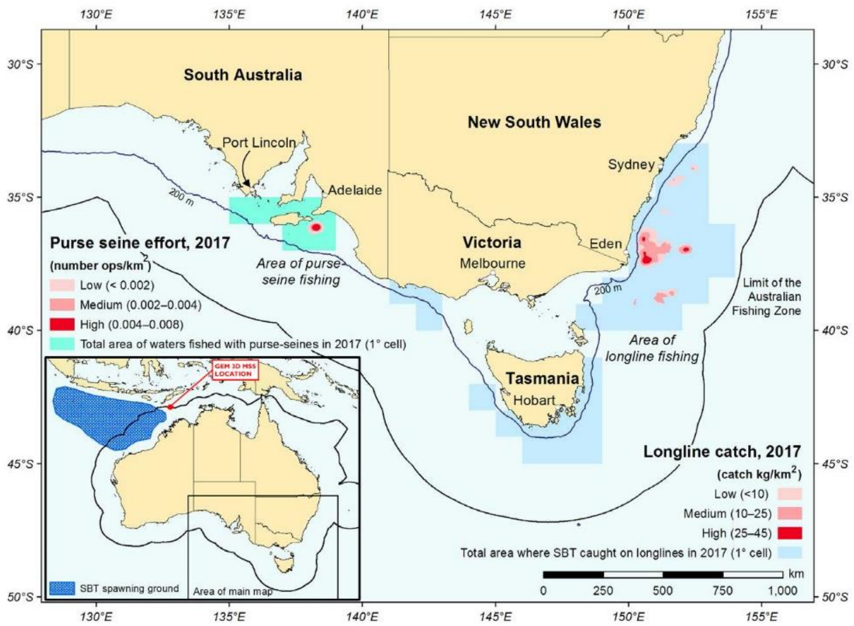


Figure 4-15: Purse-seine effort and longline catch in the SBT Fishery 2017

4.5.1.1.1.2 Western Tuna and Billfish Fishery

The Western Tuna and Billfish Fishery is managed under the Western Tuna and Billfish Management Plan 2005. It extends westward from Cape York Peninsula (142°30´E) off Queensland around the west coast of Western Australia and from there extends eastward across the Great Australian Bight to 141°E at the South Australian/ Victorian border. The fishery targets four main pelagic species, which are all highly migratory, broadbill swordfish (*Xiphias gladius*), bigeye tuna (*Thunnus obesus*), yellowfin tuna (*T. albacares*) and albacore tuna (*T. alalunga*). The catch of the fishery in 2016-2017 ranged from 320- 322 t (ABARES 2018). Historical data shows fishing effort is concentrated in the Gascoyne region of Western Australia (Figure 4-16) and although the area of waters fished varies latitudinally from season to season, the northern-most historical effort was recorded in 2013 in the Kimberley region of WA south of the OA (ABARES 2018, 2014b, 2017b, 2016b, 2015b). As such, vessels within this fishery are not expected to be encountered during the activity.

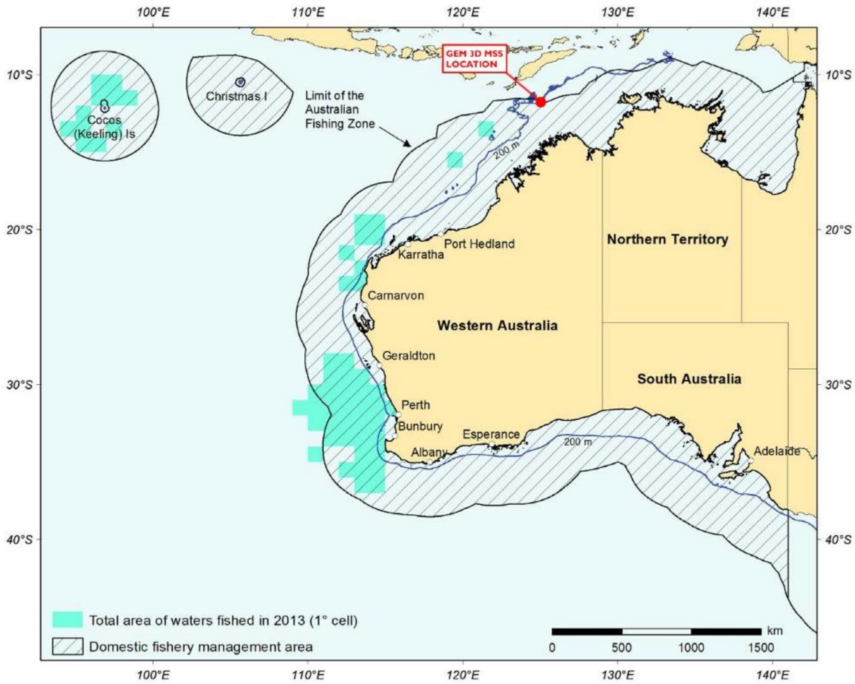


Figure 4-16: Area of the waters fished in the Western Tuna and Billfish Fishery 2013

4.5.1.1.1.3 Western Skipjack Fishery

The Western Skipjack Fishery is part of the Skipjack Tuna Fishery, which contains two stocks: one to the east and one to the west, that are assessed separately but managed together under various management arrangements and general conditions in addition to the *Fisheries Management Act 1991*. The Western Skipjack Fishery targets only skipjack tuna *Katsuwonus pelamis*. While the OA lies within the boundary of the fishery, effort within this fishery is mainly confined to the southern coast of Australia, several thousand kilometres away. No fishing effort has been recorded since the 2008-2009 season (ABARES 2018) and whilst there are nine of the possible 14 possible current permit holders (AFMA concession holder database 3/6/2019) there is no expected effort as the fishery is not currently active and management arrangements are under review (AFMA 2019b). As such, vessels within this fishery are not expected to be encountered during the activity.

4.5.1.1.2 State managed commercial fisheries

The Department of Primary Industries and Regional Development (DPIRD) manages WA state fisheries under the *Fisheries Management Act 1991*. The jurisdictions of twelve state-managed commercial fisheries overlap the OA. The areas fished and relative catch levels of these fisheries in 2016–2017 are presented in Table 4.15. Catch and effort records for the period 2014 – 2018 obtained from DPIRD's FishCube database on the 1/5/2019 show that only one of these state fisheries, the Northern Demersal Scalefish Managed Fishery (NDSMF), is active in the area overlapped by the OA. Consultation with the Western Australian Fishing Industry Council (WAFIC) and commercial fishers indicates that this is the only fishery expected to be active within the OA during the period of the proposed activity (see Appendix C). A review of state fisheries with overlapping jurisdictions but no expected activity in the OA are provided in Appendix F. Further information about the NDSMF is provided below.

Table 4-15: State-managed fisheries which overlap the Operations Area

Fishery	Geographic extent	Target species	Season	Method	Catch in 2016	Fishing occurs within the Operations Area?
Northern Demersal Scalefish Managed Fishery	**Western Australian waters east of 120°E and north of 19°59'S.**	**Red and blue spot emperor, goldband snapper**	**Year-round**	**Trap**	**1,173 t**	**Yes- DPIRD FishCube data shows effort within the last 5 years**
South-west Coast Salmon Managed Fishery	**All WA waters**	**Western Australian salmon**	**March-April**	**Beach seine nets**	**89 t**	**No – Gear type and historical effort is concentrated on metropolitan beaches**
Abalone Managed Fishery	**All WA waters**	**Roe's abalone, Greenlip abalone, Brownlip abalone**	**Year-round**	**Dive and wading**	**167 t in 2015/16**	**No- Fishery is closed in area overlapping the activity**
Kimberley Prawn Managed Fishery	**WA waters west of 123°45.00E to 126°58.00E**	**Western king prawns, brown tiger prawns, endeavour prawns, banana prawns**	**April & May, Aug-Dec.**	**Low opening otter trawl, high opening for banana prawns**	**155 t**	**Unlikely – no activity by this fishery within the OA for the years 2014 – 2017 (more recent data not available)**
Mackerel Managed Fishery	**WA waters north of 27°S latitude to the NT border**	**Spanish and grey mackerel**	**May-November**	**Near-surface trolling, jig handline fishing**	**276 t**	**Unlikely- no activity by this fishery within the OA for the years 2014 – 2017 (more recent data not available)**

Marine Aquarium Fish Managed Fishery	**All WA waters**	**Variable**	**Year-round**	**Diving**	**128,610 fishes, 16.4 t coral, live rock & sand, 75L plants**	**Unlikely – effort is concentrated in nearshore coastal waters and no activity by this fishery within the OA for the years 2014 – 2017 (more recent data not available)**
Northern Shark Fisheries	**Pelagic WA waters west of 114°50'E north of 21°46'S**	**Sandbar shark, blacktip shark**	**Year-round**	**Gillnet/ longline**	**No fishing effort since 2008/09 season**	**No – Not been operated since 2009**
Pearl Oyster Managed Fishery	**Shallow coastal waters along the North West Shelf from Exmouth to the NT**	***P. maxima***	**March- July**	**Drift diving**	**541,260 oysters**	**Unlikely – effort is concentrated in nearshore coastal waters and no activity by this fishery within the OA for the years 2014 – 2017 (more recent data not available)**
Specimen Shell Managed Fishery	**All WA waters**	**Variable**	**Year-round**	**ROV, diving**	**8,531 shells**	**Unlikely – effort is concentrated in nearshore coastal waters and no activity by this fishery within the OA for the years 2014 – 2017 (more recent data not available)**
West Coast Deep-sea Crustacean Managed Fishery	**North of 34°24"S (Cape Leeuwin) and west of the NT border on the seaward side of the 150 m to the AFZ.**	**Snow crabs, giant crabs, champagne crabs**	**Year-round**	**Baited pots in a longline formation**	**153.3 t valued at $4.8 million**	**Unlikely – no activity by this fishery within the OA for the years 2014 – 2017 (more recent data not available)**
Kimberley Crab Managed Fishery	**All WA waters east of 120°E**	**Mud crab, Blue swimmer crab**	**Year-round**	**Crab traps**	**(Gazetted in 2018)**	**No- The fishery is restricted to coastal state waters**

4.5.1.1.2.1 Northern Demersal Scalefish Managed Fishery

The Northern Demersal Scalefish Managed Fishery (NDSMF) operates in Western Australian waters east of 120° E and north of 19°59' S and targets red emperor and goldband snapper (Newman et al. 2008). In 2019 there were six vessels active in the fishery, with three of these operating from Broome, WA, and three from Darwin, NT (Principal Fisheries Scientist DPIRD pers. comm. 6 May 2019). Operators in this fishery typically use demersal traps, which are baited to attract target species. Although the baits are typically gone within three hours of trap deployment, the traps may be left in water (unbaited and open) for up to twelve days between fishing trips (Newman et al. 2011). These vessels are quite mobile when fishing and move traps over an extended area, with between 60 and 120 trap pulls per day during fishing trips lasting up to twelve days (Newman et al. 2008). An assessment of the ecological sustainability of management arrangements for the NDSMF found a trap soak time of five hours to be standard for the fishery (Department of Fisheries 2004).

The NDSMF is divided into two areas - Area 1 is inshore and restricted to line fishing methods, whereas Area 2 is offshore and open to both trap and line methods. Area 2 is historically where fishing effort is concentrated (DPIRD 2000) and is further divided into three zones, A - C. There is no overlap by the proposed survey area with Zone A (Figure 4-17). Similarly, because of the exclusion zone described in Schedule 2A of the Northern Demersal Scalefish Fishery Management Plan 2000 that bounds the Perth Treaty Area 1997 (Department of Fisheries 2016), there is also no overlap by the OA and ASA with Zone C.

Due to habitat requirements of target species (Table 4-7) operators within the NDSMF are selective in their fishing area. The majority of fishing effort by the NDSMF occurs in Zone B (Figure 4-18). In 2016 the catch within this zone was 965 t of the total 1,173 t recorded for the fishery (DoFWA 2016). The fishing range of operators within the NDSMF extends throughout the area of Zone B (Principal Fisheries Scientist DPIRD pers. comm. 6 May 2019) with the majority of effort occurring north of Broome (FishCube data obtained from DPIRD 20/06/19). Catch (kg) and effort (vessel count) data for key indicator species (goldband snapper and red emperor) for the years 2014 – 2018 (DPIRD FishCube obtained 20/06/19) were used to determine the current area actively fished by operators within the fishery (noting that catch data could often not be provided due to a confidentiality protocol which prohibits reporting of data where there are less than three fishers involved).

There is a 424.2 km^2 overlap between the OA and Zone B, as required to allow for turns by the survey vessel at the end of each survey line. This area of overlap is 0.5% of the total Zone B area, and 0.08% of the total area of the NDSMF (Table 4-16). Effort data shown in Figure 4.18 indicates < 3 vessels fished in this area of overlap during 2014 – 2018, with the exception of one reporting block in which three vessels reported catches in 2018. The amount of overlap by this block with the OA is small however, being 19 km^2 or 6% of the total area of the block. Because three vessels reported catches for this block the data is publicly available, showing that during 2018 a total catch of 10,035 kg was reported for this block. This equals 0.8% of the total catch by the NDSMF in 2018 (1,298 t), and assuming an even distribution of catch throughout this block the catch taken from the area of overlap would have been 602 kg (0.05% of the total catch by the NDSMF in 2018). This assumption is unlikely to be valid, however, because bathymetric data indicates that there is no reef habitat preferred by these species within the area of overlap (refer to Table 4-7 and Figure 4-1).

No other catch data is available for this specific reporting block (or other blocks that overlap the OA) for other years between 2014 – 2018 due to the confidentiality protocol. The online Global Fishing Watch database, which shows vessel monitoring system (VMS) tracking data for fishing vessels (including for Australian and Indonesian fisheries) indicates that three Darwin-based fishing vessels have been active in waters south of the OA during most months of the year since 2016 (Global Fishing Watch, 2019).

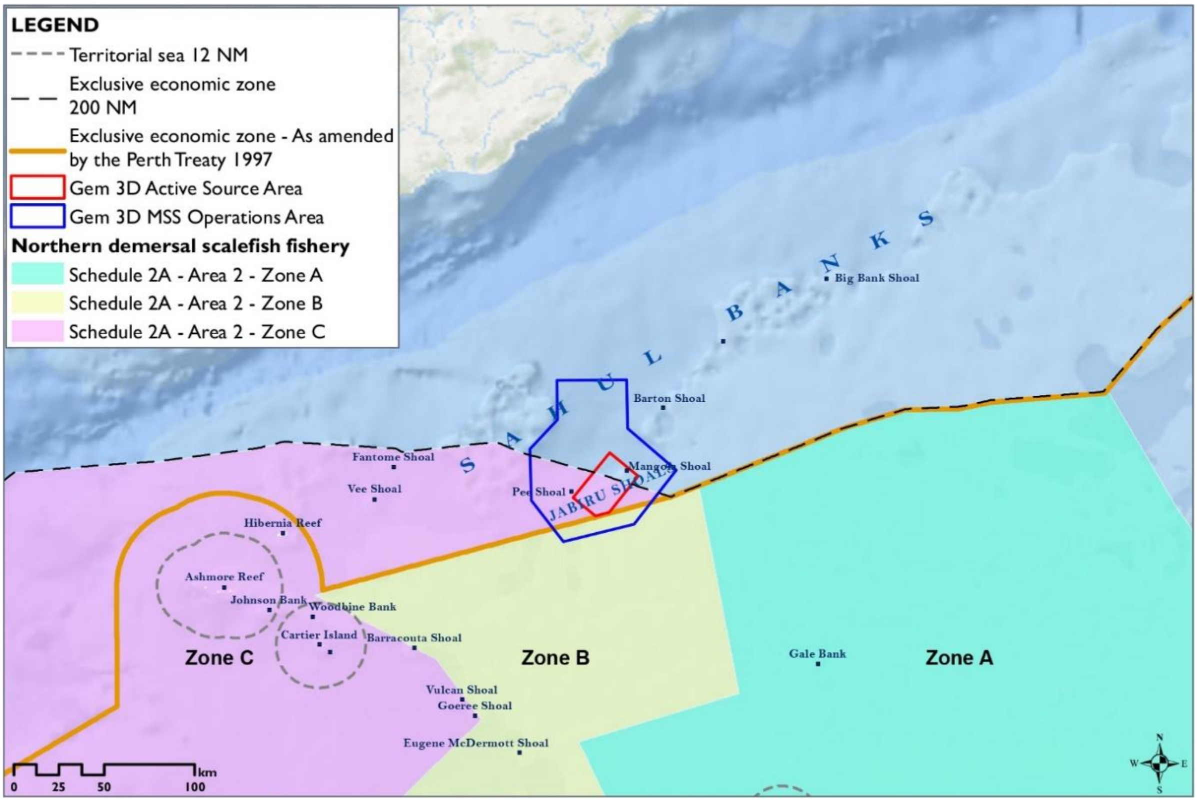


Figure 4-17: Boundaries of the Northern Demersal Scalefish Managed Fishery

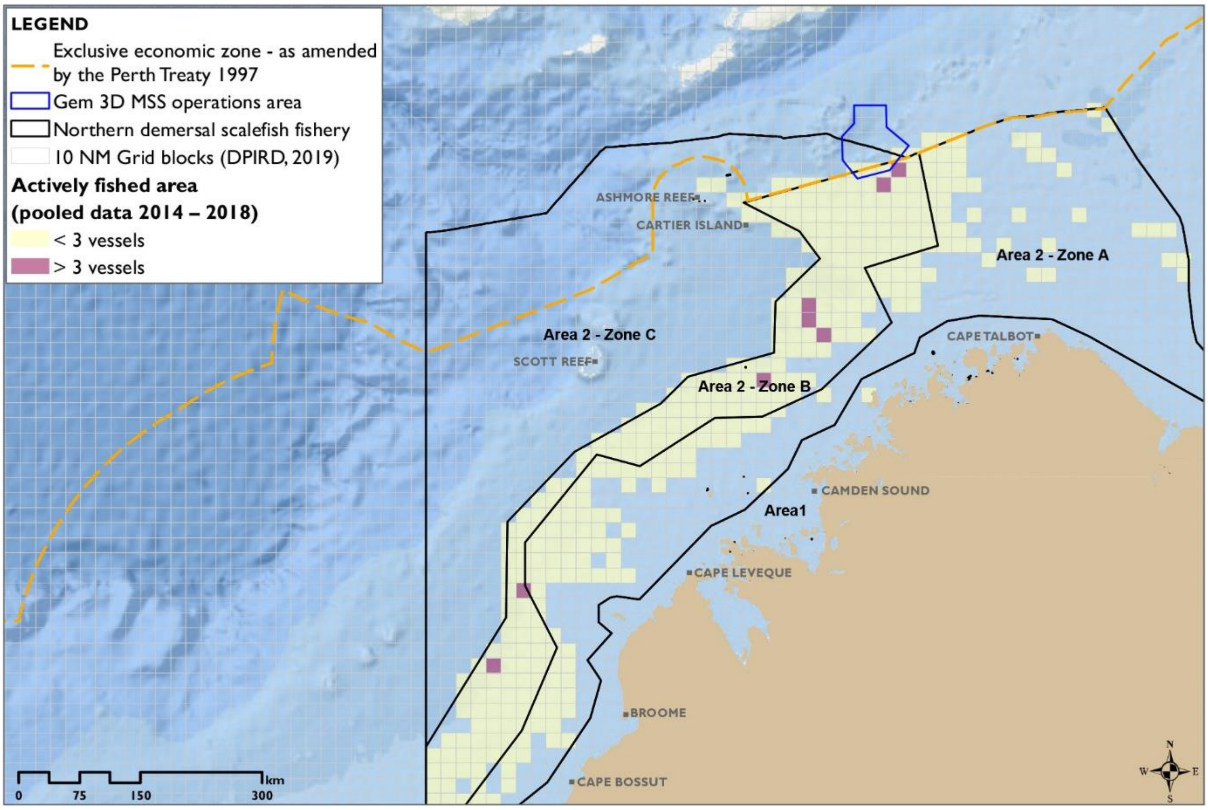


Figure 4-18: Actively fished area for the Northern Demersal Scalefish Managed Fishery for years 2014-2018 (pooled)(DPIRD 2019).

Table 4-16: Statistics for the Operations Area and the NDSMF

Description	NDSMF (total area)	Zone B (total area)	OA overlap of Zone B
Total area	**501,099** km^2	**79,622** km^2	**424.2** km^2 **(0.5%)**

4.5.1.2 Indonesian fishers

The OA is located 105 km east of the Australian Indonesian Memorandum of Understanding 1975 (MoU), which is a 50,000 km^2 area within Australia's EEZ in which Indonesian traditional fishers are able to collect target species such as trepang (sea cucumber), shark fin and other marine species for sale in Indonesia. These traditional fishers operate small wooden vessels, known as perahu and are likely to originate from the Indonesian Rote Island group, the nearest island of which lies approximately 170 km north-east of the OA. Visits to the area of the MoU by Indonesian fishermen are typically highest in August (Russell 2004).

Because most of the OA lies outside of the EEZ, as modified by the Perth Treaty, it is possible that traditional fishing vessels may visit the area in which the Gem 3D MSS will occur. However, the OA is not located within the typical route for traditional Indonesian fishermen from Indonesia to Ashmore Reef to Scott Reef, and given that the Gem 3D MSS will be undertaken outside of the peak period of activity by these fishers in Australian waters, encounters with traditional fishers is unlikely within the short (< 27 day) duration of the Gem 3D MSS. Similarly, it is unlikely that commercial Indonesian vessels will be encountered within the OA during the Gem 3D MSS because review of the Global Fishing Watch database for the period September 2016 to July 2019 demonstrates that no fishing activity attributable to Indonesian vessels with VMS that may be capable of fishing these distant waters was evident within or nearby the OA (Global Fishing Watch, 2019).

4.5.1.3 Recreational fishing and tourism

Recreational boating in the area of the proposed survey may consist of cruising yachts sailing between northern Australia and Indonesia. Cruising yachts typically occur seasonally in the region, with higher numbers of yachts during June to August, as conditions during this time are most favourable for sailing (Russell, Neil & Hilliard 2004). Most visitors arrive by private yacht with only one or two commercial tours visiting each year (DNP 2014) These vessels are expected to be present in very low numbers, with data indicating there were zero and twelve yachts recorded at the islands in August in 2001 and 2002, respectively (Russell, Neil & Hilliard 2004).

Recreational fishing, fishing charters and nature-based tours (including recreational SCUBA and snorkelling) are not expected to be active within the OA due to its distance from the nearest port (507 and 607 km from Wyndham and Darwin respectively), as well as its distance from the nearest potential shelter in event of adverse weather (Ashmore and Cartier Islands, located approximately 162 and 136 km southwest of the OA respectively). Trips to these islands are uncommon because their conservation status prohibits camping on them and requires that any fish caught must be consumed immediately. One-off specialist trips for bird watching may also occur due to the diversity and abundance of birds but these are also uncommon and not expected to result in the presence of such vessels in the OA. To date there has been no response to consultation with service providers from Darwin and throughout the Kimberley region of WA.

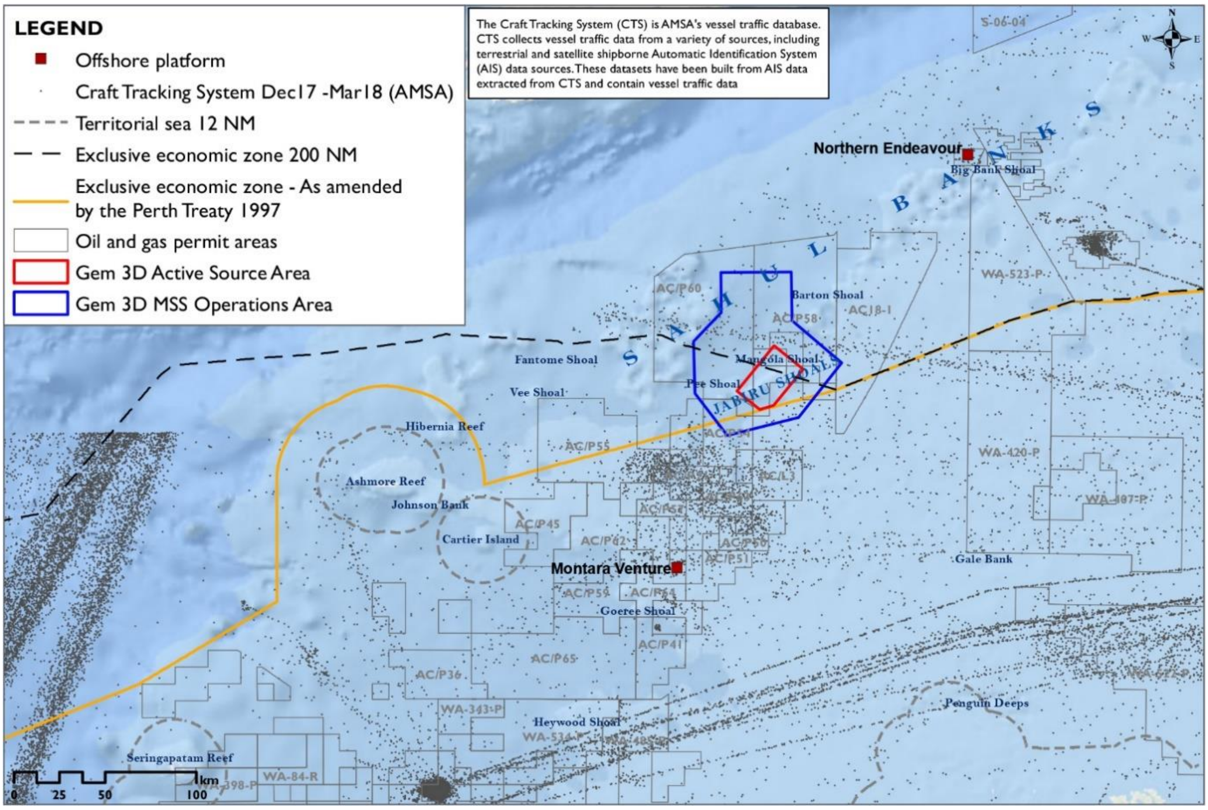
4.5.1.4 Research activities

Research activities have previously been undertaken throughout the Timor Sea area, including within the OA (AIMS 2017; Heyward et al. 2013; Heyward, Pinceratto & Smith 1997; Marine National Facility 2005; Richards et al. 2017). This research is predominantly conducted by Geoscience Australia, the Australian Institute of Marine Science (AIMS), Commonwealth Scientific and Industrial

Research Organisation (CSIRO), the Western Australian Marine Science Institution (WAMSI), and partnered universities. In 2017, AIMS commenced the three-year North-West Shoals to Shore Research Program, involving geophysical, ecological and biological studies of the north-west region including Scott Reef, Ashmore Reef and Rowley Shoals. Consultation to date with relevant research institutions indicates that there is unlikely to be any research activity conducted by these institutions during the duration of the survey.

4.5.1.5 Shipping

The majority of commercial vessels using shipping lanes in the north of Australia are trading between Australia, Indonesia, Singapore and more distant ports in south-east Asia (Russell, Neil & Hilliard 2004). Shipping activity over the past two years in the waters surrounding the OA were mapped using AMSA's Craft Tracking System and shown in Figure 4.19. This data indicates regular shipping activity along routes well to the west and south of the OA (the nearest defined route 127 km to the south). It also indicates less frequent movement by vessels nearby and through the OA, as well as variable concentrations of vessel activity across the region that are linked to oil and gas industry activity. For example, the concentration of activity in the southern portion of the OA in 2018-19 is due to the Orchid-1 exploration well project in Permit AC/P54 that was completed in early 2019 (see Section 4.5.1.7). Consultation with AMSA in May 2019 also identified that large passenger vessels and border force vessels follow the Australian EEZ, which lies through the OA. Presence of commercial shipping vessels described above during the survey period are likely intermittent and brief as the vessel transits through.



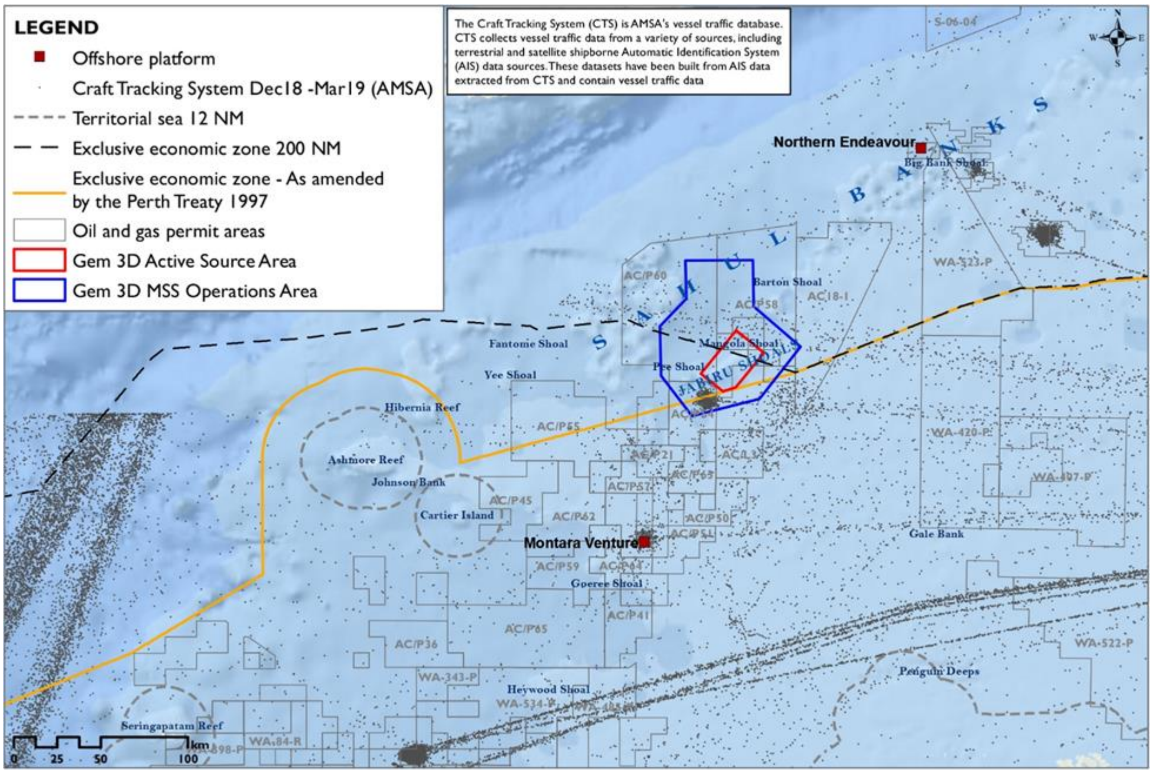


Figure 4-19: Shipping activity 2017-18 (top) and 2018-19 (bottom)

4.5.1.6 Defence

Australian Border Force (ABF) and navy vessels undertake civil and maritime surveillance within the region with the primary purpose of monitoring the passage of illegal entry vessels and illegal fishing activity within these areas. Consultation with AMSA in May 2019 identified that ABF vessels follow the Australian EEZ, which lies through the OA (see Appendix C). Cartier Island and the area within a 10 km radius surrounding the island is a gazetted Defence Practice Area, although no longer in active use for military exercise (Commonwealth of Australia 2002). It was formerly used as a bombing range and access to the island and to the area within a 10 km radius is prohibited due to risks associated with a potential presence of unexploded ordnances.

4.5.1.7 Oil and gas

A search of NOPTA's National Electronic Approvals Tracking System identified five existing retention leases directly adjacent to SapuraOMV's permit AC/P61 in the Bonaparte Basin, all held by PTTEP Australasia (Ashmore Cartier) Pty Ltd. There are production licences further afield of SapuraOMV permit (Table 4-17).

Previous seismic survey activity in the broader vicinity of the Gem 3D MSS is shown in Table 4.18. Vessel movements to the Cash/ Maple fields (Orchid-1 and following exploratory well projects, south west of the OA) have been recorded throughout 2019 (Sentinel maritime monitoring, accessed 22/07/2019; Figure 4-21). There are two other marine seismic surveys planned to occur in the immediate region that might overlap with the timing of the Gem 3D MSS obtained by a search of NOPSEMA's activity status and summaries:

- Factory 3D MSS located ~145 km to the south-west (acquisition planned over a period of 2-3 months from July 1 to December 30, 2019)
- Cygnus 3D MSS Phase 3 South 2019-2020 located ~60 km to the south-west (acquisition planned between May 2019 and end December 2020).

However, as the area of both surveys are located well inshore and hence closer to Australian ports it is unlikely that associated vessels will transit through the OA.

Table 4-17: Oil and gas titles in the vicinity of the Gem 3D MSS

Title	Titleholder	Project	Adjacent	Activity dates	Activity during Gem 3D MSS operations
AC/L5	**Timor Sea Oil & Gas Australia Pty Limited**	**Laminaria-5 Reinstatement Project**		**Jan – April 2018**	**N/A**
AC/L7	**PTTEP Australasia (Ashmore Cartier) Pty Ltd with Jadestone Energy**	**Montara**		**Ongoing**	**Operation of a facility**
AC/L8					
AC/RL12	**PTTEP Australasia (Ashmore Cartier) Pty Ltd**	**Orchid-1**	✓	**Title 2011-2020**	**Exploration well**
AC/RL6			✓		
AC/RL5			✓		
AC/RL4			✓		
AC/RL10					
AC/P60	**Total E&P Australia Exploration Pty Ltd**	**WA-408-P Exploration Drilling Campaign**	✓	**Title 2016-2022**	**N/A**
AC/P58	**Murphy Australia AC/P58 Oil Pty Ltd**	**Eupheme-1**		**Title 2014-2020**	**N/A**
AC/P65	**Shell Australia Pty Ltd**	**Factory 3D marine seismic survey**		**July 1 – Dec 2019**	**3D marine seismic survey**
AC/P41					
WA-534-P					
AC/P64		**Bratwurst-1 Prelude facility**		**Mid 2019**	**Exploration well**
SPA BZWZ87, AA 4S5L7Z	**Polarcus Asia Pacific Pty Ltd**	**Cygnus 3D Marine Seismic Survey**		**May 2019 – Dec 2020**	**3D marine seismic survey**

RL = retention lease, P = exploration permit, L = production licence

Table 4-18: Previous seismic surveys completed within 200 km of the Gem 3D MSS in the last five years

Year	Company	Survey name	Survey location	Survey status and timing	Evaluation
2014	**GX Technology Australia Pty Ltd**	**Westralia 2D SPAN MSS**	**Large multi-basin SPAN survey.**	**Completed prior to the end of Q2 2014.**	**It could not be confirmed if or when the proposed lines were acquired. However, the survey was completed at least four years ago and recovery of all impacts are expected to have occurred well before commencement of the Gem 3D MSS.** **No cumulative impacts are expected.**
2016	**Polarcus**	**Cygnus Phase I and II MSS**	**Located ~105 km south-west of the Gem 3D MSS ASA.**	**Completed prior to end of 2016.**	**The survey was completed at least 30 months prior and recovery of all impacts are expected to have occurred well before commencement of the Gem 3D MSS.** **No cumulative impacts are expected.**
2017-2018	**Polarcus**	**Cygnus Phase III North MSS**	**Located ~40 km south-west of the Gem NSS ASA.**	**Completed in January 2018.**	**The survey was completed at least 18 months prior and recovery of all impacts are expected to have occurred well before commencement of the Gem 3D MSS.** **No cumulative impacts are expected.**
2018	**Polarcus**	**Zénaïde 3D MSS**	**Located ~177 km from the Gem 3D MSS ASA.** **Maximum of 2,850 km^2 of 3D seismic acquisition in exploration permit WA-552-P.**	**Acquired between December 2017 and end April 2018.** **Maximum of 60 days of acquisition.**	**The survey was completed at least 12 months prior and recovery of all impacts are expected to have occurred well before commencement of the Gem 3D MSS.** **No cumulative impacts are expected.**

4.5.2 Cultural heritage and indigenous marine users

There are no World Heritage Properties or National Heritage Places within or immediately adjacent to the OA or within the Planning Area.

There are no known cultural or Indigenous heritage values or issues for the waters and seabed within or immediately adjacent to the OA or within the Planning Area.

4.5.3 Shipwrecks, historic places

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

A search of the Australian Historic Shipwrecks Database indicated no historic shipwrecks documented within the OA. One historic shipwreck, the Ann Millicent, lies south of Cartier Island within the boundary of the Cartier Island Marine Reserve (Commonwealth of Australia 2002) and is just inside the Planning Area.

4.5.4 Communications-Nextgen Networks North West Cable System

Nextgen Network's North West Cable System is located approximately 100 km to the southeast of the OA. The fibre optic telecommunications cable system runs between Port Hedland and Darwin.

5 Environmental impact and risk assessment methodology

5.1 Impact and risk management process - overview

As required by OPGGS(E) Regulations 10A(b), 10A(c), 13(5) and 13(6), SapuraOMV has undertaken an assessment of the environmental impacts and risks associated with the petroleum activity. The impact and risk management process is shown in Figure 5.1. This process aligns with SapuraOMV's HSE Management Systems (HSE-MM-MAN-0001), the Risk Management Procedure (AU-HS-PRO-001-1.0) and the International Standards Organization 31000:2018 Risk Management – Guidelines (ISO 2018). Figure 5-1 includes references to the major sections of this EP that cover the outcomes of each step in the process.

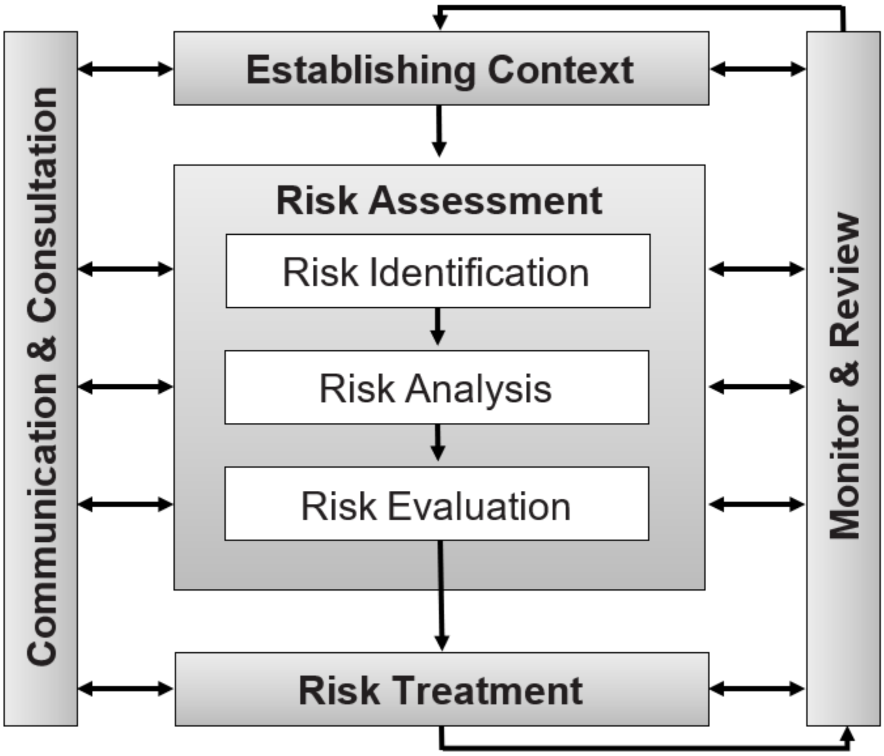


Figure 5-1: SapuraOMV impact and risk management process

SapuraOMV has followed the process in Figure 5-1, continually reviewing, analysing, evaluating and treating the impacts and risks, in response to new or updated information (e.g. ongoing relevant person or organisation feedback).

An Environmental Hazard Identification workshop was held in May 2019 to identify, analyse, evaluate and treat planned impacts and unplanned risks. The workshop was attended by seismic operations personnel, SapuraOMV HSE personnel and environmental specialists. The scope of the workshop included:

- Seismic Sound Environmental Hazard Identification (underwater noise impacts)
- Vessel Environmental Hazard Identification
  - Seismic and supply vessel planned impacts (e.g. physical interaction, presence, discharges etc)
  - Seismic and supply vessel unplanned impacts (e.g. unplanned overboard releases, vessel collision, spill response hazards etc).

An As Low As Reasonably Practicable (ALARP) review has also been held to consider additional or alternative control measures considered for specific impacts and risks as required. These control measures are implemented to achieve environmental performance outcomes (EPO) established for each environmental aspect, with environmental performance standards (EPS) set for each control to facilitate the transition from theoretical to the practical in the environmental assessment process (via associated measurement criteria).

5.2 Terms used in this impact and risk assessment process

Terms used in the impact and risk management process and in Sections 5, 6 and 7 of this EP, are defined in Table 5.1.

Table 5-1: Definitions of terms used in environmental impact and risk assessment

Term	Definition
Acceptable level[1]	**An "acceptable level" is the level of impact or risk to the environment that may be considered broadly acceptable with regard to all relevant considerations listed in Section 5.5.3.1 and compliant with the guidance presented in Environment Plan Content Requirements (NOPSEMA, 2019)**
As Low as Reasonably Practicable[2]	**Reducing impacts and risks based on the concept of reasonable practicability; the weighing up of the magnitude of impact or risk reduction against the cost of that reduction.** **In this context, a titleholder is required to implement all available control measures where the cost is not grossly disproportionate to the environmental benefit gained from implementing the control measure.**
As Low as Reasonably Practicable assessment[2]	**Process by which SapuraOMV demonstrates, through reasoned and supported arguments, that there are no other practical measures that could reasonably be taken to reduce risks further.**
Consequence[1,3]	**The outcome of an event. The consequence considers extent, duration, severity and certainty of what would happen should prevention control measures fail.**
Control measure[3,4]	**A system, an item of equipment, a person or a procedure, that is used as a basis for managing environmental impacts and risks. Control measures maintain and/or modify risk.**
Cost[5]	**The sacrifice required for implementing a control measure, which includes an impost such as the money, time, and/or trouble required to implement a particular control measure. Environmental cost may also be a cost in some circumstances (e.g. dispersant use on an oil spill).**
Environmental aspect[6]	**Element of an organisation's activities or products or services that interacts or can interact with the environment.**
Environmental impact[1,4]	**Any change to the environment, whether adverse or beneficial, that wholly or partially results from an activity of a titleholder.**
Environmental performance outcome[4]	**An environmental performance outcome is the measurable level of performance required for the management of an environmental aspect of an activity to ensure that environmental impacts and risks will be of an acceptable level.**
Environmental performance standard[4]	**An environmental performance standard is a statement of the performance required of a control measure**

Environmental risk[3]	**Risk is a deviation (positive or negative) from what is expected and reflects the uncertainty associated with unexpected events.** **A combination of the consequences of an event occurring and the likelihood of its occurrence. Environmental risks result from unplanned events that may occur as a result of the activity**
Event[3]	**The occurrence or change of a particular set of circumstances. Events can have one or more consequences and causes, can be expected or unexpected, and can be a risk source.**
Likelihood[3]	**The chance that an event may happen i.e. "likelihood". The likelihood may be determined using quantitative means (where data is available), or via qualitative means based on industry performance.**
Measurement criteria[1]	**Measurement criteria define how environmental performance will be measured and are used to determine whether the outcomes have been met during the activity.**
Predicted impact[5]	**The level of environmental impact associated with planned activities, with control measures implemented.**
Residual risk[5]	**The level of environmental risk associated with unplanned events after risk treatment (with control measures implemented).**

Source of definitions:

1. National Offshore Petroleum Safety and Environmental Management Authority Guidance Note N04750-GN1344 Environment plan content requirements (Revision 4, April 2019) (National Offshore Petroleum Safety and Environmental Management Authority 2019).
2. National Offshore Petroleum Safety and Environmental Management Authority Guidance Note N-04300-GN0166 ALARP (Revision 6, June 2015) (National Offshore Petroleum Safety and Environmental Management Authority 2015).
3. International Standard 31000:2018 Risk Management – Guidelines (International Standards Organization 2018).
4. Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2019.
5. National Offshore Petroleum Safety and Environmental Management Authority Guidance Note GL1721 Environment plan decision making (Revision 5, June 2018) (NOPSEMA 2018).
6. Australian/New Zealand Standard 14001:2016 Environmental management systems – Requirements with guidance for use (Standards Australia/ Standards New Zealand 2016).
7. Matters of national environmental significance – Significant impact guidelines 1.1 EPBC Act 1999 (Department of Environment and Energy 2013).

5.3 Communication and consultation

Internal and external relevant person or organisations have been consulted and informed throughout the development of this EP. Input has been sought in identifying, reviewing and providing feedback on impacts and risks from the following relevant person or organisations (see Section 3 for further details on consultation):

1. SapuraOMV, Searcher Seismic and RPS Australia West Pty Ltd (RPS) environmental, health and safety, emergency response (including oil spill response), and project management personnel

2. SapuraOMV Senior Geophysicist, HSE Specialist and Asset Manager and Searcher Seismic operations specialists

3. Searcher Seismic and RPS' consultation and communications personnel

4. Commonwealth and state government agencies and authorities with expertise in environmental management, fisheries management, maritime operations, emergency response, fuel spill response and local community issues

5. Relevant person or organisations (e.g. fishers and fisheries groups, community groups, titleholders and organisations)

6. Other person or organisations interested in the activity who provided relevant feedback on impacts and risks.

The impacts and risks identified have been communicated within SapuraOMV to ensure key personnel understand the impacts and risks, the basis on which decisions have been made and the reasons why certain control measures are required. As contractors are engaged for the activity, they will be made familiar with the impacts and risks, and importantly, the environmental control measures that must be implemented (as described in Section 8).

The process by which relevant persons were identified for the purpose of consultation is detailed in Section 3. The regulated public comment period may result in further input on impacts and risks. SapuraOMV has considered (and responded to) all feedback received from relevant person or organisations to date on the environmental impacts and risks assessed. The merit of all claims and objections of relevant persons has been assessed. Control measures have been adopted to address any claim or objection so that risks and impacts are reduced to ALARP using the ALARP process described in this section. Further details on relevant person or organisation feedback and SapuraOMV responses are provided in Section 3.

5.4 Establishing the context

The following information was considered when establishing the context for the impact and risk management process:

- Description of the activity, including an understanding of the nature and scale compared to similar seismic activities (Section 2), e.g. sound source levels, equipment types, location, timing and duration and the environment the activity will occur within (Section 4).
- Evaluating and understanding the company's external and internal relevant person or organisations (including objections or claims of relevant persons (Section 3)).
- Understanding of the physical, biological and socio-economic receptors in the area (Section 4), e.g. environmental values and the sensitivity of the receiving environment with respect to species, habitat distribution and location of environmentally sensitive areas (breeding, migration, resting areas); and with respect to other marine users (fishers, vessel traffic).
- The nature and scale of potential effects on valued ecosystem components associated with each impact and risk were reflected in the level of detail presented in the descriptions of impacts and risks in Sections 6 and 7. For example, seismic sound has an inherently greater potential for impact if not managed than other planned impacts and therefore was assessed in more detail (e.g. specific modelling).
- Applicable state, Commonwealth and international legislation, standards and guidelines, including species action or recovery plans and marine reserves management plans (Section 1.4 and Appendix A).
- SapuraOMV's internal policies, standards and procedures (referred to in Sections 6 to 8).

5.5 Impact and risk assessment

5.5.1 Impact and risk criteria

Environmental impacts and risks associated with the activities proposed under this EP have been assessed via a process consistent with the ISO31000:2018 Risk Management – Guidelines (International Standards Organization 2018) and SapuraOMV's Risk Management Procedure (AU-HS-PRO-001-1.0). Identified impacts and risks associated with the activity were evaluated using SapuraOMV's risk matrix (Table 5-2). Likelihood definitions are shown in Table 5-2 and environmental consequence definitions in Table 5-3. The risk ratings are defined in Table 5-4. Where an activity has the potential to impact multiple receptors the overall consequence definition given for that impact relates to the most sensitive receptor as a conservative approach to defining the consequence.

Table 5-2: SapuraOMV's quantitative and qualitative environmental risk matrix

	Consequence severity				
Likelihood	**Negligible**	**Minor**	**Moderate**	**Major**	**Critical**
	I	**II**	**III**	**IV**	**V**
Guide word: Almost certain **Consequence is expected in most circumstances (Occurs about once weekly or more; or around 50 times per year)**	3	3	4	5	5
Guide word: Likely **Consequence could occur in most circumstances (Occurs about once monthly; or around 12 times per year)**	2	3	3	4	5
Guide word: Possible **Consequence has occurred here or elsewhere** **(Occurs once yearly)**	2	2	3	3	4
Guide word: Unlikely **Consequence has not occurred here yet but could. (Occurs once or more in 10 years) ($1x10^{-1}$ to $>1x10^{-2}$ per year)**	1	2	2	3	3
Guide word: Remote **Consequence is extremely unlikely or never occurred before in industry ($1x10^{-2}$ or less per year)**	1	1	2	2	3

Table 5-3 Environmental consequence definitions

Category	Severity	Definitions
I	**Negligible**	**Temporary impact (restitution time days to weeks) on fauna, flora, habitat, aquatic ecosystem or water resources. No measurable impact to local populations, ecosystems or environmentally sensitive areas of local importance. Localised, temporary impact to individual organisms.**
II	**Minor**	**Short term impact (restitution time <1 year) on fauna, flora, habitat, populations (local) or environmentally sensitive areas of local importance but no negative effects on ecosystems.**
III	**Moderate**	**Short term impact (restitution time <1 year) on sensitive environmental features (e.g. hatchery/spawning ground) of national or regional importance, populations (national or regional) and ecosystems**

		Medium term impacts (restitution time 1-3 years) on populations (local), ecosystems or environmentally sensitive areas of local importance
IV	**Major**	**Long term impact (restitution time 1-10 years) on populations (regional or national significance), ecosystem, and sensitive environmental features (e.g. wetlands) of national or regional importance** **Longer term impacts (restitution time 3-10 years) on populations (local), ecosystems or environmentally sensitive areas of national importance**
V	**Critical**	**Destruction of sensitive environmental features. Severe impact on ecosystem** **Very long (or permanent) term impacts (restitution time >10 years) on populations (global or national), ecosystems or environmentally sensitive areas of international or national importance** **Very long (or permanent) term impacts (restitution time > 10 years) on populations (regional), ecosystems or environmentally sensitive areas of regional importance**

Table 5-4: Qualitative risk levels

Risk rating	Risk Level	Risk acceptance criteria
1	**Very Low**	**Risk is acceptable if ALARP and fulfils pre-set acceptability criteria with continual review**
2	**Low**	**Risk is acceptable if ALARP and fulfils pre-set acceptability criteria with continual review**
3	**Medium**	**Risk may be acceptable with approvals from management (Asset or Facility). Additional control measures required to be assessed.**
4	**High**	**Risk is undesirable. Must be shown to be ALARP through detailed assessment. May be acceptable with upper management approval of additional control measures implemented**
5	**Unacceptable**	**Risk is not acceptable. Consider redesign.**

5.5.2 Impact and risk identification

In identifying the impacts and risks, the following are recognised: environmental aspects, planned and unplanned events, sources and causes of events, the potential impacts and risks, affected receptors and potentially affected relevant person or organisations. The information gathered when establishing the context of the assessment (Section 5-4), is used as the basis for impact and risk identification.

All these considerations are further built into the assessment process described in Figure 5-2.

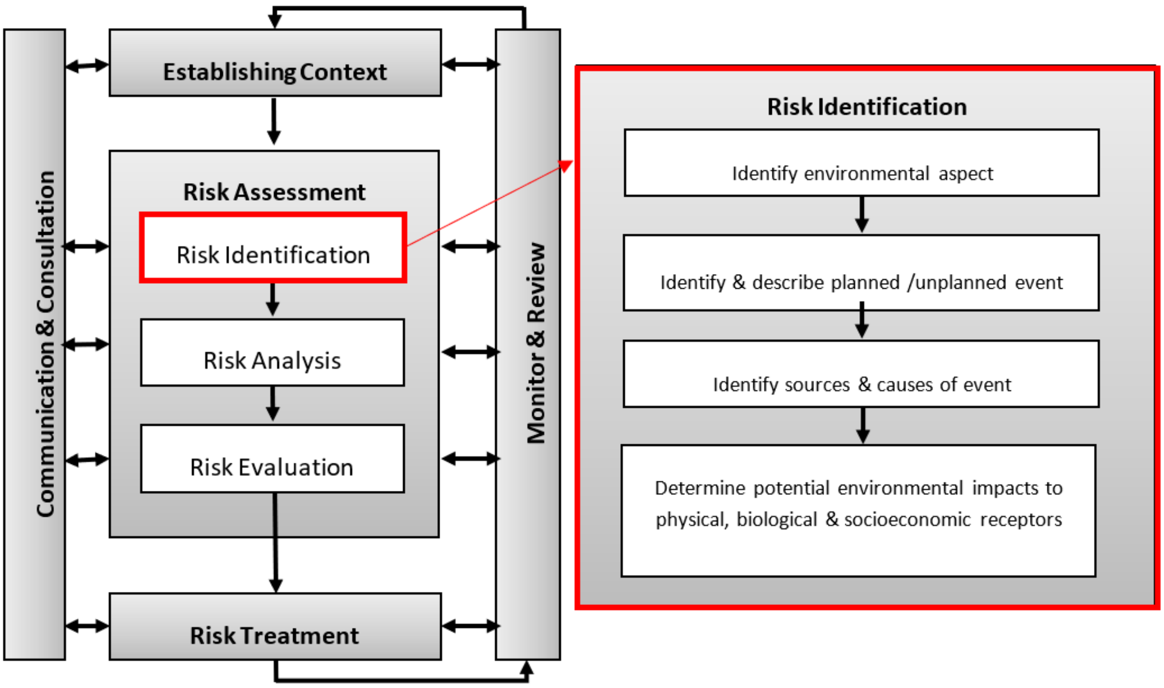


Figure 5-2: Risk identification process

5.5.2.1 Planned and unplanned events

The various planned activities and unplanned events relevant to the environmental aspects were identified and described in the context of the activity description (Section 2) for planned activities (Section 6) and on the basis of historical incidents, accidents or accident potentials for unplanned events (Section 7).

5.5.2.2 Sources and causes of events

Anticipated sources and causes of planned and unplanned events were identified during the impact and risk analysis process described in Sections 6 and 7 to assist in the development of preventative control measures.

5.5.2.3 Impacts and risks, affected receptors and potentially affected persons

The spatial and temporal characteristics of the impacts and risk were used to predict potential effects on the environmental receptors, including socio-economic receptors. This was also guided by inputs from relevant persons during consultation using professional judgement and following industry practice.

5.5.3 Impact and risk analysis

Identified impacts and risks were analysed, taking into consideration the extent, duration, severity of consequences and the certainty around understanding of the identified impact or risk. Analysis first involved defining criteria for an acceptable level of impact or risk and determining the ALARP decision context and assessment technique (Section 5.5.3.2). Following that, the consequence was determined using the environmental consequence definitions (Table 5-3) assuming standard control measures are in place.

For the impacts from each planned activity, the likelihood was assumed to be certain (probability of 1) as the predicted impact will occur. For risks from unplanned events, the likelihood was determined assuming that control measures designed to prevent the incident are in place. Likelihoods for most risks were based on relative frequency judgement, i.e. how many times the event had occurred previously.

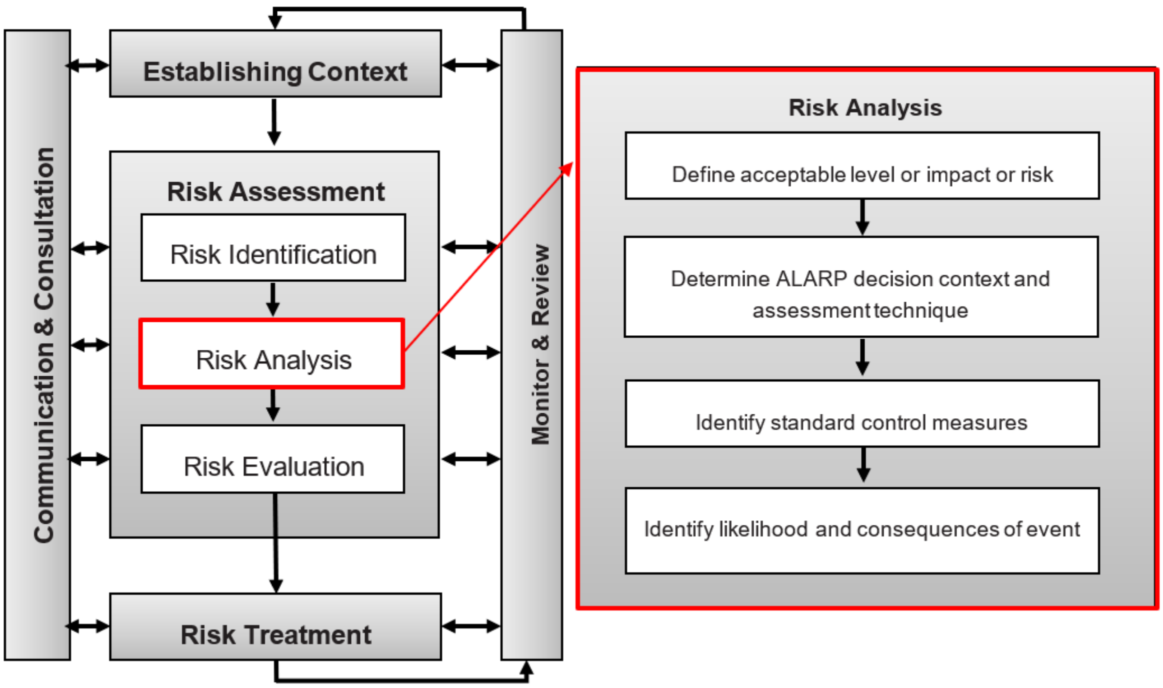


Figure 5-3: Risk analysis process

5.5.3.1 Defining an acceptable level of impact or risk

OPGGS(E) Sub-regulation 10A(c) requires that an EP demonstrate that the environmental impacts and risks of the activity will be of an acceptable level. An "acceptable level" is the level of impact or risk to the environment that may be considered broadly acceptable with regard to all relevant considerations including, but not limited to (NOPSEMA 2019):

- The existing environment
- Principles of ESD (as per Sections 3A and 30A of the EPBC Act)
- Other requirements (e.g. laws, policies, standards, conventions, statutory instruments such as recovery plans for threatened species, plans of management for protected places). As such, control measures are consistent with state, Commonwealth and international laws, widely adopted industry standards and good practices, and requirements identified in relevant state and Commonwealth species recovery plans or approved conservation advice
- Internal context (e.g. consistent with corporate environmental policy, culture and company standards and procedures)
- External context - societal values have been considered (relevant person or organisation expectations) e.g. information acquired during relevant persons consultation and/or the public comment process
- Guidance given in AS/NZS ISO 31000:2018 and HB 203:2012 for defining risk criteria may be considered when defining Acceptability Criteria
- Best practice found in internationally recognized industry guidance.

As part of the impact and risk analysis process, criteria were set for acceptable levels of each impact and risk identified. Following risk evaluation and treatment, when impacts and risks were ALARP, the predicted impacts and residual risks were compared against the acceptable level criteria. If the criteria were met, the environmental impacts and risks of the activity were considered Acceptable.

SapuraOMV's approach to assessing and mitigating environmental impacts and risks means this EP is consistent with the core objectives and principles of Australia's National Strategy for Ecologically Sustainable Development (1992), as relevant to petroleum exploration activities. By following a process consistent with the relevant parts of the National Strategy, and by reducing impacts and risks to ALARP, SapuraOMV considers the predicted impacts and residual risks described herein are consistent with ESD.

The relevant core objectives of Australia's Ecologically Sustainable Development strategy that have been incorporated into this impact and risk assessment process, are:

- To protect biological diversity
- Maintain essential ecological processes and life-support systems.

The relevant principles of Australia's Ecologically Sustainable Development Strategy that have been incorporated into SapuraOMV's impact and risk assessment process, include:

- Decision-making processes should effectively integrate both long and short-term economic, environmental, social and equity considerations
- Where 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
- Decisions and actions should provide for broad community involvement on issues which affect them
- Reducing impacts and risks to ALARP.

The risk management process is consistent with these principles because:

- It is based on consequence categories that reflect and appropriately weight short-term vs long-term effects, and which include environmental, social and equity issues (e.g. sound impacts in Section 6)
- Where there is the potential to significantly affect the biological diversity and ecological, a conservative approach has been applied (e.g. spill assessment in Section 7)
- Extensive effort has been taken to reduce scientific uncertainty (e.g. detailed and specific sound modelling in Appendix G)
- The EP is being published for broad community engagement and relevant persons have been consulted (Section 3)
- The adopted methodology includes ALARP considerations throughout the process (as demonstrated throughout Sections 6 and 7).

5.5.3.2 As Low as Reasonably Practicable decision context

OPGGS(E) Sub-regulation 10A(b) requires that an environment plan demonstrate that the environmental impacts and risks of the activity are reduced to ALARP. The United Kingdom (UK) offshore oil and gas industry has developed a framework to assist risk-related decision making ("Oil and Gas UK", formerly UKOOA 2014). This framework and SapuraOMV's HSE MS and Risk Management Procedure (AU-HS-PRO-001-1.0) were followed as part of the impact and risk assessment process. The ALARP assessment process is covered in Section 5.6 (Risk treatment).

The framework takes the form of three different decision contexts (A, B and C). The decision type is selected based on an informed discussion around the uncertainty of the risk, and it is agreed by workshop participants and documented in worksheets, based on factors including activity type, risk and uncertainty, and relevant person or organisation (stakeholder) influence. The decision contexts are shown in Figure 5.4 and defined as follows:

- Context A decisions – where the risk is relatively well understood, activities are well practiced and there is no significant stakeholder interest. It is noted however, that where good practice may not be sufficiently well-defined, additional assessment may be required.
- Context B decisions – where there is greater uncertainty or complexity around the activity and/or risk, and the risk is generating a number of concerns from stakeholders. In this instance

established good practice is not considered sufficient, and further assessment is required to support the decision and ensure that the risk is ALARP

- Context C decisions – typically involve sufficient complexity, uncertainty or stakeholder interest to require a precautionary approach. In this case, relevant good practice will still have to be met, additional assessment will be required, and the precautionary approach applied for those controls that only have a marginal cost benefit.

Decision Context	Factor	A	B	C
	Type of Activity	Nothing new or unusual Represents normal business Well understood activity Good practice well-defined	New to the organisation or geographical area Infrequent or non-standard activity Good practice not well defined or met by more than one option	New and unproven invention, design, development or application Prototype or first use No established good practice for whole activity
	Risk & Uncertainty	Risks are well understood Uncertainty is minimal	Risk amenable to assessment using well-established data and methods Some uncertainty	Significant uncertainty in risk Data or assessment methodologies unproven No consensus amongst subject matter experts
	Stakeholder Influence	No conflict with Company values No partner interest No significant media interest	No conflict with company values Some partner interest Some persons may object May attract local media attention	Potential conflict with company values Significant partner interest Pressure groups likely to object Likelihood of adverse attention from national or international media

Figure 5-4: Oil and Gas UK decision support framework

5.5.3.3 As Low as Reasonably Practicable assessment technique

The chevrons in Figure 5.4 show the assessment techniques required to demonstrate that potential impacts and risks are ALARP. The decision context provides a means to assess the relative importance of adherence to, and reliance on, Good Practice, Engineering Risk Assessment and Precautionary Approach when making decisions either to accept risk rankings or to continue to treat risks. The assessment techniques are defined as follows:

5.5.3.3.1 Good practice

The risk assessment considers compliance with requirements of the relevant Codes or Standards. The management of risk was benchmarked against good practice measures based on the industry experience, knowledge and judgement of the ALARP study team and determined to be "Good Practice" or not. Guidance on current industry practices was also taken from reference cases provided by National Energy Resources Australia (NERA 2018).

The decision-making criteria for making a Good Practice Context A decision include:

- Legislation, codes and standards (LCS): Identifies the requirements of legislation, codes and standards which are to be complied with for the activity.
- Good Industry Practice (GIP): Identifies further engineering control standards and guidelines which may be applied over and above that required to meet the legislation, codes and standards.
- Professional Judgement (PJ): Uses relevant personnel with the knowledge and experience to 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.

5.5.3.3.2 Engineering risk assessment

The engineering risk assessment considers the recognition of what is good practice, and an understanding and application of sound engineering and scientific principles and methods. This includes engineering analysis, consequence modelling, deterministic cases for hazard management as well as competent judgement and interpretation of these and other information. Control measures were introduced where they may significantly reduce the risk.

The decision-making criteria for making an Engineering Risk Assessment Context B decision (additional to Good Practice) include:

- 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 SapuraOMV's HSE Policy.

5.5.3.3.3 Precautionary approach

Where extensive scientific knowledge is lacking and there is a risk of a high consequence, the risk assessment takes a more conservative approach, including consideration of the views, concerns and perceptions of relevant persons or organisations.

The decision-making criteria for making a Precautionary Approach Context C decision (additional to Engineering Risk Assessment) include:

- Societal Values (SV): Identifies the views, concerns and perceptions of relevant stakeholders and addresses relevant stakeholder concerns as gathered through consultation.

The Environmental Hazard Identification workshop examined the environmental impacts and risks with reference to the "decision context" and "assessment technique" for the identified aspects. The decision context and assessment technique to be applied to ensure the residual impacts and risks have been reduced to ALARP are summarised for each impact (Section 6) and risk assessment (Section 7) and listed in Table 5-5.

Table 5-5: ALARP assessment techniques

Section No.	Environmental aspect	Decision context	Assessment technique
Impacts associated with planned activities (Section 6)			
6.2	**Underwater sound emissions from seismic array**	**A**	**Good practice**
6.3	**Underwater sound emission from survey vessels**	**A**	**Good practice**
6.4	**Light emissions from survey vessels**	**A**	**Good practice**
6.5	**Physical presence of survey vessels**	**A**	**Good practice**
6.6	**Atmospheric emissions from survey vessels**	**A**	**Good practice**
6.7	**Discharge of sewage, grey water and food waste from survey vessels**	**A**	**Good practice**

6.8	**Discharge of bilge water, deck drainage, cooling water and brine from survey vessels**	**A**	**Good practice**
Risks associated with unplanned events (Section 7)			
7.2	**Introduction of invasive marine species**	**A**	**Good practice**
7.3	**Collision between survey equipment and marine fauna**	**A**	**Good practice**
7.4	**Equipment grounding or emergency anchoring**	**A**	**Good practice**
7.5	**Hydrocarbon release caused by vessel fuel tank loss of containment**	**A**	**Good practice**
7.6	**Waste management and accidental loss overboard**	**A**	**Good practice**

5.5.3.4 Standard control measures

Standard (existing) control measures were identified for each impact and risk taking into consideration the context of the activity and the effectiveness of the controls in reducing risk. Measures were drawn from a range of sources, including (but not limited to):

- SapuraOMV's HSE Management System (HSE-MM-MAN-0001.Rev U) and associated policies, standards and procedures
- Relevant persons consultation
- Seismic and support vessel plans and procedures
- Industry practices, codes and standards
- Applicable state, Commonwealth and international legislation, standards and guidelines.

The effectiveness of the control measures was considered when determining the likely consequences with control measures in place (i.e. factors such as functionality, availability, reliability, survivability, independence and compatibility of control measures).

The ALARP process in Section 5.6.2 describes how the controls can fit into a hierarchy to ensure a range of options are considered.

5.5.4 Impact and risk evaluation

Impacts and risks were evaluated by comparing the results of the impact/risk analysis with the risk matrix to determine the risk level. Depending on the risk level and considering the ALARP decision context (Section 5.5.3.3) and assessment technique, further actions were considered as shown in Figure 5-5. Further action primarily included undertaking further analysis and reviews to better understand the impact or risk (e.g. additional modelling, literature reviews, data assessments, engineering assessments), considering additional risk treatment options and conducting further consultation with stakeholders. When further actions were completed, the impact and risk analysis part of the process was revisited (with the updated studies, stakeholder input or additional controls).

The evaluation of impacts and risks included consideration of the standard control measures in place and an evaluation to determine if an impact or risk requires further treatment (e.g. elimination, prevention, reduction and mitigation) to meet the defined acceptable level.

While impacts and risks are evaluated using the same methodology, their nature and scale can be different. As such, the presentation of higher order impacts (e.g. seismic sound) and risks include more detail while others may be presented in a more tabulated manner.

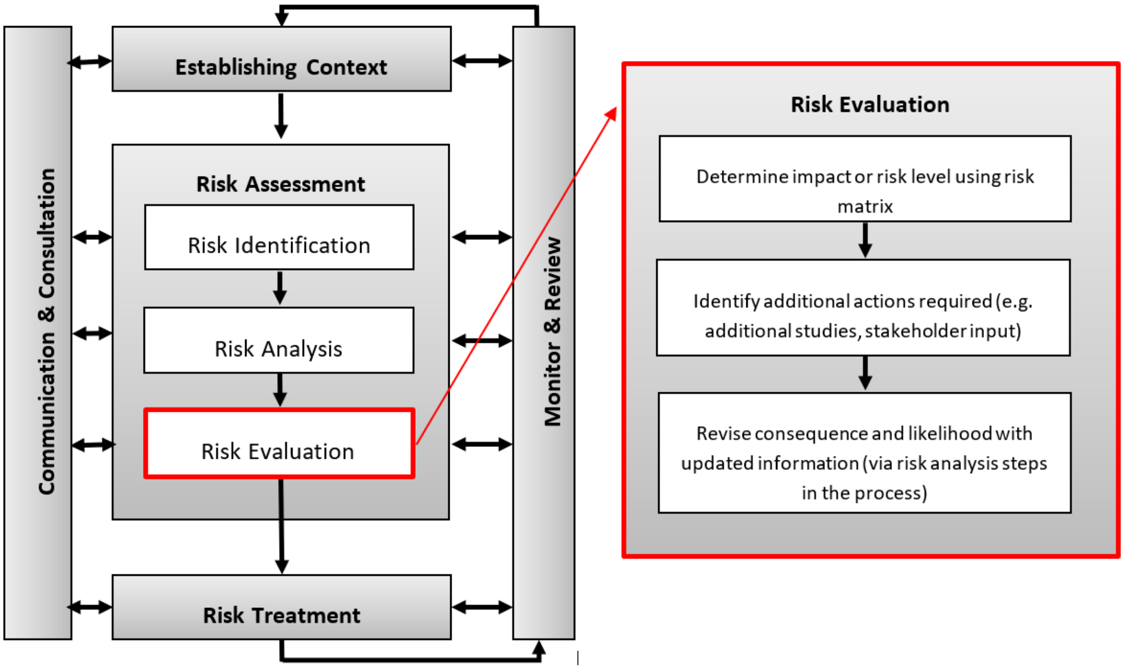


Figure 5-5: Risk evaluation process

5.6 Risk treatment

Risk treatment involved determining whether an impact or risk requires further treatment to meet the definition of acceptable level of impact or risk, to mitigate any potentially undesirable consequence, and to reach ALARP (Figure 5-6). Additional or alternative control measures were proposed and evaluated using ALARP principles. If an adopted control measure had the potential to result in additional or modified impacts and risks, those impacts, and risks were also assessed via the same process. Impact and risk treatment were completed with an assessment against the defined level of acceptable impact or risk criteria that were set earlier in the process.

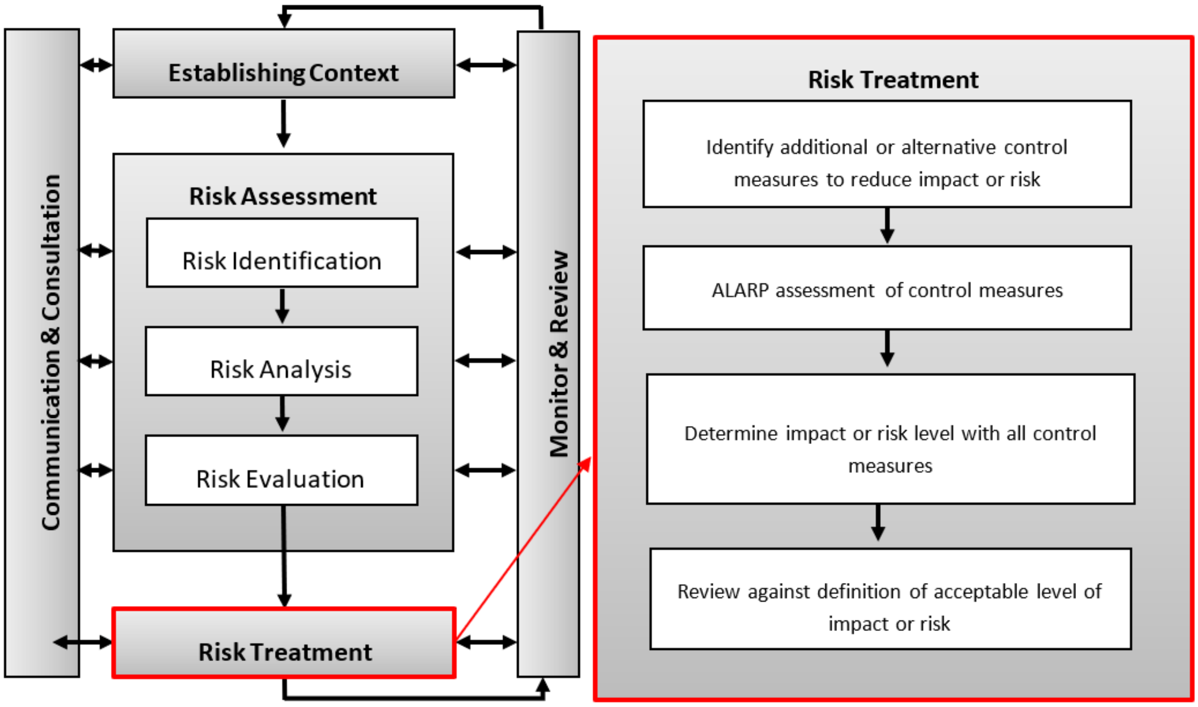


Figure 5-6: Risk treatment process

5.6.1 Control measures

Once the predicted impact or residual risk level was determined, additional control measures were identified by applying the hierarchy of controls (Table 5-6). The effectiveness of control measures was considered when determining the likelihood of events with control measures in place, i.e. factors such as functionality, availability, reliability, survivability, independence and compatibility of control measures, were considered.

5.6.2 ALARP

OPGGS(E) Sub-regulation 10A(b) requires that an environment plan demonstrate that the impacts and risks of the activity will be reduced to As Low As Reasonably Practicable (ALARP). Reducing impacts and risks to ALARP centres on the construct of reasonable practicability; the weighing up of the magnitude of the impact or risk against the cost of reduction. Additional control measures are considered reasonably practicable if the costs to implement them are not grossly disproportionate to the reduction in risk achieved.

SapuraOMV identified appropriate standard control measures by applying the hierarchy of controls shown in Table 5-6.

Table 5-6: Hierarchy of control measures

Control type	Description
Eliminate	**Completely remove the hazard**
Substitute	**Replace the material or process with a less hazardous one**
Engineering/isolation	**Provide engineering solutions to control the hazard / isolate the hazard from the environment**
Administration	**Use administrative procedures to control the hazard**

Protective	**Use appropriate protective equipment, (including emergency response and contingency planning), when other control measures are not practical or have not totally removed the hazard**

To evaluate and rate the expected net value of the additional or alternative management measures the cost/benefit evaluation was based on the:

- Cost of the control or mitigation measure as an estimated percentage of the total seismic survey cost (over 10%, between 5–10%, 2–5%, 0.5–2% and less than 0.5%), based on professional judgement.
- Environmental benefit: ranking of how much the control or mitigation measure is expected to reduce the adverse environmental effect. Sometimes this could include quantitative measures (e.g. % reduction in the intensity of sound produced), other times a qualitative estimate of predicted scale of change in impact (e.g. estimating proportion of populations that may be impacted in various seasons).

The environmental benefit criteria are defined in Table 5-7.

Table 5-7: Environmental benefit scale

Scale	Environmental benefit (percentages apply where quantifiable)
Negligible	**Control measure would yield negligible (<1%) change in adverse environmental effect**
Minor	**Control measure causes minor (1-3%) reduction in the adverse environmental effect**
Moderate	**Control measure results in moderate (3-10%) reduction in adverse environmental effect**
Significant	**Control measure significantly reduces (10-50%) the adverse environmental effect**
Major	**Control measure causes major reduction (>50%) in the adverse environmental effect**

The estimated cost criterion was qualitatively assessed by SapuraOMV personnel familiar with the practicalities of implementing the management measures. The expected net benefit of the management alternative in reducing the likelihood or the consequence, beyond that achieved by the previously identified management measures was evaluated. Personnel assessed whether each additional control measure would result in a real reduction of risk. If a control measure reduced the potential risk significantly, but did not change the risk level, it was still considered as a net benefit and a contribution to reaching ALARP.

The potential for each new control to generate negative environmental impacts, health and safety issues or operational hazards was also considered. Where the overall ‘cost’ of implementation was considered grossly disproportionate to the potential environmental (including socio-economic) benefit of a control, the control was not adopted. The control measures considered as part of ALARP assessment are documented in Sections 6 and 7.

5.6.3 Acceptability evaluation

The terms "predicted impacts" and "residual risks" describe the level of impact or risk remaining after risk treatment has been applied (i.e. the control measures are implemented, including those identified later through the ALARP and acceptability processes).

As part of an iterative process, the predicted impacts and residual risks are evaluated against the pre-determined criteria for acceptability and the process repeated until ALARP and acceptability have been demonstrated.

5.7 Monitoring and review

It is imperative that once environmental impacts and risks have been identified, assessed and reduced to ALARP and to an acceptable level, that performance monitoring and review arrangements are in place to ensure the adopted control measures are implemented and effective.

Review of the impacts and risks assessed has been undertaken throughout the environmental impact and risk management process (Figure 5-1). This included planning, gathering and analysing information, recording results and providing feedback. Performance monitoring and review of impacts and risks will continue for the duration of the activity if impacts and risks change, or new impacts and risks are identified. If the outcomes of monitoring and review prompt changes to this EP, or SapuraOMV's internal management system, the changes will be undertaken via SapuraOMV's management of change process. Monitoring and review, reporting and management of change is described in Section 8 of this EP.

6 Impacts associated with planned activities

6.1 Summary of impacts from planned activities

An "environmental impact" is defined as any adverse or beneficial change to the environment that results from a planned activity. Environmental impacts are a fundamental part of undertaking specific activities due to the unavoidable nature of the operations. The acceptability of such impacts is assessed in terms of the consequences, as their likelihood is considered almost certain (as per the risk matrix in Section 5). The process for identifying environmental impacts is described in Section 5, and the consequences of planned impacts occurring during the Gem 3D MSS are summarised in Table 6-1.

A discussion of the environmental impacts associated with the Gem 3D MSS to be carried out under this EP, the predicted environmental effects and the control measures that will be implemented to reduce impacts to As Low as Reasonably Practicable (ALARP) are presented in this section. Alternative controls identified and considered to ensure residual impacts have been reduced to ALARP are also discussed. The ALARP process is described in Section 5. Environmental performance outcomes, controls, standards and measurement criteria are provided for each type of impact.

With the controls that will be implemented, all of the planned impacts were assessed to have 'negligible' environmental consequences. (Section 5.5.1)

Table 6-1: Summary of planned impact assessments

Section No.	Source of impact (aspect)	Potential environmental effect	Consequence severity with controls in place

6.2	**Underwater sound emissions from seismic array**	**Localised and temporary behavioural disturbance to noise sensitive marine fauna, including protected cetacean species**	**Negligible**
6.3	**Physical presence of survey vessels**	**Localised and temporary displacement of other marine users within the Operations Area during seismic acquisition**	**Negligible**
6.4	**Underwater sound emissions from survey vessels**	**Localised and temporary behavioural disturbance to noise sensitive marine fauna, including small numbers of protected cetaceans**	**Negligible**
6.5	**Light emissions from survey vessels**	**Localised and temporary behavioural disturbance of light-sensitive marine fauna, including protected species (turtles, ocean-foraging birds and cetaceans)**	**Negligible**
6.6	**Atmospheric emissions from survey vessels**	**Reduced local air quality from atmospheric emissions and negligible contribution to national greenhouse gas emissions**	**Negligible**
6.7	**Discharge of sewage, grey water and food waste from survey vessels**	**Localised effects on marine biota due to increase in turbidity and nutrient concentrations**	**Negligible**
6.8	**Discharge of bilge water, deck drainage, cooling water and brine from survey vessels**	**Localised adverse effects on marine biota due to increase in temperature, salinity and potential chemical toxicity on water quality and marine biota**	**Negligible**

6.2 Underwater sound emissions from seismic array

6.2.1 Overview of impact

6.2.1.1 Source of impact

Acquisition of the Gem 3D MSS will involve the use of a seismic source, consisting of an airgun array with a maximum capacity of 2,820 in^3, towed at a water depth of 5-6 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 acquisition lines within the Active Source Area (ASA).

The seismic source will be discharged at or below full capacity (power) within the ASA, for the purpose of run-outs, source testing and soft starts during run-ins. The full seismic source will not be operational outside of the ASA, although small, individual source elements may be tested during maintenance outside the ASA but within the Operations Area (OA).

The 2,820 in^3 seismic source will produce far-field source levels up to a maximum of 255 dB re 1 µPa2m2 (PK) and per-pulse source sound exposure levels (SEL) of 228 - 231 dB re 1 µPa2.s (at 10–2,000 Hz) in the vertical direction beneath the array (Appendix G).

6.2.1.2 Physical, biological and socio-economic receptors

Without appropriate control measures in place, noise emitted from the seismic source used during the Gem 3D MSS has the potential to cause impacts to a range of sensitive receptors (described in Section 4), including:

- Marine mammals;
- Marine reptiles;
- Birds;
- Fishes and sharks;
- Zooplankton;
- Fish spawning;
- Commercial fisheries; and
- Australian Marine Parks.

Marine mammals

Table 6-2 summarises Threatened marine mammal species listed in the PMST report that may occur in or transit the region. A number of listed Migratory dolphin species may also occur in or transit the region (Section 4.4.4). Although not described as Threatened in the PMST report, a small population of dugong has been recorded at Ashmore Reef that may visit seagrass habitat on the Sahul Banks (Section 4.4.6, Appendix E).

Table 6-2: Listed Vulnerable or Endangered marine mammals that may transit the region during the period of the Gem 3D MSS

Species	Activity in region	Nearest BIA (km)	Present during Gem 3D MSS	Abundance in the area
Blue whale (including the pygmy blue whale)	**Annual northbound and southbound migration**	**OA and ASA overlap distribution BIA. ASA located ~25 km from migration BIA**	**Yes**	**Isolated individuals may be present in deeper waters west and north of the OA in Jun-Aug and Oct-Nov**
Sei whale	**No known migration, aggregation or breeding areas**	**None identified**	**Unlikely**	**Unlikely to occur in the OA**
Fin whale	**No known migration, aggregation or breeding areas**	**None identified**	**Unlikely**	**Unlikely to occur in the OA**

Marine reptiles:

Six turtle species listed in the PMST report as Threatened and Migratory may transit the Operations and Planning Areas (Section 4.4.7, Appendix E). These are described in Table 6-3. There are no nesting sites for any turtles within the area where underwater noise emissions would be detectable above background ambient underwater noise levels. Olive ridley and leatherback turtles are not known to nest in the area, but individuals may transit to foraging habitats north-west of the region.

Table 6-3: Vulnerable or Endangered marine turtles that may transit the region

Species	Activity in region	Nearest BIA (km)	Present during Gem 3D MSS	Abundance in the OA and surrounding waters
Flatback turtle	**Mating, nesting, hatching, foraging**	**Possible presence at Ashmore Reef (>170 km), Cartier Island (>140 km)**	**Yes**	**Isolated individuals**
Green turtle	**Mating, nesting, hatching, foraging**	**Ashmore Reef (>170 km)**	**Yes**	**Isolated individuals**
Hawksbill turtle	**Mating, nesting, inter-nesting, hatching, foraging**	**Ashmore Reef (>170 km), possible presence at Cartier Island (>100 km)**	**Yes**	**Isolated individuals**
Leatherback turtle	**Foraging, feeding or related behaviour.**	**Possible presence in the region.**	**Yes**	**Isolated individuals**
Loggerhead turtle	**Mating, nesting, hatching, foraging**	**Possible presence at Ashmore Reef (>170 km)**	**Yes**	**Isolated individuals**
Olive Ridley turtle	**Foraging, feeding or related behaviour.**	**Possible presence in the region.**	**Yes**	**Isolated individuals**

Seabirds:

As detailed in Section 4, Table 6-4 provides examples of Threatened or Migratory seabirds and shorebirds that may transit the region or have habitats that may occur in the region. There are no delineated BIAs overlapping the OA, only isolated foraging adults are likely to occur in the area.

Table 6-4: Examples of listed seabirds and migratory shore birds that may be in the region

Species	Activity in region	Nearest BIA or aggregation	Present during Gem 3D MSS	Abundance in the OA and surrounding waters
Vulnerable (e.g. Australian lesser noddy)	**Foraging, resting**	**No BIA in OA, possible low presence on Ashmore**	**Yes**	**Individual adults**
Endangered (e.g. red knot) and Critically Endangered (e.g. curlew sandpiper)	**Foraging-coastal Australia**	**Mainland Australia**	**Yes**	**Individual adults**

Migratory (e.g. great and lesser frigate bird, streaked shearwater, common noddy)	**Foraging, migrating**	**Not in region**	**Yes**	**Individual adults**

Fishes and elasmobranchs; zooplankton and fish spawning:

As described in Section 4.4.5 there are five shark species listed as threatened in the PMST report, including the whale shark which is considered the most likely to be present in the OA during the MSS. Table 6-5 provides summary information for this species and for plankton in the OA and surrounding waters.

Site-attached fish assemblages could occur in shallower waters on the tops of the shoals within the OA and ASA. Commercially targeted demersal and pelagic fish species may occur in the OA and surrounding waters, and these species could form spawning aggregations in the area. Plankton habitats are ubiquitous in the region without delineated aggregation areas.

Table 6-5:Summary information for whale sharks and plankton

Species	Activity in region	Nearest BIA (km)	Present during Gem 3D MSS	Abundance in the OA and surrounding waters
Whale shark	**Foraging, migrating**	**A small part of the whale shark BIA overlaps ~1/3 of the OA**	**Yes**	**Individuals, peak in Oct-Dec**
Plankton	**General distribution**	**N/A**	**Yes**	**Low abundance**

6.2.2 Impact analysis and treatment

Table 6-6: Duration of impact and ALARP assessment technique for underwater sound from seismic array

Planned event	Underwater sound from seismic array
Duration of impact	**Short to medium term – for the duration of the survey, and potentially for weeks to months following completion**
ALARP assessment technique	**The activity is a typical 3D survey similar to the majority of seismic surveys conducted in Australian marine waters in terms of technical methods and procedures. No unique or unusual equipment or operations are proposed for the Gem 3D MSS Although there remains uncertainty in the relationship between noise levels and impacts on some aquatic species, the science underlying noise modelling is well understood and an appropriate model with conservatism in model assumptions applied during the modelling process. Taking this in consideration Decision Context A should be applied to demonstrate impacts are ALARP, which includes:** **Legislation, codes and standards (LCS)**

	Good Industry Practice (GIP) **Professional Judgement (PJ)**

6.2.2.1 Context for setting standard control measures

Table 6.7 describes the context for setting the minimum controls.

Table 6-7: Context for setting standard control measures – underwater sound from seismic array

Compliance with legislative requirements: **Part A Standard Management Measures of EPBC Policy Statement 2.1 will be applied in full to mitigate potential impacts to whales. One EPBC Policy Statement 2.1 Part B Additional Management Measure (use of marine mammal observers (MMOs)) will also be applied.** **OPGGS Act: Residual risks must be reduced to ALARP (addressed in Section 5.5.3).**
Compliance with company and industry standards: **SapuraOMV's requirements for all impacts and risks to be reduced to ALARP (addressed in Section 5.5.3).** **IOGP/IAGC Recommended monitoring and mitigation measures for cetaceans during marine seismic survey geophysical operations (International Association of Oil and Gas Producers 2017).** **Seismic activities comply or exceed good industry practice such as the APPEA Code of Environmental Practice (APPEA 2008) objectives for offshore seismic surveys with respect to reducing the impacts to other marine life to a level which is ALARP and acceptable including:** • **The adoption of appropriate management measures for the survey in accordance with legislative requirements/guidelines; and** • **Utilisation of appropriate research studies/knowledge and latest data records to provide knowledge of environment in which the seismic source will operate and assess potential impacts. As such, potential receptors within the existing environment have been researched in the latest data records in Section 4.**
Alignment with objectives and compliance with requirements of applicable management, recovery and /or conservation plans: • **Blue Whale Conservation Management Plan (DoE 2015a)** • ***Balaenoptera borealis* (sei whale) conservation advice (TSSC 2015a)** • ***Balaenoptera physalus* (fin whale) conservation advice (TSSC 2015b)** • **Conservation Advice *Rhincodon typus* whale shark (TSSC 2015d)** • **Sawfish and River Sharks Multispecies Recovery Plan (Commonwealth of Australia 2015)** • **Approved Conservation Advice for *Glyphis garricki* (northern river shark) (DoE 2014)** • **Conservation Advice for *Anous tenuirostris melanops* Australian lesser noddy (TSSC 2015c)** • **Conservation Advice for *Calidris canutus* Red knot (TSSC 2016)** • **The Recovery Plan for Marine Turtles in Australia (DoEE 2017)**

6.2.2.2 Description of impact with standard controls

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).

6.2.2.2.1 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 summarised below and are explained in more detail in the acoustic modelling report (Appendix G). These criteria have been selected on the basis that they include standard thresholds, thresholds suggested by the best available science, and sound levels presented in the scientific literature for species with no suggested thresholds:

1. Peak pressure levels (PK) and frequency-weighted accumulated sound exposure levels (SEL) 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.

2. Marine mammal behavioural threshold, 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.

3. Sound exposure guidelines for fish, fish eggs, and larvae (Popper et al. 2014).

4. Thresholds for PTS effects in turtles of 232 dB re 1 µPa (PK) and 204 dB re 1 µPa2·s (SEL24h), and of 226 dB re 1 µPa (PK) and 189 dB re 1 µPa2·s (SEL24h) for TTS effects in turtles (Finneran et al. 2017). A behavioural response threshold of 166 dB re 1 µPa SPL (NSF 2011), as applied by the U.S. NMFS, along with a sound level of 175 dB re 1 µPa (SPL), associated with an increased level of behavioural response (McCauley et al. 2000a, 2000b; Moein et al. 1995; NSF 2011), were also considered.

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-to-peak pressure levels (PK-PK) at the sea floor to help assess effects of noise on crustaceans and bivalves, through comparison to results in Payne et al. (2008) and Day et al. (2016).

7. A sound level of 226 dB re 1 µPa PK reported for comparison to Heyward et al. (2018) for sponges and corals.

Additionally, the distance to an unweighted single pulse SEL of 160 dB re 1 µPa2·s was modelled to assess the size of the low-power zone required under the EPBC Act Policy Statement 2.1 (DEWHA 2008a).

Noise thresholds have been defined for both the per-pulse sound energy released, as well as the total sound energy (accumulated) that marine fauna is subjected to over a defined period of time. For recent regulatory assessments of seismic surveys, the period of total sound energy integration (i.e. accumulation) has been typically defined as 24 hours; hence, was the period used for modelling and in this assessment. For fishes this period is based on available research (Popper et al. 2014), which found fishes 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 fishes (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 fishes, sound exposures at the closest point to the seismic source are the primary exposures contributing to a receptor's accumulated level (Gedamke, Gales & Frydman 2011). Hence, thresholds based on a 24-hour exposure period are considered to be a conservative measure of potential effect.

6.2.2.2.1.1 Marine mammals and turtles

The sound exposure thresholds applied for marine mammals and marine reptiles (turtles) in the acoustic modelling study, and in this impact assessment, are summarised in Table 6-8, and are explained in more detail in the acoustic modelling report (Appendix G). Frequency weighting is also explained in Appendix A.3 of the acoustic modelling report.

Table 6-8: Unweighted SPL, weighted SEL24h, and PK thresholds for acoustic effects on marine mammals and turtles

Hearing group	Behaviour	Impairment (NMFS (2018) & Finneran et al. (2017))			
	SPL (dB re 1 µPa)	**PTS onset thresholds* (received level)**		**TTS onset thresholds* (received level)**	
		Weighted SEL_{24h} (dB re 1 $\mu Pa^2 \cdot s$)	**PK (dB re 1 µPa)**	**Weighted SEL_{24h} (dB re 1 $\mu Pa^2 \cdot s$)**	**PK (dB re 1 µPa)**
Low-frequency (LF) cetaceans	**160**[1]	**183**	**219**	**168**	**213**
Mid-frequency (MF) cetaceans		**185**	**230**	**170**	**224**
High-frequency (HF) cetaceans		**155**	**202**	**140**	**196**
Sirenians (dugong)		**190**	**226**	**175**	**220**
Turtles	**166**[2]	**204**	**232**	**189**	**226**
	175[3]				

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

1 NMFS (2014); 2 NSF (2011); 3 McCauley et al. (2000a, 2000b); Moein et al. (1995); NSF (2011).

6.2.2.2.1.2 Fishes and elasmobranchs

The sound exposure thresholds applied for fishes and elasmobranchs (sharks and rays) in the acoustic modelling study, and used in this impact assessment, are summarised in Table 6-9. These are explained in more detail in the acoustic modelling report (Appendix G).

Table 6-9: Criteria for seismic noise exposure for fish, and 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 and elasmobranchs: 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_{24}h**	**(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; SEL24h dB re 1µPa2·s. All criteria are presented as sound pressure, even for fish without swim bladders, since no data for particle motion exist. Relative risk (high, moderate, or low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

6.2.2.2.1.3 Benthic invertebrates

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 sea floor, with larger arrays and shallower water being related to higher particle motion levels, more likely relevant to effects on crustaceans and molluscs.

At the sea floor interface, crustaceans and molluscs 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, it is not possible to propose authoritative thresholds to inform this impact 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 was therefore applied in this impact assessment. Additionally, for context, the PK-PK sound levels determined for crustaceans in Day et al. (2016a) (209–212 dB re 1 µPa PK-PK) were also considered in this impact assessment.

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

6.2.2.2.2 Acoustic modelling

To assess the potential magnitude and extent of impacts from underwater noise produced during the Gem 3D MSS, SapuraOMV commissioned JASCO Applied Sciences (JASCO) to model the source levels and sound propagation at several locations that were representative of the different water depths, bathymetry and seabed properties within the ASA (Appendix G). The objective of this acoustic modelling study was to evaluate the effects of sound on marine fauna including marine mammals, marine reptiles, fishes, elasmobranchs, benthic invertebrates and zooplankton, and on socio-economic receptors such as commercial fisheries and Australian Marine Parks. Modelling considered a 2,820 in^3 seismic source towed at 5 - 6 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 pulse sound fields were predicted at seven defined locations (6 x maximum-over-depth and sea floor sites; 1 x sea floor only site) within the ASA, and accumulated sound exposure fields were predicted for one representative scenario for likely survey operations over 24 hours (refer Figure 6-1). Additionally, three other locations within the ASA with water depths of 35 m, 45 m and 55 m were chosen at random for estimation of single pulse received levels at the sea floor.

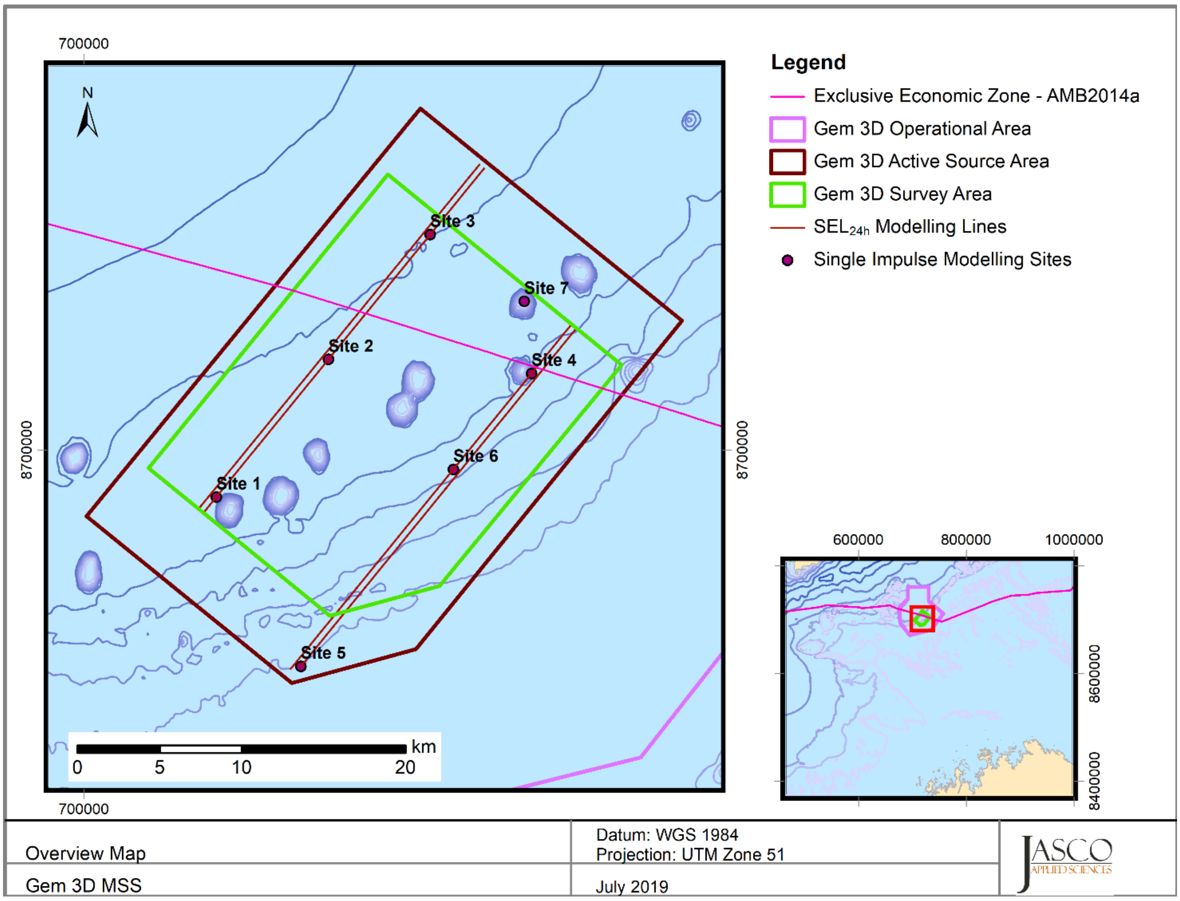


Figure 6-1: Location of single impulse modelling sites and SEL24h modelling lines for assessment of Gem 3D MSS sound emissions

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. A conservative sound speed profile that would be most supportive of sound propagation conditions for the period of the survey (i.e. worst case) was defined and applied to all modelling.

The analysis considered the distances away from the seismic source at which several effects criteria or relevant 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 sea floor for the two single pulse locations, and for the two cumulative SEL24h scenarios. 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:

- Rmax - the maximum range to the given sound level over all azimuths; and
- R95% - the range to the given sound level after the 5% farthest points were excluded.

The difference between Rmax and R95% depends on the source directivity and the non-uniformity of the acoustic environment. In some environments a sound level contour might have small anomalous isolated fringes in which case Rmax can misrepresent the area of the region exposed to such effects. In this instance R95% is considered more representative. However, in environments that have bathymetric features that affect sound propagation R95% neglects to account for these and therefore Rmax can provide a better representation of the region of effect in specific directions

(Appendix G). For this impact assessment the Rmax values have been considered due to the presence of shallow shoals.

6.2.2.2.3 Marine mammals

In the context of this EP, the term marine mammals includes cetaceans (whales and dolphins) and dugongs. The type and scale of the effect on marine mammals to seismic sounds 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).

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 TTS. The onset of TTS is often defined as threshold shift of 6 dB above the normal hearing threshold (Southall et al. 2008). If the threshold shift does not return to normal, the residual shift is called a PTS. 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. 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.

