Galactic Hybrid 2D MSS Environment Plan

Exploration

September 2021

Revision 0

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1. INTRODUCTION

1.1 Overview

Woodside Energy Ltd. (Woodside), as Titleholder under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Commonwealth) (referred to as the Environment Regulations), proposes to undertake a two-dimensional (2D) marine seismic survey (MSS) in the Bonaparte Basin within Petroleum Exploration Permit NT/P86. These activities will hereafter be referred to as the Petroleum Activities Program and form the scope of this EP. A detailed description of the activities is provided in **Section 3**.

This EP has been prepared to meet the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Commonwealth) (OPGGS Act) as administered by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

1.2 Purpose of the Environment Plan

In accordance with the objectives of the Environment Regulations, the purpose of this EP is to demonstrate that:

- The potential environmental impacts and risks (planned (routine and non-routine) and unplanned) that may result from the Petroleum Activities Program are identified.
- Appropriate management controls are implemented to reduce impacts and risks to a level that is 'as low as reasonably practicable' (ALARP) and acceptable.
- The Petroleum Activities Program is carried out in a manner consistent with the principles of ecologically sustainable development (ESD) (as defined in Section 3A of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)).

This EP describes the process and resulting outputs of the risk assessment, whereby impacts and risks are managed accordingly.

The EP defines activity-specific environmental performance outcomes (EPOs), environmental performance standards (EPSs) and measurement criteria (MC). These form the basis for monitoring, auditing and managing the Petroleum Activities Program to be performed by Woodside and its contractors. The implementation strategy (derived from the decision support framework tools) specified within this EP provides Woodside and NOPSEMA with the required level of assurance that impacts and risks associated with the activity are reduced to ALARP and are acceptable.

1.3 Scope of the Environment Plan

The scope of this EP covers the activities that define the Petroleum Activities Program, as described in **Section 3**. The spatial boundary of the Petroleum Activities Program has been described and assessed using the Operational Area. The Operational Area defines the spatial boundary of the Petroleum Activities Program and is further described in **Section 3.4**.

This EP addresses potential environmental impacts from planned activities and any potential unplanned risks that originate from within the Operational Area. Transit to and from the Operational Area by vessels associated with the Petroleum Activities Program and support vessels, as well as port activities associated with these vessels, are not within the scope of this EP. Vessels supporting the Petroleum Activities Program operating outside the Operational Area (e.g. transiting to and from port) are subject to applicable maritime regulations and other requirements and are not managed by this EP.

1.4 Environment Plan Summary

An EP summary is provided in **Table 1-1** as required by Regulation 11(4).

Table 1-1: EP summary

EP Summary material requirement	Section of EP
The location of the activity	**Section 3.4**
A description of the receiving environment	**Section 4**
A description of the activity	**Section 3**
Details of the environmental impacts and risks	**Section 6**
The control measures for the activity	**Section 6**
The arrangements for ongoing monitoring of the titleholder's environmental performance	**Section 7.5**
Response arrangements in the oil pollution emergency plan	**Section 7.10**
Consultation already undertaken and plans for ongoing consultation	**Section 5**
Details of the titleholder's nominated liaison person for the activity	**Section 1.7**

1.5 Structure of the Environment Plan

The EP has been structured to reflect the process and requirements of the Environment Regulations, as outlined in **Table 1-2**.

Table 1-2: EP process phases, applicable Environment Regulations and relevant section of EP

Criteria for acceptance	Content requirements/relevant regulations	Elements	Section of EP
Regulation 10A(a): *is appropriate for the nature and scale of the activity*	Regulation 13: *Environmental Assessment* Regulation 14: *Implementation strategy for the environment plan* Regulation 16: *Other information in the environment plan*	The principle of 'nature and scale' applies throughout the EP	**Section 2** **Section 3** **Section 4** **Section 5** **Section 6** **Section 7**
Regulation 10A(b): *demonstrates that the environmental impacts and risks of the activity will be reduced to as low as reasonably practicable* Regulation 10A(c): *demonstrates that the environmental impacts and risks of the activity will be of an acceptable level*	Regulation 13(1)–13(7): *13(1) Description of the activity* *13(2)(3) Description of the environment* *13(4) Requirements* *13(5)(6) Evaluation of environmental impacts and risks* *13(7) Environmental performance outcomes and standards* Regulation 16(a)–16(c): *A statement of the titleholder's corporate environmental policy* *A report on all consultations between the titleholder and any relevant person*	Set the context (activity and existing environment) Define 'acceptable' (the requirements, the corporate policy, relevant persons) Detail the impacts and risks Evaluate the nature and scale Detail the control measures – ALARP and acceptable	**Section 1** **Section 2** **Section 3** **Section 4** **Section 5** **Section 6** **Section 7**
Regulation 10A(d): *provides for appropriate environmental performance outcomes, environmental*	Regulation 13(7): *Environmental performance outcomes and standards*	Environmental Performance Outcomes (EPOs) Environmental Performance Standards (EPSs) Measurement Criteria (MC)	**Section 6**

Criteria for acceptance	Content requirements/relevant regulations	Elements	Section of EP
performance standards and measurement criteria			
Regulation 10A(e): *includes an appropriate implementation strategy and monitoring, recording and reporting arrangements*	Regulation 14: *Implementation strategy for the environment plan*	Implementation strategy, including: • systems, practices and procedures • performance monitoring • Oil Pollution Emergency Plan (OPEP) and scientific monitoring • ongoing consultation.	**Section 7** **Appendix D**
Regulation 10A(f): *does not involve the activity or part of the activity, other than arrangements for environmental monitoring or for responding to an emergency, being undertaken in any part of a declared World Heritage property within the meaning of the EPBC Act*	Regulation 13 (1)–13(3): *13(1) Description of the activity* *13(2) Description of the environment* *13(3) Without limiting [Regulation 13(2)(b)], particular relevant values and sensitivities may include any of the following:* *(a) the world heritage values of a declared World Heritage property within the meaning of the EPBC Act;* *(b) the national heritage values of a National Heritage place within the meaning of that Act;* *(c) the ecological character of a declared Ramsar wetland within the meaning of that Act;* *(d) the presence of a listed threatened species or listed threatened ecological community within the meaning of that Act;* *(e) the presence of a listed migratory species within the meaning of that Act;* *(f) any values and sensitivities that exist in, or in relation to, part or all of:* *(i) a Commonwealth marine area within the meaning of that Act; or* *(ii) Commonwealth land within the meaning of that Act.*	No activity, or part of the activity, undertaken in any part of a declared World Heritage property	**Section 3** **Section 4** **Section 6**
Regulation 10A(g): *(i) the titleholder has carried out the consultations required by Division 2.2A* *(ii) the measures (if any) that the titleholder has adopted, or proposes to adopt,*	Regulation 11A: *Consultation with relevant authorities, persons and organisations, etc.* Regulation 16(b): *A report on all consultations between the titleholder and any relevant person*	Consultation in preparation of the EP	**Section 5**

Criteria for acceptance	Content requirements/relevant regulations	Elements	Section of EP
because of the consultations are appropriate			
Regulation 10A(h): *complies with the Act and the regulations*	Regulation 15: *Details of the Titleholder and liaison person* Regulation 16(c): *Details of all reportable incidents in relation to the proposed activity.*	All contents of the EP must comply with the Offshore Petroleum and Greenhouse Gas Storage Act 2006 and the Environment Regulations	**Section 1.7** **Section 7**

1.6 Description of the Titleholder

Woodside is Titleholder for this activity.

1.7 Details of Titleholder, Liaison Person and Public Affairs Contact

In accordance with Regulation 15 of the Environment Regulations, details of the titleholder, liaison person and arrangements for the notification of changes are described below.

1.7.1 Titleholder

Woodside Energy Limited

11 Mount Street

Perth, Western Australia

T: 08 9348 4000

ACN: 63 005 482 986

1.7.2 Nominated Liaison Person

Andrew Winter

Senior Corporate Affairs Adviser

11 Mount Street

Perth, Western Australia

Telephone: 08 9348 4000

Email: feedback@woodside.com.au

1.7.3 Arrangements for Notifying Change

Should the titleholder, titleholder's nominated liaison person, or the contact details for either change, NOPSEMA will be notified in writing within two weeks or as soon as practicable.

1.8 Woodside Management System

The Woodside Management System (WMS) provides a structured framework of documentation to set common expectations governing how all employees and contractors at Woodside will work. Many of the standards presented in **Section 6** are drawn from the WMS documentation, which comprises four elements: compass and policies, expectations, processes and procedures, and guidelines, as outlined below (and illustrated in **Figure 1-1**).

- **Compass and Policies**: Set the enterprise-wide direction for Woodside by governing our behaviours, actions, and business decisions and ensuring we meet our legal and other external obligations.
- **Expectations**: Set essential activities or deliverables required to achieve the objectives of the Key Business Activities and provide the basis for developing processes and procedures.
- **Processes and Procedures**: Processes identify the set of interrelated or interacting activities that transform inputs into outputs, to systematically achieve a purpose or specific objective. Procedures specify what steps, by whom, and when required to carry out an activity or a process.
- **Guidelines**: Provide recommended practice and advice on how to perform the steps defined in Procedures, together with supporting information and associated tools. Guidelines provide advice on how activities or tasks may be performed, information that may be taken into consideration, or, how to use tools and systems.

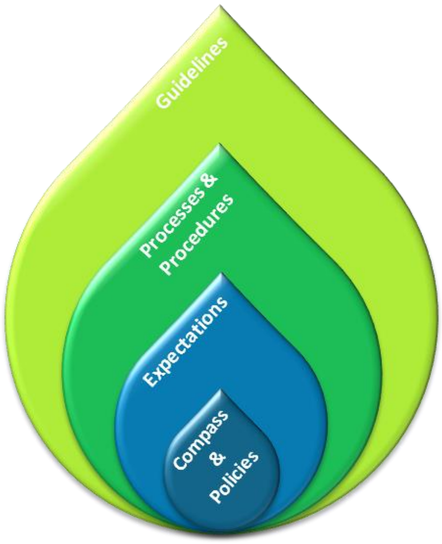


Figure 1-1: The four major elements of the WMS Seed

The WMS is organised within a business process hierarchy based upon key business activities to ensure the system remains independent of organisation structure, is globally applicable and scalable wherever required. These key business activities are grouped into management, support, and value stream activities as shown in **Figure 1-1**. The value stream activities capture, generate and deliver value through the exploration and production lifecycle. The management activities influence all areas of the business, while support activities may influence one or more value stream activities.

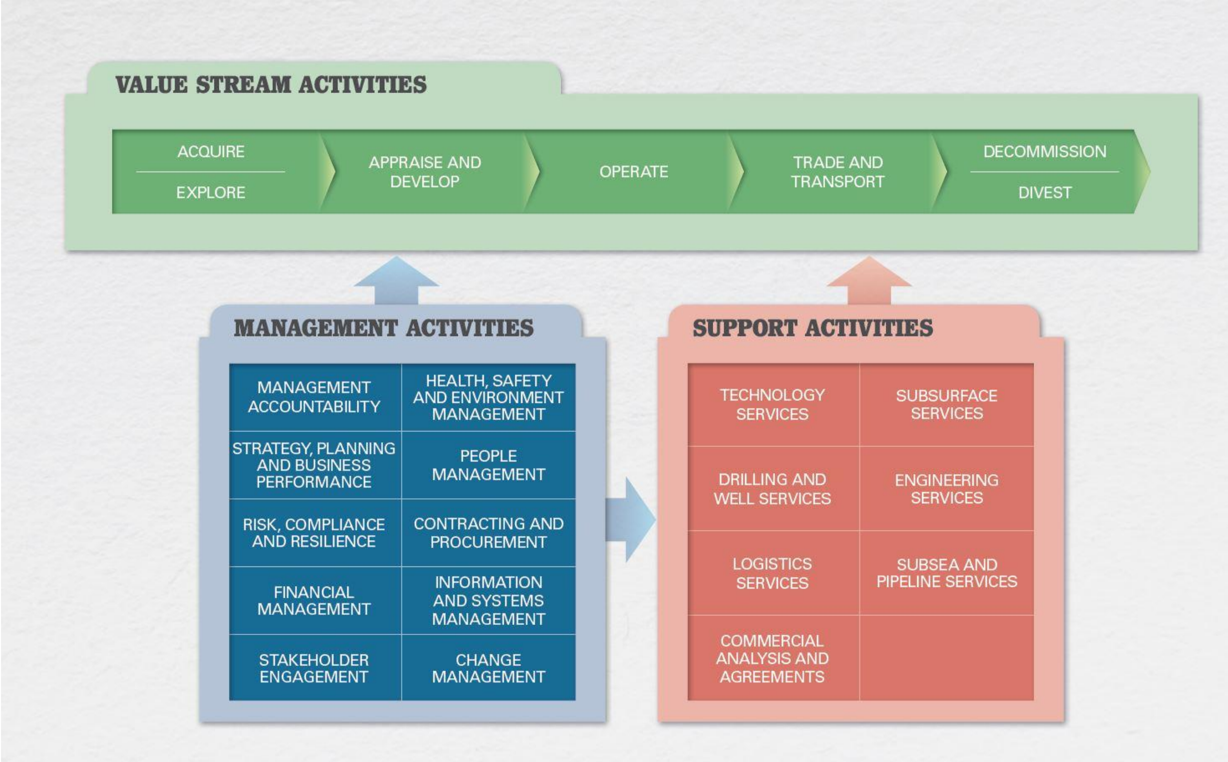


Figure 1-2: The WMS business process hierarchy

1.8.1 Health, Safety and Environment Policy

In accordance with Regulation 16(a) of the Environment Regulations, Woodside's Corporate Health, Safety and Environment Policy is provided in **Appendix A** of this EP.

1.9 Description of Relevant Requirements

In accordance with Regulation 13(4) of the Environment Regulations, a description of requirements, including legislative requirements, that apply to the activity and are relevant to managing risks and impacts of the Petroleum Activities Program are detailed in **Appendix B**. This EP will not be assessed under the WA *Environment Protection Act 1986* as the activity does not occur on State land or within State waters.

1.9.1 Applicable Environmental Legislation

1.9.1.1 Offshore Petroleum and Greenhouse Gas Storage Act 2006

The OPGGS Act controls exploration and production activities beyond three nautical miles (nm) of the mainland (and islands) to the outer extent of the Australian Exclusive Economic Zone (EEZ) at 200 nm.

1.9.1.2 Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009

The Environment Regulations apply to petroleum activities in Commonwealth waters and are administered by NOPSEMA. The objective of the Environment Regulations is to ensure petroleum activities are:

- carried out in a manner consistent with the principles of ecological sustainable development

- carried out in a manner by which the environmental impacts and risks of the activity will be reduced to ALARP
- carried out in a manner by which the environmental impacts and risks of the activity will be of an acceptable level.

1.9.1.3 Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The EPBC Act aims to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places in Australia. These are defined in the Act as Matters of National Environmental Significance (MNES). In respect to offshore petroleum activities in Commonwealth waters, these requirements are implemented by NOPSEMA through the Streamlining Offshore Petroleum Environmental Approvals Program (the Program). The Program provides for the protection of the environment by requiring all offshore petroleum activities authorised by the OPGGS Act to be conducted in accordance with an accepted EP, consistent with the principles of Ecological Sustainable Development (ESD).

Impacts on the environment include those matters protected under Part 3 of the EPBC Act. The definition of 'environment' in the Program is consistent with that used in the EPBC Act - this enables the Program to encompass all matters protected under Part 3 of the EPBC Act.

1.9.1.3.1 Recovery Plans and Threat Abatement Plans

Under s139(1)(b) of the EPBC Act, the Environment Minister must not act inconsistently with a recovery plan for a listed threatened species or ecological community or a threat abatement plan for a species or community protected under the Act. Similarly, under s268 of the EPBC Act:

"A Commonwealth agency must not take any action that contravenes a recovery plan or a threat abatement plan."

In respect to offshore petroleum activities in Commonwealth waters, these requirements are implemented by NOPSEMA via the commitments included in the Program. Commitments relating to listed threatened species and ecological communities under the Act are included in the Program Report (Commonwealth of Australia, 2014):

- NOPSEMA will not accept an Environment Plan that proposes activities that will result in unacceptable impacts to a listed threatened species or ecological community.
- NOPSEMA will not accept an Environment Plan that is inconsistent with a recovery plan or threat abatement plan for a listed threatened species or ecological community.
- NOPSEMA will have regard to any approved conservation advice in relation to a threatened species or ecological community before accepting an Environment Plan.

1.9.1.3.2 Australian Marine Parks

Under the EPBC Act, Australian Marine Parks (AMPs), formally known as Commonwealth Marine Reserves, are recognised for conserving marine habitats and the species that live and rely on these habitats. The Director of National Parks (DNP) is responsible for managing AMPs (supported by Parks Australia), and is required to publish management plans for them. Other parts of the Australian Government must not perform functions or exercise powers relating to these parks that are inconsistent with management plans (s362 of the EPBC Act). Relevant AMPs are described in **Section 4.6.1**.

Specific zones within the AMPs have been allocated conservation objectives as stated below (International Union for Conservation of Nature (IUCN) Protected Area Category) based on the Australian IUCN reserve management principles outlined in Schedule 8 of the EPBC Regulations 2000:

- Special Purpose Zone (IUCN category VI) – managed to allow specific activities through special purpose management arrangements while conserving ecosystems, habitats and native species. The zone allows or prohibits specific activities.
- Sanctuary Zone (IUCN category Ia) – managed to conserve ecosystems, habitats and native species in as natural and undisturbed a state as possible. The zone allows only authorised scientific research and monitoring.
- National Park Zone (IUCN category II) – managed to protect and conserve ecosystems, habitats and native species in as natural a state as possible. The zone only allows non extractive activities unless authorised for research and monitoring.
- Recreational Use Zone (IUCN category IV) – managed to allow recreational use, while conserving ecosystems, habitats and native species in as natural a state as possible. The zone allows for recreational fishing, but not commercial fishing.
- Habitat Protection Zone (IUCN category IV) – managed to allow activities that do not harm or cause destruction to seafloor habitats, while conserving ecosystems, habitats and native species in as natural a state as possible. Multiple Use Zone (IUCN category VI) – managed to allow ecologically sustainable use while conserving ecosystems, habitats and native species. The zone allows for a range of sustainable uses, including commercial fishing and mining, where they are consistent with park values.

The Active Source Area and Operational Area overlap a portion of the Oceanic Shoals Marine Park Multiple Use Zone (IUCN category VI). There is potential for:

- Seismic activities and run-ins, run-outs, source testing and soft starts to be undertaken in a small portion of the Oceanic Shoals Marine Park (refer to **Section 3**).

The principles for each zone determine what activities are acceptable within a protected area under the EPBC Act. The Australian IUCN Reserve Management Principles for Multiple Use Zone (IUCN category VI) are considered relevant to the scope of this EP and are provided in **Table 1-3**. Further assessment of the impacts of the activity on the values of the marine park values is provided in **Section 6.4.3**.

Table 1-3: The Australian IUCN Reserve Management Principles for Multiple Use Zones (IUCN category VI)

Condition Number	Principle
7.01	The reserve or zone should be managed mainly for the sustainable use of natural ecosystems based on the following principles.
7.02	The biological diversity and other natural values of the reserve or zone should be protected and maintained in the long-term.
7.03	Management practices should be applied to ensure ecologically sustainable use of the reserve or zone.
7.04	Management of the reserve or zone should contribute to the regional and national development to the extent that this is consistent with these principles.

In the North Marine Parks Network Management Plan (2018) Mining (petroleum activities including seismic) and oil spill response are permittable subject to approval in Multiple Use Zone (IUCN category VI), Special Purpose Zone (IUCN category VI) and Special Purpose Zone Trawl (IUCN category VI). Proposed mining operations conducted under usage rights that exist immediately before the declaration of a marine park do not require approval.

Petroleum Activities occurring within the above zones are approved by a class approval (Director of National Parks 2018a). Conditions of the Class Approval that are considered relevant to the scope of this EP are provided in **Table 1-4**.

Table 1-4: Conditions of Class Approval relevant to the Petroleum Activities Program

Condition Number	Condition	Relevant Section of EP
1	The Approved Actions must be conducted in accordance with: a) An Environmental Plan accepted under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009; b) The EPBC Act; c) The EPBC Regulations; d) The North Marine Park Network Management Plan (2018); e) Any prohibitions, restrictions or determinations made under the EPBC Regulations by the Director of National Parks; and f) All other applicable Commonwealth and State laws (to the extent those laws are capable of operating concurrently with the laws and instruments described in paragraph a) to e)).	Conditions 1a, b, c, f are met by the submitted EP (**Section 1.9.1.3.2**). 1d): The impacts on the marine park values have been considered in **Section 6.4.3**. 1e): Consultation has been undertaken with the Director of National Parks and no prohibitions, restrictions or determinations have been made (**Section 5**).
2	If requested by the Director of National Parks, an Approved Person must notify the Director prior to conducting Approved Actions within Approved Zones.	**Section 7** describes requirements to notify the DNP prior to activities within the Oceanic Shoals Marine Park Multiple Use Zone.
3	If requested by the Director of National Parks, an Approved Person must provide the Director with information relating to undertaking the Approved Actions (or gathered while undertaking the Approved Actions), that is relevant to the Director's management of the Approved Zones.	If requested by the Director of National Parks, information relating to undertaking the Approved Actions (or gathered while undertaking the Approved Actions), that is relevant to the Director's management of the Approved Zones will be provided.

1.9.1.3.3 World Heritage Properties

Australian World Heritage management principles are prescribed in Schedule 5 of the EPBC Regulations 2000. No management principles are considered relevant to the scope of this EP given there is no potential impacts to any of these areas.

2. ENVIRONMENT PLAN PROCESS

2.1 Overview

This section outlines the process that Woodside follows to prepare the EP once an activity has been defined as a petroleum activity (refer **Section 1.2**).This includes a description of the environmental risk management methodology that is used to identify, analyse and evaluate risks to meet ALARP and acceptability requirements and to develop EPOs and EPSs. This section also describes Woodside's risk management methodologies applicable to implementation strategies applied during the activity.

Regulation 13(5) of the Environment Regulations requires environmental impacts and risks of the Petroleum Activities program to be detailed and evaluated appropriate to the nature and scale of each impact and risk associated with the selected Petroleum Activities Program. The objective of the risk assessment process, described in this section, is to identify the risks and associated impacts of an activity so they can be assessed, appropriate control measures applied to eliminate, control or mitigate the impact or risk to ALARP, then determine if the impact or risk level is acceptable.

Environmental impacts and risks include those directly and indirectly associated with the Petroleum Activities Program and include potential emergency and accidental events:

- Planned activities have the potential for inherent environmental impacts.
- Environmental risks are unplanned events with the potential for impact (termed risk 'consequence').

Herein, potential impact from planned activities are termed 'impacts', and 'risks' are associated with unplanned events with the potential for impact (should the risk be realised), with such impacts termed potential 'consequence'.

2.2 Environmental Risk Management Methodology

Woodside recognises that risk is inherent to its business and effectively managing risk is vital to delivering on company objectives, success and continued growth. Woodside is committed to managing all risks proactively and effectively. The objective of Woodside's risk management system is to provide a consistent process for recognising and managing risks across its business. Achieving this objective includes ensuring risks consider impacts across the key areas of exposure: health and safety, environment, finance, reputation and brand, legal and compliance, and social and cultural. A copy of Woodside's Risk Management Policy is provided in **Appendix A**.

The environmental risk management methodology used in this EP is based on Woodside's Risk Management Procedure. This procedure aligns to industry standards such as international standard ISO 31000:2018. The WMS risk management procedure, guidelines and tools provide guidance on specific techniques for managing risk, tailored for particular areas of risk within certain business processes. Procedures applied for environmental risk management include:

- Health Safety and Environment Management Procedure
- Impact Assessment Procedure
- Process Safety Management Procedure.

The risk management methodology provides a framework to demonstrate that the risks and impacts are continually identified, reduced to ALARP and assessed to be at an acceptable level, as required by the Environment Regulations. The key steps of Woodside's Risk Management Process are shown in **Figure 2-1**. Each step and how it is applied to the scopes of this activity is described in **Sections 2.3 to 2.11.**

Figure 2-1: Woodside's risk management process

2.2.1 Healthy, Safety and Environment Management Procedure

Woodside's Health, Safety and Environment Management Procedure provides the structure for managing health, safety and environment (HSE) risks and impacts across Woodside. It defines the decision authorities for company wide HSE management activities and deliverables, and to support continuous improvement in HSE management.

2.2.2 Impact Assessment Procedure

To support effective environmental risk assessment, Woodside's Impact Assessment Procedure (**Figure 2-2**) provides the steps needed to meet required environment, health and social standards by ensuring impacts are assessed appropriate to the nature and scale of the activity, the regulatory context, the receiving environment, interests, concerns and rights of stakeholders, and the applicable framework of standards and practices.

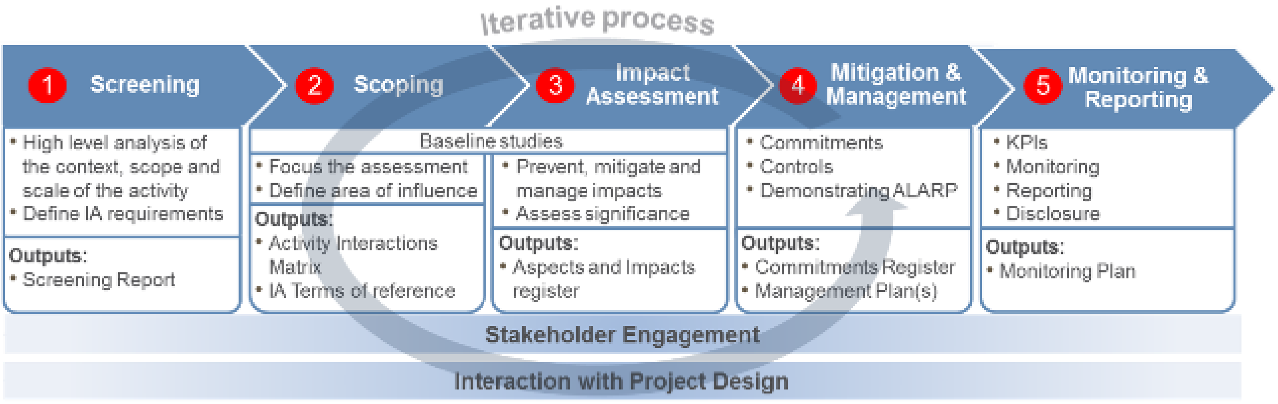


Figure 2-2: Woodside's impact assessment process

2.3 Environmental Plan Process

Figure 2-3 illustrates the EP development process. Each element of this process is discussed further in **Sections 2.3** to **2.11**.

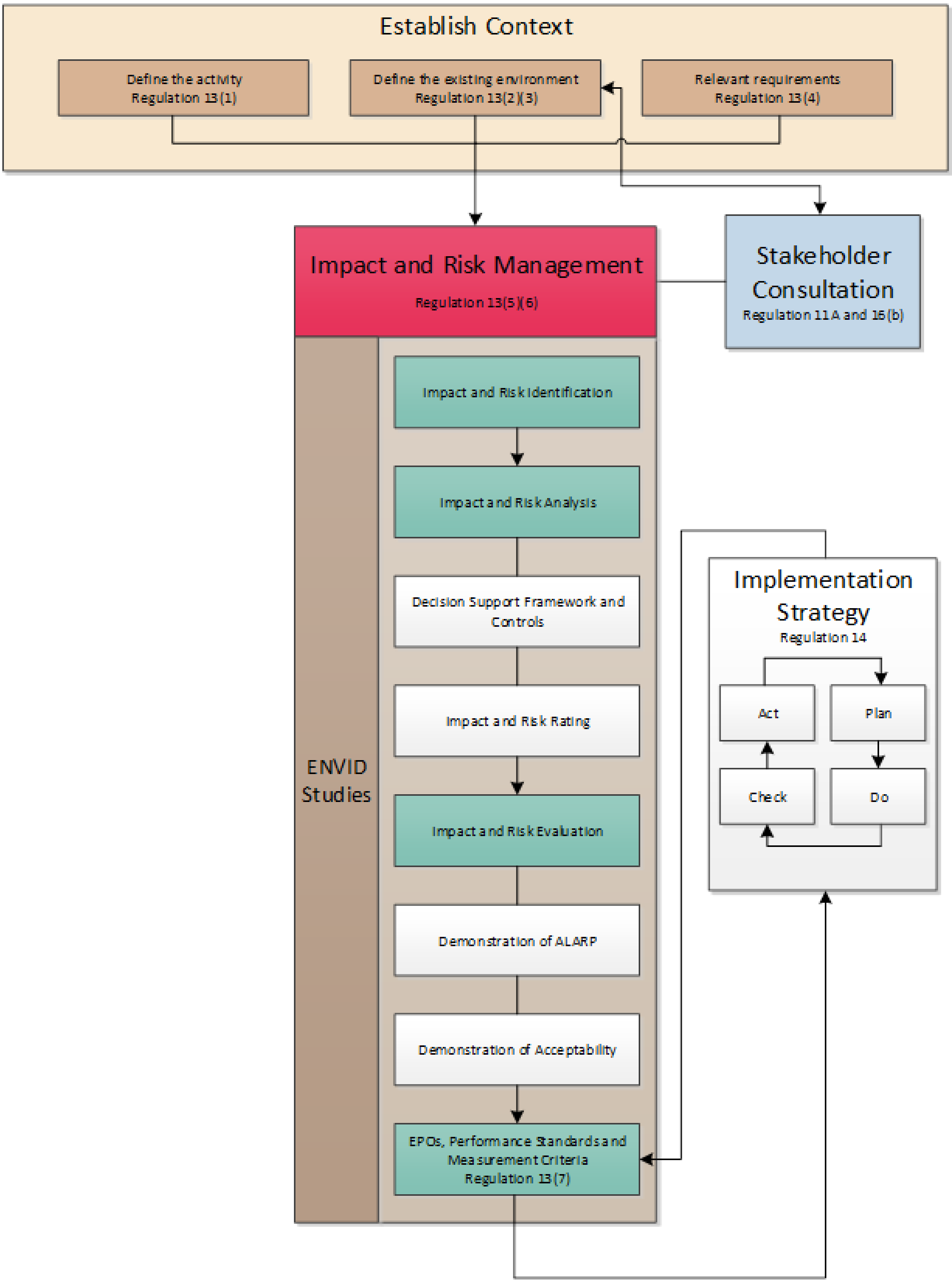


Figure 2-3: Environment Plan development process

2.4 Establish the Context

2.4.1 Define the Activity

This first stage involves evaluating whether the activity meets the definition of a 'petroleum activity' as defined in the Environment Regulations.