PTS is hearing loss from which marine fauna do not recover (permanent hair cell or receptor damage). PTS is considered injurious in marine mammals, but there are no published data on the sound levels that cause PTS in marine mammals. The NMFS (2018) criteria incorporate the best available science to estimate PTS onset in marine mammals from sound energy (SEL24h), or very loud, instantaneous peak sound pressure levels. Hence, PTS effects in marine mammals should be viewed as theoretical, as they have never actually been demonstrated in either captive or wild animals.

Without appropriate control measures in place, noise emissions from the seismic source have the potential to impact cetaceans and dugong 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 4.4.4, and summarised in Table 6.2 above, the OA and ASA overlap the general distribution BIA for pygmy blue whales off north-west Australia. As shown in Figure 4.9, the northern part of the OA overlaps the northern migration BIA for pygmy blue whales that encompasses the northern section of the migratory corridor – i.e. around the Indonesian Archipelago and the Banda Sea. The area of overlap is approximately 946 km^2, which represents an extremely small percentage (<0.0001%) of the overall area of the migration BIA. Neither the OA or the ASA overlap the southern migration BIA, which is located approximately 12 km west of the OA and approximately 45 km north-west of the ASA.

Underwater noise is identified as a key threat to blue whales in the Conservation Management Plan for the Blue Whale (DoE 2015a), and the plan includes a specific action that “Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area”.

Double et al. (2014) acknowledged that: “While anthropogenic noise may alter blue whale behaviour, it is unlikely to pose a conservation risk unless it causes population level consequences such as changes in growth, reproduction and survival of individuals. Elevated ambient noise has been responsible for abandonment or avoidance of critical habitat by a number of cetacean species…Critical habitat includes habitat used to meet essential lifecycle requirements such as foraging and breeding.”

The OA is located at least 280 km north of the closest BIA for humpback whales – the resting and calving BIA adjacent to the Kimberley coastline, and outside of the season when this species is expected to occur in that area.

As summarised in Table 4-4, there is the possibility that a number of other cetacean species may be present in the OA and surrounding waters during acquisition of the survey (e.g. killer and Bryde’s whales, pygmy and dwarf sperm whales, spotted bottlenose dolphins). The presence of these cetacean species within the OA during acquisition of the survey is likely to be limited to occasional transits of isolated individuals or small pods.

Three dugongs were sighted during an aerial survey in 1999 approximately 130 km east of Ashmore Reef (Whiting 1999). The animals were sighted in a water depth of approximately 90 m, 30 km from the nearest shallow shoal. This location is approximately 60 km south-west of the OA. Whiting (1999) hypothesised that the shallow shoals of the Sahul Banks could represent a previously unrecognized feeding habitat for dugong, with animals potentially travelling to the area from Ashmore Reef.

6.2.2.2.3.1 Modelling results

Table 6-10 presents the results of the acoustic modelling study for maximum predicted Rmax distances to PTS (injury), TTS and behavioural response thresholds in marine mammals, for all modelled scenarios (two single impulse sites and two multiple pulse scenarios). The results for the criteria applied for marine mammal PTS and TTS consider both metrics within the criteria (single pulse PK and multiple pulse SEL24h). In accordance with NMFS (2018) the longest distance associated with either metric is required to be applied for an impact assessment.

As shown in , considering the NMFS (2018) SEL24h threshold criterion, low frequency (LF)-cetaceans (such as pygmy blue whales) are predicted to experience PTS at a maximum predicted distance of 860 m from the nearest survey line, based on application of the multiple pulse SEL24h threshold across all water depths modelled (maximum-over-depth: MOD). For mid frequency (MF)-cetaceans, the maximum predicted distance to PTS effects is 20 m, based on the application of the single pulse PK metric. For high frequency (HF)-cetaceans, the maximum predicted distance to PTS effects is 310 m, again based on the application of the single pulse PK metric.

For dugong, the maximum predicted distance to TTS effects is 30 m, based on the application of the single pulse PK metric, whereas the PTS threshold for this species was not reached for either single pulse PK or multiple pulse SEL24h thresholds (Table 6-10).

The maximum predicted distance to the TTS threshold for LF-cetaceans is 22.7 km from the nearest survey line, based on application of the multiple pulse SEL24h threshold. For MF-cetaceans, the maximum predicted distance to TTS effects reduces to 20 m, based on the application of the single pulse PK metric. The maximum predicted distance to the TTS threshold for HF-cetaceans is 570 m from the nearest survey line, based on application of the single pulse PK metric. For dugong, the maximum predicted distance to the TTS threshold is 30 m from the nearest survey line, again based on 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 within 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 SEL24h radii for LF-cetaceans were larger than those for peak pressure criteria, but they represent an unlikely worst-case scenario. More realistically, whales would not stay in the same location or at the same range for 24 hours. This would particularly be the case for an animal migrating through offshore waters that don't represent critical habitat or a narrow restricted migratory pathway. Therefore, a reported radius for SEL24h 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 (Appendix G).

As shown in, predicted maximum Rmax 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 SEL24h 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 Rmax 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 LF, MF, and HF-cetaceans, and for dugong, is approximately 5.3 km, across all water depths modelled (Table 6-10).

Injury (PTS) effects are predicted to occur in LF-cetaceans only within 30 m of the seismic source, based on the application of the single pulse PK metric. This potential impact is highly unlikely to occur given the control measures that will be in place during acquisition of the survey. The concept of an individual blue whale remaining within a range of 870 m (maximum predicted distance for PTS, based on the SEL24h metric) from the operating seismic source for a full 24-hour period is not credible. Therefore, the potential impacts of noise emissions from the seismic source on marine mammals during acquisition of the Gem 3D MSS are considered to be slight and short-term, and restricted to temporary behavioural changes (avoidance) in individuals.

Marine mammal responses to seismic sounds, including avoidance, are considered unlikely to result in any real biological cost unless causing displacement from areas used for critical behaviours (e.g. breeding, feeding and resting) or preventing movement to/through important areas, such as narrow migratory corridors (DEWHA 2008b, Richardson et al 1995). The Gem 3D MSS will occur in open, oceanic waters distant from recognised breeding, feeding or resting areas for cetaceans or dugong and any temporary avoidance within up to 5.3 km of the seismic vessel will have negligible consequences.

With regards to masking of marine mammal calls, the intermittent nature and very short duration of individual seismic pulses is unlikely to result in any significant masking of vocalisations for any species in the region. It is possible that noise from the seismic source may cause individual whales to cease or alter their vocalisations at times. However, any whales migrating through the area would be exposed to seismic noise periods for less than 24-hours and acquisition of the survey would not cause long-term masking for these individuals. Therefore, the potential for masking effects is considered to be localised and is not expected to extend to or beyond the range already considered for potential behavioural impacts to marine mammals.

Table 6-10: Maximum predicted horizontal distances (Rmax) to PTS (injury), TTS and behavioural response thresholds in marine mammals, for all modelled scenarios

Potential effects	Sound exposure threshold	Rmax distance (km)	Area (km^2)
PTS			
LF-cetaceans#	**219 dB re 1 µPa (PK)**	**NR***	
	183 dB re 1 µPa2.s (SEL24h)	**96.1**	
MF-cetaceans	**230 dB re 1 µPa (PK)**	**<NR***	
	185 dB re 1 µPa2.s (SEL24h)	**–**	**–**
HF-cetaceans	**202 dB re 1 µPa (PK)**	**NR***	
	155 dB re 1 µPa2.s (SEL24h)	**1.8**	
Sirenians (dugong)	**226 dB re 1 µPa (PK)**	**–**	**–**
	190 dB re 1 µPa2.s (SEL24h)	**–**	**–**
TTS			
LF-cetaceans#	**213 dB re 1 µPa (PK)**	**NR***	
	168 dB re 1 µPa2.s (SEL24h)	**21.6**	**1,205**
MF-cetaceans	**224 dB re 1 µPa (PK)**	**<NR***	
	170 dB re 1 µPa2.s (SEL24h)	**–**	**–**
HF-cetaceans	**196 dB re 1 µPa (PK)**	**NR***	
	140 dB re 1 µPa2.s (SEL24h)	**0.5**	**60.2**
Sirenians (dugong)	**220 dB re 1 µPa (PK)**	**NR***	
	175 dB re 1 µPa2.s (SEL24h)	**0.9**	
Behavioural Response			
LF-cetaceans#	**160 dB re 1 µPa (SPL)**	**NR***	
MF-cetaceans			
HF-cetaceans			
Sirenians (dugong)			

The model does not account for shutdowns. * Not relevant. A dash indicates that the threshold was not reached.

6.2.2.2.3.2 Impact assessment conclusion

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

6.2.2.2.4 Marine reptiles

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

Without appropriate control measures in place, noise emissions from the seismic source have the potential to impact marine reptiles (turtles and sea snakes) 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.

The OA does not overlap any turtle BIA in the region. At the closest point, the boundary of the OA is located approximately:

- 94 km from the foraging BIA for flatback, loggerhead, and olive ridley turtles in the Joseph Bonaparte Gulf to the east;
- 122 km from the inter-nesting BIA for green turtles around Cartier Island;
- 155 km from the inter-nesting BIA for green and hawksbill turtles around Ashmore Reef; and
- 120 km from the designated 'Habitat Critical' for green turtles around Cartier Island; and
- 147 km from the 'Habitat Critical' for green turtles around Ashmore Reef.

The OA is located 10.3 km from the Carbonate Bank and Terrace System of the Sahul Shelf KEF. Shallow water pinnacles and banks within the KEF may represent foraging habitat for several turtle species.

The proposed timing for acquisition of the Gem 3D MSS means that there could be overlap with the nesting and breeding seasons for green, hawksbill, flatback and loggerhead turtles in the region (refer Section 4.4.9). At the closest point, the south-west boundary of the OA is located at least 120 km from the boundary of the 'Habitat Critical' for green turtles around Cartier Island and Ashmore Reef. Hence, there is very low likelihood of inter-nesting green turtles transiting through the OA and surrounding waters during acquisition of the survey.

At least 20 species of sea snake occur within the region (DEWHA 2008a). Of these, two threatened and 18 listed marine sea snake species were identified from the search of the EPBC Act Protected Matters Database as potentially occurring in the OA and surrounding waters (Appendix E). Sea snakes are likely to inhabit the shallower waters on the tops of the shoals within the OA and can be expected to occur on and adjacent to these shoals.

6.2.2.2.4.1 Modelling results

Table 6.11 presents the results of the acoustic modelling study for maximum predicted Rmax distances to PTS, TTS and behavioural response thresholds in turtles for all modelled scenarios. As indicated in this table, 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. Based on the application of the 204 dB re 1 µPa2.s (SEL24h) PTS threshold, the Rmax distance increases marginally to 30 m from the centre of the array.

The maximum predicted distance to the TTS threshold for turtles is 420 m from the nearest survey line, based on application of the multiple pulse SEL24h threshold (Table 6-11). As discussed above for marine mammals, the modelling results show that the corresponding SEL24h radius for TTS effects in turtles was considerably larger than that for the peak pressure criterion, but this represents an unlikely worst-case scenario. More realistically, turtles would not stay in the same location or at the same range for 24 hours. This would particularly be the case for turtles moving through these waters that do not represent key foraging, nesting or inter-nesting habitat for any species of turtle.

The NMFS criterion (NSF 2011) for behavioural effects in turtles (166 dB re 1 µPa SPL) could be exceeded within a distance of approximately 3 km of the operating array, and the Moein et al. (1995) criterion of 175 dB re 1 µPa (SPL) could be exceeded within 1.1 km of the array.

A 200 m buffer from the active source will be implemented around shoals that are less than 50 m deep to manage impacts to site attached fish, as described in Section 6.1.3.1. Given the maximum predicted Rmax distances to PTS and TTS effects at the sea floor are 20 m, based on application of the single pulse PK metric, turtles present on these shoals are unlikely to experience PTS or TTS effects. Similarly, a turtle located outside of this buffer zone would receive prior warning as the survey vessel approaches within the range where behavioural effects are likely to occur (1.1 – 3 km), and is likely to swim away from the approaching source and hence remain outside of the PTS or TTS effect range of the operating array. As a further precaution, if a turtle is observed within 200 m of the active source a 'turtle pause', in which airguns are not fired for a series of shots to allow a silence period as the array passes the last visual location of the turtle, will be instigated.

Therefore, the predicted impacts of noise emissions from the seismic source on green, flatback, loggerhead, and hawksbill turtles during acquisition of the Gem 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, or turtles that may be feeding on the shallow shoals within the OA when the operating source passes by in waters adjacent to (>200 m from the 50m contour of) the shoal.

Sea snake responses to seismic survey sound emissions are not well studied and thus conservatively assumed to be similar to that of turtles. Some sea snakes could occur in shallow waters on the tops of the shoals within the OA, but they are not expected to be present in large numbers. Therefore, impacts are likely to be limited to occasional disturbances to transient individuals. The potential consequence to sea snake populations is considered to be insignificant.

Table 6-11: Maximum predicted horizontal distances (Rmax) to PTS (injury), TTS and behavioural response thresholds in turtles, for all modelled scenarios

Potential effects	Sound exposure threshold	Distance Rmax (km)	Area (**km^2**)
PTS	**232 dB re 1 µPa (PK)**	**<NR#**	
	204 dB re 1 µPa2.s (SEL24h)	**2.3**	
TTS	**226 dB re 1 µPa (PK)**	**<NR#**	
	189 dB re 1 µPa2.s (SEL24h)	**55.8**	
Behavioural response	**175 dB re 1 µPa (SPL)**	**NR#**	
	166 dB re 1 µPa (SPL)	**NR#**	

Not relevant.

6.2.2.2.4.2 Impact assessment conclusion

Based on the timing and duration of the survey, the separation distances to nesting BIAs and 'Habitat Critical' areas, and the control measures proposed, predicted noise levels from seismic acquisition are not considered likely to cause PTS or TTS effects, displace any individuals from inter-nesting BIAs or 'Habitat Critical' areas, or result in any ecologically significant impacts at a population level for any species of turtle that may be present within or adjacent to the OA during the survey.

6.2.2.2.5 Seabirds

As described in Section 4.4.6, five threatened and nine migratory seabird species were identified by a search of the EPBC Act Protected Matters Database as potentially occurring in the OA and surrounding areas, through foraging, feeding, breeding or other related behaviours. Seabird species that spend the majority of their lives within the region breed at locations along the coast of Australia and at offshore islands.

There is no emergent land and no BIAs for seabirds in the OA. At the closest point, the OA is located approximately 70 km from the nearest breeding and foraging BIA, for the greater frigatebird around Ashmore Reef and Cartier Island.

Impacts to foraging seabirds have not been observed previously during seismic surveys. Only birds diving and foraging within the OA 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 survey 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. Since there are no seabed foraging BIAs in the area where underwater sound levels may be elevated, and noting the impulsive nature of seismic and very short (split second) duration of each sound pulse, only in the very unlikely event of a bird diving or foraging near the seismic source is it likely to result in a startle response. The consequence of this is expected to be negligible and impacts at a population level are extremely unlikely to occur. Greater frigatebirds, lesser frigatebirds and wedge-tailed shearwaters will not be displaced from the wider areas of the breeding and foraging BIAs around Ashmore Reef and Cartier Island.

6.2.2.2.5.1 Impact assessment conclusion

The behaviour and distribution of some fishes may be affected for short periods during and after exposure to the seismic source, which may result in short-term and localised changes in the distribution of target prey species for some seabirds. However, these effects are unlikely to be discernible to foraging birds in the context of the normal movements and variation in the distribution of fishes. Behavioural effects to foraging seabirds will also be short-term and limited to the vicinity of the seismic vessel.

6.2.2.2.6 Fishes and elasmobranchs

As described in Section 4.4.5, the OA 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 site-attached assemblages inhabiting the shallower areas on the tops of the shoals within the OA, and more mobile species including those targeted by commercial fisheries in the region, as represented by the key indicator species goldband snapper and red emperor.

The south-eastern portion of the OA overlaps a small part of the whale shark foraging BIA that extends northwards across the North West Shelf and the Browse Basin along the 200 m isobath. It is known that the 200 m isobath is an important migratory route for the species, with migration occurring between July and November. There is no overlap between the ASA and the whale shark BIA, but whale sharks could occur at low densities within both the OA and ASA. As discussed in Section 4.4.5.2 other species of shark listed under the EPBC Act (e.g. the great white shark) are not expected to occur within the OA and ASA.

The EPBC Protected Matters Search (Section 4.4.7.1) identified 30 syngnathid species (pipefishes and seahorses) that may potentially occur in the OA and surrounding waters. Species within this family are generally site-attached and associated with shallow habitats of 0-60 m depth. Pipefishes and seahorses usually 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 the presence of a number of shallow shoals within the OA, it is possible that a number of syngnathid species could occur in the area.

The OA is located adjacent to The Carbonate Bank and Terrace System of the Sahul Shelf KEF. As described in Section 4.3.2, the banks provide areas of hard substrate in an otherwise soft sediment environment and are therefore important for sessile species. Rising steeply from depths of about 80 m some banks emerge to within 30 m of the water surface, allowing light dependent organisms to thrive. There are also nine shoals within the ASA that rise to depths of between about 10 and 50 m from the surface (mean sea level). Shoals such as these that rise to within 45 m water depth support more biodiversity, such as communities of sessile benthic invertebrates including hard and soft corals, sponges, whips, fans and bryozoans (Brewer et al. 2007; Nichol et al. 2013). Brewer et al. (2007) also noted that banks within the KEF support aggregations of demersal fish species, such as snappers, emperors and groupers.

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.

6.2.2.2.6.1 Modelling results

As outlined above, and fully described in the acoustic modelling report (Appendix G), the modelling study assessed the ranges for quantitative criteria based on the Popper et al. (2014) guidelines, and considered both PK and SEL24h metrics for both water column and sea floor 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 most relevant metric for perceiving underwater sound for most fish species is particle motion but, with the exception of few species (Popper et al. 2014; Popper & Fay 2011), there is an almost complete lack of relevant data on particle motion sensitivity in fishes (Popper & 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.

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) (Boeger et al. 2006; Carroll et al. 2017; DFO 2004; Popper et al. 2016). 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. These authors used pile driving data as a proxy as the research to date had not identified a threshold level where mortality has been observed, and further note that direct application of cumulative criteria adopted for piling driving to seismic airguns would not be appropriate. This is because the received peak SEL (or "single strike" SEL) changes from shot to shot since the seismic vessel is moving and will be at different distances from the fish. Note that for piling, it is possible to determine the cumulative noise exposure as piling is a stationary noise source. Therefore, Popper et al. (2014) conclude that it is better to use a guideline based on the closest peak level for seismic airguns than one based on a cumulative exposure. 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.

As described in ERM (2017), 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 & 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 in^3) at a minimum exposure distance of 45 m. As described above, 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.

Table 6-12 presents the results of the acoustic modelling study for maximum predicted Rmax distances to mortality/PMI, recoverable injury and TTS thresholds in fishes in the ASA. Data are presented for the water column (MOD) and at the sea floor.

Table 6-13 presents the results of the acoustic modelling study for maximum predicted Rmax distances vertically beneath the seismic source to mortality/PMI and recoverable injury in fishes at the sea floor, across five different water depths. These water depths represent the shallowest and deepest of the single pulse modelling sites (Site 6 – 28 m; and Site 5 – 124 m, respectively), plus three other water depths chosen at random within the ASA. Site 6 (28 m) represents the shallowest water depth on a shoal directly beneath an acquisition line. The 35 m water depth was chosen as it represents the closest point of approach of a line to a shoal, for the nine shoals that have buffer or exclusion zones around them and are not overlapped by any acquisition lines.

The following fish types have been identified for this assessment:

- Site-attached fish assemblages associated with shallow shoals within the ASA;
- Fish assemblages associated with The Carbonate Bank and Terrace System of the Sahul Shelf KEF;
- Demersal fish species, including key indicator species such as tropical snappers and emperors (families Lutjanidae and Lethrinidae);
- Pelagic fish species, including key indicator species such as Spanish mackerel; and
- Whale sharks.

Table 6-12: Maximum predicted distances (Rmax) to mortality/PMI, recoverably injury and TTS thresholds for fish, fish eggs, and larvae for single pulse and SEL24h modelled scenarios, for water column and at the sea floor

Marine fauna group	Potential impact	Sound exposure threshold	Maximum-over-depth (MOD)		Sea floor	
			R_{max} (km)	**Area** (km^2)	**R_{max} (km)**	**Area** (km^2**)**
I **Fish: No swim bladder (incl. sharks)**	**Mortality/ PMI**	**219 dB re 1 µPa^2·s (SEL$_{24h}$)**	**0.03**	**2.22**	**–**	**–**
		213 dB re 1 µPa (PK)	**0.06**	**NR***	**0.09**	**NR***
	Recoverable injury	**216 dB re 1 µPa^2·s (SEL$_{24h}$)**	**0.03**	**2.34**	**–**	**–**
		213 dB re 1 µPa (PK)	**0.06**	**NR***	**0.09**	**NR***
	TTS	**186 dB re 1 µPa^2·s (SEL$_{24h}$)**	**1.47**	**148**	**1.27**	**131**
II **Fish: Swim bladder not involved in hearing (particle motion detection)**	**Mortality/ PMI**	**210 dB re 1 µPa^2·s (SEL$_{24h}$)**	**0.03**	**2.34**	**–**	**–**
		207 dB re 1 µPa (PK)	**0.13**	**NR***	**0.14**	**NR***
	Recoverable injury	**203 dB re 1 µPa^2·s (SEL$_{24h}$)**	**0.03**	**2.43**	**–**	**–**
		207 dB re 1 µPa (PK)	**0.13**	**NR***	**0.14**	**NR***
	TTS	**186 dB re 1 µPa^2·s (SEL$_{24h}$)**	**1.47**	**148**	**1.27**	**131**
III **Fish: Swim bladder**	**Mortality/ PMI**	**207 dB re 1 µPa^2·s (SEL$_{24h}$)**	**0.03**	**2.34**	**–**	**–**
		207 dB re 1 µPa (PK)	**0.13**	**NR***	**0.14**	**NR***

involved in hearing (primarily pressure detection)	**Recoverable injury**	**203 dB re 1 µPa²·s (SEL_{24h})**	**0.03**	**2.44**	**–**	**–**
		207 dB re 1 µPa (PK)	**0.13**	**NR***	**0.14**	**NR***
	TTS	**186 dB re 1 µPa²·s (SEL_{24h})**	**1.47**	**148**	**1.27**	**131**
Fish eggs and larvae	**Mortality/ PMI**	**210 dB re 1 µPa²·s (SEL_{24h})**	**0.03**	**2.37**	**–**	**–**
		207 dB re 1 µPa (PK)	**0.13**	**NR***	**0.14**	**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 was 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).

Table 6-13: Maximum predicted distances (Rmax) to mortality/PMI and recoverable injury thresholds for fish, fish eggs, and larvae for single pulse sites, at the sea floor

Marine fauna group	Potential impact	Sound exposure threshold	R_{max} (m)				
			28 m depth	35 m depth	45 m depth	55 m depth	124 m depth
Fish: I	**Mortality/PMI** **Recoverable injury**	**213 dB re 1 µPa (PK)**	**70**	**71**	**79**	**85**	**40**
Fish: II & III	**Mortality/PMI** **Recoverable injury**	**207 dB re 1 µPa (PK)**	**104**	**108**	**113**	**118**	**137**
Fish eggs and larvae	**Mortality/PMI**	**207 dB re 1 µPa (PK)**	**104**	**108**	**113**	**118**	**137**

6.2.2.2.6.2 Site-attached fish assemblages – shallow shoals

As described in Section 4.4.2, BRUV surveys conducted on upper areas (21-35 m) of shoals within the OA in 2010 showed a high diversity and abundance of teleost (bony fishes) and shark species typical of shallow reef systems (Table 4-9). These included species from families Pomacentridae (damselfishes) and Labridae (wrasses). Because body size is positively related to home-range area in reef fish (Nash et al. 2015), these smaller-sized species are expected to have small home ranges (tens of metres in size) compared to larger species such as those in the families Serranidae and Lethrinidae, which may regularly move hundreds or even thousands of metres (Chapman & Kramer 2000). These smaller-sized species are typically found in depths between 5-50 m water depths and protect themselves by hiding within reef structure (Allen 2009). Larger-sized species, such as the humphead Maori wrasse (*Cheilinus undulatus*) can extend down to 100 m (Edgar 2008). These larger-sized species may move across or around shoals whilst remaining in their preferred depth range, but are unlikely to move across open water to other shoals (Chapman & Kramer 2000).

There are nine shoals with minimum water depths less than 50 m (MSL) that are wholly or partially overlapped by the ASA (Figure 6-2). The maximum predicted distances to mortality/PMI and recoverable injury thresholds for fish, fish eggs, and larvae at the sea floor, for water depths <55 m, range from ~70-118 m (Table 6-12). Site-attached fish assemblages in shallow waters on these shoals could therefore be exposed to recoverable injury effects for the short period of time (< 20 minutes) that it will take to acquire the portions of the lines overlapping the shoal tops. Nevertheless, as discussed above it is unlikely that any mortality/PMI effects will occur to fishes exposed to underwater sound emissions from the seismic source during the acquisition of the Gem 3D MSS. Any recoverable injury effects experienced by site-attached fishes on the shallow shoals within the ASA are not likely to be significant for the following reasons:

- Some individuals may experience physiological impacts but are these are unlikely to have long-term or population level effects, based on the small area of impact and the broad distribution of species through the region.
- Site-attached fish assemblages on these shoals are likely to exhibit high resilience and recovery to short-term and acute disturbances, such as exposure to underwater sound emissions from seismic sources.

It is well recognised that coral reef fish assemblages exhibit high resilience and recovery to natural and anthropogenic disturbance, especially in absence of any habitat damage. As reported in Planes et al. (2005), coral reef fish assemblages at Mururoa Atoll were surprisingly resilient to the impacts of French underground nuclear testing. The pressure wave from each nuclear test caused the instantaneous removal of all fish over an area of 12 km^2 (a radius of 2 km around each test site) but left the benthic habitats and invertebrates untouched. In each case, there must also have been a much larger zone of effect where fish would have experienced sub-lethal physiological and behavioural effects, extending out many kilometres from the test site. Yet despite these intense, large scale perturbations, fish assemblages responded rapidly and were found to be restored to pre-test assemblage structure within 1-5 years (Planes et al. 2005). As long as the structural and biological integrity of the habitat is maintained, and there are neighbouring un-impacted areas that can supply recruits, coral reef fish assemblages appear able to respond rapidly to large-scale natural and anthropogenic change.

This observation is supported by another study (Syms & Jones 2000) in the Great Barrier Reef, where it was demonstrated that assemblages disturbed by fish removal were resilient, with recolonization from both immigration and larval settlement. The results of this experiment (albeit at a much reduced scale to the Mururoa Atoll example) supported a model of patch-reef fish assemblages organized by a combination of deterministic factors (such as habitat structure) and stochastic processes (such as recruitment) (Syms & Jones 2000). Similarly, in a study that examined coral bleaching, reef fish community phase shifts and the resilience of coral reefs, Bellwood et al. (2006) concluded that:

"Coral reef fishes would thus appear to be relatively resilient, in ecosystem terms, to short-term perturbations. It would appear that reef fishes are able to maintain ecosystem processes; the implicit assumption being that no change in the community composition is a reasonable indication that ecosystem processes are intact."

In a study that monitored coral and fish assemblages over 14 years on fixed sites spread over 80 km of the southern Great Barrier Reef, Halford et al. (2004) found evidence of large-scale resilience and predictable recovery of these assemblages. This study found that although processes such as settlement and immigration are ultimately responsible for replenishment of local populations, the data suggested that habitat plays a strong role in modifying fish assemblages. Tropical reef communities are typically characterized by very high species diversity in a spatially heterogeneous environment and display stochastic variability in community structure at small spatial and temporal scales. As reported by Halford et al. (2004), both coral and fish assemblages demonstrated resilience to large-scale natural disturbance and predictability in the structure of the assemblages.

Lefèvre & Bellwood (2015) examined the recolonisation of populations of small cryptic fishes on the Great Barrier Reef following experimental removal. After removing resident cryptobenthic reef fish assemblages from otherwise undisturbed coral rubble areas they observed a rapid recovery. Within eight weeks, fish assemblages were similar to their pre-removal structure in terms of fish abundance, species diversity and species richness. The return of larger species was largely mediated by recolonisation, while smaller, less mobile species relied primarily on recruitment, presumably from the plankton.

In terms of impacts to site-attached fish species from underwater sound emissions from the seismic source, the immediate impact on individuals or on schools of fish from a conservation perspective is less important than the long-term impact on populations and ecosystems, either alone or in combination with other stresses (which will often include fishing). A reduction in the numbers of fish through exposure to sound may or may not have a measurable effect on fish population recruitment. Some fish populations go through a period of density-dependent mortality and removing a small number of animals may simply result in their replacement through the improved survival of others.

As shown in Table 611, the maximum predicted distance to the TTS threshold at the sea floor for all hearing groups of fishes is 1.43 km. Therefore, site-attached fish assemblages on all of the nine shallow shoals within the ASA could potentially experience TTS effects. However, any TTS effects are not likely to be ecologically significant at a population level for the following reasons:

- 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 their review of TTS for the Santos Bethany 3D MSS (Edgell et al. 2019), which considered similar fish species as present within and adjacent to the Gem 3D MSS OA, 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 Gem 3D MSS OA and surrounding waters), being species that do not have hearing specialisations, are not likely to have much (if any) TTS as a result of the Bethany 3D survey.
- If TTS takes place, its level is likely to be sufficiently low that it will not be possible to easily differentiate it from normal variations in hearing sensitivity. Even if fishes do show some TTS, recovery will start as soon as the most intense sounds end, and recovery is likely to even occur, to a limited degree, between seismic pulses. Based on very limited data, recovery within 24 hours (or less) is very likely.

- Nothing is known about the behavioural implications of TTS in fishes in the wild. However, since the TTS is likely very transitory, the likelihood of it having a significant impact on fish fitness is very low.

Based on the qualitative approach applied in Popper et al. (2014) the likelihood of behavioural effects occurring is assessed as high within tens of metres of the seismic source (refer Table 6.11). Site-attached fish assemblages on the shallow shoals within the ASA are therefore not likely to exhibit behavioural responses to noise emissions from the seismic source.

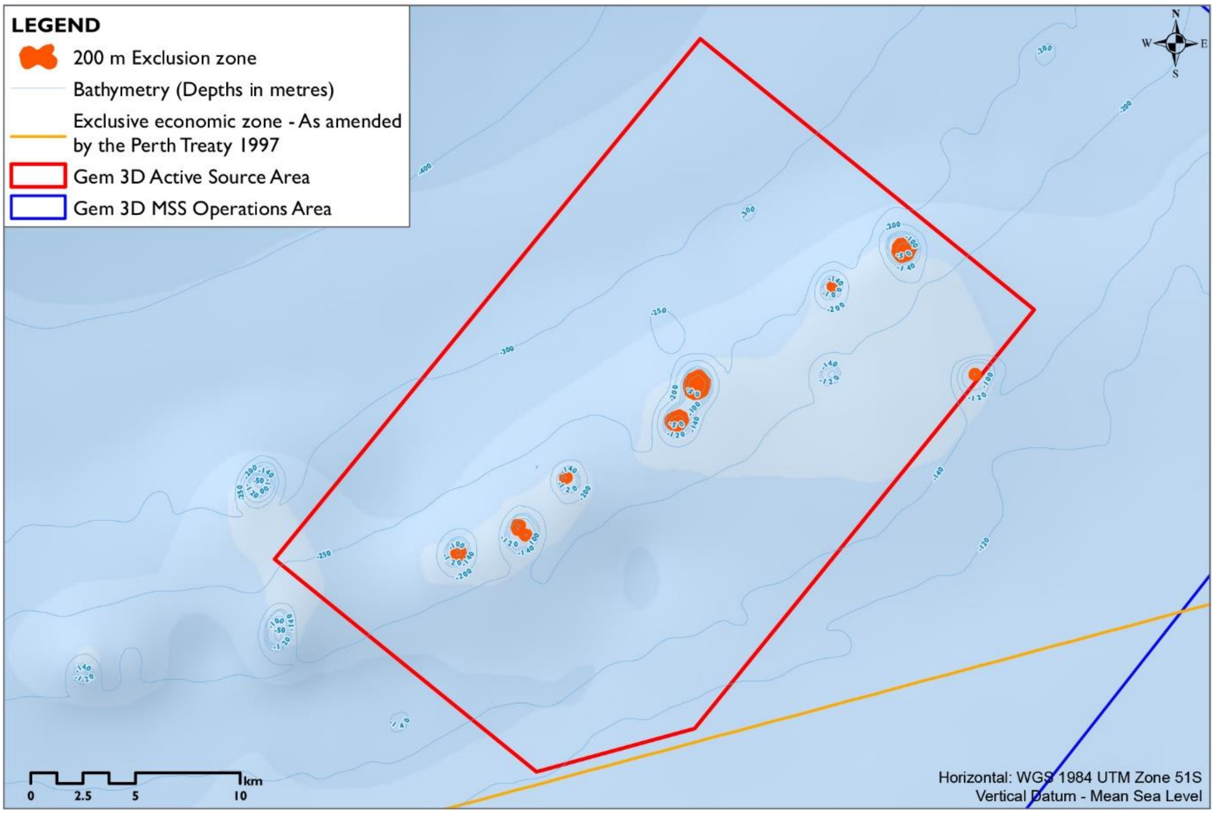


Figure 6-2: Shoals located within the Active Source Area that are less than 50 m depth (MSL)

6.2.2.2.6.3 Fish assemblages – KEF

There is no overlap between the OA and The Carbonate Banks and Shoals of the Sahul Shelf KEF. At the closest point, the south-eastern boundary of the ASA is located approximately 26 km from the boundary of the KEF. The maximum predicted distance to TTS effects in all fish hearing groups is ~1.5 km (refer Table 6-11), therefore, there will be no impacts from underwater sound emissions from the seismic source on any fish assemblages within the KEF.

6.2.2.2.6.4 Demersal fish species

As shown in Table 6-12, the maximum predicted Rmax distance to the injury threshold at the sea floor for the hearing group of fishes with swim bladders (Group II, which would represent most demersal fish), is 137 m. The maximum predicted Rmax distance 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 sea floor within areas of the ASA with water depths shallower than 124 m—e.g. a small area in the southern extent of the ASA (where Site 5 is located), and the slopes and tops of the nine shoals partially or wholly overlapped by the ASA.

However, these effects are not likely to be significant for the reasons outlined above. Demersal fish species, such as snapper and emperor, though not as strong swimmers as pelagic fish species, cannot be regarded as 'site-attached' as they are able to move away from an approaching seismic source.

Based on the maximum predicted Rmax distances to the TTS threshold (~1.5 km in the water column and ~1.3 km at the sea floor; refer Table 6-11) individuals in demersal fish communities at or close to the sea floor within the ASA 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 ~1.5 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.

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

As shown in Table 6-11, the maximum predicted Rmax 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. The maximum predicted Rmax distance to the TTS threshold in the water column for all fish hearing groups is ~1.5 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 1.5 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, potentially incurring short-term disruption to feeding or schooling behaviour.

6.2.2.2.6.6 Whale sharks

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 µPa2·s (SEL24h); and TTS (186 dB re 1 µPa2·s (SEL24h), have been used for this assessment.

As shown in Table 6-11, the maximum predicted Rmax distance to the injury threshold in the water column for the hearing group of fishes without swim bladders is 60 m. The maximum predicted Rmax distance to the TTS threshold for this fish hearing group is ~1.5 km. As described in Section 4.4.5 there are five shark species listed as threatened in the PMST report, including the whale shark which is considered the most likely to be present in the OA during the MSS. The south-eastern portion of the OA for the Gem 3D MSS overlaps a very small extent of the whale shark foraging BIA, which extends northwards across the North West Shelf and the Browse Basin along the 200 m isobath (refer Figure 4.13). It is possible that individual whale sharks may transit through the OA. This area of overlap (~436 km^2) represents an extremely small proportion (~0.2%) of the overall area of the BIA. There is no overlap between the ASA and the BIA—at the closest point, the south-east boundary of the ASA is located ~600 m from the whale shark BIA boundary.

Again, it is important to appreciate that individual whale sharks would have to remain within a range of approximately 1.5 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 (tens of metres) the seismic source 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 (TSSC 2015d) or the previously in force Whale Shark Recovery Plan 2005 – 2010 (DEH 2005b). Noise pollution is not identified as a pressure to whale sharks in the Marine Bioregional Plan for the NWMR (DSEWPaC 2012.

6.2.2.2.6.7 Impact assessment conclusion

The predicted impacts of underwater sound emissions from the seismic source on fishes and elasmobranchs during the Gem 3D MSS are considered to be localised and of no lasting effect, and restricted to recoverable injury and TTS effects to individuals that may be present on the shallow shoals, and to behavioural effects to pelagic fish and whale sharks present within the ASA.

Based on the timing and duration (up to 27 days) of seismic acquisition, and the control measures that will be implemented, predicted noise levels from seismic acquisition are not considered likely to result in any ecologically significant impacts at a population level for any species of fish that may be present within or adjacent to the ASA during the Gem 3D MSS.

6.2.2.2.7 Benthic invertebrates

Marine invertebrates lack a gas-filled bladder and are thus unable to detect the pressure component of sound waves. However, all cephalopods as well as some bivalves, echinoderms and crustaceans have a sac-like structure called a statocyst, which includes a mineralised mass (statolith) and associated sensory hairs (Carroll et al. 2017). Cephalopods have epidermal hair cells which help them to detect particle motion in their immediate vicinity (Kaifu, Akamatsu & Segawa 2008). Decapods have similar sensory setae on their body (Popper, Salmon & Horch 2001) and antennae which may be used to detect low-frequency vibrations (Montgomery et al. 2006).

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

6.2.2.2.7.1 Corals

A literature review conducted for Woodside by Dr Mardi Hastings stated that the primary mechanisms for injury of hermatypic corals from seismic airgun noise are: breaking of the external coral skeleton which could also damage the polyp tissue, and rupture or tearing of polyp tissues inside the corallites (Hastings 2008). The forces required to cause injury were predicted by Hastings (2008) in be in excess of 260 dB re 1 µPa (PK-PK received level).

Although injury to corals is theoretically possible as described by Hastings (2008), studies on the actual impacts were very limited prior to the Woodside Maxima and Gigas studies at Scott Reef (see below). A survey of coral reefs in Brunei that were subjected to seismic noise did not detect any damage to hard or soft corals, sponges or other sessile benthic organisms (IEC 2003).

The most relevant data currently available are results from exposure studies that Woodside conducted during the Maxima 3D and Gigas 2D Pilot OBC (ocean bottom cable) MSS at Scott Reef in WA.

In the Maxima 3D experiments corals in and around the lagoon were exposed to seismic signals (both experimental seismic lines and a full seismic survey) using a 2,055 in^3 source over a 59 day period. The experimental lines passed directly over the coral communities (source at 7 m depth, corals at ~60 m depth) whereas the full seismic survey passed within tens to hundreds of metres (horizontal offset). The maximum estimated received seismic signal levels at coral impact sites were 226–232 dB re 1 µPa (PK-PK), 214–220 dB re 1 µPa (SPL rms), 197–203 dB re 1 µPa2.s (single pulse SEL), and a maximum cumulative SEL of 197–203 dB re 1 µPa2.s (Heyward et al. 2018; Salgado Kent et al. 2016). Hence, the highest received PK-PK sound levels directly below the airgun array were considerably less than the 260 dB re 1 µPa (PK-PK received level) predicted by Hastings (2008) to cause physical injury to corals. The Maxima Study authors concluded that there was no effect of seismic activity measured as coral mortality, skeletal damage or visible signs of stress immediately after and up to four months following the 3D marine seismic survey (Heyward et al. 2018).

For plate corals and various soft corals including *Lobophytum* spp. and *Sarcophytum* spp., the proportion of dead and bare coral cover and the percentage cover of red algae were documented and no detectable effect was found from one or multiple passes of the seismic airgun array (Battershill et al. 2008). Further, there was no evidence of coral breakage, no signs of physiological impairment in the corals (polyp withdrawal or reduction in soft coral rigidity) and no long-term change in coral community structure related to the experimental or full seismic survey activities (Battershill et al. 2008).

The Gigas 2D Pilot OBC MSS coral monitoring study (SKM 2008) examined the potential for physical damage to a range of shallow water corals in north Scott Reef lagoon from seismic airgun emissions. This study also used a number of sub-lethal indicators of stress and mortality (partial and whole colony mortality) to determine the effects of airgun emissions on corals. The summary conclusion from this study was that emissions from the airgun array did not cause significant injury, tissue damage, sub-lethal stress or mortality to coral colonies, even when colonies are within a few metres of shots fired from the seismic array (SKM 2008). This survey had a measured at source SEL of 206 dB re 1 µPa2.s (McCauley 2008), and was therefore also well under the theoretical noise impact level predicted by Hastings (2008) to cause physical injury to corals.

Based on the research findings to date it is highly unlikely that corals (soft or hard) will be exposed to received sound levels of sufficient magnitude to cause any physical or physiological impacts. Corals would have to be within extremely close range (a few metres) of the airgun array operating at full power to be exposed to received levels high enough to potentially cause these effects.

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

6.2.2.2.7.2 Prawns

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

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

Day et al. (2016b) found airgun exposure caused damaged statocysts in rock lobsters (*Jasus edwardsii*) up to a year later. However, no such effects were detected in snow crabs after exposure to 200 shots at 10 s intervals and 17–31 Hz) (Christian, Mathieu & Buchanan 2004). For these studies, measured received noise levels were 209-212 dB re 1 µPa (PK-PK) and 197-237 dB re 1 µPa (PK-PK), respectively. Day et al. (2016b) also found that the rock lobster showed delayed time to right itself after exposure to airguns and that two out of three experiments found no difference in tail extension reflex, while one showed exposed lobsters had a 23% decrease 14 days after exposure. In contrast, no differences in righting time were detected in the American lobster (*Homarus americanus*) nine, 65, or 142 days after exposure to airgun noise (Payne et al. 2008). For these studies, measured received noise levels were 209-212 dB re 1 µPa (PK-PK) and 202 dB re 1 µPa (PK-PK), respectively.

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

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

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

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

6.2.2.2.7.3 Molluscs

Other invertebrate species that may potentially occur in the area are molluscs (cephalopods, bivalves and gastropods). Cephalopods have been found to respond to sound between 30 and 600 Hz, being most sensitive between 100 and 200 Hz, suggesting that they detect sound similarly to most fish, with the statocyst acting as an accelerometer through which they detect the particle motion component of a sound field (Kaifu, Akamatsu & Segawa 2008; Mooney et al. 2010).

Though there is anecdotal data from the stranding of giant squid (Architeuthidae spp.) that showed tissue, statolith and organ damage after seismic surveys (Guerra, González & Rocha 2004), there was no direct evidence to link the suggested cause and effect (Salgado Kent et al. 2016). Laboratory studies that exposed two species of squid to seismic noise showed that *Alloteuthis sublata* was tolerant to a sound level up to 260 dB, Loglio vulgaris was fatally injured at levels of 246 – 252 dB within 3 – 11 minutes of exposure (Norris & Mohl 1983). André et al. (2011) demonstrated that they can be injured by sweeping waves 50-400 Hz at levels of 157 dB SPL produced continuously for up to two hours. However, exposure experiments are complicated to relate to commercial seismic surveys due to either the exposure levels or the duration of the exposure event.

The most recent critical review of the potential impacts of marine seismic surveys on fish and invertebrates (Carroll et al. 2017) found that there was only a single study that indicated a mortality response in bivalve molluscs at realistic exposure levels (Day et al. 2016a). This study in the Bass Strait found that exposure to a seismic source (single airgun of either 45 in^3 or 150 in^3: maximum exposure levels of 191 – 213 dB re 1µPa PK-PK) did not cause any incidence of immediate mass mortality, however, repeated exposure (54 – 393 shots) significantly increased mortality, and the risk of mortality significantly increased with time as the majority of mortalities were recorded at the 120 day sample point (Day et al. 2016a).

This dose-dependent increased mortality translates to an annual increase of between 9.4% and 20%. These fall towards the low end of what might be expected when compared with natural mortality rates in wild scallop populations, which range from 11-51% with a six year mean of 38% (Day et al. 2016a).

Furthermore, there are a number of limitations and aspects of the Day et al. (2016a) study that mean that the findings of increased mortality must be treated with caution, especially with respect to assessing the potential risk of mortality effects in molluscs for the Gem 3D MSS. As detailed in (Przeslawski et al. 2016b), the Day et al. (2016a) study:

- Used a manipulative approach in which scallops were transplanted to the study area, exposed to an operating airgun, and then held in captivity during subsequent monitoring.
- Used scallop populations obtained from commercial sources or transplanted from other regions to coastal waters, rather than using in situ populations in the Bass Strait. Stress associated with handling during transplantation may have contributed to impacts.
- Transplanted populations (increased mortality, inability to maintain homeostasis, reflex changes, depressed immune response) after they had been exposed to an airgun in shallow water (<10 m).
- Used a single airgun at depths of 10-12 m, rather than a commercial airgun array in deeper waters.

- Identified long-term impacts after rearing scallops in suspended lantern nets such that the scallops were not in their natural environment (i.e. buried beneath sediment), thereby adding potential, though undetected, stress.

As pointed out by Salgado Kent et al. (2016) scallops naturally occur on the seabed and hence their sensory organs for detecting sound and vibration would be expected to have evolved to detect sediment borne motions (i.e. airgun signal energy coupled into the seabed). This sensory modality is not available to scallops held in the water column (in lantern nets). Hence, it is reasonable to question the findings of the Day et al. (2016a) study of increased mortality resulting from repeated exposure to airgun noise, as the scallops would not have been exposed to substrate acoustic waves and interface waves (such as Scholte waves).

Therefore, it seems likely that this observation of increased mortality, albeit minimal when compared to natural mortality rates, is probably related to other factors, such as stress caused by transplantation and the rearing of the animals in the water column rather than in seabed sediments. Indeed, in the summer 2015 scallop experiment: "both control and exposed treatments suffered complete mortality at some point after the day 14 sample point and prior to the day 120 sample point, which was not related to seismic exposure." (Day et al. 2016a).

Przeslawski et al. (2016) also recorded no impact of seismic exposure on adult scallop mortality rates or a range of physiological attributes two months after exposure to maximum sound exposure levels of 146 dB re 1µPa2.s, although this study has a number of issues with the presented acoustic sound levels, both measured and modelled, and they should not be used to interpret the effects of the sound on scallops. Additionally, the biological components of the experimental design only allowed a limited resolution in terms of effect assessment to be achieved. However, the results of this study, conducted in a low density scallop area, that no mass mortality occurred as a result of the survey, correlate with the results from Day et al. (2016a).

The Przeslawski et al. (2016) study used a 2,530 in^3 commercial airgun array at water depths of 36-61 m, and examined an in situ scallop population in seabed sediments. As such, it is probably more appropriate to use the findings of this study, rather than Day et al. (2016a), in the assessment of mortality effects in molluscs for the Gem 3D MSS. Przeslawski et al. (2016) point out that seabed substrate likely differed between their study and the Day et al. (2016a) experiment, which can affect the sound pressure and particle velocity to which the organisms are exposed, particularly as distance from the sound source increases. Measured SELs in the Przeslawski et al. (2016) study were far lower than those predicted from modelling (146 dB re 1µPa2.s SEL measured versus 170 dB re 1µPa2.s SEL predicted), and those detected from Day et al. (2016a) and other airgun arrays.

All the other papers reviewed in the Carroll et al. (2017) review found no response in respect of mortality effects in bivalve molluscs, including two other studies using the scallop *Pecten fumatus* (Harrington, McAllister & Semmens 2010; Parry et al. 2002). Parry et al. (2002) found that mortality rate and adductor muscle strength of scallops suspended in the water column and exposed to the operating airgun array (at a minimum distance of 11.7 m) was not significantly different from the controls. Harrington, McAllister & Semmens (2010) conducted a scallop (*P. fumatu*s) dredge before and two months after exposure to a 2,000 psi air gun array. No evidence of short- or long-term impacts on the survival or health of adult specimens was detected. This study was undertaken following a die-off of scallops that fisherman claimed was the result of a seismic survey but neither the fisherman nor the study could definitively attribute the scallop die-off to the survey (Salgado Kent et al. 2016).

One study examined the effects of underwater explosions on the pearl oyster (Chalmer 1986) and found that no mortality occurred in the exposed animals over a 13-week period and at a minimum exposure range of 1 m from the blast centre.

Studies have shown that seismic sounds can elicit a behavioural response in cephalopods. McCauley et al. (2003) and Fewtrell & McCauley (2012) described behavioural responses of squid (*Sepioteuthis australis*) such as squid inking at a sound exposure level of 163 dB re 1µPa2.s and an increase in movement away from the seismic source at a sound exposure level of 140 – 150 dB re 1µPa2.s. They also noted that the squid showed fewer alarm response with subsequent exposure to the seismic source.

Day et al. (2016a) found that exposed scallops had faster recessing times, elicited a novel velar flinch and had substantial disruptions in the biochemistry of the hemolymph. In one experiment there was some indication that righting time might be slowed.

The potential effects on catch rates or abundances have been tested on cephalopods with no significant differences detected between sites exposed to seismic operations and those not exposed Carroll et al. (2017). Thus it is likely that cephalopods in the area of the survey may show a behavioural response to the seismic noise and move away from the source. There is not enough information to gauge the scale of this movement, and the displacement distance, however, it is likely that they would move back to the area once the seismic source has passed.

The majority of studies undertaken on seismic impacts to molluscs have been on commercial scallops. As for other invertebrate studies results show mixed results of impacts and no impacts. Typically impacts are seen in laboratory studies or in field studies where there has been repeated exposure.

La Bella et al. (1996) examined biochemical indicators of stress in bivalves exposed to seismic noise and found that hydrocortisone, glucose and lactate levels between test and control animals were significantly different (P >0.05) in the venerid clam *Paphia aurea*, showing evidence of stress caused by acoustic noise. This was at a minimum exposure range of 7.5 m. As outlined above, seismic sources cause less impacts on benthic invertebrates than explosives, hence it is likely that bivalves and other molluscs (such as gastropods) would have to be within a very close range of a seismic source to experience pathological damage or mortality: available evidence would suggest ~ 1–2 m. It is more difficult to determine the distances at which sub-lethal effects (such as morphological, biochemical and physiological changes being indicators of some level of stress in an animal) could occur.

6.2.2.2.7.4 Modelling results

Table 6.14 shows the maximum predicted distances (Rmax) to effects thresholds for invertebrates at the sea floor, for all single pulse sites modelled. As shown in Table 6.14, at a sound exposure threshold of 209 dB re 1 µPa PK-PK, maximum predicted Rmax distance was 235 m at a water depth of 124 m.

The PK sound level at the sea floor directly underneath the seismic source was estimated for both single pulse modelling sites and compared to the sound level of 226 dB re 1 µPa PK at which no effects on mortality, skeletal damage or visible signs of stress for sponges and corals occurred up to four months following the Maxima 3D MSS (Heyward et al. (2018). It was found that the level was reached at two of the five considered sites and ranged from 6 m (at 35 m water depth) to 12 m (Site 6 - 28 m).

There is no overlap between the OA and The Carbonate Banks and Shoals of the Sahul Shelf KEF. At the closest point, the south-eastern boundary of the ASA is located approximately 26 km from the boundary of the KEF. Hence, there will be no impacts from underwater sound emissions from the seismic source on benthic invertebrates inhabiting sea floor substrates within the KEF.

Given the maximum predicted Rmax distances to the sound exposure threshold of 209 dB re 1 µPa PK-PK (ranging from 159-235 m; refer Table 6-14), benthic invertebrates (such as crustaceans and molluscs) at or close to the sea floor within the ASA could be exposed to received sound levels that have the potential to cause sub-lethal effects and behavioural disturbance. These communities of benthic invertebrates are expected to be associated primarily with hard substrates on the slopes and tops of the nine shoals partially or wholly overlapped by the ASA. The unconsolidated sandy and muddy substrate that covers most of the OA at depths of 110 to 440 m is well represented within the wider region (Pinceratto 1997; Smith et al. 1997), and this habitat has little seabed structure and low density of sessile epibenthos, including filter-feeding organisms (e.g. gorgonians, sponges, ascidians and bryozoans) and mobile invertebrates (e.g. echinoderms, prawns and detritus-feeding crabs).

Based on the research to date, mortality and mortal injury effects in benthic invertebrates that have been reported to occur in experiments relating to seismic surveys are only likely to occur at very close ranges to the source (<10 m). However, if mortality impacts did occur to benthic invertebrates, it would be within natural mortality rates and unlikely to have long term or population effects based on the small area of impact, any species impacted are likely to be widely distributed throughout the region. Physiological impacts identified may affect individuals but are unlikely to have long-term or population effects based on the small area of impact and the broad distribution of species through the region.

There is the potential for some benthic invertebrates on shallow shoals within the ASA 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 on the shoals overlapped by the ASA, therefore, impacts at a population level due to reduced fitness would be unlikely as there would be sufficient unaffected individuals to maintain the population.

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

Table 6-14: Maximum predicted distances (Rmax) to effect thresholds for invertebrates at the sea floor, for all single pulse sites

Sound exposure threshold (PK-PK)	R_{max} (m)				
	28 m depth	**35 m depth**	**45 m depth**	**55 m depth**	**124 m depth**
212 dB re 1 µPa	**106**	**121**	**120**	**124**	**127**
211 dB re 1 µPa	**109**	**125**	**142**	**135**	**149**
210 dB re 1 µPa	**156**	**129**	**153**	**170**	**175**
209 dB re 1 µPa	**162**	**173**	**159**	**182**	**235**
202 dB re 1 µPa	**286**	**297**	**302**	**293**	**520**

6.2.2.2.7.5 Impact assessment conclusion

Based on the above assessment, predicted impacts of underwater sound emissions from the seismic source on benthic invertebrates during the Gem 3D MSS will 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 sea floor within or adjacent to the ASA.

6.2.2.2.8 Zooplankton

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

Zooplankton includes fish eggs and larvae that are transported by currents and winds and hence cannot take evasive behaviour to avoid seismic sources. 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).

With respect to the Gem 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.

6.2.2.2.8.1 Modelling results

For this impact assessment the sound exposure thresholds for mortality/PMI to fish eggs and larvae from Popper et al. (2014) (refer Table 6-15), have been applied, as well as the 178 dB re 1 µPa PK-PK threshold derived from the McCauley et al. (2017) study.

Table 6-15: Maximum predicted distances (Rmax) to mortality/PMI thresholds in the water column for fish eggs and larvae, and zooplankton

Sound exposure threshold	Rmax (m)
210 dB re 1 µPa2·s (SEL24h)	**30**
207 dB re 1 µPa (PK)	**130**
178 dB re 1 µPa PK-PK	**7,960**

As shown in Table 6-15, the maximum predicted Rmax 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 Rmax distance increases to ~8 km.

McCauley et al. (2017) found that after exposure to airgun sounds generated with a single airgun (150 in^3) 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 in^3 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, Matear & Lenton 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, Matear & Lenton 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 APPEA/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, Matear & Lenton 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, Matear & Lenton (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, Matear & Lenton (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 North West Shelf from a large-scale seismic survey, considering mortality estimates of McCauley et al. (2017), and accounting for typical growth rates, natural mortality rates, and the ocean circulation in the region The approach modelled a hypothetical 3D survey (2,900 km^2 in size, over a 35-day period, in water depths of 300-800 m) on the edge of the North West Shelf during summer. To simulate the movement of zooplankton by currents, the researchers used a hydrodynamic model that seeded 0.5 million particles into CSIRO's Ocean Forecast Australia Model. Zooplankton particles could be hit multiple times by airgun pulses if they were carried by currents into the future survey path. The greatest limitation in this approach was accurate knowledge of the natural growth and mortality rates of zooplankton, and to address this the CSIRO researchers tested the sensitivity of the model to different recovery (growth-mortality) rates, and also the sensitivity of the results to ocean circulation by undertaking simulations with and without water motion (Richardson, Matear & Lenton 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, Matear & Lenton 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, Matear & Lenton 2017).

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

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, Skalski & Malme 1992). 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).

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 & 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 & 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.

6.2.2.2.8.2 Impact assessment conclusion

The predicted impacts of noise emissions from the seismic source on plankton during the Gem 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 OA.

6.2.2.2.9 Fish spawning

Two key indicator fish species of the Northern Demersal Scalefish Managed Fishery (NDSMF), goldband snapper and red emperor, could potentially spawn in the offshore waters of the OA and adjacent areas. Both of these species are lutjanids (family Lutjanidae), which are known generally to be highly fecund, broadcast spawners, releasing numerous batches of pelagic eggs into the water column over an extended spawning period, up to several million eggs per year (Lloyd 2006; Newman et al. 2008). Both species area also widely distributed in northern WA waters and have similar depth ranges and habitat (Section 4.4.7.3).

Adult goldband snapper occur in continental shelf waters in depths of 50-200 m, in association with offshore reefs, shoals, and areas of hard flat bottom with occasional benthos or vertical relief, and often form large schools (Section 4.4.7; Newman et al. 2008). ERM (2012) also recorded adult goldband snapper over relatively featureless sediment habitats in 80 m to 90 m water depths in the Montara, Padthaway, Bilyara and Tahbilk gas fields, in the Browse Basin, but did not observe this species at similar depths on the slopes of shoals in the region. Juveniles typically occur on uniform sedimentary habitat with no relief (Newman et al. 2008).

Advice from DPIRD Fisheries (DPIRD Principal Scientist, pers. comm. 23/5/2019) suggests that the Kimberley stock of goldband snapper spawn between November and May (refer Table 4-7). This period is also broadly consistent with other goldband snapper spawning in northern Australia, as reported for the Timor Sea and Arafura Sea stocks, where spawning was found to occur for an extended period from September/October, peaking in December, and remaining elevated with some fluctuations until March/April, and with minimum activity occurring during the winter months (June - August) (Lloyd 2006). Although goldband snapper are understood to be broadcast spawners, it is also understood that eggs and larvae do not travel long distances between regions and there is limited genetic connectivity between the Kimberley stock and stocks in the Timor and Arafura Seas, Broome, and the Pilbara and Exmouth stocks (Lloyd et al. 2000; Newman et al. 2008, 2000; Ovenden et al. 2002).

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

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

- At least as far to the west as 14.9ºS, 122.0ºE (Lynher Bank), but unlikely as far west as the Broome stock sampled at 17.5ºS, 120.5ºE;
- Including areas near Vulcan Shoal sampled at approximately 12.5.0ºS, 124.3ºE; and
- At least as far east as 12.0ºS, 126.0ºE, but unlikely as far east as the Timor Sea stock sampled at 10.2ºS, 129.5ºE.

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

In order to assess the potential impacts of the Gem 3D MSS on goldband snapper and red emperor spawning, the following factors have been considered:

- The potential spatial overlap between the area affected by sound (fish behaviour and masking effects) with the area potentially utilised by the spawning stock;
- The potential temporal overlap between the duration of planned acquisition and the duration of the available spawning periods and peak spawning periods;
- The likelihood of acquisition overlapping with a critical area for spawning aggregations;
- The likelihood of the activity reducing the available spawning biomass and stock recruitment success, taking into account natural variability.

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

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

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

The majority of studies reviewed on the potential effects of seismic surveys on fish behaviour suggest that behavioural responses are typically observed within several hundred metres (strong avoidance responses) to several kilometres (minor responses such as changes in direction or position in the water column) from the seismic source and quickly return to normal (within an hour) after the seismic source has passed or ceased. These behaviours have been recorded in response to SPLs of 156 dB re 1 µPa or greater and peak pressures greater than 160 dB re 1 µPa, returning to normal behaviour within as little as an hour of the seismic source passing or ceasing (Fewtrell & McCauley 2012; McCauley et al. 2000a; Miller & Cripps 2013; Pearson, Skalski & Malme 1992; Santulli et al. 1999; Wardle et al. 2001). Based on the acoustic modelling completed for the Gem 3D MSS (Appendix G), these SPL levels correspond with ranges of approximately 5 – 10 km from the active source.

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

Therefore, despite changes in behaviour typically reported as occurring within several hundred metres to several kilometres of a seismic source, the assessment of potential impacts to spawning considers the maximum reported distance 37 km; from the findings of Slotte et al. (2004) as indicative of the ranges to where the density, local abundance and behaviours of schooling fish may still continue to be influenced by seismic sound levels to some small degree. Using this as a proxy is considered to be a conservative approach, given that the 37 km maximum range reported in Slotte et al. (2004) was reported for a 3,090 in^3 array volume, which is larger than the array proposed for the Gem 3D MSS (≤2,820 in^3). However, the reported changes in distribution and local abundance were minor and so the behavioural effects at these further ranges are expected to be minimal and the method of assessment adopted in this EP is considered to be worst case.

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

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

The total areas corresponding with the 50-200 m water depths (goldband snapper range) and the 80-140 m water depths (principal goldband snapper range; Section 4.4.7) within this extent provide an indication of the total potential spawning habitat area available to this goldband snapper stock. Approximately 243,000 km^2 of seabed is available within the goldband snapper depth range of 50-200 m. Approximately 94,000 km^2 of seabed is available within the principal goldband snapper depth range of 80-140 m.

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

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

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

To provide a 'potential area of influence', the Gem 3D MSS ASA, buffered by 37 km, has been selected to provide a conservative estimate of the potential areas that may be influenced by sound emissions over the duration of the survey. While this approach is not exact, the precautionary assumptions described previously provide a conservative indication of the maximum potential spatial and temporal overlap with available spawning habitat from seismic data being acquired at any one time. The 'potential area of influence' for the Gem 3D MSS (based on the selected 37 km range) is presented in Figure 6-3.

The 'potential area of influence' and spatial overlap, expressed as a percentage of the potential goldband snapper stock, is presented in Table 6.16 for the selected 37 km range from the Gem 3D MSS ASA. This spatial analysis indicates that the 'potential area of influence' (spatial overlap) may be approximately 2% of the total area available to the Kimberley goldband snapper stock within its overall 50-200 m depth range, and approximately 2.9% spatial overlap within its principal 80-140 m depth range. It is important to note that this is simply an indication of the area that may be ensonified and where potential spawning aggregations may be influenced. It is also important to note that there is no actual reduction in the total spawning biomass, as the effects are expected to be behavioural and no fish will be lost from the stock. Instead, while some temporary cessation of aggregation and spawning could occur within this potential area of influence, it is possible that adult fish may continue to be motivated to spawn or may simply aggregate and spawn further from the seismic source.

The Gem 3D MSS is expected to take a maximum of 27 acquisition days to complete inclusive of foreseeable operational and weather downtime. Allowing for this duration and up to five days for fish abundance and behaviour to return to normal after the area is acquired, the Gem 3D MSS accounts for approximately 32 days of potential effects, which is approximately 15% temporal overlap with the spawning period for this species (November – May; Section 4.4.7, Table 6.17). In considering this, it is noted that goldband snapper are serial batch spawners, releasing multiple batches of eggs into the water column over a wide area, and spawning multiple times throughout the spawning period in response to environmental cues such as lunar phase. They do not spawn continuously. Therefore, the temporal overlap may also over-represent what may in reality be a disturbance to one or two out of many spawning events by a small proportion of the overall stock. This amount of overlap temporal and spatial overlap with goldband snapper spawning has been assessed as an acceptable level, given that no discernible population level impacts are expected to occur.

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

Given the biological connectivity of the northern Australia red emperor stocks, the spatial overlap with the red emperor spawning range is expected to be significantly less than predicted for goldband snapper and potential impacts are expected to be negligible. Other species in the region are also understood to spawn over wide areas and/or in coastal waters and, therefore, impacts to spawning are expected to be limited.

Table 6-16: 'Potential area of influence' expressed as percentage spatial overlap with the Kimberley goldband snapper stock

Parameter	Kimberley goldband snapper range	Parameter
Kimberley stock area	**~243,000** km^2	**~94,000 km^2**
ASA spatial overlap with Kimberley stock area	**274** km^2 **(~0.1%)**	**62 km^2 (~0.07%)**
ASA spatial overlap (including 37 km buffer zone) with Kimberley stock area	**4854** km^2 **(~2.0%)**	**274 km^2 (~2.9%)**

Table 6-17: *Percentage of temporal overlap with goldband snapper spawning period*

Parameter	Percentage temporal overlap with goldband snapper spawning period (1 Nov – 31 May (213 days))
Acquisition duration (max. 27 days)	**12.7%**
Acquisition duration plus 5 days of behavioural impacts (max. 32 days)	**15.0%**

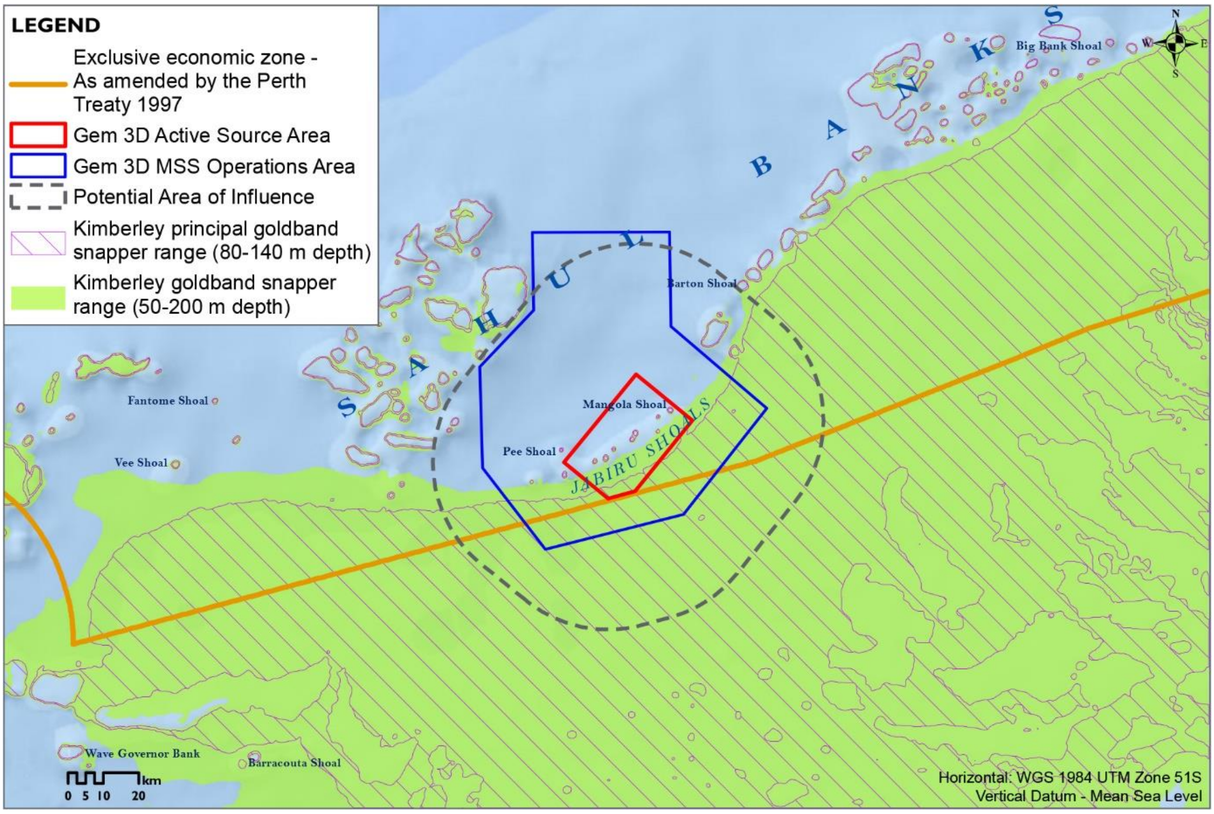


Figure 6-3: Gem 3D MSS 'potential area of influence' to fish spawning behaviour and extent of potential goldband snapper habitat

6.2.2.2.9.1 Impact assessment conclusion

Based on the timing and duration (up to 27 days) of seismic acquisition, the predicted impacts of noise emissions from the seismic source on spawning of key indicator fish species during the Gem 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 OA during acquisition activities.

6.2.2.2.10 Commercial fisheries

Increased sound levels associated with seismic acquisition may modify the behaviour, local abundance and distribution of fish species, and therefore affect commercial fisheries catch rates within the Gem 3D MSS OA and in adjacent waters. Additionally, seismic acquisition has the potential to affect commercial fisheries via displacement or exclusion of fishers from areas where they normally operate for all or part of the period during which the survey is being acquired. This potential impact is assessed in Section 6.4.

As described in Section 4.6.1, there are a number of Commonwealth and state (WA) commercial fisheries that can operate in waters overlapping the OA. However, catch and effort records show that only one of these WA fisheries, the Northern Demersal Scalefish Managed Fishery (NDSMF), is active in the area overlapped by the OA. Importantly, no Australian commercial fisheries are permitted to operate in the ASA.

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, Handegard & Ona 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 finfish 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. 2016b): "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.

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 (Przeslawski et al. 2016a). Przeslawski et al. (2016a) 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. (2016a), it is possible that fish may be displaced from a survey footprint to adjacent areas, however the total number of fish within the fishery stock remains unchanged.

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

6.2.2.2.10.1 Northern Demersal Scalefish Managed Fishery

As described in Section 4.5.1 the offshore area of the NDSMF is divided into three zones, A – C, with jurisdictions of Zones B and C overlapping the ASA. However, the outer limit of these jurisdictions is aligned with Australia's Exclusive Economic Zone which has been modified in the vicinity of the Gem 3D MSS by the Treaty between the Government of Australia and the Government of the Republic of Indonesia establishing an Exclusive Economic Zone Boundary and Certain Seabed Boundaries (Perth, 14 March 1997) (Perth Treaty). As a consequence of the Perth Treaty and modified Gem 3D MSS, most of the OA and all of the ASA are located in an area where operators in the NDSMF are not able to fish (refer to Figure 4.18). In addition, because the ASA is located approximately 0.6 km away from the Perth Treaty boundary no seismic sound emissions causing TTS and behavioural disturbance to Group II demersal fish (which includes goldband snapper and red emperor) will extend into Zone B of this fishery (as described in Section 6.1.2.2.5.1).

Potential impacts to commercial catch rates in Zone B of the NDSMF are therefore not likely to be significant, based on the following:

- No overlap between fishing areas and the ASA.
- Mortality of fish (both immediate and delayed) is considered highly unlikely based on no documented cases of fish mortality upon exposure to seismic airgun sound under experimental or field operating conditions (ERM 2017).
- In the DPIRD Fisheries risk assessment of impacts from seismic surveys (Webster et al. 2018), it is emphasised that consequence for individual fish only considers mortality and that the risk assessment is not for application to larger scale impacts such as regional aggregations, fisheries, management units and populations.
- The stock assessment for key indicator commercial fish species (e.g. goldband snapper, red emperor) indicates adequate stock status, breeding stock and fishery catch levels (Gaughan & 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.

6.2.2.2.10.2 Impact assessment conclusion

Based on the timing and duration (up to 27 days) of seismic acquisition, the predicted impacts of underwater noise emissions from the seismic source on catch rates in Zone B of the NDSMF during the Gem 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 targeted by the fishery within or adjacent to the OA.

6.2.2.2.11 Australian Marine Parks

As described in Section 4.3, the OA is located approximately 77 km from the boundary of the Multiple Use Zone (MUZ) of the Oceanic Shoals Marine Park (OSMP), which is the closest Australian Marine Park (AMP) to the activity. The ASA is located at least 98 km from the western boundary of the MUZ.

Based on the sound level isopleths for modelling Site 4 (which is the closest of the modelling sites to the OSMP boundary; refer Figure 6-1), and a tow direction of NE-SW, maximum predicted received sound levels in the water column at the boundaries of MUZ are approximately 110-120 dB re 1 µPa (SPL). The potential impacts to turtles, fishes/elasmobranchs, benthic invertebrates or zooplankton associated with the KEFs and BIAs overlapped by the MUZ of the OSMP are assessed in the sub-sections above. Received sound levels in the water column or at the sea floor within the MUZ of the OSMP will not exceed any of the sound exposure thresholds for injury, TTS or behavioural disturbance in turtles, fishes/sharks, benthic invertebrates or zooplankton that may be present within the MUZ during acquisition of the Gem 3D MSS.

6.2.2.2.11.1 Impact assessment conclusion

Considering the short duration of the Gem 3D MSS (< 27 days), spatial separation from the OSMP, 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, cultural heritage values of the OSMP, or any other AMP in the region.

6.2.2.2.12 Cumulative Seismic Noise

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 Gem 3D MSS.

This section assesses the potential for cumulative impacts associated with:

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

6.2.2.2.13 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 predicted impacts to receptors.

Table 6.18 presents a summary of the marine seismic surveys that have been undertaken in the last five years within approximately 200 km of the Gem 3D MSSOA. The footprint of impacts resulting from the Gem 3D MSS has been assessed as being localised, however a 200 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 where 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 environment plans.

Table 6-18: Previous seismic surveys completed within 200 km of the Gem 3D MSS in the last five years

Year	Company	Survey name	Survey location	Survey status and timing	Evaluation
2016	**Polarcus**	**Cygnus Phase I and II MSS**	**Located ~105 km south-west of the Gem 3D MSS ASA.**	**Completed prior to end of 2016.**	**The survey was completed at least 30 months prior and recovery of all impacts are expected to have occurred well before commencement of the Gem 3D MSS.** **No cumulative impacts are expected.**
2017-2018	**Polarcus**	**Cygnus Phase III North MSS**	**Located ~40 km south-west of the Gem NSS ASA.**	**Completed in January 2018.**	**The survey was completed at least 18 months prior and recovery of all impacts are expected to have occurred well before commencement of the Gem 3D MSS.** **No cumulative impacts are expected.**
2018	**Polarcus**	**Zénaïde 3D MSS**	**Located ~177 km from the Gem 3D MSS ASA.** **Maximum of 2,850 km^2 of 3D seismic acquisition in exploration permit WA-552-P.**	**Acquired between December 2017 and end April 2018.** **Maximum of 60 days of acquisition.**	**The survey was completed at least 12 months prior and recovery of all impacts are expected to have occurred well before commencement of the Gem 3D MSS.** **No cumulative impacts are expected.**

6.2.2.2.14 Concurrent seismic surveys

Over the scheduled period of the Gem 3D MSS there are two other marine seismic surveys with the potential to occur within the 200 km buffer distance of the OA:

1. Factory 3D MSS – Operations Area located ~145 km south-west of the Gem 3D MSS ASA; acquisition planned over a period of 2-3 months from July 1 to December 30, 2019; and

2. Cygnus 3D MSS Phase 3 South 2019-2020 – Operations Area located ~60 km south-west of the Gem 3D MSS ASA; acquisition planned between May 2019 and end December 2020.

SapuraOMV will endeavour to minimise the potential for interaction between simultaneous seismic surveys (should they occur at the same time) to minimise both potential disruptions to operations as well as potential cumulative sound impacts to the marine environment and other marine users. SapuraOMV will engage with the proponents for these two potentially concurrent seismic activities prior to commencing the Gem 3D MSS and will develop a concurrent operations plan for any concurrent surveys identified within 60 km of the ASA.

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 Gem 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 Gem 3D MSS (Appendix G) demonstrates that sound levels will be below 145 dB re 1µPa at 20 km from the source (halfway 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.

6.2.2.2.14.1 Evaluation of predicted impacts

The following section provides a summary of the predicted impacts that are expected to occur from concurrent acquisition of the Gem 3D MSS and the two other potential seismic surveys identified above.

Short-term behavioural impacts are expected to occur up to a maximum of 5.25 km from the operating seismic source for the most sensitive species of marine mammal (depending upon location and water depth) and at lesser distances for other marine fauna (see Section 6.1.2.2.3). Species are expected to be transient and no changes to migration or other important life stages are expected.

Behavioural impacts in fish are expected occur at distances of tens or hundreds of metres from the Gem 3D MSS acquisition lines, returning to normal within as little as an hour (see Section 6.1.2.2.6).

No significant discernible cumulative impacts to marine fauna are expected, given the separation distances between the Cygnus 3D MSS Phase 3 South (approximately 60 km from the Gem 3D MSS ASA) and Factory 3D MSS (approximately 145 km from the Gem 3D MSS ASA). In addition, taking the proposed 40 km minimum separation into consideration, no cumulative overlap of significant behavioural responses is expected.

Some minor 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 spawning periods for a number of the key indicator species for the NDSMF overlap with the timing of the Gem 3D MSS. There is a possibility that the Cygnus 3D MSS Phase 3 South and/or the Factory 3D MSS may be acquired concurrently with the Gem 3D MSS, however this scenario is considered very unlikely. If the surveys were completed concurrently, there would be no spatial overlap and limited temporal overlap.

Based on the maximum worst case mortality exposure suggested by McCauley et al. (2017) and modelling completed by CSIRO (Richardson, Matear & Lenton 2017), impacts to zooplankton are only expected to be significant within a short range (e.g. 8 km) of seismic survey areas. Beyond 22 days of acquisition, CSIRO (Richardson, Matear & Lenton 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, Matear & Lenton 2017). Further, natural mortality rates can be as high as ~60%, and not entirely as a result of predation (see Section 6.1.2.2.8), therefore, limited impacts are expected relative to the natural variation in zooplankton concentrations and mortality rates.

No significant discernible cumulative impacts to zooplankton are expected, given the separation distances between the Cygnus 3D MSS Phase 3 South (approximately 60 km from the Gem 3D MSS ASA) and Factory 3D MSS (approximately 145 km from the Gem 3D MSS ASA). In addition, taking the proposed 40 km separation into consideration, the cumulative impacts to zooplankton are expected to be negligible.

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 Gem 3D MSS, such impacts are expected to occur at close range to the seismic source (i.e. <235 m) (see Section 6.1.2.2.7). In the context of natural mortality, recruitment and recovery rates, the impacts to overall benthic communities are expected to be negligible.

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 6.1.2.2.10, 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. However, SapuraOMV 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. SapuraOMV will notify stakeholders prior to the commencement of the survey and will provide regular updates to fishery licence holders during survey operations.

6.2.2.2.14.2 Impact assessment conclusion

Based on the assessment presented above and the implementation of the identified controls (Table 6.22), the cumulative impact of concurrent seismic surveys is assessed as negligible.

6.2.3 ALARP treatment and evaluation

6.2.3.1 ALARP options

Additional controls which have been considered in reaching ALARP are listed in Table 6.19.

Table 6-19: ALARP options considered for impacts due to underwater sound emissions from seismic array

Additional control measure	Hierarchy / control type	Env benefit	Env Benefit scale	Cost	Practical and implemented	Rationale
Do nothing – no MSS	**Elimination**	**Avoids impacts marine fauna, although these are not significant**	**Moderate (3-10%)**	**>10% of project cost**	**Not adopted**	**There is minimal environmental benefit from this control given the predicted negligible impacts to marine fauna and other marine users.** **Titleholders are required by NOPTA to acquire seismic data within specified time frames. Data is required meet business objectives. Costs disproportionately higher than benefits.**
Minimum practical source size selected to acquire survey data and meet the geophysical objectives of the survey	**Engineering**	**Minimisation of effects to marine fauna**	**Moderate (3-10%)**	**<0.5% of project cost**	**Adopted as part of survey design process**	**Good industry practice. Utilisation of smallest practical seismic source to minimise underwater sound emissions and potential impacts to marine fauna.**
Application of EPBC Policy Statement 2.1 Part A: Standard Management Measures for whales and whale sharks	**Administrative**	**Minimise effects to cetaceans / whale sharks through visual observation, soft-starts, power downs, stop work and night-time / low visibility operations**	**Moderate (3-10%)**	**<0.5% of project cost**	**Adopted**	**Good industry practice, aligns with management actions for cetacean and whale shark management / recovery plans and conservation advice.**
Two MFOs will be on board the seismic vessel and on duty during daylight hours during the survey	**Administrative**	**Visual detection of marine fauna in proximity to seismic source**	**Moderate (3-10%)**	**<0.5% of project cost**	**Adopted**	**Although the ASA is not considered to be located within an area of moderate to high likelihood of encountering whales, the OA does overlap part of the pygmy blue whale migration BIA and so inclusion of MFOs is considered conservative.** **Consistent with Part B of EPBC Policy Statement 2.1, two MFOs will be on board the seismic vessel and on duty during daylight hours during the survey.**
200 m 'turtle pause' when a turtle is within 200 m of an active source	**Isolation**	**Elimination/minimisation of effects to turtles**	**Minor (1-3%)**	**1% of project cost**	**Adopted**	**Conservative for TTS actual effect range from the edge of the array (20 m) and practicable to implement because of difficulty in observing turtles at sea. The 'turtle pause' is a voluntary measure in which airguns are not fired for a series of shots to allow a silence period as the array passes the last visual location of the turtle. At the same time it minimises loss of seismic survey data which is particularly important given the small area of the Gem 3D MSS.**
200 m exclusion (buffer) zones established around shoals within the ASA that are < 50 m deep	**Elimination**	**Elimination/minimisation of effects to site-attached fish in shallow waters on the tops of the shoals**	**Moderate (3-10%)**	**1% of project cost**	**Adopted**	**To eliminate or minimise predicted impacts from underwater sound emissions from the seismic source on site-attached fish and invertebrate assemblages inhabiting the shallower shoals within the ASA.**
Use of recent detailed bathymetric data of shoals within the ASA in planning for the MSS	**Administrative**	**Minimisation of effects to site-attached fish in shallow waters on the tops of the shoals**	**Moderate (3-10%)**	**5% of project cost**	**Adopted**	**Good industry practice. Accurate seabed mapping minimises uncertainty in deriving and adhering to depth-based controls (exclusion zones).**
Passive Acoustic Monitoring (PAM)	**Engineering / Isolation**	**Detection of cetaceans at night-time**	**Negligible (<1%)**	**5-10% of project cost**	**Not adopted**	**Although PAM can be used to supplement visual observations made by MFOs, the method is dependent upon animals vocalising.** **Costs for engaging a trained PAM operator for the survey are approximately US$40,000. The additional cost of having a qualified PAM operator on board for the duration of the survey when few or no detections are expected was determined to outweigh any limited additional benefit that PAM might provide, particularly given**

						the proposed soft-start, night-time and low visibility procedures. Given that the OA does not overlap any critical habitat (i.e. feeding, breeding, calving areas) or a constricted migratory pathway for cetaceans, and the limited detections expected from the use of PAM, the cost of this option is considered to outweigh the limited potential for any further reduction to an already low level of risk.
Spotter vessel / aircraft	**Engineering / Isolation**	**Visual detection of marine mammals over greater ranges from the seismic source**	**Negligible (<1 %)**	**5-10% of project cost**	**Not adopted**	**The use of a dedicated spotter vessel/plane would add considerable cost to the survey and would add to the overall environmental footprint of the survey (e.g. through physical presence, emissions and discharges etc.). Lack of availability of aircraft capable of long-range, long duration flights from the nearest viable airport (Broome) is also a major consideration. Low numbers of marine mammals are expected to be encountered in the OA. Given the uncertain benefits and viability of spotter planes/vessels and the added environmental footprint, the cost associated with engaging a dedicated spotter vessel or plane are considered disproportionate to the minimal environmental benefit of identifying marine mammals ahead of the survey vessel.**
Phasing of the survey to avoid turtle inter-nesting periods in the region	**Elimination**	**Elimination/minimisation of effects to turtles**	**Negligible (<1 %)**	**>10% of project cost**	**Not adopted**	**Peak nesting periods for turtle species in the region cover the months of Oct-Mar. Exclusion of acquisition during this period would leave insufficient time to acquire the survey, given limited availability of the survey vessel. The OA is located a considerable distance away from the closest turtle nesting BIAs or 'Habitat Critical'.**
Phasing of the survey to avoid pygmy blue whale and whale shark migration period	**Elimination**	**Elimination/minimisation of effects whales and whale sharks**	**Negligible (<1 %)**	**>10% of project cost**	**Not adopted**	**The migration period for whale sharks is Jul-Nov and for blue whales Sept-Jan (south) and Apr-Aug (north). Only partial overlap with the MSS is likely therefore and given the short duration of the MSS and expectation that only isolated will be encountered the impacts to schedule and project cost are disproportionate to the minimal environmental benefit of further reduction to an already low level of risk.**
Shut down zone for foraging seabirds near the seismic source	**Elimination**	**Elimination/minimisation of effects to seabirds**	**Negligible (<1 %)**	**0.5-2% of project cost**	**Not adopted**	**Given the already very low likelihood of birds foraging near the operating seismic source and the low risk of brief startle response, no further controls are proposed. Shut-downs for seabirds would be impracticable to implement and place a disproportionate amount of effort on MFOs and crew. The OA is located a considerable distance away from the closest seabird breeding and foraging BIAs.**
Increased shut-down / lower power zone implemented for whale sharks	**Isolation**	**Elimination/minimisation of effects to whale sharks**	**Minor (1-3%)**	**0.5-2% of project cost**	**Not adopted**	**Given that the ASA does not overlap with the whale shark foraging BIA, only isolated individuals are expected to be encountered. The likelihood of being able to effectively spot a whale shark at ranges further than 500 m is unlikely, therefore, no further precaution zone is proposed and is not considered necessary given the already low level of risk.**
Conducting the survey during daylight hours only	**Elimination**	**Elimination/minimisation of effects to marine fauna in particular plankton, marine mammals and turtles**	**Moderate (3-10%)**	**>10% of project cost**	**Not adopted**	**Night-time operations may effect zooplankton which vertically migrate into surface waters at night and prohibits visual observations of marine mammals and turtles. However, impacts to plankton will be localised and short-term, and the encounter rate with marine mammals and turtle during the short period of the MSS will be low. Conversely, this control would put major scheduling constraints on the Gem 3D MSS resulting in a longer overall survey duration and additional time on the water with the potential for other impacts and risks.**
Eliminate sound emissions into the area fished by the NDSMF that are above	**Elimination**	**Elimination/minimisation of effects to NDSMF**	**Moderate (3-10%)**	**0.5 – 2% of project cost**	**Adopted**	**Good industry practise. Modifying the ASA to eliminate emissions that cause mortality or recoverable injury to commercially targeted fish minimises impacts to these species and to operators within the NDSMF.**

mortality/recoverable injury thresholds for demersal fish						
Avoidance of the goldband snapper spawning period	Elimination	Elimination/minimisation of effects to goldband snapper spawning aggregations	Minor (1-3%)	>10% of project cost	Not adopted	Avoidance of the spawning period for goldband snapper (Nov-May) was considered. However, the Gem 3D MSS could be acquired at any time between December 2019 and June 2020, depending on acceptance of the EP, vessel availability and weather constraints. Therefore, there is the potential for overlap with the spawning period. Avoidance of the spawning period is not considered to have any benefit given that the risk to fish spawning aggregations is already considered to be low. The spatial overlap of is small (conservatively 2% of goldband snapper habitat) and negligible in the context of natural variability, and the habitats in the vicinity of the ASA are considered to be of relatively low value for spawning aggregations. Given that the risk to spawning is already low, the potential cost of delaying the survey is grossly disproportionate to the minor environmental benefit that may be gained.
Payment of compensation to commercial fishers for loss of catch due to displacement or via seismic noise reducing the 'catchability' of fish	Administrative	'Make good' arrangement for NDSMF licence holders affected by the activity	Negligible (<1%)	Uncertain as cost cannot be determined	Not adopted	Not considered 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. SapuraOMV has determined that compensation for commercial fishers is not an appropriate control or mitigation measure for the Gem 3D MSS, given the nature and scale of the activity, and the negligible impact expected to licence holders in the NDSMF.
SapuraOMV will engage with proponents identified as having potential concurrent seismic activities prior to commencing the Gem 3D MSS and develop a concurrent operations plan for any concurrent surveys identified within 60 km of the ASA	Administrative	Elimination/minimisation of cumulative effects of underwater sound emissions from the seismic source	Moderate (3-10%)	<0.5% of project cost	Adopted	Good industry practice, environmental benefit outweighs additional cost.
A minimum separation distance of 40 km will be maintained between the Gem 3D MSS survey vessel and other operating seismic sources	Isolation	Elimination/minimisation of cumulative effects of underwater sound emissions from the seismic source	Moderate (3-10%)	5% of project cost	Adopted	Good industry practice, environmental benefit outweighs additional cost.

6.2.3.2 Demonstration of ALARP

Table 6-20: Demonstration of ALARP

Criteria	Demonstration
Legislation, codes and standards	**Part A of EPBC Policy Statement 2.1 are standard management procedures and will be implemented during the Gem 3D MSS.** **Consistent with Part B of EPBC Policy Statement 2.1, MFOs will be on board the seismic vessel and on duty during daylight hours during the survey.**
Good industry practice	**The maximum volume 2,820** in^3 **energy source was determined during the pre-planning phase of the Gem 3D MSS as it is the minimum source size identified to meet the geophysical objectives of the survey, taking into account the depth of the seismic targets and the characteristics of the underlying geology.** **The impact is managed in accordance with good industry practice such as IAGC's "Recommended monitoring and mitigation measures for cetaceans during marine seismic survey geophysical operations (2017)", and APPEA's CoEP requirements for using appropriate research to provide knowledge of the environment and in accordance with international conventions and legislation.**
Professional Judgement **Cost-based analysis** **Societal values**	**Impact level is already Negligible with standard practices and controls in place.** **Substitute: None identified** **Engineer: None identified** **Isolate: Refer Table 6.19** **Administrative: Refer Table 6.19**

6.2.4 Demonstration of acceptability

The level of residual impact is evaluated in Table 6-21 against the pre-set acceptability criteria.

Table 6-21: Acceptability evaluation

Acceptability Criteria	Acceptable level of impact	Evaluation against Acceptability Criteria
Internal context: **SapuraOMV's policies and HSE MS** **Env impact demonstrated to be ALARP**	**The impact management strategy and controls are consistent with SapuraOMV's corporate environmental policy, culture and company standards and procedures.** **In demonstrating ALARP – options must be considered and the cost benefit analyses used to determine if they should be adopted**	**The impact management strategy for impacts from underwater sound emissions from the seismic source reflects SapuraOMV's Environment Policy goals of preventing harm to the environment by reducing risk to ALARP, complying with applicable legal and industry standards, and continually improving environmental performance.** **Section 8 demonstrates how the HS EMS meets the requirements of this EP.** **Section 6.1.3 summarises how the impact of underwater sound emissions from the seismic source and controls adopted have reduced the predicted impact to ALARP.**

EPO is achievable and consistent with achieving acceptable performance	**The EPO states:** **Seismic acquisition conducted in a manner that meets or exceeds EPBC Policy Statement 2.1 requirements to minimise the risk of acoustic injury or biological consequences in marine fauna from acoustic disturbance by seismic sound.**	**Proposed control measures exceed the requirements set out in Part A of EPBC Policy Statement 2.1 and will ensure underwater sound emissions from the seismic source will not cause significant impacts to sensitive receptors. EPO as stated is therefore achievable and acceptable.**
ESD principles: **The following core objectives have been incorporated:** **To protect biological diversity** **Maintain essential ecological processes and health**	**The following core objective has been incorporated:** **The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making**	**SapuraOMV has reduced the impact/risk of underwater sound emissions from the seismic source to prevent serious or irreversible ecological damage. The aspect and potential interactions are well understood and managed in accordance with EPBC Policy Statement 2.1 and applicable industry standards and best practice guidance.**
External context: **Compliance with legislation and industrial standards** **Compliance with values stated in Marine Park Management Plans, species Recovery plans and Conservation plans/advice** **No direct impacts on management values of**	**This control measures must comply with legislation and industry practice e.g.:** • **EPBC Policy Statement 2.1** • **Conservation Management Plan for the Blue Whale;** • **Conservation Advice for *Balaenoptera borealis* (sei whale) (TSSC 2015b);** • **Conservation Advice for *Balaenoptera physalus* (TSSC 2015c);** • **Recovery Plan for Marine Turtles in Australia (DoEE 2017); and** • **Conservation Advice for *Rhincodon typus***	**The proposed control measures exceed the required standards and control measures set out in Part A of EPBC Policy Statement 2.1.** **The activity will be undertaken in a manner consistent with the applicable objectives and actions of the relevant species conservation or recovery plans, threat abatement plans, and conservation advice, including:** **Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area** **No impacts are predicted to occur to the values of the Oceanic Shoals Marine Park, or any other AMP in the region.**

protected areas or KEFs	**whale shark (TSSC 2015b);** • **North-west Marine Parks Network Management Plan 2018 (DNP 2018a);** • **North Marine Parks Network (DNP 2018b);** • **OPGGS Act: Residual risks must be reduced to ALARP.**	
External context: **Stakeholder expectations**	**The merit of relevant stakeholder concerns and objections have been assessed and controls adopted to reduce risks to ALARP**	**Stakeholders have not raised any specific concerns relating to impacts from the seismic source on marine fauna, commercial fisheries or the values of the Oceanic Shoals Marine Park.**

6.2.5 Predicted impact

The predicted impacts of underwater sound emissions from the seismic source on marine fauna during the Gem 3D MSS are considered to be localised and of no lasting effect, and restricted to temporary behavioural changes (avoidance) by any individuals that may inhabit the shallow shoals within the ASA, or transit the area in close proximity to the operating seismic source.

Based on the timing and duration (up to 27 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 marine fauna that may be present within or adjacent to the ASA during the survey.

Source of Impact	Predicted environmental effects	Consequence severity
Underwater sound emissions from seismic array	**Given the adopted controls, the predicted impacts of underwater sound emissions from the seismic source on marine fauna during acquisition of the Gem 3D MSS are considered to be slight and short-term, and restricted to temporary behavioural changes (avoidance) in any individuals that may inhabit the shallow shoals within the ASA, or transit the area in close proximity to the operating seismic source. With the control measures in place, the Gem 3D MSS will not result in any significant impacts to fishers operating in the NDSMF adjacent to the OA.**	**Negligible**

6.2.6 EPO, additional controls, performance standards and measurement criteria

Not conducting the seismic activity eliminates underwater sound emissions as an impact but is not acceptable. Additional control measures have been identified that further reduce the impacts from underwater sound emissions from the seismic array. The environmental performance objective, control measures, performance standards and measurement criteria are listed in Table 6-22.

Table 6-22: Summary of controls for underwater sound emissions from seismic array

EPO	Control measure	EPS	Measurement criteria
EPO I1: Seismic acquisition conducted in a manner that meets or exceeds EPBC Policy Statement 2.1 requirements to minimise the risk of acoustic injury or biological consequences in marine fauna from acoustic disturbance by seismic sound.	**Application of EPBC Policy Statement 2.1 Part A: Standard Management Measures for whales and whale sharks**	**EPS I1: Application of EPBC Policy Statement 2.1 Part A: Standard Management Measures for whales and whale sharks**	**MFO data sheets/report confirms EPBC Policy Statement 2.1 is available onboard the seismic vessel and ALL Part A and standard management measures have been implemented throughout seismic data acquisition**
	Two MFOs will be on board the seismic vessel and on duty during daylight	**EPS I2: Two MFOs are available on board the seismic vessel to manage shift duties during daylight hours during the survey.**	**Curriculum Vitae of the MFOs engaged for the Gem 3D MSS confirms:** • **UK Joint Nature Conservation Committee (JNCC) accreditation (or equivalent); and** • **at least one year (minimum four surveys) previous MFO experience.** **MFO report confirms two MFOs were on board the seismic vessel to manage shift duties for daylight visual observations during the survey.**
	'Turtle pause' to data acquisition when a turtle is within 200 m of an active source	**EPS I3: Seismic source is temporarily silenced when a turtle is sighted within 200 m of an active source.**	**MFO report confirms that firing of the seismic source is paused if a turtle is sighted within 200 m of an active source sub-array.**
	200 metre active seismic source exclusion zones will be established around the 50m depth contours (LAT) of shoals within the ASA.	**EPS I4: No operation of the seismic source within 200 m (horizontal distance) of the 50m depth contours of shoals within the ASA.**	**Survey log confirms no operation of the seismic source has occurred within 200 m of the 50m depth contours of shoals.**
	Use of recent bathymetric survey data of shoals within the ASA to	**EPS I5: Use of recent bathymetric survey data of shoals within the ASA to determine the coordinates**	**Survey log confirms that coordinates used to establish active source exclusion zones are based on pre-MSS bathymetric survey**

	ensure validity of depth data to establish exclusion zones.	**of 200m active source exclusion zones around the 50m depth contours (LAT) of all shoals within the ASA.**	
	Eliminate sound emissions into the area fished by the NDSMF that are above mortality/recoverable injury thresholds for demersal fish	**EPS I6: No discharge of seismic source within 200 m of the EEZ boundary, as amended by the Perth Treaty line**	**Survey log confirms no operation of the seismic source has occurred within 200 m of the EEZ boundary, as amended by the Perth Treaty line**

6.3 Physical presence of survey vessels

6.3.1 Overview of impact

6.3.1.1 Source of impact

The seismic survey vessel will acquire data over a period of up to 27 days during which time it will operate 24 hours a day. Due to the seismic streamers extending up to 10 km behind the survey vessel during the data acquisition process the survey vessel will be restricted in its ability to manoeuvre. There will also be at least one support vessel assisting with survey activities. Because of the physical presence of these vessels, other marine users may be temporarily displaced from their intended area of operation or transit route. Without management, the seismic streamers also present a potential navigational hazard to other marine users, and there is a possibility that fishing equipment deployed within the OA may become entangled in the streamers or run over by the survey or support vessels.

6.3.1.2 Physical, biological and socio-economic receptors

Marine users identified in Section 4.5 that may be present in the OA during the survey period include commercial fishing vessels operating in the NDSMF and commercial vessels undertaking oil and gas industry activities, large passenger vessels and Australian Border Force and navy vessels. The presence of these vessels coincident with survey operations is unlikely given the generally low levels of vessel activity in the OA and the short duration of the survey. With the management proposed, it is not expected that other commercial and recreational fishing vessels, nature-based tourist vessels, Indonesian fishing vessels (either traditional or commercial) and commercial ships following defined shipping routes will be present in the OA during the survey (Section 4.5).

6.3.2 Impact analysis and treatment

Table 6-23: Duration of impact and ALARP assessment technique regarding the physical presence of survey vessels

Planned event	Physical presence of survey vessels
Duration of impact	**Short term for the duration of the survey**
ALARP assessment technique	**Offshore vessel activities, including MSS, are standard industry practice. The potential impacts to other marine users associated with the physical presence of vessels undertaking survey activities are well understood. Seismic surveys have been conducted along the WA coast for decades and there are established and agreed practices to manage the more common risks. The application of recognised good practice is considered appropriate for management of these risks.** **No relevant person raised objections or claims regarding physical presence of vessels undertaking survey activities. Queries raised by the WA Fishing Industry Council (WAFIC) regarding interactions with commercial fishing vessels have been addressed as described in Appendix B.** **Taking this into consideration Decision Context A should be appropriate to demonstrate impacts are ALARP which includes:** • **Legislation, codes and standards (LCS)** • **Good Industry Practice (GIP)**

	• **Professional Judgement (PJ)**

6.3.2.1 Context for setting standard control measures

Table 6-24 describes the context for setting the minimum controls.

Table 6-24: Context for setting the standard control measures for the physical presence of survey vessels

Compliance with legislative requirements: • **Survey vessels to maintain appropriate lighting, navigation and communication at all times to inform other users of the position and intentions of the survey vessels, in compliance with the *Navigation Act 2012* and Chapter 5 of the International Convention on the Safety of Life at Sea (SOLAS Convention).** • **Adherence to Marine Orders Part 30: Prevention of Collisions (Issue 8) and Part 21: Safety of navigation and emergency procedures (Issue 8) specifically, use of standard maritime safety procedures (including radio contact, display of day shapes, navigational beacons, lights, streamers and reflective tail buoys).** • **Continuous (24 hour) survey operations with multiple trained crew (STCW95/Elements of Shipboard Safety) and monitoring of vessel position (radar) at all times during seismic acquisition.** • **OPGGS Act: Residual risks must be reduced to ALARP (addressed in Section 5).**
Compliance with Company and industry standards: **SapuraOMV's requirements for all impacts and risks to be reduced to ALARP (addressed in Section 5).** **Memorandum of Understanding between APPEA and fishing industry bodies including WAFIC to establish principles of cooperation, communication and consultation.** **Compliance with APPEA Principals of Conduct:** • **Enable members to co-exist with stakeholders to generate long-term mutual benefit** • **Guidance statement on undertaking seismic surveys in Western Australian waters (Webster et al. 2018):** • **Avoid key fishing areas, spawning times, aggregation areas and peak fishing times** • **Address specific advice from WAFIC, Recfishwest and individual fishers** **Compliance with survey vessel procedures associated with avoidance of in-water hazards during acquisition of seismic data.**
Alignment with objectives and compliance with requirements of applicable management, recovery and /or conservation plans: • **NA**

6.3.2.2 Description of impact with standard controls

6.3.2.2.1 Commercial Fishing

The OA slightly overlaps into Australia's Exclusive Economic Zone (EEZ) where it has been modified by the *Treaty between the Government of Australia and the Government of the Republic of Indonesia establishing an Exclusive Economic Zone Boundary and Certain Seabed Boundaries (Perth, 14 March 1997)* (Perth Treaty). Operators within Australian Commonwealth and state fisheries do not fish offshore of the Perth Treaty line (as described in Section 4.5.1), and the area of the OA inshore of this line has been minimised to that required solely for line turns by the seismic survey vessel at the end of each survey acquisition line. All other operational activities that also determine the extent of the OA, such as streamer deployment and retrieval, will occur in waters offshore of the Perth Treaty line so as to minimise interactions with fishers and their fishing equipment (Figure 6-4).