The activity is then described in relation to:

- the location
- what is to be performed
- how it is planned to be performed, including outlining operational details of the activity, and proposed timeframes.

The 'what' and 'how' are described in the context of 'environmental aspects' to inform the risk and impact assessment for planned (routine and non-routine) and unplanned (accidents, incidents and emergency conditions) activities.

The activity is described in **Section 3** and referred to as the Petroleum Activities Program.

2.4.2 Defining the Existing Environment

The context of the existing environment is described and determined by considering the nature and scale of the activity (size, type, timing, duration, complexity, and intensity of the activity), as described in **Section 3**. The purpose is to describe the existing environment that may be impacted by the activity, directly or indirectly, by planned or unplanned events.

The existing environment section (**Section 4**) is structured to define the physical, biological, socio economic and cultural attributes of the area of interest, in accordance with the definition of 'environment' in Regulation 4(a) of the Environment Regulations. These sub-sections make particular reference to:

- The environmental, and social and cultural consequences as defined by Woodside (refer to **Table 2-1**), which address key physical and biological attributes, as well as social and cultural values of the existing environment. These consequence definitions are applied to the impact and risk analysis (refer **Section 2.6.2**) and rated for all planned and unplanned activities. Additional detail is provided for evaluating unplanned hydrocarbon spill risk.
- EPBC Act Matters of National Environmental Significance (MNES), including listed threatened species and ecological communities and listed migratory species. Defining the spatial extent of the existing environment is guided by the nature and scale of the Petroleum Activities Program (and associated sources of environmental risk). This considers the Operational Area and wider environment that may be affected (EMBA), as determined by the hydrocarbon spill risk assessments presented in **Section 6.5.1**. MNES, as defined within the EPBC Act, are addressed through Woodside's impact and risk assessment (**Section 6**).
- Relevant values and sensitivities, which may include world or national Heritage Listed areas, Ramsar wetlands, listed threatened species or ecological communities, listed migratory species, and sensitive values that exist in or in relation to Commonwealth marine area or land.
- In categorising the environmental values potentially impacted by the Petroleum Activities Program (as presented in **Table 2-1**), there is standardisation of information relevant to understanding the receiving environment. Potential impacts to these environmental values are evaluated in the risk analysis (refer **Section 2.7**), and risk-rated for all planned and unplanned activities. This provides a robust approach to the overall environmental risk evaluation and its documentation in the EP.

By grouping potentially impacted environmental values by aspect (as presented in **Table 2-1**), the presentation of information about the receiving environment is standardised. This information is then consistently applied to the risk evaluation section to provide a robust approach to the overall environmental risk evaluation and its documentation in the EP.

Table 2-1: Environmental values potentially impacted by the Petroleum Activities Program which are assessed within the EP

Environmental Value Potentially Impacted Regulations 13(2)(3)					
Marine Sediment	*Water Quality*	*Air Quality*	*Ecosystems/ Habitats*	*Species*	*Socio-Economic*

2.4.3 Relevant Requirements

The relevant requirements in the context of legislation, other environmental approval requirements, conditions and standards that apply to the Petroleum Activities Program have been identified and reviewed. Relevant requirements are presented in **Appendix B** and **Section 1.9**.

Woodside's Corporate Health, Safety and Environment Policy is presented in **Appendix A**.

2.5 Impact and Risk Identification

Relevant environmental aspects and hazards have been identified to support the process to define environmental impacts and risks associated with an activity.

The environmental impact and risk assessment presented in this EP has been informed by recent and historic hazard identification studies and workshops (e.g. HAZID/Environmental Hazard Identification [ENVID]), Process Safety Risk Assessment processes, reviews and associated desktop studies associated with the Petroleum Activities Program. Risks are identified based on planned and potential interaction with the activity (based on the description in Section 3), the existing environment (Section 3) and the outcomes of Woodside's stakeholder engagement process (Section 5). The environmental outputs of applicable risk and impact workshops and associated studies are referred to as 'ENVID' hereafter in this EP.

An ENVID workshop was conducted for the marine seismic survey on 20 January 2021. Participants included project environmental advisers and geophysical operations project managers. The participants' breadth of knowledge, training and experience was sufficient to reasonably assure that the hazards that may arise in connection with the Petroleum Activities Program in this EP were identified.

Impacts and risks were identified during the ENVID for both planned (routine and non-routine) activities and unplanned (accidents, incidents and emergency conditions) events. During this process, risks that are identified as not applicable (not credible) are removed from the assessment. This is done by defining the activity and identifying that an aspect is not applicable.

The impact and risk information is then classified, evaluated and tabulated for each planned activity and unplanned event. Environmental impacts and risk are recorded in an environmental impacts and risk register. The output of the ENVID is used to present the risk assessment and forms the basis to develop performance outcomes, standards and MC. This information is presented in **Section 6**, using the format presented in **Table 2-2**.

Table 2-2: Example of layout of identification of risks and impacts in relation to risk sources

Source of Impact/Risk	*Evaluation*

	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/Habitat	Species	Socioeconomic	Decision Type	Consequence / Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Summary of source of impact/risk												

2.6 Impact and Risk Analysis

Risk analysis further develops the understanding of a risk by defining the impacts and assessing appropriate controls. Risk analysis considered previous risk assessments for similar activities, reviews of relevant studies, reviews of past performance, external stakeholder consultation feedback and a review of the existing environment.

The key steps performed for each risk identified during the risk assessment were:

1. Identify the decision type in accordance with the decision support framework.
2. Identify appropriate control measures (preventative and mitigative) aligned with the decision type.
3. Assess the risk rating or impact.

2.6.1 Decision Support Framework

To support the risk assessment process and Woodside's determination of acceptability (**Section 2.7.2**), Woodside's HSE risk management procedures include using a decision support framework based on principles set out in the Guidance on Risk Related Decision Making (Oil and Gas UK, 2014). This concept is applied during the ENVID, or equivalent preceding processes during historical design decisions, to determine the level of supporting evidence that may be required to draw sound conclusions about risk level and whether the risk is ALARP and acceptable (**Table 2-4**). This is to confirm:

- Activities do not pose an unacceptable environmental risk.
- Appropriate focus is placed on activities where the risk is anticipated to be acceptable and demonstrated to be ALARP.
- Appropriate effort is applied to manage risks based on the uncertainty of the risk, the complexity and risk rating (i.e. potential higher order environmental impacts are subject to further evaluation/assessment).

The framework provides appropriate tools, commensurate to the level of uncertainty or novelty associated with the risk (referred to as Decision Type A, B or C). The decision type is selected based on an informed discussion about the uncertainty of the risk and documented in ENVID output.

This framework enables Woodside to appropriately understand a risk and determine if the risk is acceptable and can be demonstrated to be ALARP.

2.6.1.1.1 Decision Type A

Risks classified as a Decision Type A are well understood and established practice. They generally consider recognised good industry practice, which is often embodied in legislation, codes and standards, and use professional judgement.

2.6.1.1.2 Decision Type B

Risks classified as Decision Type B typically involve greater uncertainty and complexity (and can include potential higher order impacts/risks). These risks may deviate from established practice or have some lifecycle implications, and therefore require further engineering risk assessment to support the decision and ensure the risk is ALARP. Engineering risk assessment tools may include:

- risk-based tools such as cost based analysis or modelling
- consequence modelling
- reliability analysis
- company values.

2.6.1.1.3 Decision Type C

Risks classified as a Decision Type C typically have significant risks related to environmental performance. Such risks typically involve greater complexity and uncertainty; therefore, requiring adoption of a precautionary approach. The risks may result in significant environmental impact, significant project risk/exposure, or may elicit stakeholder concerns. For these risks, in addition to Decision Type A and B tools, company and societal values need to be considered by performing broader internal and external stakeholder consultation as part of the risk assessment process.

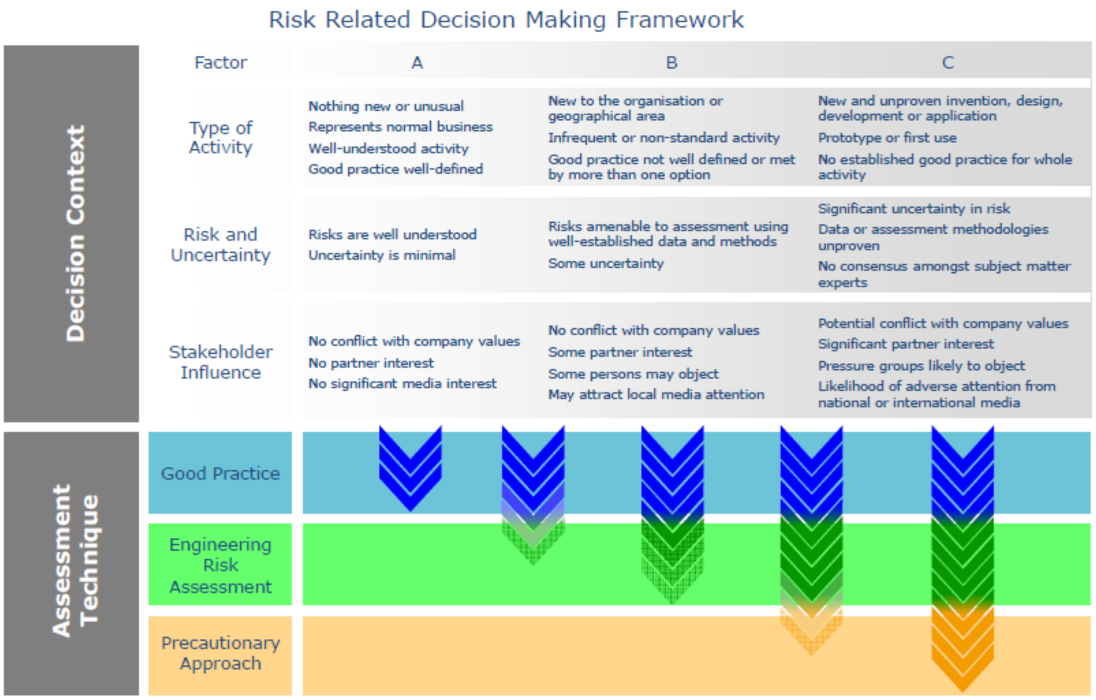


Figure 2-4: Risk-related decision-making framework (Oil and Gas UK 2014)

2.6.2 Decision Support Framework Tools

The following framework tools are applied, as appropriate, to help identify control measures based on the decision type described above:

- **Legislation, Codes and Standards (LCS)** – identifies the requirements of legislation, codes and standards which must be complied with for the activity.
- **Good Industry Practice (GP)** – identifies further engineering control standards and guidelines that may be applied by Woodside above those required to meet the LCS.

- **Professional Judgement (PJ)** – uses relevant personnel with the knowledge and experience to identify alternative controls. Woodside applies the hierarchy of control as part of the risk assessment to identify any alternative measures to control the risk.
- **Risk Based Analysis (RBA)** – 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 (CV)** – identifies values identified in Woodside's code of conduct, policies and the Woodside compass. Views, concerns and perceptions are to be considered from internal Woodside stakeholders directly affected by the planned impact or potential risk.
- **Societal Values (SV)** – identifies the views, concerns and perceptions of relevant stakeholders and addresses relevant stakeholder views, concerns and perceptions.

2.6.3 Decision Calibration

To determine that alternatives selected, and the control measures applied are suitable, the following tools may be used for calibration (i.e. checking) where required:

- **Legislation, Codes and Standards/Verification of Predictions** – verification of compliance with applicable LCS and/or good industry practice.
- **Peer Review** – independent peer review of PJs, supported by risk-based analysis, where appropriate.
- **Benchmarking** – where appropriate, benchmarking against a similar facility or activity type or situation that has been accepted to represent acceptable risk.
- **Internal Stakeholder Consultation** – consultation performed within Woodside to inform the decision and verify CVs are met.
- **External Stakeholder Consultation** – consultation performed to inform the decision and verify societal values are considered.

Where appropriate, additional calibration tools may be selected specific to the decision type and the activity.

2.6.3.1 Control Measures (Hierarchy of Controls)

Risk reduction measures are prioritised and categorised in accordance with the hierarchy of controls, where risk reduction measures at the top of the hierarchy take precedence over risk reduction measures further down:

- **Elimination** of the risk by removing the hazard.
- **Substitution** of a hazard with a less hazardous one.
- **Engineering Controls** include design measures to prevent or reduce the frequency of the risk event, or detect or control the risk event (limiting the magnitude, intensity and duration) such as:
    - Prevention: design measures that reduce the likelihood of a hazardous event occurring.
    - Detection: design measures that facilitate early detection of a hazardous event.
    - Control: design measures that limit the extent/escalation potential of a hazardous event.
    - Mitigation: design measures that protect the environment if a hazardous event occurs.
    - Response Equipment: design measures or safeguards that enable clean up/response after a hazardous event occurs.
- **Procedures and Administration** includes management systems and work instructions used to prevent or mitigate environmental exposure to hazards.