Review of fishing activity between 2014 - 2018 by operators within Commonwealth and state fisheries shows that only those in the NDSMF are active in the vicinity of the OA (Section 4.5.1). Operators in this fishery typically use demersal traps which are deployed over hard bottom areas and/or areas of relief such as rises, ridges and reefs (Newman et al. 2008). Although these traps are usually deployed for several hours during fishing trips, they may be left in water (unbaited and open) for up to twelve days between fishing trips (Newman et al. 2011). Surface buoys are attached to each trap by synthetic rope to enable retrieval. In 2019 there were six vessels active in the fishery, with three of these operating from Broome, WA, and three from Darwin, NT (Principal Fisheries Scientist DPIRD pers. comm. 6 May 2019). These vessels are mobile and move traps over an extended area with between 60 and 120 trap pulls per day (Newman et al. 2008).

There is a 424.2 km^2 overlap between the OA and Zone B of the NDSMF (the main zone of this fishery), as required to allow for turns by the survey vessel at the end of each survey line (Figure 6-4). This area of overlap is 0.5% of the total Zone B area, and 0.8% of the total area of the NDSMF (Table 4-16). Fisheries data provided by DPIRD show that less than 3 vessels operated in this area of overlap between 2014 – 2018, with the exception of a small portion (19 km^2) of one 10 x 10 nm fisheries reporting block in which three vessels reported catches during 2018. Catch data is available for this block because the number of vessels does not breach confidentiality provisions. This data indicates that a catch of 602 kg (0.05% of the total catch for 2018) may have been taken from this area of overlap with the OA, assuming an even distribution of catch throughout this block. However, the apparent lack of preferred habitat for target species within the area of overlap (Figure 4.1) suggests that this is unlikely to have been the case, with fishers targeting higher relief habitat further south. The online Global Fishing Watch database, which shows vessel monitoring system (VMS) tracking data for fishing vessels (including for Australian and Indonesian fisheries) indicates that three Darwin-based fishing vessels have been active in waters south of the OA during most months of the year since 2016 (Global Fishing Watch, 2019).

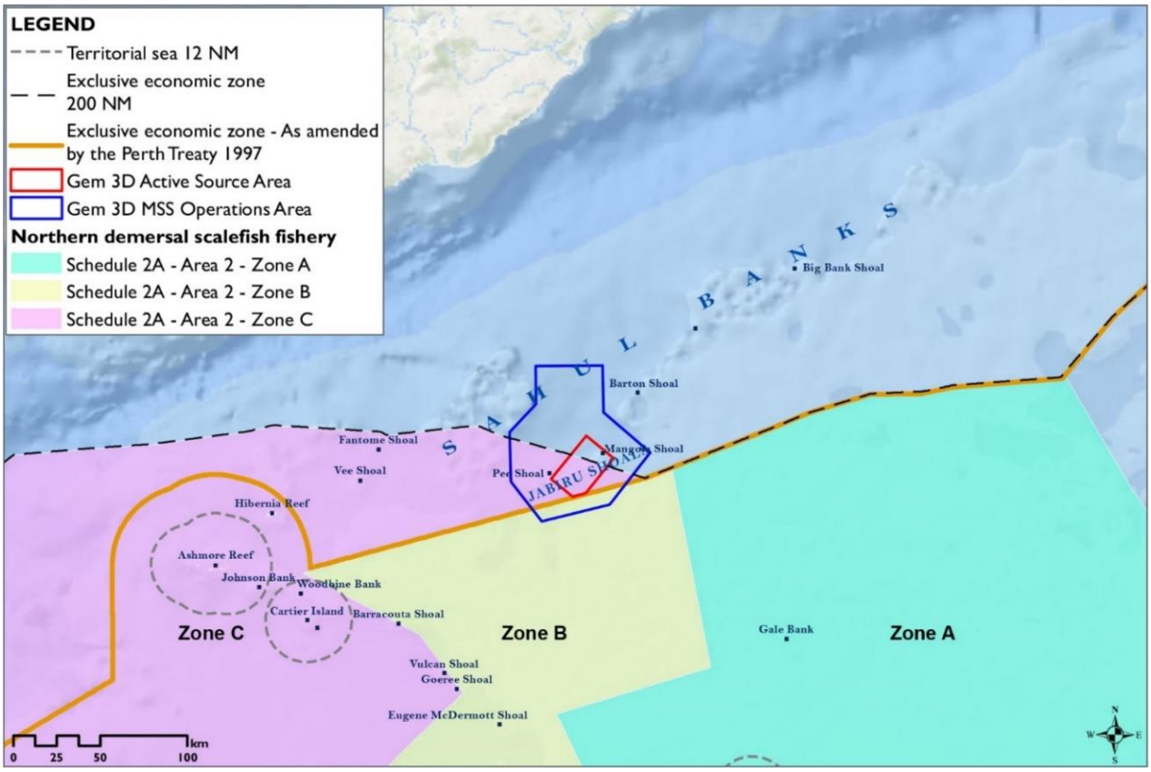


Figure 6-4: Operations Area of the Gem 3D MSS relative to the EEZ and jurisdictions of NDSMF fishing zones

6.3.2.2.1.1 Impact Assessment Conclusion

Potential impacts to operators within the NDSMF due to physical presence of the survey vessels includes displacement from fishing grounds, loss or damage to fishing equipment, and associated loss of catch. However, these impacts are unlikely to occur or be significant if they do occur, based on the following:

- The small area of overlap between fishing grounds and the OA (0.8%), with the low level of fishing effort and lack of bathymetric features indicating no key fishing habitat located within this area of overlap.
- The short duration of the survey (< 27 days), small number of vessels actively fishing northern waters of Zone B (three) and short duration of fishing trips (< 12 days), reduces the likelihood that fishing and seismic acquisition activities will coincide.
- The mobile and extensive nature of fishing operations - enables operators with the NDSMF avoid the area of overlap with the OA for the short duration of the survey, once notified of impending survey activity.
- Use of the support vessel during acquisition of seismic data to manage interactions with other vessels and to scout well ahead of the seismic survey vessel for in-water hazards. The seismic survey vessel will therefore be alerted to the presence of surface buoys and can take appropriate action during line turns that are the key activity occurring within the area of overlap between the OA and Zone B. Areas where night operations will occur will also be searched prior to nightfall.
- Comprehensive consultation program undertaken for the survey, including provision of maps, coordinates and pre-survey notifications to all potential commercial fishers to ensure they are aware of the survey location and timing and are able to plan their activities to temporarily avoid the area if necessary

Based on the above considerations the predicted impacts due to physical presence of survey vessels during the Gem 3D MSS are considered to be negligible.

6.3.2.2.2 Shipping and other vessels

The OA is situated well clear of shipping routes with the nearest route located 127 km to the south (Section 4.5). Large passenger vessels and Australian Border Force and navy vessels may transit along the boundary of the EEZ from time to time but their presence within the OA during the short period of the Gem 3D MSS (< 27 days) will be infrequent at most and short term as they transit the area.

With the management that will be implemented, including comprehensive consultation program and pre-survey notifications to AHO, AMSA, other marine users of the area will be made aware of the survey location and timing and be able to plan their activities to temporarily avoid the area if necessary. The predicted impacts due to physical presence of survey vessels during the Gem 3D MSS are therefore considered to be negligible.

6.3.2.2.2.1 Impact Assessment Conclusion

Ships and other vessels transiting through northern Australian waters are unlikely to do so through the OA during the period of the Gem 3D MSS. If this does occur, the requirement under maritime law to deviate around the seismic survey vessel situated in offshore open waters is not expected to impact their operations.

6.3.3 ALARP treatment and evaluation

6.3.3.1 ALARP options

Additional controls which have been considered in reaching ALARP are listed in Table 6-25.

Table 6-25: ALARP options considered for the physical presence of survey vessels

Control measures	Control type	Env benefit	Env benefit scale	Cost	Practical and implemented	Rationale
Seismic acquisition will only occur during daylight hours.	**Elimination**	**Daylight operations may reduce the risk of adverse interactions with other vessels or equipment including fishing buoys.**	**Minor (1-3%)**	**>50% of project cost**	**Not adopted**	**There are substantial additional costs in limiting acquisition to daylight hours. Navigation aids enable acceptable night-time Interactions between vessels. Support vessel will scout ahead for in-water hazards such as fishing buoys. Costs disproportionately higher than benefits.**
Do nothing – no MSS	**Elimination**	**Avoids impacts to activities of other vessels, although these are not significant**	**Moderate (3-10%)**	**>elimination of total project cost**	**Not adopted**	**The purpose of the MSS is to assist the hydrocarbon exploration effort in the area of interest and better understand the subsurface geology and prospectivity of the licensed title. Titleholders are required by NOPTA to acquire seismic data within specified time frames. Not conducting the survey would result in risking a successful drilling campaign and possible loss of the Title due to lack of execution of exploration commitments. Minimal benefit would be gained, given the predicted low impact of the activity on other users and the environment.**

Reduce ASA and OA to avoid commercial fishing areas	Elimination	Eliminate/ minimise impacts to fishing operators	Moderate (3-10%)	0.5 – 2% of project cost	Partially adopted (minor overlap by OA to allow for line turns)	Reduction to minimise overlap whilst still ensuring survey objectives reduces risk of adverse interactions. Minor overlap required for line turns by survey vessel
Survey vessels will be equipped with Automatic Radar Plotting Aid (ARPA) and active Automatic identification system (AIS) for detection of vessels, speed, heading.	Engineering	Eliminate/ minimise potential negative interactions with other vessels	Moderate (3-10%)	<0.5% of project cost)	Adopted	Navigation equipment that enables bridge crew to track other vessels
The Australian Hydrographic Office (AHO) advised of the survey details (survey location, timing) four weeks prior to mobilisation and following demobilisation for issue of Notice to Mariners.	Administrative	Eliminate/ minimise potential negative interactions with other vessels	Moderate (3-10%)	<0.1% of project cost)	Adopted	Issued for the prompt dissemination of information to mariners. Early notification of activities will allow fishers to plan activities around the survey and avoid negative interactions. Benefit outweighs cost.
Seismic vessel will notify AMSA's Joint Rescue Coordination Centre (JRCC) 24 to 48 hours before operations for promulgation of radio-navigation warnings. AMSA JRCC will be advised of the survey vessel's details (including vessel name, call-sign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and	Administrative	Eliminate/ minimise potential negative interactions with other vessels	Minor (1-3%)	<0.1% of project cost)	Adopted	Issued for the prompt dissemination of information to JRCC and broadcast to other mariners and fishermen to aid avoiding interaction. Benefit outweighs cost.

satellite telephone), area of operation and requested clearance from other vessels.						
AMSA JRCC will be notified at the end of the survey when operations have been completed	Administrative	Eliminate/ minimise potential negative interactions with other vessels.	Minor (1-3%)	<0.1% of project cost)	Adopted	Issued for the prompt dissemination of information to JRCC and broadcast to other mariners and fishermen.
Notification provided to all relevant persons four weeks prior to the start of the survey of details including, timing, location, duration the survey	Elimination	Eliminate/ minimise potential negative interactions with other vessels	Moderate (3-10%)	<0.1% of project cost)	Adopted	Ongoing consultation will allow stakeholders to plan activities around the survey and avoid negative interactions. Benefit outweighs cost.
WAFIC and relevant commercial fishers will be issued a 7 to 10 day forecast prior to activities commencing in the survey area	Elimination	Eliminate/ minimise potential negative interactions with other vessels	Moderate (3-10%)	<0.1% of project cost)	Adopted	Early notification of activities will allow fishers to plan activities around the survey and avoid negative interactions. Benefit outweighs cost.
Commercial fishers actively operating in or near the survey area will be kept informed of daily survey activities through SapuraOMV's 24-hour look-ahead communication.	Elimination	Eliminate/ minimise potential negative interactions with other vessels	Moderate (3-10%)	<0.1% of project cost)	Adopted	Ongoing notification of activities during the survey will allow stakeholders to plan activities around the survey and avoid negative interactions. Benefit outweighs cost

Support vessel to assist with interactions with other vessels and identify in-water hazards ahead of the seismic vessel	**Protective**	**Warning other vessels that may not be aware of the presence of the seismic vessel, minimises the risk of negative interactions. Identification of in water hazards allows the seismic vessel to avoid damage.**	**Minor (1-3%)**	**<5% of project cost)**	**Adopted**	**Warning errant or unaware vessels of the seismic vessel presence and pre-identification of in water hazards will allow avoidance actions to be undertaken in a timely manner. Benefit outweighs cost**
SapuraOMV will undertake a review two months prior to commencement of activities to ensure that any new stakeholders are identified and consulted.	**Elimination**	**Eliminate/ minimise potential negative interactions with other vessels**	**Modera te (3-10%)**	**<0.1% of project cost)**	**Adopted**	**Ongoing consultation will allow fishers to plan activities around the survey, will allow stakeholders to plan activities around the survey and avoid negative interactions. Benefit outweighs cost.**
Tail buoys clearly marked to identify streamer ends to other users	**Protective**	**Warning other vessels of the tail end, minimises the risk of damage to their equipment and the streamers.**	**Minor (1-3%)**	**<0.5% of project cost)**	**Adopted**	**Third parties can clearly see the ends of streamers and thus damage to property and risk of entanglement and streamer loss is minimised. Benefit outweighs cost**

Seismic acquisition will only occur outside peak fishing season.	**Elimination**	**Eliminate/ minimise potential negative interactions with other vessels**	**Modera te (3-10%)**	**5-10% of project cost)**	**Not adopted**	**Fishing occurs year-round whereas the duration of the Gem 3D MSS (<27 days) and overlap by the OA with the designated fishing area (424.2 km^2) are small. Timing the survey to avoid peak fishing season therefore would incur unnecessary impact to survey planning given the minimal impact to fishing. Cost outweigh benefit**
Payment of compensation to the rightful owner for any fishing equipment that has been damaged beyond repair or lost as a result of the survey activities	**Administra tive**	**'Make good' arrangement for NDSMF licence holders affected by the activity**	**Minor (1-3%)**	**At replacem ent cost.**	**Adopted**	**Benefit to fishers' livelihoods and industry reputation outweighs the cost of compensation. However, compensation for equipment that is deliberately placed to hamper the seismic vessel's movement would not be compensated. Benefit outweighs cost**

6.3.3.2 Demonstration of ALARP

Table 6-26: Demonstration of ALARP for physical presence of survey vessels

Criteria	Demonstration
Legislation, codes and standards	**Administrative:** • **Vessels comply with or exceed international and Commonwealth legislative requirements for maritime lighting, communication and navigation.**
Good industry practice	**Eliminate:** **The number of vessels and the duration (approximately 27 days) of the activity are already at minimal levels and further reduction in numbers or scope would compromise the activity and undertaking it safely.** **Administrative:** **The impact is managed and minimised to ALARP through good industry practice such as:** • **Third parties are made aware of the presence and movements of the seismic and support vessels at all times through the ongoing stakeholder consultation program and standard navigation practices such as routine radio warnings and internationally recognised lights etc.** • **Stakeholder concerns/objections received have been merit assessed and control measures developed where required (Table 9.1) and communicated back to stakeholders**
Professional Judgement **Cost-based analysis** **Societal values**	**Impact level is already Negligible with standard practices and controls in place.** **Substitute: None identified** **Engineer: None identified** **Isolate: None identified** **Administrative: Memorandum of Understanding between APPEA and Commercial Fisheries bodies (including WAFIC) that agrees on a framework to foster cooperation, communication and consultation between groups.**

6.3.4 Demonstration of acceptability

The residual impact is evaluated against the pre-set acceptability criteria in Table 6.27.

Table 6-27: Acceptability evaluation

Acceptability Criteria	Acceptable level of impact	Demonstration of acceptability
Internal context - **Policy compliance:**	**The impact management strategy and controls are consistent with SapuraOMV's corporate environmental policy, culture and company standards and procedures.**	**The impact management strategy for impacts from the physical presence of survey vessels reflects SapuraOMV's HSE MS – Element 5: Risk Assessment and Control:**

SapuraOMV's policies and HSE MS Env impact demonstrated to be ALARP	In demonstrating ALARP – options must be considered and the cost benefit analyses used to determine if they should be adopted	To ensure identification, assessment and treatment of risk considers all potentially affected parties, including external stakeholders The residual impacts meet the ALARP criteria (section 6.2.3.2).
EPO is achievable and consistent with achieving acceptable performance	The EPO states: Overlap in activities with other marine users avoided through communication before and during the survey, including notifications of survey location, timing and navigation constraints	The OA overlap represents a very small part of the NDSMF fishing area (424.2 km^2) and experiences negligible fishing effort, with numerous alternatives available. The short duration of the Gem 3D MSS (< 27 days), communication methods used during the survey, including use of support/chase vessel and location of the Gem 3D MSS in open offshore waters will reduce the potential for conflict with other users.
ESD principles	Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations	No reduction in catchability or catch rates for any commercial fishery.
External context: Compliance with legislation and industry standards	This control measures must comply with legislation and industry practice e.g.: • *Navigation Act 2012*, Chapters IV (radio communications) and V (Safety of Navigation) • AMSA Marine Orders Part 30: Prevention of collisions, Part 21: Safety and emergency arrangements, and Part 27: Safety of navigation and radio equipment. • OPGGS Act: Residual risks must be reduced to ALARP.	This legislation has been used in the development of the management controls necessary to reduce impacts from physical presence of survey vessels to ALARP. All legislated requirements will be met for navigational and safe working purposes, and to minimise potential disruption to activities of other marine users.
External context: Stakeholder expectations	The merit of relevant stakeholder concerns and objections have been assessed and controls adopted to reduce risks to ALARP.	Minimising disturbance of other users has been considered by reducing the OA as far as practicable and maintaining clear communications in line with standard national and international industry codes. There are no outstanding objections or claims regarding physical presence of survey vessels. None with merit were raised during initial consultations that remain unresolved.

6.3.5 Predicted impact

Predicted impacts from the physical presence of the seismic survey and support vessels are assessed as negligible because of the short duration of the survey, minimal overlap with activities of other stakeholders, and controls in place to ensure effective communications between parties and management of potential interactions if necessary.

Source of Impact	Predicted environmental effects	Consequence severity
Physical presence of survey vessels	**Very low numbers of commercial fishers within the NDSMF may be required to avoid the small area of overlap with the OA during the short duration of the MSS but have extensive alternative fishing areas available. Other marine users may be required to make slight alterations to their course to avoid the seismic survey and support vessels in the unlikely event that they transit the OA during the period of the Gem 3D MSS.**	**Negligible**

6.3.6 EPO, additional controls, performance standards and measurement criteria

Not conducting the seismic activity eliminates interaction with other marine users as an impact; but is not an acceptable option. No additional practical control measures have been identified as required to further reduce the impacts from physical presence of vessels undertaking survey activities.

The environmental performance objective, control measures, performance standards and measurement criteria are listed in Table 6-28.

Table 6-28: Summary of controls for the physical presence of survey vessels

EPO	Control measure	EPS	Measurement criteria
EPO I2: Overlap in activities with other marine users avoided through communication before and during the survey, including notifications of survey location, timing and navigation constraints	**Survey vessel to maintain appropriate lighting, navigation and communication at all times to inform other users of the position and intentions of the survey vessel, in compliance with the *Navigation Act 2012* and Chapter 5 of the International Convention on the Safety of Life at Sea (SOLAS Convention).**	**EPS I7: Vessel to maintain appropriate lighting, navigation and communication at all times to inform other users of the position and intentions of the survey vessel, in compliance with the *Navigation Act 2012*, COLREGS (International Regulations for Preventing Collisions at Sea 1972), Chapter IV (Radiocommunications) and Chapter V (Safety of Navigation) of SOLAS (International Convention on the Safety of Life at Sea 1974).**	**Evidence that vessels comply with COLREGS and relevant chapters of SOLAS. Any records of failure to comply are documented.**
	Adherence to Marine Orders Part 30: Prevention of Collisions (Issue 8) and Part 21: Safety of navigation and emergency procedures (Issue 8) specifically, use of standard maritime safety procedures (including radio contact, display of day shapes, navigational beacons, lights, streamers and reflective tail buoys).	**EPS I8: Vessel navigational lighting and communication system managed in accordance with AMSA Marine Orders Part 30: Prevention of collisions, Part 21: Safety and emergency arrangements and Part 27 (Safety of navigation and radio equipment).**	**Evidence that vessels have navigational lights and communication system that comply with relevant marine orders.**
	Continuous (24 hour) survey operations with multiple trained crew (STCW95/Elements of Shipboard Safety) and monitoring of vessel position (radar) at all times during seismic acquisition.	**EPS I9: Continuous (24 hour) survey operations with multiple trained crew (STCW95/Elements of Shipboard Safety) and monitoring of vessel position (radar) and depth at all times during seismic acquisition.**	**Records confirm bridge was manned continuously during survey operations, and that vessel crew have appropriate qualifications.**

	Reduce ASA and OA to avoid commercial fishing areas	**EPS I10: No overlap of ASA with commercial fishing areas and overlap by OA is limited to that required for line turns by the seismic survey vessel.**	**Survey design demonstrates no overlap by ASA with commercial fishing areas and overlap by OA is limited to that required for line turns by the seismic vessel**
	Seismic vessel will be equipped with Automatic Radar Plotting Aid (ARPA) and active Automatic identification system (AIS)	**EPS I11: Vessel equipped and using a functional ARPA and AIS at all times for detection of vessels, speed, heading and virtual outer tail buoy locations**	**Inspection records confirm ARPA and active AIS on the seismic vessel**
	The Australian Hydrographic Office (AHO) advised of the survey details for issue of Notice to Mariners.	**EPS I12: The Australian Hydrographic Office (AHO) advised of the survey details (survey location, timing) four weeks prior to mobilisation and following demobilisation for issue of Notice to Mariners.**	**Records of notification of survey details sent to the AHO four weeks prior to survey mobilisation and within two weeks of survey demobilisation.**
	Seismic vessel will notify AMSA's JRCC before operations for promulgation of radio-navigation warnings.	**EPS I13: AMSA JRCC will be advised of the survey vessel's details (including vessel name, call-sign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone), area of operation and requested clearance from other vessels. This information will be notified to AMSA RCC 24 to 48 hours before operations commence via email address (rccaus@amsa.gov.au) or phone (1800 641 792 or +61 2 6230 6811)**	**Records demonstrate that AMSA RCC have been notified of the survey vessel details and movements 24 to 48 hours prior to the start of the survey.**
	AMSA JRCC will be notified at the end of the survey	**EPS I14; AMSA JRCC will be notified at the end of the survey when operations have been completed (via email address**	**Records demonstrate that AMSA RCC have been notified of the end of survey operations.**

		(rccaus@amsa.gov.au) or phone: 1800 641 792 or +61 2 6230 6811).	
	Notification provided to all relevant persons	EPS I15: Notification provided to all relevant persons four weeks prior to the start of the survey of details including, timing, location, duration the survey	Records demonstrate notification of survey details to all relevant persons four weeks prior to the start of the survey.
	WAFIC and relevant commercial fishers will be issued a forecast prior to activities commencing in the survey area	EPS I16: WAFIC and relevant commercial fishers will be issued a 7 to 10 day forecast prior to activities commencing in the survey area	Copies of forecast notifications to relevant commercial fishers 7 to 10 days prior to activities commencing in the survey area
	Commercial fishers actively operating in or near the survey area will be kept informed of daily survey activities.	EPS I17: Commercial fishers actively operating in or near the survey area will be kept informed of daily survey activities through SapuraOMV 24-hour look-ahead communication	Sighting records of 24-hour look-ahead communications with commercial and recreational fishers
	Support vessel to assist with interactions with other vessels and identify in-water hazards ahead of the seismic vessel	EPS I18: Support vessel to manage vessel interactions and maintain communications with commercial shipping in the survey area and warning the survey vessel of in-water hazards 24/7	Records demonstrate that a dedicated support vessel is employed for the duration of the activity and records of warning errant or unaware vessels maintained.
	SapuraOMV will undertake a review prior to commencement of activities to ensure that any new stakeholders are identified and consulted.	EPS I19: SapuraOMV will undertake a review two months prior to commencement of activities to ensure that any new stakeholders are identified and consulted.	Records demonstrate SapuraOMV has undertaken a review of relevant stakeholders every six months following approval of the EP and two months prior to commencement of activities.
	Tail buoys clearly marked to identify streamer ends to other users.	EPS I20: All streamers are equipped with functional tail buoys	Records show all tail buoys marked to identify streamer ends.

	Payment of compensation to the rightful owner for any fishing equipment that has been damaged beyond repair or lost as a result of the survey activities **Compensation for lost catch due to equipment lost or damaged as a result of survey activities**	**EPS I21: Loss of Catch Disposal Records submitted by fisher for each compensation claim, showing the loss of catch compared to what they would have caught in the survey area had it not been for the damaged or lost fishing equipment.** **EPS I22: If required, an independent expert review of each fisher's claim for compensation.**	**Incident close-out report demonstrates that the rightful owner was appropriately compensated for fishing equipment lost or damaged as a consequence of survey activities, and for loss of income attributable to the lost equipment until equipment returned to full working order.** **The close-out report also includes evidence to support the claim for compensation.** **Consultation with fisheries associations demonstrates agreement on the selected independent expert appointed.**

6.4 Underwater sound emissions from survey vessels

6.4.1 Overview of impact

6.4.1.1 Source of impact

The seismic survey vessel and support vessel will generate low levels of machinery noise, especially when using propulsion thrusters. This noise will be at a much lower level than the noise emitted from the active airgun array. Seismic data acquisition activities will occur on a continuous basis (24 hours a day) throughout the survey (maximum duration of 27 days), with regular periods of time when the seismic source is not operational. Average survey line duration will be ~2.1 hours, with an average line change time of 3.3 hours. While the seismic source is operational, the underwater noise generated by vessels will be a negligible addition to the cumulative noise levels.

The assessment of underwater vessel noise below is therefore limited to periods when underwater noise levels from vessel operations are dominant –e.g. when the airgun array is not operating due to rough weather, line turns, maintenance activities and marine fauna shut-downs. These periods are not expected to last more than six days over the entire survey period.

6.4.1.2 Physical, biological and socio-economic receptors

The majority of acoustic energy radiated from large commercial vessels is below 1 kHz, and so the greatest potential for masking exists for marine fauna that produce and receive sounds within this frequency band; primarily baleen whales, fish, dugong and possibly some toothed whales (Southall et al. 2007; Ichikawa et al. 2012). Acoustic masking at higher frequencies (1 - 25 kHz) may affect toothed whales (dolphins and porpoises) in close proximity to the vessel.

The frequency range of vessel noise overlaps the hearing ranges of many fish species (Amoser et al. 2003). Hearing impairment (i.e. TTS) has been recorded for fish exposed to continuous noise from small boats and ferries for two hours (Vasconcelos et al. 2007). However, recovery was observed on cessation of vessel noise.

6.4.2 Impact analysis and treatment

Table 6-29: Duration of impact and ALARP assessment technique regarding underwater sound emissions from survey vessels

Planned event:	Underwater sound emissions from survey vessels
Duration of impact	**Short periods within the survey period when the seismic source is not operational**
ALARP assessment technique	**Vessel activity is a standard offshore practice in this region. No relevant person raised objections or claims regarding underwater sound emissions from vessels undertaking survey activities.** **Taking this in consideration Decision Context A should be applied to demonstrate impacts are ALARP which includes:** • **Legislation, codes and standards (LCS)** • **Good Industry Practice (GIP)** • **Professional Judgement (PJ)**

6.4.2.1 Context for setting standard control measures

Table 6-30 describes the context for setting the minimum controls.

Table 6-30: Context for setting standard control measures for underwater sound emissions from survey vessels

Compliance with legislative requirements: **EPBC Regulations 2000 – Part 8 Division 8.1 and Australian National Guidelines for Whale Watching and Dolphin Watching 2017 (CoA, 2017)** **OPGGS Act: Residual risks must be reduced to ALARP (addressed in Section 5.5.3).**
Compliance with Company and industry standards: **SapuraOMV's requirements for all impacts and risks to be reduced to ALARP (addressed in Section 5.5.3).** **Vessels comply with company engine maintenance procedures** **Vessels comply or exceed good industry practice such as the APPEA Code of Environmental Practice (APPEA 2008) objectives for offshore seismic surveys with respect to reducing the impacts to other marine life to a level which is ALARP and acceptable including:** • **The adoption of appropriate management measures for the survey in accordance with legislative requirements/ guidelines; and** • **Utilisation of appropriate research studies/knowledge and latest data records to provide knowledge of environment in which the seismic source will operate and assess potential impacts. As such, potential receptors within the existing environment have been researched in the latest data records in Section 4.**
Alignment with objectives and compliance with requirements of applicable management, recovery and /or conservation plans: • **Conservation Management Plan for the Blue Whale (DoE 2015a).** • **Conservation Advice for *Balaenoptera borealis* (sei whale) (TSSC 2015b).** • **Conservation Advice for *Balaenoptera physalus* (fin whale) (TSSC 2015c).** • **The Recovery Plan for Marine Turtles in Australia (DoEE 2017).** • **Approved Conservation Advice *Rhincodon typus* whale shark (TSSC 2015d)**

6.4.2.2 Description of impact with standard controls

Underwater noise emissions from vessel operations are generally within or below the range of natural noise levels experienced by marine fauna, and therefore not expected to cause any physiological damage to fauna (McCauley 1998, 2003; McCauley and Jenner 2001; and Richardson et al. 1995). The primary auditory effect of vessel noise on marine fauna is the potential masking of biologically significant sounds (Southall et al. 2007). Potential behavioural effects on marine fauna due to underwater noise from vessels include changes in vocalisation characteristics and disturbance to foraging, navigation and reproductive activities.

Vessel operations in the region as a result of oil and gas, shipping and fishing activities, are infrequent and therefore the potential for adverse impacts from vessel noise is considered low. The greatest source of noise during the activity will be from operation of the airgun array, therefore the impact assessment for the effects of noise from vessel operations on marine fauna is limited to periods when the seismic source is not operational.

Noise emissions from the survey vessels will be influenced by the activity being conducted by the vessels, for example, the seismic vessel generates less noise when drifting and more when towing the streamer array using the azimuth thrusters. Source levels from typical seismic vessels are approximately 165 - 180 dB re 1 µPa (root mean squared (rms) @ 1 m for vessels <100 m long and

180 - 190 dB re 1 µPa (rms) @ 1 m for vessels >100 m long (Richardson et al. 1995; Kipple and Gabriel 2003; and Heitmeyer et al. 2004). Marine fauna at distance from the vessel will be exposed to much lower noise levels due to attenuation of the sound energy as it travels through the water.

There has been relatively little published on behavioural observations of cetaceans exposed to continuous, low-level underwater noise, such as from vessels. An experimental study involving acoustic tagging and controlled exposure experiments with North Atlantic right whales (*Eubalaena glacialis*), showed no effect of vessel noise on the whales. Five of the six individual whales responded strongly (interrupted dive pattern and swam rapidly to the surface) to the presence of an artificial alarm stimulus (series of constant frequency and frequency modulated tones and sweeps) but ignored playbacks of vessel noise (Nowacek et al. 2004). Small cetaceans are commonly observed swimming near vessels; this attraction suggesting that the noise is not having a detrimental effect on the animals.

In summary, marine fauna that may be present within the OA are mobile and would be expected to actively avoid the survey vessels, especially during data acquisition. When the airguns are not operational, there may be localised behavioural disturbance of fauna in the immediate vicinity of the vessel. However, this would be limited to a temporary change in behaviour due to avoidance of the area. No injury or lasting impact on marine fauna as a result of exposure to vessel noise and no effects at an ecosystem function level or population level are predicted.

6.4.3 ALARP treatment and evaluation

6.4.3.1 ALARP options

Additional controls which have been considered in reaching ALARP are listed in Table 6-31.

Table 6-31: ALARP options considered for underwater sound emissions from survey vessels

Control measures	Control type	Env benefit	Env benefit scale	Cost	Practical and implemented	Rationale
Do nothing – no MSS	**Elimination**	**Removes impacts associated with noise emissions, although these are not significant**	**N/A**	**N/A**	**Not adopted**	**Titleholders are required by NOPTA to acquire seismic data within specified time frames. Minimal benefit given the predicted low impact on other users. Costs disproportionately higher than benefits.**
Internal combustion engines on survey vessels will be maintained in accordance with the manufacturer's specifications and hence noise emissions will be typical of vessels in the region.	**Engineering**	**Impacts from typical vessels are considered to be low**	**Minor (1-3%)**	**<0.5% of project cost)**	**Adopted**	**Normal maintenance activity that has both environmental and economic benefits.**
Control measures adopted for managing impacts from underwater sound from seismic array to ALARP will afford added protection in reducing potential effects from vessel noise to ALARP (refer to Section 6.1)	**Various**	**Eliminate/minimise impacts to marine fauna**	**Moderate (3-10%)**	**0.5 – 2% of project cost**	**Adopted**	**As per Section 6.1**

6.4.3.2 Demonstration of ALARP

Table 6-32: Demonstration of ALARP for underwater sound emissions from survey vessels

Criteria	Demonstration
Legislation, codes and standards	**Administrative:** • **Vessels comply with or exceed international and Commonwealth legislative requirements for maritime lighting, communication and navigation.**
Good industry practice	**Eliminate:** **The number of vessels and the duration (approximately 27 days) of the activity are already at minimal levels and further reduction in numbers or scope would compromise the activity and undertaking it safely.** **Administrative:** **The impact is managed and minimised to ALARP through good industry practice such as:** • **Third parties are made aware of the presence and movements of the seismic and support vessels at all times through the ongoing stakeholder consultation program and standard navigation practices such as routine radio warnings and internationally recognised lights etc.** • **Stakeholder concerns/objections received have been merit assessed and control measures developed where required (Table 9.1) and communicated back to stakeholders**
Professional Judgement **Cost-based analysis** **Societal values**	**Impact level is already Negligible with standard practices and controls in place.** **Substitute: None identified** **Engineer: None identified** **Isolate: None identified** **Administrative: Memorandum of Understanding between APPEA and Commercial Fisheries bodies (including WAFIC) that agrees on a framework to foster cooperation, communication and consultation between groups.**

6.4.4 Demonstration of acceptability

The residual impact is evaluated against the pre-set acceptability criteria in Table 6.33.

Table 6-33: Evaluation of acceptability criteria for underwater sound emissions from survey vessels

Acceptability Criteria	Acceptable level of impact	Demonstration of acceptability
Internal context **Policy compliance:** • **SapuraOMV's policies and HSE MS**	**The impact management strategy and controls are consistent with SapuraOMV's corporate environmental policy, culture and company standards and procedures.**	**The impact management strategy for impacts from sound emissions from survey vessels reflects SapuraOMV's Environment Policy goals of preventing harm to the environment by reducing risk to ALARP, complying with applicable legal and industry standards,**

• Env impact demonstrated to be ALARP	In demonstrating ALARP – options must be considered and the cost benefit analyses used to determine if they should be adopted	and continually improving environmental performance. Section 8 demonstrates the HSE MS can meet the requirements of this Env Plan. The residual impacts meet the ALARP criteria (section 6.6.3).
EPO is achievable and consistent with achieving acceptable performance	The EPO states: No disturbance or displacement of marine fauna from biologically important areas.	Planned maintenance of vessel engines/equipment will reduce potential effects to immediate vicinity of operations. Control measures adopted for managing impacts from underwater sound from seismic operations to ALARP will add protection in reducing exposure of EPBC listed MNES and other marine fauna to vessel noise (refer to Section 6.1).
ESD principles	The following core objectives have been incorporated: • To protect biological diversity • Maintain essential ecological processes and health.	No displacement of marine fauna from biologically important areas. No population or ecosystem effects. The impact assessment presented throughout this EP demonstrates compliance with the principles of ESD.
External context: Compliance with legislation and industry standards	This control measures must comply with legislation and industry practice e.g.: • Vessel operations will be compliant with the EPBC Regulations 2000 which ensures adequate separation distances between vessels and cetaceans. Review and assessment of threatened species recovery plans and conservation advice indicates alignment of the EP with the objectives, any applicable actions undertaken (if required), and the activity does not impede any actions by other parties enacting the Plans. The assessment must indicate preservation of values stated in marine reserves, with no direct	This legislation has been used in the development of the management controls necessary to reduce the impacts of sound emissions from vessels to ALARP. The residual impacts meet the ALARP criteria (Section 6.3.3). Review and assessment of threatened species recovery plans and conservation advice (such as the Marine Turtle Recovery Plans (DoEE 2017) or conservation plans relevant to this location (e.g. Conservation Plan for the Blue Whale, 2015-2025).

	impacts on management values of protected areas or KEFs	
External context: Stakeholder expectations	**The merit of relevant stakeholder concerns and objections have been assessed and controls adopted to reduce risks to ALARP**	**There are no outstanding objections or claims regarding underwater sound emissions from survey vessels. None with merit were raised during initial consultations that remain unresolved. Section 8 describes the ongoing stakeholder consultation process should issues arise.**

6.4.5 Predicted impact

Impacts due to underwater sound emissions from survey vessels are assessed as negligible because of the short period in which these emissions will occur and (<6 days), small area of impact and mobility of sensitive receptors.

Source of Impact	Predicted environmental effects	Consequence severity
Underwater sound emissions from survey vessels	**Localised area of avoidance and short-term behavioural effect on marine fauna species.**	**Negligible**

6.4.6 EPO, additional controls, performance standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for underwater sound from vessel operations are presented below in Table 6-34.

Table 6-34: Summary of controls for underwater sound emissions from survey vessels

EPO	Control measures	EPS	Measurement criteria
EPO I3: No disturbance or displacement of marine fauna from biologically important areas.	**All internal combustion engines on board the vessel will be maintained in accordance with the contractor's planned maintenance program.**	**EPS I23: All internal combustion engines on board the vessel will be maintained in accordance with the planned maintenance program.**	**Records and training matrix demonstrate that a qualified marine engineer is on board throughout survey**
	Interaction between survey vessel and cetaceans (whales and dolphins) within the operational area will be consistent with EPBC Regulations 2000 – Part 8 Division	**EPS I24: Interaction between survey vessel and cetaceans (whales and dolphins) within the operational area will be consistent with EPBC Regulations 2000 – Part 8**	**MFO report demonstrates no breaches of EPBC Regulations 2000 (Part 8).** **Compliance and cetacean sighting**

	8.1 (Regulation 8.04) – Interacting with cetaceans.	**Division 8.1 (Regulation 8.04) – Interacting with cetaceans:** • **vessels will not knowingly travel faster than 6 knots within 300 m of a whale or 150 m of a dolphin** • **vessels will not knowingly get closer than 100 m of a whale or 50 m of a dolphin** • **seismic survey vessels and support vessels will not intently approach within 150 m of a dolphin calf or within 300 m of a whale calf (Reg 8.06(2)).** • **If a cetacean approaches the vessel within the above zones, the vessel should avoid rapid changes in engine speed or direction.**	**reports will be completed and provided to NOPSEMA / DoEE within 3 months of completion of the survey.**
	Control measures adopted for managing impacts from underwater sound from seismic array to ALARP will afford added protection in reducing potential effects from vessel noise to ALARP (refer to Section 6.1)	**Control measures adopted for managing impacts from underwater sound from seismic array to ALARP will afford added protection in reducing potential effects from vessel noise to ALARP (refer to Section 6.1)**	**Refer to Table 6-22**

6.5 Light emissions from survey vessels

6.5.1 Overview of impact

6.5.1.1 Source of impact

For the duration of the seismic activities, safety and navigational lighting will be used on the vessels at night and in poor weather as per legislated requirements as a minimum.

Lighting for deck operations typically comprise bright white (metal halide, halogen, fluorescent etc) lights focussed on working areas but covering the vessel. For intermittent periods, spot lighting may be required for in-sea equipment inspection, deployment and retrieval. Helideck lights usually include coloured perimeter, low flood and high-mounted aviation lights. Navigation lights are typically elevated but less intense.

Direct illumination of surface waters is limited to the immediate vicinity largely within 100 m. The distance to the horizon at which the brighter components may be directly visible can be estimated using the formula:

Horizontal distance (km) = 3.57 x √height (m)

Using this formula, for typical survey vessels, the highest lights that may be mounted approximately 45 m above sea level would be visible from roughly 24 km. The area of potential light impact has been assessed as the OA plus approximately 24 km i.e. where light may be visible by sensitive receptors from the sea surface but fading to a pin prick at the edges.

6.5.1.2 Physical, biological and socio-economic receptors

The presence in the region of protected and/or threatened fauna and their sensitivity to light has been evaluated. Light may locally attract and/or affect feeding or breeding behaviours particularly of turtles, birds and fish. Light is not listed as a threat in the Conservation Management Plan for the blue whale (DoE 2015a) and blue whales may avoid the area due to sound disturbance. As such, impacts to whales are not assessed further.

Socio economic receptors were considered unimpacted by vessels' light because any impacts to commercial fish are temporary and within 100 m of the moving vessel; and because of the large distances to communities/ cities. As such, impacts of light on socio economic receptors are not considered further.

KEFs and protected areas

The OA does not overlap a Marine Park or KEF. Given the location of the activity, no impacts to Australian Marine Parks are predicted. The KEF-The Carbonate Bank and Terrace System of the Sahul Shelf lies more than 10 km from the OA with vessel lights visible from <1% of the KEF area.

Reptiles

Protected turtles listed in the PMST report as 'vulnerable' (Section 4 and Appendix E) that may transit the region are listed in Table 6-35. There are no nesting sites for any turtles within the area where vessel light is visible. The olive ridley and leatherback turtles are not known to nest in the vicinity, but individuals may transit to foraging habitats north west of the region.

Table 6-35: Listed turtles that may transit the region

Species	Nearest BIA	Present during Gem 3D MSS
Hawksbill	**Ashmore Reef (>140 km), possible presence at Cartier Island (>100 km)**	**Yes**
Flatback	**Possible presence at Ashmore Reef (>140km), Cartier Island (>100 km)**	**Yes**
Green turtle	**Ashmore Reef (>140 km)**	**Yes**
Loggerhead	**Possible presence at Ashmore Reef (>140 km)**	**Yes**

Seabirds and shorebirds

Section 4 describes those listed seabirds protected under the EPBC Act that may be present in the region. Table 6-36 summarises those with breeding or resting BIA on Ashmore Reef, Cartier Island and around Penguin Deeps, all more than 70km from the Operations Area. There are no delineated BIAs overlapping the area where vessel light is visible, only foraging adults are likely in the area. Shorebirds may cross the region during migrations (see Section 4.4.8.2).

Table 6-36: Examples of listed seabirds and migratory shore birds that may transit the Operations Area

Listed Species	BIA	Location	Present during Gem 3D MSS	Abundance in the area where light is visible
Brown booby, Lesser crested tern, Lesser frigatebird, Roseate tern, White tailed tropic bird, Wedge tailed shearwater and Red footed booby	**Breeding, resting**	**Ashmore Reef and Cartier Island, Penguin Deeps**	**Yes**	**Individual adults**

Table 6-37 provides a summary for whale sharks and plankton in the area where vessel light is visible. Commercial fish, demersal and site attached fish were not considered impacted due to the low intensity of the moving sources and small area of light directly on the ocean and hence are not discussed further. Plankton habitats are ubiquitous in the region without delineated aggregation areas.

Table 6-37: Summary information for whale sharks and plankton

Species	Activity in region	Nearest BIA from where light is visible (km)	Present during Gem 3D MSS	Abundance in the area where light is visible
Whale shark	**Foraging, migrating**	**A small part of the whole whale shark BIA overlaps southern boundary of the OA**	**Yes**	**Individuals, peak in Oct-Dec**
Plankton	**General distribution**	**N/A**	**Yes**	**Low abundance**

6.5.2 Impact analysis and treatment

Planned event:	**Artificial light spill from vessels**
Duration of impact	**Short term – for the duration of the survey**
ALARP assessment technique	**The use of lights for navigational purposes and safe work practices is a legislated requirement and standard offshore practice. The potential impacts are well understood. Sensitive shoreline nesting and aggregation habitats are >100 km distant. There is limited potential for exposing light sensitive marine receptors to changes in ambient light levels.** **Taking this into consideration Decision Context A is appropriate to demonstrate impacts are ALARP, which includes:** • **Legislation, codes and standards (LCS)** • **Good Industry Practice (GIP)** • **Professional Judgement (PJ**

6.5.2.1 Context for setting standard control measures

Table 6-38 describes the context for setting the minimum controls.

Table 6-38: Context for setting standard control measures for light emissions from survey vessels

Compliance with legislative requirements: • **Legislation (COLREGS, *Navigation Act 2012* and Chapter 5 of the International Convention for the Safety of Life at Sea (SOLAS) Convention) requires minimum lighting to reduce risk of vessel collisions. All legislated requirements will be met for navigational and to ensure safe working purposes. While this legislation does not reduce environmental impacts from light, it is provided as an indication of the minimum base level of lighting (unshrouded) that indirectly minimises environmental risks by minimising risks from spills arising from collisions and loss of containment.** • **OPGGS Act: Residual risks must be reduced to ALARP (addressed in Section 5.5.3).**
Compliance with Company and industry standards: **SapuraOMV's requirements for all impacts and risks to be reduced to ALARP (addressed in Section 0).** **Vessels comply or exceed good industry practice such as the APPEA Code of Environmental Practice (APPEA 2008) objectives for offshore seismic surveys with respect to reducing the impacts to other marine life to a level which is ALARP and acceptable including:** • **The adoption of appropriate management measures for the survey in accordance with legislative requirements/guidelines; and** • **Utilisation of appropriate research studies/knowledge and latest data records to provide knowledge of environment in which the seismic source will operate and assess potential impacts. As such, potential receptors within the existing environment have been researched with respect to impacts from light in the latest data records.**
Alignment with objectives and compliance with requirements of applicable management, recovery and /or conservation plans: • **Marine Bioregional Plan for the North West Marine Region (2012).** • **The Recovery Plan for Marine Turtles in Australia 2017-2027 (DoEE 2017)) (Action A3). This Plan is only relevant if the light sources were visible to areas known for aggregations (e.g. nesting BIA) for MNES listed turtles.**

6.5.2.2 Description of impact with standard controls

Monitoring by Woodside (Woodside 2010) indicates that light density (navigational lighting) from a rig attenuated to below 1.00 lux and 0.03 lux at distances of 300 m and 1.4 km, respectively. Light densities of 1.0 and 0.03 lux are comparable to natural light densities experienced during deep twilight and during a quarter moon. No impacts would be expected at these light levels. As such, only operational lighting is considered further.

6.5.2.2.1 KEFS, Marine Parks, Protected Areas

The Department of Energy and the Environment do not list artificial light as a concern (or potential concern) or pressure from human driven processes for the KEF- Carbonate and Terrace System of the Sahul Shelf or as light potentially affecting the region's conservational values (DoEE 2019). If impacts to listed fauna and habitats of the KEFs are negligible (see below), impacts to the KEF are considered negligible. However, the Marine Bioregional Plan for the North West Marine Region (DSEWPaC 2012) does list light as a threat to the region's values with respect to turtles and cetaceans.

6.5.2.2.2 Turtles

Artificial lights offshore can be detrimental to the sea-finding behaviours of marine turtle hatchlings if visible from nesting beaches because they can disrupt visual cues. Changes in ambient light levels may affect nesting behaviours with artificial lighting potentially deterring mature turtles from emerging from the water to nest (Salmon 2003; Salmon et al. 1992). Given the absence of marine turtle nesting and BIA where vessel lights may be visible (nesting sites and the distance to nearest foraging and breeding aggregation areas (>100 km distant), the impact to marine turtles is negligible and limited to temporary behavioural effects on individuals rather than population levels. While the Recovery Plan for Marine Turtles in Australia 2017-2027 (DoEE 2017)) has requirements for lighting minimisation adjacent to nesting beaches, this is not considered relevant to the SapuraOMV survey location.

Similarly, the Marine Bioregional Plan for the North west Marine Region (DSEWPaC 2012) lists light pollution as a concern for flatback, green, hawksbill and loggerhead turtles and of potential concern for all species of seabird and shorebirds. However, the vessel lights are not visible to known aggregation and breeding sites and the very short duration and extent of lighting associated with the survey vessels will make an insignificant contribution to anthropogenic light levels in the region.

6.5.2.2.3 Birds

There are no seabirds or migratory shorebirds with BIA that overlap areas where vessel light is visible. Studies by Wiese et al. (2001) noted that migratory birds can be attracted to lights on offshore installations when travelling within a radius of 5 km from the light source (Shell 2009), and that outside this zone, their migratory paths are unaffected. As such, numerous protected seabirds (see Section 4.6.7) that traverse the area may be temporarily attracted to the vessel lights, resulting in collision with unlit structures, disrupted foraging behaviours and disorientation. In all cases, the nesting sites of seabirds and shorebirds are more than 100 km from areas where vessel light is visible.

Protected and/or migratory seabirds may be attracted to the increased prey sources for the duration of the activity, but the area of impact is limited to a hundred metres from the vessels. In the event that deck or navigational lighting acts as an attractant to occasional seabirds or migratory shorebirds, it is not expected that this will permanently impact on migration, foraging or other behaviours.

Given the short duration of the acquisition program (up to 27 days) and the distance to breeding and resting sites, light disturbance to birds is likely to be restricted to temporary behavioural changes in birds in the immediate vicinity of the vessel.

6.5.2.2.4 Fish and zooplankton

Fish and zooplankton may be directly or indirectly attracted to the light field in the immediate vicinity of the vessels. Experiments using light traps have found that some fish and zooplankton species are attracted to light sources (Meekan et al. 2001), with traps drawing catches from up to 90 m (Milicich 1992). Lindquist et al. (Lindquist, Shaw & Hernandez 2005) concluded from a study of larval fish populations around an oil and gas platform in the Gulf of Mexico, that an enhanced abundance of clupeids (herring and sardines) and engraulids (anchovies), both of which are highly photopositive, was caused by the platform’s light fields. The concentration of organisms attracted to light results in an increase in food for predatory species, and marine predators are known to aggregate at the edges of artificial light halos. In a similar light trap study, juvenile tunas (Scombridae) and jacks (Carangidae), which are highly predatory, were thought to have been preying upon concentrations of zooplankton attracted to the light field of the platforms (Hernandez et al. 2003; Lindquist, Shaw & Hernandez 2005). This could potentially lead to increased predation rates compared to unlit areas. As the vessels are moving constantly, for fish and squid it is expected that any potential impact of increased predation would be undetectable at a population level.

The proportion of zooplankton exposed and subjected to higher predation is considered negligible due to the size of the potentially impacted area relative to the extent of unlit waters in the region.

Some PMST listed threatened species of fish (such as the great white and whale shark) may benefit from increased congregations of prey around light spilled on the water but this advantage will only be present during the seismic activities and local to the moving vessels.

Given the short duration of the acquisition program (up to 27 days) the ecological impacts to fish and zooplankton as a consequence of light emissions from survey vessels are predicted to be undetectable at a population level and considered as local (within hundreds of metres from the vessels) degradation of the environment, with rapid recovery following completion of the activity.

6.5.3 ALARP treatment and evaluation

6.5.3.1 ALARP options

Additional controls which have been considered in reaching ALARP are listed in Table 6-39.

Table 6-39: ALARP options considered for light emissions from survey vessels

Additional control measure	Control type	Env benefit	Env Benefit scale	Cost	Practical and implemented	Rationale
No night-time operations	**Elimination**	**Light glow is minimised to no lights in excess of those required by law**	**Negligible (<1%)**	**>50% of project cost**	**Not adopted**	**Limiting seismic activities to daylight hours would significantly extend the schedule with major cost impacts. The location is remote from land (closest shoreline is >300 km) and there are no turtle, reptile or bird nesting BIA areas where vessel light is visible. Negligible environmental benefit in 12-hour operations, but significant increase in charter costs and length of survey.** **Sacrifice disproportionately higher than benefit**
External lighting will be directed only onto working decks and extensive shrouding installed	**Engineering/ Isolation**	**Overspill to the ocean is reduced where practicable.**	**Negligible (<1%)**	**<0.5% of project cost**	**Partially adopted**	**Additional shrouding not required as there are no critical habitats for light-sensitive species in the area where vessels' light glow is visible** **All non-essential external lighting switched off when not in use, minimises the likelihood of altered behaviour in marine fauna. Maintaining high visibility to traditional fishermen improves their safety. Cost of re-fit disproportionately higher than benefit.**

Use only long wavelength (e.g. yellow and red light for external lighting) that is less intrusive to marine fauna	**Substitution**	**Typically used for light intensive activities in the vicinity of sensitive receptors (e.g. turtle nesting)**	**Negligible (<1%)**	**<0.5% of project cost**	**Not adopted**	**Limited/no benefit due to low likelihood of night-time encounters with sensitive receptors (no BIA for light sensitive receptors where the light is visible). Cost of re-fit disproportionately higher than environmental benefit.**
Activity deferred to time of year when turtle hatchlings are predicted to be low	**Elimination**	**Avoids peak hatching times (in the region),**	**Negligible (<1%)**	**Depending on availability of vessels, may be >10% of project cost**	**Not adopted**	**Limited/no benefit due to low likelihood of night-time encounters with sensitive receptors (individual hatchlings) - there are no BIA for light sensitive receptors in the area where the vessels' light is visible.** **Cost of changing schedules (with potential impacts to other receptors) disproportionately higher than environmental benefit.**

6.5.3.2 Demonstration of ALARP

Table 6-40: Demonstration of ALARP

Criteria	Demonstration
Legislation, codes and standards	• **Clear visual communication of the presence of seismic and support vessels to other vessels is paramount for safety of workers at night (see Section 7.4). The absence of sensitive receptors means the costs of further light reduction outweigh any negligible environmental benefits.** • **Having sufficient visible light minimises likelihood of other incidents/events of higher env risk.**
Good industry practice	**Eliminate:** • **The number of vessels and the duration of the activity are already at minimal levels and further reduction would compromise the activity. Not conducting the seismic activity would eliminate light as an impact but is not acceptable.** • **The impact is managed in accordance with good industry practice such as APPEA's CoEP requirements for using appropriate research to provide knowledge of the environment) and in accordance with international conventions and legislation.**
Professional Judgement **Cost-based analysis** **Societal values**	**Impact severity is already Negligible with standard practices and controls in place.** • **Substitute: None identified** • **Engineer: None identified** • **Isolate: None identified** • **Administrative: None identified**

6.5.4 Demonstration of acceptability

The residual impact is evaluated against the pre-set acceptability criteria in Table 6-41.

Table 6-41: Acceptability evaluation

Acceptability Criteria	Acceptable level of impact	Evaluation against Acceptability Criteria
Internal context: **SapuraOMV's policies and HSE MS** **Env impact demonstrated to be ALARP**	**The impact management strategy and controls are consistent with SapuraOMV's corporate environmental policy, culture and company standards and procedures.** **In demonstrating ALARP – options must be considered and the cost benefit analyses used to determine if they should be adopted**	**The impact management strategy for artificial lighting impacts reflects SapuraOMV's Environment Policy goals of preventing harm to the environment by reducing risk to ALARP, complying with applicable legal and industry standards, and continually improving environmental performance.** **Section 8 demonstrates how SapuraOMV HSE MS meets the requirements of this EP** **Section 6.5.3 summarises how the impact of light and controls adopted have reduced the predicted impact to ALARP**

EPO is achievable and consistent with achieving acceptable performance	**The EPO states: No disturbance beyond localised behavioural impacts to marine fauna from artificial light spill**	**As the vessel lights will be visible for a limited distance around the vessel and will not reach sensitive receptor aggregations (e.g. nesting beaches), this EPO is achievable and acceptable.**
ESD principles: **The following core objectives have been incorporated:** • **To protect biological diversity** • **Maintain essential ecological processes and health**	**The following core objectives have been incorporated:** • **To protect biological diversity** • **Maintain essential ecological processes and health.**	**The survey area is >100 km remote from aggregations of light sensitive species (e.g. BIA for turtle nesting) which maybe present along shorelines. Encounters with species will be infrequent given their dispersive characteristics.** **A full and rapid (within days) recovery of localised behavioural impacts is expected to commence daily as the vessels move throughout the Operations Area.** **There is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecological integrity is maintained when using artificial light during this activity. No direct impacts on EPBC Act listed MNES at a population level.** **The impact assessment presented throughout this EP demonstrates compliance with the principles of ESD**
External context: **Compliance with legislation and industrial standards** **Compliance with values stated in Marine Park Management Plans, species Recovery plans and Conservation plans/advice** **No direct impacts on management values of**	**Control measures must comply with legislation and industry practice e.g.:** • ***Navigation Act 2012* and Chapter 5 of the International Convention for the Safety of Life at Sea (SOLAS) Convention) requires minimum lighting to reduce risk of vessel collisions. While this legislation does not reduce environmental impacts from light, it is provided as an indication of the minimum base level of lighting (unshrouded) that indirectly minimises environmental risks by**	**Minimum legislative requirements for safe navigation and operation are provided in Section 7.4.** **The Marine Bioregional Plan for the North west Marine Region (DSEWPaC 2012) lists light pollution as a concern for listed turtles and is of potential concern for all species of seabird and shorebirds. At this location, vessel light is not visible from shoreline aggregations and light spill is minimised.** **Impacts from light were assessed against recovery and conservation plans for threatened species. No action objectives in recovery plans (e.g. the Marine Turtle Recovery Plans (DoEE 2017) and Conservation plans (e.g. for the Blue Whale), are applicable to artificial light spill at this moving vessel so far from sensitive receptors.** **The nearest CMP or AMP (Cartier Island Commonwealth waters) is more than 100 km**

protected areas or KEFs	**minimising risks from spills arising from collisions and loss of containment.** **OPGGS Act: Residual risks must be reduced to ALARP.**	**distant. <1% of the KEF – The Carbonate Bank and Terrace System of the Sahul Shelf overlaps the area where vessel light is visible.** **Impacts by light on the KEF values are assessed as negligible with no discernible changes to resident or passing populations (or habitats) of listed marine mammals, fish, birds, or plankton predicted. Any impacts to the KEF are predicted to be localised with recovery starting as the vessels move on and full recovery shortly after demobilisation.**
External context: **Stakeholder expectations**	**The merit of relevant stakeholder concerns and objections have been assessed and controls adopted to reduce risks to ALARP.**	**There are no outstanding objections or claims regarding lighting and none with merit were raised during initial consultations and remain unresolved.** **Section 8 describes ongoing communications before mobilisation and when in the field to ensure stakeholders are kept informed and updated of activities**

6.5.5 Predicted impact

Cumulative impacts from the vessels are assessed Negligible as the vessels are seldom in the same area, stationary for any length of time and the individual sources of light intensities are low. There are no sensitive receptors predicted to be impacted above a localised and temporary (approximately 27 days) level.

Source of Impact	Predicted environmental effects	Consequence severity
Vessel lights	**Local to the source, disorientation, attraction of sensitive marine fauna with disruption to natural behavioural patterns**	**Negligible**

6.5.6 EPO, controls, performance standards and measurement criteria

The environmental performance objective, control measures, performance standards and measurement criteria are listed in Table 6.42.

Table 6-42: Summary of controls for light emissions from survey vessels

EPO	Control measures	EPS	Measurement criteria
EPO I4: No disturbance beyond localised behavioural impacts to marine fauna from artificial light spill	**External lights are directed onto deck / work areas.** **External vessel lighting to be minimised where possible while maintaining appropriate lighting for safe navigation, in compliance with legislation (Section 7.4)**	**EPS I25: External artificial light spill to be minimised as much as practicable whilst meeting requirements for safe navigation and working conditions (refer section 7.4).**	**Inspection during activity to confirm that appropriate lights, shapes and communications with other vessels are implemented, with external lighting directed on work areas and minimised as much as practicable for safe navigation and operations.**

6.6 Atmospheric emissions from survey vessels

6.6.1 Overview of impact

Atmospheric emissions of greenhouse gases and other pollutants will be produced through fuel combustion in the engines of the seismic and support vessels for propulsion and deck equipment. Liquid and solid waste may be burnt within the vessels' incinerators (intermittent). The main emissions that present an environmental risk include nitrous oxides (NOx), sulfur oxides (SOx), particulate matter <10 µm, non-methane volatile organic compounds, benzene, toluene, ethylbenzene and xylenes and greenhouse gases (GHG, predominantly carbon dioxide).

6.6.1.1 Source of impact

The duration of the activity is short (< 27 days), during which time emissions will be generated from the combustion of approximately 50 m^3/day MDO cumulatively from all the vessels and possibly intermittently from incinerators. The emission of non-GHG particulate matter, such as NOX and SOX, can lead to a reduction in local air quality on a health-risk basis. The contribution to global GHG emissions of around 2,900tons CO2equiv forms part of the contribution to Australia's emissions (i.e. <0.0005% of the 558.3 million-ton CO_2 equivalent in 2018(Climate Council 2019).

6.6.1.2 Physical, biological and socio-economic receptors

The combustion of fuels and waste, in such a remote location, is not expected to impact on the health or amenity of any human settlements, all located over 200 km away, as offshore winds will rapidly disperse and diffuse gaseous emissions. As such, no marine fauna or socio-economic receptors will be impacted to a measurable degree.

6.6.2 Impact analysis and treatment

Planned event:	Air emissions from vessels
Duration of impact	**Short term – for the duration of the survey**
ALARP assessment technique	**The operation of marine diesel engines to power vessels and onboard machinery, and the use of onboard incinerators are standard industry practice and subject to international regulation. Environmental risks are well understood.** **Given the distance from sensitive receptors and the emissions are constrained to the duration of the activity with no long-term impacts to**

	human health at this location expected, the likely effects from atmospheric emissions are considered Negligible. **No relevant persons raised objections or claims regarding air emissions.** **Emissions are regulated and managed under other specific legislation; taking this in consideration, Decision Context A should be applied to demonstrate impacts are ALARP, which includes:** • **Legislation, codes and standards (LCS)** • **Good Industry Practice (GIP)** • **Professional Judgement (PJ)**

6.6.2.1 Context for setting standard control measures

Table 6-43 describes the context for setting the minimum controls.

Table 6-43: Context for setting the standard control measures for air emissions

Compliance with legislative requirements: • **Compliance with MARPOL 73/78 Annex VI as applied in Australia under Commonwealth *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and Marine Order – Part 97 (Part IIID Marine Pollution Prevention – Air Pollution), where applicable to vessel class (Regs 6,7,14) As such, vessels have international air pollution certificates and emission compliant incinerators as well as diesels engines >130 kW that meet prescribed emission standards** • **SapuraOMV will use MGO/MDO fuel during the activity, which will comply with all MARPOL requirements in relation to emissions (e.g. sulphur content).** • **OPGGS Act: Residual risks must be reduced to ALARP as addressed in Section 6.6.3.**
Compliance with Company and industry standards: • **SapuraOMV Risk Methodology Framework - All impacts/risks reduced to ALARP** • **Vessels comply or exceed good industry practice such as the APPEA Code of Environmental Practice (APPEA 2008) objectives for offshore seismic surveys with respect to reducing the impacts to other marine life to a level which is ALARP and acceptable including:** • **The vessels will implement an on-board maintenance program to ensure that all engines and equipment are well maintained and operating. This will reduce the likelihood of excessive vessel related atmospheric emissions**
Alignment with objectives and compliance with requirements of applicable management, recovery and /or conservation plans: **Alignment with objectives, actions and recommendations within:** • **Marine Bioregional Plan for the North West Marine Region (DSEWPaC 2012)** • **The Recovery Plan for Marine Turtles in Australia 2017-2027 (DoEE 2017) (Action A3)** • **Conservation Management Plan for the Blue Whale, 2015-2025 (DoE 2015d)**

6.6.2.2 Description of impact with standard controls

The atmospheric pollutant emissions are predicted to diffuse rapidly to concentrations below potential impact levels. While these emissions contribute to the GHG load in the atmosphere, they are typical of vessel petroleum and non-petroleum activities.

Accidental releases and fugitive emissions of ozone depleting substances (ODSs) are not expected to occur during the activity. Refrigeration systems containing ODS typically do not require frequent maintenance and follow well established practices to prevent accidental release of ODS. The short-term nature of the survey activity reduces the potential for maintenance being required.

With a preventative maintenance system, engines will run efficiently, and the use of low sulphur diesel will minimise the emission of SOx. Given the distance to population centres, visual amenity and the presence of dark smoke have no sensitive receptors. Hydrocarbon combustion may result in a temporary, localised reduction of air quality in the environment immediately surrounding the discharge points.

The Species Profile and Threats Database states for the KEF – The Carbonate Bank and Terrace System of the Sahul Shelf, no human pressures were listed 'as of concern' (DEE 2019). However, 'potential concerns' that may in the future detrimentally affect the region's conservational values, include changes in sea temperature and ocean acidification resulting from climate change. No specific actions are listed relating to industry's actions regarding fuel usage.

The Marine Bioregional Plan for the North West Marine Region (DSEWPaC 2012) includes climate change (resulting in changes in sea temperature and acidification) as anthropogenic pressures potentially affecting inshore dolphin, sea snakes, seabirds and migratory shorebirds, various KEFS in the region and habitats (such as corals).

The Recovery Plan for Marine Turtles notes 'Ocean acidification may have an impact on carbonate sediment production, which in turn will affect the volume and characteristics of nesting beaches, particularly in and around coral reefs. Changes in water pH may also affect foraging habitat and food availability for turtles that forage in coral reefs or feed on calcifying organisms"

The Conservation Plan for the Blue Whale notes ocean acidification as a risk to Blue Whales "Anthropogenic fossil fuel combustion and deforestation has led to an increase in atmospheric carbon dioxide levels. This results in increased absorption of carbon dioxide into the ocean and, through chemical reactions of the carbon dioxide, a decrease in pH of sea water. Laboratory experiments have shown that ocean acidification can be detrimental to Antarctic krill embryo development, which would consequently affect krill predators such as blue whales".

As such, the management controls listed are aligned with the objectives of the recovery and conservation plans in that they ensure impacts from emissions are minimised to as low as practical. However, there are no direct actions in the recovery or conservation plans that are transferrable to this EP.

Overall, the survey location is remote from sensitive receptors in an open-ocean environment where there will be rapid dispersion of atmospheric emissions. The decrease in local air quality will be temporary (< 27 days), localised and recoverable, and the contribution to global GHG levels is insignificant.

6.6.3 ALARP treatment and evaluation

6.6.3.1 ALARP options

Additional controls which have been considered in reaching ALARP are listed in Table 6-44.

Table 6-44: ALARP options considered - combustion emissions

Control measures	Control type	Env benefit	Env Benefit scale	Cost	Practical and implemented	Rationale
Compliance with Marine Order 97	**Administrative**	**Emissions managed by the implementation of a planned maintenance system (PMS) on propulsion and generation equipment**	**Neg <1%**	**<0.5%**	**Adopted**	**Good Practice – well defined and established standard practice by the offshore petroleum sector** **Environmental benefit outweighs cost**
Use a cleaner burning fuel -MDO/MGO	**Substitute**	**Emissions of particulate matter from MDO and MGO are less than from heavy fuel oil or bunker fuel** **Use of low sulphur diesel fuel to reduce sulphur emissions (SOx) from vessel combustion**	**Minor (1–3%) depending on fuel**	**2-5% or more as MGO/ MDO can cost 2x IFO or HFO and engines can require retrofitting**	**Adopted**	**Bunker oil or heavy fuel oil emissions are higher in SOx, particulate matter and other pollutants than the more expensive MDO and MGO. Also, MGO grade fuel is less persistent in the environment in the event of a release of fuel oil.** **Environmental benefit outweighs cost**

Use of alternate fuels (solar, wind, biofuels)	**Substitute**	**While the primary source may have env benefits, redundancy and back up may still have emissions**	**Minor (1–3%) depending on technology**	**Depends on technology and back up required**	**Not adopted**	**Alternative fuels not robustly or commercially proven for use in large vessels. Delays and unavailability can result in extended inefficient schedule.** **Costs outweigh benefits**
No incineration on vessels	**Eliminate**	**Onshore incineration may have less impacts by using higher efficiency incinerators than offshore incinerators**	**Neg <1%**	**0.5–2%**	**Not adopted**	**Incineration of wastes on vessels using MARPOL-certified equipment and procedures is an accepted practice which avoids potential impacts from transport, treatment and disposal onshore. Incineration saves space on board and may prevent health hazards created by long-term storage of wastes pending onshore disposal** **Cost outweighs benefit**

6.6.3.2 Demonstration of ALARP

Table 6-45: Demonstration of ALARP

Criteria	Demonstration
Legislation, codes and standards	**Administrative:** • **Vessels comply with or exceeds international and Commonwealth legislative requirements** • **Survey vessel operates under a SEEMP** • **Incineration equipment monitored for combustion temperatures. Feedstock to incinerators limited to wastes specified in the Vessel Garbage Management Plan.** • **Fuel consumption monitored**
Good industry practice	**Eliminate:** **The number of vessels and the duration (approximately 27 days) of the activity are already at minimal levels and further reduction in numbers or scope would compromise the activity.** **Administrative:** **The impact is managed and minimised to ALARP through good industry practice such as maintaining a preventative maintenance program and adherence to global legislation**
Professional Judgement **Cost-based analysis** **Societal values**	• **The absence of sensitive receptors (e.g. remote from coastal settlements) means the costs of further emission reduction outweighs any negligible environmental benefits.** • **Impact severity is already Negligible with standard practices and controls in place.** **Substitute:** • **Vessels are using low sulphur fuels with lower particulate emissions than heavy fuel oils.** **Engineer: Vessel combustion and incineration equipment compliant to MARPOL VI requirements** **Isolate: None identified** **Administrative: None identified in addition to legislative requirements**

6.6.4 Demonstration of acceptability

The residual impact is evaluated against the pre-set acceptability criteria in Table 6-46.

Table 6-46: Acceptability evaluation

Acceptability Criteria	Acceptable level of impact	Demonstration of acceptability
Internal context **Policy compliance:**	**The impact management strategy and controls are consistent with SapuraOMV's corporate**	**The impact management strategy for air emission impacts reflects SapuraOMV's Environment Policy**

• SapuraOMV's policies and HSE MS • Env impact demonstrated to be ALARP	environmental policy, culture and company standards and procedures. In demonstrating ALARP – options must be considered and the cost benefit analyses used to determine if they should be adopted.	goals of preventing harm to the environment by reducing risk to ALARP, complying with applicable legal and industry standards, and continually improving environmental performance. Section 8 demonstrates the HSE MS can meet the requirements of this EP. Section 6.6.3 summarises how the impact of air emissions and controls adopted have reduced the predicted impact to ALARP.
EPO is achievable and consistent with achieving acceptable performance	The EPO states: Air discharges comply with MARPOL 73/78 Annex VI requirements	Selected vessel is certified to be compliant with MARPOL and given the location is remote from communities, compliance with MARPOL will ensure no unacceptable reduction in air quality in the Operations Area.
ESD principles	The following core objectives have been incorporated: • To protect biological diversity • Maintain essential ecological processes and health	The combustion of the fuel will be a minor contribution to global GHG effects. Survey is in offshore waters where air environment is highly dispersive and offshore winds will assist in the dispersion and diffusion of atmospheric emissions full and rapid recovery of localised degraded air quality is expected as the vessels move throughout the Operations Area. No serious or irreversible environmental damage or significant impact to biological diversity is predicted and ecological integrity maintained when burning fuel during this activity. No direct impacts on EPBC Act listed MNES are predicted. The impact assessment presented throughout this EP demonstrates compliance with the principles of ESD.

External context: **Compliance with legislation and industry standards** **Compliance with values stated in marine reserves, species recovery plans and conservation advice**	**The control measures must comply with legislation and industry practice such as:** • ***Navigation Act 2012, Protection of the Sea (Prevention of Pollution from Ships) Act 1983*, Marine Order Part 97 (Marine Pollution Prevention – Air Pollution),** • **EPBC Regulations 2000 (IUCN principles of Schedule 8)** • **APPEA CoEP, IAGC Environment Manual** • **OPGGS Act: Residual risks must be reduced to ALARP.** **Review and assessment of threatened species recovery plans and conservation advice indicates alignment of the EP with the objectives, any applicable actions undertaken (if required), and the activity does not impede any actions by other parties enacting the Plans.** **No direct impacts on management values of protected areas or KEFs: The assessment must indicate preservation of values stated in marine reserves, with no direct impacts on management values of protected areas or KEFs**	**The legislation and industry practice has been used in the development of the management controls necessary to reduce the impacts from air emissions to ALARP.** **The residual impacts meet ALARP criteria (Section 6.5.4)** **Review and assessment of threatened species recovery plans and conservation advice (the Marine Turtle Recovery Plans (DoE, 2015) and Conservation Plan for the Blue Whale, 2015-2025) indicate climate change as a potential concern for turtles and whales. The control measures in this EP align with Australia's international commitments to reduce GHG emissions, hence reduce the threat of ocean acidification and temperature change and align with the objectives of the Recovery and Conservation plans. No management actions relevant to air discharge impacts are contained in the recovery/ management plans. The Marine Bioregional Plan for the North West Marine Region (2012) includes climate change (resulting in changes in sea temperature and acidification) as anthropogenic pressures on marine life and the various KEFs in the region.**
External context: **Stakeholder expectations**	**The merit of relevant stakeholder concerns and objections have been assessed and controls adopted to reduce risks to ALARP**	**There are no outstanding objections or claims regarding air emissions. None with merit were raised during initial consultations that remain unresolved. Section 8 describes the ongoing stakeholder consultation process should issues arise.**

6.6.5 Predicted impact

Cumulative impacts from emissions from all survey vessels during the Gem 3D MSS are assessed as Negligible due to the short duration of the MSS (< 27 days), fact that the vessels are always on the move and hence dispersing emissions, and because of the remote open ocean environment distant from sensitive receptors.

Source of Impact	Predicted environmental effects	Consequence severity
Emissions from hydrocarbon combustion	**Localised decrease in air quality, minor contribution to global GHG effects**	**Negligible**

6.6.6 EPO, controls performance standards and measurement criteria

Not conducting the seismic activity eliminates air emissions as an impact; but is not acceptable. No additional practical control measures have been identified as required to further reduce the impacts from hydrocarbon combustion emissions.

The environmental performance objective, control measures, performance standards and measurement criteria are listed in Table 6-47.

Table 6-47: Summary of controls – combustion emissions

EPO	Control measure	Env Perf Standard	Measurement criteria
EPO I5: Air discharges comply with MARPOL Annex VI requirements	**Compliance with MARPOL 73/78 Annex VI as applied under Commonwealth *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and Marine Order – Part 97 (Part IIID Marine Pollution Prevention – Air Pollution), where applicable to vessel class** **Reg 14: Use of low sulphur MGO/MDO grade of fuel oil for main engines** **Reg 6: The survey vessels will have a valid International Air Pollution Prevention (IAPP) Certificate and corresponding Australian legislation** **Reg 13: Limits on allowable NOx emission from diesel engines**	**EPS I26: All main engine fuel will be MGO/MDO with a sulphur content that meets MARPOL Annex VI standards**	**Bunkering records confirm that main engine fuel is MGO/MDO or lighter fuel oil (e.g. diesel) with MARPOL compliant sulphur content**
		EPS I27: Valid IAPP certificate for the vessel to be on board, issued by a recognised certification agency, consistent with MARPOL Annex VI	**Pre-mobilisation inspection to confirm relevant certificates (IAPP, IOPP and ISPP) are in place**
			Vessel records verify air emissions comply with MARPOL Annex VI including NOx emissions
	MARPOL Annex VI - Incinerator Vessel records verify air emissions comply with	**EPS I28: Incinerator operation is in accordance with MARPOL 73/78)**	**Incinerated waste details are recorded in the vessels' Garbage Book in accordance with**

	MARPOL Annex VI (Regulation 16)	**Only wastes approved by the vessel Garbage Management Plan shall be incinerated** **The incinerator shall operate in accordance with the manufacturer's operating manual by trained personnel** **Flue gas outlet or combustion chamber temperatures shall be monitored during incineration activities.**	**MARPOL requirements.** **Manufacturer's specifications and operating procedures are available for the operation of the incinerator**
	Emissions managed by the • **implementation of a planned** • **maintenance system (PMS) on propulsion and generation** • **equipment.**	**EPS I29: All engines on board to be maintained in accordance with the vessel on board maintenance program and associated procedures.**	**Inspection of vessel records (e.g. engineer logs) to confirm that vessel engines and equipment are maintained routinely**
		EPS I30: Fuel usage is monitored on all vessels and abnormally high consumption investigated	**Fuel use is reported in the Daily Report**

6.7 Discharge of sewage, grey water and food waste from survey vessels

6.7.1 Overview of impact

The use of ablution, laundry and galley facilities by crew will result in the generation of sewage, grey water and food waste, which are commonly discharged to the marine environment at or close to the sea surface, with potential for impacts such as localised and temporary changes to water and sediment quality.

Considering there are approximately 60 POB on the seismic and ~30 POB on the support vessel(s), a discharge of sewage, grey water and putrescible waste from each vessel can be estimated at approximately 22.5 m^3/day (based on National Energy Resources Australia estimates (NERA 2019)) for the duration of the survey (approximately 27 days).

The composition of sewage, putrescible wastes and grey water may include:

- physical particulates such as solids composed of floating, settleable, colloidal and dissolved matter,
- chemicals including nutrients (e.g. ammonia, nitrite) organics (e.g. oil and greases, endocrine disrupting compounds) and inorganics (e.g. hydrogen sulphide, surfactants etc, and)
- biological pathogens such as bacteria, viruses, parasites etc.

6.7.1.1 Source of impact

The fate and persistence of sewage, putrescible wastes and grey water may include:

- dilution, dispersion, uptake by primary producers (e.g. phytoplankton) and consumption by secondary consumers in the water column,

- biodegradation of organics through bacterial action, oxidation and evaporation,
- potential for some chemicals to persist e.g. metals and chlorinated organics, and
- localised turbidity, deposition of solid particulates and accumulation of constituents on the seabed.

The main environmental impact associated with ocean disposal of sewage and grey water is eutrophication. Eutrophication occurs when the addition of nutrients, such as nitrates and phosphates, causes adverse changes to the ecosystem, such as increased growth of primary producers such as phytoplankton and benthic algae and oxygen depletion.

6.7.1.2 Physical, biological and socio-economic receptors

Given the location, there are no industrial, recreational or fishing activities at this location that could be impacted by sewage or food waste discharge, hence socio-economic receptors are not considered further.

Open marine waters result in rapid mixing of surface and near surface water, so nutrients will not accumulate in the water column or lead to eutrophication. As such, the receptors with the greatest potential to be impacted by sewage are those in the immediate vicinity of the discharge. e.g. plankton and fish.

6.7.2 Impact analysis and treatment

The ALARP decision context is provided in Table 6-48.

Table 6-48: ALARP decision context – sewage, grey water and putrescible food discharges

Planned event	Discharge of sewage, grey water and food waste
Duration of impact	**Short term – for the duration of the survey**
ALARP assessment technique	**Waste management on vessels and the discharge of sewage, grey water and putrescible wastewater offshore from vessels is a well understood activity that is practiced daily both nationally and internationally.** **No relevant person raised objections or claims regarding sewage and waste.** **Taking this in consideration Decision Context A should be applied to demonstrate impacts are ALARP which includes:** • **Legislation, codes and standards (LCS)** • **Good Industry Practice (GIP)** • **Professional Judgement (PJ)**

6.7.2.1 Context for setting standard control measures

Table 6-49 describes the context for setting the minimum controls.

Table 6-49: Context for setting standard control measures – sewage, grey water and food waste

Compliance with legislative requirements: • **Marine Order 95 (Marine pollution prevention – garbage) 2013** • **Marine Order 96 (Marine pollution prevention – sewage) 2013** • **OPGGS Act: Residual risks must be reduced to ALARP**
Compliance with Company and industry standards:

- **SapuraOMV's requirement for all impacts and risks to be ALARP**
- **APPEA CoEP: Reducing the impacts other marine life to a level which is ALARP and Acceptable including:**
- **The adoption of appropriate management measures for the survey in accordance with legislative requirements/guidelines;**
- **Utilisation of appropriate research studies/knowledge and latest data records to provide knowledge of environment in which the seismic source will operate and assess potential impacts.**

Alignment with objectives and compliance with requirements of applicable management, recovery and /or conservation plans

- **Marine Bioregional Plan for the North West Marine Region (2012)**
- **Recovery Plan for Marine Turtles in Australia 2017-2027 (DoE, 2017),**
- **Conservation Management Plan for the Blue Whale, 2015-2025 (DoE, 2015)**
- **Balaenoptera borealis (sei whale) conservation advice (TSSC 2015a)**
- **Balaenoptera physalus (fin whale) conservation advice (TSSC 2015b)**

6.7.2.2 Description of impact with standard controls

Given a discharge of approximately 22.5 m^3 /day, and the fact the vessels are typically moving >4 kn with propellers/thrusters assisting localised dilution, the discharges are expected to be rapidly assimilated into the environment near the surface. This is supported by studies in the industry. Monitoring of sewage discharges has demonstrated that a 10 m^3 sewage discharge over 24 hrs from a stationary source in shallow water, reduced to approximately 1% of its original concentration within 50 m of the discharge location (Woodside 2010). In addition to this, monitoring at distances 50, 100 and 200 m downstream of the platform and at five different water depths confirmed that discharges were rapidly diluted or nutrients rapidly metabolised and no elevations in water quality monitoring parameters (e.g. total nitrogen, total phosphorous and selected metals) were recorded above background levels at any station. Although only a 10 m^3 discharge, this study provides some confidence to the defined mixing zone boundary, especially given the mobile nature of the vessel discharges. NERA (2019) examined modelling of large-scale sewage treatment plants and compared predicted dilutions with a reference case for a 400 POB fixed facility and concluded 150 m^3/day discharge would not exceed the 500 m mixing zone boundary.

Plankton communities have a naturally patchy distribution in both space and time (ITOPF 2011) with naturally high mortality rates, however in favourable conditions (e.g. supply of nutrients), plankton populations can rapidly increase. Once the favourable conditions cease, plankton populations will collapse and/or return to previous conditions. Plankton populations can respond to these changes by copious reproduction within short generation times (ITOPF 2011), typically returning to background conditions within tens to a few hundred metres of the discharge location (Parnell 2003).

Effects to the food web (e.g. to fish, reptiles, birds and cetaceans) are therefore not expected beyond a possible increase in prey abundance in the immediate vicinity of the vessels. Given the short duration of the survey program, no measurable ecological effects are predicted.

Overall, impact severity is assessed as Negligible. The volumes to be discharged intermittently daily during the seismic activities are small. The rapid dispersion of the wastewater discharge in the open-ocean deep-water environment is rapid. Predicted impacts are assessed as temporary (with no impacts predicted on cessation of the activity, i.e. within approximately 27 days) and localised to less than 100 m from the vessels.

6.7.3 ALARP treatment and evaluation

6.7.3.1 ALARP options

Table 6-50: ALARP options

Impact minimisation	Control type	Env benefit	Env benefit scale	Cost	Practical and implemented	Rationale
Storage of sewage and treated water on board for onshore disposal via port facilities	**Elimination**	**Onshore facilities could treat the sewage to a higher specification prior to discharge**	**Negligible (<1%)**	**0.5–2% of project cost**	**Not adopted**	**Disposal via port facilities leads to further impacts associated with air and noise emissions during vessel-to-port and port-to treatment/ disposal, HSE handling risks, costs associated with additional space and impacts from discharges in more sensitive populated areas or shallow water environments.** **Changes beyond mixing zone are negligible anyway** **Cost disproportionately higher than benefit**
Use of STP compliant with MARPOL Annex IV for discharge of sewage in special areas	**Engineering**	**Higher degree of treatment prior to waste disposal**	**Negligible (<1%)**	**0.5–2% of project cost if retrofitting required**	**Not adopted**	**The addition of chemicals (such as flocculants and defoaming agents) may be required to reduce the impacted area.** **Changes beyond mixing zone are negligible** **Cost disproportionately higher than benefit**
No discharge <15m water depth	**Administrative**	**Better dispersion and dilution achieved in deeper water**	**Negligible (<1%)**	**<0.5%**	**Adopted**	**In addition to improved dilution and dispersion, the risk of grounding and equipment entanglement is decreased and impacts from seismic sound are minimised**

6.7.3.2 Demonstration of ALARP

Table 6-51: Demonstration of ALARP

Criteria	Demonstration of ALARP
Legislation, codes and standards	• **Vessels comply with or exceeds international and Commonwealth legislative requirements** • **The International Convention for the Prevention of Pollution from Ships standard is considered to be the most appropriate standard to adhere to in this environment given the nature and scale of the activity. The International Convention for the Prevention of Pollution from Ships standard is as an internationally accepted standard that is utilised industrywide.**
Good industry practice	**Eliminate:** • **The number of vessels and the duration (approximately 27 days) of the activity are already at minimal levels and further reduction in numbers or scope would compromise the activity** • **The impact is managed in accordance with good industry practice such as APPEA's CoEP requirements for using appropriate research to provide knowledge of the environment) and in accordance with international conventions and legislation** **Substitute: None identified** **Engineer: None identified** **Isolate: None identified** **Administrative: None identified.**
Professional Judgement **Cost-based analysis** **Societal values**	• **Discharge of organic and biodegradable wastes from vessels is standard practice in the industry and represents a low impact to the receiving environment.** • **Impact consequence is already Negligible with standard practices and controls in place. No additional control measures in addition to the legislated requirements and good industry practice, are required to reduce the environmental impacts associated with sewage and food waste discharges to ALARP**

6.7.4 Demonstration of acceptability

The residual impact is evaluated against the pre-set acceptability criteria in Table 6-52.

Table 6-52: Evaluation of acceptability criteria – sewage, grey water and putrescible food waste

Acceptability Criteria	Acceptable level of impact	Demonstration of acceptability
Internal context **Policy compliance:** • **SapuraOMV's policies and HSE MS** • **Env impact demonstrated to be ALARP**	**The impact management strategy and controls are consistent with SapuraOMV's corporate environmental policy, culture and company standards and procedures.** **In demonstrating ALARP – options must be considered and the cost benefit analyses used to determine if they should be adopted**	**The impact management strategy for impacts from sewage and waste discharges reflects SapuraOMV's Environment Policy goals of preventing harm to the environment by reducing risk to ALARP, complying with applicable legal and industry standards, and continually improving environmental performance.** **Section 8 demonstrates the HSE MS can meet the requirements of this Env Plan.** **The residual impacts meet the ALARP criteria (Section 6.6.3).**
EPO is achievable and consistent with achieving acceptable performance	**The EPO states:** **Discharges of sewage, grey water and food waste comply with legislated discharge requirements for permissible discharges.**	**Proposed controls are consistent with relevant MARPOL 73/78 and applicable Marine Orders (95 & 96) for treatment of discharges. Treated sewage and grey water discharges from a moving vessel are broadly acceptable in open ocean environments due to the high level of dilution achieved on release to the receiving waters. For example, high levels of dilution in the order of approximately 200,000 to 640,000 have been recorded for effluents discharged behind large ships (USEPA, 2002; Loehr et al. 2006). The discharges and subsequent level of dilution was shown to be adequate for mitigating localised toxicity impacts to marine biota from any changes in water quality.**
ESD principles	**The following core objectives have been incorporated:** • **To protect biological diversity** • **Maintain essential ecological processes and health**	**The survey is in offshore waters where the open ocean environment is highly dispersive, and the movement of the vessels will assist in the dilution to below effect concentrations local to the vessels. Full and rapid recovery of localised degraded water quality is expected as the vessels move throughout the Operations Area.** **There is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecological integrity is maintained**

		when discharging sewage and food waste. No direct impacts on EPBC Act listed MNES are predicted. The impact assessment presented throughout this EP demonstrates compliance with the principles of ESD.
External context: **Compliance with legislation and industry standards**	This control measures must comply with legislation and industry practice e.g.: Marine Order 95 (Marine pollution prevention – garbage) 2013 Marine Order 96 (Marine pollution prevention – sewage) 2013 Industry Practice: APPEA CoEP, IAGC Environment Manual Review and assessment of threatened species recovery plans and conservation advice indicates alignment of the EP with the objectives, any applicable actions undertaken (if required), and the activity does not impede any actions by other parties enacting the Plans. The assessment must indicate preservation of values stated in marine reserves, with no direct impacts on management values of protected areas or KEFs	This legislation has been used in the development of the management controls necessary to reduce the impacts from sewage and food waste to ALARP. The residual impacts meet the ALARP criteria (Section 6.6.3). Review and assessment of threatened species recovery plans and conservation advice (such as the Marine Turtle Recovery Plans (DoEE 2017) or conservation plans relevant to this location (e.g. Conservation Plan for the Blue Whale, 2015-2025),did not identify any specific requirements for vessel sewage/food discharges. The management values of the KEF – The Carbonate Bank and Terrace System of the Sahul Shelf do not list sewage and food waste as a threat or concern.
External context: **Stakeholder expectations**	The merit of relevant stakeholder concerns and objections have been assessed and controls adopted to reduce risks to ALARP	There are no outstanding objections or claims regarding sewage and food waste discharges.None with merit were raised during initial consultations that remain unresolved. Section 8 describes the ongoing stakeholder consultation process should issues arise.

6.7.5 Predicted impact

Singular and cumulative impacts from the discharge of sewage and food waste from vessels are considered temporary and negligible due to the small volumes, location and rapid biodegradability and dilution below effect concentrations.

Source of Impact	Predicted environmental effects	Consequence severity
Discharge of sewage and food waste	**Localised decrease in water quality and sediment quality**	**Negligible**

6.7.6 EPO, controls, performance standards and measurement criteria

Not conducting the seismic activity eliminates waste discharges as an impact but is not acceptable. Additional control measures have been identified that further reduce the impacts from discharges of sewage, grey water and food waste. The environmental performance objective, control measures, performance standards and measurement criteria are listed in Table 6.53.

Table 6-53: Summary of controls – sewage, grey water and putrescible food waste

EPO	Control measure	Env Perf Standard	Measurement criteria
EPO I6: Discharges of sewage, grey water and food waste comply with legislated discharge requirements for permissible discharges.	**Where appropriate for class, requirements in accordance with Marine Order 95 (Marine pollution prevention – garbage) 2013**	**EPS I31 All food wastes discharged >3 NM and <12 NM macerated to <25 mm**	**Records show discharges of food waste are compliant with the distances specified in Marine Order 95**
		EPS I32: Macerator functional	**Records show maintenance complies with manufacturers specifications**
		EPS I33: Personnel must be appropriately trained in tasks and aware of requirements	**Records show procedures or training given to relevant crew that includes requirements for management of food waste**
		EPS I34: Records of food waste disposal to be maintained in a Garbage Record Book **EPS I35: Vessels will maintain a Garbage Management Plan which addresses the requirements for food wastes**	**Garbage book is sighted on board and confirmed maintained up to date** **Garbage Management plan is sighted on board and confirmed up to date**
		EPS I36: Vessels of 12 m or over to display placards notifying passengers and crew of the disposal requirements, including for food waste	**Evidence of placards notifying of disposal requirements being displayed is sighted**
	Where appropriate for class, requirements	**EPS I37: No discharge of treated or untreated sewage <3 NM from nearest land**	**Records show discharges of sewage are compliant with distances specified in Marine Order 96**

	in accordance with Marine Order 96 (Marine pollution prevention - Sewage) 2013	**EPS I38: Sewage discharged between 3 NM and 12 NM to be treated via an on-board sewage treatment plant (STP) approved by the International Maritime Organisation (IMO) (MARPOL MEPC.2 (IV), or MEPC.159 (55), or MEPC.227 (64)**	**Records show discharges of sewage are compliant with distances specified in Marine Order 96** **Records show that an operational STP is available onboard vessel, and is approved for use by the IMO**
		EPS I39: Sewage (treated or untreated) originating from holding tanks is discharged at a moderate rate while the ship is proceeding en route at a speed not less than 4 knots	**Records show discharges of sewage and grey water are compliant with discharge rates specified in Marine Order 96**
		EPS I40: Where appropriate for class, vessels will have valid International Sewage Pollution Prevention Certificates (ISPP)	**Where appropriate for class, valid ISPP is available on board**
		EPS I41: STP is maintained in accordance with manufacturers specifications and must be in good working order	**Records show routine completion of maintenance in accordance with manufacturer specifications or preventative maintenance system for the STP**
		EPS I42: Personnel must be appropriately trained in tasks and aware of requirement, relevant to their role	**Records show procedures or training have been given to relevant personnel that includes the requirements for the management of sewage and grey water**

6.8 Discharge of bilge water, deck drainage, cooling water and brine from survey vessels

Bilge tanks contain wastewater and small volumes of oils from machinery spaces or minor spills, detergents, solvents and other chemicals. Bilge water is typically treated to remove gross contaminants, tested and then discharged if it meets the discharge criteria and onshore disposal of concentrated oils. There will also be variable water discharges directly overboard or via deck drainage systems arising from rainfall, spray and green water, and deck activities such as cleaning/wash-down which could contain residues from minor spills.

Sea water is often used as a heat exchange medium for cooling machinery engines and other equipment. Sea water is drawn up from the ocean, de-oxygenated, sterilised, circulated as coolant then discharged to the ocean warmer than the ambient water temperature. Discharges may contain low concentrations of residual biocides and anti-scalants.

Brine wastewater may be produced by vessels' desalination processes required to supply freshwater for drinking, showers, cooking etc. The brine will have elevated salinity (typically ~10–20% more saline than ambient sea water).

6.8.1 Overview of impact

These discharges have potential for impacts from:

- Temperature differences causing thermal shock to marine organisms
- Residual chemicals with toxicological effects in high concentrations on marine fauna
- Elevated salinity degrading seawater quality.

6.8.1.1 Source of impact

Bilge/oily water engine water is typically generated at 0.01–13 m^3 per day (EMSA 2016) depending on vessel size and age, condensation and leakages in the engine room. This volume is reduced prior to discharge by 65–85% by using the oily water separator, which is designed to reduce concentrations of oil in discharge waters to 15 ppm in accordance with International Convention for the Prevention of Pollution from Ships 73/78 (Annex 1) (IMO 1983). At an average of ~ 0.3 m^3 per hour (EMSA 2016), the maximum oil discharge at 15 ppm equates to <0.005 L oil per hour.

Cooling water – while volumes vary, typical discharges can be 20-30°C above ambient. After discharge the heated water plume will be rapidly dispersed and diluted through turbulent diffusion, convection in water, flow of fluids of variable density, evaporation, radiation and convection in the air (IPPC 2001).

Desalination brine –Changes in salinity can affect the ecophysiology of marine organisms and larval stages tend to be more susceptible to impacts of increased salinity (Neuparth, Costa & Costa 2002). However, some marine species are known to be able to tolerate short-term fluctuations in salinity in the order of 20%–30% (Walker & McComb 1990) and it is expected that pelagic megafauna species would be able to tolerate short-term exposure to the slight increase in salinity caused by the discharged brine if they swim through the area.

Chemicals - typically diluted and dispersed to low concentrations close to the discharge point. Scale inhibitors and biocides are inherently safe because they are usually largely "consumed" in the inhibition process and there is only a low residual concentration in the discharge. These chemicals are mainly of concern in enclosed waters where the discharge occurs over an extended time frame (IPPC 2001).

6.8.1.2 Physical, biological and socio-economic receptors

Given the rapid dilution from mobile sources, the only receptors considered relevant are immobile biota in the upper water column such as plankton.

At this location, there are no industrial, recreational activities or intense fishing activities that could be impacted by these localised and temporary liquid discharges, hence socio-economic receptors are not considered further.

6.8.2 Impact analysis and treatment

The ALARP decision context is provided in Table 6-54.

Table 6-54: ALARP decision context – bilge, deck drainage, cooling water and brine discharges

Planned event:	Discharge of bilge water, deck drainage, cooling water and brine
Duration of impact	**Short term – for the duration of the survey (27 days)**

ALARP assessment technique	**Discharge of brine and cooling waters is an unavoidable but well understood and practiced activity both nationally and internationally. Given the nature of the discharges, their volumes and the environment that may be affected is well known, there is little uncertainty associated with this discharge and the potential environmental impacts are negligible.** **No relevant person raised objections or claims regarding bilge water, cooling water, brine and other waste waters.** **Taking this in consideration Decision Context A should be applied to demonstrate impacts are ALARP which includes:** • **Legislation, codes and standards (LCS)** • **Good Industry Practice (GIP)** • **Professional Judgement (PJ)**

6.8.2.1 Context for setting standard control measures

Table 6-55 describes the context for setting the minimum controls.

Table 6-55: Context for standard control measures – bilge, deck water, cooling and brine wastes

Compliance with legislative requirements: • **International Convention for the Prevention of Pollution from Ships 73/78 (Annex 1)** • **OPGGS Act: Residual risks must be reduced to ALARP**
Compliance with Company and industry standards: • **International Finance Corporation World Bank Group EHS Guidelines (IFC 2015) - discharges to reach within 3 °C of ambient water temperatures within 100 m of the discharge** • **SapuraOMV Risk Methodology Framework - All impacts/risks reduced to ALARP** • **APPEA CoEP: Reducing the impacts other marine life to a level which is ALARP and Acceptable including:** • **The adoption of appropriate management measures for the survey in accordance with legislative requirements/guidelines;** • **Utilisation of appropriate research studies/knowledge and latest data records to provide knowledge of environment in which the seismic source will operate and assess predicted impacts.**
Alignment with objectives and compliance with requirements of applicable management, recovery and /or conservation plans: **Alignment with objectives, actions and recommendations within:** • Marine Bioregional Plan for the North West Marine Region (2012) • The Recovery Plan for Marine Turtles in Australia 2017-2027 (DoEE 2017) (Action A3) • Conservation Management Plan for the Blue Whale, 2015-2025 (DoE 2015) • *Balaenoptera borealis* (sei whale) conservation advice (TSSC 2015a) • *Balaenoptera physalus* (fin whale) conservation advice (TSSC 2015b)

6.8.2.2 Description of impact with standard controls

6.8.2.2.1 Bilge water

If treated bilge water is discharged, the treatment controls in place ensures that only trace quantities of oil are contained in the discharge. This is predicted to rapidly dilute and disperse, especially with the vessels in constant motion. Given the small volumes released, the high rates of dilution and dispersion in the open ocean environment, the constant movement and temporary presence of the vessels in any one location, acute or chronic toxicity impacts to marine fauna is not expected. Any impacts to plankton species would be extremely localised around the vessel discharge and undetectable from natural variability.

6.8.2.2.2 Cooling water

Modelling for the Stybarrow Development for a discharge of 100,000 m^3/day of cooling water at 25°C above ambient sea water temperature showed the likelihood of surface water temperature exceeding ambient temperature by >2 °C was reduced to about 1% within 60 m–85 m of the discharge point (BHP Billiton 2004). Given the vessels will discharge much smaller volumes and will be continually on the move, the discharge stream is expected to reach background temperatures in a shorter distance from the discharge.

As such, thermal shock resulting in mortality to plankton is predicted to be localised with full recovery in the short term. Marine reptiles, cetaceans, rafting birds and fish passing through the area will be able to actively avoid entrainment in the localised plume of heated water (Langford 1990).

6.8.2.2.3 Desalination brine

As above, discharges will be rapidly mixed and diluted in the receiving waters, any impacts are expected to be limited to the immediate vicinity of the discharge where concentrations are highest. This is consistent with studies that indicate effects from increased salinity on planktonic communities in areas of high mixing and dispersion are generally limited to the point of discharge (e.g. (Azis et al. 2003)). Populations are expected to rapidly recover from any impacts once the activity ceases (or vessel moves on) as they are naturally characterised by high population turnover rates and rapid population increases (Villarino, Watson & Chust 2018). Fish larvae assemblages are expected to be widespread and any localised decrease in abundance likely to fall within natural levels of variation in population sizes.

The impact area is not predicted to be large enough to have a lasting, population-level effect on any species or an ecosystem-level effect or affect ecological function, diversity or productivity within the KEF. The wastewater discharges will all be short term (over 24 hrs for a duration of approximately 27 days) and the impacts will be localised due to rapid dispersion and dilution of the discharge streams. No significant impacts are predicted on any receptors.

6.8.3 ALARP treatment and evaluation

6.8.3.1 ALARP options

Control measures	Control type	Env benefit	Env Benefit scale	Cost	Outcome	Rationale
Compliance with the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and the *Navigation Act 2012*.	**Engineering**	**Minimises water degradation**	**Minor (1-3%)**	**<0.5%**	**Adopted**	**AMSA Marine Order 91 (Marine pollution prevention — oil) 2014 requires overboard discharge of oil is managed in accordance with MARPOL Annex I: Regulations for the prevention of pollution by oil. This is good practice that is well defined and adopted internationally.** **Benefit outweighs cost**
Additional facilities to further cool water or reduce oil in water prior to discharge.	**Engineering**	**Minimises water quality degradation**	**Negligible (<1%)**	**3–10% of project cost depending on retrofitting required, vessel availability etc**	**Not adopted**	**Use of alternative technologies e.g.to cool water (e.g. internal cooling loops with fin-fan heat exchangers) are being developed. Typically, such technologies require significant deck space and additional power to run fans and ancillary equipment, leading to more fuel consumption. However, no robust proven technologies with significant environmental benefits were identified.** **Water quality changes beyond mixing zone are negligible** **Cost disproportionately higher than benefit**

Use of standardised system (e.g. OCNS) to select chemicals of lower toxicity	**Substitute**	**Minimises water quality degradation**	**Negligible (<1%)**	**0.5-2%**	**Not adopted**	**Volumes of chemicals are small (e.g. biocides) and immediate dispersion and dilution results in localised impacts only. Biocides are required to be toxic to marine biota but active ingredient are typically chemically spent at discharge.** **Changes in water quality beyond the mixing zone are negligible,** **Cost outweighs benefit**

6.8.3.2 Demonstration of ALARP

Table 6-56: Demonstration of ALARP

Criteria	Demonstration of ALARP
Legislation, codes and standards	• **Vessels comply with or exceeds international and Commonwealth legislative requirements** • **The International Convention for the Prevention of Pollution from Ships standard is considered to be the most appropriate standard to adhere to in this environment given the nature and scale of the activity. The International Convention for the Prevention of Pollution from Ships standard is as an internationally accepted standard that is well defined and adopted industrywide.**
Good industry practice	**The impact is managed in accordance with good industry practice such as APPEA's CoEP requirements for using appropriate research to provide knowledge of the environment) and in accordance with international conventions and legislation** **Eliminate:** • **The number of vessels and the duration (approximately 27 days) of the activity are already at minimal levels and further reduction in numbers or scope would compromise the activity. Not conducting the seismic activity eliminates vessel wastewater discharges as an impact but is not acceptable. The elimination of oils, fuels and lubricants etc. is not possible due the need to maintain safe operations.** **Substitute: None identified** **Engineer:** • **Equipment to provide further cooling or treatment the discharges prior to release was not deemed ALARP. For vessels with engineered treatment systems – systems treat to an oil-in-water content of 15 ppm, with calibrated Oil Detection Monitoring Equipment (ODME) to monitor and verify discharge quality.** **Isolate:** • **Engineered systems redirect treated bilge water back into vessel tankage if off-specification bilge is detected by the ODME.** **Administrative:** • **Equipment is routinely maintained.** • **Oil Record book documents oil discharges from vessel (verification mechanism).**
Professional Judgement **Cost-based analysis** **Societal values**	**Discharge of bilge water, cooling water, brine and deck waters wastes from vessels is standard practice in the industry and represents a low impact to the receiving environment.** **Given the impact is already low, any additional costs are deemed disproportionate to any environmental benefit. ALARP treatment and evaluation**

6.8.4 Demonstration of acceptability

The residual impact is evaluated against the pre-set acceptability criteria in Table 6-57

Table 6-57: Evaluation of acceptability criteria – bilge water, deck drainage, cooling water and brine

Acceptability criteria	Acceptable level of impact	Demonstration of acceptability
Internal context: **Policy compliance** • **SapuraOMV's policies and HSE MS** • **Env impact demonstrated to be ALARP**	• **The impact management strategy and controls are consistent with SapuraOMV's corporate environmental policy, culture and company standards and procedures.** • **In demonstrating ALARP – options must be considered, and the cost benefit analyses used to determine if they should be adopted**	**The impact management strategy for wastewater impacts reflects SapuraOMV's Environment Policy goals of preventing harm to the environment by reducing risk to ALARP, complying with applicable legal and industry standards, and continually improving environmental performance.** **Section 8 demonstrates the HSE MS can meet the requirements of this EP. This EP meets the ALARP criteria in Section 6.8.3.1**
EPO is achievable and consistent with achieving acceptable performance	**EPO states:** **Discharges of bilge, deck drainage, cooling water and brine comply with legislated discharge requirements for permissible discharges.**	**Proposed controls will meet relevant legislative requirements. Wastewater discharges are expected to rapidly dilute and dissipate in the open ocean environment of the OA while vessels are moving at speeds > 4 knots. This is considered acceptable in protecting environmental values due to the small number of vessels and short duration of the Gem 3D MSS.**
ESD principles	**The following core objectives have been incorporated into the impact assessment:** • **To protect biological diversity** • **Maintain essential ecological processes and health**	**The impacts from these wastewater discharges are localised and intermittent around vessel discharge (expected to rapidly dilute and dissipate in open ocean environment while vessels are moving). Protected marine fish and plankton are widely distributed in the region with only a small portion of the populations potentially affected temporally and spatially.** **There is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecological integrity is maintained when discharging the wastewater. No direct impacts on EPBC Act listed MNES are predicted.**

		The impact assessment presented throughout this EP demonstrates compliance with the principles of ESD.
External context: **Compliance with legislation and international conventions**	**The control measures must comply with:** • **International Convention for the Prevention of Pollution from Ships 1973 (MARPOL 73/78) – Annex I,** • ***Navigation Act 2012* (Chapter 4 (Prevention of Pollution): Part 3 – Vessels Polluting or Damaging the Australian Marine Environment & Part 4 – Directions Relating to Foreign Vessels)** • ***Protection of the Seas (Prevention of Pollution by Ships) Act 1983* (Section 9 - Prohibition of Discharge of oil or oily mixture into Sea), Marine Order Part 91 (Marine Pollution Prevention - Oil)** • **EPBC Regulations 2000 (IUCN principles of Schedule 8)**	**This legislation has been used in the development of the management controls necessary to reduce the impacts from waste waters to ALARP.**
External context: **Compliance with industry standards**	**Wastewater management and disposal operations are consistent with industry practice**	**The APPEA Code of Environmental Practice (2008) objectives met for offshore seismic surveys with respect to reducing the impacts other marine life to a level which is ALARP and acceptable including:** • **The adoption of appropriate management measures such as ensuring oil in discharge remains <15 ppm and alarm system calibrated** • **By considering comparative modelling of wastewater discharges, SapuraOMV vessels are expected to meet requirements of the International Finance Corporation World Bank Group EHS Guidelines - discharges reaching to within 3 °C of ambient water temperatures within 100 m of the discharge.**

External context: **Receiving environment and activity** **Compliance with values stated in marine reserves, species recovery plans and conservation advice**	**Relevant aspects of the local receiving environment and petroleum activity have been considered in the evaluation of impacts from wastewater.** **Review and assessment of threatened species recovery plans and conservation advice indicates alignment of the EP with the objectives, any applicable actions undertaken (if required), and the activity does not impede any actions by other parties enacting the Plans.** **No direct impacts on management values of protected areas, MNES or KEFs**	**While the Recovery Plan for Marine Turtles 2017-1027 (DoEE, 2017) describes response strategies and programs for the management of impacts and risks to marine turtles and their habitat, no relevant habitats are within >100 km of the survey location. The Plan includes actions that could be relevant in oil spill response and as such is considered in Section 8 and 9. No impacts from these discharges impede the actions or recommendations of any other species conservation plans relevant to this location (e.g. Conservation Plan for the Blue Whale, 2015-2025) or values of the NW Marine Bioregional Plan** **Containment of deck and bilge system spills are addressed in the vessel's SOPEP. SapuraOMV has adopted all relevant controls contained in marine pollution law to limit marine pollution from vessels as per this requirement.** **There are no direct effects on EBPC Act listed matters of national environmental significance and the KEF - Carbonate banks and Terrace system of the Sahul Shelf Marine Park management values**
External context: **Stakeholder expectations**	**The merit of relevant stakeholder concerns and objections have been assessed and controls adopted to reduce risks to ALARP**	**There are no outstanding objections or claims regarding wastewater discharges. None with merit were raised during initial consultations that remain unresolved. Section 8 describes the ongoing stakeholder consultation process should issues arise.**

6.8.5 Predicted impact

Given the small, intermittent volumes, constant mixing effects of vessel propellers, open-ocean currents and the low residual chemicals, impacts to biota in the water column from bilge, deck, cooling water and saline discharges are predicted to be localised and temporary with no ecosystem-level effects and rapid recovery of any affected receptors. Cumulative impacts are likewise negligible due to small volumes and moving sources.

The localised and temporary environmental impacts are considered Negligible. Cumulative impacts from the vessels are also negligible due to the small volumes, location and the vessels seldom being in close proximity to each other.

Source of Impact	Predicted environmental effects	Consequence severity
Discharge of bilge water, deck drainage, cooling water and brine	**Localised, temporary decrease in water quality**	**Negligible**

6.8.6 EPO, controls performance standards and measurement criteria

The environmental performance objective, control measures, performance standards and measurement criteria are listed in Table 6-58

Table 6-58: Summary of controls – bilge, deck drainage, cooling water and brine discharges

EPO	Control measure	Env perf standard	Measurement criteria
EPO I7: Discharges of bilge, deck drainage, cooling water and brine comply with legislated discharge requirements for permissible discharges.	**Preventative maintenance programs implemented**	**EPS I43: Desalination plant and cooling water systems are maintained in accordance with planned maintenance program so as to remain in good working order.**	**Records show routine completion of maintenance in accordance with manufacturer specifications or preventative maintenance system**
	A functional oily water separator (OWS) reduces hydrocarbon concentrations <15 ppm prior to overboard discharge	**EPS I44: In accordance with Regulations 12 and 14 of MARPOL Annex I, all bilge water is treated through an OWS set to prevent the discharge of water with >15 ppm oil in water (OIW) content.** **All residual oil from the OWS is pumped to tote tanks and transferred to shore for recycling, reuse or disposal.**	**Inspections of the International Oil Pollution Prevention certificate show it is valid and inspections of the OWS show it is functional and meets required water quality.** **The Oil Transfer Book contains details of oily wastes transferred to a support vessel, or to suitable waste disposal facility.**
	A functional oil content monitor (OCM) and a bilge alarm to detect if the treated bilge water	**EPS I45: MARPOL requires the OWS has an oil content monitor (OCM) and a bilge alarm to detect if the treated**	**Inspections of the MARPOL compliant OWS show the OCM is functional, correctly calibrated and maintained according to schedule or the**

	meets the discharge requirements	bilge water meets the discharge requirements.	manufacturer's specifications.
	A functional oil content monitor (OCM) and a bilge alarm to detect if the treated bilge water meets the discharge requirements Personnel are appropriately trained in tasks and aware of requirements relevant to their role	EPS I46: OWS alarm system is calibrated and maintained in accordance with the PMS	Inspections confirm the OWS alarm system is calibrated and maintained in accordance with the PMS requirements.
		EPS I47: Personnel are competent and provided with procedures or training that describe the requirements for the operation and maintenance of the OWS, OCM and alarm system.	Records show procedures or training have been given to relevant personnel that includes the requirements for the management of the OWS, OCM and alarm system.
	Spills on deck will be managed to avoid loss to the sea in accordance with vessel Shipboard Oil Pollution Emergency Plan (SOPEP)	EPS I48: Relevant deck crews receive Shipboard Marine Pollution Emergency Plan (SMPEP)/ SOPEP training every three months.	Inspection of training records show that relevant crew have current spill response training.
	Spills on deck will be managed to avoid loss to the sea in accordance with vessel Shipboard Oil Pollution Emergency Plan (SOPEP)	EPS I49: Minor spill response kits are available in relevant locations, are fully stocked and ready for use in the event of a spill to deck to prevent or minimise discharge overboard.	Site inspection verifies that response kits are available in relevant locations and are fully stocked.

7 Risks from unplanned activities – accidents, incidents

7.1 Summary of risks from unplanned activities

This section describes the outcome of the environmental risk assessment of unplanned events associated with activities described in Section 2 of this EP. The process for identifying environmental risks are described in Section 5, and the residual risk from unplanned events occurring during the Gem 3D MSS are summarised in Table 7-1.

A discussion of the environmental risks associated with the Gem 3D MSS to be carried out under this EP, the predicted environmental effects and the control measures that will be implemented to reduce risks to As Low as Reasonably Practicable (ALARP) are presented in this section. Alternative controls identified and considered to ensure residual risks have been reduced to ALARP are also discussed. The ALARP process is described in Section 5. Environmental performance outcomes, controls, standards and measurement criteria are provided for each type of impact.

With the controls that will be implemented, the potential unplanned events that might occur during the Gem 3D MSS were assessed to present a ‘very low’ or ‘low’ level of residual environmental risk.

Table 7-1: Summary of unplanned events risk assessment

Section No.	Source of risk	Potential environmental effect	Residual risk level
7.2	Introduction of invasive marine species	Increased competition with native species and changes in ecosystem function	Low
7.3	Collision between survey vessels/ equipment and marine fauna	Injury or mortality of marine fauna	Very low
7.4	Equipment grounding or emergency anchoring	Localised damage to the benthic habitat and disturbance or injury to associated benthos	Low
7.5	Hydrocarbon release caused by vessel fuel tank loss of containment	Reduction of water quality and toxicity or physical coating effects to marine fauna or shallow water habitats within the Planning Area	Low
7.6	Waste management and accidental loss overboard	Reduction in water or benthic habitat quality from physical or toxicity effects Impacts to individual fauna from entanglement or ingestion	Very low

7.2 Introduction of invasive marine species

7.2.1 Overview of risk

7.2.1.1 Source of risk

The survey vessel contracted for the Gem 3D MSS will either mobilise from an Australian or an international port to the survey area. Vessels mobilising from foreign ports may act as a vector of invasive marine species (IMS). IMS may be carried on the vessel in the form of hull/ niche biofouling or within ballast water tanks and may be released as larvae from reproductive marine growth or during ballast water exchange activities. During the survey, the vessels will ballast and de-ballast to improve stability, even out vessel stresses and adjust vessel draft, list and trim, with regard to the weight of equipment and fuel, potable water and so forth on board at any one time. In summary the following activities have the potential to result in the introduction of IMS:

- Discharge of vessel ballast water containing foreign species
- Translocation of biofouling species on the vessel hull or in niches (e.g., sea chests, bilges, strainers)
- Immersing biofouled in-water vessel equipment (e.g. anchor chains)
- Immersing biofouled in water survey equipment (e.g. streamers, tail buoys).

The Convention on Biological Diversity (1760 UNTS 79; 31 ILM 818 5 June 1992, entered into force 29 December 1993) defines a non-native species as “a species introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce”. Non-native species are known from all parts of the world and have been transported by several different anthropogenic means (Geller, Carlton & Powers 1993). Australia has over 250 IMS and although most do not cause a problem, some may become aggressive pests with detrimental effects on biodiversity and ecology (Department of Agriculture 2019). Ballast water exchanges have been implicated in the introduction of marine pest species (Hayes & Sliwa 2003), with sixty marine species becoming established in Western Australia. Most are temperate species that occur south of Geraldton; only six tropical species have become established north of Shark Bay (Wells, McDonald & Huisman 2009).

The potential biofouling risk posed by a vessel relates to its history prior to entering the survey area. The main factors associated with the risk of introducing IMS are:

- Time spent by vessel in foreign ports, especially those with known IMS infestations
- Transit by vessel from similar bioregions
- Suitability of survey area habitats for IMS survival and establishment
- Time since vessel hull cleaning
- Condition and age of vessel anti-fouling
- Type of vessel ballast water.

The risks and potential effects of the introduction and establishment of IMS during seismic surveys are well understood with legislative requirements and industry agreed good practices to manage risks. The application of recognised good practice is generally considered appropriate to manage the risk.

7.2.1.2 Physical, biological and socio-economic receptors

Within the OA the marine environmental receptors most susceptible to potential impacts from IMS are the shallow banks and shoals (see Table 4-1).

In the unlikely event that a species is introduced, and it survives in the new environment, they then have the potential to colonise a new region and establish a new population. This can cause a range of ecological effects, including increased competition with native species and changes in ecosystem function.

7.2.2 Risk analysis and treatment

Table 7-2: Duration of impact and ALARP assessment technique regarding the introduction of IMS

Unplanned event: Introduction of IMS	
Duration of impact Long term >3 years if IMS become established	
ALARP assessment technique	**Good Practice Context A decision which includes:** **Legislation, codes and standards (LCS)** **Good Industry Practice (GIP)** **Professional Judgement (PJ)**

7.2.2.1 Context for setting standard control measures

Table 7-3 describes the context for setting the minimum controls.

Table 7-3: Context for setting standard control measures – introduction of IMS

Compliance with legislative requirements:
• **International Conventions:**

• **International Convention for Control & Management of Ship Ballast Water & Sediments 2004;** • **International Convention on Control of Harmful Anti-fouling Systems in Ships 2001.** • **Legislation:** • ***Biosecurity Act 2015* (Chapter 5, Part 3 – Management of discharge of ballast water & Chapter 4 – Managing Biosecurity risks: conveyances)** • ***Protection of the Sea (Harmful Anti-Fouling Systems) Act 2006*** • **Marine Order Part 98 (Marine Pollution Prevention – anti-fouling systems)** • **EPBC Regulations 2000 (IUCN principles of Schedule 8)** • **Guidelines/Standards:** • **Australian Ballast Water Management Requirements (DAWR 2017)**
Compliance with company and industry standards: • **National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Commonwealth of Australia 2009)** • **APPEA Code of Environmental Practice 2008**
Alignment with objectives and compliance with requirements of applicable management, recovery and /or conservation plans: • **Commonwealth Recovery Plans relevant to this activity do not involve IMS.** • **There are no Australian Marine Parks within the Operations Area.**

7.2.2.2 Description of risk with standard controls

If established, IMS can compete with native species, modify habitats and can threaten endemic biodiversity and abundance. Island, reef and other shallow-water ecosystems and native species are vulnerable to invasive species from direct impacts such as predation or damage to important habitat, or indirect impacts such as competition with native species for habitat and food. These species can have detrimental effects on aquaculture industries if they are competitors with or predators of commercially important species (Arthur, Summerson & Mazur 2015). Within the OA the environmental values most susceptible to IMS are the shoals that rise to depths of 10 – 50 m (MSL; Section 4.4.2) which support diverse benthic communities, including numerous species of corals, sponges, seagrasses, crustaceans and fish. The benthic habitats of these shallow shoals also provide feeding grounds for macrofauna such as marine turtles, particularly those which rise to depths of less than 20 m. However, the remote, oceanic environment of the OA and deeper water of the majority of the area where IMS could potentially be introduced is not conducive to the establishment of IMS even in the unlikely event of release into the marine environment. Consequently, standard control measures consistent with relevant regulations and industry specific guidelines are expected to reduce the residual risk of introducing IMS during the short period of the MSS to low.

7.2.3 ALARP treatment and evaluation

7.2.3.1 ALARP options

Additional controls which have been considered in reaching ALARP are listed in Table 7-4.

Table 7-4: ALARP options considered for the risk of introduction of IMS

Control measure	Control type	Env benefit	Env benefit scale	Cost	Practicable and implemented	Rationale
Ballast water tanks of survey vessels within the OA contain 'low-risk' ballast water, as described in the *Australian Ballast Water Management Requirements* (DAWR 2017)	**Elimination**	**Reduces likelihood of IMS establishment**	**Minor (1-3%)**	**<0.5% of project cost**	**Adopted**	**Benefit: This action would not normally be required by vessels outside of 12 NM from any land mass and in waters greater than 50 m deep so ensures extra level of protection to habitats within the OA beyond standard controls, Also enables flexibility and safety in vessel operations as ballast water exchange will subsequently be acceptable within the OA during the MSS** **Cost: Ballast water exchange is a standard vessel activity and the operational cost associated with ensuring an exchange to low risk ballast water are insignificant.**
Hull cleaning and new anti-fouling coat application to vessel hull and niche areas on every occasion prior to entry into bioregion waters.	**Engineering**	**Reduces likelihood of IMS establishment**	**Minor (1-3%)**	**>10% of project cost**	**Not adopted**	**Benefit: The benefit of this control measure is limited due to the vessel complying with the *Biosecurity Act 2015* and the oceanic location of the survey which already reduces the risk of IMS establishment to low.** **Cost: This action without a justifiable risk (i.e. presence of IMS) is a substantial cost without a net environmental benefit due to the other risk reduction measures in place.**

7.2.3.2 Demonstration of ALARP

Table 7-5: Demonstration of ALARP for introduction of IMS

Criteria	Demonstration
Legislation, codes and standards	**Compliance with:** **International Conventions:** • **International Convention for Control & Management of Ship Ballast Water & Sediments 2004;** • **International Convention on Control of Harmful Anti-fouling Systems in Ships 2001.** **Legislation:** • ***Biosecurity Act 2015*** **(Chapter 5, Part 3 – Management of discharge of ballast water & Chapter 4 – Managing Biosecurity risks: conveyances)** • ***Protection of the Sea (Harmful Anti-Fouling Systems) Act 2006*** • **Marine Order Part 98 (Marine Pollution Prevention – anti-fouling systems)** **Guidelines/Standards:** • **Australian Ballast Water Management Requirements (DAWR, 2017)** • **National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Commonwealth of Australia 2009)**
Good industry practice	**Eliminate: Use of a vessel and immersible equipment (towed seismic equipment) that remain submerged in water is unavoidable, and thus biofouling of the hull and other niches, and the uptake of marine organisms in ballast water exchange can occur. This risk is unavoidable and cannot be eliminated.** **In-water equipment cleaned prior to use in the survey area.** **Utilisation of local vessels as support where possible to reduce international IMS risk.** **Substitute: None identified** **Engineer: Vessels have current anti-fouling coating systems to reduce IMS attachment.** **Isolate: None Identified** **Administrative: International vessels adhere to Australian Ballast Water Management requirements prior to entry into Australian waters. DAWR regulate biosecurity aspects of vessels which enter Australian waters.** **International vessels are assessed for IMS risk and corrective action taken to eliminate IMS risk.**
Professional Judgement	**Alternate controls identified and implemented where practicable. Controls adopted cover multiple levels on the control hierarchy.**
Cost-based analysis	**Not applicable to decision-making criteria for making a Good Practice context A decision**

Societal values	**Not applicable to decision-making criteria for making a Good Practice context A decision**

7.2.4 Demonstration of acceptability

The residual risk is evaluated against the pre-set acceptability criteria in Table 7-6.

Table 7-6: Acceptability evaluation

Acceptability criteria	Acceptable level of impact	Demonstration of acceptability
Internal context: **Policy compliance** • **SapuraOMV's policies and HSE MS** • **Env impact demonstrated to be ALARP**	• **The risk management strategy and controls are consistent with SapuraOMV's corporate environmental policy, culture and company standards and procedures.** • **The risk of IMS introduction has been reduced to a level that is ALARP.**	• **The risk management strategy for IMS introduction reflects SapuraOMV's Environment Policy goals of preventing harm to the environment by reducing risk to ALARP, complying with applicable legal and industry standards, and continually improving environmental performance.** • **Section 8 demonstrates the HSE MS can meet the requirements of this EP.** • **The process outlined in Section 5 for reducing risks to ALARP has been implemented for the risk of introducing IMS and has been demonstrated above in Table 7.4.**
EPO is achievable and consistent with achieving acceptable performance	**The EPO states:** • **No introduction of IMS into Australian waters.**	**Compliance with legislative requirements for ballast water management and biosecurity is considered acceptable in meeting the EPO of 'no introduction of IMS into Australian waters'.**
ESD principles	**The following core objectives of ESD have been incorporated:** • **To protect biological diversity** • **Maintain essential ecological processes and life support systems.**	**The risk management process has adopted a series of controls to reduce the residual risk of introducing IMS to ALARP. As a result of minimising the risk of introducing IMS the biological diversity and essential ecological processes are likely to be supported and maintained.**
External context: **Receiving environment and activity**	**Relevant aspects of the local receiving environment and petroleum activity have been considered in the evaluation of risk of the introduction of IMS.**	**The majority of the survey is in deeper waters which is not conducive to supporting the establishment of IMS. The necessary controls have been adopted to prevent the release of ballast water in shallow waters near the shallow water shoals.**

External context: Compliance with legislation and industrial standards	Compliant with the Commonwealth legislation: • *Biosecurity Act 2015* • Australian Ballast Water Management Requirements: Version 7 • National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Commonwealth of Australia 2009)	Operations will be compliant with these pieces of legislation. Predictions are therefore considered acceptable because the Act and national guidance mandates quarantine requirements (for ballast and biofouling) and risk assessments for vessels to follow prior to entering Australian waters.
External context: Compliance with values stated in Marine Park Management Plans, species management/ recovery plans and conservation advice	Residual risks posed by IMS introduction associated with the survey are consistent with the relevant management plans and advices.	The Australian and State Marine Parks do not overlap the OA. There are no specific conservation objectives and actions relating to IMS in the species conservation/recovery plans and conservation advice for species that could be encountered during the survey; however the activity will be undertaken in a manner to maintain existing biological diversity and avoid the introduction and establishment of IMS.
External Context: Stakeholder Expectations	The merit of relevant stakeholder concerns and objections have been assessed and controls adopted to reduce risks to ALARP.	There are no outstanding objections or claims regarding IMS and none with merit were raised during initial consultations and remain unresolved.

7.2.5 Risk level

Consequence	Likelihood	Risk
Major: Ecological impacts to the marine environment could be long term and could have regional or national significance. Impacts could occur to populations of multiple species that have ecosystem level consequences.	Remote	Low

7.2.6 EPO, additional controls, performance standards and measurement criteria

No additional practical control measures have been identified that would further reduce the risk of introducing IMS during the Gem 3D MSS. The EPOs, control measures, performance standards and measurement criteria are listed in Table 7-7.

Table 7-7: Summary of controls for the risk of introduction of invasive marine species

EPO	Control	EPS	Measurement criteria
EPO R1: No introduction of IMS into the Gem 3D MSS Operations Area.	**Compliance with:** • **Australian Ballast Water Management Requirements: Version 7** • ***Biosecurity Act 2015* (Chapter 5, Part 3 – Management of discharge of ballast water & Chapter 4 – Managing Biosecurity risks: conveyances)** • **National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Commonwealth of Australia 2009)**	**EPS R1: Survey vessels carry a valid Ballast Water Management Plan**	**Record of a valid Ballast Water Management Plan onboard vessels prior to MSS.**
		EPS R2: Survey vessels comply with National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Commonwealth of Australia 2009) • **Biofouling Record Book kept outlining marine fouling management actions** • **Biofouling risk assessment shows low risk of IMS presence prior to entry into Australian waters** • **Recent hull inspections (if required based on biofouling risk assessment)** • **Survey vessel has a certified anti-fouling coating on the hull and coating is in sound condition. Anti-fouling system certification is in place in accordance with AMSA Marine Order Part 98 (Anti-fouling systems).**	**Vessel operational history records show details of last dry-docking, cleaning, anti-fouling renewal.** **Biofouling risk assessment report confirming survey vessel poses low risk of introducing IMS.** **International Anti-fouling System Certificate shows ant-fouling is in date**
		EPS R3: Routine cleaning and inspection of submersible equipment (airgun array, streamers, tail buoys), consistent with the requirements of the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Commonwealth of Australia 2009).	**Evidence / records confirm submersible equipment inspected and found free of biofouling prior to commencing the activity.** **In the event that biofouling is observed on equipment, it is clean and a record of the type of cleaning is kept.**

	Ballast water tanks of survey vessels within the OA contain 'low-risk' ballast water, as defined in the Australian Ballast Water Management Requirements (DAWR 2017)	**EPS R4: At least 95% of the ballast water onboard survey vessels within the OA has been obtained from a low-risk source as defined in the Australian Ballast Water Management Requirements (DAWR 2017)**	**Ballast water exchange records demonstrate that ballast water on survey vessels within the OA has been obtained from a low-risk source**

7.3 Collision between survey vessels/equipment and marine fauna

7.3.1 Overview of risk

7.3.1.1 Source of risk

During the activity, the seismic and support vessels working within the OA present a potential physical hazard (risk of collision) to marine fauna that may be swimming across the sail-lines at or near the sea surface. Vessel speed has been identified as a major contributing factor in the occurrence and severity of vessel collisions with marine vertebrates (Hazel et al. 2007; Laist & Shaw 2006), large whale species in particular (Jensen, Silber & Calambokidis 2004; Laist et al. 2001). Damage and risk of injury is greatly increased at higher speeds and is a higher risk for vessels travelling at 14 knots or faster because the fauna have less time to take evasive action (Laist et al. 2001). The seismic vessel will maintain a bottom speed of 4 - 5 knots during data acquisition and will acoustically announce its approach from distance; therefore marine fauna are likely to be aware of its presence and will be able to evade the vessel. Speed by the support vessel within the OA will vary depending on activity and will typically be < 6 knots but at times >10 knots.

The towed seismic streamers also present the possibility of interaction with fauna near the surface, although this is reduced as most fauna are expected to avoid the vessel. Depending on design of the tail buoys that are attached to the end of each seismic streamer, there may be the potential for turtle entrapment.

Under extreme circumstances hydrophone streamers may be lost and, if not recovered, could present a risk of entanglement with marine fauna. The streamers are equipped with recovery aid devices, which inflate and bring the equipment back to the surface where it can be retrieved by the survey vessels. Recovery of streamers is standard industry practice and undertaken where safe and practicable to do so, which removes the ongoing risk of faunal entanglement.

7.3.1.2 Physical, biological and socio-economic receptors

The OA overlaps the BIA for migrating pygmy blue whales and low numbers of this species may occur in the area during the survey (Section 4.4.4). Whale sharks are unlikely to be present in the OA in significant numbers during the survey, as the survey period is outside their July – November migration period (Section 4.4.5). There may also be individual turtles transiting the OA, although it is distant from any recognised BIA (see Section 4.4.7).

7.3.2 Risk analysis and treatment

Table 7-8: Duration of impact and ALARP assessment technique regarding collision between survey vessels/equipment and marine fauna

Unplanned event: Collision between survey vessel/ equipment and marine fauna	
Duration of impact	**Short term – for the duration of the survey**
ALARP assessment technique	**Good Practice context A decision which includes:** • **Legislation, codes and standards (LCS)** • **Good Industry Practice (GIP)** • **Professional Judgement (PJ)**

7.3.2.1 Context for setting standard control measures

Table 7-9 describes the context for setting the minimum controls.

Table 7-9: Context for setting standard control measures - collision between survey equipment and marine fauna

Compliance with legislative requirements: • **Part A of EPBC Policy Statement 2.1 are standard management procedures and will be implemented during the Gem 3D MSS.** • **Consistent with Part B of EPBC Policy Statement 2.1, MFOs will be on board the seismic vessel and on duty during daylight hours during the survey.** • **EPBC Regulation 2000 (Part 8) requirements for proximity distances and vessel management if cetaceans are identified within certain buffer zones to the vessels.**
Compliance with Company and Industry standards: • **Survey vessel operational procedures for effectively and safely undertaking seismic surveys** • **APPEA Code of Environmental Practice 2008**
Alignment with objectives and compliance with requirements of applicable management, recovery and /or conservation plans: • **Management actions identified in the Conservation Management Plan for the Blue Whale (2015-2025) to minimise vessel collisions (DoE 2015)** • **Sei Whale Conservation Advice (DoE 2015) and Fin Whale Conservation Advice (DoE 2015) management actions for reporting strike incidents** • **Consideration of actions recommended in Conservation Advice for whale sharks to mitigate collision with vessels and transit time of large vessels and the Recovery Plan for marine turtles for vessel disturbance.** • **EPBC Policy Statement 2.1 (Part A)**

7.3.2.2 Description of risk with standard controls

7.3.2.2.1 Potential impacts to marine mammals

Vulnerability of marine mammals to vessel collision will vary according to behaviour (e.g. surfacing habits, direction of travel in relation to shipping routes); morphology; the function of preferred habitat (e.g. breeding, feeding) and density in areas of vessel activity; and aspects of shipping such as vessel type, speed, density and location. Slow moving species that occur frequently at the surface in areas that overlap with shipping activity are the most vulnerable (Hazel et al. 2007).

The OA does not overlap with any areas important for marine mammal feeding or breeding and significant numbers of any species are not expected to occur in the area. The low vessel speeds and relatively small area of activity makes it very unlikely that collisions with any species will occur during the short duration of the survey.

The OA is outside the southern migration BIA for pygmy blue whales but overlaps a small portion (<0.0001%) of the northern migration BIA (Figure 4.9) and overlaps the general distribution BIA for this species off north-west Australia. The Conservation Management Plan for the Blue Whale (DoE 2015a) reports that there have been 2 records of likely ship strikes of blue whales in Australian waters since 2006. Since pygmy blue whales are considered noise sensitive and likely to display avoidance behaviour, the likelihood of physical interaction with this species by survey vessels or equipment is very low.

The OA is located at least 280 km north of the closest BIA for humpback whales – the resting and calving BIA adjacent to the Kimberley coastline – and outside of the time of year when this species occurs in that area.

As summarised in Table 4-4, there is the possibility that isolated individuals or small pods of other marine mammals may be present in the OA during acquisition of the survey, but this is likely to be limited to occasional transits as there are no BIAs for these species within the OA and the area is not known to be used for feeding, breeding or resting by any of these species.

Management actions identified in the Conservation Management Plan for the Blue Whale (DoE 2015a), Sei Whale Conservation Advice (TSSC 2015) and Fin Whale Conservation Advice (TSSC 2015b) require vessel collisions to be avoided by carrying out risk assessments and implementing mitigation measures if required, as well as ensuring all vessel strike incidents are reported in the National Ship Strike Database.

7.3.2.2.2 Potential impacts to whale sharks

Whale sharks spend a significant amount of their time close to the surface of the water (DoEE 2019) and are therefore vulnerable to vessel strike. There is evidence of whale sharks being hit by vessels globally (Newman et al. 2018). The Conservation Advice for Whale Sharks (TSSC 2015d) identifies boat strike from large vessels as a threat to the recovery of the species. The conservation management action potentially relevant to boat strike for the Gem 3D MSS is minimising offshore developments and transit time of large vessels in areas close to marine features likely to correlate with whale shark aggregations (Ningaloo Reef, Christmas Island and the Coral Sea) and along the northward migration route that follows the northern Western Australian coastline (as set out in the Conservation Values Atlas 2014), noting that the OA is distant from aggregation areas and outside the main migration period for whale sharks.

The south-eastern portion of the OA for the Gem 3D MSS overlaps a very small extent (-436 km^2, 0.2% of the overall BIA area) of the whale shark foraging BIA (Figure 4-13). It is possible that individual whale sharks may transit through the OA. However, the underwater noise generated by the operating seismic vessel is considered likely to cause localised avoidance behaviour in whale sharks as described in Section 6, reducing the potential for physical interactions. The Gem 3D MSS is of short duration (27 days) and will only pass through the BIA overlap for a small percentage of the total survey time (i.e. 9.2% or 2.5 days). Furthermore, the seismic vessel will be slow-moving, which poses a lower risk of impact than the existing shipping activity in the region.

Since there is no regulatory guidance that provides specific management actions to prevent vessel strike incidents to whale sharks, Part 8 of the EPBC Regulations – Interactions with Cetaceans and Whales has been used as a guideline for the management actions taken for the Gem 3D MSS. The demonstration that the EP is consistent with these best practice actions can be found in the acceptability demonstration below.

7.3.2.2.3 Potential impacts to marine turtles

Boat strikes are a known cause of death and injury in marine turtles. Turtles are most vulnerable to boat strike when they are in shallow waters, basking at the surface or coming to the surface to breathe.

Marine turtles on the sea surface or in shallow coastal waters have been observed to avoid approaching vessels by typically moving away from the vessels track. While the potential for vessel strikes at various speeds has not been quantified, the success of avoidance behaviour is a factor of the response time available (i.e. visual observation distance/vessel speed).

There are no BIAs for turtles in or near the OA and given the large distances (>100 kms) to areas of importance for marine turtles in the region, there is very low likelihood of individual turtles transiting through the OA during acquisition of the survey.

The Recovery Plan for Marine Turtles in Australia 2017-2027 (DoEE 2017) states that "although the outcome can be fatal for individual turtles, boat strike (as a standalone threat) has not been shown to cause stock level declines. There are therefore no management actions stipulated by the Recovery Plan, however the Plan does refer to the Commonwealth Government's Draft National Strategy for Mitigating Vessel Strike of Marine Mega-fauna to provide guidance on reducing collision risk with vessels. The Draft Strategy is not yet finalised; however it lists key actions relating to mitigation to reduce the likelihood and severity of mega-fauna collisions, which include identifying best practice mitigation and development of a vessel strike management plan in locations where the relative risk of vessel strike is high. Since the relative risk of vessel strike from the survey is low, and the fauna observation and avoidance measures that will be implemented are considered best practice, the survey is consistent with the Recovery Plan.

7.3.3 ALARP treatment and evaluation

7.3.3.1 ALARP options

Additional controls which have been considered in reaching ALARP are listed in Table 7-10.

Table 7-10: ALARP options considered for the risk of collision between survey vessels/equipment and marine fauna

Control measures	Control type	Env benefit	Env benefit scale	Cost	Practicable and implemented	Rationale
Reduce number of vessels in the field by not using support vessels	**Elimination**	**Reduces probability of boat strike**	**Negligible (<1%)**	**5–10% of project cost**	**Not adopted**	**Benefit: risk is already low and potential additional benefit of this control is minimal.** **Cost: Reducing vessels used increases safety risk (through increased possibility of collision with fishing equipment, flotsam or jetsam), reduces ability to manage stakeholder interactions and recover lost gear, and increases likelihood of environmental impacts/risks due to collisions, grounding, spills etc.**
Remove streamers and airgun array from water when not in use	**Elimination**	**Reduces probability of equipment entanglement**	**Negligible (<1%)**	**>50% of project cost**	**Not adopted**	**Benefit: Since the risk has already been reduced to low using standard control measures, this control will only have minimal additional environmental benefit and would be grossly disproportionate to the increased costs (outlined above) of implementation.** **Cost: It would increase health and safety risks and would prolong the overall survey time, therefore increasing the risk of interference with fauna and stakeholders, atmospheric emissions and survey cost beyond the benefit gained to the environment.**
Retrofitting turtle guards onto streamer tail buoys.	**Engineering**	**Reduces probability of equipment**	**Negligible (<1%)**	**<1% of project cost**	**Adopted**	**Benefit: May slightly reduce risk of turtle entanglement although risk already low**

		entanglement for turtles				
No night-time operations	**Elimination**	**Reduces probability of fauna strike at night**	**Negligible (<1%)**	**>50% of project cost**	**Not adopted**	**Benefit: Risk already low due to short duration of survey, low numbers of fauna expected, slow vessel speeds and expected avoidance of operating vessels. Minimal additional benefit.** **Cost: Limiting seismic activities to daylight hours only would significantly extend the time required to acquire data for individual activities. This would at least double the survey time and, therefore, increase the likelihood of interactions with diurnal fauna, the overall duration of seismic impacts, and interaction with commercial fisheries. Further, increasing the duration of the survey would increase the transit time of the seismic vessel which does not align with the Whale Shark Conservation Advice (TSSCa) (Section 7.2.2.2). These costs are grossly disproportionate to the benefits given the risk has already been reduce to low using standard controls.**
Survey acquisition outside of key fauna migration periods	**Elimination**	**Reduces the probability of encountering fauna.**	**Negligible (<1%)**	**>10% of project cost**	**Not adopted**	**Benefit: Risk already low due to short duration of survey, low numbers of fauna expected, slow vessel speeds and expected fauna avoidance of operating vessels. Minimal additional benefit.** **Cost: The periods of peak fauna abundance cannot be reasonably avoided because of the different timings for different species (eg turtles vs whales vs whale sharks) and with the northern and southern blue whale migrations spanning 10 months of the calendar year. It is impracticable and commercially prohibitive to restrict the window for completing**

						the MSS to short and/or disjointed periods given operational considerations.
Application of EPBC Policy Statement 2.1 Part A: Standard Management Measures for whales and whale sharks	Administrative	Extends management measures to whale sharks	Moderate (3-10%)	<0.5% of project cost	Adopted	Good industry practice, aligns with management actions for cetacean and whale shark management / recovery plans and conservation advice.
Two MFOs will be on board the seismic vessel and on duty during daylight hours during the survey	Administrative	Visual detection of marine fauna in proximity to seismic source	Moderate (3-10%)	<0.5% of project cost	Adopted	Although the ASA is not considered to be located within an area of moderate to high likelihood of encountering whales, the OA does overlap part of the pygmy blue whale migration BIA and so inclusion of MFOs is considered conservative. Consistent with Part B of EPBC Policy Statement 2.1, two MFOs will be on board the seismic vessel and on duty during daylight hours during the survey.

7.3.3.2 Demonstration of ALARP

Table 7-11: Demonstration of ALARP for collision between survey vessel/equipment and marine fauna

Criteria	Demonstration
Legislation, codes and standards	**Part A of EPBC Policy Statement 2.1 are standard management procedures and will be implemented during the Gem 3D MSS.** **Consistent with Part B of EPBC Policy Statement 2.1, MFOs will be on board the seismic vessel and on duty during daylight hours during the survey.** **EPBC Regulations 2000 – Part 8 Division 8.1 Interactions with cetaceans.**
Good industry practice	**Eliminate: Soft start procedures will be conducted prior to acquisition commencing. This will encourage noise sensitive marine fauna to move away from the vessel, reducing the likelihood of collision or entanglement.** **Slow speed of vessel during seismic acquisition (<5 knots) will reduce collision risk** **Substitute: None identified** **Engineer: Buoys and automatic recovery devices attached to streamer to facilitate recovery in the event of loss. Turtle guards fitted to streamer tail buoys.** **Isolate: Adoption of EPBC Regulation 2000 (Part 8) requirements for proximity distances and vessel management if cetaceans, and whale sharks are identified within certain buffer zones to the vessels** **Administrative: MFO to maintain watch for marine fauna during the day during seismic operations with observed fauna to be avoided if safe to do so.** **All crews are inducted into these requirements** **All vessel incidents with marine mammals will be reported in the National Ship Strike Database**
Professional Judgement	**Alternate controls identified and implemented where practicable. Controls adopted cover multiple levels on the control hierarchy.**
Cost-based analysis	**Not applicable to decision-making criteria for making a Good Practice context A decision**
Societal values	**Not applicable to decision-making criteria for making a Good Practice context A decision**

7.3.4 Demonstration of Acceptability

The residual impact is evaluated against the pre-set acceptability criteria in Table 7-12.

Table 7-12: Acceptability evaluation

Acceptability criteria	Acceptable level of impact	Demonstration of acceptability
Internal context:	• **The risk management**	• **The risk management strategy for marine fauna collision risk reflects SapuraOMV's**

Policy compliance: • SapuraOMV's policies and HSE MS • Env impact demonstrated to be ALARP	strategy and controls are consistent with SapuraOMV's corporate environmental policy, culture and company standards and procedures. • The risk of collision between survey vessels/equipment and marine fauna has been reduced to a level that is ALARP.	Environment Policy goals of preventing harm to the environment by reducing risk to ALARP, complying with applicable legal and industry standards, and continually improving environmental performance. • Section 8 demonstrates the HSE MS can meet the requirements of this EP. • The process outlined in Section 5 for reducing risks to ALARP has been implemented for the risk of collision between survey vessels/equipment and marine fauna and has been demonstrated above in Table 7-9.
EPO is achievable and consistent with achieving acceptable performance	The EPO states: • No injury or death of marine fauna due to collision with a survey vessel or entanglement with towed survey equipment during the Gem 3D MSS	Generally slow vessel speeds, low numbers of fauna and vessel operations compliant with all maritime law relating to cetaceans, including soft start measures during seismic operations that will encourage noise sensitive marine fauna to move away from the vessel, expected to be successful in reducing the likelihood of collision or entanglement. No injury or death considered an inherently acceptable level of performance.
ESD principles	The following core objectives of ESD have been incorporated: • To protect biological diversity • Maintain essential ecological processes and life support systems.	The risk management process has adopted a series of controls to reduce the residual risk of collision with marine fauna to ALARP. As a result of minimising the risk of collision with marine fauna the biological diversity and essential ecological processes are likely to be supported and maintained.
External context: Receiving environment and activity	Evaluation of the relevant aspects of the local receiving environment and petroleum activity have been considered in the evaluation of impacts from the risk	Fauna at highest risk of collision are those that spend considerable time in surface waters, are slow moving and large. Such fauna that may occur in the vicinity of the OA include cetaceans, whale sharks and less likely marine turtles. These fauna are mobile and would be expected to actively avoid the slow-moving seismic vessel, especially

	of collision with marine fauna.	during data acquisition where the seismic vessel will acquire data at a vessel speed of (<5 knots). Few encounters with large marine fauna are expected and likely limited to individuals transiting through the area. The OA is distant from areas of importance for marine turtles, and overlaps only a small percentage of the overall BIAs for the pygmy blue whale and whale shark. Furthermore, soft start measures and the seismic sound during seismic operations will encourage noise sensitive marine fauna to move away from the vessel, reducing the likelihood of collision or entanglement. No impact at population levels. No effects at an ecosystem function level are predicted.
External context: Compliance with legislation and industrial standards	Compliant with the Commonwealth legislation: • EPBC Regulation 2000 (Part 8) requirements • EPBC Policy Statement 2.1 (Part A and one element of Part B)	This legislation has been used in the development of the management controls necessary to reduce the risk of striking marine fauna with vessels and survey equipment to ALARP. In addition a precautionary approach has been taken for managing interactions with whale sharks (noting there is a small overlap of the OA and their foraging BIA), whereby the requirements for interactions with cetaceans under EPBC Regulation 2000 Part 8 and EPBC Policy Statement 2.1 have been extended to whale sharks, and a control measure/EPS has been adopted to implement this. With control measures implemented, the risk associated with marine fauna impacts from vessel strikes / entanglement will not have any population level impacts.
External Context: Compliance with values stated in Marine Park Management Plans, species management/ recovery plans and conservation advice	Residual risks posed by collision between vessels and survey equipment with marine fauna during the survey are consistent with the relevant management plans and advices.	The Australian and State Marine Parks do not overlap the OA. Section 7.2.2.2 describes how the EP and control measures align with the relevant conservation objectives / management actions in species management / recovery plans for the pygmy blue whale, sei whale, fin whale, whale shark and marine turtles. Collision prevention measures have been adopted from EPBC Regulations 2000 – Part 8 Division 8.1 so that risks from vessel strike are not inconsistent with the: In addition a precautionary approach has been taken for managing interactions with whale sharks (noting there is a small overlap of the OA and their foraging BIA), whereby the requirements for interactions with cetaceans under EPBC Regulation

		2000 Part 8 have been extended to whale sharks, and a control measure/EPS has been adopted to implement this. **Few encounters with large marine fauna are expected and likely limited to individuals transiting through or in the vicinity of the area. Furthermore, soft start measures during seismic operations will encourage noise sensitive marine fauna to move away from the vessel, reducing the likelihood of collision or entanglement.**
External Context: Stakeholder Expectations	**The merit of stakeholder concerns and objections have been assessed and controls adopted to reduce risks to ALARP.**	**There are no outstanding objections or claims regarding collisions with marine fauna and none with merit were raised during initial consultations and remain unresolved.**

7.3.5 Risk level

Consequence	Likelihood	Risk
Minor: Short term impacts on individuals in the population. Effects could either be sub-lethal or lethal to individuals. The number of individuals impacted is likely to be very low with no measurable or long-term effects on populations or ecosystems.	**Remote**	**Very Low**

7.3.6 EPO, additional controls, performance standards and measurement criteria

No additional practical control measures have been identified that would further reduce the risk of collision between survey vessels/equipment and marine fauna during the Gem 3D MSS. The environmental performance objective, control measures, performance standards and measurement criteria are listed in Table 7-13.

Table 7-13: Summary of controls for collision between survey vessel/equipment and marine fauna

EPO	Control	EPS	Measurement criteria
EPO R2: No injury or death of marine fauna due to collision with a survey vessel or entanglement with towed survey equipment	**Application of EPBC Policy Statement 2.1 Part A: Standard Management Measures for whales and whale sharks.**	**EPS R5: Application of EPBC Policy Statement 2.1 Part A: Standard Management Measures for whales and whale sharks.**	**MFO data sheets/report confirms EPBC Policy Statement 2.1 is available onboard the seismic vessel and ALL Part A and standard management measures have been implemented throughout seismic data acquisition.**
	Two MFOs will be on board the seismic vessel and on duty during daylight	**EPS R6: Two MFOs are available on board the seismic vessel to manage**	**Curriculum Vitae of the MFOs engaged for the Gem 3D MSS confirms:**

during the Gem 3D MSS		shift duties during daylight hours during the survey.	• UK Joint Nature Conservation Committee (JNCC) accreditation (or equivalent); and • at least one year (minimum four surveys) previous MFO experience. MFO report confirms two MFOs were on board the seismic vessel to manage shift duties for daylight visual observations during the survey.
	Implementation of industry good practice measures: • buoys and automatic recovery devices attached to streamers to facilitate recovery in the event of loss • presence of support vessel to assist with recovery or lost streamers • Seismic survey vessel will not travel at greater than 5 knots during seismic acquisition • Seismic and support vessels crews are inducted in their responsibilities as required regarding marine fauna interactions	EPS R7: Buoys and automatic recovery devices attached to streamers.	Pre-start inspection shows evidence that buoys and automatic recovery devices are attached to streamer
		EPS R8: Support vessel available to assist with recovery of lost streamers.	Incident report for lost equipment documents assistance provided by support vessel to retrieve lost streamers.
		EPS R9: Seismic survey vessel will not travel at greater than 5 knots during seismic acquisition.	Vessel log confirms vessel speed did not exceed 5 knots during acquisition.
		EPS R10: Seismic and support vessels crews are inducted in their responsibilities as required regarding marine fauna interactions.	Records show that the seismic and support vessel crew inductions includes responsibilities regarding marine fauna interactions
	Alignment with fauna management plans: All vessel strike incidents are reported in the National Ship Strike Database	EPS R11: All vessel strike incidents are reported in the National Ship Strike Database at https://data. marine mammals.gov.au/r	MFO report confirms that all vessel strike incidents are reported in the National Ship Strike Database.

		eport/ship strike	
	All known or suspected threatened fauna injuries or death will be reported to the DoEE within 2 hours of the incident.	**EPS R12: All known or suspected threatened fauna injuries or death will be reported to the DoEE within 2 hours of the incident.**	**Incident report verifies contact was made or attempted to DoEE within 2 hours of the incident. MFO report confirms that all vessel strike incidents are reported in the National Ship Strike Database.**
	All entangled marine fauna recovered to the seismic or support vessels will be returned to the sea as quickly as practicable.	**EPS R13: All entangled marine fauna recovered to the seismic or support vessels will be returned to the sea as quickly as practicable.**	**MFO report confirms that any marine life recovered with wet equipment was recorded and then quickly returned to the ocean.** **Incident report verifies contact was made or attempted to DoEE within 2 hours of the incident.**
	Interaction between survey vessel and cetaceans (whales and dolphins) within the operational area will be consistent with EPBC Regulations 2000 – Part 8 Division 8.1 (Regulation 8.04) – Interacting with cetaceans.	**EPS I24: Interaction between survey vessel and cetaceans (whales and dolphins) within the operational area will be consistent with EPBC Regulations 2000 – Part 8 Division 8.1 (Regulation 8.04) – Interacting with cetaceans:** • **vessels will not knowingly travel faster than 6 knots within 300 m of a whale or 150 m of a dolphin** • **vessels will not knowingly get closer than 100 m of a whale or 50 m of a dolphin**	**MFO report demonstrates no breaches of EPBC Regulations 2000 (Part 8).** **Compliance and cetacean sighting reports will be completed and provided to NOPSEMA / DoEE within 3 months of completion of the survey.**

		• **seismic survey vessels and support vessels will not intently approach within 150 m of a dolphin calf or within 300 m of a whale calf (Reg 8.06(2)).** **If a cetacean approaches the vessel within the above zones, the vessel should avoid rapid changes in engine speed or direction.**	

7.4 Equipment grounding or emergency anchoring

7.4.1 Overview of risk

7.4.1.1 Source of risk

Vessel grounding is not a risk during the Gem 3D MSS because the draft of vessels used in the survey (maximum 7.5 m) is considerably less than the shallowest depth in the survey area (13 m Lowest Astronomical Tide). Under normal operations, no anchoring will be undertaken by the survey vessels within the survey area. However, unplanned anchoring could occur in the event of an emergency in order to maintain the safety of the vessel and crew. The shallow depths of some shoals located within the OA also present a risk that the towed acoustic array including seismic streamers extending up to 10 km behind the seismic vessel at a depth of 5-6 m may be grounded on habitat on top of the shoals.

Both anchoring and grounding of towed acoustic array could potentially result in localised damage to the benthic habitat and disturbance or injury to associated fauna. The extent of disturbance will depend on the amount of anchor chain deployed, the amount of acoustic array grounded and the nature of the seabed.

Equipment grounding could only occur in the unlikely event of loss of vessel steerage resulting on an inability to avoid charted or surveyed shallows or contact with uncharted/unsurveyed shoals. Emergency anchoring would only be required in the event of total loss of vessel propulsion and inability to go under tow from the support vessel due to weather/sea conditions or other compounding situation.

7.4.1.2 Physical, biological and socio-economic receptors

The nine shallowest shoals within the OA have minimum depths ranging from 0 - 22 m (Figure 4-1) These banks and shoals support diverse benthic communities including numerous species of corals, sponges, seagrasses, crustaceans and site attached fish. The benthic habitats of these shallow shoals may also provide feeding grounds for macrofauna such as marine turtles and dugongs, particularly those which rise to depths of less than 20 m.

7.4.2 Risk analysis and treatment

Table 7-14: Duration of impact and ALARP assessment technique regarding equipment grounding and emergency anchoring

Unplanned event: equipment grounding and emergency anchoring	
Duration of impact	**Long term impacts (1-3 years) to local populations of fauna, flora and habitats**
ALARP assessment technique	**Good Practice Context A decision which includes:** • **Legislation, codes and standards (LCS)** • **Good Industry Practice (GIP)** • **Professional Judgement (PJ)**

7.4.2.1 Context for setting standard control measures

Table 7.15 describes the context for setting the minimum controls.

Table 7-15: Context for setting standard control measures - equipment grounding and emergency anchoring

Compliance with legislative requirements: • ***Navigation Act 2012*** **and Navigation Regulations 2013**
Compliance with Company and industry standards: • **Survey vessel operational procedures for effectively and safely undertaking seismic surveys** • **APPEA Code of Environmental Practice 2008**
• **Alignment with objectives and compliance with requirements of applicable management, recovery and /or conservation plans: None applicable**

7.4.2.2 Description of risks with standard controls

The most likely impact from equipment grounding or emergency anchoring are impacts to benthic habitats. The extent of the impact will likely depend on the depth that the seabed is contacted, with greater damage in shallower waters that are inhabited by corals, macroalgae and benthic invertebrates.

The impacts to benthic habitats are likely to be localised to the site of contact. The benthic habitats potentially affected have widespread regional distributions (see Section 4.4.2) and recovery would occur through colonisation and/or recruitment from adjacent unaffected areas. Emergency anchoring is a very uncommon occurrence in the offshore oil and gas industry in Australia and in general the likelihood of equipment grounding is also very small.

The survey will be conducted by a specialist seismic contractor, with a competent crew operating in compliance with all relevant maritime and navigation regulations. Given the relatively short duration of the survey, the comprehensive operating procedures and equipment redundancy in place to avoid incidents, and the separation distances (minimum depth exclusion zone) between acquisition activities and shallow areas in the OA that will be maintained for this survey, there is very low likelihood of these events occurring during the Gems MSS.

7.4.3 ALARP treatment and evaluation

7.4.3.1 ALARP options

Additional controls which have been considered in reaching ALARP are listed in Table 7-16.

Table 7-16: ALARP options considered for the risk of equipment grounding and emergency anchoring

Control measures	Control type	Env benefit	Env benefit scale	Cost	Practicable and implemented	Rationale
Minimum depth operating exclusion zones established around the <50m depth shoals in the ASA.	**Elimination**	**Avoids grounding and damage to shoals and associated fauna**	**Moderate (3-10%)**	**1% of project cost**	**Adopted**	**Benefit: This is an effective control that eliminates the risk of vessel grounding and aligns with safe navigation practices.** **Cost: potentially limits the area of data acquisition and value of the dataset, but data set is still of technical and commercial value.**
Use of recent, detailed bathymetric survey data of ASA for MSS	**Administrative**	**Accurate depth data reduce potential vessel and equipment grounding**	**Moderate (3-10%)**	**5% of project cost**	**Adopted**	**Benefit: Accurate seabed mapping minimises uncertainty in deriving and adhering to depth-based controls (exclusion zones).** **Cost: An additional cost of running a dedicated bathymetric survey.**

7.4.3.2 Demonstration of ALARP

Table 7-17: Demonstration of ALARP for equipment grounding and emergency anchoring

Criteria	Demonstration
Legislation, codes and standards	**Compliance with the *Navigation Act 2012* and Navigation Regulations 2013**
Good industry practice	**Eliminate:** **Any lost equipment will be recovered where safe and practicable to do so** **Substitute: None identified** **Engineer:** **Streamers equipped with streamer recovery devices (SRDs) and buoys designed to bring the equipment to the surface if lost accidentally and facilitate recovery** **Isolate: None identified** **Administrative:** **Operational procedures in place on board the seismic vessel for deployment and retrieval of towed equipment, to reduce potential for steamer loss** **Vessel to be operated by suitably qualified and experienced crew** **Vessel mechanical equipment maintained in accordance with planned maintenance system**
Professional Judgement	**Alternate controls identified and implemented where practicable. Controls adopted cover multiple levels on the control hierarchy.**
Cost-based analysis	**Not applicable to decision-making criteria for making a Good Practice Context A decision**
Societal values	**Not applicable to decision-making criteria for making a Good Practice Context A decision**

7.4.4 Demonstration of acceptability

The residual impact is evaluated against the pre-set acceptability criteria in Table 7-18.

Table 7-18: Acceptability evaluation

Acceptability criteria	Acceptable level of impact	Demonstration of acceptability
External context: **Receiving environment and activity**	**Evaluation of the relevant aspects of the local receiving environment and petroleum activity have been considered in the evaluation of risks from vessel**	**The majority of the survey area is in deep waters and the potential for grounding and emergency anchoring is only a risk while navigating around the shallow water shoals in the OA.**

	grounding and emergency anchoring	
External context: Risk management options	Evaluation of the risk management options available to managing the risk of impacts from vessel and equipment grounding and emergency anchoring	The risk of vessel and equipment grounding and emergency anchoring cannot be reduced below the level of Low because the controls available are likelihood reduction measures rather than consequence reduction measures. The control measures used in achieving ALARP have already reduced the likelihood level to the lowest possible level of Remote. As a result, the risk can only be reduced to Low rather than Very Low.
Internal context Policy compliance: SapuraOMV's policies and HSE MS Environment impact demonstrated to be ALARP	The impact management strategy and controls are consistent with SapuraOMV's corporate environmental policy, culture and company standards and procedures. In demonstrating ALARP – options must be considered and the cost benefit analyses used to determine if they should be adopted.	The risk management strategy vessel grounding, equipment grounding and emergency anchoring reflects SapuraOMV's Environment Policy goals of preventing harm to the environment by reducing risk to ALARP, complying with applicable legal and industry standards, and continually improving environmental performance. Section 8 demonstrates the HSE MS can meet the requirements of this EP.
EPO is achievable and consistent with achieving acceptable performance	The EPO states: No loss or disturbance to benthic habitats due to equipment grounding or emergency anchoring.	Proposed controls on vessel navigation and maintenance standards expected to avoid grounding or need for emergency anchoring and no impact is an acceptable level of performance.
External Context: Australian Marine Park Management Plans, Species Recovery Plans and Conservation Advices	Residual risks posed by vessel and equipment grounding and emergency anchoring associated with the survey are consistent with the relevant management plans and advices.	No Australian Marine Park overlaps the OA. Species Recovery Plans and Conservation Advices are not relevant to this risk.
Legislative criteria & standards	Compliant with State and Commonwealth legislation.	SapuraOMV will conduct the survey consistent with and use the relevant provisions within the *Navigation Act 2012* and Navigation Regulations 2013

External Context: Stakeholder Expectations	**The merit of stakeholder concerns and objections have been assessed and controls adopted to reduce risks to ALARP.**	**There are no outstanding objections or claims regarding vessel/equipment grounding and none with merit were raised during initial consultations and remain unresolved.**
Environmental risk demonstrated to be ALARP	**The risk of vessel and survey equipment grounding has been reduced to a level that is ALARP.**	**The process outlined in Section 5 for reducing risks to ALARP has been implemented for the risk of vessel and equipment grounding and has been demonstrated above. The cost of introducing further controls for the management of vessel and equipment grounding and emergency anchoring is grossly disproportionate to any small reduction in risk to the environmental.**
ESD principles	**The following core objectives of ESD have been incorporated:** **To protect biological diversity** **Maintain essential ecological processes and life support systems.**	**The risk management process has adopted a series of controls to reduce the residual risk of vessel and equipment grounding and emergency anchoring to ALARP. As a result of minimising the risk of introducing IMS the biological diversity and essential ecological processes are likely to be supported and maintained.**

7.4.5 Risk level

Consequence	Likelihood	Risk
Moderate: medium term (1-3 years) impacts to local populations of fauna, flora and habitats associated with the shallow water shoals.	**Remote**	**Low**

7.4.6 EPO, additional controls, performance standards and measurement criteria

The environmental performance objective, control measures, performance standards and measurement criteria are listed in Table 7-19.

Table 7-19: Summary of controls for equipment grounding or emergency anchoring

EPO	Controls	EPS	Measurement criteria
EPO R3: No loss or disturbance to benthic habitats due to equipment grounding or	**Operational procedures will be in place on board the seismic vessel for deployment and retrieval of towed equipment on board, to reduce potential for steamer loss**	**EPS R14: MSS operational procedures will be in place on board the seismic survey vessel for deployment and retrieval of towed equipment on board**	**Vessel inspections show evidence of implementing seismic survey vessel procedure for streamer retrieval and recovery**
		EPS R15: No anchoring within the OA during the	**Vessel log indicates vessel did not anchor in**

emergency anchoring	No anchoring unless in the event of an emergency and all attempt must be made to minimise damage to benthic habitat.	Gem 3D MSS unless in the event of an emergency. If emergency anchoring is necessary, the minimum length of anchor chain to safely hold the vessel is deployed	the OA during the Gem 3D MSS unless in an emergency
			Vessel crew induction includes vessel anchoring procedures.
	Minimum depth operational exclusion zones will be established around the <50m depth shoals in the ASA	EPS R16: No operation of a seismic vessel within designated minimum depth exclusion zone around the <50m depth shoals in the ASA	Survey log confirms no operation of the seismic vessel has occurred within the minimum depth exclusion zone.
	Recent bathymetric data of shoals within the ASA used to ensure validity of exclusion zones	EPS R17: Recent detailed bathymetric data used to define the coordinates of 200m active source exclusion zones around the 50m depth contours of shoals in the ASA	Survey log confirms that coordinates used to define active source exclusion zones are based on pre-bathymetric survey
	Streamers equipped with streamer recovery devices (SRDs) and buoys designed to bring the equipment to the surface if lost accidentally and facilitate recovery.	EPS R18: Streamers equipped with Streamer Recovery Device (SRDs) designed to bring the equipment to the surface if lost accidentally.	Records demonstrate that streamers are equipped with SRDs set to auto-inflate at less than actual water depth.
	Survey equipment lost overboard during the Gem 3D MSS will be recovered where safe and practicable to do so.	EPS R19: Lost streamer recovery procedure (including shallow water recovery e.g. by grappling) carried on board survey vessel.	On board inspection shows lost streamer recovery procedure includes shallow water recovery without SRD.
		EPS R20: Lost survey equipment will be recovered where safe and practicable to do so.	Records of streamer loss will be documented
			Records show equipment lost to the marine environment and attempts to recover lost towed equipment

7.5 Hydrocarbon release caused by vessel fuel tank loss of containment

7.5.1 Overview of risk

7.5.1.1 Source of risk

This section assesses and manages the risk of a marine diesel (MGO or MDO) spill due to fuel tank loss of containment as a result of a vessel collision. The worst-case scenario is considered, with all smaller incidents expected to present the same type of described impacts but with smaller magnitude.

The survey vessel will not be re-fuelled during the Gem 3D MSS and therefore loss of containment during re-fuelling is not considered a risk.

The vessels will be fuelled with MGO/ MDO, carried in separate fuel cells which are interconnected and isolatable. In the event of an incident such as a catastrophic vessel collision or grounding that ruptured a fuel cell, the total volume of fuel released would be reduced by isolating the compromised fuel cell and transferring fuel to adjacent cells. Nevertheless, a significant volume of MGO/ MDO fuel may be released to the marine environment.

AMSA considers the maximum realistic spill scenario for vessel collisions or grounding is the loss of the entire volume of the single largest fuel tank (AMSA 2016). This provides a conservative volume estimate as the tanks are never completely full and considers the largest volume tank even when assessing the risk of a spill from smaller tank sizes.

A precautionary approach has been taken in the decision-making process for this EP. The oil spill risk assessment presented is based upon a worst-case spill scenario of complete loss of the contents of the largest single fuel tank in the event of vessel collision. Given the extremely low likelihood of two very unlikely events occurring (catastrophic collision/vessel grounding and complete loss of fuel tank) the risk assessment is considered inherently conservative.

The assessment in this EP has considered the description of consequences contained in the NERA Reference Case 2018:1003. This is considered highly conservative for the Gem 3D MSS since it considered spills of up to 700 m^3 and MDO as well as the less persistent MGO. The seismic vessel contracted for the Gem 3D MSS will use MGO/MDO and will have a largest tank volume (and hence maximum spill volume) of less than half that considered in the Reference Case.

7.5.1.2 Physical, biological and socio-economic receptors

To determine the environment that may be affected by an accidental release of diesel from a vessel, this EP uses NERA Reference Case 2018:1003 – Consequence analysis of an accidental release of diesel (NERA 2018). Therefore, this assessment considers the potential for impacts from a diesel spill to comprise sensitive environmental receptors that occur to a depth of 10 m below the surface within a 150 km radius boundary around the OA referred to as the Planning Area. The Planning Area encompasses a broad range of environmental sensitivities including Marine Protected Areas, KEFs, BIAs and threatened and migratory species that may be exposed to contact with spilled hydrocarbons (Section 4).

The environmental values and sensitivities within the Planning Area that are could be affected in the event of a large spill are:

- Water quality
- Marine mammals
- Marine reptiles
- Seabirds
- Fish (including sharks)
- Plankton,

- Benthic habitats, and
- Socio-economic receptors.

Mammals

The EPBC Act PMST (Appendix E) identified 27 listed marine mammals that are likely to, may, or are known to occur within the Planning Area (see Section 4.4.4). Four of these are also Listed Threatened Species. Additionally, nine marine mammal species that are likely to, may, or are known to occur within the Planning Area are listed as Migratory. The OA is recognised as an area through which pygmy blue whales migrate (Double et. al 2014).

Marine Reptiles

The EPBC Act PMST (Appendix E) identified 27 listed marine reptiles that are likely to, may, or are known to occur within the Planning Area (see Section 4.4.7). Eight of the species identified are listed as Threatened under the EPBC Act. Marine turtles are vulnerable to the effects of hydrocarbon spills at all life stages (eggs, post hatchlings, juveniles and adults) while in the water or onshore (NOAA 2010).

Birds

The EPBC Act PMST (Appendix E) identified 18 listed seabirds and shorebirds that are likely to, may, or are known to occur within the Planning Area (Section 4.4.6). Five of the species identified are listed as Threatened under the EPBC Act.

Fish (including sharks)

The EPBC Act PMST (Appendix E) identified 10 listed sharks and rays that are likely to, may, or are known to occur within the Planning Area (see Section 4.4.5). The EPBC Act PMST search identified 30 listed teleost fish species that are likely to, may, or are known to occur within the Operations and Planning Areas. These are described in further detail in Section 4. Commercial species and site-attached reef species are described in Sections 4.4.5.3 and Section 4.4.5.4, respectively.

Plankton

Planktonic communities are generally mixed including phytoplankton and secondary consuming zooplankton (crustaceans (e.g. copepods)), and the eggs and larvae of fish and invertebrates (Section 4.4.1). Phytoplankton biomass varies in the Planning Area; levels in the OA are relatively low compared to levels immediately surrounding Cartier Island, which likely reflects localised upwelling (Section 4.4.1).

Benthic habitats

Benthic habitat to a depth of 10 m within the Planning Area include platform reefs east of Cartier Island and isolated shallow banks and shelf edge atolls including one shoal within the OA that rises to 10 m (Mean Sea Level). These shallow support more diverse and higher density benthic assemblages of hard and soft corals, gorgonians, encrusting sponges, seagrass and macroalgae. These shoals are noted for their enhanced local productivity relative to surrounding areas and associated fish communities (Section 4.4.2).

Socio-economic receptors

Socio-economic receptors to a depth of 10 m within the Planning Area include other marine users such as commercial fishers, tourist operators and defence vessels. There are no World Heritage Properties, National Heritage Places or known cultural or Indigenous heritage values for the waters and seabed within the Planning Area (Section 4.5). The historic shipwreck Ann Millicent, which is exposed at low tide, is located south of in the south-west of the Cartier Island Marine Reserve near the extremity of the Planning Area (Section 4.5).

7.5.2 Risk analysis and treatment

Table 7-20: Duration of impact and ALARP assessment technique regarding hydrocarbon release caused by vessel fuel tank loss of containment

Unplanned event: Hydrocarbon release caused by vessel fuel tank loss of containment	
Duration of impact	**Long term (1-3 years) impacts to local populations of fauna, flora and habitats**
ALARP assessment technique	**Good Practice context A decision which includes:** • **Legislation, codes and standards (LCS)** • **Good Industry Practice (GIP)** • **Professional Judgement (PJ)**

7.5.2.1 Context for setting standard control measures

Table 7-21 describes the context for setting the minimum controls.

Table 7-21: Context for setting standard control measures - hydrocarbon release caused by vessel fuel tank loss of containment

Compliance with legislative requirements: • ***Protection of the Sea (Prevention of Pollution from Ships) Act 1983*** • **Compliance with MARPOL 73/78 Annex I (as applied in Australia under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*); and AMSA Marine Orders - Part 91 Marine Pollution Prevention - Oil)**
Compliance with Company and industry standards: • **Survey vessel operational procedures** • **APPEA Code of Environmental Practice 2008**
Alignment with objectives and compliance with requirements of applicable management, recovery and /or conservation plans: • **North-west Marine Parks Network Management Plan 2018**

7.5.2.2 Potential impacts to biological and socio-economic receptors with standard controls

7.5.2.2.1 Overview

Potential impacts to the environment will be greatest in the immediate vicinity of the spill when the toxic aromatic components of the fuel will be at their greatest concentration and when the hydrocarbon is at its thickest on the surface of the receiving waters. The potential sensitive receptors in the immediate areas of the spill will include fish, cetaceans, marine reptiles and seabirds at the sea surface, which may ingest hydrocarbons or become coated.

Entrained hydrocarbons may pose different risks to habitats and fauna compared to a surface slick. However, as a result of the dilution of entrained oil in the water column, toxic impacts of entrained diesel are likely to be less than that of a surface slick. As the entrained hydrocarbons will be in the surface waters only, the extent of entrained hydrocarbons is predicted to be the same as that as the surface hydrocarbon spread.

Toxic effects

The short exposure times likely to be experienced by potential receptors, minimal impacts from exposure to toxic hydrocarbons are anticipated and the rapid evaporation and loss of the more toxic aromatic components of the diesel results in a reducing toxicity threat to marine fauna with time. Passive / low mobility fauna such as plankton and small fish in the surface water are most likely to be affected by the hydrocarbons. Significant impacts to larger marine fauna species such as marine mammals, fish (sharks), marine reptiles and seabirds are unlikely (but possible) given the relatively small area of impact anticipated and the short duration of the spill.

Physical effects

In the immediate spill area, marine fauna interacting with surface waters may be exposed to hydrocarbons on the surface at concentrations above the threshold of 10 g/m2 used for oiling impacts to sensitive receptors but given the low adhesive potential of the hydrocarbon significant impacts are not anticipated.

Impacts are not expected to be significant at the sea surface with the high volatility and low adhesive potential of the hydrocarbon resulting in low persistence in the environment.

Details of environmental impacts of entrained and surface MGO/ MDO on sensitive receptors found within the Planning Area are presented below. A summary of the environmental impacts of entrained and surface MGO/ MDO on protected areas which may be contacted is provided below.

7.5.2.2.2 Zone of potential impact

The zone of potential impact (Planning Area, see Section 4.1.1) has been derived from using the spill dispersion prediction documented in the consequence analysis of an accidental release of diesel reference case by National Energy Resources Australia (NERA 2018). The prediction is based on 26 stochastic model outputs of diesel spills with the following range of variables:

- All offshore petroleum locations across Australia predominantly from the north west coast and Bass Strait
- All summer, winter, and transitional season prevailing conditions
- Tropical, temperate and cold-water temperatures
- Air temperatures ranging from 15 ºC to 30 ºC
- Between 100 - 250 separate release events in each model result
- The release events in each model were run for between 20 and 40 days
- A release duration ranging from instantaneous to 6 hours
- Release volumes ranging from 100 m^3 to 864 m^3.

The results from these simulations predict the maximum dispersion of surface oil from a spill of up to 700 m^3 in volume is 150 km from the source at a threshold of >10 g/m2 of up to 700 m^3 in volume. Entrained oil may travel beyond 150 km from the source however the highest concentration is likely to be in the top few metres of water. Modelling undertaken for the Polarcus Rosemary MSS EP, also off the northern West Australian coastline, predicted that the entrained component of spilled MGO would be concentrated in the surface few metres of the water column.

At the boundary between the slick and the seawater, waves and turbulence can cause the slick to fragment and droplets of varying sizes, become mixed with the upper levels of the water column. Larger, denser droplets rise to the surface and coalesce with the slick; however, some of the smaller droplets whose densities are closer to that of seawater will remain suspended (“entrained” or “naturally dispersed”) in the water column. Weathering and fate modelling for MGO shows that, under varying current and wave conditions, approximately 35% of the spilled oil could be entrained within the surface waters after five hours (Inpex 2009).

Using ADIOS software to predict spill duration, which uses a range of environmental variable inputs, an MGO/ MDO spill of 700 m^3 is predicted to have a duration of 18-144 hours dependent on wind speed (NERA 2018). Logically, a spill of less than half that volume of low persistence MGO, with the smaller maximum fuel tank size expected on the Gem 3D survey vessel, is likely to be of considerably shorter duration.

Water quality

In the event of an oil spill during the activity most of the spilled oil will be concentrated in surface waters, either as a surface slick or as entrained oil in near surface waters. The elevated concentrations of dissolved aromatic hydrocarbons associated with surface diesel slicks would likely cause a localised reduction in water quality and may be acutely toxic to organisms present in surface waters in the area of a spill. These impacts to water quality are likely to only last for several days after the spill.

Plankton

Hydrocarbons have been shown to result in detrimental impacts to phytoplankton (Viñas et al. 2009), however studies of planktonic communities following spills of a similar nature to that of a vessel fuel tank spill did not detect statistically significant impacts resulting from hydrocarbon exposure (Varela et al. 2006). Any impacts of a diesel spill to planktonic communities in the pelagic environment would be of short duration given the rate at which the spill would disperse and weather and the dynamic nature of planktonic communities (Davenport 1982).

Benthic habitats

Benthic habitats within the Planning Area and close to the water's surface, where the entrained oil is predicted to be located, include the shallow water shoals such as Jabiru and Pee shoals and other shoals within the vicinity of the Gem 3D MSS (see Section 4.4.2 Benthic habitats and communities). There is also potential for impacts to benthic habitats in the shallow waters around Cartier Island.

Corals are generally more susceptible to entrained oils due to the higher likelihood of contact. Impacts can occur due to acute and chronic exposure and range from mortality to effects on growth and reproduction. The impacts generally vary between levels of exposure and differ among species (Shigenaka et al. 2010).

Benthic macroalgae and filter feeding communities exposed to hydrocarbons may experience sub-lethal impacts such as reduced growth and reproduction at lower hydrocarbon concentrations (Carman, Fleeger & Pomarico 1997). While most research has been conducted on crude oil and dispersant effects, the results provide an indication of relative sensitivity of various communities. Given the range of benthic habitats in the Planning Area are well represented in the region and across other shoals, and the relatively small likelihood of contact with entrained oil with benthic habitats at the shoal, impacts of an oil spill on protected areas and benthic habitats within the Planning Area are expected to be localised and relatively minor, with rapid (<1 year) natural recovery.

Fish and sharks

Fish may be adversely affected if the oil coats their gills, reducing respiratory efficiency and increasing the incidence of irritation and infection. Fish may also ingest hydrocarbon droplets or contaminated food, leading to reduced growth and hydrocarbon tainting of their flesh, possibly making them unfit for human consumption. Within the NWMR, bony fish are identified as of "less concern" to pressures arising from oil pollution (DSEWPaC 2012).

Given that sharks and fishes are mobile fauna, they are expected to be able actively avoid high concentrations of dissolved and entrained oil, which would only be present for less than one day. As such, no long-term impacts to sharks and fishes are expected.

Marine turtles

There is a very small risk of low thresholds or surface and entrained MGO/ MDO reaching areas important to marine turtles, notably Cartier Island which supports significant populations of feeding green, loggerhead and hawksbill turtles and critical nesting and inter-nesting habitats for green turtles. Isolated turtles transiting other areas affected by a spill could also be exposed to hydrocarbons.

Marine turtles are vulnerable to the effects of hydrocarbon spills at all life stages (eggs, post-hatchlings, juveniles and adults) whilst in the water or onshore (Limpus 2009). Contact with hydrocarbons can have lethal or sub-lethal physical or toxic effects or impair mobility. On contact with surface slicks, turtles may experience irritation and injury to airways or lungs, eyes and mucous membranes of the mouth and nasal or other cavities, with the toxic components affecting respiration, salt gland function and blood chemistry (Ylitalo et al. 2017).

Given the limited spatial extent and very short (<6 days) duration of a spill, there is a very small risk of significant numbers of turtles being impacted via the pathways described above.

Marine mammals

In the unlikely event of an MGO/ MDO spill there is the potential for impacts to pygmy blue whales due to the proximity of the activity to the pygmy blue whale migration and distribution BIAs. In addition, other threatened or migratory whales as well as dolphins, may be encountered in the vicinity of the survey area, although they are unlikely to be present in significant numbers as the area is not known to be used for feeding, breeding or resting aggregations by any of these species (see Section 4.4.6).

The effects of MGO/ MDO exposure include irritation of eyes/mouth and potential illness. Surface respiration could lead to accidental ingestion of hydrocarbons or result in the coating of sensitive epidermal surfaces. However, direct contact with hydrocarbons appears to have little deleterious effect on whales, although inhalation of evaporated toxic components may pose a greater risk (Hoffman et al. 2002). The greatest potential for respiratory damage would be in the first few hours immediately following a spill before the aromatic components evaporate (Neff 2002).

Seabirds and shorebirds

In the unlikely event of a major spill there is the potential for impacts to seabird and shorebird avifauna due to the proximity of the activity to the BIAs of a number species and the likely occurrence of nine migratory species in the vicinity of the operational area. The BIAs are used for breeding and resting and are detailed in Section 4.

Entrained hydrocarbons are less likely to have impacts on seabirds and shorebirds except for when they are diving and foraging in the water column. During these activities there is the potential for sub-lethal effects such as irritation to eye/mouth and potential illness (Troisi, Barton & Bexton 2016).

Surface diesel is likely to be a greater threat to seabirds and shorebirds due to smothering of the oil on their feathers which can result in ingestion while preening. Diesel can also erode feathers causing chemical damage to the feather structure that subsequently affects ability to thermoregulate and maintain buoyancy on water (Fritt-Rasmussen et al. 2016).

Protected areas

Protected areas that may overlap with a vessel spill are the Cartier Island Marine Park, Kimberley Marine Park and Oceanic Shoals Marine Park (see Table 4.3). The values with the potential to be impacted include environmental values (biodiversity), water quality, habitats, cultural heritage and socioeconomic values. In the unlikely event of a spill these values may be impacted by entrained and surface hydrocarbons.

The impacts to environmental, water quality and habitats are described under their respective headings above. Impacts to cultural heritage values are limited to those associated with the Ann Millicent wreck at Cartier Island, as described below.

The conservation values that may be affected by a vessel spill within the Oceanic Shoals Marine Park are described in Section 4. However, the extent of the impact is unlikely to involve all the receptors and conservation values of the marine park because; a) dissolved and entrained hydrocarbons are likely to remain closer to the surface; b) the spill is likely to overlap with only the western portion of the park at concentrations of biological relevance and c) the Planning Area radius of 150 km is highly conservative and so spilled diesel is highly unlikely to contact this protected area.

KEFs

In the unlikely event of a significant MGO/ MDO spill there is potential for a spatial overlap with the carbonate bank and terrace system of the Sahul Shelf KEF, the continental slope demersal fish communities KEF and the Ashmore Reef and Cartier Island and surrounding Commonwealth waters KEF.

The carbonate bank and terrace system of the Sahul shelf KEF and the continental slope demersal fish communities KEF are both in waters deep relative to the shallow water (surface few metres) that entrained hydrocarbons are likely to affect (see zone of impact section above). Therefore, impacts to these KEFs from a vessel spill are very unlikely.

The Ashmore Reef and Cartier Island and surrounding Commonwealth waters KEF lies within the intertidal zone and therefore has the potential to be impacted by a hydrocarbon spill. The sensitive receptors that could potentially be impacted are detailed in Section 4. Contact with diesel from a vessel spill could result in temporary impacts to these receptors through both entrained and surface oil smothering.

Commercial fisheries

The state and Commonwealth commercial fisheries that overlap the Gem 3D MSS Planning Area are described in Section 4. There is no commercial fishing expected within the ASA due to the limitations of the Perth Treaty line (see Section 4) and limited commercial fishing effort expected within the OA. A hydrocarbon spill has the potential to impact these fisheries most likely through exclusion of fishers from areas they normally fish due to the presence of surface oil, and/or oiling of vessel hulls and trap gear (traps, buoys, lines) if the equipment is deployed or retrieved through surface slicks. However, these impacts are likely to be temporary and short term in nature due to the spill naturally dispersing and evaporating.

Defence

There is very little defence activity in the vicinity of the activity area that could be impacted by a diesel spill.

Tourism

The extent and types of tourism in the vicinity of the activity area are described in Section 4. Tourism in the vicinity of the activity is sparse due to its remote location, therefore any impacts from a hydrocarbon spill are likely to be minimal. There is little to no recreational fishing in the vicinity of the Gem 3D MSS due to its remote location. In addition, a diesel spill is likely to only last for up to 6 days and therefore any impacts to tourism are likely to be temporary.

Shipwrecks and historic places

The shipwreck Ann Millicent at Cartier Island may potentially be coated by surface MGO as it is exposed at low tide. The contact is unlikely to damage the physical structure of the steel wreck and given the volatile nature of MGO/ MDO any oil contamination is likely to be bioremediated relatively rapidly (DSEWPAC 2012).

Oil and gas industry

The Montara Venture and Northern Endeavour facilities are within the predicted diesel spill Planning Area. Therefore, operations at these facilities could be disrupted by an MGO/ MDO spill.

Shipping

There is considerable shipping activity in the region that the activity is being undertaken. An MGO/ MDO spill has the potential to locally and temporarily influence the movements of ship traffic that may transit through the Planning Area. The consequences would be negligible given the oceanic location of the survey, the relatively low levels of shipping and the small extent and short duration of any disruption.

7.5.3 ALARP treatment and evaluation

7.5.3.1 ALARP options

Additional controls which have been considered in reaching ALARP are listed in Table 7.22.

Table 7-22: ALARP options considered for the risk of hydrocarbon release caused by vessel fuel tank loss of containment

Control measures	Control type	Env benefit	Env benefit scale	Cost	Practicable and implemented	Rationale
Seismic vessel design includes double skinned hull	**Engineering**	**Reduces the likelihood of fuel spill in the event of vessel damage**	**Significant (10-50%)**	**Dependent on availability of appropriate vessel**	**Adopted**	**Benefit: This is an effective control that greatly reduces the risk of fuel tank holing in the event of vessel grounding or collision.** **Cost: Potentially limits the vessels available to contract, but vessels with this specification exist.**

7.5.3.2 Demonstration of ALARP

Table 7-23: Demonstration of ALARP – Hydrocarbon release caused by vessel fuel tank loss of containment

Criteria	Demonstration
Legislation, codes and standards	**Compliance with:** • **MARPOL 73/78 Annex I (as applied in Australia under the Protection of the Sea (Prevention of Pollution from Ships) Act 1983)); and AMSA Marine Orders - Part 91 Marine Pollution Prevention - Oil):** • **Current vessel SOPEP in place** • **OPEP developed that details the response processes in the event of a marine pollution incident during the Gem 3D MSS** • **Survey vessels hold a valid IOPP Certificate, where required, under vessel class.** • **Navigation Act 2012 (Chapter 3 – Vessel Safety) and subordinate legislation:** • **Marine Order 3 (Seagoing Qualifications)** • **Marine Order 21 (Safe Navigation and Emergency Procedures)** • **Marine Order 27 (Safety of navigation and radio equipment)** • **Marine Oder 30 (Prevention of Collisions)** • **Marine Order 58 (Safe Management of Vessels)** • **EPBC Act 1999 and EPBC Regulations 2000 (IUCN Principles)** • **Australian Maritime Safety Authority Act 1990** • **National Plan for Maritime Environmental Emergencies (AMSA 2019).**
Good industry practice	**Eliminate: None identified** **Substitute: Use of MDO/MGO to eliminate permanent and ongoing impacts of more persistent fuel oils** **Engineer: None identified.** **Isolate: None identified** **Administrative:** • **The Australian Hydrographic Office (AHO) advised of the survey details (survey location, timing) four weeks prior to mobilisation and following demobilisation for issue of Notice to Mariners.** • **AMSA's JRCC will be advised of the survey vessel's details (including vessel name, call-sign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone), area of operation and requested clearance from other vessels. This information will be notified to AMSA RCC 24 to 48 hours before operations commence via email address (rccaus@amsa.gov.au) or phone (1800 641 792 or +61 2 6230 6811)** • **AMSA RCC will be notified at the end of the survey when operations have been completed (via email address (rccaus@amsa.gov.au) or phone: 1800 641 792 or +61 2 6230 6811).** • **Support vessel(s) will undertake surveillance (during a spill) and manage interactions with other marine users" vessels transiting near the seismic vessel or streamers**

	• Responsibilities of survey crew under the OPEP (see Appendix H) and SOPEP are included as part of the project induction • Continuous (24 hour) survey operations, with survey team and bridge crew monitoring vessel position and depth at all times during seismic acquisition
Professional Judgement	**Alternate controls identified and implemented where practicable. Controls adopted cover multiple levels on the control hierarchy.**
Cost-based analysis	**Not applicable to decision-making criteria for making a Good Practice context A decision**
Societal values	**Not applicable to decision-making criteria for making a Good Practice context A decision**

7.5.4 Demonstration of acceptability

The residual impact is evaluated against the pre-set acceptability criteria in Table 7-24.

Table 7-24: Evaluation of acceptability criteria for hydrocarbon release caused by vessel fuel tank loss of containment

Acceptability criteria	Acceptable level of impact	Demonstration of acceptability
External context: **Receiving environment and activity**	**Evaluation of the relevant aspects of the local receiving environment and petroleum activity have been considered in the evaluation of risks from an MGO/MDO spill**	**The MSS will be completed in a remote location where activity by other vessels is low. Water depths in the survey area are typically in excess of 200 m and the shallowest shoal rises to 10 m MSL. A bathymetric survey will confirm water depths around these shoals prior to the MSS to inform safe navigation requirements. A petroleum spill in the survey area will be rapidly dispersed by the prevailing current thereby minimising contact with sensitive receptors.**
External context: **Risk management options**	**Evaluation of the risk management options available to managing the risk of impacts from vessel fuel loss of containment**	**The risk of vessel fuel loss of containment cannot be reduced below the level of Low because the controls available are likelihood reduction measures rather than consequence reduction measures. The control measures used in achieving ALARP have already reduced the likelihood level to the lowest possible level of Remote. As a result, the risk can only be reduced to Low rather than Very Low.**
Internal context **Policy compliance:** **SapuraOMV's policies and HSE MS**	**The impact management strategy and controls are consistent with SapuraOMV's corporate environmental policy, culture and company standards and procedures.**	**The risk management strategy for loss of containment for vessel fuel reflects SapuraOMV's Environment Policy goals of preventing harm to the environment by reducing risk to ALARP, complying with applicable legal and industry standards, and continually improving environmental performance.**

Env impact demonstrated to be ALARP	**In demonstrating ALARP – options must be considered and the cost benefit analyses used to determine if they should be adopted.**	**Section 8 demonstrates the HSE MS can meet the requirements of this EP.**
EPO is achievable and consistent with achieving acceptable performance	**The EPO states:** **No hydrocarbon release to the marine environment due to vessel fuel tank loss of containment during the Gem 3D MSS.**	**Proposed controls expected to avoid vessel collisions that could result in tank rupture and no spills is considered acceptable environmental performance.**
External Context: Australian Marine Park Management Plans, Species Recovery Plans and Conservation Advices	**Residual risks posed by vessel fuel loss of containment associated with the survey are consistent with the relevant management plans and advices.**	**Strategic objectives of the North-west Marine Parks Network Management Plan 2018 include:** • **the protection and conservation of biodiversity and other natural, cultural and heritage values of marine parks in the North-west Network; and** • **ecologically sustainable use and enjoyment of the natural resources within marine parks in the Northwest Network, where this is consistent with the above objective.** **An MGO/ MDO spill is considered consistent with the above strategic objectives because, firstly the spill is not a planned activity and has a very low likelihood of occurring, secondly in the unlikely event of occurring the impacts are unlikely to be permanent due to the non-persistent nature of MDO/ MGO, and thirdly all reasonable measures have been put in place to reduce this risk to ALARP.**
Legislative criteria & standards	**Compliant with State and Commonwealth legislation**	**Compliant with the following legislation:** • **MARPOL 73/78 Annex I (as applied in Australia under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*)); and AMSA Marine Orders - Part 91 Marine Pollution Prevention - Oil):** • **current SOPEP in place** • **survey vessels hold a valid IOPP Certificate, where required, under vessel class.** • ***Navigation Act 2012* (Chapter 3 – Vessel Safety) and subordinate legislation:** • **Marine Order 3 (Seagoing Qualifications)** • **Marine Order 21 (Safe Navigation and Emergency Procedures)**

		• Marine Order 27 (Safety of navigation and radio equipment) • Marine Oder 30 (Prevention of Collisions) • Marine Order 58 (Safe Management of Vessels) • EPBC Act 1999 and EPBC Regulations 2000 (IUCN Principles) • *Australian Maritime Safety Authority Act 1990* • National Plan for Maritime Environmental Emergencies (AMSA 2019).
External Context: Stakeholder Expectations	The merit of stakeholder concerns and objections have been assessed and controls adopted to reduce risks to ALARP.	There are no outstanding objections or claims regarding hydrocarbon release from fuel tanks and none with merit were raised during initial consultations and remain unresolved.
Environmental risk demonstrated to be ALARP	The risk of hydrocarbon release caused by a vessel fuel tank loss of containment been reduced to a level that is ALARP.	The process outlined in Section 5 for reducing risks to ALARP has been implemented for the risk of hydrocarbon release caused by a vessel fuel tank loss of containment and has been demonstrated above. The cost of introducing further controls for the management of unplanned hydrocarbon release is grossly disproportionate to any small reduction in risk to the environmental.
ESD principles	The following core objectives of ESD have been incorporated: To protect biological diversity Maintain essential ecological processes and life support systems.	The risk management process has adopted a series of controls to reduce the residual risk of vessel fuel loss of containment to ALARP. As a result of minimising the risk of introducing IMS the biological diversity and essential ecological processes are likely to be supported and maintained.

7.5.5 Risk level

Consequence	Likelihood	Risk
Moderate: medium term (1-3 years) impacts to local populations of fauna, flora and habitats associated with the shallow water shoals and islands within the Planning Area.	Remote	Low

7.5.6 EPO, additional controls, performance standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for hydrocarbon release caused by vessel fuel tank loss of containment are presented below in Table 7-25.

Table 7-25: Summary of controls for the risk of hydrocarbon release caused by vessel fuel tank loss of containment

EPO	Controls	EPS	Measurement criteria
EPO R4: No hydrocarbon release to the marine environment due to vessel fuel tank loss of containment during the Gem 3D MSS.	**Compliance with MARPOL 73/78 Annex I (as applied in Australia under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983)); and* AMSA Marine Orders - Part 91 Marine Pollution Prevention - Oil)**	**EPS R21: Survey vessels are compliant with MARPOL 73/78 Annex I (as applied in Australia under *the Protection of the Sea (Prevention of Pollution from Ships) Act 1983)*); and AMSA Marine Orders - Part 91 Marine Pollution Prevention - Oil):** • **current SOPEP in place** • **survey vessels hold a valid IOPP Certificate, where required, under vessel class.**	**Records demonstrate the SOPEP is present on survey vessels.** **Records demonstrate the survey vessel holds an IOPP certificate, if required under vessel class.** **Incident report log demonstrates no release of hydrocarbons to the marine environment due to fuel tank loss of containment**
	Compliance with Marine Orders Part 30: Prevention of Collisions (Issue 8) and Marine Orders Part 21: Safety of navigation and emergency procedures, Issue 8, specifically the use of standard maritime safety procedures (including radio contact, display of navigational beacons and lights)	**EPS R22: Survey vessel are compliant with Marine Orders Part 30: Prevention of Collisions (Issue 8) and Marine Orders Part 21: Safety of navigation and emergency procedures, Issue 8, specifically the use of standard maritime safety procedures (including radio contact, display of navigational beacons and lights).**	**Records demonstrate compliance with standard maritime safety procedures and equipment.**
	The Australian Hydrographic Office (AHO) advised of the survey details (survey location, timing) four weeks prior to mobilisation and following demobilisation for issue of Notice to Mariners	**EPS R23: The Australian Hydrographic Office (AHO) advised of the survey details (survey location, timing) four weeks prior to mobilisation and following demobilisation for issue of Notice to Mariners.**	**Records of notification of survey details sent to the AHO four weeks prior to survey mobilisation and within two weeks of survey demobilisation.**
	AMSA's JRCC advised of the survey vessel's details (including vessel name, call-sign and Maritime Mobile Service	**EPS R24: AMSA's JRCC advised of the survey vessel's details (including vessel name, call-sign and Maritime Mobile Service Identity**	**Pre-survey notification demonstrates that AMSA RCC have been notified of the survey vessel details and**

	Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone), area of operation and requested clearance from other vessels.	(MMSI)), satellite communications details (including INMARSAT-C and satellite telephone), area of operation and requested clearance from other vessels. This information will be notified to AMSA RCC 24 to 48 hours before operations commence via email address (rccaus@amsa.gov.au) or phone (1800 641 792 or +61 2 6230 6811).	movements 24 to 48 hours prior to the start of the survey.
	AMSA JRCC notified at the end of the survey when operations have been completed.	EPS R25: AMSA RCC notified at the end of the survey when operations have been completed (via email address (rccaus@amsa.gov.au) or phone: 1800 641 792 or +61 2 6230 6811).	End of survey notification demonstrates that AMSA RCC have been notified of the completion of survey operations.
	Support vessel(s) will undertake surveillance (during a spill) and manage interactions with other marine users' vessels transiting near the seismic vessel or streamers.	EPS R26: Support vessel(s) will undertake surveillance (during a spill) and manage interactions with other marine users" vessels transiting the OA.	Support vessel log confirm that it/they have been employed for the duration of the activity and manage interactions with other marine users within the OA.
	Survey vessels only use MDO or MGO fuel types	EPS R27: Survey vessels only uses MGO/ MDO fuel oil.	Bunkering records demonstrate MGO/ MDO fuel oil used.
	The SOPEP and OPEP are tested prior to the MSS and can be implemented in the event of a spill.	EPS R28: The SOPEP and OPEP are tested prior to the MSS and can be implemented in the event of a spill.	Records show that: the SOPEP and OPEP have been tested in accordance with methods described in both documents the specified project induction includes responsibilities of survey crew for response and notification protocols under the OPEP and SOPEP.

	Vessel to maintain appropriate lighting, navigation and communication systems at all times to inform other users of the position and intentions of the survey vessel, in compliance with the *Navigation Act 2012* and Chapter 5 of the SOLAS Convention.	**EPS R29: Vessel to maintain appropriate lighting, navigation and communication at all times to inform other users of the position and intentions of the survey vessel, in compliance with the *Navigation Act 2012* and Chapter 5 of the SOLAS Convention.**	**Records show no failure to comply with requirements for appropriate navigation, lighting and communication during survey, in accordance with the *Navigation Act 2012* and Chapter 5 of the SOLAS Convention. Any records of failure to comply are documented.**
	Continuous (24 hour) survey operations, with survey team and bridge crew monitoring for other vessels at all times during seismic acquisition.	**EPS R30: Continuous (24 hour) survey operations, with survey team and bridge crew monitoring vessel position and depth at all times during seismic acquisition.**	**Records confirm bridge was manned continuously during survey operations, and that survey vessel crew have appropriate qualifications.**
	Seismic vessel has double skinned hull	**EPS R31: Seismic vessel design includes double skinned hull.**	**Survey records confirm contracted seismic vessel holds certification that demonstrates double skin hull.**

7.6 Waste management and accidental loss overboard

7.6.1 Overview of risk

7.6.1.1 Source of risk

During the survey, small quantities of solid non-biodegradable and hazardous wastes may be produced. These wastes will be created, handled and stored on the vessels in accordance with each vessel's Garbage Management Plan (GMP), which requires the disposal of waste ashore in an appropriately licenced facility and adopts the waste minimisation hierarchy to avoid waste releases to sea.

Solid non-biodegradable wastes include paper and cardboard, wooden pallets, scrap steel, metal, aluminium, paint can, glass and plastics and ropes. Hazardous wastes include hydrocarbon contaminated materials (e.g., oily rags, oil filters, hydraulic oils), batteries, empty paint cans, cleaning products, aerosol cans, fluorescent tubes etc.

The use of incinerators onboard is discussed in Section 6.5.

In normal circumstances, no impacts to the marine environment should occur. However, accidental release to the marine environment is possible especially in rough ocean conditions when items (e.g. packaging materials) may roll off or be blown from the deck. Sources of waste material that may be lost overboard are:

- Windblown material: While volumes may be small, materials such as plastic and packaging may impact marine fauna through ingestion, entanglement etc, resulting in mortality.
- Solid hazardous waste (e.g. paint cans containing paint residue, batteries) would be expected to settle on the seabed if dropped overboard. Over time, hazardous materials may leach into the seabed and surrounds, with the substrate becoming toxic and unsuitable for colonisation by benthic biota.
- Liquid hazardous wastes released to the ocean reduce water quality with either direct or indirect effects on marine organisms. Impacts would be limited to the immediate area surrounding the release, prior to the dilution with the surrounding seawater, potentially impacting plankton and local fish.