- **Emergency Response and Contingency Planning** includes methods to enable recovery from the impact of an event (e.g. protection barriers deployed near the sensitive receptor).

2.6.4 Impact and Risk Classification

Environmental impacts and risks are assessed to determine their potential significance or consequence. The impact significance or consequence considers the magnitude of the impact or risk and the sensitivity of the potentially impacted receptor (represented by **Figure 2-5**).

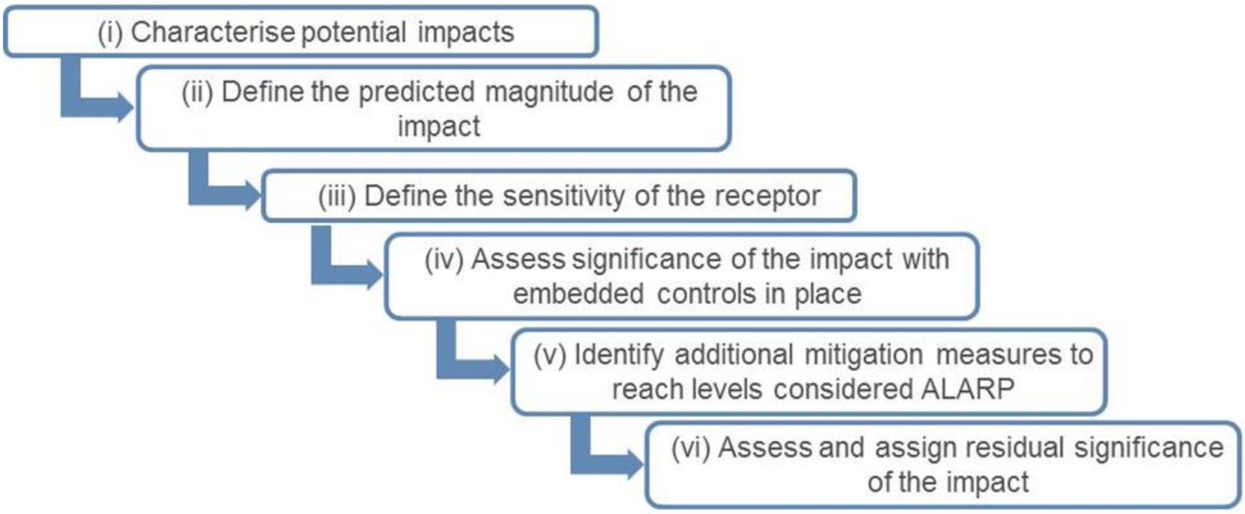


Figure 2-5: Environmental impact and risk analysis

Impacts are classified in accordance with the consequence (**Section 2.4**) outlined in the Woodside Risk Management Procedure and Risk Matrix.

Risks are assessed qualitatively and/or quantitatively in terms of both likelihood and consequence in accordance with the Woodside Risk Management Procedure and Risk Matrix.

The impact and risk information is summarised, including classification, and evaluation information, as shown in the example in **Table 2-2**, evaluated for each planned activity and unplanned event.

Table 2-3: Woodside risk matrix (environment and social and cultural) consequence descriptions

Environment	Social and Cultural	Consequence Level
Catastrophic, long-term impact (more than 50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	Catastrophic, long-term impact (more than 20 years) to a community, social infrastructure or highly valued areas/items of international cultural significance	*A*
Major, long-term impact (ten to 50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	Major, long-term impact (five to 20 years) to a community, social infrastructure or highly valued areas/items of national cultural significance	*B*
Moderate, medium-term impact (two to ten years) on ecosystems, species, habitat or physical or biological attributes	Moderate, medium term Impact (two to five years) to a community, social infrastructure or highly valued areas/items of national cultural significance	*C*
Minor, short-term impact (one to two years) on species, habitat (but not affecting ecosystems function), physical or biological attributes	Minor, short-term impact (one to two years) to a community or highly valued areas/items of cultural significance	*D*

Environment	Social and Cultural	Consequence Level
Slight, short-term impact (less than one year) on species, habitat (but not affecting ecosystems function), physical or biological attributes	Slight, short-term impact (less than one year) to a community or areas/items of cultural significance	***E***
No lasting effect (less than one month); localised impact not significant to environmental receptors	No lasting effect (less than one month); localised impact not significant to areas/items of cultural significance	***F***

2.6.5 Risk Rating Process

The risk rating process is performed to assign a level of risk to each risk event, measured in terms of consequence and likelihood. The assigned risk level is therefore determined after identifying the decision type and appropriate control measures.

The risk rating process considers the potential environmental consequences and, where applicable, the social and cultural consequences of the risk. The risk ratings are assigned using the Woodside risk matrix (**Figure 2-6**).

The risk rating process is performed using the following steps:

2.6.5.1 Select the Consequence Level

Determine the worst-case credible consequence associated with the selected event, assuming all controls (preventative and mitigative) are absent or have failed (**Table 2-3**). Where more than one potential consequence applies, select the highest severity consequence level.

2.6.5.2 Select the Likelihood Level

Determine the description that best fits the chance of the selected consequence occurring, assuming reasonable effectiveness of the preventative and mitigative controls (**Table 2-4**).

Table 2-4: Woodside risk matrix likelihood levels

Likelihood Description						
Frequency	1 in 100,000–1,000,000 years	1 in 10,000–100,000 years	1 in 1000–10,000 years	1 in 100–1,000 years	1 in 10–100 years	>1 in 10 years
Experience	**Remote**: Unheard of in the industry	**Highly Unlikely**: Has occurred once or twice in the industry	**Unlikely**: Has occurred many times in the industry but not at Woodside	**Possible**: Has occurred once or twice in Woodside or may possibly occur	**Likely**: Has occurred frequently at Woodside or is likely to occur	**Highly Likely**: Has occurred frequently at the location or is expected to occur
Likelihood Level	**0**	**1**	**2**	**3**	**4**	**5**

2.6.5.3 Calculate the Risk Rating

The risk level is derived from the consequence and likelihood levels determined above in accordance with the risk matrix shown in **Figure 2-6**. A likelihood and risk rating is only applied to environmental risks using the Woodside risk matrix.

This risk level is used as an input into the risk evaluation process and ultimately for prioritising further risk reduction measures. Once each risk is treated to ALARP, the risk rating articulates the ALARP baseline risk as an output of the ENVID studies.

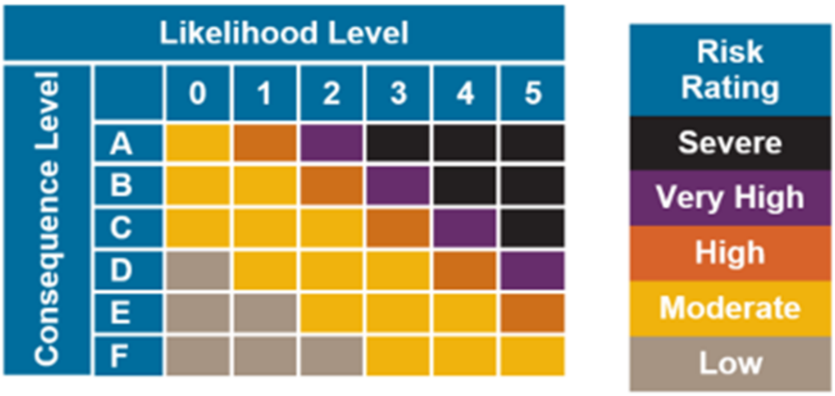


Figure 2-6: Woodside risk matrix – risk level

To support ongoing risk management (a key component of Woodside's Process Safety Management Framework – refer to Implementation Strategy (**Section 7**)), Woodside uses the concept of 'current risk' and applies a current risk rating to indicate the current or 'live' level of risk, considering the controls that are currently in place and regularly effective. Current risk rating is effective in articulating potential divergence from baseline risk, such as if certain controls fail or could potentially be compromised. Current risk ratings aid in the communication and visibility of the risk events, and ensures risk is continually managed to ALARP by identifying risk reduction measures and assessing acceptability.

2.7 Impact and Risk Evaluation

Environmental impacts and risks cover a wider range of issues, differing species, persistence, reversibility, resilience, cumulative effects, and variability in severity than safety risks. Determining the degree of environmental risk, and the corresponding threshold for whether a risk/impact has been reduced to ALARP and is acceptable, is evaluated to a level appropriate to the nature and scale of each impact or risk. Evaluation includes considering the:

- Decision Type
- Principles of ESD – as defined under the EPBC Act
- Internal context – ensuring the proposed controls and risk level are consistent with Woodside policies, procedures and standards (**Section 6** and **Appendix A**)
- External context – the environment consequence (**Section 6**) and stakeholder acceptability (**Section 5**)
- Other requirements – ensuring the proposed controls and risk level are consistent with national and international standards, laws and policies.

In accordance with Environment Regulation 10A(a), 10A(b), 10A(c) and 13(5)(b), Woodside applies the process described in the subsections below to demonstrate ALARP and acceptability for environmental impacts and risks, appropriate to the nature and scale of each impact or risk.

2.7.1 Demonstration of ALARP

Descriptions have been provided in **Table 2-5** to articulate how Woodside demonstrates that different risks, impacts and Decision Types identified within the EP are ALARP.

Table 2-5: Summary of Woodside's criteria for ALARP demonstration

Risk	Impact	Decision Type
Low and Moderate ***(below C level consequences)***	***Negligible, Slight, or Minor*** ***(D, E or F)***	***A***

Risk	Impact	Decision Type
Woodside demonstrates these risks, impacts and decision types are reduced to ALARP if: • controls identified meet legislative requirements, industry codes and standards, applicable company requirements and industry guidelines • further effort towards impact/risk reduction (beyond employing opportunistic measures) is not reasonably practicable without sacrifices grossly disproportionate to the benefit gained.		
High, Very High or Severe (C+ consequence risks)	***Moderate and above (A, B or C)***	***B and C***
Woodside demonstrates these higher order risks, impacts and decision types are reduced to ALARP (where it can be demonstrated using good industry practice and risk-based analysis) that: • legislative requirements, applicable company requirements and industry codes and standards are met • societal concerns are accounted for • the alternative control measures are grossly disproportionate to the benefit gained.		

2.7.2 Demonstration of Acceptability

Descriptions have been provided in **Table 2-6** to articulate how Woodside demonstrates that different risks, impacts and Decision Types identified within the EP are Acceptable.

Table 2-6: Summary of Woodside's criteria for acceptability

Risk	Impact	Decision type
Low and moderate	***Negligible, slight, or minor (D, E or F)***	***A***
Woodside demonstrates these lower order risks, impacts and decision types are of a level that is 'Broadly Acceptable' if they meet: • legislative requirements • industry codes and standards • applicable company requirements and where further effort towards reducing risk (beyond employing opportunistic measures) is not reasonably practicable without sacrifices grossly disproportionate to the benefit gained.		
High, very high or severe	***Moderate and above (D, E or F)***	***B and C***
Woodside demonstrates these higher order risks, impacts and decision types are of an 'Acceptable' level if it can be demonstrated that the predicted levels of impact and/or residual risk, are: • managed to ALARP (as described in **Section 2.7.1**), and • meet the following criteria, appropriate to the nature and scale of each impact and risk: – Impact/risk does not contravene relevant principles of ESD, as defined under the EPBC Act. – Internal context – the proposed controls and consequence/risk level are consistent with Woodside policies, procedures and standards. – External context – stakeholder expectations and feedback have been considered (**Section 5**). – Other requirements – the proposed controls and consequence/risk level are consistent with national and international industry standards, laws and policies, and applicable plans for management and conservation advices, conventions, and significant impact guidelines (e.g. for MNES) have been considered. Where there are significant complexities in assessing and managing impacts to different receptors and for demonstrating how these impacts are acceptable (e.g. significant stakeholder concern for specific receptors, lack of consensus of appropriate controls or standards), acceptability may be demonstrated separately for key receptors. This is not applicable for risks, given the consequence of an unplanned risk event occurring may not be acceptable and, therefore, acceptability is demonstrated in the context of the residual likelihood of an event occurring.		

2.8 Recovery Plan and Threat Abatement Plan Assessment

To support the demonstration of acceptability, a separate assessment is undertaken to demonstrate that the EP is not inconsistent with any relevant recovery plans or threat abatement plans (refer **Section 1.9.1.3.1**).The steps in this process are:

- Identify relevant listed threatened species and ecological communities (**Section 4.4.4**).
- Identify relevant recovery plans and threat abatement plans (**Section 4.4.4.1**).
- List all objectives and (where relevant) the action areas of these plans, and assess whether these objectives/action areas apply to government, the Titleholder, and the Petroleum Activities Program (**Section 6.6**).
- For those objectives/action areas applicable to the Petroleum Activities Program, identify the relevant actions of each plan, and evaluate whether impacts and risks resulting from the activity are clearly not inconsistent with that action (**Section 6.6**).

2.9 Environmental Performance Outcomes, Standards and Measurement Criteria

EPOs, EPSs and MC have been defined to address the potential environmental impacts and risks and are presented in **Section 6**.

2.10 Implementation, Monitoring, Review and Reporting

An implementation strategy for the Petroleum Activities Program describes the specific measures and arrangements to be implemented for the duration of the Petroleum Activities Program. The implementation strategy is based on the principles of AS/NZS ISO 14001:2016 Environmental Management Systems, and demonstrates:

- control measures are effective in reducing the environmental impacts and risks of the Petroleum Activities Program to ALARP and acceptable levels.
- EPOs and standards set out in the EP are met through monitoring, recording, audit, management of non-conformance and review.
- all environmental impacts and risks of the Petroleum Activities Program are periodically reviewed in accordance with Woodside's risk management procedures.
- roles and responsibilities are clearly defined, and personnel are competent and appropriately trained to implement the requirements set out in this EP, including in emergencies or potential emergencies.
- arrangements are in place to respond to and monitor impacts from oil pollution emergencies.
- environmental reporting requirements, including 'reportable incidents', are met.
- appropriate stakeholder consultation is performed throughout the activity.

The implementation strategy is presented in **Section 7**.