7.6.1.2 Physical, biological and socio-economic receptors

No socio-economic activity (such as commercial fishing) is predicted to be impacted by accidental waste disposal at sea, hence socio-economic receptors are not discussed further.

Buoyant materials floating near the surface such as plastics can impact seabirds, whales and turtles. Given the likely low abundance of listed threatened species within the OA (see Section 4) it is unlikely there will be individuals close to the vessel (given it is moving and emits noise). The worst-case impacts from a single low likelihood event of windblown material has been assessed as harm to a single animal (minor impacts).

Benthic habitats (e.g. corals, sponges and sediments) can be degraded from solid wastes smothering or leaching toxic components resulting in localised loss of biota (e.g. infauna).

Hazardous liquid wastes that degrade water quality through toxicity impacts, prior to dilution and dispersion to below effect concentrations, could result in the mortality of individual fish and local plankton populations.

7.6.2 Risk analysis and treatment

Table 7-26: Duration of impact and ALARP assessment technique regarding waste management and accidental loss overboard

Unplanned event: waste management and accidental loss overboard	
Duration of impact	**Short term impact <1 year**
ALARP assessment technique	**Good Practice context A decision which includes:** • **Legislation, codes and standards (LCS)** • **Good Industry Practice (GIP)** • **Professional Judgement (PJ)**

7.6.2.1 Context for setting standard control measures

Table 7-27 describes the context for setting the minimum controls.

Table 7-27: Context for setting standard control measures - waste management and accidental loss overboard

Compliance with legislative requirements: • **MARPOL Annex V and Marine Order 95 (Marine pollution prevention – garbage) 2018**
Compliance with Company and industry standards: • **APPEA CoEP: Reducing the impacts other marine life to a level which is ALARP and Acceptable**
Alignment with objectives and compliance with requirements of applicable management, recovery and /or conservation plans: • **The Recovery Plan for Marine Turtles in Australia 2017-2027 (DoEE 2017)** • **Conservation Management Plan for the Blue Whale, 2015-2025 (DoE 2015)** • **Balaenoptera borealis (sei whale) conservation advice (TSSC 2015a)** • **Balaenoptera physalus (fin whale) conservation advice (TSSC 2015b)** •

7.6.2.2 Potential impacts to biological and socio-economic receptors with standard controls

Impacts resulting from the routine management of sold or liquid hazardous and non-hazardous wastes are expected to be negligible, as there will be no planned discharge of solid wastes to the marine environment. Windblown waste would be rare as wastes will be stored in closed containers; hence volumes would be small but floating waste such as plastics etc. could be widely dispersed by local currents/winds, with potential to result in (individual) fauna mortality or injury through ingestion or entanglement.

Discharge of liquid and solid hazardous wastes have the potential to create a localised change in water quality and temporary ecological impacts. With the proposed management and discharge controls onboard in place, such incidents are considered unlikely and accidental volumes spilled are likely to be small, the impact recoverable and residual risk low.

The Marine Bioregional Plan for the North West Marine Region (DSEWPaC 2012) describes the threats from marine debris to marine life especially turtles and cetaceans. The Recovery Plan for Marine Turtles in Australia 2017-2027 (DoEE 2017) and Conservation Plan for Blue Whales (DoE 2015a) require the prevention, removal and mitigation of debris under the EPBC Act Threat

Abatement Plan (TAP) for Marine Debris on Vertebrate Marine Life For the purposes of the TAP, harmful marine debris refers to all plastics and other types of debris from domestic or international sources that may cause harm to vertebrate marine wildlife. This includes land-sourced waste and garbage (such as bags, bottles, ropes, fibreglass, piping, insulation, paints and adhesives), abandoned fishing gear from recreational and commercial fisheries (e.g. strapping bands, synthetic ropes, derelict fishing nets, floats, hooks, fishing line and wire trace), and ship-sourced, solid, nonbiodegradable floating materials disposed of at sea (e.g. fibreglass, insulation). It does not include debris that is not harmful to marine wildlife such as floating wooden objects and metal objects which do not cause entanglement and are unable to be ingested. Marine debris resulting from the legal disposal of garbage such as food, paper, rags, glass, metal and crockery at sea under the provisions of the International Convention for the Prevention of Pollution from Ships (MARPOL) are outside the scope of the TAP (DoEE 2018). Plastics are targeted particularly for their durability and cigarette butts for their ability to leach toxic compounds.

Control measures adopted within the survey to prevent wastes considered as 'marine debris' from entering the marine environment are contained within this EP and reflect the TAP Objective 1 to 'contribute to the long-term prevention of the incidence of harmful marine debris within the marine environment. All wastes, except those which are controlled by MARPOL (sewage and food-scraps, treated bilge waters– see Sections 6.6 and 6.7 and incinerated -see Section 6.5) are returned to shore for disposal in accordance with legislated requirements. Onshore disposal activities are documented via state waste manifesting systems.

7.6.3 ALARP treatment and evaluation

7.6.3.1 ALARP options

Additional controls which have been considered in reaching ALARP are listed in Table 7-28.

Table 7-28: ALARP options considered for waste management and accidental loss overboard

Control measures	Control type	Env benefit	Env benefit scale	Cost	Practicable and implemented	Rationale
Compliance with Marine Order 95 (Marine pollution prevention – garbage) 2018	**Administrative**	**Reduces likelihood of accidental loss of waste overboard**	**Minor (1-3%)**	**<0.5% project cost assuming vessel has an incinerator**	**Adopted**	**Sets out the requirements for garbage management plans and garbage record books**
Immediate removal of the garbage from the survey vessel to a shore-based facility	**Elimination**	**Reduces likelihood of accidental loss of waste overboard**	**Minor (1-3%)**	**5-10% of project cost**	**Not adopted**	**Prevents 'overboard' incidents** **This would result in additional fuel usage (emissions increase) and increased risk associated with the increased number of waste transfer events between vessels. Survey OA location and distances from onshore facilities, combined with the short duration of the Activity preclude this option. The additional impacts and risks are also not considered a practical alternative to secure storage on the survey vessel.**

7.6.3.2 Demonstration of ALARP

Table 7-29: Demonstration of ALARP for waste management and accidental loss overboard

Criteria	Demonstration
Legislation, codes and standards	**Compliance with:** ***Protection of the Sea (Prevention of Pollution from Ships) Act 1983*** **Marine Order 94 (Marine Pollution Prevention – Packaged Harmful Substances)** **Marine Order 95 (Marine Pollution Prevention – Garbage)** **MARPOL Annex V Garbage Record Book Marine Notice 2017/03 and the MARPOL Annex V Discharges Marine Notice 2017/04** **Shipboard incineration compliant with MARPOL Regulation 16.1 - 9**
Good industry practice	**Eliminate:** **Not having the survey or minimising the number of vessels further is not practical or acceptable** **Substitute: None identified** **Engineer: None identified.** **Isolate: None identified** **Administrative:** **Garbage Management Plans- vessels adopt the waste minimisation hierarchy which considers waste elimination, followed by reduction, recycling and treatment/disposal. Waste generation is eliminated wherever possible.** **Administrative controls are in place such as all wastes are containerised (with lids), labelled and stored in dedicated areas, waste storages are routinely inspected for housekeeping standards etc.** **All personnel are inducted into these requirements during vessel induction.**
Professional Judgement	**Alternate controls identified and implemented where practicable. Controls adopted cover multiple levels on the control hierarchy.**
Cost-based analysis	**Not applicable to decision-making criteria for making a Good Practice context A decision**
Societal values	**Not applicable to decision-making criteria for making a Good Practice context A decision**

7.6.4 Demonstration of acceptability

The residual impact is evaluated against the pre-set acceptability criteria in Table 7-30.

Table 7-30: Demonstration of acceptability criteria for waste management and accidental loss overboard

Acceptability criteria	Acceptable level of impact	Demonstration of acceptability
External context: **ESD principles:** **The following core objectives have been incorporated:** **To protect biological diversity** **Maintain essential ecological processes and health**	**Evaluation of the relevant aspects of the local receiving environment and petroleum activity have been considered in the evaluation of impacts from accidental loss of waste overboard.**	**The necessary controls have been adopted to prevent the accidental loss of waste overboard.**
External Context: Australian Marine Park Management Plans, Species Recovery Plans and Conservation Advices	**Residual risks posed by accidental loss of waste overboard during the survey are consistent with the relevant management plans and advices.** **Marine Bioregional Plan for the North West Marine Region (DSEWPaC 2012)** **Recovery Plan for Marine Turtles 2017-1027 (DoEE 2017)** **Conservation Management Plan for the Blue Whale 2015-2025 (DoE 2015a)** **The Marine Bioregional Plan for the North West Marine Region (2012) states marine debris is *of concern* or *of potential concern* for multiple conservation values in the region, because of the vulnerability of the region to the pressure, and because it is listed under the EPBC Act as a key threatening process**	**Measures adopted in this EP for vessel waste management are consistent with the objectives and actions outlined in the relevant recovery and conservation plans for marine turtles and blue whales respectively (Section 4).** **With these control measures in place, there are no direct effects on EBPC Act listed matters of national environmental significance and the KEF - Carbonate banks and Terrace system of the Sahul Shelf Marine Park management values.**

Internal context - **Policy compliance:** **SapuraOMV's policies and HSE MS** **Env impact demonstrated to be ALARP**	**The impact management strategy and controls are consistent with SapuraOMV's corporate environmental policy, culture and company standards and procedures.** **In demonstrating ALARP – options must be considered and the cost benefit analyses used to determine if they should be adopted.**	**The risk management strategy for waste management onboard reflects SapuraOMV's Environment Policy goals of preventing harm to the environment by reducing risk to** **ALARP, complying with applicable legal and industry standards, and continually improving environmental performance.** **Section 8 demonstrates the HSE MS can meet the requirements of this EP.**
EPO is achievable and consistent with achieving acceptable performance	**The EPO states:** **No accidental release of waste overboard during the Gem 3D MSS.**	**Short duration of survey and small volumes of waste readily manageable through good housekeeping and no accidental release of waste overboard is considered inherently acceptable.**
Legislative criteria & standards	**This EP complies with requirements of:** ***Navigation Act 2012*** ***Protection of the Sea (Prevention of Pollution from Ships) Act 1983*** **Marine Order 94 (Marine Pollution Prevention – Packaged Harmful Substances)** **Marine Order 95 (Marine Pollution Prevention – Garbage)** **The APPEA Code of Environmental Practice (2008) objectives are met for this offshore seismic survey with respect to reducing the impacts to marine life to a level which is ALARP and acceptable.**	**This legislation has been used in the development of the management controls necessary to reduce the risk of accidental loss of waste overboard to ALARP.** **With control measures implemented This Environment Plan meets the ALARP criteria (Section 7.6.3) as required by SapuraOMV, OPGGS Act and APPEA CoEP.**
External Context: Stakeholder Expectations	**The merit of stakeholder concerns and objections have been assessed and controls adopted to reduce risks to ALARP.**	**There are no outstanding objections or claims regarding wastewater discharges and none with merit were raised during initial consultations and remain unresolved.**

Environmental risk demonstrated to be ALARP	**The risk of losing waste overboard has been reduced to a level that is ALARP.**	**The process outlined in Section 5 for reducing risks to ALARP has been implemented for the risk of accidental loss of waste overboard and has been demonstrated above. The cost of introducing further controls is grossly disproportionate to any small environmental benefit.**
ESD principles	**The following core objectives of ESD have been incorporated:** **To protect biological diversity** **Maintain essential ecological processes and life support systems.**	**The environment is highly dispersive and will rapidly dilute liquid materials and disperse buoyant materials. Solid, non-buoyant wastes will settle to the seabed. Localised effects are predicted to non-protected species (e.g. fish and immobile plankton and porifora) which are widespread in the region.** **There is no threat of serious or irreversible environmental damage or significant impact to biological diversity and ecological integrity is maintained should an accidental discharge occur.** **The impact assessment presented throughout this EP demonstrates compliance with the principles of ESD.**

7.6.5 Risk level

Consequence	Likelihood	Risk
Negligible: temporary term (days-weeks) impact to fauna, flora within the OA.	**Remote**	**Very Low**

7.6.6 EPO, additional controls, performance standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for waste management and accidental loss overboard are presented below in Table 7-31.

Table 7-31: Summary of controls for waste management and accidental loss overboard

EPO	Control measure	Env Performance Standards	Measurement criteria
EPO R5: No accidental release of waste overboard during the Gem 3D MSS	**Compliance with the requirements of:** ***Protection of the Sea (Prevention of Pollution from Ships) Act 1983*** • **Marine Order 94 (Marine Pollution Prevention – Packaged Harmful Substances)** • **Marine Order 95 (Marine Pollution Prevention – Garbage)**	**EPS R32: The vessels will operate under Vessel Garbage Management Plans (applicable to vessels >100 T or certified to carry more than 15 people).** **The Garbage Management Plan incorporates the requirements of IMO Resolution MEPC. 219(63) with respect to waste minimisation and garbage handling; and the restrictions on disposal of solid and hazardous waste (reflecting MARPOL Annex V).**	**Records verify that survey vessel Garbage Management Plans meet these IMO requirements** **Incident records verify no incidents of waste lost overboard**
		EPS R33: Handling of waste on-board the survey vessels in line with the Regs to ensure: • **No discharge of general operational or maintenance wastes or plastics or plastic products of any kind.** • **Waste containers are covered with tightly fitting, secure lids to prevent any solid wastes from blowing overboard.** • **All solid, liquid and hazardous wastes (other than bilge water, sewage and food wastes) are appropriately treated (eg incinerated or compacted if possible) and stored in designated areas before being sent ashore for recycling, disposal or treatment.** • **Any liquid waste storage on deck must have at least one barrier (i.e. bunding) to prevent deck spills entering the marine environment. This can include containment lips on deck (primary bunding) and/or secondary containment measures (bunding, containment pallet, transport packs, absorbent pad barriers etc.) in place.** • **Correct segregation of solid and hazardous wastes in labelled dedicated areas.**	**Inspection records verify that waste is stored and handled to prevent overboard incidents.**

	MARPOL Annex V Garbage Record Book Marine Notice 2017/03 and the MARPOL Annex V Discharges Marine Notice 2017/04	EPS R34: The vessels will maintain Garbage Record Books (applicable to vessels >400 T or certified to carry more than 15 people engaged in international voyages). Books log permitted discharges to sea, onshore facilities and other vessels as well as accidental overboard loss.	MARPOL Annex V Garbage Record Book Marine Notice 2017/03 and the MARPOL Annex V Discharges Marine Notice 2017/04
	Shipboard incineration compliant with MARPOL Regulation 16.1 - 9 • Incinerator specs • Permitted waste that may be burnt • Operator training requirements • Required temperatures for complete incineration	EPS R35: Incinerator and use compliant with MARPOL and IMO requirements and operated in accordance with established operating procedures that align with manufacturers' specifications.	IAAP certificate verifies incinerator is IMO approved and garbage burnt is permitted. Manufacturers Specification and Operating Procedures are available for incineration activities.
		EPS R36: Crew members are inducted into garbage management procedures to minimise the potential for unpermitted wastes being discharged overboard and to ensure effective waste segregation.	Induction records verify that all crew personnel are aware of these requirements.

8 Implementation strategy

As required by Regulation 14 of the OPGGS(E) Regulations, this section of the EP describes the implementation strategy for the Gem 3D MSS.

8.1 SapuraOMV health, safety and environmental management system

All SapuraOMV activities, including the Gem 3D MSS, are undertaken consistently with the SapuraOMV Health, Safety and Environmental (HSE) Policy and HSE Management System (HSEMS) (HSE-MM-MAN-0001). The purpose of the HSEMS is to provide clear direction on managing HSE related risks, impacts or threats associated with its core business as an exploration and production company.

SapuraOMV HSE objectives are to:

- continuously provide a workplace:
  - that is free from injury or illness
  - that promotes a healthy workplace and mitigates significant health risks
  - that has minimum environmental footprint
- continuously enhance operational integrity and safe behaviours through a continual focus on minimising HSE risks.

The HSEMS applies to all phases of SapuraOMV business activities and to contractors that operate within SapuraOMV management and/or control of activities. In other instances, an agreed bridging document outlines the relevance of the HSEMS to those contractor management systems.

The HSEMS is built on four fundamental management principles:

- Leadership
- Risk management
- Effective implementation
- Continuous improvement.

These fundamental management principles are described in detail in the HSEMS.

The HSEMS framework shown in Figure 8-1 supports the implementation of these principles and comprises the following:

- Policies: SapuraOMV's HSE Policy is provided in Figure 8-2.
- Elements and expectations: there are ten HSEMS Elements that provide high level guidance on HSE requirements (Table 8-1). Expectations are statements within HSEMS Elements stating an anticipated outcome of HSEMS implementation.
- Management system standards: Standards covering areas such as auditing, risk assessment, incident notification, incident investigation, management of change (MoC) and the like that define requirements to meet the expectations of the HSEMS Elements.
- Hazard management standards: Standards that define the requirements for managing hazards associated with their activities. For example, they cover topics such as waste management, sulphide management and working at heights.
- Australian procedures: Procedures that support Australian specific activities and are aligned with the HSEMS expectations and comply with regulatory requirements. The following procedures support the current activity:
  - Risk Management Procedure AU-HS-PRO-001-1.0
  - Training and Competency Procedure AU-HS-PRO-002-1.0

- Management of Change Procedure AU-HS-PRO-003-1.0
- Contractor Management Procedure AU-HS-PRO-004-1.0
- Incident Investigation and Reporting Procedure AU-HS-PRO-005-1.0
- Document and Records Management Procedure AU-HS-PRO-007-1.0
- Health, Safety & Environment Assurance Procedure AU-HS-PRO-008-1.0

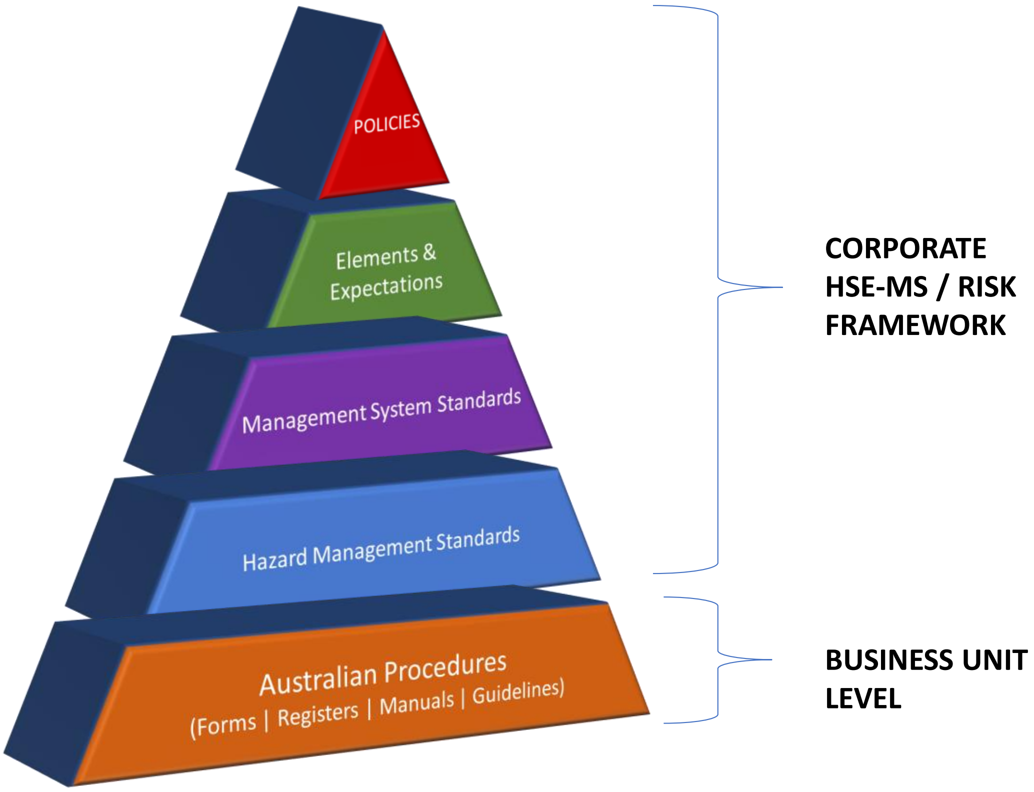


Figure 8-1: HSEMS framework

Health, Safety and Environmental Policy

SapuraOMV Upstream Sdn. Bhd. recognizes that implementing good Health, Safety & Environmental (HSE) management is critical to achieving, maintaining and continually improving operational excellence for long term business sustainability.

In line with this aspiration, we shall comply with all applicable HSE legal requirements and other requirements in the country we operate.

We remain committed towards prevention of work place injuries, occupational illnesses, property damages and minimizing our impact on the environment through pollution prevention, emissions reduction and waste recycling by:

- establishing, implementing and improving Health, Safety and Environmental Management System (HSEMS) to ensure continual improvement in HSE management and performance;
- managing all HSE risks associated with our business activities and provide control measures to eliminate or reduce all HSE risks to as low as reasonably practicable (ALARP) to our employees, subcontractors, vendors, stakeholders, and to the environment;
- demonstrating leadership commitment, assuring responsibility and accountability at management and supervisory levels in championing HSE initiatives and ensuring compliance with HSE policies and procedures;
- periodically measuring and reviewing HSE performance against HSE objectives and standards;
- ensuring asset integrity and reliability of facilities, equipment and processes to safeguard our people, the environment, our asset and our reputation;
- incorporating HSE performance indicator targets for senior management staff and all employees;
- providing adequate resources including competent human resources to achieve HSE objectives;
- continually developing our employees' skills and competencies through training opportunities;
- encouraging a proactive intervention culture and transparency in HSE reporting as an integral part of our HSE best practice; and
- communicating the essence and intent of this policy to our employees and other stakeholders.

SapuraOMV Upstream Sdn. Bhd. employees and other stakeholders including subcontractors, vendors, suppliers and visitors shall remain fully committed to achieving the objectives of this policy.

MAMDOUH RADAWI	MUHAMMAD ZAMRI JUSOH	WOLFGANG STOCK
Chief Operating Officer	Chief Executive Officer	Chief Financial Officer

22nd July 2019

Figure 8-2: SapuraOMV HSE Policy

Table 8-1: HSEMS Elements

Element	Purpose
1 – Commitment and accountability	**Supports the development of a SapuraOMV culture and individual behaviours that recognise operating responsibly is expected. It underpins the Leadership Management Fundamental by establishing:** • **personal commitment on the part of all the organisations managers and workers to apply the HSEMS to achieve business policies and objectives** • **accountability based on well-defined authority levels, acceptance of decision making and a clear understanding of job responsibilities to deliver results.**
2 – Policies, standards and objectives	**Ensures appropriate policies are in place to define the expected outcomes of HSE implementation including:** • **limiting risk exposure** • **providing commitments and boundaries to guide activities and priorities and define success criteria** • **assisting SapuraOMV to meet or exceed regulatory requirements and other voluntary commitments to which the organisation subscribes and setting responsible expectations where regulatory requirements do not exist.**
3 – Organisation, resources and capability	**Ensures SapuraOMV is clear about who does what, has everything needed in place and that the necessary skills and experience area applied by:** • **describing how SapuraOMV is structured to deliver its planned objectives effectively and efficiently** • **establishing relationships and verifying controls to maintain sufficient and effective supply of goods and services** • **ensuring the capability of managers and workforce is supported by appropriate levels of competence, fitness and behaviour to work effectively.**
4 – Stakeholders and customers	**Develop effective relationships with stakeholders and customers, including:** • **forming open and sustainable relationships to address issues of mutual interest or concern across the lifecycle of activities and products** • **confirming SapuraOMV has identified and clearly communicated relevant risks that need to be understood, addressed and managed** • **verifying that the SapuraOMV's products and services meet the expectations of its customers in terms of quality, performance and technical support.**
5 – Risk assessment and control	• **To identify, assess and treat risks related to SapuraOMV's activities. Where eliminating risks is not feasible, risk controls are defined to reduce risks to an acceptable level.** • **To ensure identifications, assessment and treatment of risk considers all potentially affected parties, including external stakeholders.**

6 – Asset design and integrity	**To ensure assets are designed and constructed (or selected) to be suitable for their purpose or task. They should then be operated, inspected and maintained to achieve and sustain robust standards of integrity and performance throughout their lifecycle.**
7 – Plans and procedures	**To establish how to prepare and document plans and procedures identified as necessary to manage SapuraOMV's risks and opportunities. Plans and procedures integrate the results of the risk assessments to prepare for executing work and implementing risk controls/barriers.**
8 – Execution of activities	**Ensure that authorised and competent persons, as defined in plans and procedures, consistently execute activities and associated risk controls with discipline.**
9 – Monitoring, reporting and learning	**Aims to:** • **monitor effectiveness of the HSEMS and act on reliable and accurate data from, for example, incidents, events, near misses, emissions, process excursions, status of actions, inspections, observations, grievances, surveys and non-conformances** • **report data and information (e.g. leading and lagging indicators) that provide a clear understanding of performance to meet both company and stakeholder needs** • **investigate events and analyse data and information to identify causes and suitable actions to address weaknesses and opportunities for improvement** • **actively seek positive learning from activities, feedback, innovation and experience** • **ensure immediate learnings and corrective actions are applied and communicated.**
10 – Assurance, review and improvement	**To systematically assess and review the HSEMS to ensure effectiveness, suitability and fitness-for-purpose is sustained and improvement plans are developed at each level of the organisation.**

8.2 Ongoing consultation

Subregulation 14(9) of the OPGGS(E) Regulations specifies that the implementation strategy must provide for appropriate consultation with relevant authorities of the Commonwealth, state or territory, and other relevant interested persons or organisations (see Section 3, relevant persons or organisations).

In addition to the consultation process undertaken during the preparation of this EP, SapuraOMV will also provide for appropriate consultation up to and during the Gem 3D MSS. The following will apply as part of the ongoing consultation process:

- SapuraOMV will maintain a dedicated email address to enable ongoing communication by stakeholders throughout the Gem 3D MSS (Gem3D@searcherseismic.com).
- SapuraOMV will provide notifications to relevant persons at key project milestones in accordance with Table 8-3, Section 8.10.1 of this EP.
- If SapuraOMV becomes aware of a change in the potential to affect a relevant person or organisation's functions, interests or activities, or the control measures identified in this Environment Plan are found to be less adequate than currently understood, SapuraOMV will

contact the relevant person(s) concerned and provide appropriate information regarding the change and provide reasonable time for responses and to address any new concerns that arise.

- If SapuraOMV becomes aware of the potential to affect a relevant person’s functions, interests or activities at any time during the survey that was not identified prior to commencing the Gem 3D MSS, SapuraOMV will immediately attempt to contact and consult with the relevant person(s).
- If consultation identifies a significant new environmental impact or risk for the Gem 3D MSS (Figure 3-1), or a significant increase in an already identified impact or risk, the Management of Change process will be triggered (Section 8.11).

SapuraOMV will continue to provide updates and advise of any material changes to the Gem 3D MSS as planning and implementation processes progress. Following the public comment period and NOPSEMA acceptance of the final EP, the accepted Environment Plan and appendices (other than those containing sensitive material), will be published on NOPSEMA’s website. A summary of the Relevant Persons Consultation Report will be included.

8.3 Organisational structure, roles and responsibilities

8.3.1 Chain of command

The organisational structure and chain of command for the Gem 3D MSS is in Figure 8-3. Roles and responsibilities relevant to the Gem 3D MSS and the implementation of this EP are in the sections that follow.

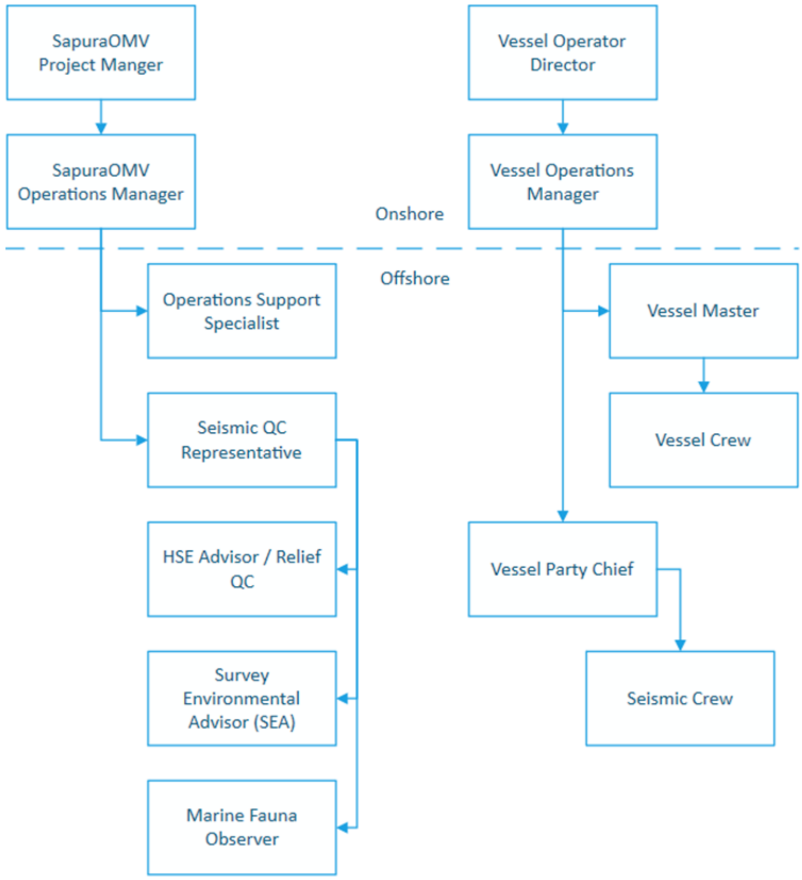


Figure 8-3: Chain of command for the Gem 3D MSS

8.3.2 SapuraOMV

8.3.2.1 SapuraOMV Project Manager

- Has overall responsibility and accountability for meeting SapuraOMV's exploration permit commitments to Australian government regulators and monitoring and maintaining company performance standards to those expected by both regulators and company executives.

8.3.2.2 SapuraOMV Operations Manager

SapuraOMV has contracted the expertise of Searcher Seismic to support the Gem 3DMSS (see Section 1.2). The nominated Liaison Person for this Environment Plan is Searcher Seismic's Operations Manager who will also act as the SapuraOMV Operations Manager, to ensure that:

- All statutory approvals have been obtained and are adhered to for the Gem 3D MSS
- The HSEMS is implemented
- Sufficient resources are available to meet the environmental performance outcomes in this EP, including for emergency situations
- Contractor personnel are competent to fulfil their designated roles
- Environmental impacts and risks associated with the Gem 3D MSS have been identified and any new or increased impacts or risks are managed via the SapuraOMV Management of Change Procedure (AU-HS-PRO-003-1.0)
- Ongoing stakeholder consultation is undertaken for the duration of the Gem 3D MSS
- Compliance assurance activities are conducted for the Gem 3D MSS
- Reporting and notification activities described in this EP are completed within the required timeframes.

8.3.2.3 Operations Support Specialist

The Operations Support Specialist:

- Provide support, environmental assistance, project management,
- Report co-ordination, government and third-party liaison for company
- Operations activities, including preparation of approvals documentation and stakeholder consultation.

8.3.2.4 SapuraOMV Offshore QC Representative

The SapuraOMV Offshore Representative is responsible for:

- Ensuring the Gem 3D MSS is carried out in accordance with regulatory requirements and this EP
- Acting as SapuraOMV's offshore representative, relaying instruction from company management to the crew, monitoring data quality and operational productivity.
- Reporting to SapuraOMV, daily, the operational performance (including any incidents), regulatory compliance, HSE statistics, 24 hour look ahead and data quality issues.
- Acting as the lead representative and main conduit for communications between offshore contractor management and SapuraOMV's onshore project team.

8.3.2.5 Survey Environmental Advisor (SEA)

The Survey Environmental Advisor is responsible for:

- Ensuring new or increased impacts or risks identified during the Gem 3D MSS are managed via the SapuraOMV Management of Change Procedure (AU-HS-PRO-003-1.0)
- Chemicals that will or may be discharged offshore are assessed prior to use
- Vessel personnel complete an environmental component of the Gem 3D MSS project induction
- Ensuring that environmental monitoring identified in Section 8.6 is conducted and recorded
- Maintaining records that demonstrate compliance with this EP
- HSE issues are communicated via systems such as the daily report and daily pre-start meetings
- Environmental incidents are managed and reported to the Offshore QC Representative, for subsequent reporting as described in Section 8.10
- Spill response requirements are implemented in accordance with the OPEP
- Monitoring and reporting on the compliance of all EP commitments, through observations and assessments of performance against stated criteria.
- Gathering evidence to support compliance or, as may be required, to document any and all breaches of the EP commitments.
- Ensuring all criteria in the EP Compliance Register are assessed at the recommended intervals for each item.
- Holding a dual role as part-time MFO to support the dedicated MFO during breaks etc.
- Reporting to the Seismic QC Representative for daily operational and reporting matters.
- Preparing weekly and survey close-out reports for NOPSEMA using the applicable notification and reporting forms for the activity.

8.3.2.6 HSE Advisor/Relief QC

SapuraOMV will assign a Health, Safety and Environmental (HSE) Advisor to:

- Monitor vessel HSE performance and compliance with the activity Project HSE Plan, SapuraOMV's HSE Management System and recognised industry standards.
- Relieve the SapuraOMV Offshore QC Representative during break and off-shift periods.
- Report to the SapuraOMV QC Representative (but has the authority to shut down any unsafe acts observed).

- Notify the SapuraOMV Operations Manager in the event of an oil spill or other safety or environmental non-conformance.

8.3.2.7 Marine Fauna Observer

Marine fauna observers are responsible for ensuring:

- They conduct visual observations for marine fauna during the Gem 3D MSS in accordance with the requirements of this EP
- Immediately notifying the Vessel Master and/or Party Chief of relevant marine fauna sightings
- Maintaining records that demonstrate compliance with the marine fauna observation requirements in this EP, including filling in a sightings database for submission to government and SapuraOMV on survey completion.

8.3.3 Vessel contractor

8.3.3.1 Vessel Operations Manager

The Vessel Operations Manager is responsible for ensuring:

- Compliance with all SapuraOMV requirements for the survey, including the requirements of this EP relevant to survey vessel activities
- That all relevant HSE documentation is in place for the vessel, according to the company's HSEMS requirements
- A current Emergency Response Plan (ERP) and Shipboard Oil Pollution Emergency Plan (SOPEP) are in place
- The vessel's compliance with all company standards, policies and procedures
- Incidents are thoroughly investigated (including performing root-cause analyses if required), with corrective actions logged, completed and closed out
- Vessel inspections are reviewed, non-conformances are investigated, and corrective actions completed
- Ownership of the vessel's HSE statistics and leading and lagging indicators of HSE performance.

8.3.3.2 Vessel Master

The Vessel Master is responsible for ensuring:

- Vessel operations are conducted in accordance with legislative requirements and this EP, including compliance with maritime law
- Vessel-related inspections, emergency drills, training and inductions are undertaken
- Calibration and maintenance of equipment and records meet statutory requirements
- The vessel's ERP, SOPEP and the OPEP are implemented as appropriate in the event of an oil spill.

8.3.3.3 Party Chief

The Party Chief will be located on the vessel and is responsible for the direction, oversight, logging and reporting on the day-to-day conduct of the survey. The Party Chief is responsible for ensuring:

- Safe execution of all operations carried out by the seismic operators and technicians onboard the vessel
- Seismic operations are conducted in accordance with the SapuraOMV HSEMS and this EP
- Control measures adopted within this EP relating to operation of the seismic source are implemented (e.g. pre-watch, soft-start procedures, etc.)
- Equipment calibrated and maintained in accordance with manufacturers specifications or the vessel preventative maintenance system
- Records are maintained for marine equipment testing and inspections

- Ensuring that non-conformances, near misses and incidents are reported in accordance with Section 8.10.

8.3.3.4 Gem 3D MSS All offshore personnel

All offshore personnel are responsible for ensuring:

- They complete the Gem 3D MSS induction
- They participate in emergency drills and exercises required during the Gem 3D MSS
- Any near misses or incidents are immediately reported to their line supervisor.

8.4 Contractor management

SapuraOMV's Contractor Management Procedure (AU-HS-PRO-004-1.0) outlines the process for contractor management, from tendering, to contract award and execution of the Gem 3D MSS.

The requirement to comply with this EP will be included in contracts for the Gem 3D MSS. Prior to contract award, contractors are required to demonstrate they have a health, safety and environment management system in place that provides a systematic approach for meeting SapuraOMV's requirements, and the requirements in this EP, including the OPEP (Appendix H).

During the Gem 3D MSS, contractor personnel are required to attend an induction that covers aspects of this EP and ensures they are aware of their environmental responsibilities. Contractor performance is assessed via inspections and monitoring key performance indicators (KPIs) relevant to their scope of work.

8.5 Training and competency

SapuraOMV implement Training and Competency Procedure AU-HS-PRO-002-1.0 to ensure training and competency requirements are tracked. Contractors are required to have their own systems and procedures for ensuring their personnel have the necessary training and competency to perform their role. SapuraOMV and their contractors are required to maintain training and competency records.

Training and competency requirements specific to this EP are:

- Gem 3D MSS induction that covers environmental requirements in this EP and facilitates general environmental awareness
- MFOs will have:

– UK Joint Nature Conservation Committee (JNCC) accreditation (or equivalent); and

– at least one year (minimum four surveys) previous MFO experience.

The training and competency requirements for personnel with responsibilities in oil spill response are outlined in the Vessel SOPEP and the OPEP.

8.6 Monitoring and record keeping

SapuraOMV will undertake regular monitoring of its environmental performance during the Gem 3D MSS in accordance with the Gem 3D MSS EP Compliance Register described in Section 8.7. In particular, SapuraOMV will maintain a quantitative record of emissions and discharges as required under Regulation 14(7) of the OPGGS(E). This record will include all emissions and discharges to the air and water and can be monitored and audited against the environmental performance standards. Table 8-2 outlines the proposed monitoring, auditing and reporting program that will be implemented for the Gem 3D MSS.

Table 8-2: Summary of monitoring and record-keeping for the Gem 3D MSS

Environmental aspect or activity	Monitoring requirement	Records	Reporting
Underwater sound from seismic array	**Adherence to EPBC Policy Statement 2.1 Part A Standard Management Procedures and specific Part B Additional Management Procedures, as specified in Section 6.2** **Application of defined precaution zones**	**Start-up delays, power downs or stop work procedures instigated as a result of cetacean sightings**	**MFO Final Report** **If incident breaches relevant EPO or EPS – recordable environmental incident** **If incident involves injury or death to EPBC listed species – reportable environmental incident** **Post-survey Environmental Review Report**
	Marine fauna sightings	**Cetacean sighting records (CSA database)** **Turtle sightings**	
	Additional ALARP controls described in Section 6.2	**MFO data sheets** **Vessel log** **Survey log**	
Physical presence of survey vessels	**Any incidents involving negative interactions with commercial fishing vessels communications with other commercial fishers in the area** **Communications with commercial fishers in the OA**	**Vessel log** **Communication log** **Survey logs**	**SapuraOMV incident report** **If incident breaches relevant EPO or EPS – recordable environmental incident** **Post-survey Environmental Review Report** **If incident involves damage to commercial fishing gear within the OA or other negative interactions – reportable environmental incident**
	Any incidents involving negative interactions with commercial shipping **Communications with other marine users in the OA**		
	Additional ALARP controls described in Section 6.3		
Underwater sound emissions from survey vessels	**ALARP controls described in Section 6.4**	**Vessel log** **Survey log** **MFO data sheets**	**MFO final report** **Post-survey Environmental Review Report**

Light emissions from survey vessels	Assessments of whether lighting is at minimum level required for safe operation and navigation	Records of periodic assessments by Vessel Master, or delegate	Post-survey Environmental Review Report
Atmospheric emissions from survey vessels	ALARP controls described in Section 6.6	Vessel log Engine room log	Post-survey Environmental Review Report
Discharge of sewage, grey water and food waste from survey vessels	Discharge location Quantities discharged Discharge parameters (vessel speed; discharge rate)	Vessel log Engine room log	Post-survey Environmental Review Report If incident breaches relevant EPO or EPS – recordable environmental incident
	Additional ALARP controls described in Section 6.7		
Discharge of bilge water, deck drainage, cooling water and brine from survey vessels	Discharge location Quantities discharged Treatment of potentially contaminated water prior to discharge	Vessel log Engine room log	Post-survey Operations Report (internal) If incident breaches relevant EPO or EPS – recordable environmental incident
	Additional ALARP controls described in Section 6.8		
Introduction of invasive marine species	Ballast water discharge occurrences and locations	Vessel log Ballast water record book IMS risk assessment report or inspection records Anti-foulant treatment records/certification for survey and support vessels Records of survey and support vessel movements immediately prior to the Gem 3D MSS	Post-survey Operations Report (internal) Post-survey Environmental Review Report If incident breaches relevant EPO or EPS – recordable environmental incident
	Management of biofouling		
	Additional ALARP controls described in Section 7.2		

Collision between survey equipment and marine fauna	Any interactions between marine fauna and survey vessels Any incidents involving turtle entanglement in tail buoys Additional ALARP controls described in Section 7.3	Support vessel/towed equipment and marine fauna interaction records Vessel log MFO records	SapuraOMV incident report If incident involves injury or death to EPBC listed species – reportable environmental incident If incident breaches relevant EPO or EPS – recordable environmental incident Post-survey Environmental Review Report MFO Final Report
Equipment grounding and emergency anchoring	No planned anchoring Impacts to seabed through damage, dragging or loss of towed seismic array Attempts to recover lost equipment Additional ALARP controls described in Section 7.4	Vessel log Survey log	SapuraOMV incident report If incident involves loss of a streamer and associated equipment – recordable environmental incident If incident breaches relevant EPO or EPS – recordable environmental incident Post-survey Environmental Review Report
Hydrocarbon release	Any incidents involving vessel collisions Spill location Volumes of fuel/oil spills Spill response activities Communications with other marine users in the OA Additional ALARP controls described in Section 7.5	Vessel log Bunkering records Communication logs Type I Operational Monitoring records – vessel visual observations of surface slicks; GPS tracking data; modelling outputs; GIS mapping	SapuraOMV incident report Spill >80 L – reportable environmental incident If incident involves an oil spill leading to acute or chronic effects on, or smothering of, marine fauna and/or habitats – reportable

		Type II Scientific Monitoring records as appropriate	environmental incident If incident breaches relevant EPO or EPS – recordable environmental incident Post-survey Environmental Review Report Incident report (including SITREP and POLREP) to AMSA
Loss of waste overboard	Discharge location Quantities and types of materials accidentally discharged Attempts to recover lost objects Additional ALARP controls described in Section 7.6	Vessel log Incident reports	SapuraOMV incident report Release/discharge >80 L – reportable environmental incident (external – NOPSEMA; Section 8.8.2) If incident breaches relevant EPO or EPS – recordable environmental incident Post-survey Environmental Review Report
Training	Details of crew environmental inductions	Induction attendance record sheets Induction materials	Internal Post-survey Environmental Review Report
Incident reporting	Number and details of environmental incidents	SapuraOMV HSE incident reports	Internal Post-survey Environmental Review Report
Conformance reporting	Conformance with EPOs, EPS' and commitments listed on the Environmental Commitments Register	Completed environmental inspection/audit check sheet	Internal Post-survey Environmental Review Report

8.7 Environmental assurance

SapuraOMV implements the risk-based assurance process HSE Assurance Procedure AU-HS-PRO-008-1.0 to monitor and manage:

- Conformance with HSEMS expectations
- Organisational capability
- Effectiveness of the HSEMS in meeting objectives, stakeholder and business needs.

In keeping with the above, a Gem 3D MSS EP Compliance Register (CR) will be drafted for use by the SEA during the Gem 3D MSS to log and gather evidence of compliance with all EP commitments. The CR will be the primary source of compliance monitoring and can be submitted to NOPSEMA in the event of a compliance audit. Routine inspections will be undertaken onboard survey vessels as part of this process, and the results, findings, actions and learnings that arise from all assurance activities will be recorded and any corrective actions identified and tracked to closure.

8.8 Management of non-conformances

If non-conformances are identified during environmental monitoring, assurance or performance monitoring, they will be elevated to the SapuraOMV Operations Manager, investigated, corrective actions developed and tracked until close-out.

8.9 Emergency Response

The survey vessel will have a vessel-specific Emergency Response Plan (ERP) and SOPEP. In addition, an OPEP has been developed for the Gem 3D MSS, in accordance with Regulation 14(8) of the OPGGS(E) Regulations. The OPEP is provided in Appendix H and describes the spill response framework, response strategies, response organisation, equipment and resources, exercises and drills, and mobilisation of the SapuraOMV Incident Management Team (IMT).

As described in the OPEP, AMSA is the Control Agency for marine pollution events in Commonwealth waters and will therefore direct and lead the spill response arrangements and monitoring requirements in the event of a significant marine oil spill. The vessel SOPEP is the principal response document for the vessel in the event of an oil spill, providing specific response provisions to contain onboard spills or mitigate oil spills originating from the vessel. Specific emergency procedures include steps to control discharges for bunkering spills, hull damage, fire and explosions, collisions, tank failure, sinking and vapour release.

SapuraOMV will review the vessel ERP and SOPEP prior to mobilisation to ensure they meet the requirements for emergency and oil spill response in this EP. The ERP, SOPEP and OPEP will be tested prior to commencement of the survey.

The feasible spill response options identified in the OPEP are limited to source control, monitoring and evaluation, and (possibly) oiled wildlife recovery. Vessel activity associated with these responses would present the same impacts and risks assessed for survey operations in Sections 6 and 7 and is not expected to introduce additional hazards to the marine environment or to result in significant additional potential impacts to those previously described.

8.10 Environmental notifications and reporting

8.10.1 Notifications

Environmental notifications relevant to the Gem 3D MSS include those that are required under the OPGGS(E) Regulations, those requested by relevant persons during the formal consultation

period and those that SapuraOMV have committed to (Table 8-3) The notification process in event of oil spills are described in the Gem 3D MSS OPEP (Appendix H).

Table 8-3: Notification requirements for the Gem 3D MSS

Relevant person or organisation	Responsible	Notification	Method	Timing
Prior to Gem 3D MSS commencing				
Commonwealth NOPSEMA	**SapuraOMV Operations Manager**	**Notice of commencement of Gem 3D MSS.** **Email: submissions@ nopsema.gov.au**	**Written**	**At least ten days prior to mobilisation**
Commonwealth Australian Maritime Safety Authority	**SapuraOMV Operations Manager**	**Notice to the Joint Rescue Coordination Centre (JRCC) of estimated mobilisation date and details to enable AusCoast warning broadcasts to be issued.** **Email: rccaus@amsa.gov.au** **Phone: 1800 641 792 or +61 2 6230 6811.** **Information required includes vessel details (name, callsign and Maritime Mobile** **Service Identity (MMSI)), satellite communications details (INMARSAT-C and satellite telephone), area of operation, requested clearance from other vessels and when operations start and end.**	**Written/ verbal**	**24-48 hours prior to mobilisation**
Commonwealth Department of Defence/ Australian Hydrographic Office	**SapuraOMV Operations Manager**	**Notice of the estimated mobilisation date to enable the promulgation of Notice to Mariners.** **Email: datacentre@hydro. gov.au**	**Written**	**No less than four working weeks before operations commence**
Commonwealth Department of Environment and Energy, Director of National Parks	**SapuraOMV Operations Manager**	**Change of survey details.** **Email: marineparks@ environment.gov.au**	**Written**	**As soon as practicable after the EP is approved**
Western Australian Department of	**SapuraOMV Operations Manager**	**Notice prior to commencement confirming**	**Written**	**Prior to mobilisation**

Mines, Industry Regulation and Safety		the start date of the proposed activity. Email: petroleum.environment@dmirs.wa.gov.au		
Relevant persons or organisations listed in Appendix B	SapuraOMV Operations Manager	Notification of commencement of the survey	Written	14 days prior to mobilisation unless otherwise requested
Ingress/ titleholders	SapuraOMV Operations Manager	Date and time of expected entry to and exit from the Title(s)	Written	14 days prior to entry into the title(s) unless otherwise requested
During Gem 3D MSS				
Commonwealth NOPSEMA	SapuraOMV Operations Manager	Notice of a change of contact person, titleholder or joint venture arrangement. Email: submissions@nopsema.gov.au	Written	As required
After Gem 3D MSS is completed				
Commonwealth NOPSEMA	SapuraOMV Operations Manager	Notice of completion of the Gem 3D MSS. Email: submissions@nopsema.gov.au	Written	Within 10 days of demobilising
		Notice of the end date of operation of the EP. Email: submissions@nopsema.gov.au	Written	When all activities and obligations under the EP have been completed
Western Australian Department of Mines, Industry Regulation and Safety	SapuraOMV Operations Manager	Notice confirming cessation of the activity. Email: petroleum.environment@dmirs.wa.gov.au	Written	Following demobilisation

Commonwealth Department of Defence/ Australian Hydrographic Office	**SapuraOMV Operations Manager**	**Notice confirming cessation of the activity to enable the promulgation of Notice to Mariners.** **Email: datacentre@hydro.gov.au**	**Written**	**Following demobilisation**
Relevant persons or organisations listed in Appendix B	**SapuraOMV Operations Manager**	**Notice of completion of the survey**	**Written**	**Within 14 days of demobilisation unless otherwise requested**

8.10.2 Routine reporting

The OPGGS(E) Regulations require SapuraOMV to report recordable incidents to NOPSEMA on a monthly basis. Recordable incidents are defined as "a breach of an environmental performance outcome or environmental performance standard and is not a reportable incident".

In accordance with the OPGGS(E) Regulations SapuraOMV will provide a monthly recordable incident report as soon as practicable after the end of the calendar month or by the 15th day of every month. The report will include:

- All recordable incidents that occurred during the calendar month
- All material facts and circumstances concerning the recordable incidents
- Any action taken to avoid or mitigate any adverse environment consequences of the recordable incidents the corrective action that has been taken, or is proposed to be taken, to stop, control or remedy the recordable incident
- The action that has been taken, or is proposed to be taken, to prevent a similar incident occurring in the future.

The report will be completed using the online proforma at http://www.nopsema.gov.au/environmental-management/environmental-resources/ or emailed to submissions@nopsema.gov.au. If no recordable incidents have occurred during the calendar month, SapuraOMV will lodge a report listing nil incidents.

8.10.3 Incident reporting

In accordance with SapuraOMV Incident Notification, Investigation and Reporting Procedure (AU-HS-PRO-005-1.0), all personnel must report incidents to their line supervisors as soon as possible. The external incident reporting requirements that apply during the Gem 3D MSS are in Table 8-4. External reporting in the event of an oil spill is also covered in the OPEP (see Appendix H).

The OPGGS(E) Regulations require SapuraOMV to report reportable incidents to NOPSEMA no later than two hours after the incident is identified. Reportable incidents are defined as "a breach of an environmental performance outcome that has caused, or has the potential to cause, moderate to significant environmental damage". Based on the assessment in Section 7 of this EP, the following risks have the potential to result in "moderate to major environmental damage":

- Introduction of invasive marine species (Section 7.2)
- Equipment grounding and emergency anchoring (Section 7.4)
- Hydrocarbon release caused by vessel fuel tank loss of containment (Section 7.5).

Table 8-4: External incident reporting requirements

Relevant person or organisation	Responsible	Report	Method	Timing
Reportable incidents				
Commonwealth NOPSEMA	**SapuraOMV Operations Manager**	**Verbal report that must include:** • **all material facts and circumstances concerning the incident that are known at the time** • **any actions taken to avoid or mitigate any adverse environmental effects** • **any corrective actions that have been taken, or are proposed to be taken, to prevent a repeat of similar incidents occurring.** **Phone: 08-6461 7090.**	**Verbal**	**ASAP or not later than two hours after incident is identified**
		Written report that as a minimum must include: • **all material facts and circumstances concerning the incident that are known at the time** • **any actions taken to avoid or mitigate any adverse environmental effects** • **any corrective actions that have been taken, or may be taken, to stop, control or remedy the reportable incident** • **actions taken, or proposed to be taken, to prevent a repeat of similar incidents occurring.** **Complete proforma at: http://www.nopsema.gov.au/environmental-management/environmental-resources/, and**	**Written**	**ASAP and not later than three days after the first occurrence of the incident**

		submit online, or via email at submissions@ nopsema.gov.au.		
Commonwealth NOPTA	SapuraOMV Operations Manager	A copy of the written reportable incident report (refer to above). Email: info@nopta.gov.au	Written	Within seven days of providing a written report
WA Department of Mines, Industry Regulation and Safety (DMIRS)	SapuraOMV Operations Manager	A copy of the written reportable incident report (refer to above). Email: petroleum.environment@dmirs.wa.gov.au	Written	Within seven days of providing a written report
Injury to EPBC Act listed migratory or threatened species				
Commonwealth Department of Environment and Energy	SapuraOMV Operations Manager	Phone: (02) 6274 1372 or 1800 110 395. Email: compliance@environment.gov.au	Verbal or written	ASAP but no later than three days of becoming aware of the incident
Commonwealth NOPSEMA	SapuraOMV Operations Manager	Email: submissions@nopsema.gov.au	Written	As above
Injury to whales from ship strike				
Australian Antarctic Division – Australian Marine Mammal Centre	SapuraOMV Operations Manager	Online via the National Ship Strike Database: https://data.marinemammals.gov.au/report/ship strike/new	Online form	ASAP or within seven days of becoming aware of the incident
Introduction of invasive marine species				
Commonwealth Department of Agriculture and Water Resources – Marine Biosecurity Unit	SapuraOMV Operations Manager	Pests and any other species that appear to have clear impacts or invasive characteristics. Email WA Department of Fisheries (contact details provided below).	Verbal or written	Within 24 hours following confirmation that species has invasive characteristics

WA Department of Primary Industries and Regional Development	**SapuraOMV Operations Manager**	**Pests and any other species that appear to have clear impacts or invasive characteristics.** **Phone: 1800 815 507.** **Email: biosecurity@fish.wa.gov.au**	**Verbal or written**	**As above**

8.10.4 Performance reporting

SapuraOMV will submit an environmental performance report to NOPSEMA within three months of completion of the Gem 3D MSS. Developing the report will involve reviewing the performance monitoring data and records described in Section 8.6 for accuracy, completeness and compliance with the environmental performance outcomes and environmental performance standards in this EP. Additional information that could be included in the report (if relevant) is:

- Consultation events with relevant persons to demonstrate ongoing consultation conducted as outlined in Section 8.2 and Section 8.10.1
- Reports and records from assurance activities conducted, non-conformances identified, corrective actions raised and closed out
- MoC records verify changes that were identified and approved during the Gem 3D MSS considered the requirements of the OPGGS(E) Regulations and this EP
- Recordable and reportable incident records, and evidence that corrective actions have been closed out and the incident reporting requirements in this EP were met.

8.11 Management of Change

SapuraOMV implement the Management of Change (MoC) Procedure (AU-HS-PRO-003-1.0) to manage the control of changes. The objective of this Procedure is to ensure that:

- Workforce could recognise change and implement the MoC process as required
- Change is adequately managed, risk assessed, and the corresponding impact known.

The MoC process map within the Management of Change Procedure (AU-HS-PRO-003-1.0) includes the following steps:

- Development: the MoC process is only initiated after all appropriate development and pre-work has been done and support to proceed with the activity has been given
- Initiation and documentation: MoC process formally initiated by the Change Proposer, using the SapuraOMV MoC form
- Registration and tracking: MoC form is registered with the MoC System Administrator
- Endorsement: endorsement to proceed with the MoC is provided
- Risk assessment and nomination of required reviews: review of associated HSE and business risks is conducted, and technical/specialist reviewers are nominated
- Technical/specialist and impact reviews: reviews conducted, including assessing the implications of the change with regard to this EP (e.g. changes to the activity that are not defined as part of the petroleum activity definition in Section 2 of this EP, new or increased impacts or risks not assessed in the EP, changes to legislation, changes to emergency response frameworks, etc)
- Implementation plan: an implementation plan and communication approach are developed
- Approval: approval to proceed with the MoC is provided
- Implementation: implementation occurs in accordance with the approved MoC and implementation plan, and documentation updates are completed
- Completion review: after implementation is completed, a completion review is performed
- Closeout and recording when completion review is signed off by the Change Implementer and Approver, the MoC form and associated documentation is filed in MoC register.

Any change to the survey activities described in this EP will be subject to a MoC assessment in accordance with the Management of Change Procedure. Under Regulation 17 of the OPGGS(E) Regulations, the following changes will require this EP to be revised and submitted to NOPSEMA:

- A new activity (proposed revision to be submitted before the commencement of a new activity)
- Any significant modification or new stage of the activity that is not provided for in this EP (proposed revision to be submitted before or as soon as practicable after)

- The occurrence of any significant new environmental impact or risk, or significant increase in an existing environmental impact or risk, not provided for in this EP; or
- The occurrence of a series of new environmental impacts or risks, or a series of increases in existing environmental impacts or risks, which, taken together, amount to the occurrence of:

  i. A significant new environmental impact or risk; or

  ii. A significant increase in an existing environmental impact or risk that is not provided for in this EP

- If a change in the titleholder will result in a change in the manner in which the environmental impacts and risks of an activity are managed (proposed revision to be submitted as soon as practicable).

8.12 Environment plan reviews

SapuraOMV's Management of Change Procedure (AU-HS-PRO-003-1.0) will be followed to assess changes or modifications to the Gem 3D MSS (described in Section 2.0 of this EP) to determine if the change triggers a revision of the EP under Regulation 17 of the OPGGS(E) Regulations.

If the change does not trigger revision under the OPGGS(E) Regulations, SapuraOMV will amend the EP and record the changes within the EP. If the MoC assessment determines that a change does trigger a revision of the EP SapuraOMV will update the EP and re-submit it to NOPSEMA for acceptance. If NOPSEMA require revision and resubmission of the EP under Regulation 18 of the OPGGS(E) Regulations, SapuraOMV will update the EP and re-submit it to NOPSEMA for acceptance.

Updates made to the EP will be communicated to SapuraOMV personnel and contractors involved in the Gem 3D MSS and a copy of the updated EP provided to them.

8.13 Records management

SapuraOMV will store and maintain operational documents and records that are relevant to this EP. Records generated for the Gem 3D MSS will be retrievable and retained for five years after the day when the EP ceases to be in force. Operational documents and records associated with this EP could include:

- The EP that is in force and any versions of the EP previously in force
- Induction presentation and induction attendance records
- Training certification records, training and competency matrices
- Daily reports
- Sewage logs and waste manifests
- Biofouling records (e.g. biofouling management plan and record book)
- Marine fauna observation sheets
- Calibration and maintenance records
- Inspection records
- Environmental performance report
- MoC records
- Consultation records
- Written incident notifications
- Recordable and reportable incident reports
- Incident investigation records
- Evidence of close-out of corrective actions from incident investigations and inspections.

Records will be made available in accordance with Regulation 28 of the OPGGS(E) Regulations to the persons listed under OPGGS(E) Regulations Subregulation 28(2) (on request in writing).

9 References

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TSSC 2015c, Threatened Species Scientific Committee. Approved Conservation Advice Megaptera novaeangliae humpback whale. Department of Environment and Energy, Canberra.

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TSSC 2015e, Threatened Species Scientific Committee. Approved Conservation Advice Anous tenuirostris melanops Australian lesser noddy, Canberra.

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Appendix A: Summary of relevant Commonwealth legislation

Legislation	Scope	Application to Activities	Related International Conventions	Administering Authority
Australian Maritime Safety Authority Act 1990 **(AMSA Act)**	**Facilitates international co-operation and mutual assistance in preparing and responding to a major oil spill incident and encourages countries to develop and maintain an adequate capability to deal with oil pollution emergencies.** **The National Plan for Maritime Environmental Emergencies (the National Plan) (AMSA 2019) is managed by the Australian Maritime Safety Authority (AMSA) and sets out national arrangements, policies and principles for the management of maritime environmental emergencies. It gives administrative effect to Australia's emergency response obligations relating to the:** • **International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990** • **Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances, 2000 (OPRC-HNS Protocol)** • **International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969 (Intervention Convention)** • **Articles 198 and 221 of the United Nations Convention on the Law of the Sea, 1982.**	**Description of the requirements: The AMSA Act is applicable to offshore petroleum activities where these have the potential to affect maritime safety and/or result in pollution and other environmental damage associated with the operation of ships. This is particularly relevant to the potential risk of oil spills associated with the operation of ships.** **Meeting the requirements: Impacts and risks associated with vessel movements as part of the proposed activity are discussed in Section 6 and Section 7 of the environment plan (EP). Further details on the National Plan and oil spill response are described in the OPEP in Appendix J.**	**International Convention on Oil Pollution Preparedness, Response and Cooperation 1990** **Protocol on Preparedness, Response and Cooperation to Pollution Incidents by Hazardous and Noxious Substances 2000**	**AMSA**
Biosecurity Act 2015, Amendment (Ballast Water and Other Measures) Act 2017 **and Regulations 2016**	**Facilitates the management of biosecurity threats to plant, animal and human health in Australia. The regulations stipulate that all information regarding the voyage of a vessel and ballast water is declared correctly to biosecurity officers as soon as they enter Australian coastal seas.**	**Description of the requirements: These Acts and Regulations are applicable to offshore petroleum activities where it regulates the condition of vessels entering Australian waters, including ballast water, ballast tank sediment and hull fouling. If survey vessels are sourced from international ports, they will adhere to the Department of Agriculture (DoA) guidelines regarding quarantine clearance to enter Australian waters and ports.** **Meeting the requirements: Management requirements relating to biosecurity are addressed in Section 6 and 7 of the EP.**	**International Convention for the Control and Management of Ships Ballast Water and Sediments (Ballast Water Convention) 2004**	**DoA, Department of Health**
Environment Protection (Sea Dumping) Act 1981	**Aims to prevent the deliberate disposal of wastes (loading, dumping, and incineration) at sea from vessels, aircraft, and platforms.**	**Description of the requirements: A sea dumping permit is required for any disposal of waste at sea from vessels, aircraft and platforms involved in the conduct of petroleum exploration. Given that the activity may involve the use of an incinerator and there is the potential for material to be lost overboard, this Act is applicable.** **Meeting the requirements: Management considerations of waste disposal relating to this Act are addressed in Section 6 and 7 of the EP.**	**Australia-Indonesia Delimitation Treaty (the Perth Treaty)**	**Department of Environment and Energy (DoEE)**
Environment Protection and Biodiversity Conservation Act 1999 **(EBPC Act) and Regulations 2000**	**The EBPC Act aims to** • **protect matters of national environmental significance (MNES);** • **provides for Commonwealth environmental assessment and approval processes; and** • **provides an integrated system for biodiversity conservation and management of protected area.**	**Description of the requirements: An assessment of activities where they have the potential to impact on matters on MNES is required to be presented in the EP.** **Meeting the requirements: Impacts and risks to MNES as part of the proposed activity are discussed in Section 6 and Section 7 of the EP.** **An EBPC Act Protected Matters Database Search (PMST Search), included in Appendix A, lists the marine species or habitat, including threatened species, as potentially occurring within the planning area. A description of these species is**	• **Agenda 21, 1992, Chapter 15 Conservation of biological diversity** • **Convention on International Trade in Endangered Species of Wild Fauna and Flora 1973**	**DoEE in general and NOPSEMA for offshore petroleum activities.**

	MNES are • World Heritage properties; • Listed threatened species and communities; • Migratory species under international agreements; • nuclear actions; • Commonwealth marine reserves and the Great Barrier Reef Marine Park; and • water trigger for coal seam gas and coal mining developments. The assessment process is delegated to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) under the EBPC Act. The Act also allows for the development of threatened species recovery plans, threat abatement plans and species conservation advice.	included in Section 4 of the EP. Threatened species recovery plans, threat abatement plans, bioregional plans and species conservation and management advices for potentially impacted species and regions are included in Sections 6 and 7.	• Japan Australia Migratory Bird Agreement • China Australia Migratory Bird Agreement • Republic of Korea Australia Migratory Bird Agreement • Convention on Wetlands of International Importance especially as Waterfowl Habitat 1971 (RAMSAR) • International Convention for the Regulation of Whaling 1946 • Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) 1979	
Fisheries Management Act 1991	This Act aims to implement efficient and cost-effective fisheries management on behalf of the Commonwealth, ensure that the exploitation of fisheries resources and related activities are conducted in a manner consistent with the principles of Ecological Sustainable Development (ESD), maximise the net economic returns to the Australian community from the management of Australian fisheries, ensure accountability to the fishing industry and to the Australian community in Australian Fisheries Management Authority's (AFMA) management of Australian fisheries resources, and achieve government targets in relation to the recovery of the costs of AFMA.	Description of the requirements: This Act provides regulatory and other mechanisms to support the necessary fisheries management decisions in the event of a hydrocarbon spill in Commonwealth waters. Meeting the requirements: Impacts and risks to fisheries that may be affected as part of the proposed activity are discussed in Section 6 and Section 7 of the EP. Further details on the Act and oil spill response are described in the OPEP in Appendix H.	N/A	DoA and AFMA
Historic Shipwrecks Act 1976 repealed 1/07/19 by the *Underwater Cultural Heritage Act 2018*	Protects the heritage values of shipwrecks, aircraft and other types of cultural heritage and relics (older than 75 years) below the low water mark.	Description of the requirements: Anyone who finds the remains of an item of underwater cultural heritage, or an article associated with a such needs to notify the relevant authorities as soon as possible and no later than one week to give information about what has been found and its location. Meeting the requirements: Section 4 of the EP details that there are no known historic shipwrecks within the permit area. In the event of a discovery of underwater cultural heritage artefacts this legislation may become relevant.	• Agreement between the Netherlands and Australia concerning old Dutch shipwrecks 1972 • Convention on Protection of the Underwater Cultural Heritage 2001	DoEE
Navigation Act 2012, Navigation Regulations 2013	The Act regulates international ship and seafarer safety as well as the protection of the marine environment from shipping and the actions of seafarers in Australian waters.	Description of the requirements: All ships involved in petroleum activities in Australian waters are required to abide by the requirements under this Act. Several Marine Orders (MO) are enacted under this Act which relate to offshore petroleum activities that are planned or unplanned events of the activity, including:	International Convention for the Prevention of Pollution from Ships (MARPOL)	Department of Infrastructure, Regional Development and Cities and AMSA

	The Act also gives effect to international conventions for maritime issues where Australia is a signatory. The Act regulates vessel survey and certification, vessel construction standards, personnel qualifications and welfare, occupational health and safety, handling of cargoes, passengers, marine pollution prevention, monitoring and enforcement activities.	• MO Part 21: Safety of navigation and emergency arrangements • MO Part 30: Prevention of collisions • MO Part 50: Special purpose vessels • MO Part 58: Safe management of vessels Meeting the requirements: The survey and support vessels will adhere to the relevant MOs while in Commonwealth waters. Management measures relating to vessel operations and safety can be found in Section 6 and 7 of the EP.		
Offshore Petroleum and Greenhouse Gas Storage Act 2006 **(OPGGS Act) and Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2019 (OPGGS(E) Regulations)**	The OPGGS Act addresses all licencing, health, safety, environmental and royalty issues for offshore petroleum exploration and development operations extending beyond the Australian three nautical mile limit. Part 2 of the OPEGGS(E) regulations specifies that an EP must be prepared for and petroleum activity	Description of the requirements: The OPGGS(E) provides the regulatory frameworks for all offshore petroleum exploration and recovery, the injection of greenhouse gas substances and other purposes for which an operation to carry out a seismic survey is defined as a *key greenhouse gas operation*, and a *key petroleum operation*. The Act is to ensure that this activity is carried out: • consistent with the principles of ecologically sustainable development as set out in section 3A of the EPBC Act; • so that environmental impacts and risks of the activity are reduced to ALARP; • so that environmental impacts and risks of the activity are of an acceptable level. Meeting the requirements: Demonstration that the proposed activities will be undertaken in line with the principles of ecologically sustainable development and that impacts are risks resulting from these activities are ALARP and acceptable is provided in Section 6 and 7 of the EP.	N/A	Department of Industry, Innovation and Science and NOPSEMA
Ozone Protection and Synthetic Greenhouse Gas Management Act 1989	This Act provides for measures to protect the ozone layer and to minimise emissions of synthetic greenhouse gasses. It regulates the manufacture, importation and use of ozone depleting substances.	Description of the requirements: This Act applies to offshore petroleum activities where an operator is required to use substances listed under the Act for the operation of machinery such as refrigeration and air condition systems. Meeting the requirements: Vessels undertaking this activity will have a register of ozone-depleting substances as appropriate where they are present. Relevant management measures are presented in Sections 6, 7 of the EP.	• Montreal Protocol on Substances that Deplete the Ozone Layer 1987 • United Nations Framework Convention on Climate Change 1992	DoEE
Protection of the Sea (Civil Liability for Bunker Oil Pollution Damage) Act 2008	Sets up a compensation scheme for those who suffer damage caused by spills of pol that is carried as fuel in ships' bunkers. There is an obligation on ships over 1000 gross tonnage to carry insurance certificates when leaving/ entering Australian ports or leaving/ entering an offshore facility within Australian coastal waters.	Description of the requirements: Vessels over 1000 gross tonnage involved in the activity as described in Section 2 of the EP are required to abide by this Act. Meeting the requirements: The vessels involved in this activity will hold the necessary insurance certificates where required.	International Convention on Civil Liability for Bunker Oil Pollution Damage 2001	Department of Industry, Innovation and Science and AMSA
Protection of the Sea (Harmful Anti-fouling Systems) Act 2006	This Act 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.	Description of the requirements: Vessels over 400 gross tonnes involved int eh activity as described in Section 2 of the EP are required to abide by this Act. Meeting the requirements: Australian vessels involved in the activity as described in Section 2 of the EP that meet the criteria of the Act will hold a current anti-fouling certificate and cannot use harmful anti-fouling products.	International Convention on Control of Harmful Anti-fouling Systems in Ships 2001	Department of Infrastructure, Regional Development and Cities and AMSA
Protection of the Sea (Prevention of Pollution from Ships) Act 1983	This Act aims to protect the marine environment from pollution by oil and other harmful substances discharged from ships in Australian waters. It also invokes certain requirements of the MARPOL Convention 73/78 Annex I such	All ships involved in petroleum activities in Australian waters are required to abide by the requirements under this Act. Several Marine Orders (MO) are enacted under this Act which relate to offshore petroleum activities that are planned or unplanned events of the activity, including:	MARPOL Convention 73/78 Annex I	Department of Industry, Innovation and Science and AMSA

	as those relating to discharge of noxious liquid substances, sewerage, garbage, and air pollution. This Act requires ships greater than 400 gross tonnes to have pollution emergency plans in place and provides for emergency discharges from ships.	• MO Part 21: Safety of navigation and emergency procedures • MO Part 30: Prevention of Collisions • MO Part 91: Marine pollution prevention- oil • MO Part 93: Marine pollution prevention- noxious liquid substances • MO Part 94: Marine pollution prevention- packaged harmful substances • MO Part 95: Marine pollution prevention- garbage • MO Part 96: Marine pollution prevention- sewage • MO Part 97: Marine pollution prevention- air pollution • MO Part 98: Marine pollution prevention- anti-fouling systems Vessels undertaking this activity will adhere to the relevant MOs by having in place and implementing where applicable the required certificates and plans. These, and other management measures related to pollution are detailed in Section 6, 7 of the EP.		

Appendix B: Relevant persons consultation report

NOTE: This report has been redacted to preserve the privacy of those persons or organisations consulted. This can include the removal personal information (as defined by the *Privacy Act 1988*) and the removal of any information that was provided during consultation where that person has requested for that information not to be published as per OPGGS(E) Regulations 2019 subregulation 11(A). SapuraOMV has made reasonable efforts to inform each relevant person consulted that they may request for particular information not to be published.

Regulatory requirements

Table B.5 Demonstration that the OPGGS(E) Regulations have been met

Sub-regulation	Regulatory requirement	Notes
10A(g)	**Criteria for acceptance of an environment plan** **For regulation 10, the criteria for acceptance of an environment plan are that the plan:** **(g) demonstrates that:** **(i) the titleholder has carried out the consultations required by Division 2.2A; and** **(ii) the measures (if any) that the titleholder has adopted, or proposes to adopt, because of the consultations are appropriate.**	**The process by which consultation was carried out is described in Section 3 of this EP.** **The outcomes of the process are documented in this Appendix.** **Together, these demonstrate that the requirements of Division 2.2A have been met.**
11A(1)	**Consultation with relevant authorities, persons and organisations, etc** **In the course of preparing an environment plan, or a revision of an environment plan, a titleholder must consult each of the following (a relevant person):** **(a) each Department or agency of the Commonwealth to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant;** **(b) each Department or agency of a State or the Northern Territory to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant;** **(c) the Department of the responsible State Minister, or the responsible Northern Territory Minister;** **(d) a person or organisation whose functions, interests or activities may be affected by the activities to be carried out under the environment plan, or the revision of the environment plan;**	**Section 3 of this EP summarises the process Spectrum used to identify and consult with relevant stakeholders.** **Table B.6 provides the current list of relevant stakeholders for the Gem 3D MSS. Other key stakeholders that were potentially relevant, but either advised they were not, or SapuraOMV deemed they were not are in Table B.7.**

	(e) any other person or organisation that the titleholder considers relevant.	
11A(2)	**Consultation with relevant authorities, persons and organisations, etc** **For the purpose of the consultation, the titleholder must give each relevant person sufficient information to allow the relevant person to make an informed assessment of the possible consequences of the activity on the functions, interests or activities of the relevant person.**	**The approach undertaken to provide sufficient information is described in Section 3 of this EP.** **Table B.4 lists all information provided to each relevant stakeholder.** **Records of the information provided to stakeholders and a copy of them is provided in this appendix.**
11A(3)	**Consultation with relevant authorities, persons and organisations, etc** **The titleholder must allow a relevant person a reasonable period for the consultation.**	**The approach undertaken to provide a reasonable period for the consultation is described in Section 3 of this EP.** **Table B.4 lists the timeframes that have been provided for each relevant stakeholder.** **Records of the information provided to stakeholders and a copy of them is provided in this appendix.**
11A(4)	**Consultation with relevant authorities, persons and organisations, etc** **The titleholder must tell each relevant person the titleholder consults that:** **(a) the relevant person may request that particular information the relevant person provides in the consultation not be published; and** **(b) information subject to such a request is not to be published under this Part.**	**The approach undertaken to notify each relevant person that they may request sensitive information not to be published is described in Section 3 of this EP.** **Records of the information provided to stakeholders and a copy of them is provided in this appendix.**

14(9)	**Implementation strategy for the environment plan** **The implementation strategy must provide for appropriate consultation with:** **(a) Relevant authorities of the Commonwealth, a State or Territory; and** **(b) Other relevant interested persons or organisations.**	**The process for ongoing consultation is described in Section 3 of this EP. A schedule of notifications to stakeholders is provided in the Implementation Strategy.**
16(b)	**Other information in the environment plan** **(b) a report on all consultations between the titleholder and any relevant person, for regulation 11A, that contains:** **(i) a summary of each response made by a relevant person; and** **(ii) an assessment of the merits of any objection or claim about the adverse impact of each activity to which the environment plan relates; and** **(iii) a statement of the titleholder's response, or proposed response, if any, to each objection or claim; and** **a copy of the full text of any response by a relevant person.**	**Table B.4 and Appendix C.** **Records of the information provided to stakeholders and a copy of them is provided in this appendix.**

Relevant persons or organisations

Persons or organisations are considered relevant if their functions, interests and activities overlap with the Operations Area (further explanation can be found in Section 3 of the EP). Table B.6 provides the current list of relevant persons or organisations for the Gem 3D MSS. This includes those persons or organisations who have not yet responded to consultation.

Relevant persons or organisations were grouped according to their common functions, interests and activities as follows:

- Government agencies, authorities and representatives – Commonwealth (15)
- Government agencies, authorities and representatives – Western Australia (13),
- Government agencies, authorities and representatives – Northern Territory (5),
- Associations (7),
- Fishing companies and fishers (10),
- Tourism and recreation (28),
- Research organisations / institutions (12),
- Industry operators (6).

A total of 96 relevant persons or organisations have been consulted for the Gem 3D MSS EP. Of these, a summary of relevant persons or organisation feedback, assessment of merit and SapuraOMV responses is given in Table B.8.

. Other potential persons or organisations that were consulted but advised they were not relevant are included in Table B.7.

Table B.6 Relevant persons or organisations consulted for the Gem 3D MSS

Relevant organisation or individual	Reason identified as relevant
Government agencies, authorities and representatives – Commonwealth	
Australian Border Force **Australian Customs and Border Protection** **Australian Hydrographic Office** **Australian Marine Oil Spill Centre (AMSOC)** **Australian Maritime Safety Authority** **Clean Energy Regulator** **Department of Defence** **Department of Industry, Innovation and Science** **Department of the Environment and Energy** **Department of Agriculture and Water Resources** **Department of Communications and the Arts** **Department of Foreign Affairs and Trade** **Department of Infrastructure** **Federal Member for Durak** **Maritime Border Control**	***Relevant Person under Regulation 11A(1)(a)***
Government agencies, authorities and representatives – Western Australia	
Broome Chamber of Commerce and Industry **Wyndham Chamber of Commerce**	***Relevant Person under Regulation 11A(1)(b)***
Broome Port Authority **Kimberley Ports Authority**	
Department of Primary Industries and Regional Development **Department of Mines, Industry Regulation and Safety** **Department of Minister and Cabinet (Minister for Environment)** **Department of Planning, Lands and Heritage** **Department of Transport (Marine Operations)** **Shire of Broome** **Shire of Derby West Kimberley** **Shire of Wyndham East Kimberley** **State Member for Kimberley**	***Relevant Person under Regulation 11A(1)(b)***

Government agencies, authorities and representatives – Northern Territory	
Darwin Chamber of Commerce Department of Primary Industry and Resources Department of the Chief Minister Northern Land Council Parks and Wildlife Commissions	*Relevant Person under Regulation 11A(1)(b)*
Associations	
Australian Fishing Trade Association Commonwealth Fisheries Association Recfishwest WA Game Fishing Association Western Australian Fishing Industry Council Australian Southern Bluefin Tuna Industry Association	*Relevant Person under Regulation 11A(1)(d)*
Australian Petroleum Production and Exploration Association (APPEA)	
Fishing companies and fishers	
NDSMF Fisher ID #244 KFM Leasing Pty Ltd Lenden Nominees Pty Ltd NDSMF Fisher ID #104 NDSF Licences Holding Company Pty Ltd NDSMF Fisher ID #166 NDSMF Fisher ID #198 Coyrecup Lake Pty Ltd Northern Wildcatch Seafood Australia Pty Ltd	*Relevant Person under Regulation 11A(1)(d)* Owner/ operator in the Northern Demersal Scalefish Fishery
Ocean Wild Tuna UpTop Fisheries Pty Ltd (*Note the same contact for Ocean Wild Tuna so only one record for consultation is included*)	*Relevant Person under Regulation 11A(1)(d)* Owner/ operator in the Western Tuna and Billfish Fishery
Tourism and recreation	
Absolute Ocean Charters Aviair BlueWater Adventure Charters	*Relevant Person under Regulation 11A(1)(d)*

Broome Aviation **Broome Billfish Charters** **Broome Coast Charters** **Broome Whale Watching Sentosa Charters** **Eco Abrolhos – Kimberley Cruises** **Fly Broome** **Go Beyond Broome** **Great Escape Charters** **HeliSpirit** **Horizontal Falls Seaplane Adventures** **Karma IV** **KAS Helicopters** **Kimberley Air Tours** **Kimberley Whale Watching** **King Leopold Air** **Kingfisher Tours** **Lady M Luxury Cruises** **Makira Game and Sportfishing Charters** **NT Bush Pilots** **One tide Charters** **The Great Escape Charter Company** **True North Adventure Cruises** **Unreel Adventure Safaris** **WA Barra Charters** **West Kimberley Fishing Tours**	**Tourism operation fishing potentially active in the Planning Area**
Research and conservation	
Australian Conservation Foundation **Australian Marine Conservation Society** **Conservation Council of WA** **Environs Kimberley** **International Fund for Animal Welfare** **Wilderness Society** **World Wildlife Fund Australia** **The Western Australian Museum** **CSIRO**	***Relevant Person under Regulation 11A(1)(d)*** **Conservation and research interests/ activities within or near the Operations Area**

Australian Institute of Marine Science	
Centre for Whale Research WA **Recfishing Research**	***Relevant Person under Regulation 11A(1)(d)*** **Research interests/ activities within or near the Operations Area**
Industry Operators	
Telstra **Vocus Communications (Nextgen Network)** **Northern Oil & Gas Australia Pty Ltd (*Note the same contact for Total E&P Australia Exploration P/L so only one record for consultation is included*)** **Total E&P Australia Exploration P/L** **PTTEP Australia Timor Sea P/L** **PTTEP Australasia (Ashmore Cartier) P/L**	***Relevant Person under Regulation 11A(1)(c)***

Potentially interested persons or organisations

Persons or organisations are considered 'potentially interested' if their functions, activities and interests overlap with the Planning Area and for the purposes of planning but have advised SapuraOMV that they are not relevant to the survey for various reasons. Government departments and agencies that advised SapuraOMV that their jurisdiction does not overlap the activity but requested to remain informed about the Gem 3D MSS are also listed in Table B.3. Persons or organisations that have not responded to consultation are included in the 'relevant persons or organisations' summary in Table B.6.

A total of 11 potentially interested parties have been identified and are listed in Table B.7.

Table B.7 Potentially interested parties engaged by SapuraOMV for the Gem 3D MSS

Persons or organisations
Government agencies, authorities and representatives – Commonwealth
Director of National Parks **Commonwealth Marine Reserves Branch** **National Native Title Tribunal** **Geoscience Australia**
Government agencies, authorities and representatives – Western Australia
Department of Biodiversity, Conservation and Attractions **Office of the Environmental Protection Authority** **Department of Water and Environment Regulation**

Broome Future Alliance/ Independent Community Board
Government agencies, authorities and representatives – Northern Territory
Department of Primary Industry – Major Projects **Department of Fisheries**
Associations
Pearl Producers Association of WA

Information provided to persons or organisations

The following documents were provided to relevant persons or organisations during consultation and are referred to throughout Appendix B.

DocRef C001 - Invitation for Consultation

Invitation For Consultation

Gem 3D Marine Seismic Survey

Browse Basin, Australia

Key Information

Sapura Exploration and Production (Western Australia) Pty Ltd (SEPWA), is preparing the Environment Plan for a 3D marine seismic survey in the Browse Basin in the Northern offshore region of Western Australia.

Searcher Seismic Pty Ltd (Searcher) has been contracted by SEPWA to assist in the regulatory environmental approvals process, including stakeholder consultation and communications related to the survey activity.

Throughout the project development Searcher will provide each relevant person sufficient information to allow them to make an informed assessment of the possible consequences of our proposed survey on their functions, interests or activities. If you have any feedback, comments or questions on this activity, or do not think that this activity will affect your functions, interests or activities, then you may contact us via:-

Contact

Paul Miller
Operations Manager
SEARCHER SEISMIC PTY LTD

PHONE:
+61 (0)8 9327 0301

WEBSITE:
searcherseismic.com/gem-3d-feedback.htm

EMAIL:
Gem3D@searcherseismic.com

MOBILE DEVICE:
Scan this QR code to access the stakeholder registration and feedback form.

Introduction

Sapura Exploration and Production (Western Australia) Pty Ltd (SEPWA), is operator of petroleum exploration permit AC/P61, located in the Vulcan Sub-basin, western Bonaparte Basin in the Timor Sea, approximately 250 km offshore of northern WA and 626 km from Darwin. SEPWA is planning to conduct a 3-dimensional marine seismic survey over an area of approximately 420 square kilometres.

Timing

The proposed activity is scheduled to commence sometime between December 2019 and June 2020 and is expected to take approximately three weeks to complete.

Final survey timing will be dependent on environmental considerations, regulatory approvals, vessel availability and weather conditions. Based on these unknown influences, the option to conduct the activity at any time between December 2019 and the first half of 2020, whilst adhering to any identified environmental constraints, will be sought for approval from the relevant government regulators.

Every effort will be made to time the activity to minimise any potential adverse effects on relevant stakeholders, with particular emphasis on commercial fishers and their key fishery resources.

About SEPWA

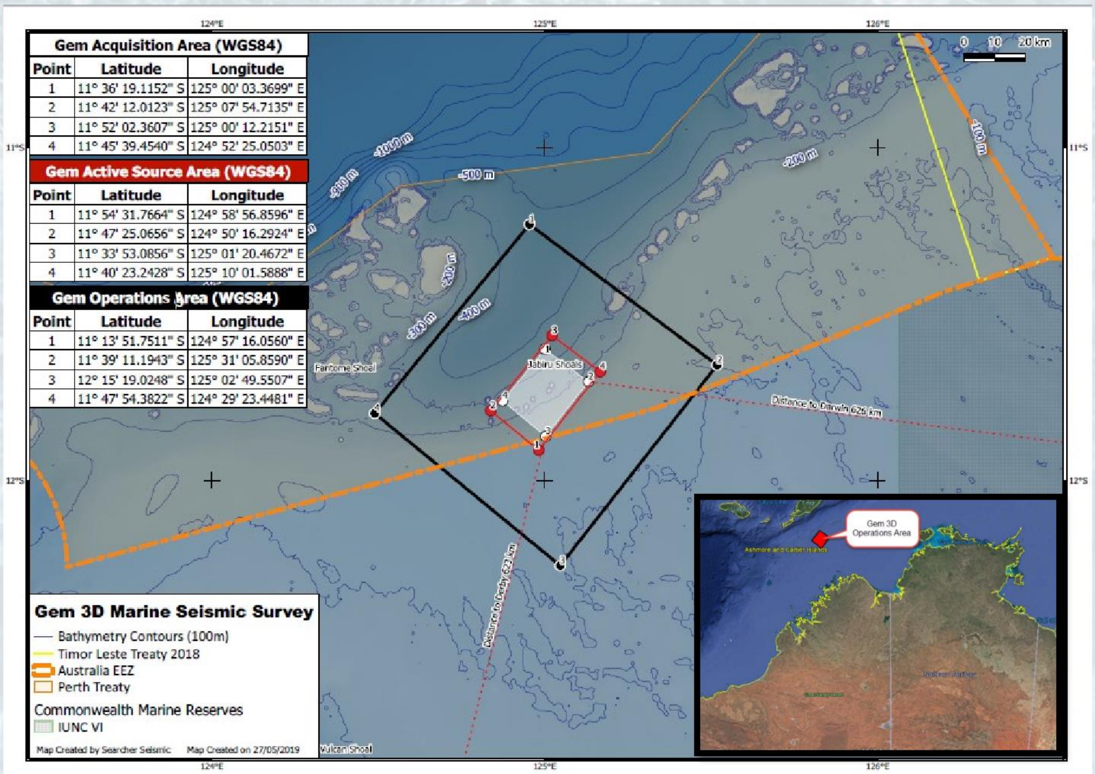
Sapura Exploration and Production (Western Australia) Pty Ltd is a wholly owned subsidiary of KL-based Sapura-OMV (formerly Sapura Upstream). SEPWA holds 70% interest and is Operator of three offshore Western Australia exploration permits, AC/P61, EP 483 and TP/25, WA-412-P. Finder Energy holds the remaining 30% interest in all permits. The Gem 3D survey is SEPWA's first Australian seismic survey activity and is drawing on the experience and expertise of Searcher Seismic to assist in the planning and execution phases of the project. SEPWA's primary objective is achieving operational excellence, whilst maintaining the highest levels of environmental and safety compliance standards.

Searcher Seismic

sapura energy

OMV

Proposed Activity



The Gem 3D seismic survey area is located entirely within offshore Commonwealth waters, approximately 620 km West of Darwin and around the same distance NNE of Derby. The Operational Area is in excess of 200 km from the Western Australian mainland. A location map and boundary co-ordinates are provided above.

The survey **'Acquisition Area' (AA)** is approximately 420 square kilometres in size and the area where 3D seismic data will be acquired and is the focus area in which SEPWA needs to better image the subsurface geology to assess the hydrocarbons potential. The AA is located fully within the 1997 Perth Treaty area, which is not yet ratified, but is recognised as the boundary of the Australian Economic Exclusive Zone (EEZ) by the governments of Australia and Indonesia.

The survey **'Active Source Area' (ASA)** of 655 square kilometres is the area within which the seismic energy source (airguns) will be operational and seismic data will be acquired, including soft start procedures and line run-outs (required to obtain full fold coverage). The full seismic source will not be operational outside of the survey active source area, although small, individual source elements may be tested during maintenance outside the ASA but within the Operations Area.

The **'Operations Area' (OA)** or 'operational buffer' around the survey area is required for activities including streamer deployment and retrieval, maintenance and recovery and routine vessel manoeuvring. The OA is 6,435 square kilometres in size but operations will be conducted mainly within the ASA , with the OA limited to non-seismic vessel activities.

Seismic data will be acquired in parallel lines in a racetrack pattern within the ASA over a 24-hour period, with shut downs for routine and reactive maintenance, repairs, transit and line turns, fauna and stakeholder avoidance. Vessel survey operations, other than transit to and from the activity areas, will not take place outside the OA. Full energy source array activity in the ASA will average less than 3 hours, before silence periods of a similar duration during line turns, prior to commencement of subsequent lines. The process will continue until all survey lines, plus any re-acquisitions or 'infill' lines have been acquired and the AA has been adequately surveyed to meet the activity's geological 3D imaging objectives.

Environmental Management

Searcher Seismic has been chosen by SEPWA to assist in preparing the Environment Plan (EP) for its Gem 3D project due to Searcher's significant local experience in undertaking the same processes for its own multi-client projects in recent years. Searcher and SEPWA have engaged an experienced environmental consultancy company, RPS, to coordinate and compile the environmental baseline study and impact assessments required by the Commonwealth regulator, NOPSEMA.

Environmental Impact Assessment

As required by Offshore Petroleum Greenhouse Gas Storage Environment Regulations 2009, SEPWA is undertaking an assessment of the planned environmental impacts and unplanned environmental risks associated with the proposed seismic survey. This includes assessment of impacts and risks to other marine users including fishers, government agencies and ship owners. A number of species covered under the "Matters of National Environmental Significance" and "Other Matters" protected by the *Environment Protection and Biodiversity Conservation Act 1999*, have also been identified as potentially occurring within the survey ASA and OA. Species listed as Vulnerable or Endangered will be the subject of a comprehensive Environment Plan risk assessment and mitigation planning process in order to minimise any identified risks to acceptable levels. There are no Commonwealth or State Marine Reserves and Parks or listed Key Ecological Features (KEFs) occurring within the survey's ASA .

The seismic survey vessel and any support vessels that may be imported into Australia to conduct this seismic survey activity, probably amongst others, will do so under the strict requirements of the biosecurity legislation administered by the Australian Department of Agriculture and Water Resources, and will be required to undertake inspections by a department biosecurity officer prior to mobilisation to the OA. An Oil Pollution Emergency Plan (OPEP) specific to the activity will also be developed, as required by the OPGGS(E) Regulations.

Potential Impacts to Stakeholders

Marine seismic surveys can potentially impact other marine users, including temporary displacement of commercial or recreational fishers and interaction with commercial shipping and other marine traffic. It is also possible that pelagic or demersal fish stocks may temporarily relocate during the activity. SEPWA will be closely consulting with all identified relevant licensed fishers in the survey Planning Area in an effort to minimise any negative operational or commercial impacts to those fishers and their livelihoods. As the AA is located wholly within the Perth Treaty area and is outside of any designated shipping channels it is probable that any effects to commercial fishing activities or general shipping traffic will be minimal.

Further information regarding seismic surveying methods and their potential effects can be found on the International Association of Geophysical Contractors (IAGC) web site on the "Resources" page:- https://www.iagc.org/resources.html, or by completing the online form, via email or by phone and asking for further information to enable you to adequately assess whether the activity might affect your functions, interests or activities .

Stakeholder Engagement

SEPWA encourages open, two-way communication with stakeholders throughout the planning and implementation of the proposed activities. Reviewing this Invitation For Consultation package is the first stage of a more comprehensive stakeholder engagement process. The next stage will be for all persons or organisations that wish to continue to be included in the consultation process to register their interest via the simple online registration form that can be accessed through the Searcher web site address listed on the first page, or via scanning the QR code and completing the form on a mobile device. Some basic multiple choice question options and fields for additional feedback are provided within the feedback questionnaire, including the option to request direct communications with Searcher's Project Management Team. The option to opt out of any further communications on this matter also exists.

Under the regulations, stakeholder consultation is a mandatory process for the proponent (SEPWA) but voluntary for potential stakeholders. Searcher recognises the risk of "stakeholder fatigue" and the inconvenience consultation may cause for those that have no interest in the proposed activity. Unfortunately, failure to respond to this invitation to consult will not be accepted by the regulator NOPSEMA as a lack of interest, so your assistance in completing the online feedback form would be greatly appreciated and will help avoid further contact from us if you do decide to opt out of future correspondence in relation to this activity. If we do not hear from you then we will continue to provide you with updates to allow for circumstances such as extended post delivery times and perusal of this information.

SEPWA will provide all stakeholder feedback to NOPSEMA, within the proposed activity's environment plan. Under recent changes to Environment Regulations, all environment plans for offshore oil and gas activities will be published, and draft environment plans for offshore seismic surveys and exploration drilling activities will be open for an additional 30-day public comment period prior to NOPSEMA assessment.

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Invitation For Consultation

Gem 3D Marine Seismic Survey

Browse Basin, Australia

Key Information

SapuraOMV Upstream (Western Australia) Pty Ltd (SOMV), is preparing an Environment Plan for a 3D marine seismic survey in the Browse Basin in the Northern offshore region of Western Australia.

Searcher Seismic Pty Ltd (Searcher) has been contracted by SOMV to assist in the regulatory environmental approvals process, including stakeholder consultation and communications related to the survey activity.

Throughout the project development Searcher will provide each relevant person sufficient information to allow them to make an informed assessment of the possible consequences of the proposed survey on their functions, interests or activities. If you have any feedback, comments or questions on this activity, or do not think that this activity will affect your functions, interests or activities, then you may contact us via:-

Contact

Paul Miller
Operations Manager
SEARCHER SEISMIC PTY LTD

PHONE:
+61 (0)8 9327 0301

WEBSITE:
searcherseismic.com/gem-3d-feedback.htm

EMAIL:
Gem3D@searcherseismic.com

MOBILE DEVICE:
Scan this QR code to access the stakeholder registration and feedback form.

Introduction

In 2018, SOMV farmed-in to exploration permit AC/P 61 that was previously held by Finder Exploration Pty Ltd (Finder). SOMV is now the registered titleholder and the operator of AC/P 61, located in the Vulcan Sub-basin, western Bonaparte Basin, in the Timor Sea, approximately 250 km offshore of northern WA and 626 km from Darwin. .

The planned 'Gem 3D Marine Seismic Survey' is SOMV's first Australian seismic survey, with an acquisition area of approximately 410 square kilometres in size (see location details following pages).

Timing

The proposed activity is scheduled to commence sometime between December 2019 and June 2020 and is expected to take approximately three weeks to complete.

Final survey timing will be dependent on environmental considerations, regulatory approvals, vessel availability and weather conditions. Based on these unknown influences, the option to conduct the activity at any time between December 2019 and the first half of 2020, whilst adhering to any identified environmental constraints, will be sought for approval from the relevant government regulators.

Every effort will be made to time the activity to minimise any potential adverse effects on relevant stakeholders, with particular emphasis on commercial fishers and their key fishery resources.

About SOMV

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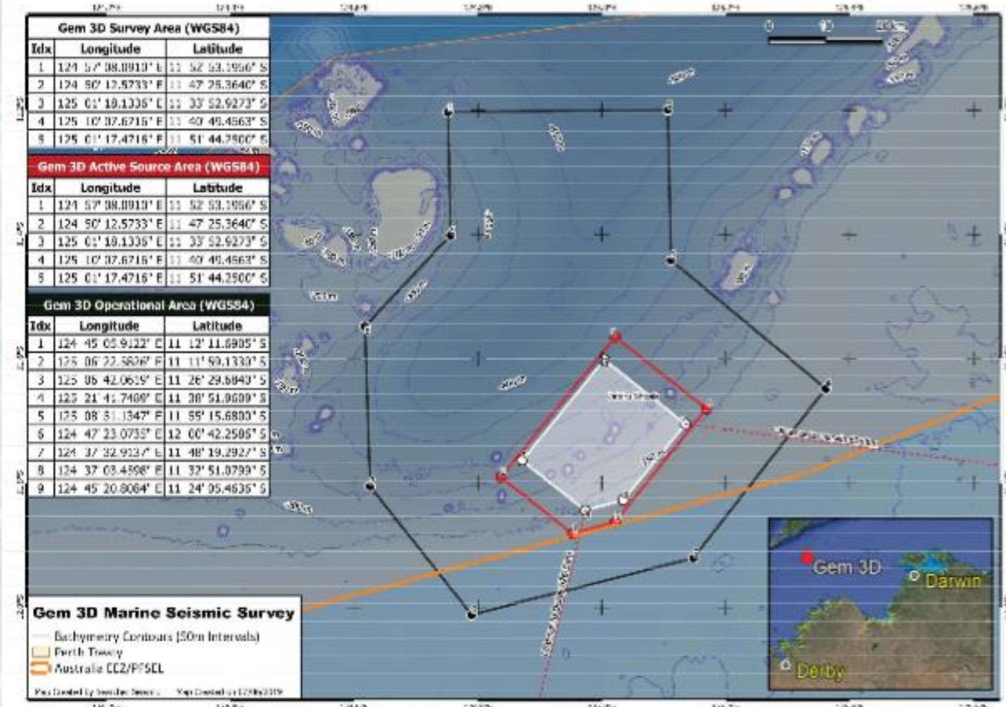
Searcher Seismic

sapura energy

OMV

Proposed Activity



Gem 3D Survey Area (WGS84)		
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Gem 3D Operational Area (WGS84)		
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The Gem 3D seismic survey area is located entirely within offshore Commonwealth waters, approximately 620 km West of Darwin and around the same distance NNE of Derby. The Operational Area is in excess of 240 km from the Western Australian mainland, in water depths between 450m and less than 10m in the shallowest patches of the Jabiru Shoals. A location map and boundary co-ordinates are provided above.

The survey **'Acquisition Area' (AA)** is approximately 410 square kilometres in size and the area where 3D seismic data will be acquired and is the seismic data focus area. The AA is located fully within the 1997 Perth Treaty area, which is not yet ratified, but is recognised as the boundary of the Australian Economic Exclusive Zone (EEZ) by the governments of Australia and Indonesia. The EEZ boundary coincides with the Provisional Fisheries Surveillance and Enforcement Line (PFSEL), which is the agreed delimitation boundary of legal fishing activity between Australia and Indonesia.

The survey **'Active Source Area' (ASA)** of 647 square kilometres is the area within which the seismic energy source (airguns) will be operational and seismic data will be acquired, including soft start procedures and line run-outs (required to obtain full fold coverage). The full seismic source will not be operational outside of the survey active source area, although small, individual source elements may be tested during maintenance outside the ASA but within the Operations Area. The entire ASA is also located beyond the Australian EEZ.

The **'Operations Area' (OA)** or 'operational buffer' around the survey area is required for activities including streamer deployment and retrieval, maintenance and recovery and routine vessel manoeuvring. The OA is 4,760 square kilometres in size but operations will be conducted mainly within the ASA , with the OA limited to non-seismic vessel activities. The majority of the OA is located beyond the Australian EEZ.

Seismic data will be acquired in parallel lines in a racetrack pattern within the ASA over a 24-hour period, with shut downs for routine and reactive maintenance, repairs, transit and line turns, fauna and stakeholder avoidance. Vessel survey operations, other than transit to and from the activity areas, will not take place outside the OA. Full energy source array activity in the ASA will average less than 3 hours, before silence periods of a similar duration during line turns, prior to commencement of subsequent lines. The process will continue until all survey lines, plus any re-acquisitions or 'infill' lines have been acquired.

Environmental Impact Assessment

As required by Offshore Petroleum Greenhouse Gas Storage Environment Regulations 2009, SOMV is undertaking an assessment of the planned environmental impacts and unplanned environmental risks associated with the proposed seismic survey. This includes assessment of impacts and risks to other marine users including fishers, government agencies and ship owners. A number of species covered under the "Matters of National Environmental Significance" and "Other Matters" protected by the *Environment Protection and Biodiversity Conservation Act 1999*, have also been identified as potentially occurring within the survey ASA and OA. Species listed as Vulnerable or Endangered will be the subject of a comprehensive Environment Plan risk assessment and mitigation planning process in order to minimise any identified risks to acceptable levels. There are no Commonwealth or State Marine Reserves and Parks or listed Key Ecological Features (KEFs) occurring within the survey's OA .

The seismic survey vessel and any support vessels that may be imported into Australia to conduct this seismic survey activity, probably amongst others, will do so under the strict requirements of the biosecurity legislation administered by the Australian Department of Agriculture and Water Resources, and will be required to undertake inspections by a department biosecurity officer prior to mobilisation to the OA. An Oil Pollution Emergency Plan (OPEP) specific to the activity will also be developed, as required by the OPGGS(E) Regulations.

Potential Impacts to Stakeholders

Marine seismic surveys can potentially impact other marine users, including temporary displacement of commercial or recreational fishers and interaction with commercial shipping and other marine traffic. It is also possible that pelagic or demersal fish stocks may temporarily relocate during the activity. SOMV will be closely consulting with all relevant licensed fishers in the survey Planning Area in an effort to minimise any negative operational or commercial impacts to those fishers and their livelihoods.

As the AA and ASA are located wholly within the Perth Treaty area and outside of any designated shipping channels it is probable that any effects to commercial fishing activities or general shipping traffic will be minimal. Stakeholders with information or suspicions to the contrary are encouraged to provide feedback through the communications channels provided.

Further information regarding seismic surveying methods and their potential effects can be found on the International Association of Geophysical Contractors (IAGC) web site on the "Resources" page:- https://www.iagc.org/resources.html, or by completing the online form, via email or by phone and asking for further information to enable you to adequately assess whether the activity might affect your functions, interests or activities .

Stakeholder Engagement

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DocRef C001.2- Invitation for Consultation update 20190627

Stakeholder Update

Gem 3D Marine Seismic Survey

June 27th, 2019

Searcher Seismic

sapura energy

OMV

Key Information

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Contact

Gem 3D Stakeholder Consultation Team

PHONE:
+61 (0)8 9327 0301

WEBSITE:
searcherseismic.com/gem-3d-feedback.htm

EMAIL:
Gem3D@searcherseismic.com

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Register

Updated Information

Since the previous Invitation for Consultation document was circulated the proponent of the activity has changed business entity names from Sapura Exploration and Production (Western Australia) Pty Ltd (SEPWA) to SapuraOMV Upstream (Western Australia) Pty Ltd (SOMV).

In addition to the name change, the proposed seismic survey design has been revised to reduce potential impacts to Australian commercial fishing activities. The Acquisition Area (AA) and Active Source Area (ASA) have been reduced in size so that they do not lie within the Australian Exclusive Economic Zone (EEZ), and the Operations Area has been minimised within the EEZ.

Maps and details of the revised survey planning areas can be found on the following page.

Purpose

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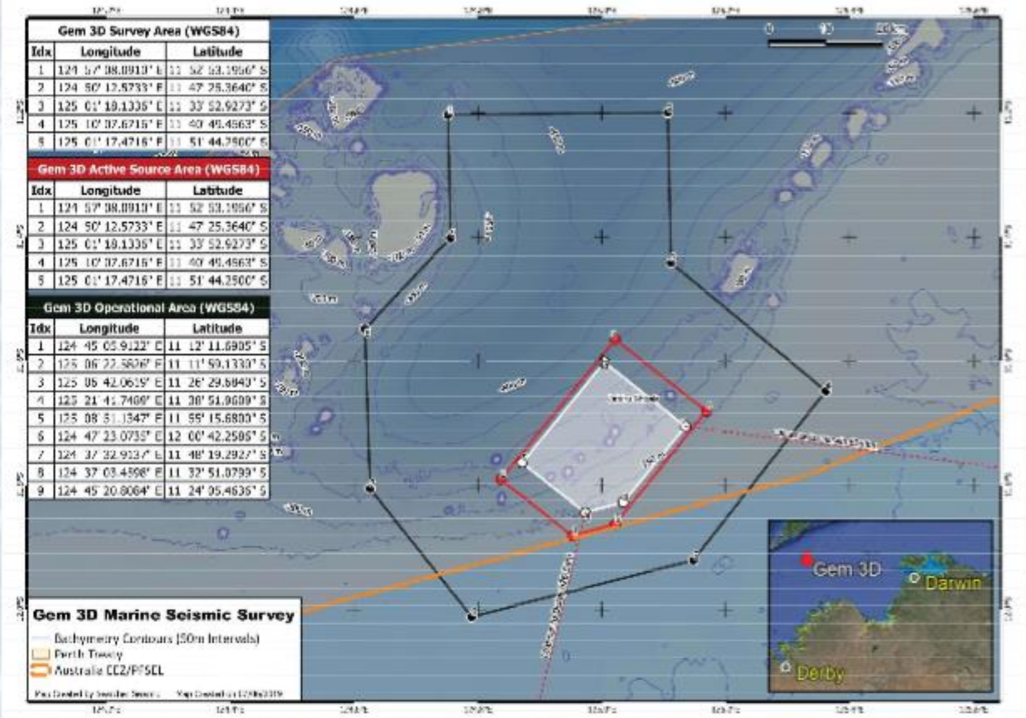
Proposed Activity



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Stakeholder Update

Gem 3D Marine Seismic Survey

July 4th, 2019

Searcher Seismic

sapura energy

OMV

Key Information

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Contact

Gem 3D Stakeholder Consultation Team

PHONE:
+61 (0)8 9327 0301

WEBSITE:
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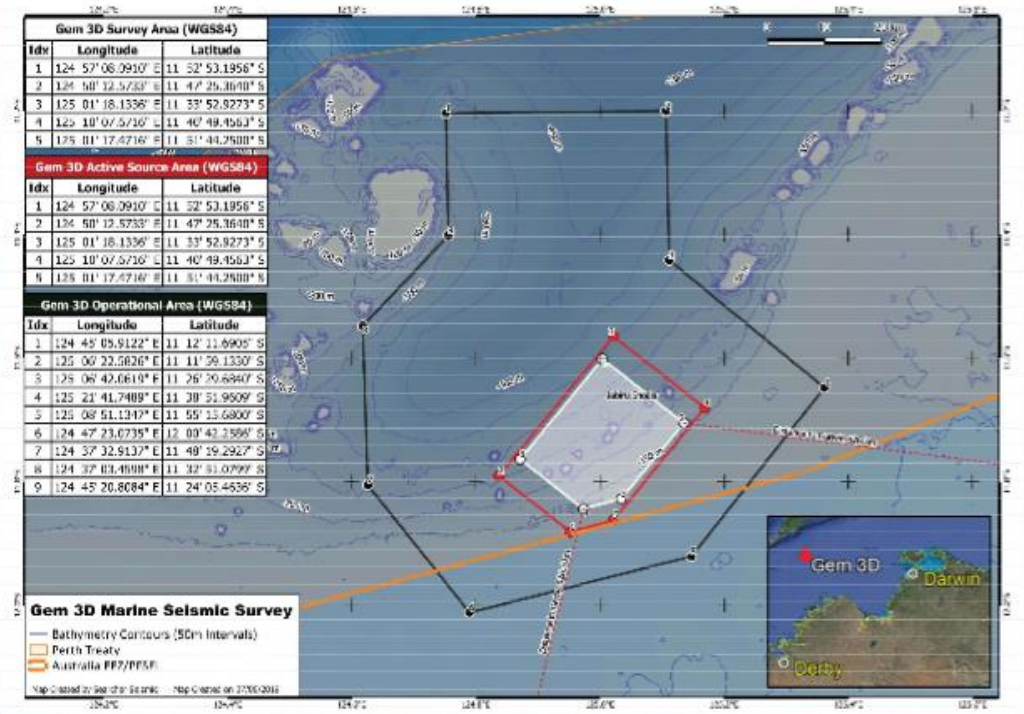
Searcher Seismic

Proposed Activity

sapura energy OMV



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Seismic data will be acquired in parallel lines in a racetrack pattern within the ASA over 24-hour daily operations for the duration of the survey, being approximately 3 weeks, with shut downs for routine and reactive maintenance, repairs, transit and line turns, fauna and stakeholder avoidance. Vessel survey operations, other than transit to and from the activity areas, will not take place outside the OA. Full energy source array activity in the ASA will average less than 3 hours, before silence periods of a similar duration during line turns, prior to commencement of subsequent lines. The process will continue until all survey lines, plus any re-acquisitions or 'infill' lines have been acquired.

Environmental Impact Assessment

As required by Offshore Petroleum Greenhouse Gas Storage Environment Regulations 2009, SapuraOMV is undertaking an assessment of the planned environmental impacts and unplanned environmental risks associated with the proposed seismic survey. This includes assessment of impacts and risks to other marine users including fishers, government agencies and ship owners. A number of species covered under the "Matters of National Environmental Significance" and "Other Matters" protected by the *Environment Protection and Biodiversity Conservation Act 1999*, have also been identified as potentially occurring within the survey ASA and OA. Species listed as Vulnerable or Endangered will be the subject of a comprehensive Environment Plan risk assessment and mitigation planning process in order to minimise any identified risks to acceptable levels. There are no Commonwealth or State Marine Reserves and Parks or listed Key Ecological Features (KEFs) occurring within the survey's OA .

The seismic survey vessel and any support vessels that may be imported into Australia to conduct this seismic survey activity, probably amongst others, will do so under the strict requirements of the biosecurity legislation administered by the Australian Department of Agriculture and Water Resources, and will be required to undertake inspections by a department biosecurity officer prior to mobilisation to the OA. An Oil Pollution Emergency Plan (OPEP) specific to the activity will also be developed, as required by the OPGGS(E) Regulations.

Potential Impacts to Stakeholders

Marine seismic surveys can potentially impact other marine users, including temporary displacement of commercial or recreational fishers and interaction with commercial shipping and other marine traffic. It is also possible that pelagic or demersal fish stocks may temporarily relocate during the activity. SapuraOMV will be closely consulting with all relevant licensed fishers in the survey Planning Area in an effort to minimise any negative operational or commercial impacts to those fishers and their livelihoods.

As the AA and ASA are located wholly within the Perth Treaty area and outside of any designated shipping channels it is probable that any effects to commercial fishing activities or general shipping traffic will be minimal. Stakeholders with information or details to the contrary are encouraged to provide feedback through the communications channels provided.

Further information regarding seismic surveying methods and their potential effects can be found on the International Association of Geophysical Contractors (IAGC) web site on the "Resources" page:- https://www.iagc.org/resources.html, or by completing the online form, via email or by phone and asking for further information to enable you to adequately assess whether the activity might affect your functions, interests or activities .

Stakeholder Engagement

SapuraOMV encourages open, two-way communication with stakeholders throughout the planning and implementation of the proposed activities. Reviewing this Invitation For Consultation package is the first stage of a more comprehensive stakeholder engagement process. The next stage will be for all persons or organisations that wish to continue to be included in the consultation process to register their interest via the simple online registration form that can be accessed through the Searcher web site address listed on the first page, or via scanning the QR code and completing the form on a mobile device. Some basic multiple choice question options and fields for additional feedback are provided within the feedback questionnaire, including the option to request direct communications with Searcher's Project Management Team. The option to opt out of any further communications on this matter also exists.

Under the regulations, stakeholder consultation is a mandatory process for the proponent (SapuraOMV) but voluntary for potential stakeholders. Searcher recognises the risk of "stakeholder fatigue" and the inconvenience consultation may cause for those that have no interest in the proposed activity. Unfortunately, failure to respond to this invitation to consult will not be accepted by the regulator NOPSEMA as a lack of interest, so your assistance in completing the online feedback form would be greatly appreciated and will help avoid further contact from us if you do decide to opt out of future correspondence in relation to this activity. If we do not hear from you then we will continue to provide you with updates to allow for circumstances such as extended post delivery times and perusal of this information.

SapuraOMV will provide all stakeholder feedback to NOPSEMA, within the proposed activity's environment plan. Under recent changes to Environment Regulations, all environment plans for offshore oil and gas activities will be published, and draft environment plans for offshore seismic surveys and exploration drilling activities will be open for an additional 30-day public comment period prior to NOPSEMA assessment.

Stakeholders are to advise if any feedback given to SapuraOMV, through Searcher, is to remain confidential and not to be made available for public release within the draft or final Environment Plan. This is a one click option in the online feedback form, or can be requested via the alternative contact methods provided.

DocRef C002- Invitation for Consultation with Commercial Fishers

Invitation For Consultation with Commercial Fishers

Gem 3D Marine Seismic Survey

Browse Basin, Australia

Key Information

SapuraOMV Upstream (Western Australia) Pty Ltd (SOMV), is preparing an Environment Plan for a 3D marine seismic survey in the Browse Basin in the Northern offshore region of Western Australia.

Searcher Seismic Pty Ltd (Searcher) has been contracted by SOMV to assist in the regulatory environmental approvals process, including stakeholder consultation and communications related to the survey activity.

Throughout the project development Searcher will provide each relevant person sufficient information to allow them to make an informed assessment of the possible consequences of the proposed survey on their functions, interests or activities. If you have any feedback, comments or questions on this activity, or do not think that this activity will affect your functions, interests or activities, then you may contact us via:-

Contact

Paul Miller
Operations Manager
SEARCHER SEISMIC PTY LTD

PHONE:
+61 (0)8 9327 0301

WEBSITE:
searcherseismic.com/gem-3d-feedback.htm

EMAIL:
Gem3D@searcherseismic.com

MOBILE DEVICE:
Scan this QR code to access the stakeholder registration and feedback form.

Introduction

In 2018, SOMV farmed-in to exploration permit AC/P 61 that was previously held by Finder Exploration Pty Ltd (Finder). SOMV is now the registered titleholder and the operator of AC/P 61, located in the Vulcan Sub-basin, western Bonaparte Basin, in the Timor Sea, approximately 250 km offshore of northern WA and 626 km from Darwin. .

The planned 'Gem 3D Marine Seismic Survey' is SOMV's first Australian seismic survey, with an acquisition area of approximately 410 square kilometres in size (see location details following pages).

Timing

The proposed activity is scheduled to commence sometime between December 2019 and June 2020 and is expected to take approximately three weeks to complete.

Final survey timing will be dependent on environmental considerations, regulatory approvals, vessel availability and weather conditions. Based on these unknown influences, the option to conduct the activity at any time between December 2019 and the first half of 2020, whilst adhering to any identified environmental constraints, will be sought for approval from the relevant government regulators.

Every effort will be made to time the activity to minimise any potential adverse effects on relevant stakeholders, with particular emphasis on commercial fishers and their key fishery resources. This Invitation for Consultation document includes an initial assessment of the potential for interaction with each of the overlapping commercial fisheries, including the timing component.

About SOMV

SOMV is a wholly owned subsidiary of SapuraOMV Upstream Sdn. Bhd. (SapuraOMV); a strategic partnership between Sapura Energy Berhad and OMV AG. SapuraOMV is a leading independent oil and gas company with assets in Malaysia and exploration interests in Australia, New Zealand and Mexico.

Searcher Seismic

sapura energy

OMV

Searcher Seismic

Proposed Activity

sapura energy OMV

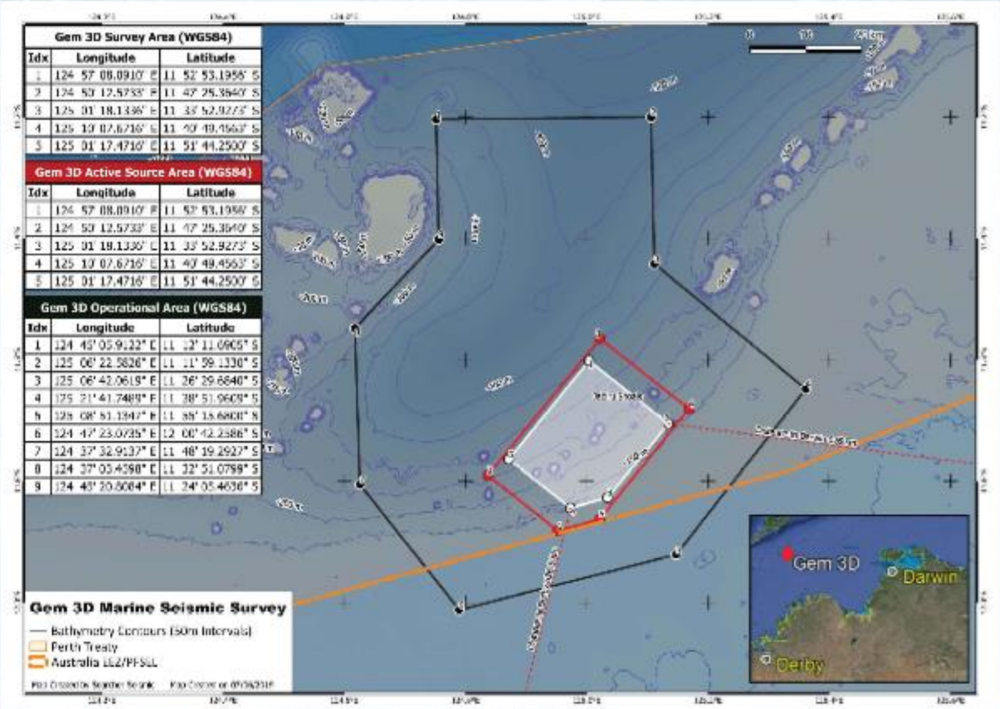

Figure 1—Proposed Activity Location Map

The Gem 3D seismic survey area is located entirely within offshore Commonwealth waters, approximately 620 km West of Darwin and around the same distance NNE of Derby. The Operations Area is in excess of 240 km from the Western Australian mainland, in water depths between 450m and less than 10m in the shallowest patches of the Jabiru Shoals. A location map and boundary co-ordinates are provided above.

The survey **'Acquisition Area' (AA)** is approximately 410 square kilometres in size and the area where 3D seismic data will be acquired and is the seismic data focus area. The AA is located fully within the 1997 Perth Treaty area, which is not yet ratified, but is recognised as the boundary of the Australian Economic Exclusive Zone (EEZ) by the governments of Australia and Indonesia. The EEZ boundary coincides with the Provisional Fisheries Surveillance and Enforcement Line (PFSEL), which is the agreed delimitation boundary of legal fishing activity between Australia and Indonesia. The AA is offshore of the PFSEL.

The survey **'Active Source Area' (ASA)** of 647 square kilometres is the area within which the seismic energy source (airguns) will be Operations and seismic data will be acquired, including soft start procedures and line run-outs (required to obtain full fold coverage). The full seismic source will not be operational outside of the survey active source area, although small, individual source elements may be tested during maintenance outside the ASA but within the Operations Area. The entire ASA is also located beyond the Australian EEZ./PFSEL.

The **'Operations Area' (OA)** or 'operational buffer' around the survey area is required for activities including streamer deployment and retrieval, maintenance and recovery and routine vessel manoeuvring. The OA is 4,760 square kilometres in size but operations will be conducted mainly within the ASA , with the OA limited to non-seismic vessel activities. The OA is mostly offshore the EEZ/PFSEL.

Seismic data will be acquired in parallel lines in a racetrack pattern within the ASA over a 24-hour period, with shut downs for routine and reactive maintenance, repairs, transit and line turns, fauna and stakeholder avoidance. Vessel survey operations, other than transit to and from the activity areas, will not take place outside the OA. Full energy source array activity in the ASA will average less than 3 hours, before silence periods of a similar duration during line turns, prior to commencement of subsequent lines. The process will continue until all survey lines, plus any re-acquisitions or 'infill' lines have been acquired.

Environmental Impact Assessment

As required by Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS(E) Regulations), SOMV is undertaking an assessment of the planned environmental impacts and unplanned environmental risks associated with the proposed seismic survey. This includes assessment of impacts and risks to other marine users including fishers, government agencies and ship owners. A number of species covered under the "Matters of National Environmental Significance" and "Other Matters" protected by the *Environment Protection and Biodiversity Conservation Act 1999*, have also been identified as potentially occurring within the survey ASA and OA. Species listed as Vulnerable or Endangered will be the subject of a comprehensive impact and risk assessment in order to minimise these to as low as reasonably practicable (ALARP) and acceptable levels.. There are no Commonwealth or State Marine Reserves and Parks or listed Key Ecological Features (KEFs) occurring within the survey's OA .However risks posed by a fuel spill from the survey vessel to environment receptors, including the nearest land (Cartier Island), located approximately 140 km from the OA, will also be assessed and reduced to ALARP and acceptable levels.

The seismic survey vessel and any support vessels that may be imported into Australia to conduct this seismic survey activity, probably amongst others, will do so under the strict requirements of the biosecurity legislation administered by the Australian Department of Agriculture and Water Resources, and will be required to undertake inspections by a department biosecurity officer prior to mobilisation to the OA. An Oil Pollution Emergency Plan (OPEP) specific to the activity will also be developed, as required by the OPGGS(E) Regulations.

Potential Impacts to Stakeholders

Marine seismic surveys can potentially impact other marine users, including temporary displacement of commercial or recreational fishers and interaction with commercial shipping and other marine traffic. It is also possible that pelagic or demersal fish stocks may temporarily relocate during the activity. SOMV will be closely consulting with all relevant licensed fishers in the survey Planning Area in an effort to minimise any negative operational or commercial impacts to those fishers and their livelihoods. An initial Impact Assessment of the commercial fishing activities in each of the overlapping Commonwealth and State Managed fisheries is included In the following pages. This initial assessment has since been reviewed by [redacted] Executive Officer Resource Access, at WAFIC, with her verbatim (transcribed from hand written) feedback inserted thereafter *in red italic text*, where originally added.

As the AA and ASA are located wholly within the Perth Treaty area and outside of any designated shipping channels it is probable that any effects to commercial fishing activities or general shipping traffic will be minimal. Stakeholders with information or suspicions to the contrary are encouraged to provide feedback through the communications channels provided. *correct*

Further information regarding seismic surveying methods and their potential effects can be found on the International Association of Geophysical Contractors (IAGC) web site on the "Resources" page:- https://www.iagc.org/resources.html, or by completing the online form, via email or by phone and asking for further information to enable you to adequately assess whether the activity might affect your functions, interests or activities .

Stakeholder Engagement

SOMV encourages open, two-way communication with stakeholders throughout the planning and implementation of the proposed activities. Reviewing this Invitation For Consultation package is the first stage of a more comprehensive stakeholder engagement process. The next stage will be for all persons or organisations that wish to continue to be included in the consultation process to register their interest via the simple online registration form that can be accessed through the Searcher web site address listed on the first page, or via scanning the QR code and completing the form on a mobile device. Some basic multiple choice question options and fields for additional feedback are provided within the feedback questionnaire, including the option to request direct communications with Searcher's Project Management Team. The option to opt out of any further communications on this matter also exists.

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SOMV will provide all stakeholder feedback to NOPSEMA, within the proposed activity's environment plan. Under recent changes to environment regulations, all environment plans for offshore oil and gas activities will be published, and draft environment plans for offshore seismic surveys and exploration drilling activities will be open for an additional 30-day public comment period prior to NOPSEMA assessment.

Stakeholders are to advise if any feedback given to SOMV, through Searcher, is to remain confidential and not to be made available for public release within the draft or final Environment Plan. This is a one click option in the online feedback form, or can be requested via the alternative contact methods provided.

Potential Effects to Commercial Fishing

The following potential effects of the seismic survey activity have been identified and have formed the basis of a Risk Assessment, with resultant control measures defined in order to reduce the risks to ALARP and acceptable levels.

Temporary Displacement of Others

It is possible that the presence of the survey and any support vessels in the Operations Area could force temporary displacement of other marine users, including fishing vessels and other commercial or recreational shipping traffic. During survey operations the seismic vessel will be towing up to ten seismic streamers, each up to 8,500 metres in length and at depths between 7 and 15 meres below the sea surface. Survey vessel manoeuvrability is therefore restricted and other traffic may be asked to deviate from their courses or to move away from stationary locations in order to provide safe passage for the survey vessel and its towed equipment.

Due to the relatively remote location of the Gem 3D OA, more than 200km from the Australian mainland and with the major portion of the OA existing beyond the Australian Exclusive Economic Zone (EEZ) and outside of any commercial shipping routes it is not anticipated that any significant interactions with other marine users will occur. However, the following control measures will be implemented:-

- Tailbuoys clearly marked to identify streamer ends to other users
- Survey area minimised as much as practicable whilst still achieving the survey objectives
- Consultation with other users during the development of the EP prior to and during the survey activity. In particular, the ASA has been reduced to avoid areas inshore of the Perth Treaty line which are open to fishing by Australian fishers.
- Notification of the activity to the AMSA/JRCC and AHS which will issue Notice to Mariners and AusCoast Warning in relation to the activity
- Maintain appropriate navigational lights and day shapes at all times, in accordance with COLREGS to inform other users of the vessel's actions. Additional communications will be carried out, as required, during the activity using a range of means . E.g. marine VHF radio, telephone, signal lights etc.
- Use of a support vessel to interact with commercial fishers and other vessels present
- 24-48 hour notification to commercial fishers (communications at sea) regarding look-ahead activities
- In the event of equipment loss, other users notified as required (including AMSA and NOPSEMA)

Altered Behaviour or Injury of Marine Fauna

It is possible that the activation of the seismic energy source in close proximity to marine fauna can cause behavioural responses, such as temporary relocation of pelagic or demersal fish species, marine mammals and other swimming species. It is also possible that either Temporary or Permanent Threshold Shifts (TTS/PTS) in the hearing of certain species of marine fauna, including fish, could result from close proximity exposure to the sound source. A more detailed evaluation of the potential effects of the energy source on various marine fauna will be provided in the Environment Plan, to be published on the NOPSEMA web site prior to assessment, or can be made available to relevant stakeholders prior to publication, once finalised, on request.

In order to minimise the risks associated with underwater sound emissions from the Seismic Array the following control measures will be implemented:-

- The smallest practicable seismic array size to meet the geophysical objectives of the survey will be used, (based on a comprehensive third-party sound source modelling).
- Avoid concurrent seismic surveys by other operators, with time share operations implemented if required.
- Consultation with the Western Australian Fishing Industry Council (WAFIC) regarding the potential for activities in the marine aquarium and specimen shell managed fisheries prior to the survey to advise on survey programme to reduce the potential for the presence of commercial divers in the vicinity of the survey area.
- Identification of, and consultation with, commercial fisheries who may be active within the OA and impacted by survey activities.
- Results of site specific, energy source sound modelling, once completed, will be made available to relevant stakeholders, on request.

Searcher Seismic

Potential Effects to Commercial Fishing

sapura energy OMV

Negative Impacts on Plankton

The potential impacts of seismic surveys on plankton, including fish eggs and larvae, will depend on the species in question, the life history stages, the specifications of the airgun array, the distance between the airgun discharge and the plankton, the number of discharges, the water depth and the seabed features. Proximity to the source (i.e. airgun array) will also be variable due to diel migration of plankton (including fish larvae) between surface and deep waters.

Richardson et al. (2017) showed that zooplankton communities can begin to recover during the survey period during periods of good oceanic circulation (and periods of upwelling), and therefore a continuous decline in zooplankton throughout the survey period is not anticipated and parts of the survey area would progressively recover during the survey.

It is unlikely there would be localised patches of reduced food availability for plankton feeders over the period of the survey and during the 3-day recovery period (as modelled by Richardson et al. (2017)). No population level effects are expected in commercially caught finfish species, or to their catch rates as an indirect result of impacts on eggs/larvae.

Based on the results of the modelling and research thresholds, impacts to these species, particularly at the population level, is expected to be negligible. A control will be in place during survey operations to avoid surveying in waters shallower than a prescribed depth, based on final sound modelling results, in order to reduce impacts on spawning.

As with the potential effects on fish, a more detailed analysis of the activity-specific effects, based on the selected energy source and survey location, will be provided in the EP for publication during the public consultation period. Relevant stakeholders can request early results of the analysis, once finalised, by making contact through the feedback channels provided.

Introduction of Invasive Marine Species

Although unlikely, it is possible that the seismic survey vessel, like any vessel entering Australian commonwealth waters, could introduce non-indigenous marine species (NIMS) through either biofouling or in ship's ballast water. This could result in competition, predation or displacement of native species, alteration of natural ecological processes, introduction of pathogens with the potential to impact on human and/or ecological health, reduction and/or competition with commercial fish and aquaculture species and increased maintenance of vessels and marine infrastructure. Standard inspection and quarantine control measures will be implemented to reduce the risk of introduction of NIMS to ALARP.

Overlapping Fisheries

The jurisdiction of three Commonwealth and eleven WA state fisheries overlap the Operations Area (Table 1). Due to the location of the MSS it is important to note that the outer limit of these jurisdictions is aligned with Australia's Exclusive Economic Zone, including where this has been modified by the Treaty between the Government of Australia and the Government of the Republic of Indonesia establishing an Exclusive Economic Zone Boundary and Certain Seabed Boundaries (Perth, 14 March 1997) (Perth Treaty) (Delimitation Treaties Infobase 2002).

Although not yet in force, Australia acts consistently with the arrangements of this treaty (AFMA 2014). This treaty line passes through the Operations Area. It also coincides with the Provisional Fisheries Surveillance and Enforcement Line (PFSEL), which is based on an agreement made between the governments of Indonesia and Australia in 1981 and prohibits Australian fishing vessels equipped to fish for swimming species moving north of the line unless their gear is stowed and secured (DoFWA 2016). As such, operators in state and Commonwealth fisheries described in Table 1 are not legally eligible to fish and are not expected to be present in those parts of the Operations Area offshore of the Perth Treaty line, as shown in Figure 1.

Table 1—Commercial fisheries overlapping the Gem 3D MSS Operations Area

Commonwealth	**State**
Southern Bluefin Tuna Fishery (SBT)	South-west Coast Salmon Managed Fishery
Western Tuna and Billfish Fishery *WTBF*	Abalone Managed Fishery
Western Skipjack Tuna Fishery	Kimberley Prawn Managed Fishery
	Northern Shark Fisheries
	Mackerel Managed Fishery
	Kimberley Crab Managed Fishery
	Marine Aquarium Fish Managed Fishery
	Northern Demersal Scalefish Managed Fishery
	Pearl Oyster Managed Fishery
	Specimen Shell Managed Fishery
	West Coast Deep-sea Crustacean Managed Fishery

WAFIC: *Confirm state fisheries. You will need to liaise wi*[redacted] *WTBF adherence to the Treaty.*

Commonwealth Fisheries

The Australian Fisheries Management Authority manages all Commonwealth fisheries under the *Fisheries Management Act 1991*. Three Commonwealth-managed commercial fisheries intersect the Operations Area and the jurisdictional area of each fishery is shown in Figure 2. The areas fished and relative catch levels of the three Commonwealth-managed fisheries in 2016–2017 are presented in Table 2.

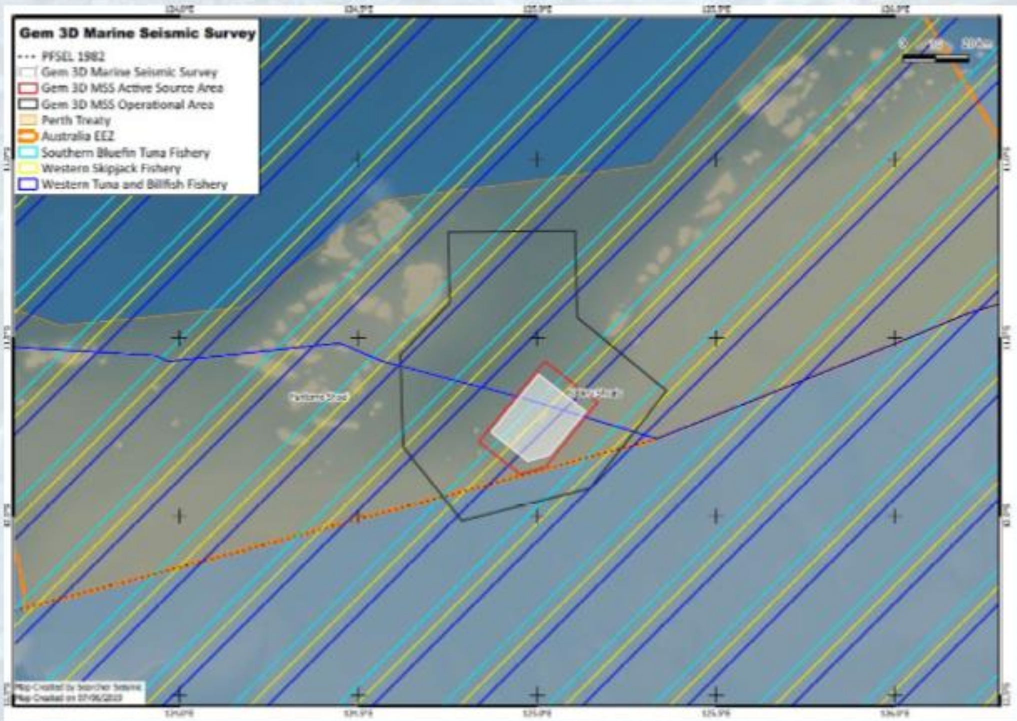

Figure 2—Overlapping Commonwealth Managed Fisheries

Table 2—Commonwealth-managed fisheries which overlap the Operations Area

Fishery	Geographic extent	Target species	Season	Method	Catch and value	Fishing occurs within the Operations Area?
Southern Bluefin Tuna Fishery	All AFZ waters (3–200 nm). Most of the Australian catch is taken in the Great Australian Bight (GAB), with small amounts taken off south-east Australia.	Juvenile southern bluefin tuna (2–5 years)	Fishing occurs from the start of Dec to the end of Mar. After feeding in the grow-out cages, fish are generally harvested in Aug	Purse seine (in the GAB), pole and line, longline and trolling (off south-east Australia)	5,697 t valued at $38.57 million in 2016-17 season	Unlikely- fishing effort is concentrated in the GAB and off south-east Australia.
Western Tuna and Billfish Fishery	All AFZ waters (3–200 nm) from Cape York (QLD) to the VIC–SA border. In recent years, effort has concentrated off south-west WA and SA	Yellowfin tuna, bigeye tuna, skipjack tuna, albacore, billfish	Year-round	Pole and line, purse seine, pelagic longline, troll, rod and reel, handline	2016-2017 ranged from 320-322 tonnes. Value not reported.	Unlikely- Effort data shows fishing effort is concentrated offshore of the 200 m isobath and to the south of the Operations Area
Western Skipjack Tuna Fishery	All external Commonwealth and state waters out to 200 nm	Skipjack tuna	Year-round	Purse seine and pole	Not active	No – licence holders have not participated in the fishery since 2008-09

Southern Bluefin Tuna Fishery

The Southern Bluefin Tuna Fishery targets southern bluefin tuna *(Thunnus maccoyii)* under the *Southern Bluefin Tuna Fishery Management Plan 1995*. Effort in this fishery is concentrated in the Great Australian Bight, several thousand kilometres from the location of the proposed activity (Figure 3). SBT catch in 2016 represented 10.68% of all Commonwealth fisheries catch for that year (AFMA 2018a). Southern bluefin tuna spawn in the North West Shelf region of Western Australia between September and March, approximately 150 km from the Operations Area .The larvae may be seasonally abundant in surface waters of the broader region during these months and migrating adult tuna may transit through the region. Due to the large distance between the actively fished area and the location of the activity, vessels participating in this fishery are not expected to be encountered during the activity.

Email communications with WAFIC indicated that "There is no SBT fishing in WA, quota holders are not relevant parties to EP activities in WA. However, the resource must be part of the EP – [as] it's [part of] the SBT migratory route." Consequently, the SBT fishers will be consulted directly via the Australian Southern Bluefin Tuna Industry Association (ASBTIA), as recommended by WAFIC.

WAFIC: *Correct—Send Gem information to ASBTIA*

Overlapping Commercial Fisheries Summary

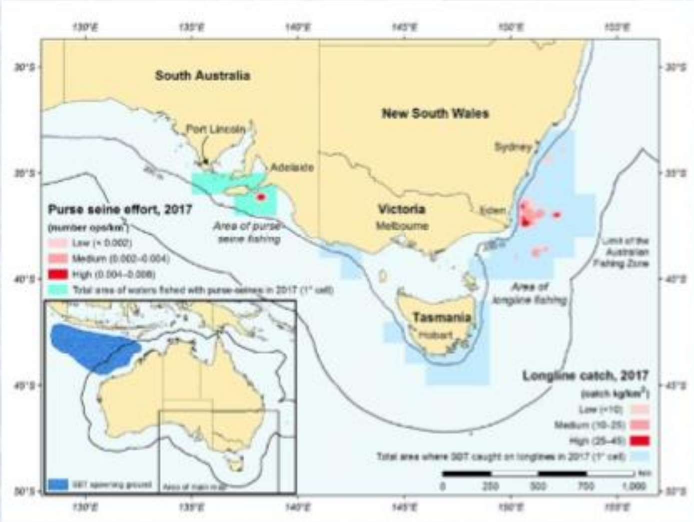

Figure 3— Purse-seine effort and longline catch in the SBT Fishery 2017

Western Tuna and Billfish Fishery

The Western Tuna and Billfish Fishery is a Commonwealth fishery managed by the Australian Fisheries Management Authority (AFMA) under the *Western Tuna and Billfish Management Plan 2005*. It extends westward from Cape York Peninsula (142° 30´E) off Queensland around the west coast of Western Australia and from there extends eastward across the Great Australian Bight to 141°E at the South Australian/ Victorian border. The fishery targets four main pelagic species, which are all highly migratory:

Broadbill swordfish *(Xiphias gladius)*,
Bigeye tuna (*Thunnus obesus)*,
Yellowfin tuna *(T. albacares)*,
Albacore tuna *(T. alalunga.)*.

WAFIC: *I am unsure if the treaty is observed. One active fishe*[redacted] *(Ocean Wild / Uptop Fisheries).* [email address redacted] *Please liaise* [redacted] *he has ongoing concerns re seismic impacts on his fishery / the resource.*

Information available from the Australian Bureau of Agricultural and Resource Economics and Sciences indicates that the estimated catch and value of this fishery in 2016-2017 ranged from 3200- 322 tonnes (ABARES 2018), representing 0.58% of all Commonwealth fisheries catch for that year (AFMA 2018a). Historical data shows fishing effort is concentrated offshore of the 200 m isobath and to the south of the Operations Area (AFMA 2018b). As such, vessels within this fishery are not expected to be encountered during the activity. Communications from WAFIC have indicated "There is only one active operator in WA for the Commonwealth-managed Western Tuna and Billfish Fishery" and that "He fishes west and north and in deeper waters, not usually as far north as this proposed survey ..". The named operator will be consulted directly, as recommended by WAFIC.

Western Skipjack Fishery

The Western Skipjack Fishery is part of the Skipjack Tuna Fishery, which contains two stocks: one to the east and one to the west, that are assessed separately but managed together under various management arrangements and general conditions in addition to the *Fisheries Management Act 1991*. The Western Skipjack Fishery targets only skipjack tuna *Katsuwonus pelamis*. While the Operations Area lies within the boundary of the fishery, effort within this fishery is mainly confined to the southern coast of Australia, several thousand kilometres away. No fishing effort has been recorded since the 2008-2009 season (ABARES 2018) and there is no expected effort as the fishery is not currently active (AFMA 2019a). As such, vessels are not expected to be encountered during the activity. WAFIC: *incorrect. There are no fishers operating in this fishery*

References:

ABARES 2018, Fishery status reports 2018. Available from: http://data.daff.gov.au/data/warehouse/9aam/fsrXXd9abm_/fsr18d9abm_20180928/00_FishStatus2018_1.0.0.pdf.
AFMA 2014, Multiple Fishery (Closures) Direction No. 1.

Western Australian State Commercial Fisheries

The following WA state fisheries have jurisdictions overlapping, but no recent (since 2014) catch or effort in the Operations Area is recorded in the Fishcube database. Due to the location of the proposed seismic survey, it is important to note that jurisdiction of these fisheries lies within the outer limits of Australia's Exclusive Economic Zone, including where modified by the *Treaty between the Government of Australia and the Government of the Republic of Indonesia establishing an Exclusive Economic Zone Boundary and Certain Seabed Boundaries (Perth, 14 March 1997)* (Perth Treaty) https://www.un.org/Depts/los/LEGISLATIONANDTREATIES/PDFFILES/TREATIES/AUS-IDN1997EEZ.pdf (accessed 29/5/19). Although not yet in force, Australia acts consistently with the treaty arrangements (AFMA Multiple Fishery (Closures) Direction No. 1 2014). State and Commonwealth fisheries are not able to fish offshore of this boundary, which passes through the Operations Area. Advice from the Western Australian Fishing Industry Council (WAFIC) and information provided below confirms that operators in these fisheries are not expected to be active in the Operations Area during the seismic survey.

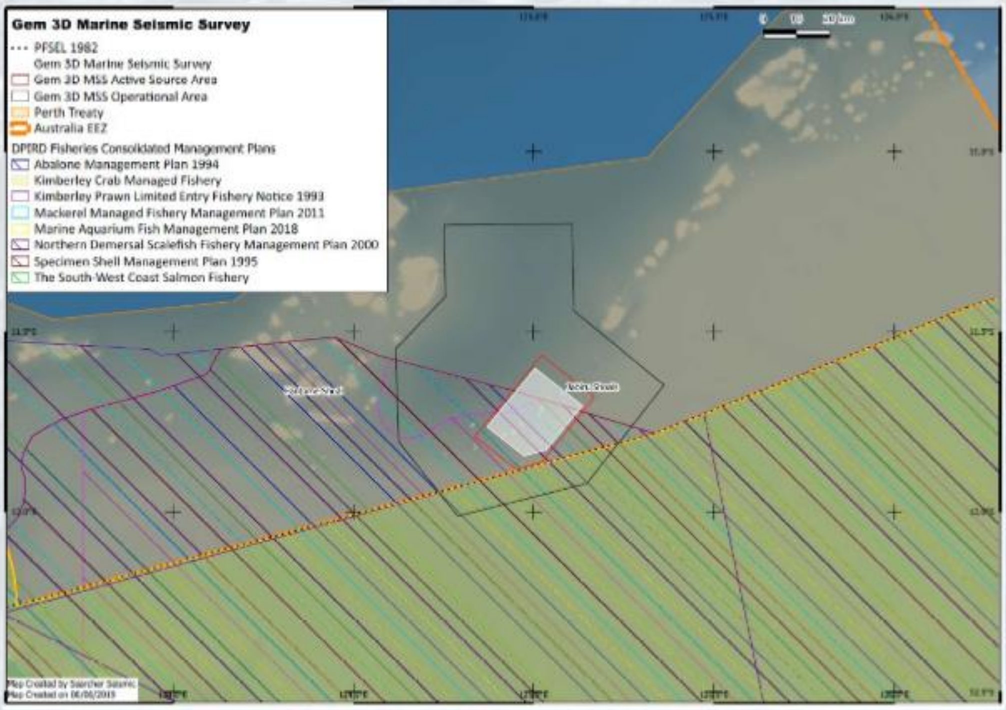

Figure 4—Overlapping State Managed Fisheries

South-west Coast Salmon Managed Fishery

The South-west Coast Salmon Managed Fishery is active on various metropolitan beaches in the south of Western Australia. Fishing method is beach seine netting (ABARES 2018). Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operations Area for the years 2014 – 2017 (more recent data not available). Discussion with WAFIC and DPIRD (Steve Newman, DPIRD Principal Scientist, pers. comm.) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

WAFIC: *Correct—zero interaction*

Abalone Managed Fishery

The Abalone Managed Fishery is active in the southern region of Western Australia. Fishing methods are dive and wading. Fishing was closed in Area 8, the area of WA waters north of Moore River during the 2011/12 season due to the catastrophic mortality observed following a marine heatwave in 2010/11 and remains closed (ABARES 2018). Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operations Area for the years 2014 – 2017 (more recent data not available). Discussion with WAFIC and DPIRD (Steve Newman, DPIRD Principal Scientist, pers. comm.) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

WAFIC: *Correct—zero interaction*

Kimberley Prawn Managed Fishery

The jurisdiction of the Kimberley Managed Prawn Fishery partially overlaps the Operations Area. The gear used consists of otter trawls and is typically restricted to depths less than 60 m. The fishery is generally active between April and May, and August to November each year (ABARES 2018). Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operations Area for the years 2014 – 2017 (more recent data not available). Discussion with WAFIC and DPIRD (Steve Newman, DPIRD Principal Scientist, *pers. comm.*) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

WAFIC: *Correct—zero interaction*

Mackerel Managed Fishery

The Mackerel Managed Fishery targets Spanish mackerel (*Scomberomorus commerson*), with smaller landings of other species such as grey mackerel (*S. semifasciatus*). The fishery extends from Cape Leeuwin on the southern west coast of Australia to the Western Australian/Northern Territory Border, and historically most of the catch is landed in the Pilbara and Kimberley regions (Lewis & Jones 2017). Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operations Area for the years 2014 – 2017 (more recent data not available). Mackerel form spawning schools around inshore reefs in north coast bioregion, with a peak spawning period between September and January The Mackerel Managed Fishery runs primarily from May to November.(DPIRD 2019). Discussion with WAFIC and DPIRD (Steve Newman, DPIRD Principal Scientist, pers. comm.) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

WAFIC: *Correct—zero interaction*

Kimberley Crab Managed Fishery

The Kimberley Crab Managed Fishery management plan was drafted in October 2018. The fishery targets mud and blue swimmer crabs within state coastal waters. Although the fishery management plan includes all Western Australian waters, the fishery is closed seaward of the WA coastal waters (DPIRD 2018). Consequently, interactions between fishing vessels and the survey will not occur.

WAFIC: *Correct—zero interaction*

Marine Aquarium Fish Managed Fishery

The Marine Aquarium Fish Managed Fishery management plan allows effort within all WA state waters, however historically effort is concentrated in waters south of Broome near Perth, Geraldton, Exmouth and Dampier (Newman et al. 2017). The fishery targets more than 950 species of marine aquarium fishes, plus coral, live rock, algae, seagrasses and invertebrates. Due to the special handling requirements of live fish, catch effort is relatively low and is concentrated in nearshore coastal waters. Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operations Area for the years 2014 – 2017 (more recent data not available). Discussion with WAFIC and DPIRD (Steve Newman, DPIRD Principal Scientist, pers. comm.) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

WAFIC: *Correct—zero interaction*

Searcher Seismic

Overlapping Commercial Fisheries Summary

sapura energy OMV

Northern Shark Fisheries

The Northern Shark Fisheries consist of the state managed Western Australian North Coast Shark Fishery and the Joint Authority Northern Shark Fishery. No activity has been reported in either of these fisheries since the 2008/09 season, with low levels of activity reported prior to these years (DPIRD 2016). Similarly, catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operations Area for the years 2014 – 2017 (more recent data not available). Discussion with WAFIC and DPIRD (Steve Newman, DPIRD Principal Scientist, pers. comm.) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

WAFIC: *Correct—zero interaction*

Pearl Oyster Managed Fishery

The WA pearl oyster fishery is the only remaining significant wild-stock fishery for pearl oysters in the world. It is a quota-based, dive fishery, operating in shallow coastal waters (< 35 m depth) along the NWS from Exmouth to the NT border. The harvest method is drift diving. Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operations Area for the years 2014 – 2017 (more recent data not available). Discussion with WAFIC and DPIRD (Steve Newman, DPIRD Principal Scientist, pers. comm.) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

WAFIC: *Correct—zero interaction*

Specimen Shell Managed Fishery

The Specimen Shell Managed Fishery is based on the collection of shell specimens for display, sale, or cataloguing. Over 200 species are allowed to be taken under the management plan by either diving of Remotely Operated Vehicle (ROV) at depths from 60 m-300 m. Fishing is permitted within all WA waters, however historical effort is concentrated in coastal waters adjacent to population centres such as Broome, Karratha, Carnarvon and Perth (Hart et al. 2017). Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operations Area for the years 2014 – 2017 (more recent data not available). Discussion with WAFIC and DPIRD (Steve Newman, DPIRD Principal Scientist, pers. comm.) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

WAFIC: *Correct—zero interaction*

West Coast Deep-sea Crustacean Managed Fishery

The West Coast Deep-sea Crustacean Managed Fishery is a quota-based pot fishery that mostly operates in depths of 500–800 m, with no fishing is permitted on the landward side of the 150 m isobath. The only allowable method fishing is baited pots on long-lines, with most set on muddy seabed. The boundaries of this fishery include all WA waters of the Indian Ocean and the Timor Sea north of 34°24'S. Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operations Area for the years 2014 – 2017 (more recent data not available). Discussion with WAFIC and DPIRD (Steve Newman, DPIRD Principal Scientist, pers. comm.) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

WAFIC: *Correct—zero interaction*

Northern Demersal Scalefish Managed Fishery

The Northern Demersal Scalefish Managed Fishery (NDSMF) operates in Western Australian waters east of 120°E and north of 19°59'S. In 2019 there were six vessels active in the fishery, with three of these operating from Broome, WA and three from Darwin, NT (Dr S. Newman, Principal Fisheries Scientist DPIRD pers. comm. 6 May 2019). Operators in this fishery typically use demersal traps, which are baited to attract target species. Although the baits are typically gone within three hours of trap deployment, the traps may be left in water (unbaited and open) for up to twelve days between fishing trips (Newman et al. 2011), An assessment of the ecological sustainability of management arrangements for the NDSMF found a trap soak time of five hours to be standard for the fishery (Department of Fisheries 2004).

The NDSMF is divided into two areas - Area 1 is inshore and restricted to line fishing methods, whereas Area 2 is offshore and open to both trap and line methods. Area 2 is historically where fishing effort is concentrated (DPIRD 2000). It is further divided into three zones, A - C. There is no overlap by the OA and ASA with Zone A(Figure 5). Similarly, because of the exclusion zone described in Schedule 2A of the *Northern Demersal Scalefish Fishery Management Plan 2000* that bounds the Perth Treaty Area 1997, there is also no overlap by the OA and ASA with Zone C. The majority of fishing effort by the NDSMF occurs in Zone B (DoFWA 2016). In 2016 the catch within this zone was 965 t (DoFWA 2016). The fishing range of operators within the NDSMF extends throughout the area of Zone B (Dr S. Newman, Principal Fisheries Scientist DPIRD pers. comm. 6 May 2019).

WAFIC: *Note no interaction in the acquisition area, Note there may be interaction in the operational area. Please obtain a current license list from DPIRD (Fisheries) and advise license holders. Please ensure there is a succinct covering email noting the small chance of interaction with vessel turns. We get A LOT of emails—make sure the info is clear and not overdone.*

There is minimal (~434km^2) overlap between the OA and Zone B. The four-year average of vessel count in the area of the NDSMF overlapping the OA demonstrates an increase of effort from September to March, with the peak in November. Vessel count was used as a substitute for weight of total catch as this more accurately reflected vessel activity when many blocks returned a total weight of zero. Across Zone B, as a whole, the catches generally increase from a low in July through to a peak in October – November each year (2014-2016), although data for 2017 and 2018 suggests higher catches in the period February to May and therefore considerable variability between years. According to DPIRD (2019) the Northern Demersal Scalefish Fishery target the entire demersal suite of fish's year round and that most Key Species spawn throughout their range (rather than aggregating at specific locations) Due to the minimal overlap of the OA with the NDSF and the relatively small size and location of the ASA beyond the fishing area boundary it is not expected that there will be any interaction with the fishery, or any significant impacts to its fish stocks.

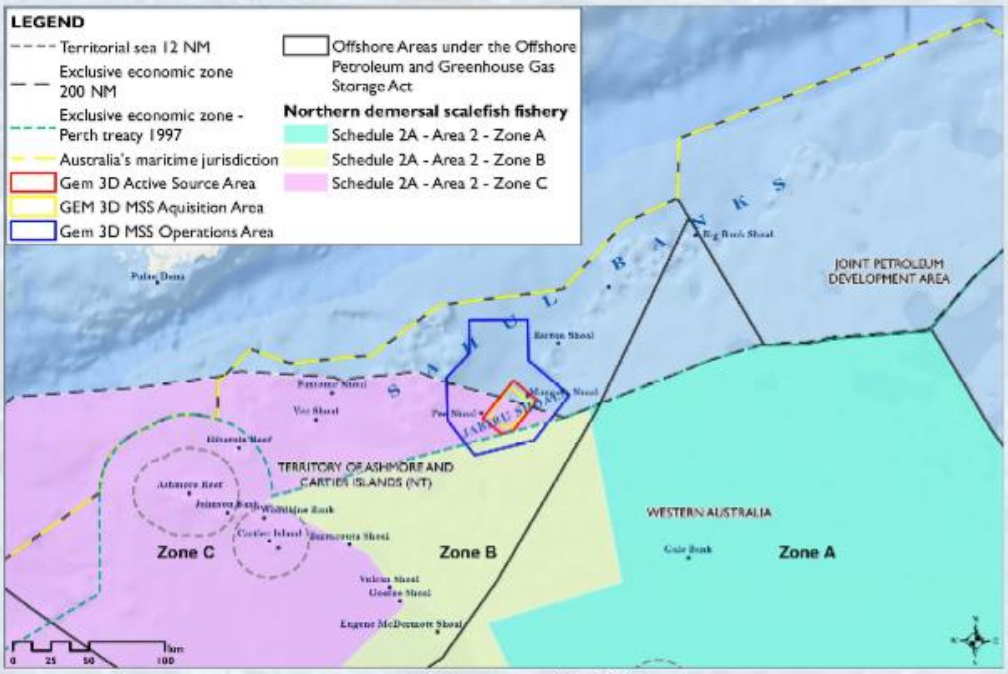

Figure 5—Northern Demersal Scalefish Zones

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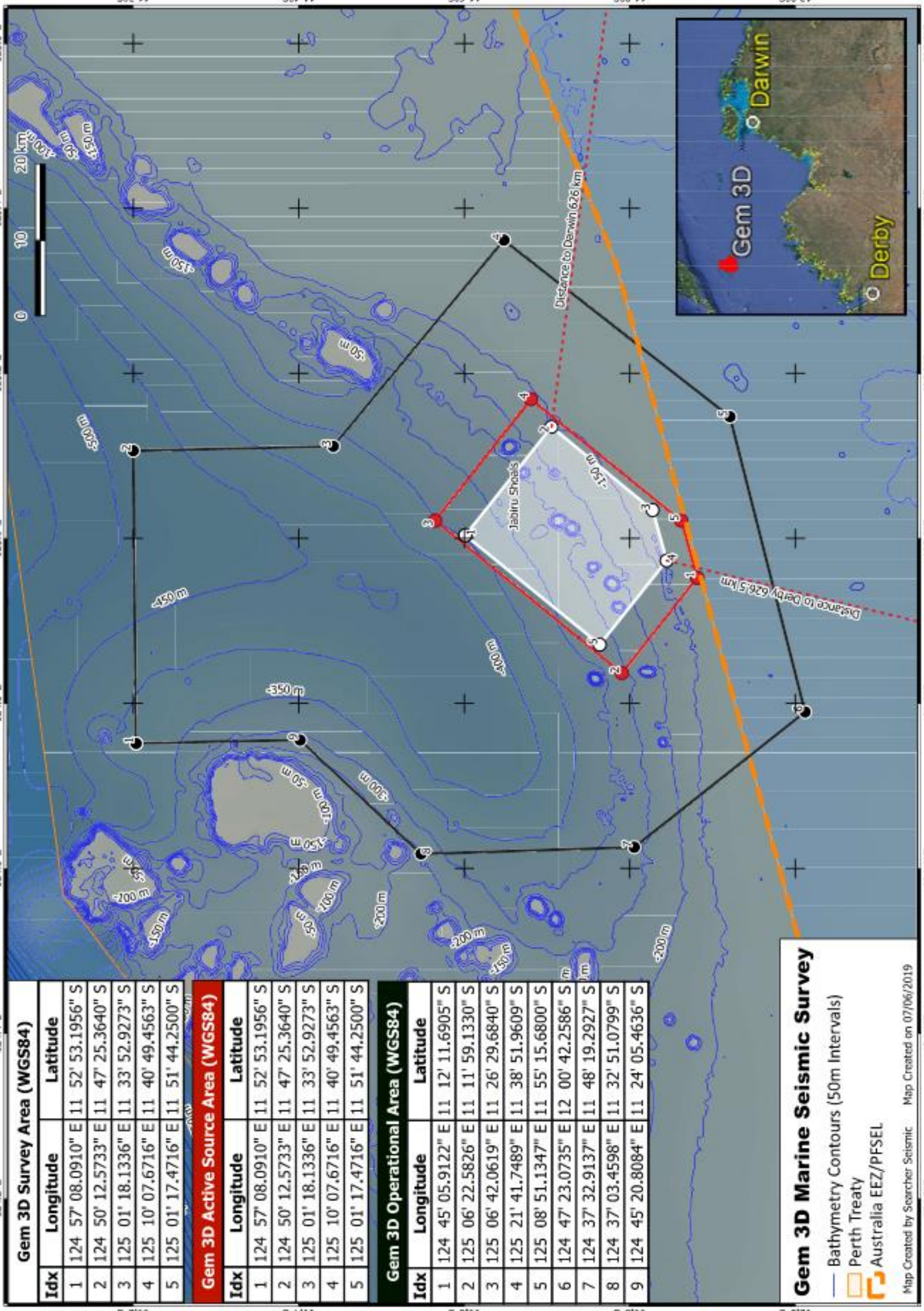
DocRef C003- Survey Extents Map Update 20190607



Gem 3D Survey Area (WGS84)

Idx	Longitude	Latitude
1	124 57' 08.0910" E	11 52' 53.1956" S
2	124 50' 12.5733" E	11 47' 25.3640" S
3	125 01' 18.1336" E	11 33' 52.9273" S
4	125 10' 07.6716" E	11 40' 49.4563" S
5	125 01' 17.4716" E	11 51' 44.2500" S

Gem 3D Active Source Area (WGS84)

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Gem 3D Operational Area (WGS84)

Idx	Longitude	Latitude
1	124 45' 05.9122" E	11 12' 11.6905" S
2	125 06' 22.5826" E	11 11' 59.1330" S
3	125 06' 42.0619" E	11 26' 29.6840" S
4	125 21' 41.7489" E	11 38' 51.9609" S
5	125 08' 51.1347" E	11 55' 15.6800" S
6	124 47' 23.0735" E	12 00' 42.2586" S
7	124 37' 32.9137" E	11 48' 19.2927" S
8	124 37' 03.4598" E	11 32' 51.0799" S
9	124 45' 20.8084" E	11 24' 05.4636" S

DocRef C004- Fisheries Post Cover Letter

14 June 2019

Proposed Gem 3D Marine Seismic Survey

SapuraOMV Upstream (Western Australia) Pty Ltd (SOMV) is planning to conduct a 3-dimensional marine seismic survey over an area of approximately 410 square kilometres located in the Timor Sea, approximately 250 km offshore of northern WA and 626 km from Darwin, in the vicinity of the Pee, Jabiru and Mangola Shoals. The proposed activity is scheduled to commence sometime between December 2019 and June 2020 and is expected to take approximately three weeks of active operations to complete. SOMV is currently preparing an Environment Plan (EP) for the activity.

Searcher Seismic Pty Ltd (Searcher) has been contracted by SOMV to assist in the regulatory environmental approvals process, including stakeholder consultation and communications related to the survey activity. Your valuable feedback will assist us in assessing how (if at all) the activity may affect your functions, interests or activities within the survey planning area.

As the survey's Acquisition Area (AA) and Active Source Area (ASA) are both located outside (north of) the boundary of the Australian Exclusive Economic Zone (EEZ), with only a small percentage of the Operations Area (OA) remaining within the EEZ, it is not anticipated that the survey and any support vessel involved will interact directly with any Australian commercial fishing vessels that may be working in the area, other than possibly during survey vessel line turns. Entry into the EEZ from the AA and ASA will be avoided, where practical, to further reduce the potential for vessel interactions.

A comprehensive environmental risk assessment will be conducted and control measures implemented to reduce any risks to the environment and the commercial interests of other marine users to ALARP and acceptable. The full EP will be published on the NOPSEMA web site for public review and comment prior to assessment by the regulator. Should you have any particular concerns we will be happy to provide relevant information regarding those concerns to you prior to the public comment period, as and when such information becomes available, on request.

Please find enclosed an "Invitation for Consultation with Commercial Fishers" PDF document for the Gem 3D Marine Seismic Survey (MSS), requesting your general comments and feedback by 15th July 2019 for consideration at the initial planning phase of the project.

Please review the document for more detailed information, feedback form access and contact information.

SOMV and Searcher welcomes feedback at any time and your comments can be directed to:

EMAIL: Gem3D@searcherseismic.com

Written correspondence can also be addressed to:

Gem 3D MSS Campaign
Searcher Seismic Pty Ltd
PO Box 844
WEST PERTH WA 6872.

Otherwise please do not hesitate contact us via the form, email, phone or post should you require any further clarification or information.

Thanks and regards

Gem 3D MSS | Consultation Team
Searcher Seismic Pty Ltd
PO Box 844 West Perth WA 6872
T: +61 8 9327 0301 **W:** searcherseismic.com

Stakeholder Update

Gem 3D Marine Seismic Survey

July 25th, 2019

Searcher Seismic

sapura energy

OMV

Key Information

SapuraOMV Upstream (Western Australia) Pty Ltd (SapuraOMV), is preparing an Environment Plan for a 3D marine seismic survey in the Browse Basin in the Northern offshore region of Western Australia.

Searcher Seismic Pty Ltd (Searcher) has been contracted by SapuraOMV to assist in the regulatory environmental approvals process, including stakeholder consultation and communications related to the survey activity.

Throughout the project development Searcher will provide each relevant person sufficient information to allow them to make an informed assessment of the possible consequences of the proposed survey on their functions, interests or activities. If you have any feedback, comments or questions on this activity, or do not think that this activity will affect your functions, interests or activities, then you may contact us via:-

Contact

Gem 3D Stakeholder Consultation Team

PHONE:
+61 (0)8 9327 0301

WEBSITE:
searcherseismic.com/gem-3d-feedback.htm

EMAIL:
Gem3D@searcherseismic.com

MOBILE DEVICE:
Click on or scan this QR code to access the stakeholder registration and feedback form.

Register

Updated Information

Since the previous Invitation for Consultation document was circulated SapuraOMV & Searcher have reviewed feedback to date from relevant stakeholders and have undertaken to address any concerns in the Planning Phase of the Gem 3D Marine Seismic Survey. As such, information regarding impact assessments and relevant controls that have been added to the Gem 3D MSS activity for the following sources of impacts from the MSS:

Underwater sound emissions from the seismic array

Physical presence of survey vessels

Operational discharges from vessels (light, atmospheric, liquid)

These are described in more detail in the subsequent pages.

Purpose

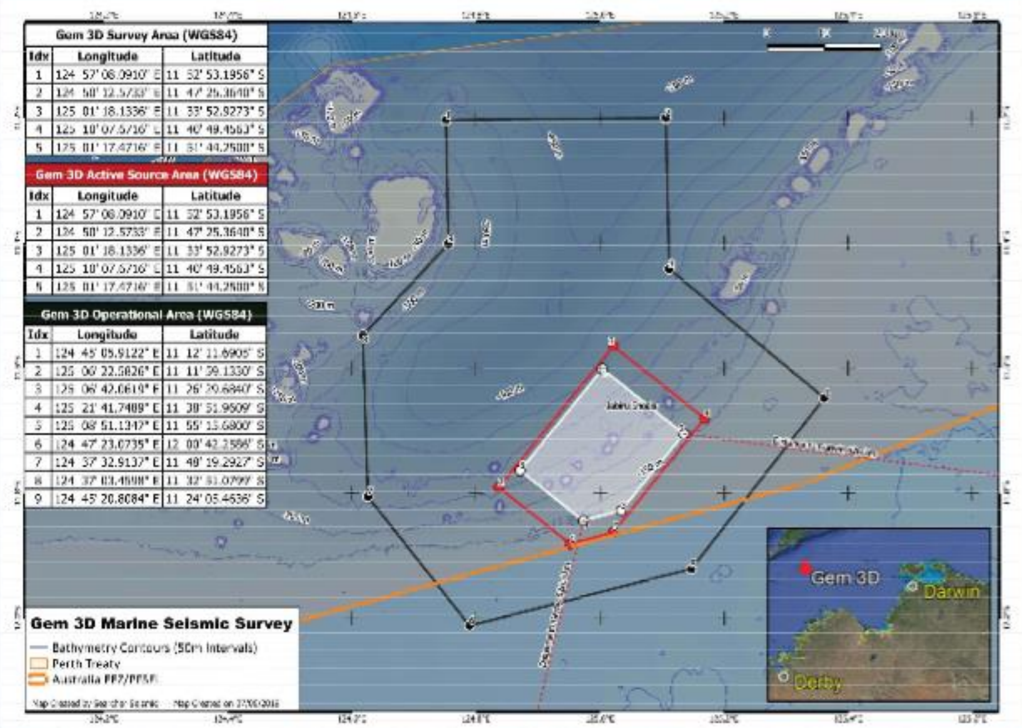
You have received this Stakeholder Update flyer either because you have registered your interest in being kept informed about the planned activity, or because you have been identified as a potentially relevant person but have not yet responded to the initial Invitation for Consultation information package. If you wish to opt out of further project updates please let us know by emailing us, clicking on or scanning the "Opt Out" QR Code below with your mobile device and filling in your email address. Alternatively, please formally register as a stakeholder using your preferred method of those provided in the column to the left.

SapuraOMV and Searcher welcomes any feedback and would be pleased to engage in dialogue with any person or organisation that wishes to register as a relevant stakeholder

About SapuraOMV

SapuraOMV is a wholly owned subsidiary of SapuraOMV Upstream Sdn. Bhd. (SapuraOMV); a strategic partnership between Sapura Energy Berhad and OMV AG. SapuraOMV is a leading independent oil and gas company with assets in Malaysia and exploration interests in Australia, New Zealand and Mexico.

Opt Out



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The Gem 3D seismic survey area is located entirely within offshore Commonwealth waters, approximately 620 km West of Darwin and around the same distance NNE of Derby. The Operational Area is in excess of 240 km from the Western Australian mainland, in water depths between 450m and less than 10m in the shallowest patches of the Jabiru Shoals. A location map and boundary co-ordinates are provided above.

The survey **'Acquisition Area' (AA)** is approximately 410 square kilometres in size and the area where 3D seismic data will be acquired and is the seismic data focus area. The AA is located fully within the 1997 Perth Treaty area, which is not yet ratified, but is recognised as the boundary of the Australian Economic Exclusive Zone (EEZ) by the governments of Australia and Indonesia. The EEZ boundary coincides with the Provisional Fisheries Surveillance and Enforcement Line (PFSEL), which is the agreed delimitation boundary of legal fishing activity between Australia and Indonesia.

The survey **'Active Source Area' (ASA)** of 647 square kilometres is the area within which the seismic energy source (airguns) will be operational and seismic data will be acquired, including soft start procedures and line run-outs (required to obtain full fold coverage). The full seismic source will not be operational outside of the survey active source area, although small, individual source elements may be tested during maintenance outside the ASA but within the Operations Area. The entire ASA is also located beyond the Australian EEZ.

The **'Operations Area' (OA)** or 'operational buffer' around the survey area is required for activities including streamer deployment and retrieval, maintenance and recovery and routine vessel manoeuvring. The OA is 4,760 square kilometres in size but operations will be conducted mainly within the ASA , with the OA limited to non-seismic vessel activities. The majority of the OA is located beyond the Australian EEZ.

Seismic data will be acquired in parallel lines in a racetrack pattern within the ASA over 24-hour daily operations for the duration of the survey, being approximately 3 weeks, with shut downs for routine and reactive maintenance, repairs, transit and line turns, fauna and stakeholder avoidance. Vessel survey operations, other than transit to and from the activity areas, will not take place outside the OA. Full energy source array activity in the ASA will average less than 3 hours, before silence periods of a similar duration during line turns, prior to commencement of subsequent lines. The process will continue until all survey lines, plus any re-acquisitions or 'infill' lines have been acquired.

Underwater sound emissions from the seismic array

Acquisition of the Gem MSS will involve the use of a seismic source, consisting of an airgun array towed at a water depth of 5 – 6 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 acquisition lines within the Active Source Area (ASA), which defines the area in which the sound source will be active. 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).

To assess the potential magnitude and extent of impacts from underwater noise produced during the Gem MSS, SapuraOMV commissioned JASCO Applied Sciences to model the source levels and sound propagation at several locations that were representative of the different water depths, bathymetry and seabed properties within the ASA (Figure 1).

The objective of this acoustic modelling study was to evaluate the effects of sound on marine fauna including marine mammals, marine reptiles, fishes, elasmobranchs, benthic invertebrates and zooplankton, and on socio-economic receptors such as commercial fisheries and Australian Marine Parks. The modelling methodology considered source directivity and range-dependent environmental properties in each of the areas assessed. The results of the sound modelling was compared against sound exposure thresholds for marine fauna and other receptors:

The modelling process and comparison against threshold limits was then used to complete an impact assessment based on the setting of 'standard control measures':

- Compliance with legislative requirements:
  - Part A Standard Management Measures of EPBC Policy Statement 2.1 will be applied in full to mitigate potential impacts to whales. One EPBC Policy Statement 2.1 Part B Additional Management Measure will also be applied.
  - OPGGS Act: Residual risks must be reduced to ALARP
- Compliance with Company and industry standards:
- Alignment with objectives and compliance with requirements of applicable management, recovery and /or conservation plans:

With these controls in place, the following assessment of impacts have been made:

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

Marine reptiles: Based on the timing and duration of the survey, the separation distances to nesting BIAs and 'Habitat Critical' areas, and the control measures proposed, predicted noise levels from seismic acquisition are not considered likely to cause PTS effects, displace any individuals from inter-nesting BIAs or 'Habitat Critical' areas, or result in any ecologically significant impacts at a population level for any species of turtle that may be present within or adjacent to the OA during the survey.

Fishes and sharks (demersal, pelagic species including key indicator species of commercial interest (goldband snapper and red emperor), site-attached reef species and whale sharks): The potential impacts of underwater sound emissions from the seismic source on fishes and elasmobranchs during the Gem MSS are considered to be localised and of no lasting effect, and restricted to recoverable injury effects and TTS in individuals that may be present on the shallow shoals within the ASA in close proximity to the operating seismic source. Based on the timing and duration (up to 27 days) of seismic acquisition, and the control measures that will be implemented, predicted noise levels from seismic acquisition are not considered likely to result in any ecologically significant impacts at a population level for any species of fish that may be present within or adjacent to the OA during the Gem MSS.

Benthic invertebrates (corals, prawns, molluscs): The potential impacts of underwater sound emissions from the seismic source on benthic invertebrates during the Gem 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 ASA.

Zooplankton: The potential impacts of noise emissions from the seismic source on plankton during the Gem 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 OA.

Underwater sound emissions from the seismic array cont.

Fish spawning: Based on the timing and duration (up to 27 days) of seismic acquisition, the potential impacts of noise emissions from the seismic source on spawning of key indicator fish species during the Gem 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 OA during acquisition activities.

Commercial fisheries: There are a number of Commonwealth and State (WA) commercial fisheries that can operate in waters overlapping the OA, or in adjacent waters. Catch and effort records for the period 2014 – 2018 obtained from DPIRD's FishCube database show that only one of these WA fisheries, the Northern Demersal Scalefish Managed Fishery (NDSMF), is active in the area overlapped by the OA. Consultation with the Western Australian Fishing Industry Council (WAFIC) and commercial fishers indicates that this is the only fishery expected to be active within the OA during the period of the proposed activity. Further details about the overlap by the OA with this fishery are described in the next section, however based on the timing and duration (up to 27 days) of seismic acquisition, the potential impacts of underwater noise emissions from the seismic source on catch rates in Zone B of the NDSMF during the Gem 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 targeted by the fishery within or adjacent to the OA.

Australian Marine Parks: Based on the timing and duration (27 days) of the Gem MSS, spatial separation from the nearest AMP (77 km to the Oceanic Shoals Marine Park (OSMP)), 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, cultural heritage values of the OSMP, or any other AMP in the region.

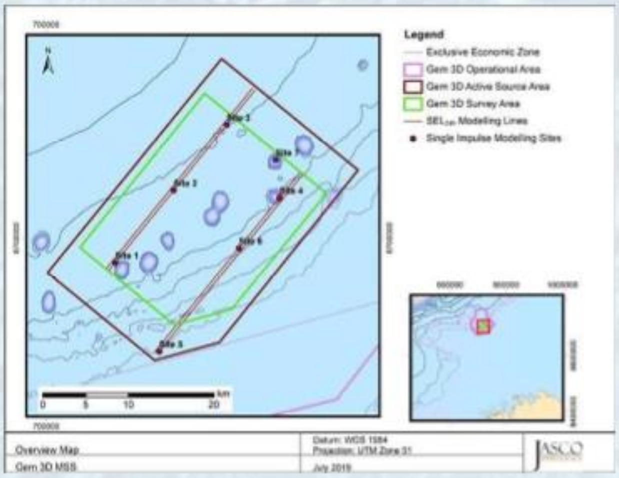
In addition to the above, the following controls will be adopted to ensure that the impacts associated with underwater sound emissions from the seismic array are As Low As Reasonably Practicable (ALARP) and acceptable:

- Minimum source size selected to acquire survey data and meet the geophysical objectives of the survey (based on specific sound source modelling)
- Two Marine Fauna Observers will be on board the seismic vessel and on duty during daylight hours during the survey
- 200 m 'turtle pause' when a turtle is within 200 m of the active source
- Exclusion zones established around seven shallowest shoals within the ASA
- Bathymetric survey of ASA prior to MSS in order to confirm depths and hence sound emission distances
- Eliminate sound emissions into the area fished by the NDSMF that are above mortality/recoverable injury thresholds for demersal fish (zero overlap with the area fished by the NDSMF)
- SapuraOMV will engage with proponents identified as having potential concurrent seismic activities prior to commencing the Gem MSS and develop a concurrent operations plan for any concurrent surveys identified within 60 km of the ASA
- A minimum separation distance of 40 km will be maintained between the Gem MSS survey vessel and other operating seismic sources

With all these controls in place, the potential impacts of underwater sound emissions from the seismic source on marine fauna during acquisition of the Gem MSS are considered to be slight and short-term, and restricted to temporary behavioural changes (avoidance) in any individuals that may inhabit the shallow shoals within the ASA, or transit the area in close proximity to the operating seismic source. With the control measures in place, the Gem MSS will not result in any significant impacts to fishers operating in the NDSMF adjacent to the OA.

Figure 1.

Location of single impulse modelling sites and lines for assessment of Gem MSS sound emissions



Physical presence of survey vessels

The seismic survey vessel will acquire data over a period of up to 27 days during which time it will operate 24 hours a day. Due to the seismic streamers extending 8.5 km behind the survey vessel and data acquisition process the survey vessel will be restricted in its ability to manoeuvre. There will also be a support vessel assisting with survey activities. Because of the physical presence of these vessels, other marine users may be temporarily displaced from their intended area of operation or transit route. The seismic streamers also present a navigational hazard to other marine users, and fishing equipment deployed within the OA may become entangled in the streamers or run over by the survey or support vessels. Marine users that may be present in the OA during the survey period include commercial fishing vessels operating in the WA Northern Demersal Scalefish Managed Fishery (NDSMF) and commercial vessels undertaking oil and gas industry activities, large passenger vessels, and Australian Border Force and navy vessels. In most cases the presence of these vessels will be unlikely due to the short duration of the survey. It is not expected that other commercial and recreational fishing vessels, nature-based tourist vessels, traditional Indonesian vessels, and commercial ships following defined shipping routes will be present in the OA during the survey

Standard control measures that will assist in limiting adverse interactions with other vessels during the Gem MSS include compliance with legislative requirements for maintenance of appropriate navigation, communications and maritime lighting in order to inform other uses of the position and intentions of the survey vessels, and compliance with SapuraOMV and industry standards (including the memorandum of understanding between APPEA and fishing industry bodies to establish principles of cooperation, communication and consultation). With these controls in place the following impact assessments have been made:

Commercial fishing vessels (NDSMF): The OA overlaps Australia's Exclusive Economic Zone (EEZ) where it has been modified by the *Treaty between the Government of Australia and the Government of the Republic of Indonesia establishing an Exclusive Economic Zone Boundary and Certain Seabed Boundaries (Perth, 14 March 1997)* (Perth Treaty). Operators within Australian Commonwealth and state fisheries do not fish offshore of the Perth Treaty line, and the area of the OA inshore of this line has been minimised to that required solely for line turns by the seismic survey vessel at the end of each survey acquisition line. All other operational activities such as streamer deployment and retrieval that also determine the extent of the OA will occur in waters offshore of the Perth Treaty line to avoid unnecessary interaction with fishers and their fishing equipment (Figure 2). The shape of the OA has also been designed to minimise the risk of equipment grounding on shallow shoals.

Review of fishing activity between 2014 - 2018 by operators within Commonwealth and state fisheries shows that only those in the NDSMF are active in the vicinity of the OA. Operators in this fishery typically use demersal traps which are deployed over hard bottom areas and/or areas of relief such as rises, ridges and reefs. Although the baits are typically gone within three hours of trap deployment, the traps may be left in water (unbaited and open) for up to twelve days between fishing trips. Surface buoys are attached to each trap by synthetic rope to enable retrieval. There is a 424.2 km2 overlap between the OA and Zone B, representing 0.5% of the total Zone B area (0.08% of the total area of the NDSMF) therefore very little of the annual catch by the NDSMF is likely to have been taken from this area of overlap.

Potential impacts to operators within the NDSMF due to physical presence of the survey vessels includes displacement from fishing grounds, loss or damage to fishing equipment, and associated loss of catch. However, these impacts are unlikely to occur or be significant if they do occur, based on the following:

- The very small area of overlap between fishing grounds and the OA, with no obvious bathymetric features indicating key fishing habitat located within this area of overlap.
- The short duration of the survey (< 27 days), small number of vessels actively fishing northern waters of Zone B (three) and short duration of fishing trips (< 12 days), reduces the likelihood that fishing and seismic acquisition activities will coincide.
- The mobile and extensive nature of fishing operations - enables operators with the NDSMF avoid the area of overlap with the OA, once notified of impending survey activity.
- A key role of the support vessel during acquisition of seismic data is to manage interactions with other vessels and to scout well ahead of the seismic survey vessel for inwater hazards. The seismic survey vessel will therefore be alerted to the presence of surface buoys and can take appropriate action during line turns that are the key activity occurring within the area of overlap between the OA and Zone B. Areas where night operations will occur will also be searched prior to nightfall.

Based on the above considerations the potential impacts due to physical presence of survey vessels during the Gem MSS are considered to be slight and short-term.

Physical presence of survey vessels cont.

Shipping and other vessels: The OA is situated well clear of shipping routes with the nearest route located 127 km to the south. Large passenger vessels and Australian Border Force and navy vessels may transit along the boundary of the EEZ from time to time but their presence within the OA during the short period of the Gem MSS (< 27 days) will be infrequent at most and short term as they transit the area. There are two other marine seismic surveys planned to occur in the vicinity and during the period of the Gem MSS:

- Factory 3D MSS located ~145 km to the south-west (acquisition planned over 2-3 months between Jul 1 to Dec 30, 2019)
- Cygnus 3D MSS Phase 3 South 2019-2020 located ~60 km to the south-west (acquisition planned between May 19 and end Dec 20).

However, as the area of both surveys are located well inshore and hence closer to Australian ports it is unlikely that associated vessels will transit through the OA.

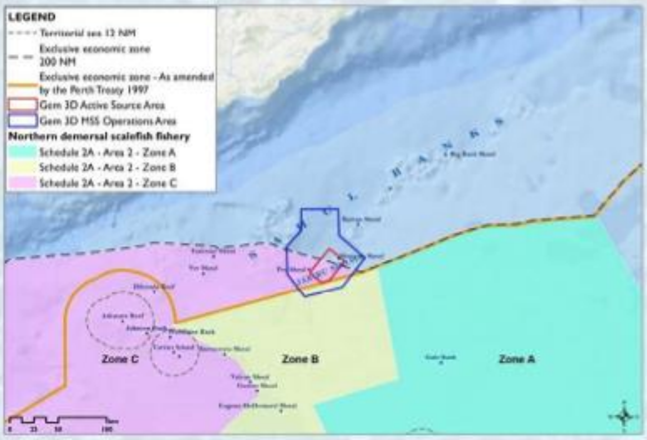
In addition to the above, the following controls will be adopted to ensure that the impacts associated with underwater sound emissions from the seismic array are As Low As Reasonably Practicable (ALARP) and acceptable:

- Reduce ASA and OA to avoid commercial fishing areas
- Seismic vessel shall not acquire data simultaneously within 50 km of another seismic vessel in the event that another vessel is acquiring data
- Survey vessels will be equipped with Automatic Radar Plotting Aid (ARPA) and active Automatic identification system (AIS) for detection of vessels, speed, heading and virtual outer tail buoy locations
- The Australian Hydrographic Service (AHS) advised of the survey details (survey location, timing) four weeks prior to mobilisation and following demobilisation for issue of Notice to Mariners.
- Seismic vessel will notify AMSA's Joint Rescue Coordination Centre (JRCC) 24 to 48 hours before operations for promulgation of radio-navigation warnings. AMSA JRCC will be advised of the survey vessel's details (including vessel name, call-sign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone), area of operation and requested clearance from other vessels.
- AMSA JRCC will be notified at the end of the survey when operations have been completed
- Notification provided to all relevant persons four weeks prior to the start of the survey of details including, timing, location, duration the survey
- WAFIC and relevant commercial fishers will be issued a 7 to 10 day forecast prior to activities commencing in the survey area
- Commercial fishers actively operating in or near the survey area will be kept informed of daily survey activities through SapuraOMVs 24-hour look-ahead communication
- Support vessel to assist with interactions with other vessels and identify inwater hazards ahead of the seismic vessel
- SapuraOMV will undertake a review two months prior to commencement of activities to ensure that any new stakeholders are identified and consulted
- Tail buoys clearly marked to identify streamer ends to other users
- Payment of compensation to the rightful owner for any fishing equipment that has been damaged beyond repair or lost as a result of the survey activities

With all these controls in place the predicted impacts from the physical presence of the survey and vessels are assessed as negligible because of the short duration of the survey, minimal overlap with activities of other stakeholders, and controls in place to ensure effective communications between parties.

Figure 2.

Operations Area of the Gem MSS relative to the EEZ and fishing zones



Operational discharges and emissions from survey vessels (light, atmospheric, liquid, underwater sound)

Operational discharges from survey vessels include those required for normal ship functions including deck lighting, engine operations, . During the 27 days of the MSS the following controls will be instigated in addition to 'standard controls' (eg legislative requirements) to minimise potential impacts to marine fauna from these discharges and emissions:

- External lighting will be directed only onto working decks to avoid impacts to light-sensitive species (eg turtles, birds)
- Atmospheric emissions will be minimised by ensuring only vessels using marine diesel or marine gas oil are used (instead of vessels using heavy fuel oils), and by ensuring all vessels have a planned maintenance system for engine equipment in place.
- Underwater sound emissions will be minimised by ensuring vessel engines are maintained in accordance with the planned maintenance system
- No discharges of grey water, sewage and food waste in waters less than 15 m depth (ie over shallow shoals)
- All discharges of bilge water, deck drainage and engine cooling water are compliant with MARPOL Annex 1 to minimise water degradation

With these controls in place the environmental impacts associated with operational discharges and emissions from survey vessels will be negligible.

Stakeholder Engagement

SapuraOMV encourages open, two-way communication with stakeholders throughout the planning and implementation of the proposed activities.

You have received this Stakeholder Update flyer either because you have registered your interest in being kept informed about the planned activity, or because you have been identified as a potentially relevant person but have not yet responded to the initial Invitation for Consultation information package. If you wish to opt out of further project updates please let us know by emailing us, clicking on or scanning the "Opt Out" QR Code with your mobile device and filling in your email address. Alternatively, please formally register as a stakeholder using your preferred method of those provided in the column to the left.

Under the regulations, stakeholder consultation is a mandatory process for the proponent (SapuraOMV) but voluntary for potential stakeholders. Searcher recognises the risk of "stakeholder fatigue" and the inconvenience consultation may cause for those that have no interest in the proposed activity. Unfortunately, failure to respond is not be accepted by the regulator NOPSEMA as a lack of interest, so your assistance in completing the online feedback form would be greatly appreciated and will help avoid further contact from us if you do decide to opt out of future correspondence in relation to this activity. If we do not hear from you then we will continue to provide you with updates to allow for circumstances such as extended post delivery times and perusal of this information.

SapuraOMV will provide all stakeholder feedback to NOPSEMA, within the proposed activity's environment plan. Under recent changes to Environment Regulations, all environment plans for offshore oil and gas activities will be published, and draft environment plans for offshore seismic surveys and exploration drilling activities will be open for an additional 30-day public comment period prior to NOPSEMA assessment.

Stakeholders are to advise if any feedback given to SapuraOMV, through Searcher, is to remain confidential and not to be made available for public release within the draft or final Environment Plan. This is a one click option in the online feedback form, or can be requested via the alternative contact methods provided.

DocRef C006 – Gem 3D MSS- StakeHolderPlanningPhase IA-Controls, Fisheries Post

31 July 2019

Proposed Gem 3D Marine Seismic Survey

To Whom This May Concern,

SapuraOMV & Searcher have reviewed feedback to date from relevant stakeholders and have undertaken to address any concerns identified in the Planning Phase of the Gem 3D survey. As such please find attached information regarding impact assessment and relevant controls that have been added to the Gem 3D MSS activity.

As advised previously SapuraOMV and Searcher welcomes feedback at any time and contact details are provided on the attachment to allow you to provide feedback or opt out of further communications.

Please note we are in correspondence with Western Australian Fishing Industry Council (WAFIC). Should you wish to delegate your comments or concerns to be addressed through WAFIC please let us know by any of the reply methods detailed on the attachment.

Please do not hesitate should you require any further clarification or information.

Kindest Regards

Gem 3D MSS | Consultation Team

Searcher Seismic Pty Ltd
PO Box 844 West Perth WA 6872
T: +61 8 9327 0301 **W:** searcherseismic.com

Relevant stakeholder feedback, assessment of merit and SapuraOMV response

This section summarises relevant stakeholder feedback, SapuraOMV's assessment of merit of that feedback and response. For each relevant stakeholder the following information is provided in

- Dates and methods of all consultation events with that stakeholder
- A summary of the feedback received from relevant that stakeholders for each event
- An assessment of the merits of any objections or claims raised for each event
- A statement of SapuraOMV's response, or proposed response, as a result of the consultation (where appropriate)
- A summary of the arrangement for ongoing consultation with that stakeholder

SapuraOMV has used the NOPSEMA definition for "objections or claims" to identify and respond to them. An 'objection or claim' is taken to mean:

- To express opposition, protest, concern or complaint about the proposed activities; a request or demand that certain action be taken by the titleholder to address adverse impacts; and
- An assertion that there will be an adverse impact; or allegation to cast doubt about the manner in which the activities will be managed

Table B.8 Summary of relevant persons or organisation feedback, assessment of merit and SapuraOMV response

Relevant Person or organisation	Date	Method	Summary of response by relevant person/ information provided by SapuraOMV	Merit assessment and statement of SapuraOMV response	Ongoing consultation
Absolute Ocean Charters	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**N/A**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Australian Border Force	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**N/A**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Australian Conservation Foundation	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**N/A**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Australian Customs and Border Protection Service (Coast Watch)	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**N/A**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is**
	29/05/2019 13:52	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**N/A**	
	29/05/2019 13:52	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**N/A**	

	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	N/A	required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Australian Fisheries Management Authority	17/06/2019 15:19	Email	Original notification Email and Flyer (C002) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	17/06/2019 15:19	Email	Original notification Email and Flyer (C002)	NA	
	24/06/2019 10:30	Email	Original notification Email and Flyer (C002) resent from Gem3D@searcherseismic.comdue to the first email being sent to the incorrect email address.	NA	
	30/07/2019 23:51	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
	30/07/2019 23:51	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Australian Fishing Trade Association	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	N/A	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	

Australian Hydrographic Office	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	N/A	Stakeholder is considered relevant and SapuraOMV will continue to consult with them.
	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	N/A	
	29/05/2019 14:31	Email	1. Confirmation of receipt of original notification email.	No objections or claims. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	2/07/2019 19:51	Email	1. Confirmation of receipt of updated notification email.	No objections or claims. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.	
Australian Institute of Marine Science	17/07/2019 12:13	Email	Initial notification Email and Flyer (C001.3) sent from Gem3D@searcherseismic.com	NA	No response to date. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.
	24/07/2019 15:45	Voice mail	Phone call and left message to AIMS.	NA	
	29/07/2019 16:45	Phone Call	1. AIMS must remain impartial and therefore have no comment on the survey and do not require further information.	No objections or claims. SOMV Will not continue to consult with this stakeholder.	
	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	N/A	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
Australian Marine Conservation Society	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
Australian Marine Oil	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	N/A	No response has been received at the time of

Spill Centre (AMSOC)- General Manager	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Australian Maritime Safety Authority	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	N/A	This stakeholder is considered relevant and SapuraOMV will continue to consult with them.
	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	N/A	
	31/05/2019 12:53	Email	1. Provided a vessel traffic plot of the area of interest Vessels include passenger, tanker, cargo, support craft will be encountered. Large passenger vessels and Border Force vessels follow the EEZ. 2. Notify JRCC 24-48 hours before operations commence; 3. AHO must be contacted no less than four working weeks before operations commence.	The following statements are merited due to role as regulatory body for maritime safety: 1. Vessel interactions Section 6 of the EP. SapuraOMV to ensure potential impacts and risks associated with vessel interactions have been assessed in the EP and control measures have been adopted to manage interactions with vessels in the vicinity of the activity. 2. Notification Section 9 of the EP. SapuraOMV to ensure that the appropriate JRCC; notification requirements are included in the EP. 3. Notification Section 9 of the EP. SapuraOMV to ensure that the appropriate AHO notification requirements are included in the EP.	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	2/07/2019 8:20	Email	1. Provided a vessel traffic plot of the area of interest Vessels include passenger, tanker, cargo, support craft will be encountered. Large passenger vessels and Border Force vessels follow the EEZ. 2. Notify JRCC 24-48 hours before operations commence; 3. AHO must be contacted no less than four working weeks before operations commence.	The following statements are merited due to role as regulatory body for maritime safety: 1. Vessel interactions Section 6 of the EP. SapuraOMV to ensure potential impacts and risks associated with vessel interactions have been assessed in the EP and control measures have been adopted to manage interactions with vessels in the vicinity of the activity. 2. Notification Section 9 of the EP. SapuraOMV to ensure that the appropriate JRCC notification requirements are included in the EP. 3. Notification Section 9 of the EP. SapuraOMV to ensure that the appropriate AHO notification requirements are included in the EP.	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	

Australian Maritime Safety Authority (Emergency Response Div)	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response to date. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.**
	29/05/2019 13:52	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
Australian Petroleum Production and Exploration Association (APPEA)-Chief Executive	**29/05/2019 13:52**	**Email**	**1. As of 1 April, contact is no longer working for APPEA. 2. New Contact details supplied.**	**No objections or claims. SapuraOMV will use the new contact details provided.**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	29/05/2019 13:54	**Email**	**Original notification Email (E001) and Flyer (C001) sent to additional contact from Gem3D@searcherseismic.com**	**NA**	
	4/06/2019 9:40	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com to the new contact details provided.**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Australian Southern Bluefin Tuna Industry Association	**13/06/2019 15:41**	**Email**	**Initial notification Email and Flyer (C002) sent from Gem3D@searcherseismic.com**	**N/A**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Aviair	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	

BlueWater Adventure Charters	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Broome Aviation	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Broome Billfish Charters	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Broome Chamber of Commerce and Industry	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	

	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Broome Coast Charters	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Broome Port Authority	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Broome Whale Watching Sentosa Charters	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Centre for Whale Research WA	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	

Clean Energy Regulator	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No feedback to date. This stakeholder is considered relevant and SapuraOMV will continue to consult with them.**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
	31/07/2019 9:48	**Voice mail**	**1. Voice mail left from the Clean Energy Regulator asking for a call-back.**	**No objections or claims. SapuraOMV to call back on the provided phone number.**	
	31/07/2019 10:05	**Phone Call**	**Phone call between SapuraOMV and the Clean Energy Regulator: 1. Stakeholder unsure why they were contacted as they do not think they are relevant for this survey, but will confirm in house and respond via email.**	**No objections or claims. SapuraOMV will wait for the response email.**	
	31/07/2019 12:19	**Email**	**1. Thank you for the email regarding the proposed Gem 3D MSS survey. The email will be forwarded to the relevant department.**	**No objections or claims. SapuraOMV will wait for the email response.**	
	31/07/2019 12:26	**Email**	**Email thanking stakeholder for forwarding the email.**	**NA**	
Commonwealth Department of Defence (DoD)	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Commonwealth Department of Industry, Innovation and Science (DIIS)	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	29/05/2019 13:52	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	
	29/05/2019 13:53	**Email**	**1. Contact is currently out of the office and will return on 31 May. New contact provided if urgent.**	**No objections or claims. SapuraOMV will wait until stakeholder is back at work.**	
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	

	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Commonwealth Department of the Environment and Energy (DoEE)-Heritage Section	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Commonwealth Department of the Environment and Energy-Assessments & Sea Dumping Branch	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	29/05/2019 13:53	Email	1. New contact for Stakeholder provided.	No objections or claims. SapuraOMV will send update department contact details.	
	29/05/2019 14:35	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Commonwealth Fisheries Association	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	17/06/2019 13:52	Email	Original notification Email and Flyer (C002) sent from Gem3D@searcherseismic.com	NA	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Commonwealth Scientific and Industrial Research	17/07/2019 12:13	Email	Initial notification Email and Flyer (C001.3) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is
	18/07/2019 7:37	Email	1. Please forward information to the 2 emails provided.	No objections or claims. SapuraOMV will forward the information to the emails provided.	
	18/07/2019 11:55	Email	Initial notification Email and Flyer (C001.3) sent from Gem3D@searcherseismic.com	NA	

Organisation (CSIRO)	18/07/2019 11:55	Email	Initial notification Email and Flyer (C001.3) sent from Gem3D@searcherseismic.com	NA	required. Stakeholder will be kept informed through notifications.
	24/07/2019 10:37	Phone Call	1. CSIRO research vessel will be in Fremantle in December so there will be no conflict with the survey.	No objection or claims. The absence of a CSIRO vessel in the survey area in Dec will be noted.	
	24/07/2019 10:38	Phone Call	1. CSIRO research vessel will be in Fremantle in December so there will be no conflict with the survey. 2. Please confirm the above with the CSIRO Energy WA Department.	No objection or claims. The absence of a CSIRO vessel in the survey area in Dec will be noted.	
	24/07/2019 22:52	Email	Initial notification Email and Flyer (C001.3) sent from Gem3D@searcherseismic.com	NA	
	2/08/2019 3:08	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Conservation Council of WA	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Coyrecup lake Pty Ltd *(For consultation after 13/06/19 please refer to the WAFIC records)*	13/06/2019 15:49	Email	Initial notification Email and Flyer (C002) sent from Gem3D@searcherseismic.com	N/A	This stakeholder is considered relevant. Further notifications and consultation with this stakeholder will be made via WAFIC.
	13/06/2019 15:49	Phone Call	Phone call summary: 1. Stakeholder asked why NOPSEMA was involved if survey was outside the EEZ boundary. SapuraOMV advised that although the Active Area was outside the EEZ that the survey was within the Perth Treaty Area with part of the operational area within the EEZ boundary. 2. SapuraOMV advised that NOPTA would be consulting with the Indonesian government. 3. Stakeholder said that in general fishers were tired of getting so many emails regarding seismic surveys. Seismic surveys appear to get priority and fishers are expected to get out of the way when a seismic survey was mobilised. 4. Stakeholder noted that as the Gem 3D survey is outside the EEZ zone it won't have any relevance to him. 5. Stakeholder requested that further notifications are made via WAFIC.	The following objections and claims are merited due to stakeholders activity and interests as a commercial fisherman in the vicinity of the OA: 3. Seismic surveys appear to get priority over fishers when the survey is mobilised. This relates to the displacement of other marine users (fishers) and is addressed in Section 6 of the EP. Controls in place to moderate displacement were communicated to the stakeholder within C002 which was sent via email on 13/06/2019. These include: Tail buoys clearly marked to identify streamer ends Survey area minimised as much as practical whilst still achieving the survey objectives Consultation with stakeholders during the development of the EP Notification of the activity to the AMSA/JRCC for the promulgation of the Notice to Mariners Maintaining appropriate navigational lights and day shapes at all times, in accordance with COLREGS to inform other users of the vessels actions	

				Additional communications with vessels in the survey area via marine VHF radio etc **Use of a support vessel to interact with commercial fishers and other vessels present** **24-48 hours notification to commercial fishers regarding lookahead activities** **Other water users notified in the event of equipment loss**	
Darwin Chamber of Commerce	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Department of Agriculture and Water Resources-Biosecurity	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	13/06/2019 14:30	**Email**	**1. Thank you for providing information to the DoA.** **2. DoA manages the regulation of ballast water in Australia, the department has produced a Biofouling Consultation Regulation Impact Statement to be implemented in 2020.** **3. must meet the requirements set out in the Australia's Ballast Water Management Requirements.** **4. Considers an effective management plan and record book to be in line with the International Maritime Organization's 2011 Biofouling guidelines.** **5. Further information can be found at http://www.marinepests.gov.au/commercial/offshore-infrastructure.**	**The following advice is considered merited due to the Departments regulatory role, and are covered in Invasive marine species, Section 6 of the EP:** **2. and 3. SapuraOMV will comply with all biofouling management and biosecurity requirements during the proposed activity.** **4. any vessels used during the survey, brought in from overseas will be inspected for biofouling and cleaned as necessary with records of the last antifouling coating, and IMP inspection made available. Ballast water will be managed in accordance with current guidelines and a ballast water management plan and record book will be in place and available for each vessel used in the conduct of the survey**	
	18/06/2019 12:01	**Email**	**Notification of change of Operator Name "Sapura Exploration and Production (Western Australia) Pty Ltd" to "SapuraOMV Upstream (Western Australia) Pty Ltd". and reduction in survey extents, included in attached map.** **Confirmation that SapuraOMV will comply with all biofouling management and biosecurity requirements during the proposed Gem 3D MSS, including biofouling inspections and water ballast management plan and record book.** **Unless there are further concerns SapuraOMV will only make further contact if there are any relevant changes to the survey activity.**	**NA**	
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Department of	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response has been received at the time of**

Agriculture and Water Resources-Fisheries	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Department of Agriculture and Water Resources-Ports	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	29/05/2019 13:53	Email	1. Confirmation of receipt of notification and endeavouring to respond in appropriate time frame.	No objections or claims. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Department of Communications and the Arts	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Department of Defence - Directorate of Property Acquisition, Mining and Native Title	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Department of Foreign	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of

Affairs and Trade	29/05/2019 13:53	Email	1. Out of Office reply received, alternative contact provided if urgent.	No objections or claims. SapuraOMV will resend the information to the alternate contact email provided.	EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	30/05/2019 12:34	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com to the alternate contact email provided.	NA	
	30/05/2019 12:34	Email	1. Confirmation of receipt of email, notification of public holiday.	No objections or claims. SapuraOMV will await a response from the new contact.	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Department of Infrastructure	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Department of Minister and Cabinet - Minister for Environment; Disability Services; Electoral Affairs	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	29/05/2019 13:53	Email	1. Auto response confirming receipt of email, formal response will be sent to in due course.	No objections or claims.	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	1/07/2019 15:17	Email	1. Auto response confirming receipt of email, formal response will be sent to in due course.	No objections or claims.	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
	30/07/2019 23:33	Email	1. Auto reply confirming receipt of email.	No objections or claims.	
Department of Minister and Cabinet - Minister for Mines	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	

and Petroleum; Energy; Industrial Relations	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
Department of the Chief Minister (NT)	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Department of Transport-Marine Operations	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
ECO ABROLHOS - Kimberley Cruises	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Environs Kimberley	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	

					will be kept informed through notifications.
Federal Member for Durak-Broome Office	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	29/05/2019 13:53	Email	1. Automated confirmation of delivery, information provided for online contact form	No objections or claims.	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	1/07/2019 15:18	Email	1. Automated confirmation of delivery, information provided for online contact form	No objections or claims.	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Fly Broome	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Go Beyond Broome	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Great Escape Charters	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response to date. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.
HeliSpirit	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of

	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Horizontal Falls Seaplane Adventures	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
International Fund For Animal Welfare	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Karma IV	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
KAS Helicopters	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	

	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
Kfm Leasing Pty Ltd	14/06/2019 16:10	Post	Initial notification Letter (C004) and Flyer (C002)	NA	No response to date. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.
	1/08/2019 10:55	Post	Updated Letter (C006) and Flyer (C005) with Planning Phase Controls Implemented from received feedback		
Kimberley Air Tours	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Kimberley Ports Authority	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Kimberley Whale Watching	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	

King Leopold Air	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Kingfisher Tours	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Lady M Luxury Cruises	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Lenden Nominees Pty Ltd	**14/06/2019 16:10**	**Post**	**Initial notification Letter (C004) and Flyer (C002)**	**N/A**	**No response to date. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.**
	1/08/2019 10:55	**Post**	**Updated Letter (C006) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**		
Makaira Game and Sportfishing Charters	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	

					required. Stakeholder will be kept informed through notifications.
Maritime Border Control	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Ndsf Licences Holding Company Pty Ltd	**14/06/2019 16:10**	**Post**	**Initial notification Letter (C004) and Flyer (C002)**	**N/A**	**No response to date. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.**
	1/08/2019 10:55	**Post**	**Updated Letter (C006) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**		
NDSMF ID #104	**14/06/2019 16:10**	**Post**	**Initial notification Letter (C004) and Flyer (C002)**	**N/A**	**No response to date. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.**
	1/08/2019 10:55	**Post**	**Updated Letter (C006) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**		
NDSMF ID #166	**14/06/2019 16:10**	**Post**	**Initial notification Letter (C004) and Flyer (C002)**	**N/A**	**No response to date. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.**
	1/08/2019 10:55	**Post**	**Updated Letter (C006) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**		
NDSMF ID #198	**14/06/2019 16:10**	**Post**	**Initial notification Letter (C004) and Flyer (C002)**	**N/A**	**No response to date. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.**
	1/08/2019 10:55	**Post**	**Updated Letter (C006) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**		
NDSMF ID #244	**14/06/2019 16:10**	**Post**	**Initial notification Letter (C004) and Flyer (C002)**	**NA**	**No response to date. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.**
	1/08/2019 10:55	**Post**	**Updated Letter (C006) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**		

Northbound Charters	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Northern Land Council	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Northern Oil and Gas Australia Pty Ltd	**10/07/2019 17:42**	**Email**	**Initial notification of survey with C001.3 Stakeholder invitation flyer**	**NA**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Northern Wildcatch Seafood Australia Pty Ltd	**13/06/2019 15:49**	**Email**	**Initial notification Email and Flyer (C002) sent from Gem3D@searcherseismic.com**	**N/A**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	13/06/2019 15:49	**Email**	**Initial notification Email and Flyer (C002) sent from Gem3D@searcherseismic.com**	**N/A**	
	16/07/2019 4:58	**Email**	**1. Please add another email address to our contact card for this survey.**	**No objections or claims. The additional contact method will be added.**	
	16/07/2019 13:16	**Phone Call**	**Called and spoke to representative of the stakeholder who confirmed that the email address was valid however advised of a better email address.**	**SapuraOMV will re-send the notification letter to the new email address provided.**	
	16/07/2019 13:52	**Email**	**Initial notification Email and Flyer (C002) re-sent from Gem3D@searcherseismic.com to a better contact email for the stakeholder.**	**N/A**	

	16/07/2019 16:48	Email	Email to stakeholder thank you for confirming the emails.	NA	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
NT Department of Primary Industry-Major Projects	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	29/05/2019 13:56	Email	1. Out of office till 11 June 2019 - for urgent enquiries alternative contact supplied	No objections or claims. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
NT Parks and Wildlife Commission	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
NW Bush Pilots	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Ocean Wild Tuna	13/06/2019 15:34	Email	Initial notification Email and Flyer (C002) sent from Gem3D@searcherseismic.com	N/A	No response has been received at the time of EP submission. Based on the lack of concerns raised during
	16/06/2019 12:38	Phone Call	Failed phone call to stakeholder, bad reception.	NA	

	16/06/2019 12:39	Phone Call	Phone call to office of stakeholder to obtain better contact number.	NA	consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	4/07/2019 15:22	Phone Call	Phone call but there was bad reception	NA	
	4/07/2019 15:24	Phone Call	Message left for titleholder, bad reception and could not make out the message.	NA	
	4/07/2019 15:26	Phone Call	Phone call to stakeholder and left a message.	NA	
	9/07/2019 14:37	Phone Call	Phone call no answer	NA	
	24/07/2019 14:54	Voice mail	Phone call and left message for stakeholder.	NA	
	24/07/2019 14:54	Phone Call	SMS to stakeholder due to poor phone reception. SapuraOMV is communicating with WAFIC for this survey. If you have any comments please contact us or reply NO to indicate that you are not relevant to this survey and do not want to be contacted further.	NA	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
One Tide Charters	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
PTTEP Australasia (Ashmore Cartier) P/L	3/07/2019 18:42	Email	Ingress Letter sent with Flyer (C001.2)	NA	Stakeholder is considered relevant and SapuraOMV will continue to consult with them.
	12/07/2019 13:05	Email	1. The ingress information has been passed on to the legal team who will prepare a response.	No objections or claims. SapuraOMV will wait for the response.	
	12/07/2019 14:35	Email	Thanking stakeholder for the reply.	NA	
	19/07/2019 10:24	Email	1. Can you please amend the documents in the described ways (redacted due to legal reasons). 2. There are no technical objections to ingress over the PTTEP blocks in the	No objections or claims in relation to the preparation of the environment plan.	