2.11 Stakeholder Consultation

A stakeholder assessment is performed to identify relevant persons (as defined under Regulation 11A of the Environment Regulations). An activity update is issued electronically to relevant stakeholders to provide a reasonable consultation period. Further details and information are provided to any stakeholder if requested.

Each stakeholder response is summarised and assessed and a response, where appropriate, is provided by Woodside.

The stakeholder consultation, along with the process for ongoing engagement and consultation throughout the activity, is presented in **Section 5**. A copy of the full text correspondence with relevant people is provided in **Appendix F**.

3. DESCRIPTION OF THE ACTIVITY

3.1 Overview

This section has been prepared in accordance with Regulation 13(1) of the Environment Regulations, and describes the activities to be performed as part of the Petroleum Activities Program under this EP.

3.2 Project Overview

The proposed Petroleum Activities Program comprises a 2D MSS in the Bonaparte Basin. **Table 3-1** provides an overview of the key characteristics of the seismic survey. The commencement of the activities is subject to approvals, vessel availability and weather constraints.

Table 3-1: Petroleum Activities Program overview

Item	Description
Petroleum Title	NT/P86
Location	Bonaparte Basin
Active Source Area (km^2)	16,373 km^2
Operational Area (km^2)	21,140 km^2
Water Depths in the Active Source Area	12 m - 384 m
Vessels	Up to three vessels – one seismic acquisition vessel and up to two chase/ support vessels

3.3 Purpose of the Activity

The purpose of the survey is to acquire geophysical data to improve subsurface imaging within NT/P86 that allows Woodside to define and assess the commerciality of potential hydrocarbon accumulations in NT/P86 and adjacent waters.

3.4 Location

The proposed seismic survey is located fully within the Australian Commonwealth seabed extents of the Bonaparte Basin. The northern part of the survey extends beyond the limits of the Australian Exclusive Economic Zone (EEZ) (Commonwealth waters); and approximately 4935 km^2 of the Active Source Area and approximately 6043 km^2 of the Operational Area are located within an area of overlapping jurisdiction (the 1997 Perth Treaty area), subject to the seabed jurisdiction of Australia and the water column jurisdiction of Indonesia, as described in **Section 4.5.2**.

For the purposes of this EP, two areas have been defined for the survey based on the type of activities that will be undertaken and the discharge of the seismic source. The following areas apply:

- Active Source Area
- Operational Area

These areas are presented in **Figure 3-1**, and a description of each area are provided below.

The southern boundary of the Operational Area is located approximately 187 km north of Darwin and approximately 45 km north of Cape Van Diemen, on the north-west coast of Melville Island. The closest emergent feature to the Operational Area is Seagull Island, which is located approximately 7 km north-west of Cape Van Diemen and approximately 40 km south of the southern boundary of the Operational Area. The Operational Area overlaps with the Multiple Use Zone of the Oceanic Shoals Marine Park. Further details of this AMP are described in **Section 4.6.1**.

3.4.1 Active Source Area

The Active Source Area is defined as the maximum potential area within which seismic acoustic emissions may occur for the purpose of acquiring data. Vessel run-ins, run-outs and soft starts where the acoustic source is active will occur within the Active Source Area. Seismic source testing (i.e. bubble tests) will also occur within the Active Source Area. The seismic source will not be discharged outside of this area.

The extent of the Active Source Area is approximately 16,373 km^2, within which up to a maximum of 4475 full-fold line km of 2D seismic data will be acquired. Boundary coordinates for the area are provided in **Table 3-2** and shown in **Figure 3-1**.

3.4.2 Operational Area

The Operational Area includes both the Active Source Area and a surrounding buffer for the purpose of vessel line turns and other vessel manoeuvres. The seismic source will not be discharged within this buffer.

The extent of the Operational Area is approximately 21,140 km^2. Boundary coordinates for the area are provided in **Table 3-2** and shown in **Figure 3-1.**

Table 3-2: Boundary coordinates

Location Point (GDA94 Degrees Minutes)	Latitude	Longitude
Active Source Area		
1	09°15.79840001' S	131°20.53010680' E
2	09°30.57563119' S	131°20.53380865' E
3	09°55.33574446' S	131°14.35040415' E
4	09°55.32835159' S	131°04.43423189' E
5	10°32.94085564' S	130°49.75517297' E
6	10°40.33772682' S	130°42.36029595' E
7	10°40.31488870' S	129°51.14678407' E
8	09°42.79360837' S	130°07.16020891' E
9	09°25.21802315' S	130°24.60787043' E
Operational Area		
1	09°13.91561839' S	131°25.98763874' E
2	09°31.23569306' S	131°25.99624075' E
3	10°00.75571893' S	131°18.63168297' E
4	10°00.77413932' S	131°08.41281281' E
5	10°35.96635342' S	130°54.44034437' E
6	10°45.75954419' S	130°44.65191238' E
7	10°45.72635904' S	129°43.85698078' E
8	09°40.03281565' S	130°02.22359102' E
9	09°25.47502563' S	130°16.67714101' E

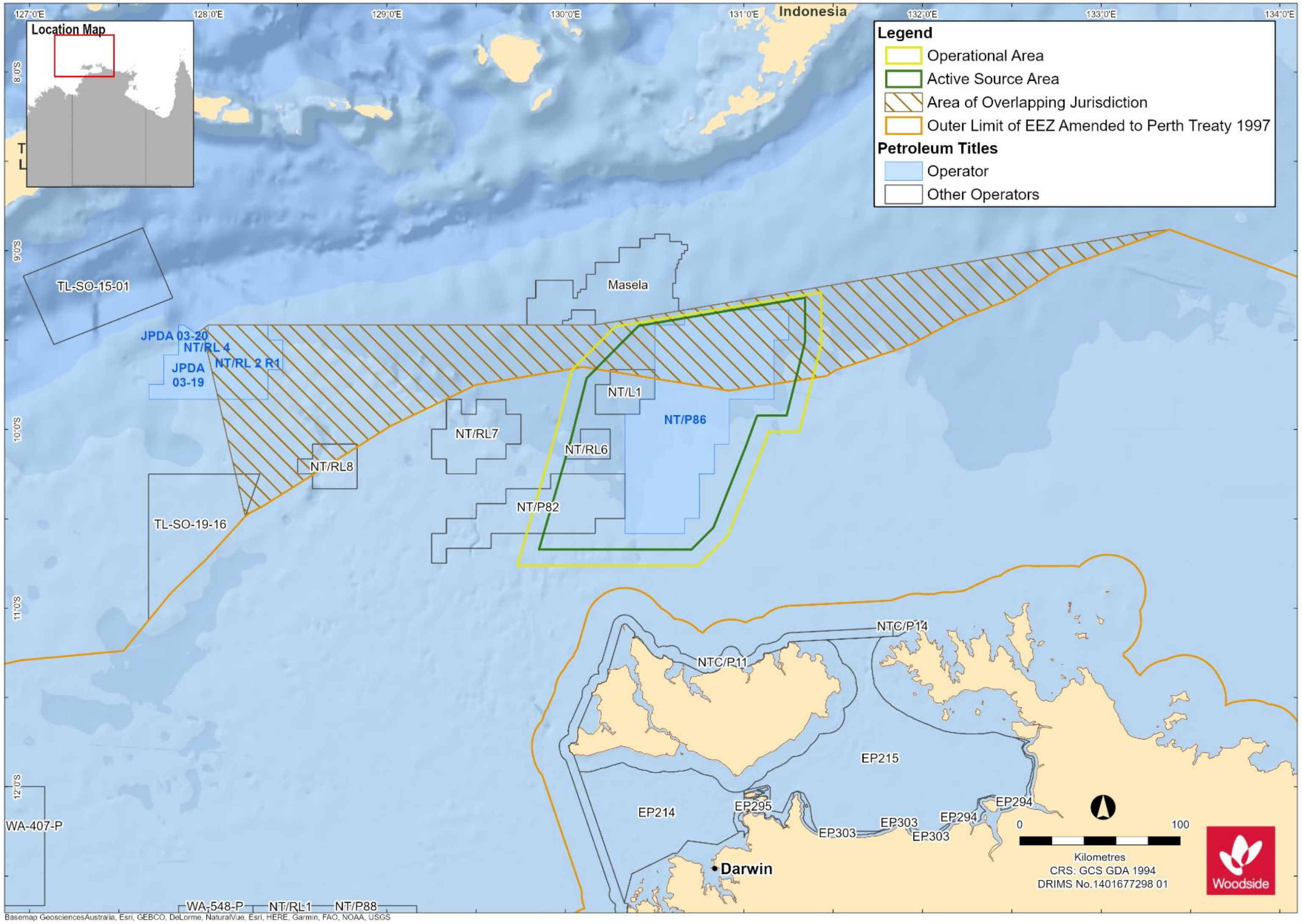


Figure 3-1: Location of the Active Source Area and Operational Area

3.5 Timing and Duration

The survey will take place between 1 May and 16 August 2022. The survey duration will depend upon the final selected line plan (refer to **Section 3.6.4**). For example, the survey duration will be approximately 30 – 35 days for up to 2275 full-fold line km of 2D seismic data, and approximately 55 – 60 days for up to 4475 full-fold line km of 2D seismic data.

The survey duration relates to the time that the seismic survey vessel is in the Operational Area with the towed seismic source array and streamers deployed for the purpose of undertaking the Petroleum Activities Program. In the event that the seismic vessel needs to demobilise from the Operational Area (for example, a severe weather event), any time that the vessel is demobilised from the Operational Area will not be counted towards the survey duration. Survey durations also exclude any pre-scouting that may be required, prior to the commencement of survey acquisition, as determined through stakeholder engagement activities. Pre-scouting activities will be completed within the 1 May to 16 August timeframe.

The exact start and end dates of the survey will be communicated to stakeholders, in accordance with the ongoing stakeholder consultation process described in **Section 5** and commitments made in **Section 6** of this EP.

3.6 Activity Components

3.6.1 Survey Method

The survey proposed is similar to most others conducted in Australian marine waters (in terms of technical methods and procedures), with the exception of the proposed use of a combination of autonomous underwater vehicle (AUV) nodes and commercial seismic nodes (see **Section 3.6.3.2**). The survey will be conducted using a single seismic vessel. It will involve the acquisition of up to approximately 4475 full-fold line km of 2D seismic data.

The seismic vessel will traverse pre-determined sail lines within the Active Source Area. As the vessel travels along a survey line series, seismic air sources are used to generate acoustic pulses approximately every 9 – 18 seconds, based on a 25 m shot point interval and approximately 4 knot tow speed. These acoustic pulses are directed vertically through the water column and into the seabed. The released sound will be attenuated and reflected at geological boundaries, with the reflected signals detected by sensitive microphones called ‘hydrophones’, embedded within a cable(s), or a streamer(s) towed behind the survey vessel, with the addition of AUV and commercial seismic nodes deployed to detect the signal from the seabed.

The reflected sound is then processed to generate a seismic image providing information about the structure and composition of geological formations below the seabed.

3.6.2 Seismic Source

The proposed survey will use a seismic source array within the Active Source Area, consisting of air-powered sources to generate acoustic pulses by periodically discharging compressed air into the water column. Energy from these pulses reflects from the boundaries between geological layers in the sub-surface; the reflected energy of seismic traces is recorded by a series of receivers in the form of towed-streamers and AUV nodes.

The seismic source will be a ‘single source’ with a total discharge volume of up to 3500 cubic inches (cuin). Further information regarding operation of the seismic source during seismic data acquisition is provided in **Section 3.6.4**.

3.6.3 Receiver Technology

3.6.3.1 Solid Streamers

The proposed survey will use a seismic vessel to tow solid streamer(s) (refer to **Table 3-3**). Advances in cable technology have led to a new generation of seismic streamers, moving away from the traditional fluid-filled cable to a solid cable, constructed from extruded foam or gel where the requirement for fluid has been reduced. This move to solid streamers subsequently reduces the risk of streamers releasing fluid to the environment.

The streamers will be fitted with steering devices in the form of remote-controlled wings, which enable both precise depth control and horizontal steering. Horizontal streamer steering reduces feather (where the streamer tends to veer offline due to wind and currents) correction and enables active steering. Streamer recovery devices (SRDs) will be fitted to the streamer. If the streamer drops below about 50 m depth, the SRDs automatically deploy inflatable air bags to raise the streamer to the surface for retrieval.

3.6.3.2 AUV and Commercial Nodes

The use of nodes in seismic surveys and technology are common practice in the global petroleum industry and are not new to Australia. The advancement in this technology is the novel use of AUV seismic nodes in Australian waters. This technological advancement removes the need for ROV seafloor placement of the nodes in conventional deployment, significantly reduces the time required to deploy/retrieve the AUV nodes reducing future survey durations and potential displacement of other marine users. The improvement to both seismic data quality and efficiency from AUV node acquisition has the potential to reduce both the extent and duration for future seismic surveys in the area.

The proposed survey will use the support vessel and/or the chase vessel to deploy and retrieve the AUV seismic nodes within the Active Source Area. The AUV nodes use current AUV technology similar to Slocum gliders – these are autonomous vehicles that move up and down through the water column by changing buoyancy. The proposed AUV nodes are cylindrical in shape with short wings on the sides for flight stabilisation and steering. They are approximately 1000 mm long and 300 millimetres (mm) in diameter (weights approximately 30 kilograms (kg) in air and 10 kg in sea water). The AUV nodes operate autonomously through the water column and are adapted to settle temporarily on the seabed and listen to/record the seismic signal. As a control the AUV nodes will be fitted with thrusters to be periodically used for propulsion, navigation assistance, managing low impact landings and assist with take-offs as required.

The AUV nodes will be paired with equivalent commercial nodes to ground truth the technology in terms of the verification of seismic data recorded. As an additional control the commercial nodes may most probably be deployed and recovered by a small ROV but may also be tethered by a rope to a buoy. The commercial nodes will weigh approximately 15 kg (6.5 kg in sea water) and measure approximately 346 mm (length), by 218 mm (width) and 138 mm (height).

The planned number of AUV and commercial nodes to be deployed is approximately 15-20. The nodes will be deployed on the seabed along the 20 km lengths of the three existing intersecting lines during the survey. At the end of the survey, when the streamer is recovered, the seismic vessel will re-acquire approximately 20 km lengths along these three lines for a period of between 24 to 48 hr with the same source configuration and source interval. Each AUV node is planned to have approximately five placements along these lines during this final trial period before retrieval.

Recovery devices are included within each AUV node, which will deploy inflatable air bags to raise the node to the surface if the node is unable to surface. An additional control of a ROV will also be used as a failsafe to recover the AUV nodes as required as well as for deployment and recovery of the commercial nodes. The AUV nodes will be pre-programed prior to deployment and will be supported during subsea deployment by ultra-short baseline (USBL) acoustic positioning updates from the surface vessels. When at the surface, the AUV nodes positioning systems operate via radio frequency and Iridium satellite. The AUV units will have onboard “Health check” diagnostic capability to confirm all sensors are working as expected and where found to be in fault the AUV will surface and message the supporting vessels for retrieval.

3.6.4 Seismic Data Acquisition

2D seismic data will be acquired along a grid of broadly-spaced, approximately orthogonal lines (spaced approximately 5 - 15 km apart) within the Active Source Area. Lines will be orientated approximately northeast-southwest and northwest-southeast. A maximum of 4475 line km of 2D seismic data will be acquired, including a limited number of well-to-seismic tie lines to link the 2D data acquisition with exploration data available at existing well locations in the region.

Two indicative line orientation examples are presented in **Figure 3-2**, a potential base case (2275 full-fold line km) and a potential extended case (4475 line km). The final line plan will be designed in accordance with the parameters and the environmental management measures outlined in this EP.

The seismic vessel will traverse the sail lines at a speed of approximately 4 knots. The seismic vessel will tow a seismic source array and a single streamer beneath the water surface. As the vessel travels along the sail lines, a series of acoustic pulses (approximately every 9 – 18 seconds based on a shot point interval of approximately 25 m) will be directed down through the water column and seabed. The seismic source array will be towed at a water depth of approximately 6 – 8 m. The streamer will extend up to approximately 12 km behind the vessel at a depth of approximately 15 – 20 m. **Figure 3-2** also indicates an area where AUV nodes and commercial nodes will be deployed for the purpose of acquiring approximately 60 km of intersecting acquisition lines during the survey. At the end of the survey, the seismic vessel will re-acquire approximately 20 km lengths along these three lines for a period of between 24 to 48 hr with the same source configuration and source interval. The seismic vessel will acquire the data along the selected lines towing only the seismic source (i.e. no streamer deployed).

A summary of the 2D seismic survey parameters is provided in **Table 3-3**.

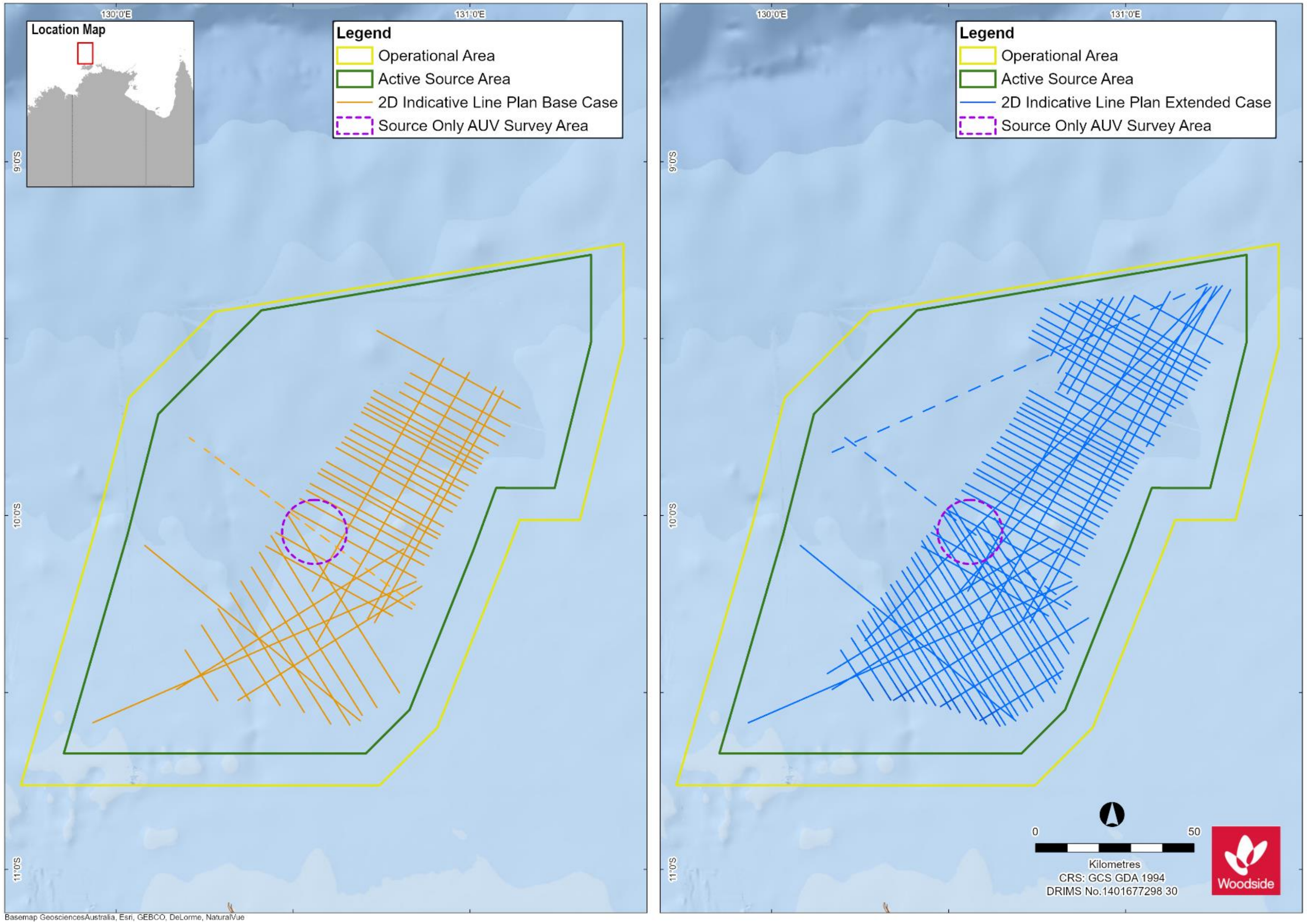


Figure 3-2: Example acquisition line plans

Table 3-3: Survey acquisition parameters

Parameter		Galactic Hybrid 2D MSS
General parameters	Max. line km of seismic data	4475 km
	Max. sail line length	~200 km
	Line separation (nominal)	1.5 – 15 km
	Line orientation	NE/SW and NW/SE
	Seismic vessel sail line speed	3 – 5 knots
Acoustic emissions	Airgun array capacity (approximate)	<3500 cuin
	Operating pressure	2000 psi
	Airgun array tow depth	6 – 8 m
	Shot point interval	25 m
	Peak frequency range	2-200 Hz
Acoustic reception	Streamer type	Solid
	No. of streamers (approximate)	1
	Streamer length (approximate)	12 km
	Streamer spacing	N/A
	Streamer depth (approximate)	> 15 m

3.6.5 Project Vessels

The survey will be conducted using a single seismic vessel. The chase/support vessel, capable of AUV/commercial seismic node deployment/retrieval, will accompany the seismic vessel and may re-supply it with fuel and other logistical and operational supplies (including taking the seismic vessel under tow, if required). An additional chase/support vessel may be used to manage interactions with shipping and fishing activities, if required.

Vessels used during the survey are required to operate in accordance with the seismic contractor's operations and HSE policies and procedures, which are incorporated into project documentation that has been assured by Woodside. Where the support/chase vessels are sourced from a secondary company, those vessels will be operated under their own safety management system which will be abridged to the primary seismic contractors safety management system if/where applicable. **Table 3-4** outlines the typical parameters of the vessels that will be used during the survey.

Table 3-4: Typical vessel specifications

Specification	Seismic Vessel	Support Vessel	Chase Vessel
Gross registered tonnage (GRT)	~8,000–12,000	~3,000	<600
Length overall	~110 m	~65 m	~22 m
Breadth	~40 m	~20 m	~6 m
Draft (max)	8 m	7 m	~2 m
Persons on board	60	12 - 20	4–12
Fuel type	Marine diesel oil (MDO)	MDO	MDO
Max capacity of largest fuel tank	650 m^3	<650 m^3	<250 m^3

The seismic vessel and towed array, comprising the airgun array and a single streamer, which includes header buoy and tail buoy, are surrounded by a Safe Navigation Area (SNA). The SNA will extend to a radius of 3 nm around the seismic vessel and towed equipment. The support/chase vessel will be used to ensure third party vessels are prevented from approaching or entering the SNA.

Potable water, primarily for accommodation and associated domestic areas, will be generated on the seismic and support/chase vessels using a reverse osmosis system. This process will produce brine, which is diluted and discharged at the sea surface in accordance with the controls detailed in **Section 6.4.6.**

The project vessels will also discharge deck drainage from open drainage areas, bilge water from closed drainage areas, putrescible waste and treated sewage and grey water. Any hazardous and non-hazardous waste will be appropriately stored and transported to shore for disposal.

3.6.6 Helicopters

Crew changes, if required during the survey, will be conducted (depending on timing) either via a combination of a helicopter operating out of Darwin linking up with the seismic vessel, or, more probably, via support/chase vessel port calls.

3.6.7 Refuelling

At-sea refuelling (bunkering) of the seismic vessel may occur, depending on fuel consumption during the survey. At-sea refuelling operations will only occur within the Operational Area, and in accordance with contractor operational procedures and the control measures outlined in **Section 6.5.3**.

4. DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 Overview

In accordance with Regulations 13(2) and 13(3) of the Environment Regulations, this section describes the existing environment that may be affected by the activity (planned and unplanned, as described in **Section 3**), including details of the particular relevant values and sensitivities of the environment, which were used for the risk assessment.

The EMBA[1] is the largest spatial extent where unplanned events could have an environmental consequence on the surrounding environment. For this EP, the EMBA is the potential spatial extent of surface and in-water hydrocarbons at concentrations above ecological impact thresholds, in the event of the worst-case credible spill. The ecological impact thresholds used to delineate the EMBA are defined in **Section 6.5.1**. The worst-case credible spill scenario for this EP is a vessel collision resulting in hydrocarbon release. Note, no shoreline accumulation of hydrocarbons above threshold concentrations (100 g/m^2 or 10 g/m^2) resulted from the modelled worst-case credible spill. Woodside recognises that hydrocarbons may be visible at lower concentrations than the ecological impact thresholds defined in **Section 6.5.1**. These visible hydrocarbons are not expected to cause ecological impacts. In respect of this, an additional socio-cultural EMBA is defined, as the potential spatial extent within which social-cultural impacts may occur from changes to the visual amenity of the marine environment. Receptors relevant to the socio-cultural EMBA include Commonwealth and Northern Territory marine protected areas (MPAs), National and Commonwealth Heritage Listed places, areas of tourism and recreation, and commercial and traditional fisheries. For this EP, the socio-cultural EMBA for surface hydrocarbons encompasses an area fully within the boundaries of the EMBA for ecological impacts. The EMBA and socio-cultural EMBA are described in **Table 4-1** and shown in **Figure 4-1**.

It should be noted that each EMBA presented does not represent the predicted coverage of any one hydrocarbon spill or a depiction of a slick or plume at any particular instant in time. Rather, the areas are a composite of a large number of theoretical paths, integrated over the full duration of the simulations under variations in metocean conditions.

Table 4-1: Hydrocarbon spill thresholds used to define exposure areas for surface and in-water hydrocarbons

Hydrocarbon type	EMBA[1]	Socio-cultural EMBA[1]	Planning area for scientific monitoring
Surface	10 g/m^2 This represents the minimum oil thickness (0.01 mm) at which ecological impacts (e.g. to birds and marine mammals) are expected to occur.	1 g/m^2 This represents a wider area where a visible sheen may be present on the surface and, therefore, the concentration at which socio-cultural impacts to the visual amenity of the marine environment may occur. However, it is below concentrations at which ecological impacts are expected to occur. This low exposure value also establishes the planning area for scientific monitoring (NOPSEMA guidance note: A652993, April 2019).	
Dissolved	50 ppb This represents potential toxic effects, particularly sublethal effects to highly sensitive species (NOPSEMA guidance note: A652993, April 2019). As dissolved hydrocarbons are within the water column and not visible, impacts to socio-cultural receptors are associated with ecological impacts. Therefore, dissolved hydrocarbons at this threshold also represent the level at		10 ppb This low exposure value establishes the planning area for scientific monitoring (based on potential for exceedance of water quality triggers) (NOPSEMA guidance note: A652993,

[1] Note, the EMBA has been defined by extrapolating the spill modelling results (for the different hydrocarbon fates) to each corner of the Operational Area.