			Vulcan-sub basin as requested by SapuraOMV, there are no facilities in the area or any activities planned.		
	19/07/2019 22:51	Email	Please find attached the amended ingress documents.		
	19/07/2019 23:04	Email	1. Thank you for the amended ingress documents.		
Recfishing Research	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
RecFishWest	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Shire of Broome	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	Stakeholder is considered relevant. Fair consultation completed and closed. No further action required.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	5/07/2019 9:31	Email	1. No comments about the proposed survey.	NA	
	1/08/2019 3:25	Email	1. No comments about the proposed survey.	NA	
Shire of Derby West Kimberley	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	

	3/07/2019 15:13	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Shire of Wyndham East Kimberley	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	29/05/2019 13:53	Email	1. Confirmation of receipt of email and has been forwarded to relevant officer for response.	No objections or claims. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	1/07/2019 15:17	Email	1. Confirmation of receipt of email and has been forwarded to relevant officer for response.	No objections or claims.	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
State Member for Kimberley	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Telstra	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
The Great Escape	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of

Charter Company	**1/07/2019 15:17**	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	**EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Total E&P Australia Exploration P/L	**3/07/2019 18:42**	**Email**	**Ingress Letter sent with Flyer (C001.2)**	**NA**	**No response to date. Stakeholder is considered relevant and SapuraOMV will continue to consult with them.**
	4/07/2019 11:22	**Email**	**1. Thank you for the email we will respond shortly.**	**No objections or claims. SapuraOMV will wait for the response.**	
	4/07/2019 12:26	**Email**	**Thanking stakeholder for the response.**	**NA**	
	4/07/2019 12:26	**Email**	**Follow up email to stakeholder regarding response to ingress letter.**	**NA**	
True North Adventure Cruises	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Tuna Australia	**17/06/2019 12:59**	**Email**	**Initial notification email (C004) and Flyer (C002) sent by email**	**N/A**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.**
	30/07/2019 23:33	**Email**	**Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback**	**NA**	
Unreel Adventure Safaris	**29/05/2019 13:52**	**Email**	**Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com**	**NA**	**No response has been received at the time of EP submission. Based on the lack of concerns raised during**
	1/07/2019 15:17	**Email**	**Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com**	**N/A**	

	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
Uptop Fisheries Pty Ltd	13/06/2019 15:34	Email	Initial notification Email and Flyer (C002) sent from Gem3D@searcherseismic.com	N/A	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Vocus Communications (Nextgen Network)	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	
	29/05/2019 13:58	Email	1. Confirmation of receipt, to be processed as soon as possible.	No objections or claims.	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	1/07/2019 15:37	Email	1. Confirmation of receipt, to be processed as soon as possible.	No objections or claims.	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
	30/07/2019 23:36	Email	1. Confirmation of support ticket and Vocus will respond as soon as possible.	No objections or claims. SapuraOMV will wait for the confirmation email.	
	1/08/2019 14:42	Phone Call	1. Vocus have closed out communication and will send a confirmation email.	No objections or claims. SapuraOMV will wait for the confirmation email.	
WA Barra Charters	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	

	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
WA Department of Fisheries (DPIRD)	1/05/2019 16:41	Email	RPS provided survey extents and requesting information on fish catch data.	NA	Stakeholder is considered relevant and SapuraOMV will continue to consult with them.
	6/05/2019 9:37	Email	1. Provide requested FIshCube data.	No objections or claims.	
	13/05/2019 1:00	Meeting	1.Discussed fishing methods used by operators in the NDSMF, including fishing area relative to the Perth Treaty line. DPIRD advised that most fishers abide by this line even though it is not in force. 2. There is no likelihood of other fisheries in the area 3. DPRID provided information on the ecology of key target species of the NDSMF.	No objections or claims. Dr Newman's information will be included in the EP.	
	29/05/2019 1:21	Email	RPS requesting a copy of the 2016 review paper, an updated table of fish species spawning biocharacteristics for goldband, rankin and bluespotted for Kimberley area and confirmation of the number of NDSMF fishers operating out of Broome and Darwin.	NA	
	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	
	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	
	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	
	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	
	29/05/2019 13:53	Email	1. Out of office till 30/5/2019, alternative contact provided if urgent.	No objections or claims.	
	29/05/2019 13:53	Email	1. Enquiry email will be forwarded to relevant officer of the Department	No objections or claims.	
	29/05/2019 14:20	Email	Notification to stakeholder that Fisheries specific notification Flyer will be provided in due course and may organise meeting in near future.	NA	
	30/05/2019 23:24	Email	1.Confirmation of receipt of email and will wait for Fisheries specific information to be provided then will advise if need to meet.	No objections or claims.	
	5/06/2019 1:58	Email	1.Discussed fishing methods used by operators in the NDSMF, including fishing area relative to the Perth Treaty line. DPIRD advised that most fishers abide by this line even though it is not in force.	The information provided by Dr Newman will be included in the EP.	

			2. There is no likelihood of other fisheries in the area **3. DPIRD provided information on the ecology of key target species of the NDSMF.**		
	12/06/2019 15:41	**Email**	**Provided DPIRD with the latest draft of the consultation information package for review and comment and highlighted that SapuraOMV plans to deliver a specific commercial fishing consultation package which is attached with WAFIC's annotated comments.** **Relays WAFIC's instruction to SapuraOMV to not 'blanket' email all licenced fishers in the activity area, only the active fishers. Requests DPIRD to review WAFIC's annotations and inform SapuraOMV if they concur with WAFIC's consultation advice.** **Advises that SapuraOMV will circulate the fisheries consultation letter by the end of the week unless DPIRD has specific concerns that delay the deadline.**	**N/A**	
	17/06/2019 14:27	**Email**	**1. DPIRD confirmed that they have received the notification email and is preparing a response. Wishes to confirm the volume sound source is approximately 3000 cubic inch.**	**"No new objections or claims.** **SapuraOMV to respond and clarify the sound source volume is approximately 3000in/3, which will be confirmed after a contractor advises of the survey equipment available. An independent reviewer has recommended an array of ~100barM peak to peak power output and an array of around 2800-3000in3 to achieve the desired survey outputs. SapuraOMV can supply a copy of the sound modelling once completed if requested.**	
	17/06/2019 14:46	**Email**	**SapuraOMV advised DPIRD the sound source volume is approximately 3000in/3, which will be confirmed after a contractor advises of the survey equipment available. An independent reviewer has recommended an array ; ~100barM peak to peak power output; and an array of around 2800-3000in3 to achieve the desired survey outputs. SapuraOMV can supply a copy of the sound modelling once completed if requested.**	**NA**	
	17/06/2019 15:35	**Email**	**"1. Thanks for consultation package. Notes the information provided WAFIC was never passed to DPIRD until your late last week so this is the first review of the information.** **2. DPIRD requests that SapuraOMV consults representative bodies: Western Australian Fishing Industry Council (WAFIC); Pearl Producers Association of WA; Recfishwest; and Relevant Traditional Owner groups.** **3. Request that individual commercial fishers and charter operators that fish in the affected area are consulted and gives details of how to identify these stakeholders** **4. Request SapuraOMV utilise FishCube data and clearly articulate this use in the EP and communicate it with stakeholders** **5. Expect that SapuraOMV considers and incorporates the recommendations published by NOPSEMA on the Acoustic Impact evaluation and management** **6. Expects that SapuraOMV has incorporated the outcomes of the Risk Assessment of the potential impacts of seismic air gun surveys on marine finfish and invertebrates in Western Australia, June 2018, and developed the appropriate controls to reduce the risk.** **7. Does not support any proposed seismic survey where the risk from the sound source is severe or high to immobile and mobile invertebrates and demersal finfish, unless scientific peer reviewed literature (location and species specific) demonstrates there is no impact.** **8. It is not clear in the information provided what the water depth range is in**	**"The following responses are merited due to the stakeholder's role as a government department:** **2. and 11. SapuraOMV has already engaged with WAFIC and RecfishWest directly, has engaged with Traditional Owners via the Native Title Tribunal and other local associations, and will engage with the Pearl Producers Association.** **3. Commercial fishers have been identified via the DPIRD process described and SapuraOMV will consult with those judged to be relevant to the activity** **4. FishCube data has been and will continue to provide information for the impact assessment process for the EP, this has been referenced in the EP and will be communicated with stakeholders accordingly** **5. SapuraOMV will considers the recommendations published by NOPSEMA on the Acoustic Impact evaluation and management and incorporate if deemed appropriate to the activity** **6. SapuraOMV will consider the outcomes of the Risk Assessment of the potential impacts of seismic air gun surveys on marine finfish and invertebrates in Western Australia** **7. SapuraOMV notes that the Department does not support proposed seismic surveys with an assessed severe or high risk to immobile invertebrates and demersal fish unless there is peer reviewed demonstration that there is no impact. SapuraOMV has proposed the following mitigation and control measures and will consider further controls following completion of seismic**	

			the acquisition area 9. full seismic source should not be used in shallow waters (<50m) 10. requests that no seismic survey acquisition occurs during spawning periods for key species. If unavoidable then Management controls to mitigate the risk/impact should be assessed and provided to relevant stakeholders and provided an updated finfish spawning table 11. Advises that WAFIC can provide and clarify information on the potential impact to affected fishers 12. Concur that is likely to be minimal impact with State Fisheries due to the location 13. DPIRD reserves the right to update this advice to ensure it reflects any significant management or environmental changes that occurs."	sound modelling in order to reduce impacts from seismic sound to ALARP and acceptable levels. • Use the smallest practicable seismic array size to meet the geophysical objectives of the survey • Avoid concurrent seismic surveys by other operators, with time share operations implemented if required. • Consultation with the marine aquarium and specimen shell managed fisheries prior to the survey to advise on survey programme to reduce the potential for the presence of commercial divers in the vicinity of the survey area, subject to stakeholder consultation feedback. • Power down of the acoustic source to the lowest possible setting when not collecting data, or undertaking soft start procedures (e.g. during line turns or when moving to another part of the survey area). 8. The water depth range in the acquisition area is not yet adequately defined. SapuraOMV will undertake a comprehensive pre survey bathy to update this information and will provide the result to the Department when available if requested. 9. SapuraOMV has proposed to not acquire data in waters less than 50m as part of the mitigation and controls for underwater sound impact 10. Thank you for the updated spawning period table for key indicator species. SapuraOMV will assess these periods against the proposed operation period and if overlap is unavoidable, will put in place management controls to mitigate the risk/impact to spawning periods of key species and communicate these when practicable to relevant stakeholders, including DPIRD."	
	18/06/2019 14:46	Email	Confirmation of engagement with suggested Stakeholders; Also that Acoustic recommendation from NOPSEMA and appropriate mitigation measures are being considered to reduce impacts from seismic sound to ALARP and acceptable levels; Bathymetry survey data will be forwarded to the Department when available if requested; Thanking Stakeholder for spawning period table which will be assessed against the proposed operation period with management control used if overlap is unavoidable.	NA	
	19/06/2019 14:46	Email	"1. DPIRD would like to receive the water depth information from the pre-survey bathymetry studies once available 2. Given the location of the survey and as advised by WAFIC and confirmed with Fishcube data marine aquarium and specimen shell managed fisheries is not active in the area"	"The following response is merited due to the stakeholders government department role: 1. SapuraOMV will provide the bathymetry survey data to DPIRD when it becomes available. 2. Displacement of fisheries, section 6 of the EP: DPIRD advises that the marine aquarium and specimen shell managed fisheries are not active in proposed survey area."	
	1/08/2019 12:06	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
	1/08/2019 12:06	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
	1/08/2019 12:07	Email	1. Please continue all further communications to alternate contact within the department (provided)	No objections or claims. SapuraOMV will contact the alternate person as requested.	

	1/08/2019 12:27	Voice mail	Voice mail left for alternate contact provided with contact details for the survey, advising that the bathymetry data requested is available and requesting confirmation that this is the correct contact for this communication.	NA	
	1/08/2019 21:12	Email	Followed up phone message with email and forwarded consultation email Planning Phase controls email, Flyers C002 & C005, also forwarded emails from 17 June 2019 15:35/18 June 2019 16:48/19 June 2019 09:50		
	2/08/2019 8:39	Phone Call	1. New contact at DPIRD advised had been handed over from the previous person but was unable to locate information relating to the Gem 3D MSS.	No objections or claims. SapuraOMV to resend the consultation details to the new DPIRD contact person.	
WA Department of Mines, Industry Regulation and Safety (DMIRS)	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	Stakeholder is considered relevant and SapuraOMV will provide the notifications as advised.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	1/07/2019 17:12	Email	1. DMIRS notes the activity will be assessed by NOPSEMA. 2. Does not require further information at this time. 3. Please provide a pre-start notification confirming the start date of the proposed activity and a cessation notification to inform DMIRS upon completion of the activity, to petroleum.environment@dmirs.wa.gov.au. 4. Further information on incident reporting is also provided.	No objections or claims. DMIRS is considered relevant due to their role as a regulatory authority. SapuraOMV will include the notification in Section 8 of the EP.	
	1/08/2019 18:12	Email	SapuraOMV confirm that we will provide a pre-start notification confirming the start date of the proposed activity and a cessation notification to inform DMIRS upon completion of the activity, to petroleum.environment@dmirs.wa.gov.au. SapuraOMV have also reviewed and will comply with the Consultation Guidance Note for information pertaining to the reporting of incidents during the Gem 3D MSS activities.	NA	
WA Department of Planning, Lands and Heritage - Registrar of Aboriginal Sites	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
WA Game Fishing Association	29/05/2019 13:52	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	

	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
West Kimberley Fishing Tours	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Western Australian Fishing Industry Council (WAFIC)	1/05/2019 11:11	Phone Call	Missed phone call from WAFIC to RPS.	NA	This stakeholder is considered relevant and SapuraOMV will continue to consult with them.
	1/05/2019 11:36	Email	Email to WAFIC from RPS supplying an alternate contact number.	NA	
	1/05/2019 12:13	Email	1.Engagement with the commercial fishing sector must be bespoke to the fishers and include identification of potential risks and proposed mitigation's to ALARP level. 2. The information should be sent in one complete form –so it is not time consuming, costly and does not increase stakeholder fatigue. 3. Long, complicated technical information needs to be reduced, inclusion of clear maps (marked with latitudes, longitudes, distance to the coast). 3. “no reply” from a commercial fishing licence holder does not indicate a lack of interest in the project or a lack of potential impact on the commercial licence holder’s commercial fishing activity. 4. WAFIC says SapuraOMV must consult directly with key commercial fishing industry associations and each licence holder in each potentially impacted fishery (unless there is an agreed engagement process in place with the industry association and or individual licence holders). just because the legal boundaries of the fishery extend to the 200nm line doesn’t necessarily mean they are relevant parties to the activity. 5. allow for an appropriate time frame to complete open and transparent two-way engagement with the commercial fishing sector, Please allow a minimum of eight (8) weeks. 6. Face-to-face consultation should be an integral part of the proponent’s engagement strategy 7. Recreational Fishing from support / commercial vessels Commercial fishers are not permitted (illegal) to recreational fish whilst engaged in commercial fishing activity, Can the proponent confirm that the “No fishing from support/commercial vessels” policy is abided by all at operator / proponent level and also strictly enforced and communicated with contractors and subcontractors? 8. Is the proponent’s staff, contractors and sub-contractors all aware of the	The following objections and claims are merited due to WAFIC’s role as an industry representative. The following points will be addressed in a meeting with WAFIC on 8/05/19: 1-6 Consultation strategy - Section 3 of the EP. SapuraOMV will respond at a later date with details regarding 22. Compensation- Section 3 and Section 6 of the EP "Make good process" As yet SapuraOMV have received no feedback from any fishers that wish to be identified as a potentially affected party and therefore any Make Good Agreement discussions would be premature. A Make Good Agreement will be negotiated with any fishers that can demonstrate negative commercial or resource effects directly attributable to the activity.	

			difference between exclusion zones and cautionary zones and what is your communication strategy to staff of these? **9. What is the proponent's communication policy with all staff and vessel crew, contractors and sub-contractors regarding interacting and protecting the rights of active commercial fishers on the water?** **10. All support vessels must divert around active commercial fishing activity and remain clear of underwater fishing gear (even if not convenient to do so).** **11. All support vessels are to avoid any close and or disruptive engagement with any commercial fishing activity.** **12. All support vessels in the vicinity of a commercial fishing vessel are to do their utmost not to create an ocean disturbance risking disruption to schooling fish, etc.** **13. Will the proponent plan this activity based on a "best possible window of opportunity"?** **14. The proponent is to prepare and provide in the consultation information pack an assessment matrix (12 month view) for commercial fishers (and the EP) to provide a clear visual and to identify a best possible "window of opportunity" for the proposed survey. This matrix is to include each commercial fishery. Peak spawning for the key indicator species of each fishery and fishing activity levels. This can also incorporate other environmental; considerations such as whale migration, other megafauna etc.** **15. What is your overarching communications strategy to deliver all EP agreed requirements to all staff, contractors and subcontractors etc?** **16. What processes does SapuraOMV have in place to quantitively assess any potential damage to fish stocks, fish spawn, the food chain such as plankton etc. due to the impact of seismic survey activity?** **17. Does the proponent plan to do any bespoke pre-survey up-to-date environment assessments, covering commercial fishing key indicator species, stock assessments, the food chain etc? If not, what science is the proponent using to have a complete understanding of the marine environment prior to the commencement of a seismic survey?** **18. What science is the proponent using to demonstrate they have full understanding of fish spawning practices in the region of the proposed seismic survey and how does the proponent plan to avoid any survey dates which may potentially impact fish etc. spawning periods of commercial fishing key indicator species for each fishery?** **19. If the proponent cannot avoid spawning periods of commercial fishing key indicator species for each fishery, if there is not a "best possible window of opportunity", what science will the proponent use to assess any potential adverse impacts on the commercial fishing sector?** **20. What science is the proponent using to demonstrate they have a full understanding of fish behavioural activities and will completely avoid all seismic activities during key fish schooling, migrating patterns etc?** **21. If the proponent is not planning on completing any bespoke pre seismic survey fish stock etc surveys, should there be any negative impacts on commercial fishing activity / commercial fishing resource necessitating assessment and potential make good arrangements, what science is the proponent relying on to understand the pre and post seismic survey potential environmental impacts? How will this science be used within the make good framework should post survey impacts become evident?** **22. If a best possible window of opportunity cannot be achieved, what is the**		

			proponent's policy regarding any potential impacts to the commercial fishing sector and "make good" requirements? How does the proponent intend to address a formal "make good framework" within the EP, in the event of any negative impacts on the commercial fishing sector?		
	2/05/2019 9:45	Phone Call	Phone call to WAFIC from Searcher to arrange a meeting to address objections and claims raised in the previous email.	NA	
	7/05/2019 16:38	Email	Email request for meeting and submission for first draft of Invitation for consultation document DocRef C001. Meeting organised for 08/05/2019 10:00AM	NA	
	8/05/2019 10:00	Meeting	Initial meeting with WAFIC regarding consultation strategies with commercial fishing industry for Gem 3D MSS in WAFIC's Fremantle office. (Minutes in Appendix F): 1. WAFIC have requested that consultation is mindful of stakeholder fatigue, is only targeted to potentially affected parties and supplied a list of required information to be included in consultation packs. 2. WAFIC request a ""make good process"" for commercial fishers based on science; 3. WAFIC requests that the commercial fishery section of the EP is very clearly defined, work closely with affected fishers. 4. WAFIC highlights that they are developing a stakeholder guideline in conjunction with the FRDC and fishers but this is still in progress. 5. States that fishers are confused, they provide information to industry but don't appear to be heard, so there needs to be mutual understanding. 6. WAFIC notes that other industry companies have consulted with WAFIC and is it this feedback that has influenced the decision of NOPSEMA on EP's, not protesters. 7. WAFIC supplied information regarding data access on fish catch and effort in WA. 8. WAFIC listed and detailed contact information for industry associations and the level of consultation they require. 9. WAFIC detailed their fee-for service that they can provided for consultation purposes. 10. WAFIC will email through fisheries profile documentation.	During the meeting with WAFIC, SapuraOMV replied to the merited requests. The requests are merited due to WAFIC's role as a commercial fishing industry representative: 1. Consultation strategy - Section 3 of the EP. Will develop consultation packages with the requested information in mind, will be mindful of stakeholder fatigue and will work with WAFIC to attempt to only contact affected fishers. 3. EP content Section 4 - Clearly defined commercial fishery section in the EP: SapuraOMV will be transparent with WAFIC during the development of the EP and will welcome comment when the draft is published as part of the public comment process. SapuraOMV will respond at a later date with details regarding 2. Compensation- Section 3 and Section 6 of the EP "Make good process"	
	9/05/2019 13:22	Email	1. Stakeholder thanking again for the meeting the previous week. 2. Providing contact details for the Commonwealth fisheries that overlap the Gem 3D survey area. ie for the SBT fishery, the WTB fishery and three operators for the NWST. 3. Stakeholder noted that the CFA was currently recruiting for a new Executive Officer. 4. Stakeholder noted that information regarding the fee for services discussed at the meeting would follow under separate email.	No new objections or claims.	
	9/05/2019 14:50	Email	Email to Stakeholder thanking for the meeting the previous day and advising of the intention to meet with NOPSEMA the following Monday, May 13th, to discuss the WAFIC preferred consultation strategy with commercial fishing industry. Advised Stakeholder of concerns regarding not contacting all fishers	N/A	

			that have a legal right to fish the area, regardless of whether they have history or plans to fish the area.		
	20/05/2019 17:07	Email	1. WAFIC providing details of Fee for Services, stating that it was not a key focus but was available on a best needs, selective basis, dependent on personnel resource availability. 2. Stakeholder noted SapuraOMV concerns regarding NOPSEMA's requirement to consult with all fishers that may be affected but also that the commercial fishing industry has a problem with unnecessary consultation. 3. WAFIC offered to provide a complete list of fisheries that overlap the activity and conduct a "relevant party review" of which fishers were likely to be those potentially affected.	No new objections or claims.	
	21/05/2019 0:00	Phone Call	Phone call to WAFIC to seek clarification and further discuss the content of the Fee for Service proposal document sent via email on May 20th. WAFIC confirmed there are three levels of service that can be offered.	N/A	
	28/05/2019 16:23	Email	Requested a second meeting with Stakeholder to progress discussions on consultation with commercial fishers.	N/A	
	28/05/2019 16:42	Email	1. Response from WAFIC stating that they were unable to meet again in the near future due to workload and staff holidays. 2. WAFIC suggested delaying consultation until the end of June.	The following request has merit due to WAFIC's role as an industry representative and relates to the process of consultation: 1. Delay consultation until June 2019. SapuraOMV does not consider delaying all consultation until WAFIC is available as a viable option for this activity due to time constraints. Will keep WAFIC informed of progress and will welcome WAFIC involvement when they are available.	
	29/05/2019 10:52	Email	Email to Stakeholder stating that delaying further consultation with commercial fisheries for one month was not an option for Gem3d survey. SapuraOMV suggested keeping WAFIC informed of progress and would welcome involvement when time was available. Advised WAFIC that as the majority of activity takes place outside the EEZ as bounded by the Perth Treaty line there is limited commercial fishing expected to take place within the area.	NA	
	11/06/2019 16:40	Email	Email to Stakeholder with Draft Consultation Material DocRef C002-DraftV4 for Commercial Fishers - Gem 3D MSS for written comment or feedback as to the accuracy of the assessment. SapuraOMV noted there is a planned newspaper advert for the following weekend. Notified WAFIC that the planned survey areas have been amended so that they fall entirely outside the Perth Treaty Area to minimise displacement and interaction with Australian commercial fishers. Notified WAFIC that contrary to their indication the Commonwealth Northwest Slope Trawl Fishery has active fishers in the area the jurisdiction of the fishery does not overlap the activity area and as such will not be consulted with. Requested that since WAFIC have indicated they could provide a consultation review but have also indicated that due to lack of resources this is not possible that SapuraOMV will continue to be as transparent with WAFIC during the consultation process as possible.	NA	

	11/06/2019 17:25	Email	1. Email from Stakeholder requesting urgent confirmation of services to be rendered to be able to prioritise review of draft consultation material, and will call to discuss. 2. Expressed frustration that SapuraOMV intends to consult with every commercial fisher that has jurisdiction over the activity area.	The following claims are merited due to WAFIC role in industry representation: 1. Consultation process, Section 3 of the EP. SapuraOMV will call WAFIC to confirm arrangements. 2. Stakeholder identification, Section 3 of the EP. This objection is not merited as it is unrealistic and not the intention as indicated in previous consultation with WAFIC, however SapuraOMV will respond to this objection via email (see below)	
	11/06/2019 17:33	Email	Email to WAFIC confirming that only a quick review of the consultation material is required and to advise that information submitted is correct. Affirmed that that approach to consultation has not changed and wish to cut down the amount of unnecessary consultation with commercial fishers through development of a stakeholder list with WAFIC.	NA	
	11/06/2019 17:45	Phone Call	Phone call to Stakeholder confirming that only a quick review to advise that information submitted is confirmed	NA	
	11/06/2019 18:28	Email	Email from WAFIC with commented copy of draft consultation material DocRef C002-DraftV4 and confirmation of further consultation contacts. 1. Indication that the assumption of minimal interference with shipping and fishing is expected is correct. 2. Request that SapuraOMV confirm state fishers 3. SapuraOMV will need to liaise with a particular commercial fisher from the WTBF Commonwealth fishery to confirm they adhere to the Perth Treaty 4. Request that SapuraOMV consult with ABSTIA 5. States that WAFIC is unsure if the Perth Treaty is observed by fishers and provided contact details for the aforementioned WTBF fisher that may not. 6. Confirm that there is no expected interaction with fishers from the South-West coast salmon managed fishery, abalone managed fishery, Mackerel Managed Fishery, Kimberley Crab Managed Fishery, Marine Aquarium Fish Managed Fishery, Northern Shark Fishery, Pearl Oyster Fishery, Specimen Shell Managed Fishery, West Coast Deep Sea crustacean managed fishery and the Kimberley Prawn Managed Fishery and corrects their official name. 7. Notes there will be no interaction with the Northern Demersal Scalefish Managed Fishery in the Activity Acquisition area. There may be interaction in the Operational Area. 8. WAFIC requests SapuraOMV obtain a current list of active licence holders of the fishery from DPIRD with a succinct covering email including notification of vessel turns that is clear and concise. 9. WAFIC states that the comment that vessels from the Western Skipjack Fishery are not expected to be encountered due to the lack of effort in the fishery since 2008/09 is incorrect. WAFIC say there is no fishers operating in this fishery.	The following claims are merited due to the stakeholders role as an industry advisor: 1. Vessel interaction Section 6 of the EP. SapuraOMV to ensure that potential impacts and risks from vessel interactions have been assessed in the EP and control methods are described and implemented in the EP 2. Consultation Section 3 of the EP. SapuraOMV has already contacted DPIRD and AFMA to obtain current licence holder contact information. 3. Consultation section 3 of the EP. SapuraOMV will lease with the WTBT fisher to confirm if they fish in the activity area 4. Consultation section 3 of the EP. SapuraOMV will consult with ABSTIA during the consultation process described in the EP 5. Fisher displacement section 6 of the EP. SapuraOMV will consult with commercial fishers to confirm whether they conform to the Perth Treaty as indicated by consultation with DPIRD. 6. Fisher displacement Section 6 of the EP. SapuraOMV to ensure that potential impacts and risks from vessel interactions have been assessed in the EP and control methods are described and implemented in the EP 7. Fisher displacement Section 6 of the EP. SapuraOMV to ensure that potential impacts and risks from vessel interactions with fishers from the NDSMF have been assessed in the EP and control methods are described and implemented in the EP in consultation with fishers 8. Consultation section 3 of the EP. As already covered by comment 2. The following claims are not merited as they are nonsensical (possible error) 9. Fisher displacement Section 6 of the EP. SapuraOMV will not respond to this comment.	
	11/06/2019 19:30	Email	Email to Stakeholder sincerely thanking for expedient response and contact details provided.	NA	

	13/06/2019 16:56	Email	Email to WAFIC to request possibility of email addresses of fishermen from the NDSMF that SapuraOMV does not currently have.	NA	
	13/06/2019 17:10	Email	1. WAFIC does not give out email contacts. 2. SapuraOMV need licence holder details from Area 2 of the NDSMF. The list provided is incorrect as it does not show a key operator, is it from Area 1? 3. SapuraOMV need to contact DPIRD to obtain a current licence holder list of the fishery.	No objections or claims. The recommendations of WAFIC to obtain licence holder contacts from DPIRD have been done at the beginning of the project and so there is no need to re do this. The list provided to WAFIC was only the contact details that SapuraOMV requested from WAFIC and was not supposed to represent the whole fishery.	
	14/06/2019 21:50	Email	Email to Stakeholder thanking regardless of not being able to release contact emails. Confirming that all Area 2 contacts have been emailed where possible and that only those with missing details were requested. Will contact remainder by post.	NA	
	1/08/2019 20:40	Email	Email noting SapuraOMV & Searcher have reviewed feedback to date from relevant stakeholders and forwarding impact assessment and relevant controls that have been added to the Gem 3D MSS activity. Attached the email WAFIC sent to RPS prior to the Gem 3D team starting their consultation and requested whether any specific points in the email are still needed to be address and noting we will be happy to do so if there are.	NA	
Western Australian Museum	17/07/2019 0:13	Email	Initial notification Email and Flyer (C001.3) sent from Gem3D@searcherseismic.com	NA	This stakeholder is considered relevant and SapuraOMV will continue to consult with them.
	17/07/2019 16:23	Email	Initial notification Email and Flyer (C001.3) sent from Gem3D@searcherseismic.com to the newly provided contact address.	NA	
	24/07/2019 16:15	Phone Call	1. WAM supplied an email address to receive the notification package at.	SapuraOMV will send the package to the supplied email.	
	24/07/2019 16:23	Email	No objections or claims. 1. Out of office and alternate contact provided.	SapuraOMV will make contact on Monday when the representative is back in the office.	
	24/07/2019 16:30	Phone Call	Phone call from SapuraOMV to WAM to obtain a better contact person after getting an out of office reply. WAM will email a response.	No objections or claims. SapuraOMV will wait for a response from WAM.	
	24/07/2019 16:30	Email	Initial notification Email and Flyer (C001.3) sent from Gem3D@searcherseismic.com	NA	
	24/07/2019 19:14	Email	No objections or claims. 1. Best person to communicate with will be back in the office on Monday at the original contact email.	SapuraOMV will make contact on Monday when the representative is back in the office.	
	24/07/2019 21:02	Email	Email to stakeholder, SapuraOMV will wait for WAM representative to be back in the office and make contact.	NA	
	29/07/2019 14:33	Email	1. Thank you for contacting us regarding the survey. 2. If during the course of the survey there is a discovery made of a shipwreck or other underwater cultural heritage feature, including aircraft, it is a legal requirement to report it to the WA Museum under the (Commonwealth)	No objections or claims. The required notifications will be added into Section 8 of the EP.	

			Underwater Cultural Heritage Act 2018. 2. The WAM is not currently aware of any shipwrecks in the area.		
	2/08/2019 2:53	Email	Email to WAM to confirm that the contact details for notifications/ reporting any discoveries of underwater heritage as described in the email will be included in the EP.	NA	
Wilderness Society	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
World Wildlife Fund Australia	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	29/05/2019 13:53	Email	1. Your enquiry has been received and a member of our Supporter Relations team will respond	No objections or claims.	
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	
Wyndham Chamber of Commerce	29/05/2019 13:52	Email	Original notification Email (E001) and Flyer (C001) sent from Gem3D@searcherseismic.com	NA	No response has been received at the time of EP submission. Based on the lack of concerns raised during consultation no further attempts to contact this stakeholder is required. Stakeholder will be kept informed through notifications.
	1/07/2019 15:17	Email	Updated email notification Email (E002) and Flyer (C001.2) sent from Gem3D@searcherseismic.com	N/A	
	30/07/2019 23:33	Email	Updated email notification Email (E003) and Flyer (C005) with Planning Phase Controls Implemented from received feedback	NA	

Appendix C: Relevant persons consultation records – not for publication

NOTE: This report is considered sensitive information as described by NOPSEMA Policy note N-04750-PL1347 Revision 7 2019 and is not to be published in the public domain.

Appendix D: Response to public comments

NOTE: This will be complied following the 30-day public comment period.

Appendix E: EPBC Act protected matters search report

Australian Government
Department of the Environment and Energy

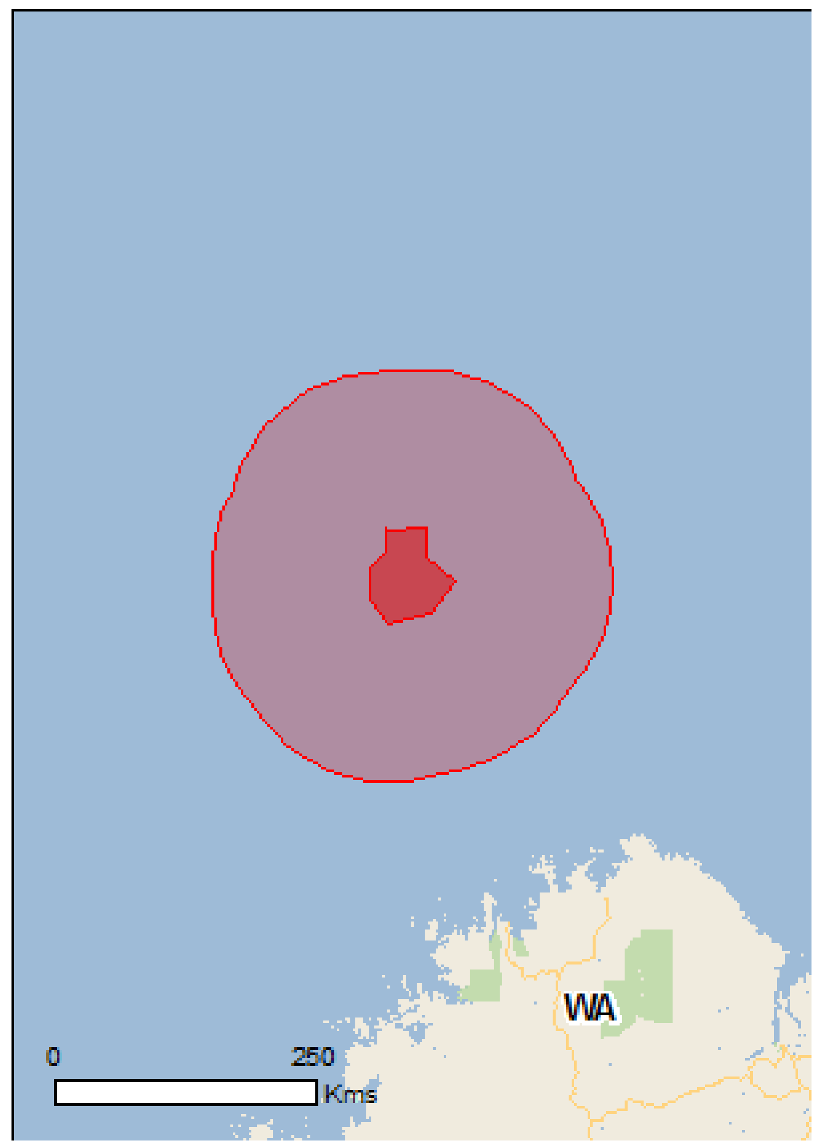
EPBC Act Protected Matters Report

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.

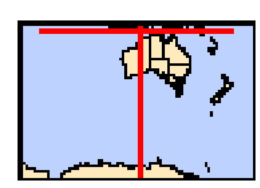
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 14/08/19 14:44:36



Coordinates
Buffer: 150.0Km



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:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	22
Listed Migratory Species:	45

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:	80
Whales and Other Cetaceans:	26
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	3

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)	4

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Ashmore reef national nature reserve	Within 10km of Ramsar

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
Extended Continental Shelf

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		
Anous tenuirostris melanops		
Australian Lesser Noddy [26000]	Vulnerable	Foraging, feeding or related behaviour known to 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
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

Name	Status	Type of Presence
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Aipysurus apraefrontalis		
Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus foliosquama		
Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour 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	Foraging, feeding or related behaviour known to occur within area
Lepidochelys olivacea		
Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sharks		
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Glyphis garricki		
Northern River Shark, New Guinea River Shark [82454]	Endangered	Species or species habitat may occur within area
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	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]		Foraging, feeding or related behaviour known to occur within area
Calonectris leucomelas		
Streaked Shearwater [1077]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding 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
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Sula sula Red-footed Booby [1023]		Breeding known 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 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	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	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	Foraging, feeding or related behaviour known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat likely to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat may 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
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat may occur within area
Migratory Terrestrial Species		
Cecropis daurica Red-rumped Swallow [80610]		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
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anous stolidus Common Noddy [825]		Foraging, feeding or related behaviour known to occur within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Foraging, feeding or related behaviour known to 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]		Breeding likely to occur within area

Name	Threatened	Type of Presence
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Hirundo daurica Red-rumped Swallow [59480]		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 area
Phaethon lepturus White-tailed Tropicbird [1014]		Foraging, feeding or related behaviour likely to occur within area
Sterna bengalensis Lesser Crested Tern [815]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Sula sula Red-footed Booby [1023]		Breeding known to occur within area
Fish		
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
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

Name	Threatened	Type of Presence
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 known 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 foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus fuscus Dusky Seasnake [1119]		Species or species habitat known to occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur

Name	Threatened	Type of Presence
		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
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis coggeri Slender-necked Seasnake [25925]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis 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
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour 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

Name	Status	Type of Presence
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
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 likely to occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		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

Name	Status	Type of Presence
		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
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
Cartier Island	Sanctuary Zone (IUCN Ia)
Kimberley	Multiple Use Zone (IUCN VI)
Oceanic Shoals	Multiple Use Zone (IUCN VI)

Extra Information

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Ancient coastline at 125 m depth contour	North-west
Ashmore Reef and Cartier Island and surrounding	North-west
Carbonate bank and terrace system of the Sahul	North-west
Continental Slope Demersal Fish Communities	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

-11.203395 124.753797,-11.18184 125.094374,-11.432314 125.102613,-11.631458 125.344313,-11.911095 125.132826,-11.99708 124.781263,-11.79551 124.616468,-11.52383 124.616468,-11.397315 124.753797,-11.198006 124.748304,-11.203395 124.753797

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 F: Overview of commercial fisheries relevant to the Gem 3D marine seismic survey

Western Australian State commercial fisheries

The jurisdiction of eleven WA state fisheries overlap the Operations Area (Section 4). However, ten of these are not active in this area, as determined by catch and effort data sourced from DPIRD on the 24/4/19 for the years 2014 – 2017 (Fish Cube WA; more recent data not available). Description of these fisheries is provided below. Due to the location of the MSS it is important to note that the outer limit of these jurisdictions is aligned with Australia's Exclusive Economic Zone, including where this has been modified by the *Treaty between the Government of Australia and the Government of the Republic of Indonesia establishing an Exclusive Economic Zone Boundary and Certain Seabed Boundaries (Perth, 14 March 1997)* (Delimitation Treaties Infobase 2002), referred to here as the Perth Treaty. Although not yet in force, Australia acts consistently with the arrangements of this treaty (AFMA 2014). The treaty line passes through the Operational Area. It also coincides with the Provisional Fisheries Surveillance and Enforcement Line (PFSEL), which is based on an agreement made between the governments of Indonesia and Australia in 1981 and prohibits Australian fishing vessels equipped to fish for swimming species (including licensed NDSMF vessels) moving north of the line unless their gear is stowed and secured (DoFWA 2016). As such, operators in state and Commonwealth fisheries described in Section 4 are not able to fish and are not expected to be present in those parts of the Operational Area offshore of the Perth Treaty line.

South-west Coast Salmon Managed Fishery

The South-west Coast Salmon Managed Fishery is active on various metropolitan beaches in the south of Western Australia. Fishing method is beach seine netting (ABARES 2018). Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operational Area for the years 2014 – 2017 (more recent data not available). Discussion with WAFIC and DPIRD (DPIRD Principal Scientist, pers. comm.) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

Abalone Managed Fishery

The Abalone Managed Fishery is active in the southern region of Western Australia. Fishing methods are dive and wading. Fishing was closed in Area 8, the area of WA waters north of Moore River during the 2011/12 season due to the catastrophic mortality observed following a marine heatwave in 2010/11 and remains closed (ABARES 2018). Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operational Area for the years 2014 – 2017 (more recent data not available). Discussion with WAFIC and DPIRD (DPIRD Principal Scientist, pers. comm.) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

Kimberley Prawn Managed Fishery

The jurisdiction of the Kimberley Prawn Managed Fishery partially overlaps the Operational Area. The gear used consists of otter trawls and is typically restricted to depths less than 60 m. The fishery is generally active between April and May, and August to November each year (ABARES 2018). Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operational Area for the years 2014 – 2017 (more recent data not available). Discussion with WAFIC and DPIRD (DPIRD Principal Scientist, pers. comm.) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

Mackerel Managed Fishery

The Mackerel Managed Fishery targets Spanish mackerel (*Scomberomorus commerson*), with smaller landings of other species such as grey mackerel (*S. semifasciatus*). The fishery extends from Cape Leeuwin on the southern west coast of Australia to the Western Australian/Northern Territory Border, and historically most of the catch is landed in the Pilbara and Kimberley regions (Lewis & Jones 2017). Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operational Area for the years 2014 – 2017 (more recent data not available). Discussion with WAFIC and DPIRD (DPIRD Principal Scientist, pers. comm.) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

Marine Aquarium Fish Managed Fishery

The Marine Aquarium Fish Managed Fishery management plan allows effort within all WA state waters, however historically effort is concentrated in waters south of Broome near Perth, Geraldton, Exmouth and Dampier (Newman et al. 2017). The fishery targets more than 950 species of marine aquarium fishes, plus coral, live rock, algae, seagrasses and invertebrates. Due to the special handling requirements of live fish, catch effort is relatively low and is concentrated in nearshore coastal waters. Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operational Area for the years 2014 – 2017 (more recent data not available). Consultation undertaken with WAFIC and DPIRD (DPIRD Principal Scientist, pers. comm. and DPIRD consultation Appendix B) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

Northern Shark Fisheries

The Northern Shark Fisheries consist of the state managed Western Australian North Coast Shark Fishery and the Joint Authority Northern Shark Fishery. No activity has been reported in either of these fisheries since the 2008/09 season, with low levels of activity reported prior to these years (DPIRD 2016). Similarly, catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operational Area for the years 2014 – 2017 (more recent data not available). Discussion with WAFIC and DPIRD (DPIRD Principal Scientist, pers. comm.) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

Pearl Oyster Managed Fishery

The WA pearl oyster fishery is the only remaining significant wild-stock fishery for pearl oysters in the world. It is a quota-based, dive fishery, operating in shallow coastal waters (< 35 m depth) along the NWS from Exmouth to the NT border. The harvest method is drift diving. Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operational Area for the years 2014 – 2017 (more recent data not available). Discussion with WAFIC and DPIRD (DPIRD Principal Scientist, pers. comm.) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

Specimen Shell Managed Fishery

The Specimen Shell Managed Fishery is based on the collection of shell specimens for display, sale, or cataloguing. Over 200 species are allowed to be taken under the management plan by either diving of Remotely Operated Vehicle (ROV) at depths from 60 m-300 m. Fishing is permitted within all WA waters, however historical effort is concentrated in coastal waters adjacent to population centres such as Broome, Karratha, Carnarvon and Perth (Hart et al. 2017). Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operational Area for the years 2014 – 2017 (more recent data not available). Consultation with WAFIC and DPIRD (DPIRD Principal Scientist, pers. comm. and DPIRD consultation Appendix B) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

West Coast Deep-sea Crustacean Managed Fishery

The West Coast Deep-sea Crustacean Managed Fishery is a quota-based pot fishery that mostly operates in depths of 500–800 m, with no fishing is permitted on the landward side of the 150 m isobath. The only allowable method fishing is baited pots on long-lines, with most set on muddy seabed. The boundaries of this fishery include all WA waters of the Indian Ocean and the Timor Sea north of 34°24'S. Catch and effort data sourced from DPIRD on the 24/4/19 (Fish Cube WA) shows that there was no activity by this fishery within the Operational Area for the years 2014 – 2017 (more recent data not available). Discussion with WAFIC and DPIRD (DPIRD Principal Scientist, pers. comm.) confirms the expectation that no interaction with this fishery will occur during the seismic survey.

Kimberley Crab Managed Fishery

The Kimberley Crab Managed Fishery management plan was drafted in October 2018. The fishery targets mud and blue swimmer crabs within state coastal waters. Although the fishery management plan includes all Western Australian waters, the fishery is closed seaward of the WA coastal waters (DPIRD 2018). Consequently, interactions between fishing vessels and the survey will not occur.

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Appendix G: Acoustic sound modelling report

Gem 3-D Marine Seismic Survey

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

Submitted to:

Jeremy Fitzpatrick
RPS
Contract: Agreement dated 11 June 2019

Authors:

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Craig McPherson

30 July 2019

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Disclaimer:

The results presented herein are relevant within the specific context described in this report. They could be misinterpreted if not considered in the light of all the information contained in this report. Accordingly, if information from this report is used in documents released to the public or to regulatory bodies, such documents must clearly cite the original report, which shall be made readily available to the recipients in integral and unedited form.

Contents

Figures

Tables

Executive Summary

JASCO Applied Sciences performed a numerical estimation study of underwater sound levels associated with the planned SapuraOMV Gem 3-D Marine Seismic Survey (MSS) to assist in understanding the potential acoustic impact on key regional receptors including fish, marine mammals, turtles, benthic invertebrates, and plankton. Modelling considered a 2820 in^3 seismic source in a flip-flop configuration, towed at a 5 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 Active Source 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. 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.

Marine mammal injury and behaviour

- The maximum distance where the National Marine Fisheries Service (2014) (NMFS) marine mammal behavioural response criterion of 160 dB re 1 µPa (SPL) could be exceeded varied between 4.21 and 5.07 km (Site 4, 140 m and Site 5, 124 m).
- The results for marine mammal injury considered the criteria from the NMFS (2018) technical guidance. NMFS (2018) allows for two metrics in the criteria (PK and SEL_{24h}) for the assessment of marine mammal Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS). The longest distance associated with either metric is required to be applied for assessment. Table 1 summarises the maximum distances for PTS, along with the relevant metric associated with the maximum PTS distance.
- The SEL_{24h} 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 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, marine mammals (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.

Table 1. Summary of maximum marine mammal PTS onset distances.

Relevant hearing group	Metric associated with longest distance to PTS onset	R_{max} (km)
Low-frequency cetaceans†	SEL_{24h}	0.86
Mid-frequency cetaceans	—	—
High-frequency cetaceans	PK	0.31
Sirenians (dugong)	—	—

† The model does not account for shutdowns.
A dash indicates the threshold is not reached within the limits of the modelling resolution.

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 (horizontal modelling resolution for FWRAM) from the centre of the array. Because the arrays are not a point source (approximately 14 m x 8 m) the actual ranges from the edge of airgun arrays are smaller than the distance from the centre.
- The maximum distance to the SEL_{24h} metric for PTS onset was 30 m and 0.42 km for TTS onset. As is the case with marine mammals, a reported radius for SEL_{24h} criteria does not mean that turtles 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.
- 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) McCauley et al. (2000b), McCauley et al. (2000a) 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†	0.87	1.05
166‡	2.55	2.98

† Threshold for turtle behavioural response to impulsive noise (McCauley et al. 2000b, McCauley et al. 2000a).
‡ 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} 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
- As is the case with marine mammals and turtles discussed above, a reported radius for SEL_{24h} criteria does not mean that fish 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 if it remained in that location for 24 hours. The radii associated with the SEL_{24h} metric represent an unlikely worst-case scenario; as more realistically, fish would not stay in the same location for 24 hours.
- Table 3 summarises the distances to injury criteria for fish, fish eggs, and fish larvae along with the relevant metric associated with the reported criteria.

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}	1.47	SEL_{24h}	1.27
Fish: Swim bladder not involved in hearing Swim bladder involved in hearing	Injury	PK	0.13	PK	0.14
	TTS	SEL_{24h}	1.47	SEL_{24h}	1.27
Fish eggs, and larvae	Injury	SEL_{24h}	0.13	PK	0.14

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 286 and 520 m depending on the modelled site.
- 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 reached at two of the five considered sites, and ranged from 6 m (at 35 m water depth) to 12 m (Site 6 - 28 m).
- 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 5.97 km to 7.96 km.

1. Introduction

JASCO Applied Sciences (JASCO) performed a numerical estimation study of underwater sound levels associated with the planned SapuraOMV Gem 3-D Marine Seismic Survey (MSS) to assist in understanding the potential acoustic impact on key regional receptors including fish, marine mammals, turtles, benthic invertebrates and plankton. Modelling considered a 2820 in^3 seismic source in a dual source, flip-flop configuration, towed at 5 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 Active Source 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 potential survey periods was defined and applied at each of the modelling locations.

The modelling methodology considered source directivity and range-dependent environmental properties. Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p), zero-to-peak pressure levels (PK, L_{pk}), peak-to-peak pressure levels (PK-PK; $L_{pk\text{-}pk}$), and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria.

2. Modelling Scenarios

Six 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 ~4.5 knots, with an impulse interval of 12.5 m. The considered survey acquisition lines took ~3.3 h (each) to traverse with ~3.6 h of turn time required between the lines, accounted for 8802 impulses. During line turns the seismic source was not in operation. A range independent model was used to determine close range levels and thresholds for seafloor receptors at Site 6. Seafloor sound levels were examined considering water depths of 28, 35, 45, 55, and 124 m and using geological profiles consistent with associated water depths.

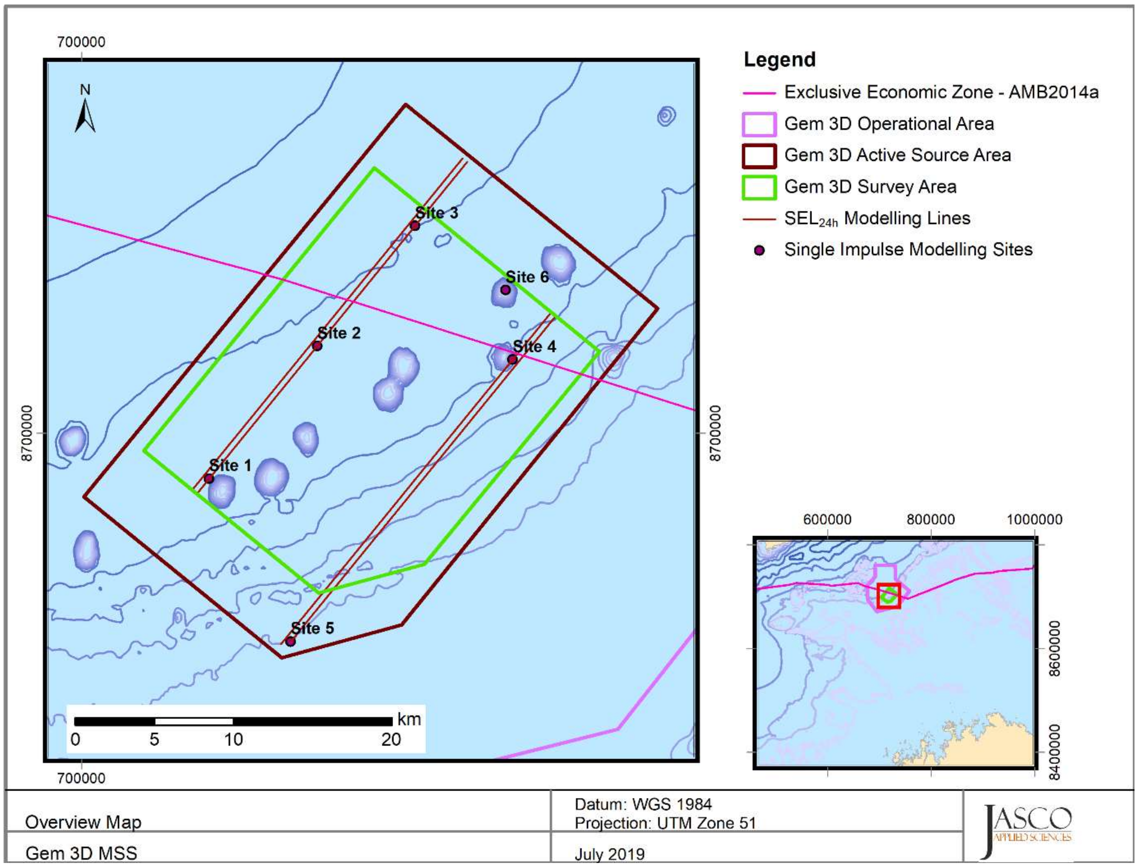

Figure 1. Overview of the modelling sites, acquisition lines, and features for the GEM 3-D MSS modelling.

Table 4. Location details for the modelling sites.

Site	Latitude (S)	Longitude (E)	UTM (WGS1984) Zone 51S		Water depth (m)	Tow direction (°)
			X (m)	Y (m)		
1	11° 46' 45.8212"	124° 54' 33.5302"	708049	8697132	240	39
2	11° 38' 02.8380"	125° 01' 39.8413"	714882	8705520	280	39
3	11° 42' 11.3766"	124° 58' 17.2440"	721073	8713115	301	39
4	11° 42' 36.2734"	125° 05' 05.7081"	727248	8704666	140	219
5	11° 40' 13.8441"	125° 04' 50.1869"	713199	8686830	124	219
6	11° 52' 19.8831"	124° 57' 25.9861"	726810	8709047	28*	219

* VSTACK modelling location only.

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 18405:2017 (2017).

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 3.1–3.3 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. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Finneran et al. (2017) for the onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) in turtles.
5. Turtle behavioural response threshold of 166 dB re 1 µPa SPL (L_p) (NSF 2011), as applied by the US NMFS, along with a sound level associated with behavioural disturbance 175 dB re 1 µPa (SPL) (McCauley et al. 2000b, 2000a).
6. 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.
7. Peak-peak pressure levels (PK-PK; $L_{pk\text{-}pk}$) at the seafloor to help assess effects of noise on crustaceans and bivalves, through comparing to results in Day et al. (2016) and Payne et al. (2008).
8. 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 marine mammals, fish, turtles, fish eggs, and fish larvae and benthic invertebrates.

3.1. Marine Mammals

The criteria applied in this study to assess possible effects of airgun noise on marine mammals 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 marine mammals.

<table>
<tr><th rowspan="3">Hearing group</th><th>NMFS (2014)</th><th colspan="4">NMFS (2018)</th></tr>
<tr><th>Behaviour</th><th colspan="2">PTS onset thresholds* (received level)</th><th colspan="2">TTS onset thresholds* (received level)</th></tr>
<tr><th>SPL (L_p; dB re 1 µPa)</th><th>Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)</th><th>PK (L_{pk}; dB re 1 µPa)</th><th>Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)</th><th>PK (L_{pk}; dB re 1 µPa)</th></tr>
<tr><td>Low-frequency cetaceans</td><td rowspan="4">160</td><td>183</td><td>219</td><td>168</td><td>213</td></tr>
<tr><td>Mid-frequency cetaceans</td><td>185</td><td>230</td><td>170</td><td>224</td></tr>
<tr><td>High-frequency cetaceans</td><td>155</td><td>202</td><td>140</td><td>196</td></tr>
<tr><td>Sirenians (Dugongs)</td><td>190</td><td>226</td><td>175</td><td>220</td></tr>
</table>

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.
L_p–denotes sound pressure level period and has a reference value of 1 µPa.
L_{pk}, flat–peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa.
L_E - denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa^{2}s.
Subscripts indicate the designated 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 marine mammals (NMFS 2014) which 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 marine mammals, this report applies the criteria recommended by NMFS (2018), considering both PTS and TTS, to help assess the potential for injuries to marine mammals. 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, 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. 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 (McCauley et al. 2000b, McCauley et al. 2000a), 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}). 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.

Finneran et al. (2017) presented revised thresholds for turtle injury, considering both PK and frequency weighted SEL, which have been applied in this study, along with the NMFS criterion for behavioural disturbance (SPL of 166 dB re 1 µPa), and a criterion for increased behavioural disturbance (SPL of 175 dB re 1 µPa) (McCauley et al. 2000b, McCauley et al. 2000a) (Table 7).

Table 7. Acoustic effects of impulsive noise on turtles: Unweighted SPL, SEL_{24h}, and PK thresholds

NSF (2011)	McCauley et al. (2000a)	Finneran et al. (2017)			
Behaviour		PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
SPL (L_p; dB re 1 µPa)		Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)	PK (L_{pk}; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)	PK (L_{pk}; dB re 1 µPa)
160	175	204	232	189	226

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.
L_p-denotes sound pressure level period and has a reference value of 1 µPa.
L_{pk}, flat–peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa.
L_E - denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa^{2}s.

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. (2016), current literature does not clearly define an appropriate metric or identify relevant levels (pressure or particle motion) for an assessment. This includes the consideration of what particle motion levels lead to a behavioural response, or mortality. Therefore, at this stage, we cannot propose authoritative thresholds to inform the impact assessment. However, levels can be determined for pressure metrics presented in literature to assist the assessment.

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

4. Methods

4.1. Acoustic Source Model

The pressure signature of the individual airguns and the composite 1/3-octave-band point-source equivalent directional levels (i.e., source levels) of the 2820 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, 5 Hz to 1024 Hz).
- Wavenumber integration model (VSTACK, 10 Hz to 1024 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-BELLHOP was used to calculate SEL of a 360° area around each source location. FWRAM was used to model synthetic seismic pulses and to generate a generalised range-dependent SEL to SPL conversion function for the considered modelling sites. The range-dependent conversion function was applied to predicted per-pulse SEL results from MONM-BELLHOP to estimate SPL values. FWRAM was also used to calculate water column PK and PK-PK levels.

VSTACK was used to calculate close range PK and PK-PK levels along transects at the seafloor from the loudest broadside direction of the seismic source for multiple water depths.

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. Two 2820 in^3 seismic source arrays consisting of two strings each were modelled in a flip-flop configuration. The two arrays considered were towed at a depth of 5 m, and the lateral distance between the arrays was 25 m. A single sound speed profile for July was considered in this modelling study; this was identified as the seasonal period that would provide the greatest propagation (Appendix D.3.2) due to the presence of a moderate surface duct. Sediment in the area was modelled as a succession from soft to hard sediments (silty carbonate sand to calcarenite) in for sites 1–5 and hard Isolated Carbonate Build-ups (ICB) over the shallow water pinnacle location for site 6 (Tables D-1 and D-3).

4.4. Accumulated SEL

During a seismic survey, new sound energy is introduced into the environment with each pulse from the seismic source. While some impact criteria are based on the per-pulse energy released, others, such as the marine mammal and fish SEL criteria used in this report (Sections 3.1–3.3) account for the total acoustic energy marine fauna is subjected to over a specified period of time, defined in this report as 24 h. An accurate assessment of the accumulated sound energy depends not only on the parameters of each seismic pulse impulse, but also on the number of impulses delivered in a period and the relative positions of the impulses.

When there are many seismic pulses, it becomes computationally prohibitive to perform sound propagation modelling for every single event. The distance between the consecutive seismic impulses is small enough, however, that the environmental parameters that influence sound propagation are virtually the same for many impulse points. The acoustic fields can, therefore, be modelled for a subset of seismic pulses and estimated at several adjacent ones. After sound fields from representative impulse locations are calculated, they are adjusted to account for the source position for nearby impulses.

Although estimating the cumulative sound field with the described approach is not as precise as modelling sound propagation at every impulse location, small-scale, site-specific sound propagation features tend to blur and become less relevant when sound fields from adjacent impulses are summed. Larger scale sound propagation features, primarily dependent on water depth, dominate the cumulative field. The accuracy of the present method acceptably reflects those large-scale features, thus providing a meaningful estimate of a wide area SEL field in a computationally feasible framework.

To produce the map of accumulated received sound level distributions and calculate distances to specified sound level thresholds, the maximum-over-depth level was calculated at each sampling point within the modelled region. The radial grids of maximum-over-depth and seafloor sound levels for each impulse were then resampled (by linear triangulation) to produce a regular Cartesian grid. The sound field grids from all impulses were summed (Equation A-5) to produce the cumulative sound field grid with cell sizes of 20 m. The contours and threshold ranges were calculated from these flat Cartesian projections of the modelled acoustic fields. The single-impulse SEL fields were computed over model grids 200 × 200 km in range, which encompasses the full area of the cumulative grid (the entire survey area).

The unweighted (fish) and frequency-weighted SEL_{24h} results were rendered as contour maps, including contours that focus on the relevant criteria-based thresholds. Only contours at ranges larger than the nearfield of the seismic source were rendered.

4.5. Geometry and Modelled Regions

To assess sound levels with MONM-BELLHOP, the sound field modelling calculated propagation losses up to distances at least 100 km from the source, with a horizontal separation of 20 m between receiver points along the modelled radials. The sound fields were modelled with a horizontal angular resolution of $\Delta\theta$ = 2.5° for a total of N = 144 radial planes. Receiver depths were chosen to span the entire water column over the modelled areas, from 2 m to a maximum of 2300 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 1 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 1000 m and a variable receiver range increment that increased away from the source was used. The increment increased from 10 to 25 m. Received levels were computed for receivers at the 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 8 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 8. Far-field source level specifications for the 2820 in^3 array, for a 5 m tow depth. Source levels are for a point-like acoustic source with equivalent far-field acoustic output in the specified direction. Sound level metrics are per-pulse and unweighted.

Direction	Peak source pressure level ($L_{S,pk}$) (dB re 1 µPa m)	Per-pulse source SEL ($L_{S,E}$) (dB 1 µPa^{2}m^{2}s)	
		10–2000 Hz	2000–25000 Hz
Broadside	249.7	224.9	186.8
Endfire	244.8	223.0	186.8
Vertical	255.2	228.0	194.2
Vertical (surface affected source level)	255.2	230.7	197.4

5.2. Per-pulse Sound Fields

5.2.1. Tabulated results

Per-pulse results for the 2820 in³ seismic source towed at 5 m are presented for SPL, SEL, PK, and PK-PK, including seafloor PK and PK-PK. Tables 9–12 list the estimated ranges for the various applicable maximum-over-depth per-pulse effects criteria and isopleths of interest. Tables 13 and 14 list the estimated ranges for seafloor per-pulse effects criteria and isopleths of interest.

5.2.1.1. Entire water column

Table 9. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 2820 in^3 array to modelled maximum-over-depth unweighted per-pulse SEL isopleths from the five modelled single impulse sites.

Per-pulse SEL (L_E; dB re 1 µPa²·s)	Site 1 (240 m)		Site 2 (280 m)		Site 3 (301 m)		Site 4 (140 m)		Site 5 (124 m)	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	0.03	0.03	0.04	0.03	0.05	0.05	0.03	0.03	0.04	0.04
180	0.15	0.12	0.14	0.13	0.14	0.12	0.17	0.13	0.16	0.13
170	0.71	0.57	0.71	0.61	0.71	0.58	0.67	0.54	0.59	0.50
160†	**1.80**	**1.48**	**1.89**	**1.60**	**1.96**	**1.66**	**1.82**	**1.49**	**2.01**	**1.66**
150	6.40	5.19	6.92	5.20	6.19	4.93	4.70	3.97	6.27	4.49
140	17.4	13.7	21.5	14.8	19.5	15.5	14.0	11.0	14.9	11.6
130	40.9	34.2	40.2	35.1	39.5	34.1	40.7	33.4	32.7	24.1
120	55.3	45.3	51.4	43.5	53.6	44.9	87.6	71.6	60.5	49.5

† Low power zone assessment criteria DEWHA (2008).

Table 10. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 2820 in^3 array to modelled maximum-over-depth SPL isopleths from the five modelled single impulse sites.

SPL (L_p; dB re 1 µPa)	Site 1 (240 m)		Site 2 (280 m)		Site 3 (301 m)		Site 4 (140 m)		Site 5 (124 m)	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
190	0.13	0.12	0.12	0.10	0.13	0.11	0.13	0.11	0.12	0.11
180	0.61	0.47	0.56	0.45	0.51	0.41	0.60	0.48	0.55	0.47
175#	**0.95**	**0.77**	**1.01**	**0.88**	**1.05**	**0.92**	**0.87**	**0.71**	**0.90**	**0.73**
170	1.68	1.36	1.66	1.30	1.69	1.28	1.67	1.25	1.88	1.43
166†	**2.77**	**2.22**	**2.98**	**2.31**	**2.61**	**2.27**	**2.55**	**1.90**	**2.77**	**2.25**
160‡	**4.95**	**4.08**	**5.05**	**4.11**	**4.96**	**4.14**	**4.21**	**3.57**	**5.07**	**3.97**
150	14.0	11.7	15.2	11.6	14.5	11.8	12.0	9.23	13.4	10.3
140	37.5	31.3	37.1	31.4	35.5	30.2	39.3	31.5	29.0	21.2
130	54.0	44.2	48.7	41.6	50.5	42.6	83.3	68.5	58.7	48.3

Threshold for turtle behavioural response to impulsive noise (McCauley et al. 2000b).
† Threshold for turtle behavioural response to impulsive noise (NSF 2011).
‡ Marine mammal behavioural threshold for impulsive sound sources (NMFS 2014).

Table 11. Maximum (R_{max}) horizontal distances (km) from the 2820 in^3 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 (240 m)	Site 3 (301 m)	Site 5 (124 m)
Low-frequency cetaceans (PTS)	219	0.03	0.03	0.03
Low-frequency cetaceans (TTS)	213	0.06	0.06	0.06
Mid-frequency cetaceans (PTS)	230	—	—	—
Mid-frequency cetaceans (TTS)	224	—	—	—
High-frequency cetaceans (PTS)	202	0.21	0.21	0.31
High-frequency cetaceans (TTS)	196	0.41	0.42	0.57
Sirenians (PTS)	226	—	—	—
Sirenians (TTS)	220	0.03	0.03	0.03
Fish: No swim bladder (also applied to sharks)	213	0.06	0.06	0.06
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	0.13	0.13	0.13
Turtles (PTS)	232	—	—	—
Turtles (TTS)	226	—	—	—

A dash indicates the threshold is not reached within the limits of the modelling resolution.

Table 12. Maximum (R_{max}) horizontal distances (in km) from the 2820 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 (240 m)	Site 3 (301 m)	Site 5 (124 m)
178	5.97	7.96	7.68

5.2.1.2. Seafloor

Table 13. Maximum (R_{max}) horizontal distances (in m) from the 2820 in^3 array to modelled seafloor peak pressure level thresholds (PK) from two single-impulse modelling sites (Table 4) and representative depths.

Hearing group/animal type	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (m)				
		Site 6 (28 m)	35 m	45 m	55 m	Site 5 (124 m)
Sound levels for sponges and corals†	226	12	6	—	—	—
Fish: No swim bladder (also applied to sharks)	213	70	71	79	85	40
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	104	108	113	118	137

† Heyward et al. (2018)
A dash indicates the threshold is not reached within the limits of the modelling resolution.

Table 14. Maximum (R_{max}) horizontal distances (in m) from the 2820 in^3 array to modelled seafloor peak-peak pressure level thresholds (PK-PK) from five modelling sites (Table 4). Results included in relation to benthic invertebrates (Section 3.3).

PK-PK (L_{pk-pk}; dB re 1 µPa)	Distance R_{max} (m)				
	Site 6 (28 m)	35 m	45 m	55 m	Site 5 (124 m)
213	102	107	111	115	109
212	106	121	120	124	127
211	109	125	142	135	149
210	156	129	153	170	175
209	162	173	159	182	235
202	286	297	302	293	520

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 2–11.

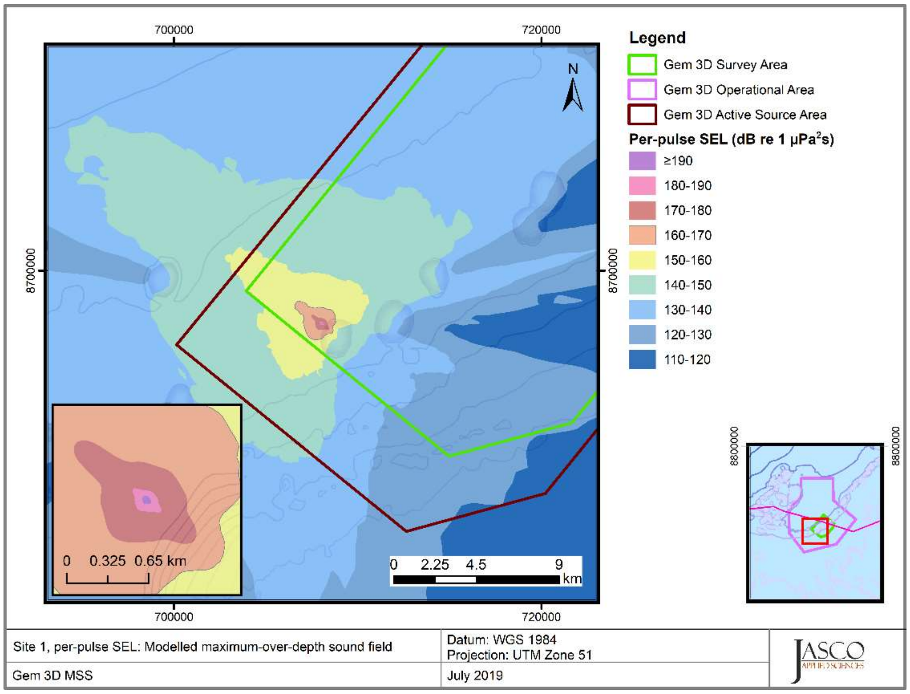

Figure 2. *Site 1, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth results.

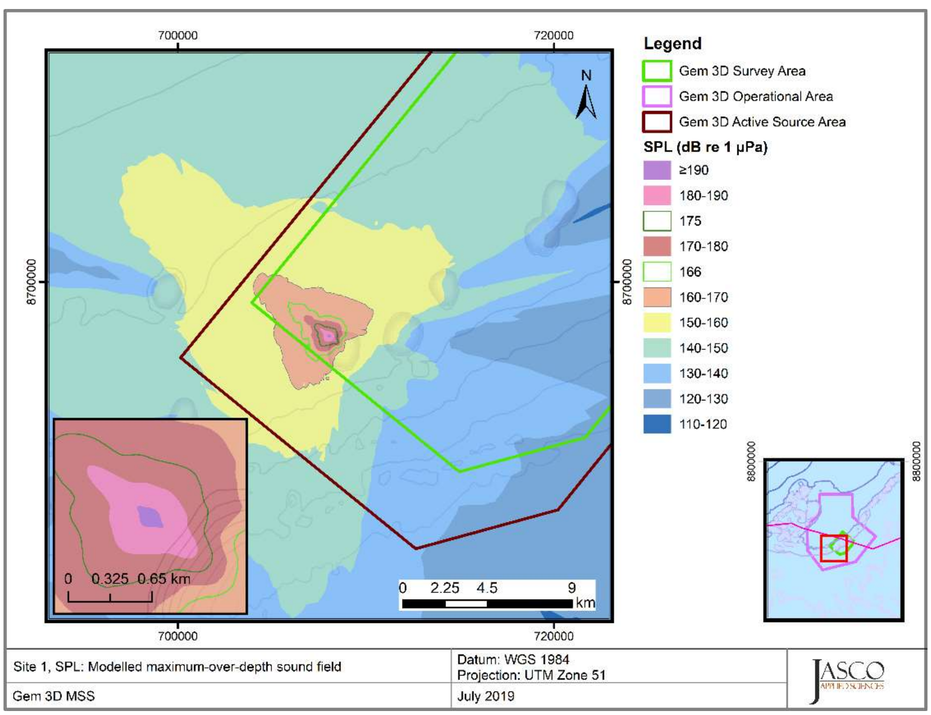

Figure 3. *Site 1, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

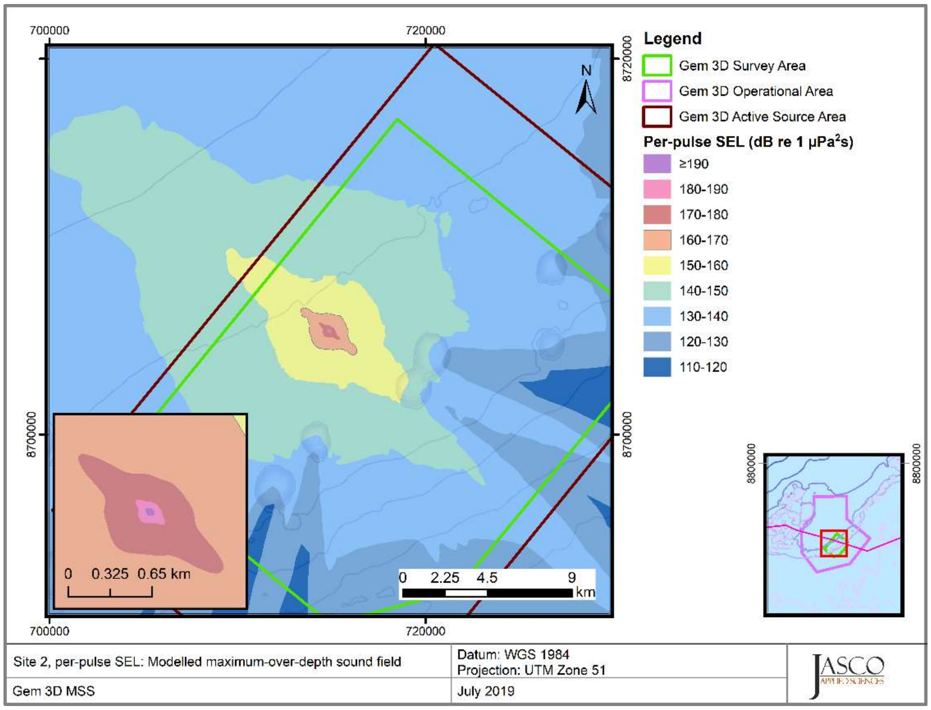

Figure 4. *Site 2, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth results.

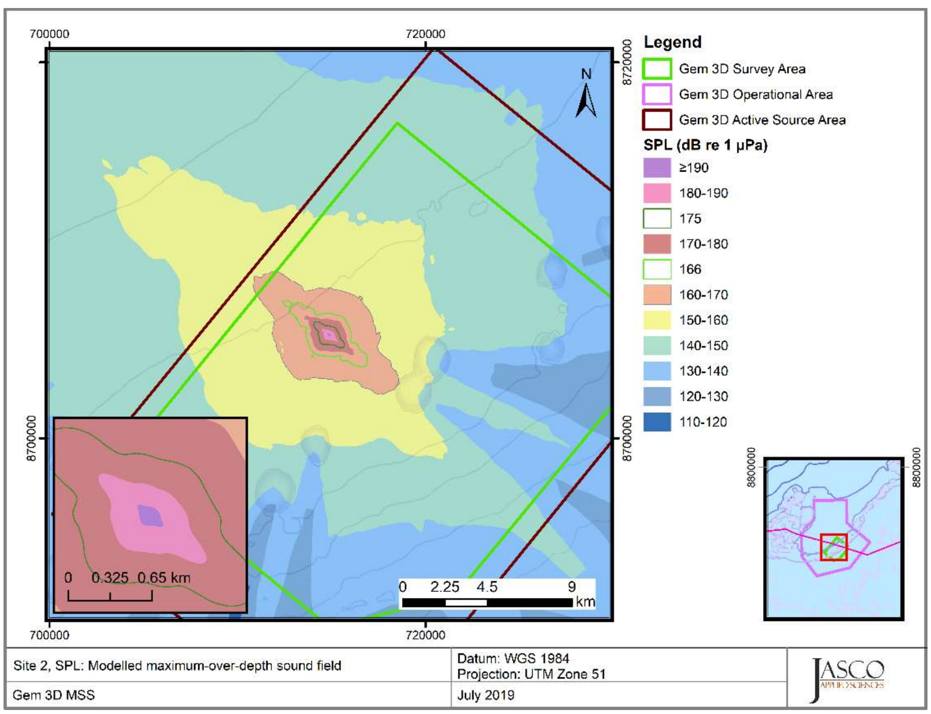

Figure 5. *Site 2, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

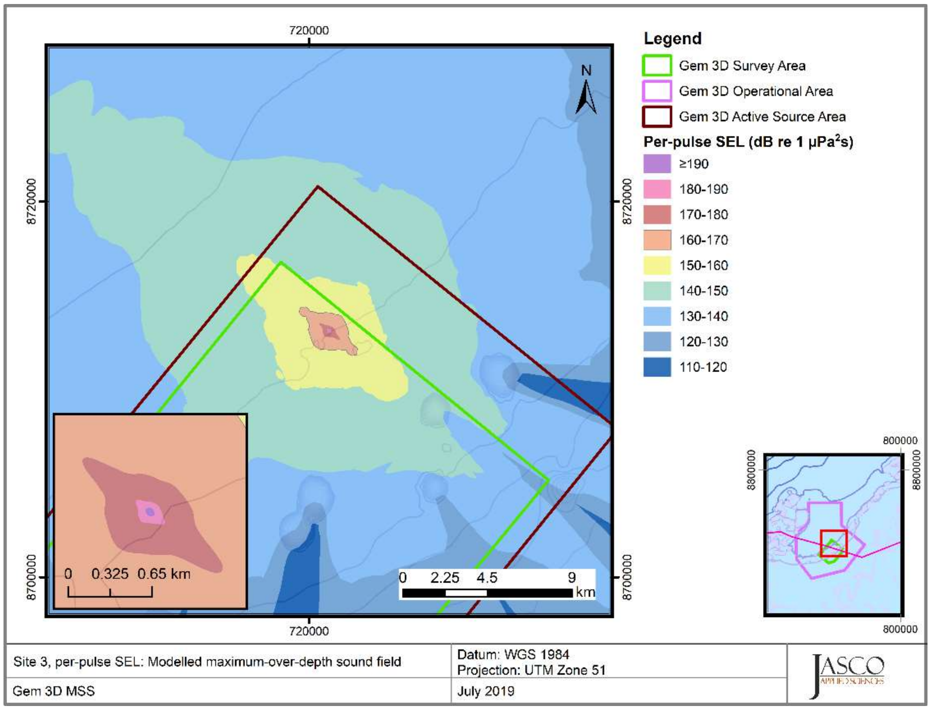

Figure 6. *Site 3, per-pulse SEL*: Sound level contour map showing unweighted maximum-over-depth results.

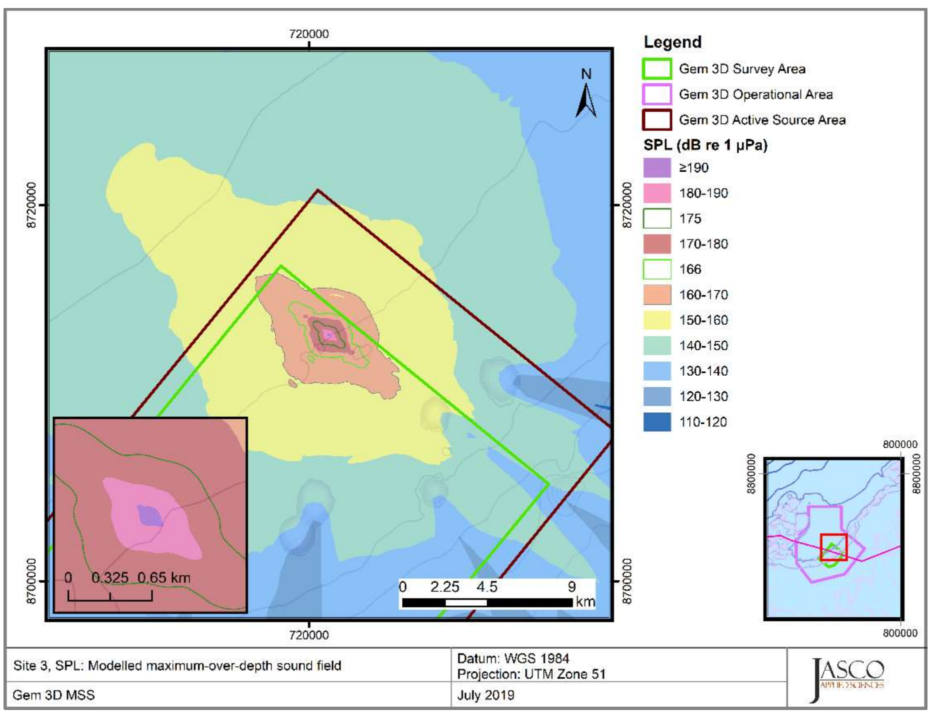

Figure 7. *Site 3, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

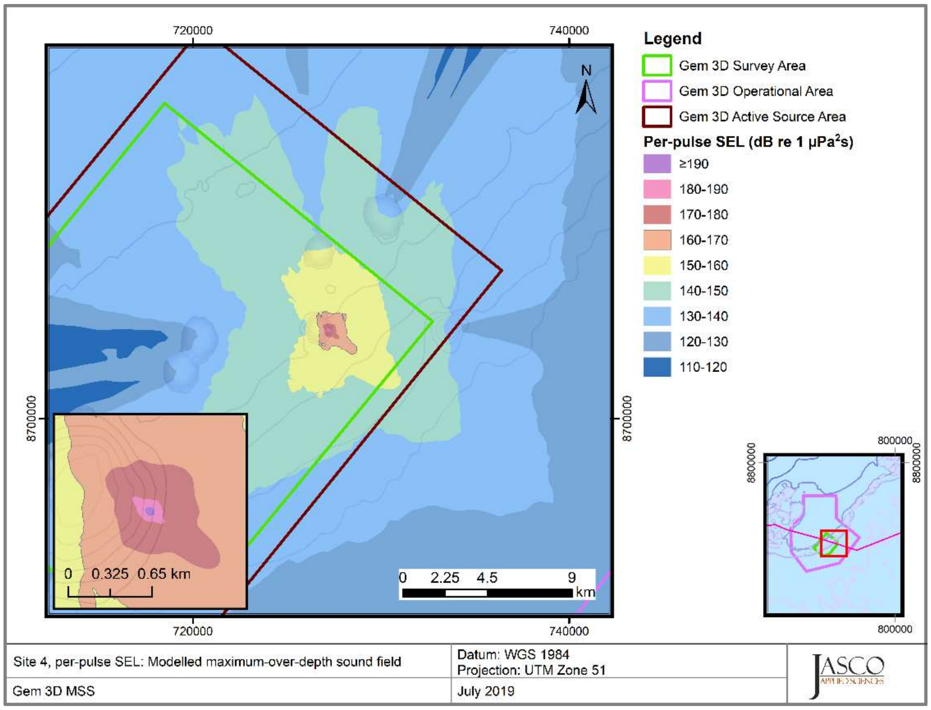

Figure 8. *Site 4, per-pulse SEL*: Sound level contour map showing unweighted maximum-over-depth results.

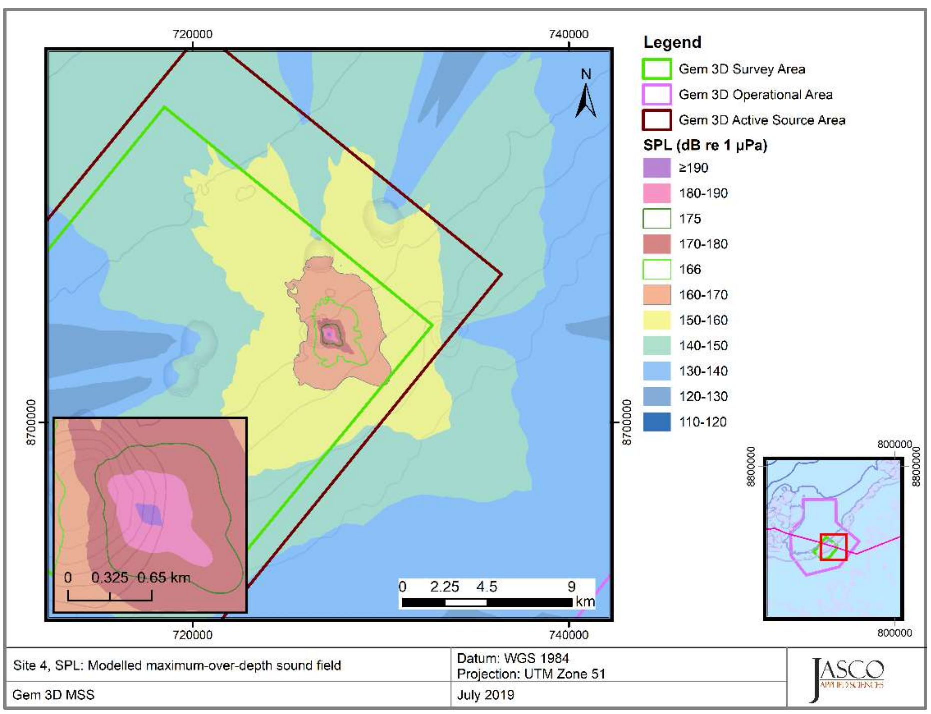

Figure 9. *Site 4, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

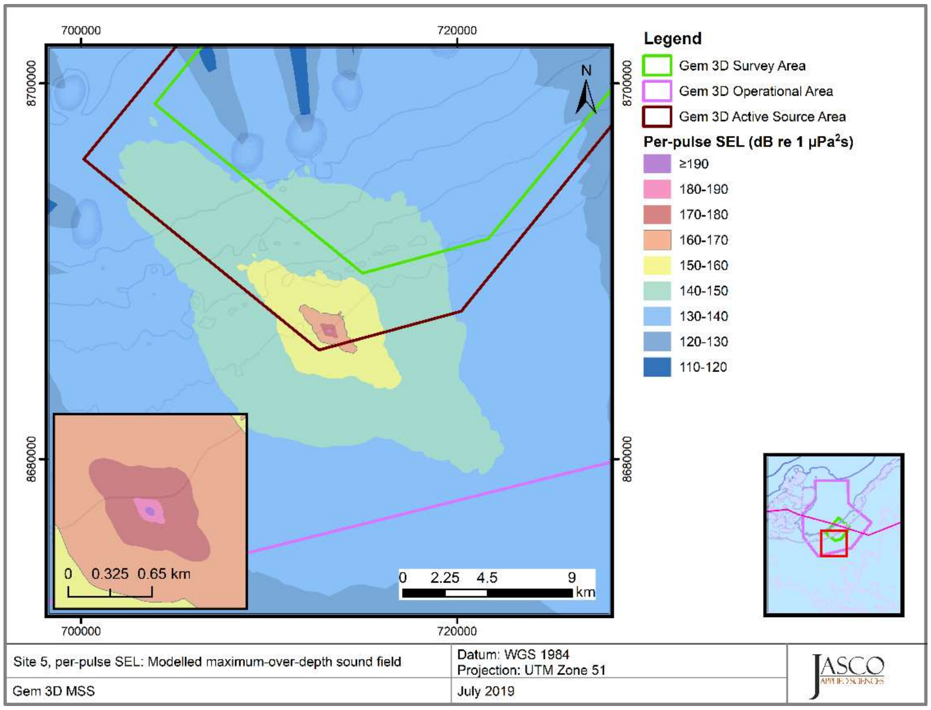

Figure 10: *Site 5, per-pulse SEL*: Sound level contour map showing unweighted maximum-over-depth results.

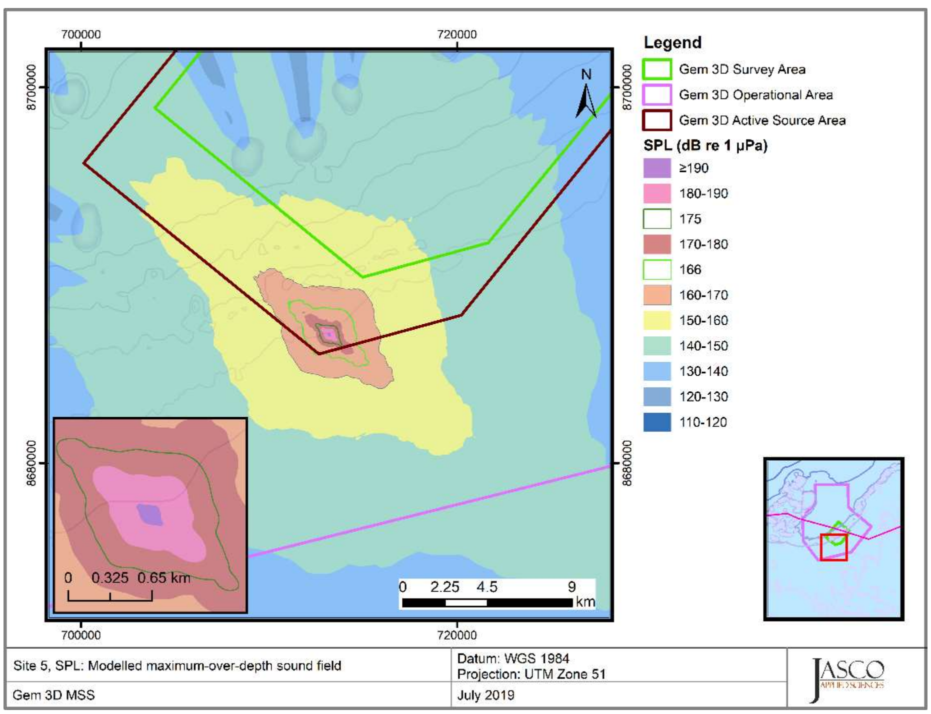

Figure 11: *Site 5, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

5.2.2.2. Vertical slices of modelled sound fields

Vertical slices of the SPL sound fields for the 2820 in^3 airgun array are shown in Figures 12–16.

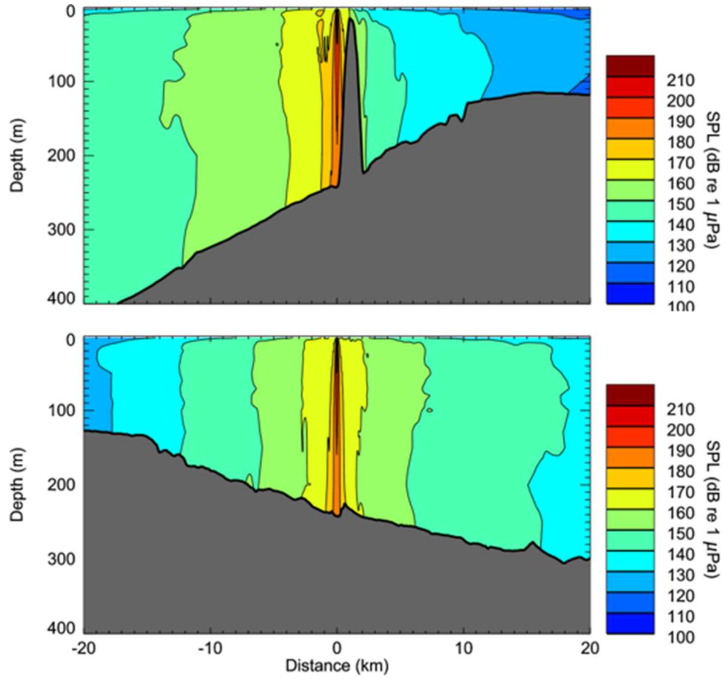

Figure 12. *Site 1, SPL*: Vertical slice of the predicted SPL for the 2820 in^3 array. Levels are shown along the broadside (top) and endfire (bottom) directions.

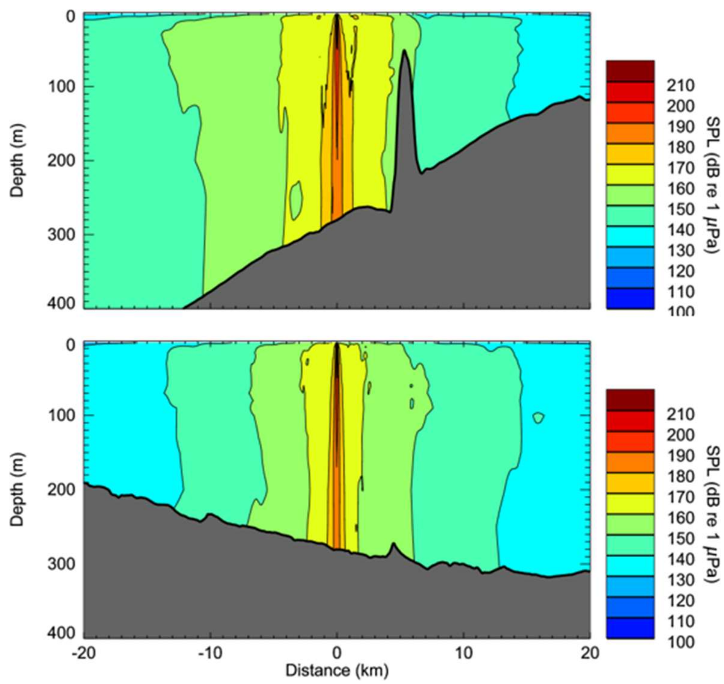

Figure 13. *Site 2, SPL*: Vertical slice of the predicted SPL for the 2820 in^3 array. Levels are shown along the broadside (top) and endfire (bottom) directions.

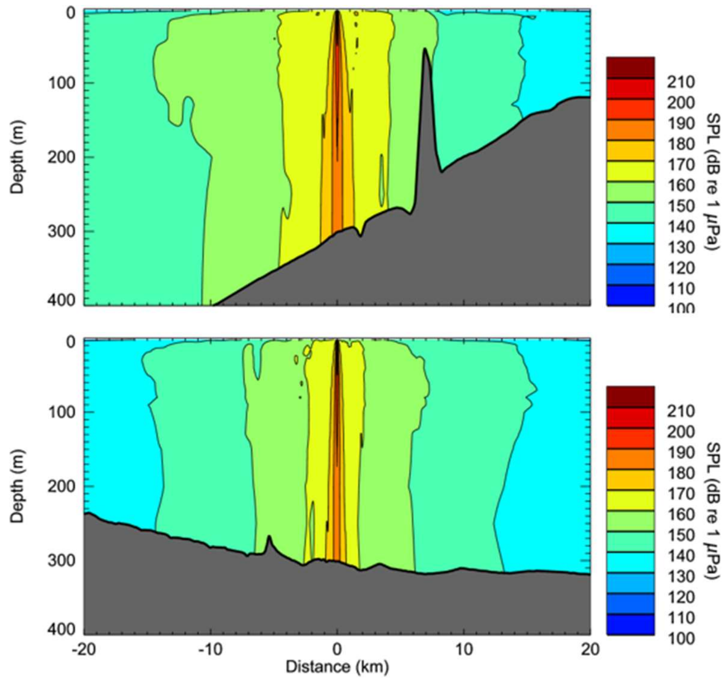

Figure 14. *Site 3, SPL*: Vertical slice of the predicted SPL for the 2820 in^3 array. Levels are shown along the broadside (top) and endfire (bottom) directions.