Hydrocarbon type	EMBA[1]	Socio-cultural EMBA[1]	Planning area for scientific monitoring
	which socio-cultural impacts may occur. The review and results are presented in **Section 6.5.1.**		April 2019). This area is described further in **Appendix D**. In the event of a spill, DNP will be notified of AMPs which may be contacted by hydrocarbons at this threshold **Table 7-3.**
Entrained	100 ppb This represents potential toxic effects, particularly sublethal effects to highly sensitive species (NOPSEMA guidance note: A652993, April 2019). As entrained hydrocarbons are within the water column and not visible, impacts to socio-cultural receptors are associated with ecological impacts. Therefore, entrained hydrocarbons at this threshold also represent the level at which socio-cultural impacts may occur.		
Shoreline	100 g/m^2 This represents the threshold that could impact the survival and reproductive capacity of benthic epifaunal invertebrates living in intertidal habitat.	10 g/m^2 This represents the volume where hydrocarbons may be visible on the shoreline but is below concentrations at which ecological impacts are expected to occur.	N/A

[1] Further details including the source of the thresholds used to define the exposure areas in this table are provided in **Section 6.5.1.**

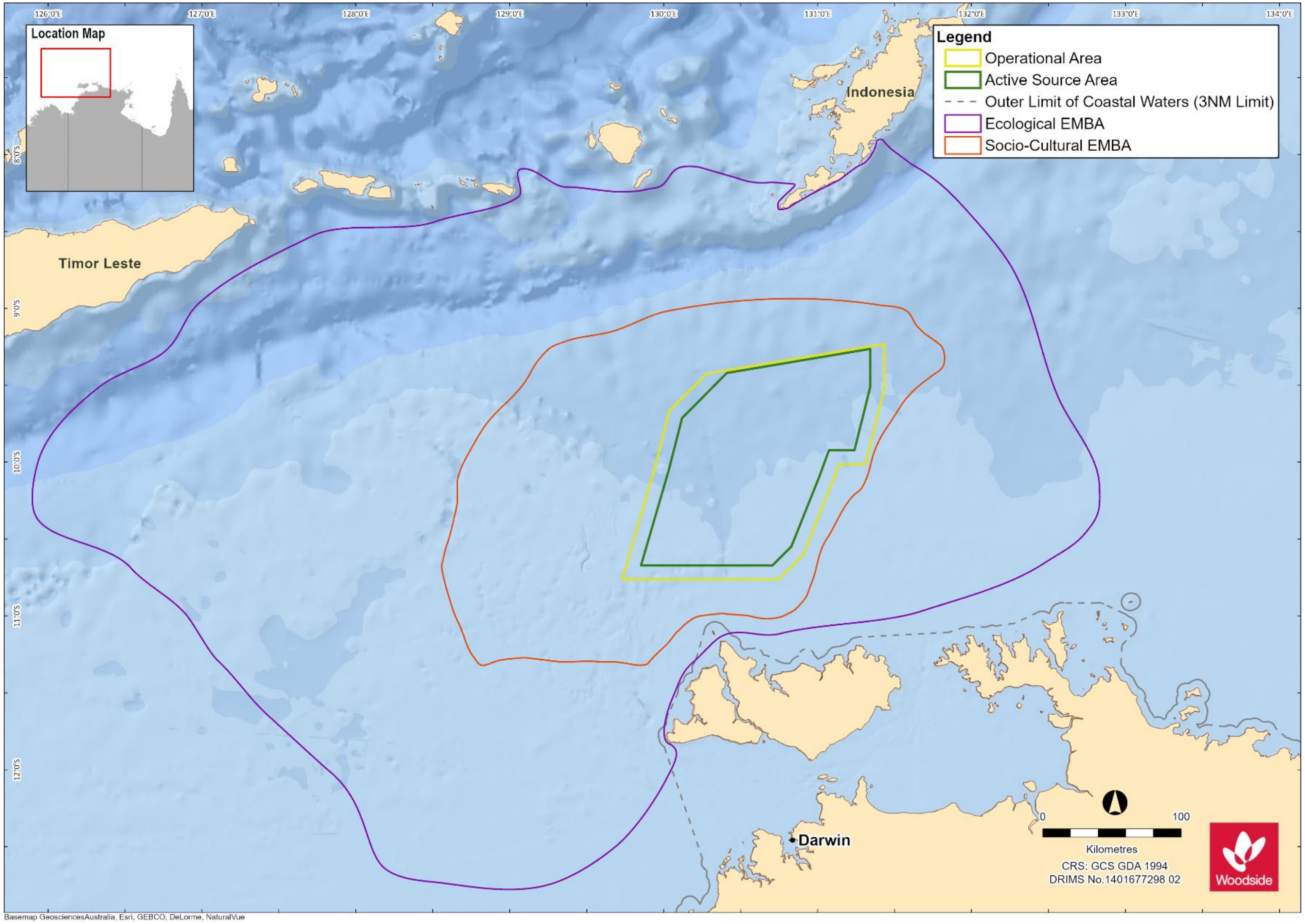


Figure 4-1: Environment that may be affected by the Petroleum Activities Program

4.2 Regional Context

The Operational Area is located within the North Marine Region (NMR), as defined under the Integrated Marine and Coastal Regionalisation of Australia (IMCRA v4.0) (Commonwealth of Australia, 2006), in water depths of about 11 m to 405 m. The NMR comprises Commonwealth waters from west Cape York Peninsula to the NT/WA border. The region covers approximately 625,689 km^2 of tropical waters in the Gulf of Carpentaria and Arafura and Timor seas. Within the NMR, the Operational Area overlaps with two provincial bioregions—the Northwest Shelf Transition and Timor Transition (**Figure 4-2**).

The Northwest Shelf Transition is characterised by the following biophysical features (DSEWPaC), 2012a):

- Located mostly on the continental shelf, with some small areas extending onto the continental slope.
- Water depths range between 0-330 m, with the majority of the bioregion occurring in depths of 10-100 m.
- The Indonesian Throughflow (ITF) is the dominant oceanographic feature and dominates the majority of the water column.
- The strength of the ITF and its influence in the bioregion varies seasonally in association with the North-west Monsoon.
- Contains a variety of geomorphic features, including terraces, plateaus, sand banks, canyons and reefs.
- 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 Timor Transition is characterised by the following biophysical features (DSEWPaC, 2012a):
- Comprises shelf terrace and slope that extends into waters 200-300 m deep in the Arafura Depression.
- Extensively dissected into a series of canyons around 80-100 m deep and 20 km wide.
- The ITF brings warm waters from the western Pacific Ocean through the Indonesian Sea into the Timor and Arafura Seas.
- Sediments are mainly rich in calcium carbonate, although sediment type varies from sandy substrate to soft muddy sediments and hard rocky substrate.
- Primarily influenced by oceanographic processes associated with tides, which also dominate the process of mobilising of seabed sediments in deeper waters and channels of the Arafura sea.
- Pelagic species are prominent in the open water environment of the Timor Transition, and the shelf edge is believed to support distinct benthic communities associate with cooler water upwellings.

A small portion of the south-west corner of the EMBA enters the North-west Marine Region (NWMR). Additionally, another marine provincial bioregion, the Northern Shelf Province, overlaps with the south-east section of the EMBA.

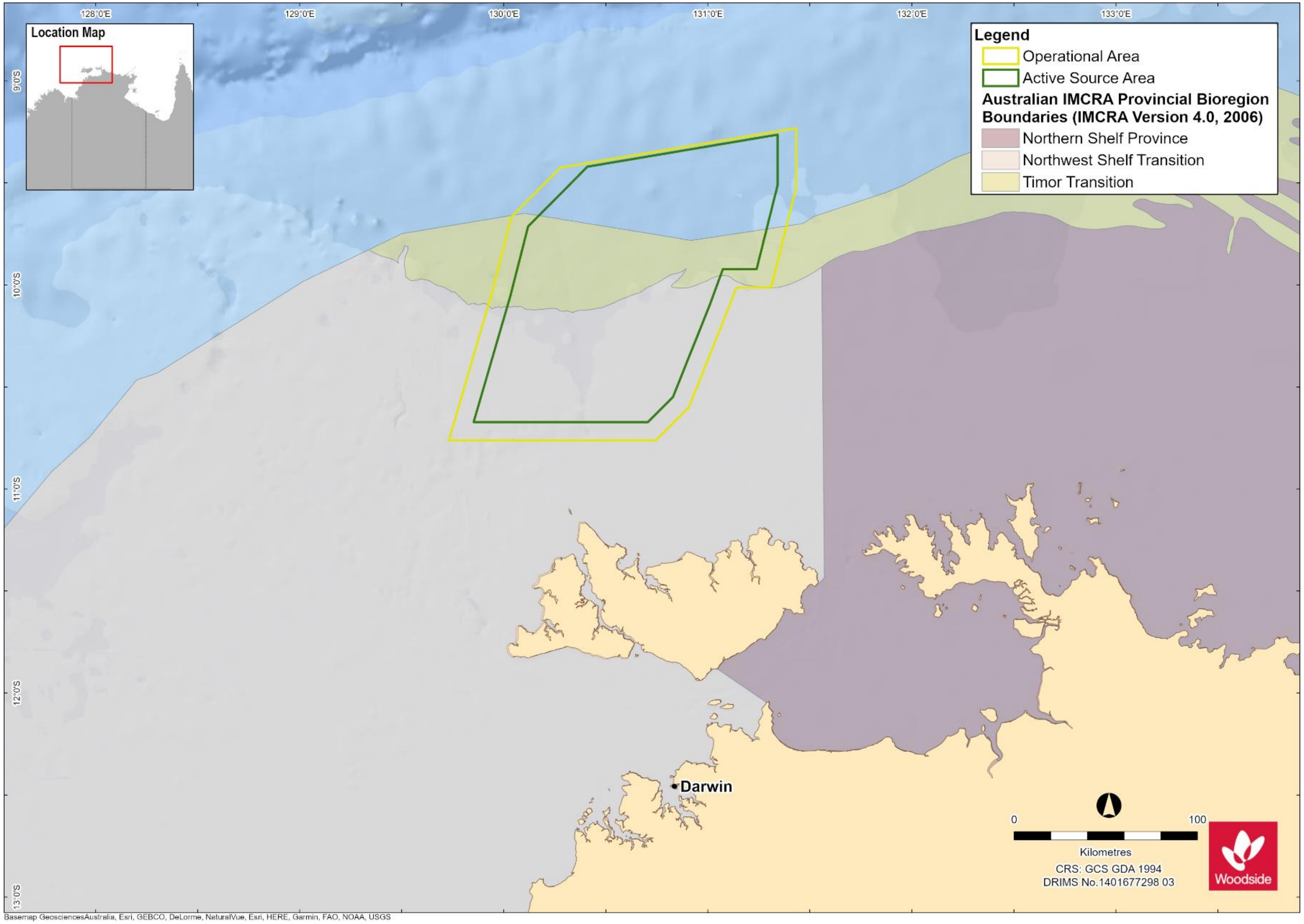


Figure 4-2: Location of the IMCRA provincial bioregions with reference to the Operational Area

4.3 Physical Environment

Table 4-2 provides a summary of the physical characteristics of the environment within the Operational Area and EMBA, as relevant to the Petroleum Activities Program.

Table 4-2: Physical characteristics of the Operational Area and EMBA

Receptor	Description
Climate and meteorology	
Seasonal patterns	The NMR experiences a tropical monsoonal climate with distinct wet (October to March) and dry (April to September) seasons. The region experiences complex weather cycles including high temperatures and heavy seasonal yet variable rainfall and cyclones, which can both be destructive (loss of seagrass and mangroves) and constructive (mobilisation of sediment into coastal habitats).
Air temperature	Average maximum temperatures during summer of 33.7 ºC and average minimum temperatures of 18.5 ºC in winter (Bureau of Meteorology [BoM], 2020), as measured at Darwin Airport located about 183 km south of the Operational Area (**Figure 4-3**).
Rainfall	Average maximum rainfall of 412.6 millimetres (mm) during summer and average minimum rainfall of 2.6 mm ºC in winter (BoM, 2020), as measured at Darwin Airport located about 183 km south of the Operational Area (**Figure 4-3**).
Wind	Winds vary seasonally, with a strong tendency for winds from the west during summer and the south-east in winter (Rothlisberg et al., 2005). Offshore winds in summer are predominantly from the west-north-west to west-south-west due to the North West Monsoon (Woodside, 2019). Winds typically weaken and are more variable during the transitional period between the summer and winter regimes (typically April and August).
Tropical cyclones	Tropical cyclones are common in the region and usually form in an active monsoon trough, producing heavy rains, strong wind, large swells and storm surges. Tropical cyclone activity can occur between November and April and is most frequent in the area during January to March, with an annual average of about one storm per month. Cyclones are less frequent in the area in the months of November, December and April. However, historically, the most severe storms have occurred in April.
Oceanography	
Currents	The large-scale ocean circulation of the NMR is influenced primarily by tidal flows which drive long-term transport patterns through the region. The movement of tidal waters across the northern Australian marine environment is complex, due to the barrier of islands and submerged reefs in the Torres Strait hindering tidal energy entering from the Coral Sea. The region experiences minor influence from oceanographic currents including the Indonesian Throughflow (ITF) and South Equatorial Current (DSEWPaC, 2012a). The ITF transports warm waters from the Pacific Ocean into the Indian Ocean through the Indonesian seas (**Figure 4-4**). The strength of the ITF is seasonal with it being weakened during the wet season when the strong south-westerly winds cause intermittent reversals of the currents (Brewer et al., 2007). The strengthening of the ITF in the dry season coincides with the development of the prevailing south-westerly flowing Holloway Current, which transports waters from the Banda and Arafura seas and the Gulf of Carpentaria southwards along the shelf (DEWHA, 2008b). The waters within the north of the Operational Area may be marginally influenced by the South Equatorial Current, the strength of which varies seasonally. Surface currents around the Timor Trench move westward into the Indian Ocean during the dry season but have no particular direction during the wet season (DEWHA, 2008b). Currents at 30 m below mean sea level vary in direction but most often come from the north-west and south-east, averaging speeds of 0.18 m/s^{-1} and occasionally reaching speeds greater than 0.8 m/s^{-1} (**Figure 4-5**). Currents at 30 m above sea bed generally come from the NNW or SSE, averaging speeds of 0.12 m/s^{-1} (**Figure 4-6**).
Tides	Tides in the NMR are typically semi-diurnal, with two daily high tides and two daily low tides. Tides are the primary influencer of oceanographic processes in the Timor Transition bioregion, and drive the mobilisation of seabed sediments in deeper waters and channels of the Arafura Depression. Storm surges and cyclonic events can significantly raise sea levels above predicted tidal heights (Pearce et al., 2003).
Wave height	Waves in the region are generally <1 m in height year-round, with the highest waves usually occurring in winter. In summer, waves flow from the south-west due to south-westerly wind-sea generated waves from summer monsoons and the persistent perennial Indian Ocean Swell (originating in the