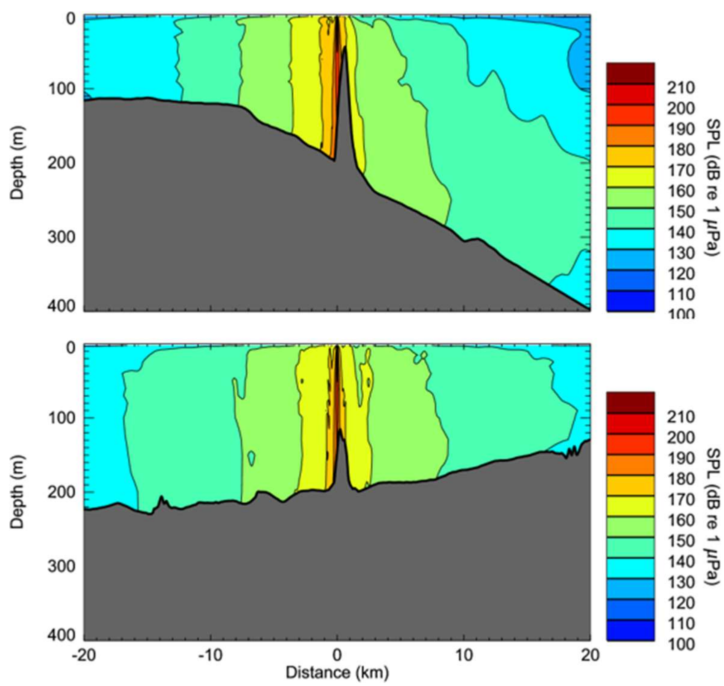

Figure 15. *Site 4, SPL*: Vertical slice of the predicted SPL for the 2820 in^3 array. Levels are shown along the broadside (top) and endfire (bottom) directions.

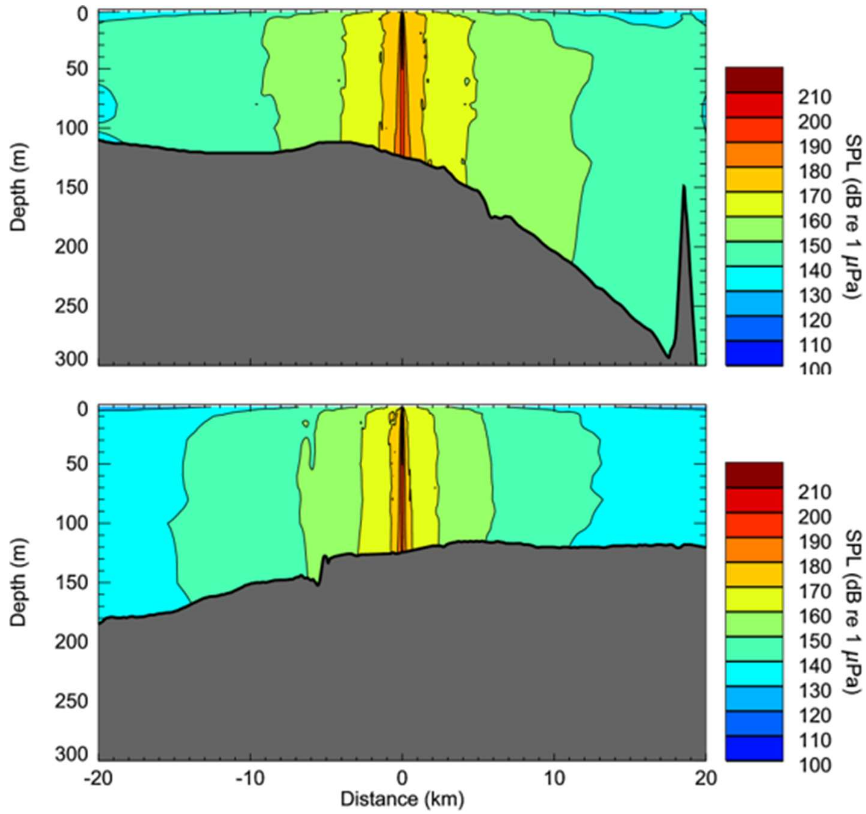

Figure 16. *Site 5, SPL*: Vertical slice of the predicted SPL for the 2820 in^3 array. Levels are shown along the broadside (top) and endfire (bottom) directions.

5.3. Multiple Pulse Sound Fields

The SEL_{24h} results for the proposed survey are presented for one possible operational scenario within the Active Source Area. Tables 15 and 16 show the estimated ranges to the appropriate cumulative exposure criterion contour for the various marine fauna groups considered and the corresponding ensonified areas. The ranges in this section are the perpendicular distance from the survey line to the relevant isopleth. Estimates of the maximum-over-depth sound fields, including threshold contours relating to marine mammals and fish, are presented in Figure 17, while estimates of the sound field at the seafloor and threshold contours relevant to fish are presented in Figure 18.

Table 15. Maximum-over-depth distances (in km) to frequency-weighted SEL_{24h} based marine mammal PTS and TTS thresholds NMFS (2018) and turtles (Finneran et al. 2017).

Hearing group	PTS		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	183	0.86	96.1
Mid-frequency cetaceans	185	—	—
High-frequency cetaceans	155	0.03	1.83
Sirenians (dugong)	190	—	—
Turtles	204	0.03	2.3
Hearing group	**TTS**		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	168	21.6	1205
Mid-frequency cetaceans	170	—	—
High-frequency cetaceans	140	0.50	60.2
Sirenians (dugong)	175	0.02	0.90
Turtles	189	0.42	55.8

A dash indicates the threshold is not reached within the limits of the modelling resolution.

Table 16. 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	2.22	—	—
II, Turtles, fish eggs and fish larvae	210	0.03	2.34	—	—
III	207	0.03	2.34	—	—
Fish recoverable injury					
I	216	0.03	2.34	—	—
II, III	203	0.03	2.43	—	—
Fish TTS					
I, II, III	186	1.47	148	1.27	132

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.
A dash indicates the threshold is not reached within the limits of the modelling resolution.

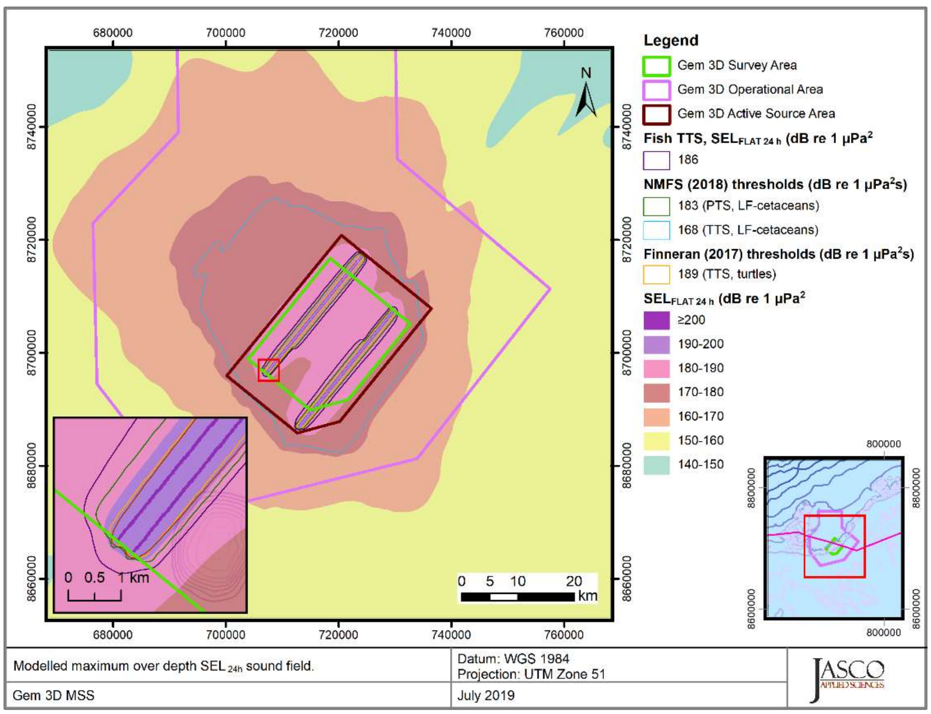

Figure 17. Sound level contour map showing maximum-over-depth SEL_{24h} results.

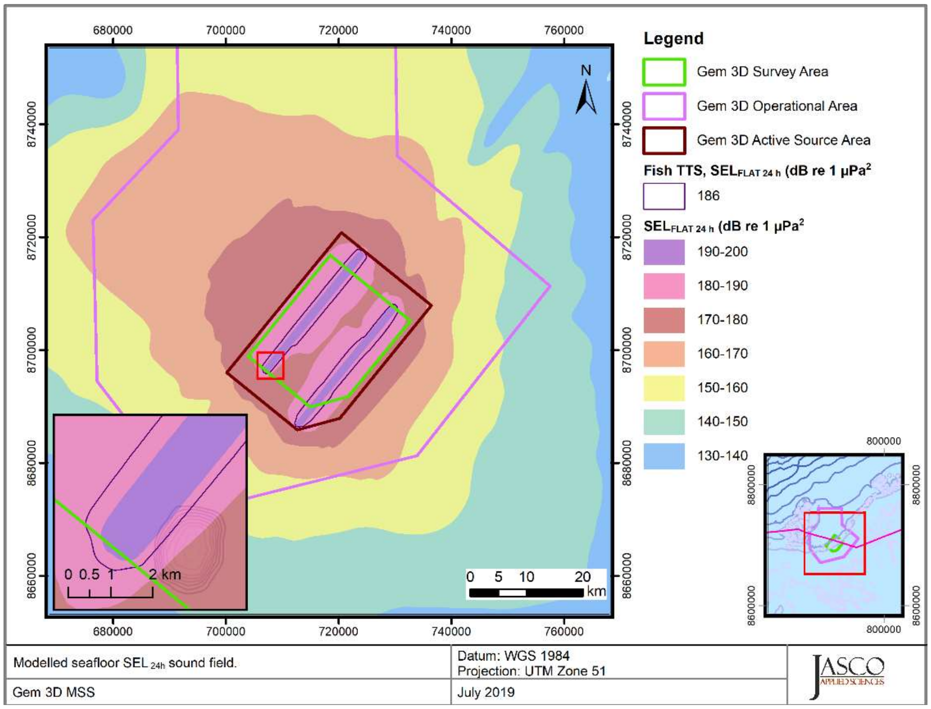

Figure 18. Sound level contour map showing seafloor SEL_{24h} results.

6. Discussion

6.1. Overview and Source Levels

This modelling study predicted underwater sound levels associated with the planned Gem 3-D MSS. The underwater sound field was modelled for a 2820 in^3 seismic source (Appendix B) with a water column sound speed profile for July. An analysis of seasonal sound speed profiles, the results of which are presented in Appendix D.3.2, indicated that the month of July was the most conducive to sound propagation due to the presence of a moderate surface duct; as such it was selected to ensure a conservative estimation of distances to received sound level thresholds over the potential survey periods; 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 125 to about 251 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 2820 in^3 array operating at 5 m depth was 224.9 dB 1 $\mu Pa^2 m^2 s$ in the broadside direction and 223.0 dB 1 $\mu Pa^2 m^2 s$ in the endfire direction. The peak pressure level in the same directions was 249.7 and 244.8 dB re 1 µPa m, respectively, these results are presented in Table 8.

6.2. Per-Pulse Sound Fields

At all modelling 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 primarily due to the directionality of the array. However, the acoustic footprints were significantly influenced by changes in the bathymetry, particularly around the isolate carbonate build-up (ICB) (Nicholas et al. 2015) pinnacles, see Figure D-3 for a regional bathymetric map. These pinnacles, which rise to a minimum water depth of 28 m within the Active Source Area, can block the propagation of acoustic energy at certain azimuths as shown in the footprint maps in Section 5.2.2.

The array directionality and frequency content coupled with bathymetry had a considerable effect on propagation at longer distances, with generally larger lobes of sound energy extending into the deeper waters to the North and West of the Active Source Area where no pinnacle was present. The vertical slice plots (Section 5.2.2.2) assist in demonstrating the influence of the regional bathymetry, pinnacles, source location and sound speed profile on sound propagation from the array.

The sound speed profile (Figure D-4) was primarily downward refracting apart from a moderate surface duct which extended to approximately 80 m from the sea surface. The sound speed profile had a minimum sound speed at approximately 1000 m that forms the sound channel axis. For source locations near the shelf break, significant amounts energy can be reflected from the seabed and trapped in the sound channel which can then propagate for large distances within the ocean interior. This phenomenon resulted in large ranges to all isopleths in the offshore directions where a pinnacle is not present.

The surface duct in the sound speed profile is approximately 80 m thick and will only effective trap frequencies above 260 Hz (Jensen et al. 2011). The presence of a surface duct has the potential to trap levels at high frequencies which would otherwise dissipate more rapidly in range due to spreading and seabed loss. As an example, for some source locations where an ICB pinnacle is present along the propagation path, the maximum range to a threshold can be associated with energy trapped in the surface duct where it can effectively propagate over the ICB, which would otherwise block majority of energy. However, this phenomenon is not present in all case, because it is controlled by frequency content and water depth.

The distances to PK based potential injury criteria (Section 3.2 and 3.3) for fish and benthic crustaceans at the seafloor for Site 6 marginally increased with increasing depth (Tables 13 and 14). Furthermore, the distances to thresholds were generally greater for Site 5 as compared to Site 6. The distances to these criteria did not always consistently change with increasing depth as any correlation between water depth and threshold distance is related to complex patterns of surface and seabed reflections that affect sound propagation in shallow water. However, the number of modelling sites and water depths considered within the Active Source Area, provides a good representation of potential variability for seabed receptors.

6.3. Multiple Pulse Sound Fields

The accumulated SEL over 24 hours of seismic operation was modelled considering representative scenarios with realistic acquisition patterns for the Gem 3-D seismic survey. The modelling 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 marine mammals and the SEL_{24h} based fish and marine mammal criteria. The results were presented as maps of the accumulated exposure levels and tabulated values of ranges to threshold levels and exposure areas for the given effects criteria (Section 5.3).

The footprints and range maxima for all accumulated SEL thresholds substantially influenced by the locations of the source near the shelf break. For a survey lines that run parallel to the shelf break energy that is transmitted into the water column in the offshore direction can be trapped in the sound channel and propagate with minimal loss, as discussed above. This effect is manifested in the extended isopleths and R_{max} distances to thresholds in the offshore direction shown Figures 17 and 18. Furthermore, as levels generally decay away from the source the rate of decay decreases with range, propagation effects of this nature can further reduce the decay rate and allow lower levels to persist to longer ranges.

6.4. 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.

Marine mammal 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 4.21 and 5.07 km (Site 4, 140 m and Site 5, 124 m), provided in Table 10.
- 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 17 summarises the maximum distances for PTS, along with the relevant metric and the location of the results within this report.
- The SEL_{24h} 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 and turtles 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 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.

Table 17. Summary of maximum marine mammal PTS onset distances for modelled scenarios (PK values from

Table 11 and SEL_{24h} values from Table 15)

Relevant hearing group	Metric associated with longest distance to PTS onset	R_{max} (km)
Low-frequency cetaceans†	SEL_{24h}	0.86
Mid-frequency cetaceans	—	—
High-frequency cetaceans	PK	0.31
Sirenians (dugong)	—	—

† The model does not account for shutdowns.
A dash indicates the threshold is not reached within the limits of the modelling resolution.

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 (horizontal modelling resolution for FWRAM) from the centre of the array. Because the arrays are not a point source (approximately 14 m x 8 m) the actual ranges from the edge of airgun arrays are smaller than the distance from the centre.
- The maximum distance to the SEL_{24h} metric for PTS onset was 30 m and 0.42 km for TTS onset. As is the case with marine mammals, a reported radius for SEL_{24h} criteria does not mean that turtles 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.
- 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) McCauley et al. (2000b), McCauley et al. (2000a) could be exceeded are summarised in Table 18.

Table 18. Distances to turtle behavioural response criteria (from Table 10).

SPL (L_p; dB re 1 µPa)	Distance (km)	
	Min	Max
175†	0.87	1.05
166‡	2.55	2.98

† Threshold for turtle behavioural response to impulsive noise (McCauley et al. 2000b, McCauley et al. 2000a).
‡ 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} metrics associated with mortality and potential mortal injury and impairment in the following groups:
    - Fish without a swim bladder (also appropriate for sharks in the absence of other information)
    - Fish with a swim bladder that do not use it for hearing
    - Fish that use their swim bladders for hearing
    - Fish eggs and fish larvae

Table 19 summarises the distances to injury criteria for fish, fish eggs, and fish larvae along with the relevant metric and the location of the information within this report.

Table 19. Summary of maximum fish, fish eggs, and larvae injury and TTS onset distances for single impulse and SEL24h modelled scenarios (PK values from Tables 11 and 13, SEL_{24h} values from

Table 16).

Relevant hearing group	Injury criteria	Water column		Seafloor	
		Metric associated with longest distance to injury criteria	R_{max} (km)	Metric associated with longest distance to injury criteria	R_{max} (km)
Fish: No swim bladder	Injury	PK	0.06	PK	0.08
	TTS	$SEL_{24}h$	1.47	SEL_{24h}	1.27
Fish: Swim bladder not involved in hearing Swim bladder involved in hearing	Injury	PK	0.13	PK	0.14
	TTS	SEL_{24h}	1.47	SEL_{24h}	1.27
Fish eggs, and larvae	Injury	SEL_{24h}	0.13	PK	0.14

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 286 and 520 m depending on the modelled site (Table 14).
- 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 reached at two of the five considered sites and ranged from 6 m to 12 m in 28 m and 35 m water depth (Table 13).
- 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 5.97 km to 7.96 km (Table 12).

Glossary

1/3-octave
One third of an octave. Note: A one-third octave is approximately equal to one decidecade (1/3 oct ≈ 1.003 ddec; ISO 2017).

1/3-octave-band
Frequency band whose bandwidth is one one-third octave. Note: The bandwidth of a one-third octave-band increases with increasing centre frequency.

90%-energy time window
The time interval over which the cumulative energy rises from 5 to 95% of the total pulse energy. This interval contains 90% of the total pulse energy. Symbol: T_{90}.

azimuth
A horizontal angle relative to a reference direction, which is often magnetic north or the direction of travel. In navigation it is also called bearing.

broadband sound level
The total sound pressure level measured over a specified frequency range. If the frequency range is unspecified, it refers to the entire measured frequency range.

broadside direction
Perpendicular to the travel direction of a source. Compare with endfire direction.

cavitation
A rapid formation and collapse of vapor cavities (i.e., bubbles or voids) in water, most often caused by a rapid change in pressure. Fast-spinning vessel propellers typically cause cavitation, which creates a lot of noise.

cetacean
Any animal in the order Cetacea. These are aquatic, mostly 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.

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-pk}; $L_{p,pk-pk}$; 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:

$$L_{E,N} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}}\right). \tag{A-5}$$

If applied, the frequency weighting of an acoustic event should be specified, as in the case of weighted SEL (e.g., $L_{E,LFC,24h}$; Appendix A.3). The use of fast, slow, or impulse exponential-time-averaging or other time-related characteristics should else be specified.

A.2. Marine Mammal Impact Criteria

It has been long recognised that 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
Sirenians (dugongs and manatees)	1.8	2	4,300	25,000	2.62

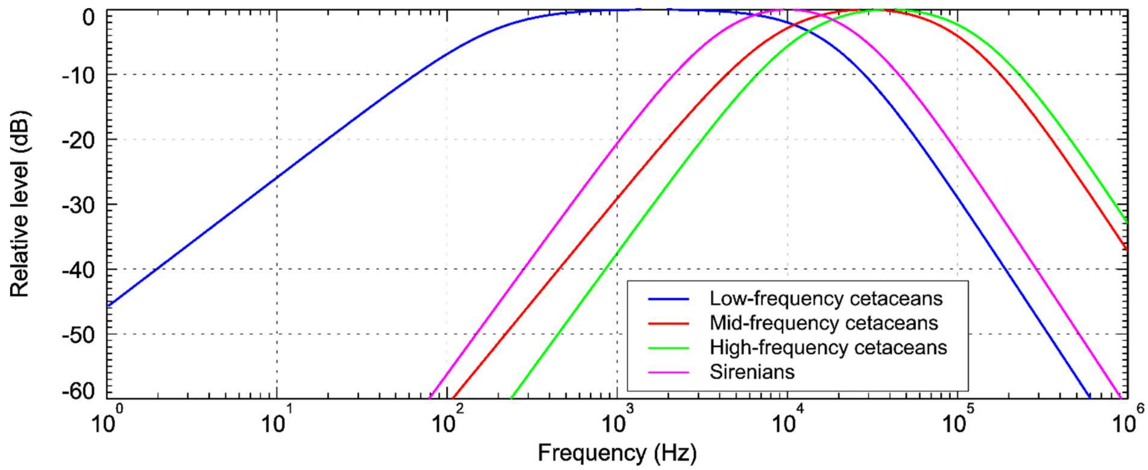


Figure A-1. Auditory weighting functions for functional marine mammal hearing groups used in this project as recommended by NMFS (2018).

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:

$$R_{\mathrm{nf}} < \frac{l^2}{4\lambda} \tag{B-1}$$

where λ is the sound wavelength and l is the longest dimension of the array (Lurton 2002, §5.2.4). For example, a seismic source length of l = 21 m yields a near-field range of 147 m at 2 kHz and 7 m at 100 Hz. Beyond this R_{nf} range, the array is assumed to radiate like a directional point source and is treated as such for propagation modelling.

The interactions between individual elements of the array create directionality in the overall acoustic emission. Generally, this directionality is prominent mainly at frequencies in the mid-range between tens of hertz to several hundred hertz. At lower frequencies, with acoustic wavelengths much larger than the inter-airgun separation distances, the directionality is small. At higher frequencies, the pattern of lobes is too finely spaced to be resolved and the effective directivity is less.

B.2. Array Source Levels and Directivity

Figure B-1 shows the broadside (perpendicular to the tow direction), endfire (parallel to the tow direction), and vertical overpressure signature and corresponding power spectrum levels for the 2820 in^3 array (Appendix D.4).

Horizontal 1/3-octave-band source levels are shown as a function of band centre frequency and azimuth (Figure B-2); directivity in the sound field is most noticeable at mid-frequencies as described in the model detail in Appendix B.1.

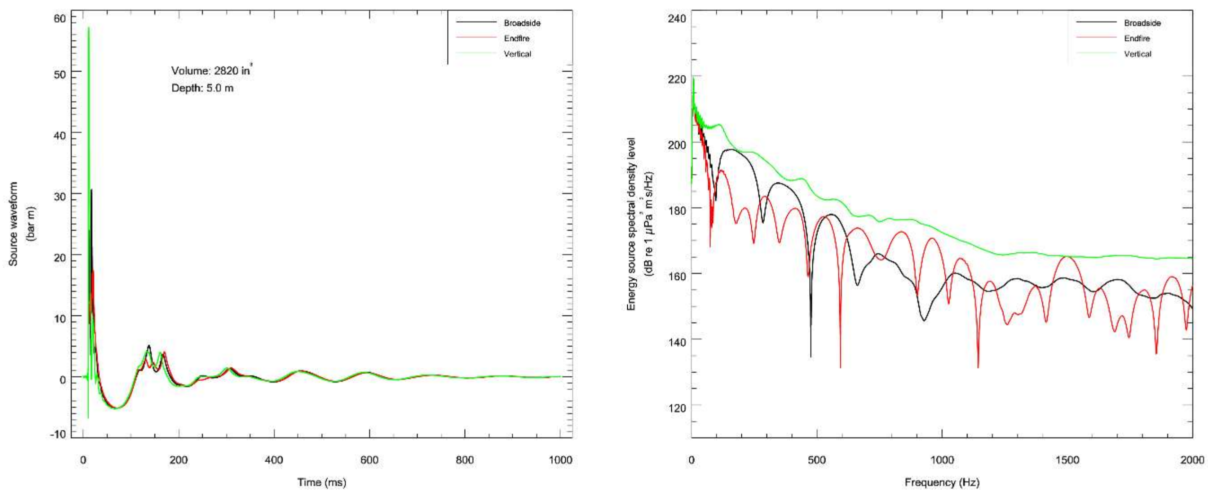


Figure B-1. Predicted source level details for the 2820 in^3 array at a 5 m towed depth. (Left) the overpressure signature and (right) the power spectrum for in-plane horizontal (broadside), perpendicular (endfire), and vertical directions.

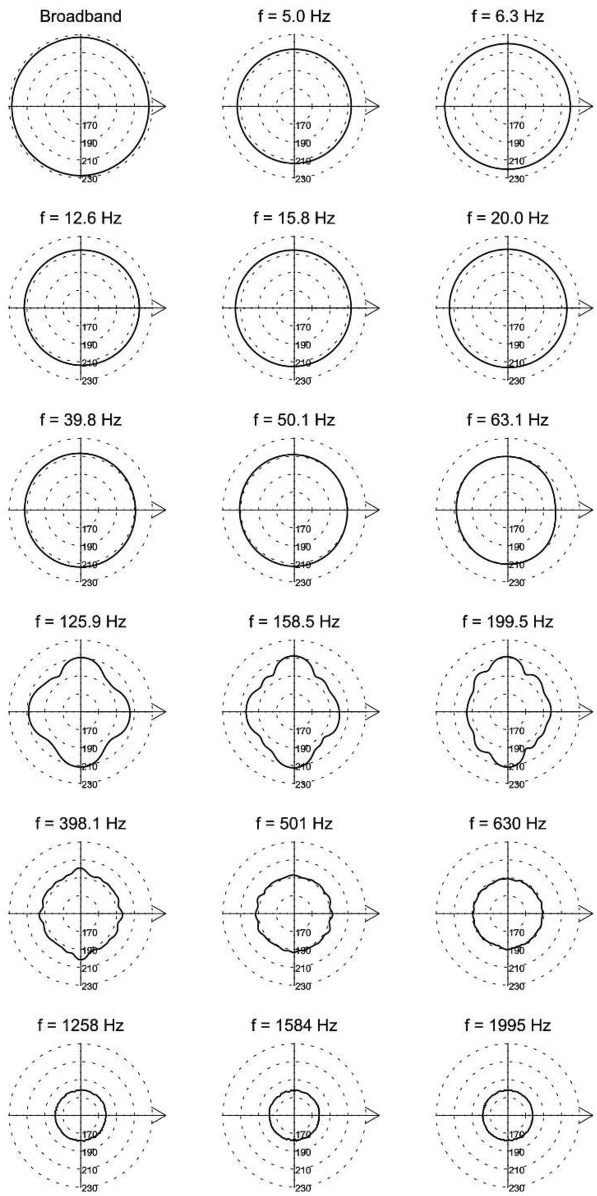


Figure B-2. Directionality of the predicted horizontal source levels for the 2820 in^3 seismic source array, 10 Hz to 2 kHz. Source levels (in dB re 1 μPa^2·s m^2) are shown as a function of azimuth for the centre frequencies of the 1/3-octave-bands modelled; frequencies are shown above the plots. The perpendicular direction to the frame is to the right. Tow depth is 5 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).

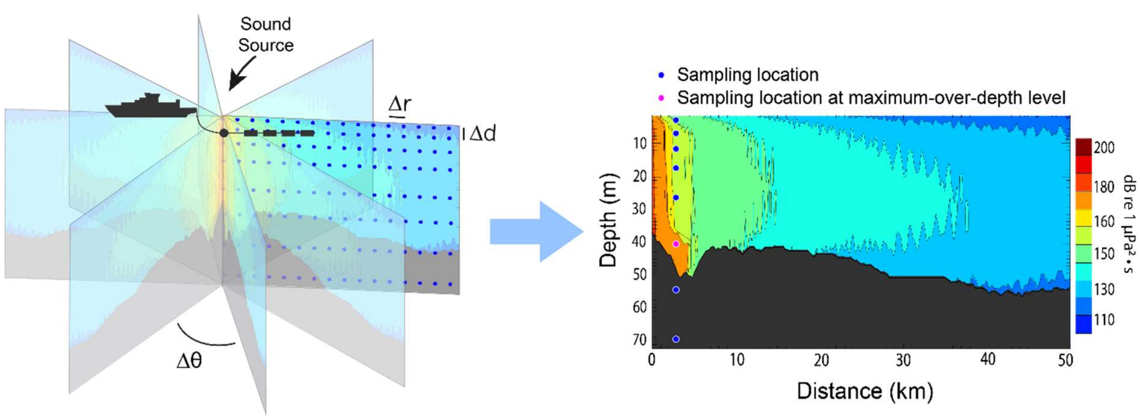


Figure C-1. The N×2-D and maximum-over-depth modelling approach used by MONM.

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).

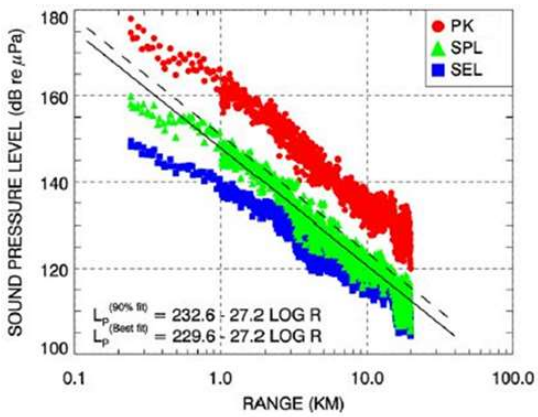


Figure C-2. PK and SPL and per-pulse SEL versus range from a 20 in^3 seismic source. Solid line is the least squares best fit to SPL. Dashed line is the best fit line increased by 3.0 dB to exceed 90% of all SPL values (90th percentile fit) (Ireland et al. 2009, Figure 10).

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.

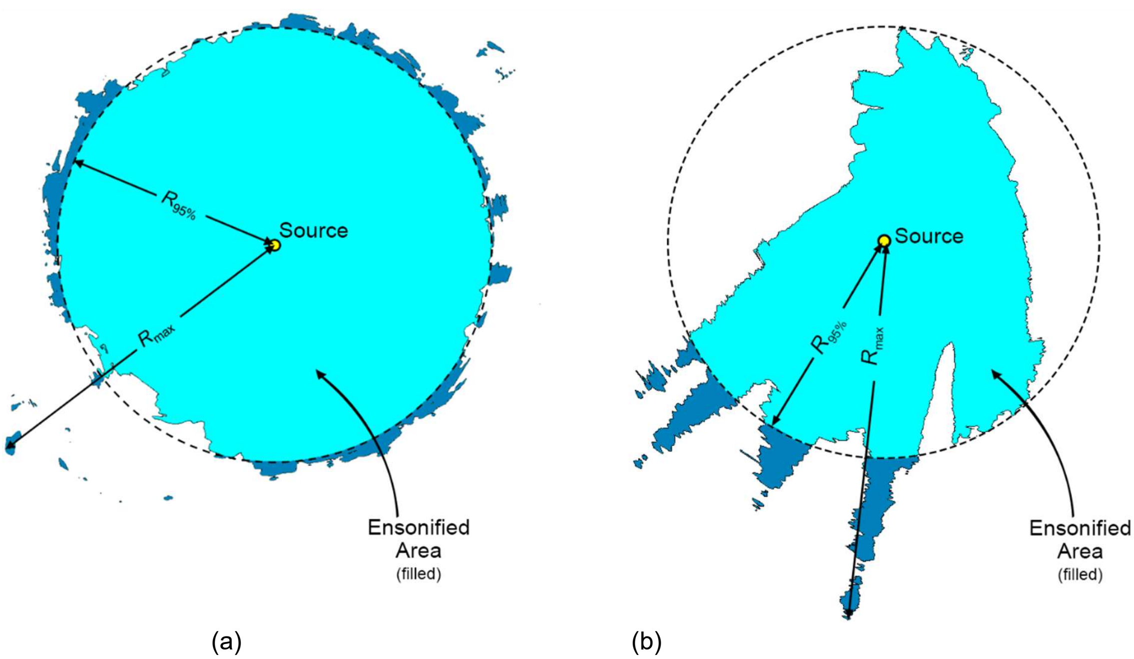
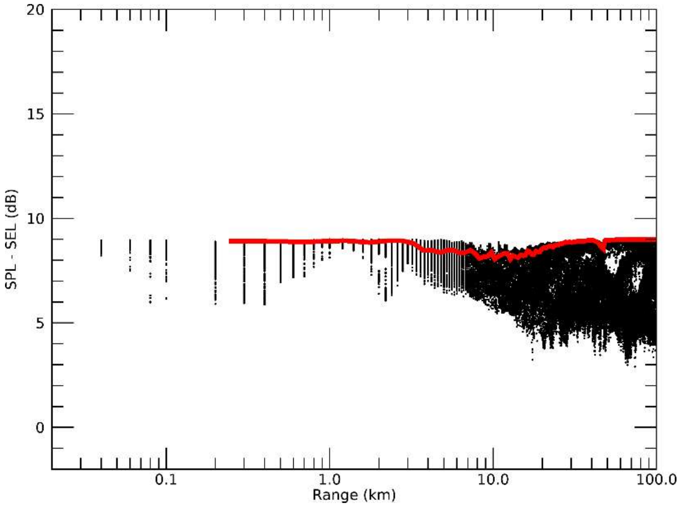


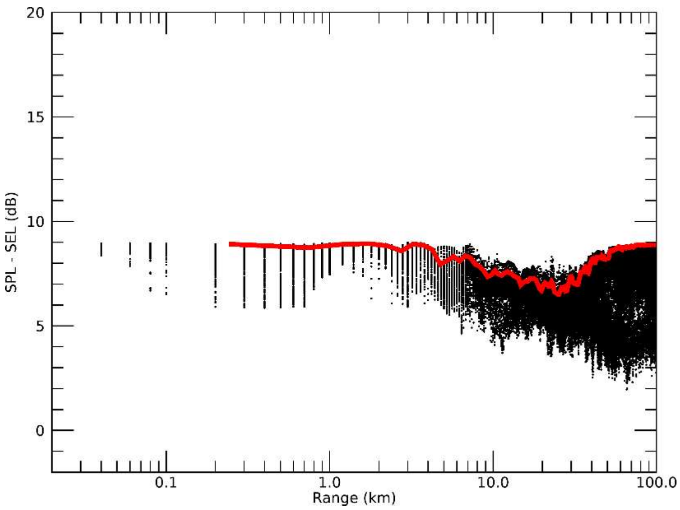
Figure D-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified 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 three sites.





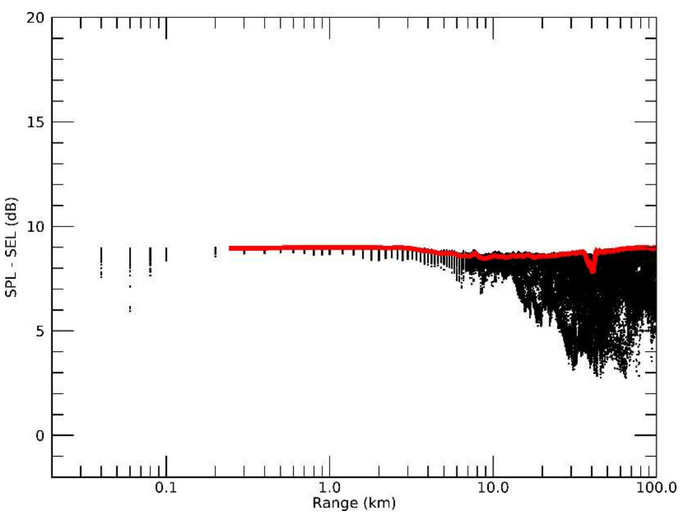


Figure D-2. Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Slices are shown for the 2820 in^3 modelled Site 1 (top), Site 3 (middle) and Site 5 (bottom). Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; 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 51 S) with a regular grid spacing of 200 × 200 m to generate the bathymetry in Figure D-3.

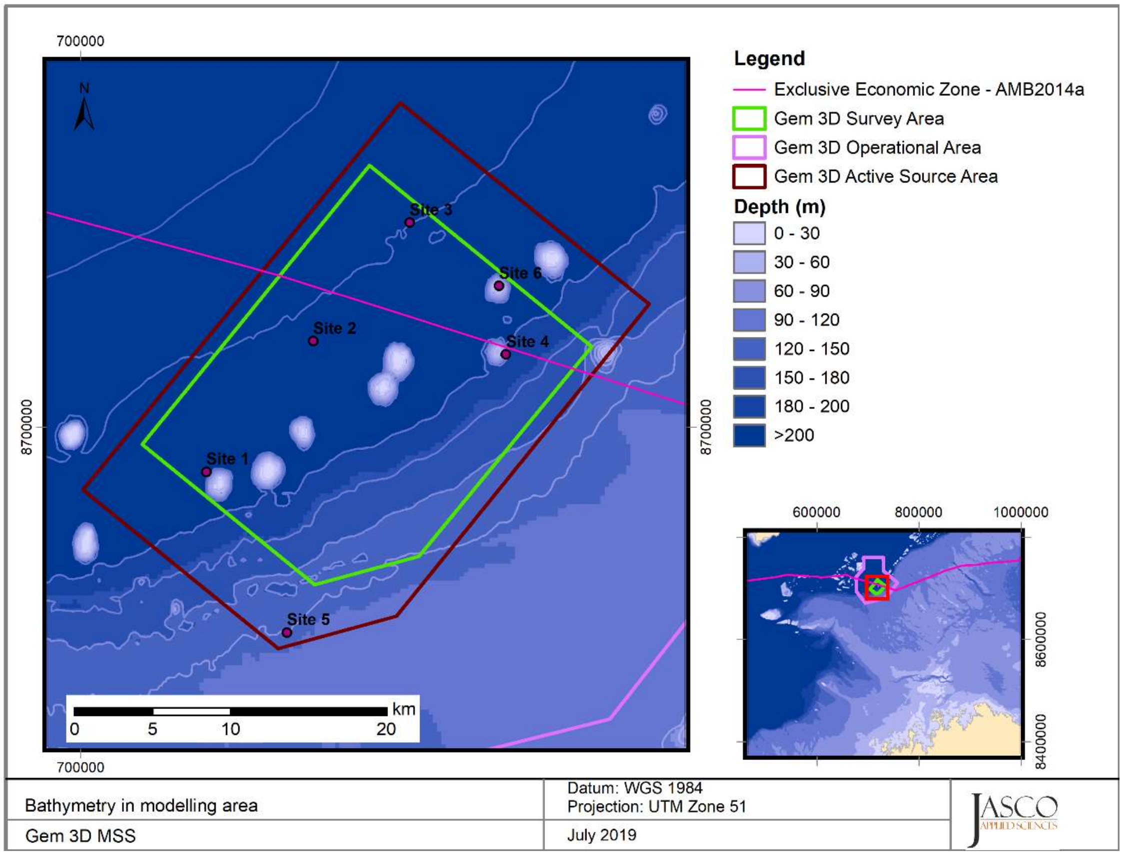


Figure D-3. Bathymetry map of the modelling area.

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.

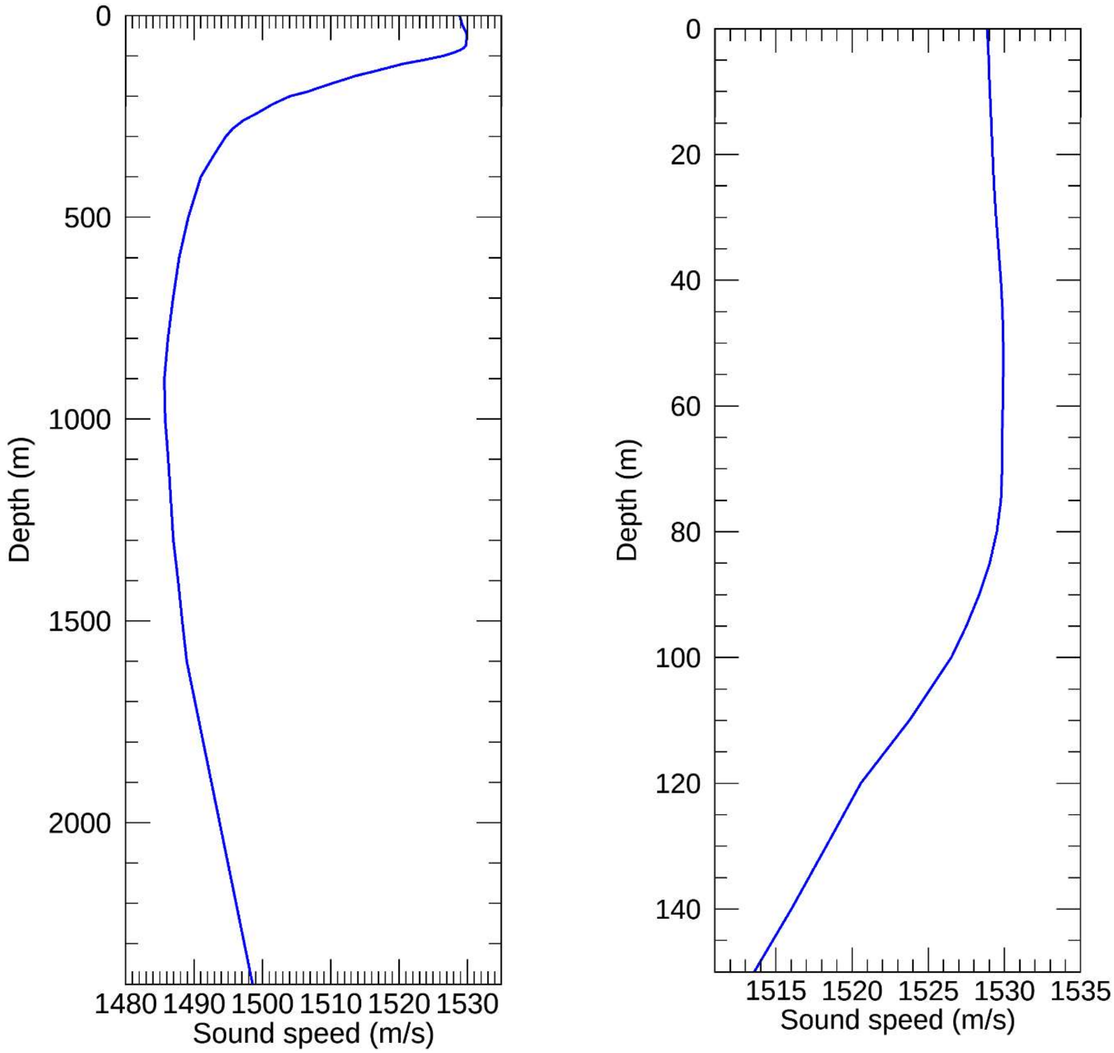


Figure D-4. The final sound speed profile (July) used for the modelling showing the entire water column (left) and the top 150 m within the profile (right). Profiles are calculated from temperature and salinity profiles from GDEM V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

D.3.3. Geoacoustics

For modelling sites 1–5 relevant geologic data was extracted from the Marine Sediments (MARS) database (Heap 2009) within the modelling area. Using the available MARS shallow core information, the surficial sediment was determined to be appropriately represented as a muddy carbonate sand. Based on this information and properties for carbonate sediments and calcarenite from Hamilton (1980) and Duncan et al. (2013), the geoacoustic profile in

Table D-1 was derived.

For modelling site 6, which is located above a shallow water shoal the geology was considered to be sufficiently similar to an Isolated Carbonate Build-up (ICB) discussed in (Nicholas et al. 2015). Based on this geologic information, the MARS sediment information and properties for carbonate sediments and calcarenite from Hamilton (1980) and Duncan et al. (2013), the geoacoustic profile in Table D-2 was derived.

Table D-1. Geoacoustic profile for all sites 1–5 used for MONM-BELLHOP and FWRAM in this study. Within each depth interval, each parameter varies linearly within the stated depths. The compressional wave is the primary wave. The shear wave is the secondary wave.

Depth below seafloor (m)	Predicted lithology	Density (g/cm³)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed (m/s)	Attenuation (dB/λ)
0–20.6	Muddy carbonate sand (unconsolidated)	1.77–1.80	1646.0–1681.1	0.97–1.18		
20.6–42.2		1.80 - 1.83	1681.1–1717.6	1.18–1.30		
42.2–64.6	Increasingly consolidated muddy carbonate sand	1.83–1.86	1717.6–1755.1	1.30–1.13		
64.6–90.7		1.86–1.89	1755.1–1798.3	1.13–0.92	386.5	1.9
90.7–200.0		1.89–2.02	1798.3–1973.6	0.92		
200.0–500.0	Consolidated carbonate sand/ semi-cemented calcarenite	2.02–2.32	1973.6–2409.0	0.92		
>500.0	Well-cemented calcarenite	1.90	2600.0	0.20		

Table D-2. Geoacoustic profile for site 6 used with VSTACK for this study. Within each depth interval the geoacoustic parameters are constant. The compressional wave is the primary wave. The shear wave is the secondary wave.

Depth below seafloor (m)	Predicted lithology	Density (g/cm³)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed (m/s)	Attenuation (dB/λ)
0.0–1.0	Muddy carbonate sand (unconsolidated)	1.77	1646.9	0.98	387.5	1.90
>1.0	Well-cemented calcarenite	1.90	2600.0	0.20	1200	0.4

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-3.

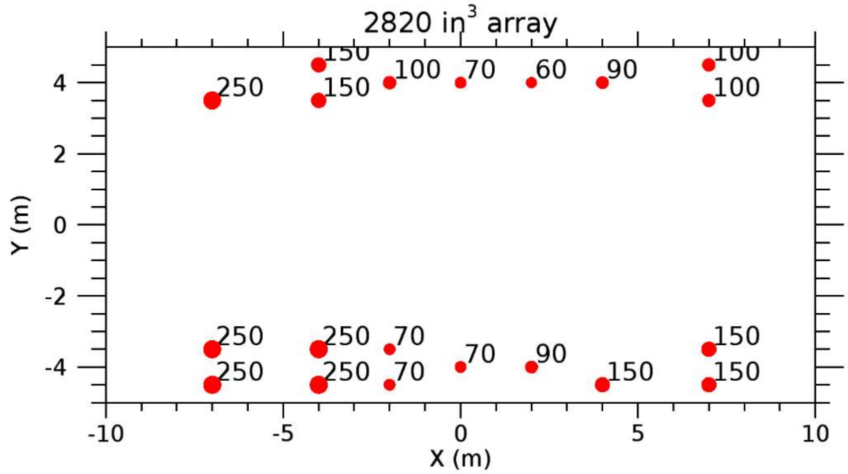


Figure D-5. Layout of the modelled 2820 in^3 seismic source array. Tow depth is 5 m. The labels indicate the firing volume (in cubic inches) for each airgun. Also see Table D-3.

Table D-3. Layout of the modelled 2820 in^3 seismic source array. Tow depth is 5 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	-4.5	5	150	11	-7	-3.5	5	250
2	7	-3.5	5	150	12	7	3.5	5	100
3	4	-4.5	5	150	13	7	4.5	5	100
4	2	-4	5	90	14	4	4	5	90
5	0	-4	5	70	15	2	4	5	60
6	-2	-4.5	5	70	16	0	4	5	70
7	-2	-3.5	5	70	17	-2	4	5	100
8	-4	-4.5	5	250	18	-4	3.5	5	150
9	-4	-3.5	5	250	19	-4	4.5	5	150
10	-7	-4.5	5	250	20	-7	3.5	5	250

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 H: Oil Pollution Emergency Plan

GEM 3D MARINE SEISMIC SURVEY

Oil Pollution Emergency Plan

Rev 1.0
5/09/2019

Document Number: AU-HS-EXT-011-1.0

Contents

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Appendices

APPROVAL

ACTION	NAME	POSITION	INITIAL	DATE
Document Owner	RPS	Consultant	RPS	5-SEP-19
Reviewed by	MC	Senior HSE Specialist	MC	5-SEP-19
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1.0	5-Sep-2019	RPS	Senior HSE Specialist	Project Manager	Asset / Country Manager	Issued to NOPSEMA for public consultation

Abbreviations

Acronym/abbreviation	Description
3D	3-dimensional
AFMA	Australian Fisheries Management Authority
ALARP	As Low as Reasonably Practicable
AMSA	Australian Maritime Safety Authority
BAOAC	Bonn Agreement Oil Appearance Code
CA	Control Agency
DNP	Director of National Parks
DoEE	Department of the Environment and Energy
EP	Environment Plan
ERP	Emergency Response Plan
GPS	Global positioning service
HSE	Health, Environment and Safety
HSEMS	Health, Environment and Safety Management System
IMT	Incident management team
IOGP	International Association of Oil & Gas Producers
IPIECA	International Petroleum Industry Environmental Conservation Association
API	American Petroleum Institute
MARPOL	International Convention for the Prevention of Pollution from Ships
MEE	Western Australian State Hazard Plan for Maritime Environmental Emergencies
MSS	Marine Seismic Survey
NATPLAN	National Plan for Maritime Environmental Emergencies
NEBA	Net Environmental Benefits Analysis
NERA	National Energy Resources Australia

NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
OMP	Operational monitoring plan
OPEP	Oil Pollution Emergency Plan
OPGGS Act	Offshore Petroleum and Greenhouse Gas Storage Act 2006
OPGGS(E) Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
OSMP	Operational and scientific monitoring plan
POLREP	Marine pollution report
PPE	Personal protective equipment
QA/QC	Quality assurance and quality control
SIMA	Spill Impact Mitigation Assessment
SIMOPS	Simultaneous operations
SMP	Scientific monitoring plan
SapuraOMV	Sapura OMV Upstream (Western Australia) Pty Ltd
SOPEP	Shipboard Oil Pollution Emergency Plan
Units of measure	Description
km	Kilometres
knts	Knots
m	Metres

1 Introduction

1.1 Purpose

This Oil Pollution Emergency Plan (OPEP) has been developed to detail the response processes to be utilised in the event of a marine pollution incident associated with the Gem 3D Marine Seismic Survey (Gem 3D MSS).

This OPEP has been developed to meet the requirements of the following:

- Offshore Petroleum and Greenhouse Gas Storage Act 2006 (OPGGS Act)
- Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS(E) Regulations).

1.2 Scope

Any spill where oil is released and enters, or has the potential to enter, the marine environment is an oil spill for the purposes of this OPEP. This OPEP covers Gem 3D MSS activities associated with the permit AC/P61 and the centre point coordinates being 11° 46' 9.935" S, 124° 58' 49.438" E which is approximately 260 km from the nearest Australian (Western Australia) shoreline as shown in Figure 1-1.

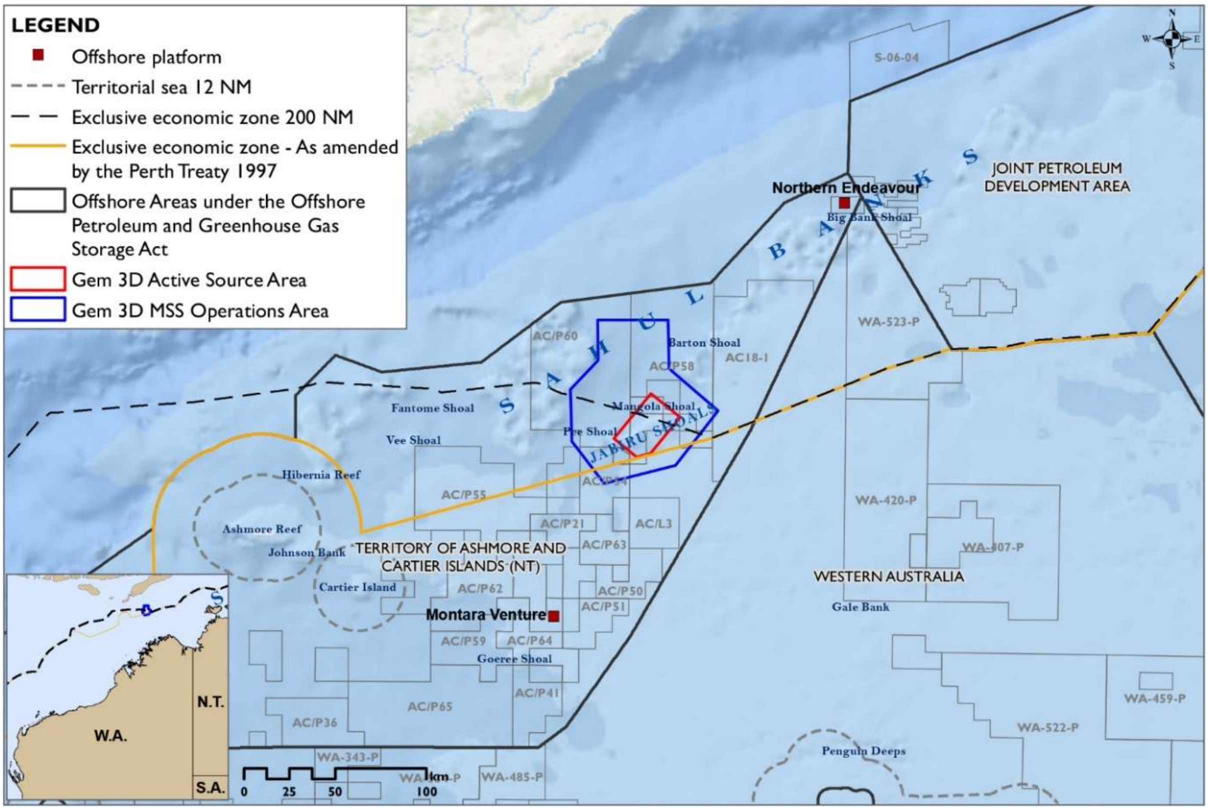

Figure 1-1 Gem 3D MSS survey area

1.3 Spill response priorities

The following are the priorities during an oil pollution emergency response for the Gem 3D MSS activity:

1. Protection of human life, health and personal safety
2. Containment of the pollution source on board the vessel, preventing pollution entering the marine environment
3. Prevention of a slick reaching environmentally sensitive locations

4. Prevention of impacts to commercial/industrial resources, properties and assets
5. Protection of cultural, recreational and human amenity resources.

1.4 Interface with other plans

This OPEP forms part of the wider emergency management framework which links to the following documents:

- National Plan for Maritime Environmental Emergencies (NATPLAN)
- Vessel Shipboard Oil Pollution Emergency Plan (SOPEP).

2 Spill response framework

2.1 Level response structure

In line with the NATPLAN, marine oil spills are divided into three categories ('Levels') depending on their size and the resources and capabilities required for an effective response. This OPEP recognises that under existing Commonwealth and State Intergovernmental Agreements, various authorities have been nominated with control agency responsibility for spills within harbours, State waters and Commonwealth waters around Australia. The definition of a control agency as per the NATPLAN is "the agency or company assigned by legislation, administrative arrangements or within the relevant contingency plan, to control response activities to a maritime environmental emergency".

For the purposes of the Gem 3D MSS, a Level 3 response which requires international resources is deemed not credible, therefore Table 2-1 defines the response resources and Control Agency arrangements for Level 1 and 2 spills in the activity area (Commonwealth waters).

Table 2-1 Spill level, response resource requirements and control agency

Spill source	**Location**	**Resources required and control agency (ca)**	
		Level 1 spill	**Level 2 spill**
Survey vessel	Within Operations Area	Local resources on board vessel required CA = Vessel owner	Local to national resources required CA= AMSA*

*Australian Maritime Safety Authority

2.2 Types of and characteristics of hydrocarbon

The oil types that may be released during the activity as a result of an incident include:

- Marine diesel
- Hydraulic oils
- Lubricating oils.

The two worst case scenarios identified involve diesel and are:

- Minor spill on deck (Level 1 spill)
- Vessel collision during survey activities resulting in damage to one or more marine diesel tanks (Level 2 spill)
    - Based on the vessel tank configuration and holding volumes, the maximum credible spill volume would be <300 m^3 (maximum size of a single fuel tank) over a period of six hours.

2.3 Environment that may be affected (Planning Area)

The Planning Area for the Gem 3D MSS is based on a 150 km buffer around the Operations Area, which would be the spatial extent of a worst case spill based on NERA Offshore Petroleum Reference Case 2018:1003 (NERA 2018). This area has been used to identify the environmental sensitivities to inform a response process.

2.4 Net Environmental Benefit Analysis (NEBA) / Spill Impact Mitigation Assessment (SIMA)

NEBA and SIMA are both commonly-used processes for evaluating the potential benefits vs impacts of spill response options. In this way, the most appropriate response action(s) can be determined to maximise potential for environmental protection. AMSA will conduct an on-going NEBA/SIMA process for a Level 2 spill as part of their response. The following is a summary of steps normally used to conduct a NEBA or SIMA (based on IPIECA-API-IOGP 2017; IPIECA-IOGP 2015):

1. Compile and evaluate data (oil properties, oil trajectory/modelling, environmental sensitivities, identification of potential response options)).
2. Predict outcomes (characterising effects of different response options against a 'no action' scenario).
3. Balance trade-offs (assess the potential impact on each environmental sensitivity by the oil and potential impacts of response options).
4. Determine the most appropriate method(s) of response to maximise potential for environmental protection.

SapuraOMV will support AMSA in the NEBA/SIMA process as required by utilising internal and/or third-party environmental and oil response expertise.

3 Response strategies

The fuel oil to be used during the Gem 3D MSS will be marine diesel oil (MDO) or marine gas oil (MGO). Any MDO/ MGO spill to the marine environment is expected to undergo rapid spreading together with physical dispersion and evaporative loss, resulting in surface slicks thinning and breaking up quickly while the light-end hydrocarbon components will weather off. Taking into account the potential spill volumes, location of the survey and metocean conditions, Table 3-1 demonstrates the various response strategies for a Level 2 spill and their viability for this activity. A Level 1 spill (minor spill to deck) will be dealt with under the vessels SOPEP.

Table 3-1 Response strategies

Response strategy	Applicability	Advantages	Disadvantages	Net Environmental Benefit Assessment	Viable
Stop the spill	Source control application including transferring diesel into another secured containment where practicable.	Prevent or reduce volume of diesel entering the environment	Nil	Reduces potential for and scale of impacts to marine environment.	Yes
Monitor and evaluate / natural remediation	Marine diesel is visible on the water surface and the movement of slicks can be visually monitored. Components of marine diesel may remain entrained in the water column, which can be determined through monitoring methods Visual monitoring of slicks (e.g. using the Bonn Agreement Oil Appearance Code (BAOAC), (Bonn Agreement 2016)) can be undertaken from the survey vessel or from aircraft.	Allows assessment of areas and resources potentially impacted by oil. No additional disturbance of shorelines and wildlife from response activities. Minimal health and safety risks to responders.	Potential for longer periods of exposure of sensitive resources to hydrocarbons.	Provides valuable information and low level of environmental impact associated with response option.	Yes, based on small release volumes in open ocean with high air and water temperatures

Response strategy	Applicability	Advantages	Disadvantages	Net Environmental Benefit Assessment	Viable
On-water recovery – booms and skimmers	Generally, the properties of light fuel oils will preclude use of this option. In very calm conditions, sorbent materials may be deployed to remove some marine diesel from the water surface.	May remove some of the marine diesel volume from the water surface prior to it reaching shorelines or sensitive resources.	Waste generation, risk of recovery equipment being lost or damaged and not effective/safe in high energy conditions. Hydrocarbon type and likely thickness of surface slick are not amenable to effective containment and recovery.	Marine diesel is unlikely to impact shorelines or nearshore areas. Weathered residues are likely to be of limited toxicity and will naturally degrade. Containment and recovery will generate considerable additional waste for specialist disposal - diesel may be best left to degrade naturally. Scenario has a limited volume as per the fuel capacity of the vessel.	Not viable due to small release volumes, high energy offshore seas, logistical constraints, negligible environmental benefit.
Dispersant application	Group II hydrocarbons (such as marine diesel) are considered to be readily dispersible at most sea temperatures without the use of dispersants. Chemical treatment (dispersant) use on surface thicknesses below those of Group II hydrocarbons are typically ineffective (e.g. due to 'punching through', where the dispersant	Given the location, fuel type and quantities there are no apparent advantages.	Risks associated with the operation of aircraft offshore for aerial application. Risks associated with the use of application equipment operated from vessels. Dispersed marine diesel may have higher toxicity to sensitive marine resources. Dispersion increases risk of exposure to subsurface environments.	Immediate environmental impact through localized increase in toxicity levels within the marine environment from chemical dispersants. Weathered marine diesel has a low toxicity and best option likely to be to let volatile elements evaporate naturally. Planning Area indicates that marine diesel is unlikely to	Not viable – small release volumes, low encounter rate and negligible environmental benefit.

Response strategy	Applicability	Advantages	Disadvantages	Net Environmental Benefit Assessment	Viable
	passes through the surface oil and into the surface waters beneath). The timeframes for mobilisation of aircraft and AMSA personnel may therefore restrict timeframes for practical use.		Potential human health and environmental risks from use of chemical dispersants.	impact shorelines or nearshore areas and if it does it will be in low and isolated quantities, resulting in only minor impacts. Scenario has a limited volume based on the fuel capacity of the vessel.	
Shoreline protection, deflection and clean-up	Cartier Island is an unvegetated sand cay located 146 km from the Operations Area.	Potentially reduce the volume of marine diesel stranding ashore at sensitive locations.	Significant safety risk to responders due to unexploded ordnances in and around Cartier Island. Due to this risk landing on Cartier Island or anchoring anywhere within the Cartier Island Marine Park is strictly prohibited without express prior approval. If anchoring is necessary due to emergency, great care should be taken to ensure anchoring is on sand, and anchors do not drag. Shoreline activities will also result in disturbance of shorelines and nearby reef areas, as well as to wildlife. Such activities will have limited effectiveness for light fuel oils that will be well dispersed at this distance from the spill zone.	In the unlikely event that hydrocarbons from a Level 2 spill accumulate on the Cartier Island shoreline, the level of accumulation is likely to be well below a threshold of effective response (where benefit outweighs potential environmental impacts and the safety considerations associated with unexploded ordnance).	Not viable - response strategy will be ineffective for highly weathered hydrocarbons and too risky to implement due to unexploded ordnance in the area.

Response strategy	Applicability	Advantages	Disadvantages	Net Environmental Benefit Assessment	Viable
Oiled Wildlife response	This response would only be activated where it is positively identified that wildlife has been oiled. As there are no shorelines within the Planning Area, the potential for shoreline oiling at levels to cause impact in an area of high wildlife concentrations is considered negligible to unlikely.	Pre-emptive capture or hazing may reduce risk of exposure of birds to oil. Rehabilitation of oiled wildlife may reduce impacts to populations.	Safety risks to responders collecting wildlife from the offshore environments including unexploded ordnances in and around Cartier Island.	Hazing or pre-emptive capture of birds on shorelines is considered of no net benefit due to the distance of the Operations Area from the nearest shoreline (146 km). Large numbers of oiled wildlife are unlikely to be captured and taken into care due to the offshore location, time to respond, potential of finding oiled wildlife, and mobility of wildlife.	Potentially for level 2 spills when oiled wildlife are discovered and safely accessible– response will be coordinated by AMSA.

4 Spill Response Resources

This section provides an overview of response resources that can be sourced in the event of a Level 1 or 2 spill (Figure 4 1).

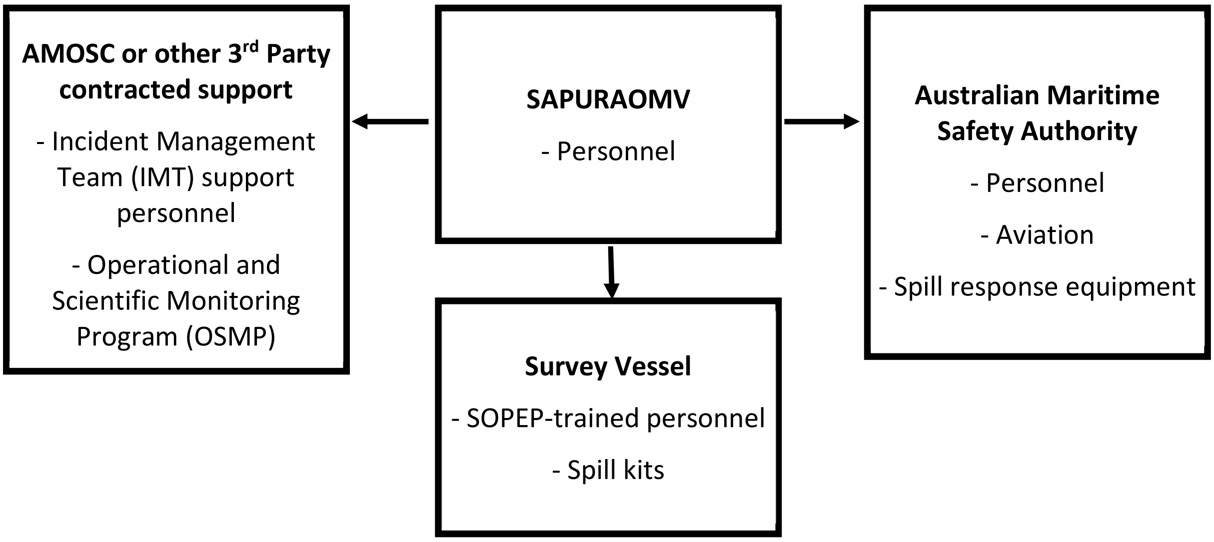

Figure 4-1 Response organisation

4.1 Vessels

Level 1 spill response equipment such as personal protective equipment, sorbent materials, containment material and waste bags will be located on the seismic vessel as per the requirements within the vessel Shipboard Oil Pollution Emergency Plan (SOPEP) and associated emergency response documentation.

4.2 Personnel

4.2.1 Vessel

Vessel crew will be trained as per the requirements of the vessel SOPEP in the use of all spill response equipment on board.

4.2.2 SapuraOMV

Select SapuraOMV personnel (i.e. IMT) will be trained and available to provide support as per the response process defined within this OPEP.

4.3 Australian Maritime Safety Authority (AMSA)

AMSA will be the Control Agency for a Level 2 spill. They will provide trained personnel, aviation resources to conduct aerial surveillance activities (including aerial observers) and level 2 spill response equipment where deemed necessary.

4.4 Operational and Scientific Monitoring Program support

Marine science specialists and/or consultants will provide support for the management and implementation of an Operational and Scientific Monitoring Program and would be mobilised to respond at short notice (existing service contracting arrangements) should they be required.

5 Operational and Scientific Monitoring Program

In the event of a significant oil spill incident (Level 2 or Level 3 spills) during SapuraOMV's offshore petroleum activities, the Operational and Scientific Monitoring Program (OSMP) has a number of monitoring studies that will be implemented to inform spill responses (Monitor and Evaluate Plan - Operational Monitoring) and to evaluate the impacts to and recovery of the marine environment (Scientific Monitoring). The overall OSMP is structured as follows:

- A general Operational and Scientific Monitoring Framework (OSMF) that outlines the overall linkages common across most of the operational and scientific monitoring studies that does not need to be tailored for a specific project, region or country.

- A catalogue of Sampling and Analysis Plans (SAPs) that provide detailed implementation specifications for each operational and scientific study. These SAPs have been developed to be sufficiently general to be utilised across projects, regions and country with minimal modification.

- Activity Specific Implementation Plans that provide details of personnel, plant, study design elements (frequency, locations, water depths, etc.) to carry out monitoring that is tailored to a spill from a specific activity or region.

The relationship between these three elements that comprise the OSMP are illustrated in Figure 5-1.

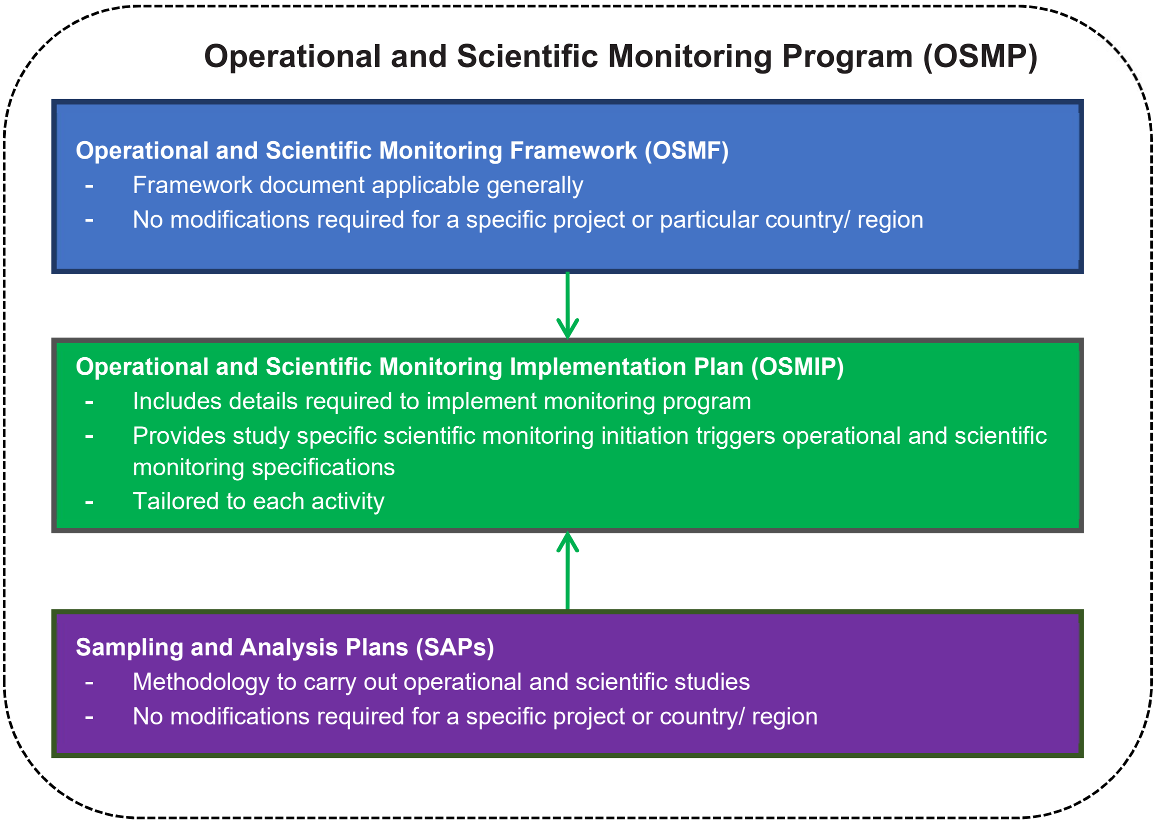

Figure 5-1 Overview of structure of OSMP elements

5.1 Monitor and Evaluate Plan (operational monitoring)

Operational (or Type I) monitoring is used to collect information about the behaviour and potential impacts of the oil spill and the efficacy of associated response operations, and to aid decision making during the response. It provides verifiable information on the extent and quantity of exposure, and the effectiveness and impacts of response operations. Operational monitoring typically ceases once the spill response has been terminated (NOPSEMA 2016).

Operational monitoring resources are deployed in accordance with the NATPLAN. Real-time monitoring information, along with up to date information on weather conditions, satellite imagery and existing charts is used, as well as details of the spill (provided by the Vessel Master and/or reports from other marine users). Vessels and aircraft may be mobilised along with first strike response resources, which may include rapid response teams to gauge impacts on the environment. This allows information to be gathered and predictions to be made of the distribution and characteristics of the spill (e.g. extent, weathering, persistence, movement, sensitive resources at risk). This will inform what further responses may be required, including which scientific (or Type II) monitoring scopes may be activated.

The Vessel Master will fully cooperate with AMSA following a Level 1 or Level 2 spill in accordance with the vessel SOPEP. SapuraOMV will implement, assist with, or contribute to (including funding) operational monitoring as directed by AMSA (for a Level 2 spill where AMSA are the Control Agency).

The immediate response for all Level 2 (and 3) spill incidents includes the Monitor and Evaluate Plan (operational monitoring). The Monitor and Evaluate Plan is comprised of the following three sub-plans for the operational monitoring studies:

- Operational Monitoring Study OS1: Hydrocarbon Surveillance and Tracking (refer to Sections 7.3.1 and 7.3.2).
- Operational Monitoring Study OS2: Forecast Modelling (refer to Section 7.3.3).
- Operational Monitoring Study OS3: Shoreline Assessment. Since there are access issues for the only shoreline within the Planning Area (including potential unexploded ordnances), there is unlikely to be a requirement to initiate OS3.

5.2 Scientific Monitoring Plan (scientific monitoring)

Scientific (type II) monitoring addresses defined objectives and collects scientifically-robust information for the purposes of determining short and long-term environmental impacts (both from the spill and associated response) and subsequent recovery from the spilled oil and oil spill response activities. SapuraOMV will implement, assist with, and contribute to (including funding) scientific monitoring where triggered in the event of a Level 2 spill.

Scientifically-rigorous monitoring plans would be developed and implemented in conjunction with support agencies, subject matter experts and other stakeholders (e.g. research organisations, Department of the Environment and Energy (DoEE), oil and gas titleholders, fisheries stakeholders). Scientific monitoring may continue for some time following the termination of the operational monitoring response (NOPSEMA 2016).

In the event of the requirement to undertake scientific monitoring, SapuraOMV would utilise its existing Call-off Contract(s) with specialist marine science service providers to rapidly establish and deploy the required resources to undertake the monitoring activities. Scientific monitoring could include some, or all, of the elements described in Table 5.1.

Table 5-1 Scientific monitoring tasks, key receptors and initiation and termination triggers

Scientific Study	Objective	Key receptors	Initiation	Termination
SM04: Monitoring for Hydrocarbons in Marine Waters	To monitor presence of hydrocarbons in marine waters to provide data to quantify impacts and recovery to key habitats and sensitive receptors	Marine water quality	If modelling predicts that an impact on a sensitive resource that is closely linked to marine water quality is likely	When the results of the monitoring task to date have achieved the majority of the objectives When correlations and cause / effect relationships of the oil spill have been established for marine water quality Where water quality is considered to have returned to a condition comparable with unimpacted areas
SM05: Monitoring for Hydrocarbons in Subtidal and Intertidal Sediments	To understand the behaviour, persistence and fate of hydrocarbons in marine sediments (subtidal, intertidal and shoreline sites as applicable) to provide data to quantify impacts and recovery to key habitats and sensitive receptors	Marine sediment quality	If modelling predicts that an impact on a sensitive resource that is closely linked to marine sediment quality is likely	When the results of the monitoring task to date have achieved the majority of the objectives When correlations and cause / effect relationships of the oil spill have been established for marine sediment quality Where marine sediment quality is considered to have returned to a condition comparable with unimpacted areas
SM06: Monitoring for Hydrocarbons in Intertidal and Subtidal Benthic Communities	To enable assessment of impacts and subsequent recovery of benthic marine habitats (soft and hard substrate habitats) and associated demersal and macro epibenthic organisms (e.g. corals, macroalgae, seagrass, sponges and other filter feeders, motile invertebrates and associated fishes) in response to a spill event and associated response activities. Monitoring to document recovery of affected biota and habitats.	Corals, seagrass, filter feeders, invertebrates, macroalgae, demersal fishes	If modelling predicts contact Any reports of contact Dispersants used by CA over sensitive habitats/ assemblages	When all reasonable and practical measures have been taken to assess the effects or impact of the spill on benthic habitats / communities When oil pollution effects / impacts on benthos are no longer detectable (i.e. determined as 'not statistically significant' between the impact and reference sites) When restoration or recovery of impact sites including resumption of key biological processes (e.g. reproduction and recruitment) necessary for post-impact recovery is demonstrated

SM09: Determination of Impact of Oil Spill on Marine Megafauna and Recovery	To assess any short-term or longer-term environmental effects on non-avian marine wildlife that may have resulted from the oil spill (i.e. damage extent and recovery). Monitoring to document recovery of affected biota and habitats.	Sea snakes, marine turtles, marine mammals, sharks/rays, crocodiles, bony fishes.	Modelling indicates possible contact with populations Reports of oiled non-avian marine wildlife indicating contact in important areas.	When all reasonable and practical measures have been taken to assess the effects or impact of the spill on non-avian marine wildlife When restoration or resumption of key biological processes (e.g. abundance, distribution, breeding) necessary to ensure post-impact recovery is demonstrated When oil pollution impacts on non-avian marine wildlife are no longer detectable (i.e. determined as ‘not statistically significant’ between the impact and reference sites).
SM10: Determination Impact of Oil Spill on Seabirds and Shorebird Populations and Recovery	To assess any short-term or longer-term environmental effects on seabirds and (where relevant) shorebird populations within the study area that may have resulted from the oil spill, and subsequent recovery.	Seabird and shorebird populations	Modelling indicates possible contact with seabird and/or foraging shorebird populations Any reports of oiled birds indicating contact in important areas.	When the extent of damage and rate of recovery of key seabird and (where relevant) shorebird behaviour and breeding activities has been determined When oil pollution impacts on seabirds and (where relevant) shorebirds are no longer detectable (i.e. determined as ‘not statistically significant’ between the impact and reference sites) When the affected environment or natural resource has returned to baseline conditions in terms of breeding population (for seabirds) or counts (for shorebirds), with regard to reference sites.

Each Scientific Monitoring Study will have a detailed sampling and analysis plan (SAP) guided by NOPSEMA's *Information Paper on Operational and Scientific Monitoring Programs* (NOPSEMA 2016).

5.3 OSMP implementation

SapuraOMV will develop a detailed implementation plan for undertaking the scientific monitoring activities as described in Table 5-1. SapuraOMV will access vessel and aircraft contractors along the Western Australian coast, analytical laboratories, equipment suppliers and specialist sub-consultants on an as required basis.

6 Waste management

The following types of oily materials and waste may be generated during an oil spill event:

- Oil (pure or near pure diesel)
- Oily material (oily sorbents, Personal Protection Equipment (PPE), as well as liquid mixed with debris, soil, water, or other material)
- Oily water (large amount water with some oil, with possible small amounts of debris)
- Deceased fauna.

Waste management for a Level 1 spill would be conducted by the vessel master as per the vessel SOPEP, whilst AMSA will direct all requirements for a Level 2 spill.

7 Response – marine diesel spill

This section describes the response actions for a diesel spill from the survey vessel within the Planning Area.

7.1 Response process

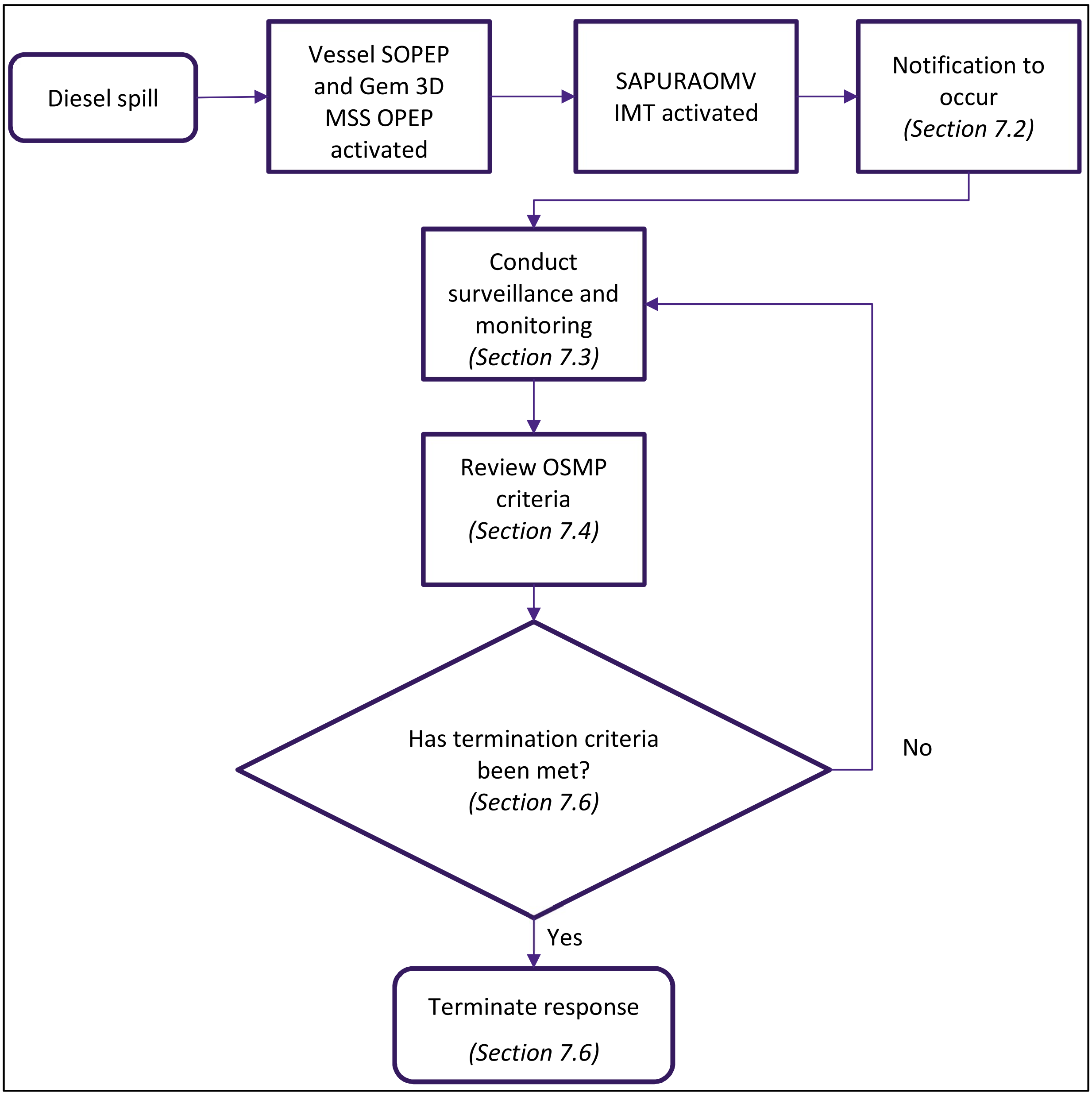

Figure 7-1 Response process

7.2 Notification requirements

Notification requirements for spills from the survey vessel occurring during the Gem 3D MSS are defined in Table 7-1 with the response process outlined in Figure 7-1. See also Appendix A (POLREP) and Appendix B (Contacts) for additional information.

Table 7-1 Notification requirements for spills during the Gem 3D MSS

Organisation to notify		Who makes contact?	Contact details	Communication form	Time frame to contact
SapuraOMV		Vessel Master	SapuraOMV Incident Commander	Verbal	ASAP
Australian Maritime Safety Authority (AMSA)		Vessel Master and SapuraOMV Incident Commander	1800 641 792	Verbal	ASAP
			Appendix A https://amsa-forms. nogginoca.com/ public/ polrep.html	Written – POLREP	Post-verbal notification
National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA)	If >80 L	SapuraOMV Incident Commander	+61 8 6461 7090	Verbal	Two hours
			submissions@nopsema. gov.au	Written – POLREP	Three days
	If <80 L	SapuraOMV Operations Manager	submissions@nopsema. gov.au	Written – monthly report	No later than 15 days from end of month
Commonwealth Director of National Parks (DNP)		SapuraOMV Incident Commander	+61 419 293 465	Verbal	Within two hours if potential impact to national marine park identified

7.3 Surveillance and monitoring

7.3.1 Vessel surveillance

Vessel surveillance actions required following a spill are defined in Table 7.2.

Table 7-2 Vessel-based surveillance response requirements

Task	Who?
Request any available vessel in close proximity to monitor spill.	Vessel Master/AMSA
Provide SapuraOMV Incident Commander information on spill such as trajectory, appearance and area of coverage.	Vessel Master/AMSA
Request additional vessel surveillance support through AMSA	SapuraOMV Incident Commander

Termination criteria: continue to monitor spill through vessel surveillance until: • Slick is no longer visible • Aerial surveillance has commenced.	

7.3.2 Aerial surveillance

Aerial surveillance actions required following a spill are defined in Table 7.3.

Table 7-3 Aerial surveillance response requirements

Task	Who?
Request aerial surveillance support (aircraft and trained aerial observers)	AMSA (Level 2)
Supply a copy of the Aerial Observer Log (Appendix D) if required.	SapuraOMV IMT
Prepare and provide to the aviation contractor a pre-flight information pack containing: Safety considerations: • Identify and obtain the appropriate personal protective equipment (PPE), aviation lifejackets should be worn in aircraft • Identify risks and necessary controls • Communicate the risks and controls in place through a pre-operation safety brief. Operational Communications Plan that documents: • Specific contacts and names of assets deployed • Methods of communication with personnel (including the crew of aircraft/vessels) • Call signs and radio communication frequencies.	AMSA
Conduct pre-flight briefing, which shall include: Location of the area of operation Radio frequencies used in the area and on the response Call signs of other aircraft operating in the vicinity Locations of any temporary or permanent exclusion zones.	AMSA
Use a global positioning system (GPS) to track aerial surveillance operations.	AMSA

Conduct localised search: • Use the predicted spill location as a starting point and conduct a localised search to determine the exact position of the spill • The aerial observer should sit directly behind the pilot, so the same perspective is shared, making it easier to direct the aircraft to the spill • Observers will have different perspectives. Ensure a comprehensive hand over brief is given to maintain consistency of approach • Fly the length and width of the spill (noting time taken and speed) • Record and report observations of wildlife that are present in the area.	AMSA
Record aerial surveillance using: • Annotated maps or charts • Photographs (preferably geo-referenced) • Aerial surveillance logs.	AMSA
Undertake calculations (on the return journey or when the aircraft has landed): calculate distance of spill length or width Distance of slick length or width (nm) = (time taken to fly (seconds) × speed (knots))/(3600 (or 60 if time taken to fly is in minutes)) divide answer by 1.85 to convert to km calculate spill area. Spill area (〖km〗 ^2) = length (km) × width (km).	AMSA
Calculate spill volume: 1. Use the Bonn Agreement Oil Appearance Code (BAOAC) (Appendix C) to estimate the percentage spill coverage 2. Divide the spill into percentage areas based on its appearance (e.g. 10% sheen, 40% rainbow and 50% metallic) 3. Use the following equation to calculate the minimum and maximum spill= volume for each oil type: Minimum spill volume (〖km〗 ^3)×area covered with specific appearance (%)×layer thickness (max or min)(microns) 4. Add together all the calculated volumes to calculate a total volume. The Air Operations Branch Director may decide that International Tanker Owners Pollution Federation (ITOPF) oil observation guidance could be used by aerial observers instead of the BAOAC. ITOPF methods are in the Aerial Observation of Marine Oil Spills Technical Information Paper (ITOPF 2011).	AMSA

Upon completion, provide the following: • Aerial surveillance logs • Location of oil identified (e.g. shown on a map or chart, waypoints on GPS or geo-referenced photo) • Quantity of oil observed and calculations • Other relevant information on the aerial surveillance operations (e.g. pilot operational hours, fuel logs, maintenance issues, logistical requirements, aerial simultaneous operations (SIMOPS) issues).	AMSA
Termination criteria: Continue routine aerial observations daily during daylight hours until: No slick can be observed.	

7.3.3 Oil spill trajectory modelling

7.3.3.1 Computer modelling (Level 2 spill only)

Computer-based Oil Spill Trajectory Modelling (OSTM) requirements are defined in Table 7.4.

Table 7-4 Requirements for oil spill trajectory modelling

Task	Who?
Request oil spill trajectory modelling (OSTM).	AMSA
Termination criteria: Repeat modelling as required until the response is terminated by the relevant control agency.	AMSA

7.3.3.2 Manual calculation

If computer modelling is not yet available for a specific trajectory calculation, then a manual calculation can be completed (Table 7.5).

Table 7-5 Requirements for the manual calculation of spill trajectories

Task	Who?
Using vectors, draw the resulting distance of 3% of wind speed and 100% of current from the initial spill location for a 1-hour duration.	SapuraOMV IMT
Repeat this process for each hour using the new location and predicted wind/current.	SapuraOMV IMT
Termination criteria: Level 1 Spill – prediction for +12 hours has been completed Level 2 Spill – Repeat manual calculations as required until computer modelling methods are available to provide the information required.	SapuraOMV IMT AMSA

7.4 Operational and Scientific Monitoring Program

Requirements for the implementation for the OSMP are defined in Table 7.6.

Table 7-6 OSMP requirements

Task	Who?
Review data from surveillance and monitoring methods and compare against OSMP activation criteria (Section 5). Activate the operational and scientific monitoring program (OSMP) if activation criteria have been met.	SapuraOMV IMT
Mobilise relevant OSMP resources and commence monitoring in accordance with the requirements of the OSMP.	SapuraOMV IMT
Continually review OSMP activation criteria and mobilise resources as necessary.	SapuraOMV IMT
Review operational monitoring plan (OMP) termination criteria until termination of spill response phase.	SapuraOMV IMT
Termination criteria: Continue scientific monitoring plan (SMP) activities until termination criteria have been met as per Section 5.	

7.5 Oiled wildlife response

Wildlife protection and response operations will be directed by AMSA as the relevant control agency, subject to the requirements of the response (as determined by the control agency) and the type and location of the pollution incident. SapuraOMV will provide support to AMSA for the duration of the response. Table 7.7 provides the process which would be undertaken in the event of wildlife response.

Table 7-7 Requirements for oiled wildlife response

Task	Who?
Notify the relevant agency when injured/oiled wildlife is confirmed or could potentially occur. Note that notifications of oiled wildlife will occur via the relevant control agency(s).	AMSA, supported by SapuraOMV IMT
Obtain any licences required from the relevant state wildlife licensing authority, at the time of any incident and prior to undertaking any exclusion, hazing or fauna handling activities such as pre-emptive capture.	AMSA
Provide additional support to control agency(s) as directed by AMSA	SapuraOMV IMT
Activate the relevant scientific monitoring program depending on species impacted, in consultation with AMSA.	SapuraOMV IMT
Termination criteria: Continue supporting the control agency in oiled wildlife response until: • all injured/oiled wildlife have been treated or euthanised • dead wildlife and waste have been disposed of • control agency(s) have ceased a response under their relevant plans.	SapuraOMV IMT

7.6 Response termination criteria

The overall response will be terminated once SapuraOMV/AMSA and relevant government agencies agree the following criteria have been met:

- The source of the spill has been controlled such that no further hydrocarbons will be released
- All termination criteria are met for
  - Section 7.3 Surveillance and monitoring
  - Section 7.4 Operational and Scientific Monitoring Program
  - Section 7.5 Oiled wildlife response
  - All individual responses have been terminated by achieving termination criteria and/or where it has been identified (e.g. via health and safety assessment or net environmental benefit analysis (NEBA)) that the response strategy is likely to result in an increased risk to human health, or environmental and socioeconomic receptors (hence the response can no longer be defined as being as low as reasonably practicable (ALARP) and acceptable).

SapuraOMV will appoint an investigation team following termination of a spill response. This team will be responsible for undertaking:

- An investigation into the cause of the spill. Feedback will be sought from stakeholders as part of the investigation and evaluation of response success
- An after-action review of both the emergency and spill response actions
- Close-out of all SapuraOMV IMT and emergency response personnel actions
- Implementation of a lessons learned assessment process, which will form the basis of a post-incident improvement action plan
- Liaison with all involved external agencies to support their post-incident investigations and close-out activities.

8 Ongoing response preparedness

8.1 Review

The OPEP shall be reviewed:

- Annually, at least once every 12 months (if applicable)
- Following any project changes that may affect the Oil Spill Response coordination or capabilities
- Following routine testing of the plan
- After any activation of the plan.

8.2 Training

Training relating to the Gem 3D MSS in terms of oil spill response is demonstrated in Table 8.1.

Table 8-1 Training requirements

Training	**Role**	
	Vessel crew	**SapuraOMV project personnel**
Vessel SOPEP	X	
Vessel response equipment	X	
Gem 3D MSS OPEP		X

8.3 Testing of the OPEP

The OPEP will be tested:

- Prior to the commencement of activity
- When response arrangements are significantly modified
- Following any response exercises, as required by any actions defined in the post-response report
- When changes occur to the project activity or location
- No later than 12 months after the most recent exercise (if applicable).

The objectives for spill response exercises undertaken prior to this project (as required by OPGGS(E) Regulation 15 (8B)(a)) are to ensure that the level of preparedness is appropriate to the nature and scale of the activity and that the response arrangements can be effectively implemented. Therefore, a desk top exercise to test the IMT mobilisation and incident notification for a worst case, vessel collision, scenario will be undertaken prior to mobilisation.

9 References

Bonn Agreement 2016, Bonn Agreement Oil Appearance Code.

IPIECA-API-IOGP 2017, Guidelines on implementing spill impact mitigation assessment (SIMA): A technical support document to accompany the IPIECA-IOGP guidance on net environmental benefit analysis (NEBA).

IPIECA-IOGP 2015, Response strategy development using net environmental benefit analysis (NEBA): Good practice guidelines for incident management and emergency response personnel.

ITOPF 2011, Technical Information Paper 1 – Aerial Observation of Marine Oil Spills, London, United Kingdom.

NERA 2018, Environment Plan Reference Case: Consequence analysis of an accidental release of diesel. Available from: https://referencecases.nera.org.au/Attachment?Action=Download&Attachment_id=227.

NOPSEMA 2016, Information Paper: Operational and scientific monitoring programs (N-04700-IP1349), Perth, Australia.

Appendix A: Marine pollution report (POLREP)

Electronic version: https://www.amsa.gov.au/file/1138/download?token=_HzjDb_t

Online completion: https://amsa-forms.nogginoca.com/public/

MO91/2

Australian Government
Australian Maritime Safety Authority

HARMFUL SUBSTANCES REPORT (POLREP)

Marine Order 91 *(Marine pollution prevention – Oil) 2013*

To: General Manager, Ship Safety Division,
General Manager, Marine Environment Division and
General Manager, Emergency Response Division
through Rescue Coordination Centre (RCC) Australia

Telex: 7162349
Telephone: +61 (0)2 6230 6811
Freecall: 1800 641 792 (within Australia)
Facsimile: +61 (0)2 6230 6868
AFTN: YSARYCYX
E-mail: rccaus@amsa.gov.au

(Note: If any of the following items of the vessel reporting format are inappropriate they should be omitted from the report. These items of the standard reporting format are referred to in IMO Resolution A.851(20)).

A. Name of vessel | Call sign | Flag

B. Date and time of event *(Note: Time must be expressed as Coordinated Universal Time (UTC))*

C. Position: latitude and longitude

or

D. Position: true bearing and distance

E. True course (as a three digit group)

F. Speed (in knots and tenths of a knot as a 3-digit group)

L. Route information – details of intended track

M. Full details of radio stations and frequencies being guarded

N. Time of next report *(Note: Time must be expressed as Coordinated Universal Time (UTC))*

P. Type and quantities of cargo and bunkers on board

Q. Brief details of defects, damage, deficiencies or other limitations.
These must include the condition of the vessel and the ability to transfer cargo, ballast or fuel

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R. Brief details of actual pollution. These should include the type of oil, an estimate of the quantity discharged, whether the discharge is continuing, the cause of the discharge and, if possible, an estimate of the movement of the slick

S. Weather and sea conditions, including wind force and direction and relevant tidal or current details

T. Name, address, telephone and facsimile numbers of the vessel's owner and representative *(manager or operator of the vessel, or their agents)*

Owner		Representative	
Telephone	Facsimile	Telephone	Facsimile

U. Type of vessel | Length | Breadth | Tonnage

X. 1. Action being taken with regard to the discharge and to the movement of the vessel

2. Assistance or salvage efforts which have been requested or which have been provided by others

3. The master of an assisting or salvaging vessel should report the particulars of the action undertaken or planned

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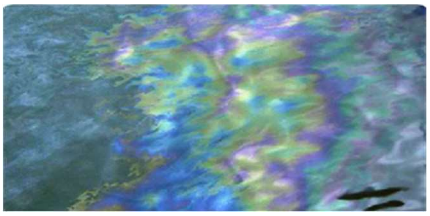
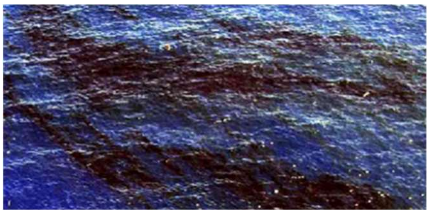
Appendix B: Contacts

Organisation	Name & position	Contact details
SapuraOMV Upstream (Western Australia) Pty Ltd	Gem 3D MSS Project Manager	+61 8 6118 4990 gem.australia@sapura-omv.com
Searcher Seismic Pty Ltd	Paul Miller Operations Manager (SapuraOMV rep)	+61 8 9327 0300
Australian Maritime Safety Authority (AMSA)	Joint Rescue Coordination Centre (JRCC) 24/7 Emergency Line	1800 641 792 +61 2 6230 6811 rccaus@amsa.gov.au
National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA)		+61 8 6461 7090 submissions@nopsema.gov.au
Commonwealth Director of National Parks (DNP)	Director of National Parks	+61 419 293 465
Australian Marine Soil Spill Centre (AMOSC)	24 /7 Emergency Line	+61 438 379 328 amosc@amosc.com.au

Appendix C: Bonn Agreement oil appearance code

Image	Description
	**CODE 1 - Oil Sheen Silvery (0.04 µm – 0.3 µm)** Very thin films of oil reflect the incoming light better than the surrounding water and can be seen as a silvery or grey sheen. Above a certain height or angle of view the sheen may no longer be observed.
	**CODE 2 - Oil Sheen Rainbow (0.3 µm – 5.0 µm)** Rainbow oil appearance is caused by an optical effect that is independent of oil type. Depending on angle of view and layer thickness, the distinctive colours will be diffuse to very bright. Bad light conditions may cause the colours to appear duller. A consistent layer of oil in the rainbow region will show different colours across the slick because of the change in angle of view. Therefore, if rainbow is present, a range of colours will be visible.
	**CODE 3 - Oil Sheen Metallic (5.0 µm – 50 µm)** Although a range of colours can be observed (e.g. blue, purple, red and greenish) the colours will be distinctly different to a ”rainbow”. Metallic sheens will appear as a relatively homogeneous colour (blue, brown, purple or another colour). The ”metallic” appearance – caused by a mirror effect - is the common factor, with the colour dependent on light and sky conditions. For example, blue can be observed in clear, blue-sky conditions.
	**CODE 4 - Discontinuous True Colour (50 µm – 200 µm)** For oil slicks thicker than 50 µm, the true colour will gradually dominate. Brown oils will appear brown, black oils will appear black. Patchiness in colour due to thinner areas within the slick, results in a discontinuous appearance (though dominated by the true oil colour). The term “discontinuous” therefore should not be mistaken as necessarily describing the surface coverage of the oil.
	**CODE 5 - Continuous True Colour (>200 µm)** The true colour of the specific oil is the dominant effect in this category. A more homogenous colour can be observed with no discontinuity as described in Code 4. This category is strongly oil type dependent and colours may be more diffuse in overcast conditions.

Appendix D: Aerial surveillance observer log

Survey Details									
Date:		Start time		End time		Observers:			
Incident:						Area of survey:			
Aircraft Type:		Call sign				Average altitude:		Remote sensing used	

Weather Conditions			
Wind speed (knots)		Wind direction	
Cloud base (feet)		Visibility (Nm)	
Time high water		Current direction	
Time low water		Current speed (Nm)	

Slick Details							
Slick grid parameters by lat/long				Slick grid parameters by air speed		Slick grid dimensions	
Length Axis		Width Axis		Length Axis	Width Axis	Length	Nm
Start Latitude		Start Latitude		Time (seconds)	Time (seconds)	Width	Nm
Start Longitude		Start Longitude				Length	km
End Latitude		End Latitude		Air Speed (Knots)	Air Speed (Knots)	Width	km
End Longitude		End Longitude				Total Grid Area	km^2

Code	Colour	%age cover observed		Total Grid Area	Area per oil code		Factor	Oil volume	
1	Silver		%			km^2	40 – 300 L/km^2		L
2	Rainbow		%			km^2	300 – 5,000 L/km^2		L
3	Metallic		%			km^2	5,000 – 50,000 L/km^2		L
4	Discontinuous true oil colour		%			km^2	50,000 – 200,000 L/km^2		L
5	Continuous true oil colour		%			km^2	>200,000 L/km^2		L
Non shaded areas to be completed on flight. Shaded areas completed on return.							TOTAL		l