Receptor	Description
	Southern Ocean) arriving from the south-west (Woodside, 2019). In winter, waves are influenced by wind-sea generated waves from overland winter Trade Winds (easterlies) and persistent perennial Indian Ocean Swell (originating in the Southern Ocean) arriving from the south-west (Woodside, 2019).
Seawater characteristics	Surface waters are relatively warm year round due to the tropical water supplied by the ITF, with temperatures ranging from 26.5 °C to 28.2 °C (Locarnini et al., 2018). Near seabed temperatures in deeper waters (greater than 200 m water depth) are less variable, with temperatures averaging 15.8 °C year round. Jacobs (2016) investigated water quality samples located within and nearby to the Operational Area and found the majority of metal concentrations were below the Australian and New Zealand Environment and Conservation Council (ANZECC) and Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000), with copper concentrations occasionally reported to slightly exceed the guidelines. Total recoverable hydrocarbons and benzene, touluene, xylenes and naphthalene were below laboratory reporting limits at all sites and depths for each season (Jacobs, 2016). Variation in surface salinity across the region throughout the year is minimal, with little difference in salinity between the surface water and bottom water at all sites during all seasons (Jacobs, 2016). The only potential factors affecting surface water salinity are climatic events (i.e. precipitation and evaporation). Turbidity is primarily influenced by sediment transport by oceanic swells and primary productivity (Pearce et al., 2003). Turbidity in the region is very low and stable across all seasons (Jacobs, 2016).
Bathymetry and seabed habitats	
Bathymetry	The majority of the seabed within the Operational Area can be characterised by a largely uniform slope of moderate gradient covering the mid-outer continental shelf and slope (**Figure 4-7**). Depths within the Operational Area range from 11 m at Lynedoch Bank to 405 m at the northern extent of the Operational Area. The gradient of the slope in the southern half of the Operational Area averages -0.2% before increasing in the northern half to -0.4%. The south-west portion of the Operational Area partially overlaps with the Van Diemen Rise which, as a whole, represents an area of relatively complex bathymetry containing several geomorphic features including carbonate banks, terraces, ridges and valleys (Przeslawski et al., 2011). The portion of the Operational Area that overlaps the Van Diemen Rise is characterised by deep-water channels along the seabed and bank environments that are interspersed by relatively shallow channels (Heap et al., 2010). The benthic communities associated with the Van Diemen Rise are described in **Section 4.4.3.3**. The shelf edge occurs at water depths of 120–180 m (Jongsma, 1974). Extensive palaeo-river channels up to 150 km long, 5 km wide and 240 m deep connect the Joseph Bonaparte Gulf (JBG) Ocean Basin with the old shoreline at the edge of the shelf. These channels funnel cooler oceanic waters up onto the Van Diemen Rise (DEWHA, 2008).
Marine sediment	Sediments within the Timor Transition are mainly calcium carbonate rich, although sediment type varies from sandy substrate to soft muddy sediments and hard rocky substrate (DEWHA, 2008). Sediments within the Northwest Shelf Transition are characteristically different from other areas of the NMR, as they tend to be dominated by soft muds, which are the result of relict mud deposition as well as modern carbonate and terrigenous mud deposition (DEWHA, 2008). Sediment within the Operational Area largely consists of sandy substrate to soft muddy sediments, with hard substrate types occurring at Lynedoch Bank and Goodrich Bank. On the outer shelf and upper shelf slope carbonate sediments are mixed with terrigenous clays from Indonesian rivers (Heap et al., 2004).
Other physical attributes	
Air quality	There is limited air quality data for the NMR, however ambient air quality in the Operational Area is expected to be of high quality.
Ambient light	Given the remoteness of the region, anthropogenic light emissions in the Operational Area are expected to be limited to occasional vessels traversing through the area. No fixed light sources (e.g. offshore oil and gas platforms) are currently present within the Operational Area.
Ambient noise	Physical and biological processes contribute to natural background sound. Physical processes include that of wind and waves, while biological noise sources include vocalisations of marine mammals and other marine species, for example pygmy blue whales and dolphins. Anthropogenic noise may come from vessels, seismic survey signals and mooring activities. Given the remoteness of the region,

Receptor	Description
	anthropogenic noise in the Operational Area is expected to be limited to occasional vessels traversing through the area.

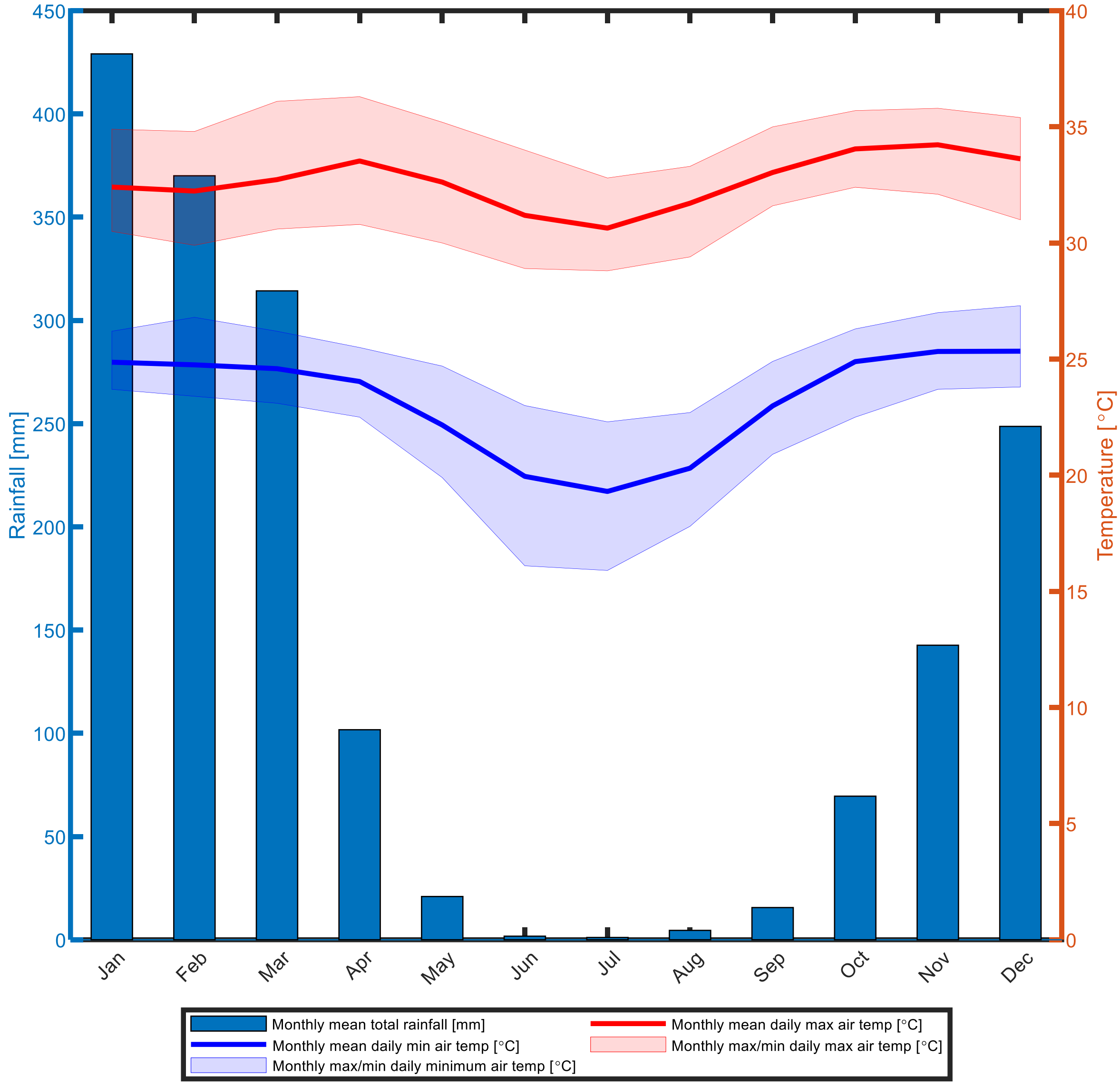


Figure 4-3: Monthly average total rainfall (mm) and air temperature (°C), calculated based on observations at the Darwin Airport weather station from 1941-2020 (BoM, 2020).

Bars show the monthly average total rainfall values, and thick blue and red lines denote monthly average daily minimum and maximum air temperatures, respectively. Shaded blue and red areas denote monthly recorded extremes of daily minimum and maximum air temperature, respectively.

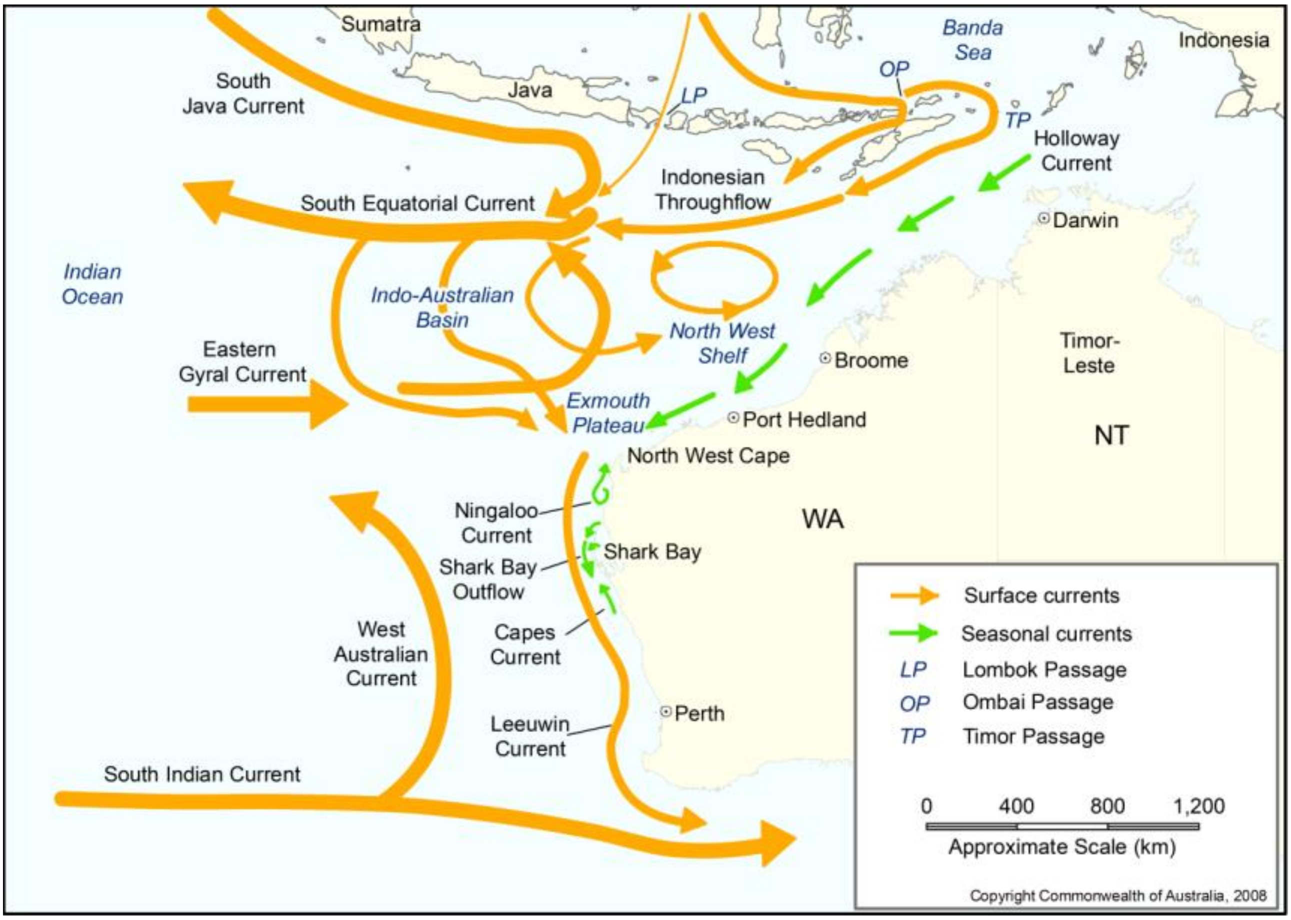


Figure 4-4: Large-scale ocean circulation influencing north-west Australian waters (DEWHA, 2008)

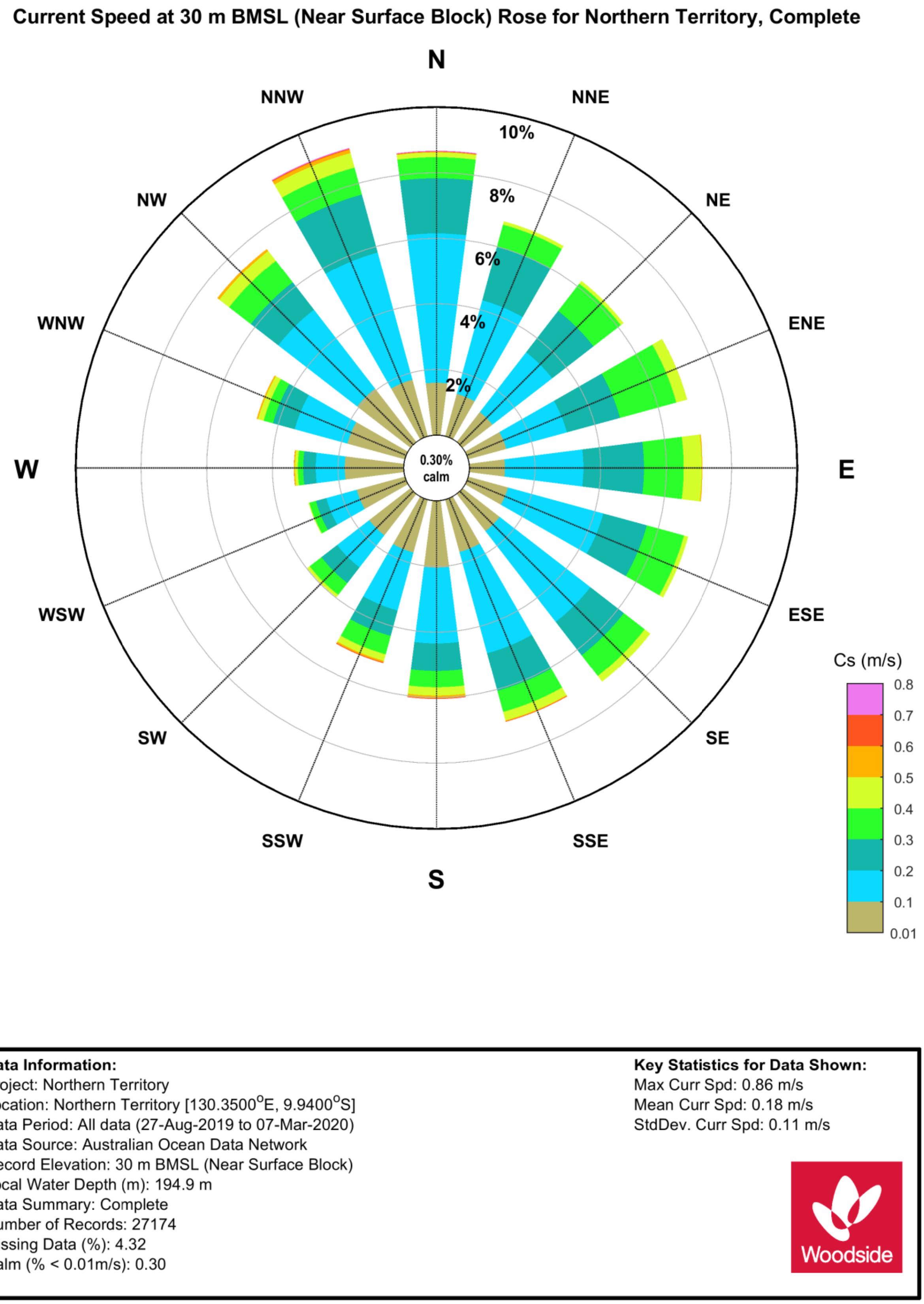
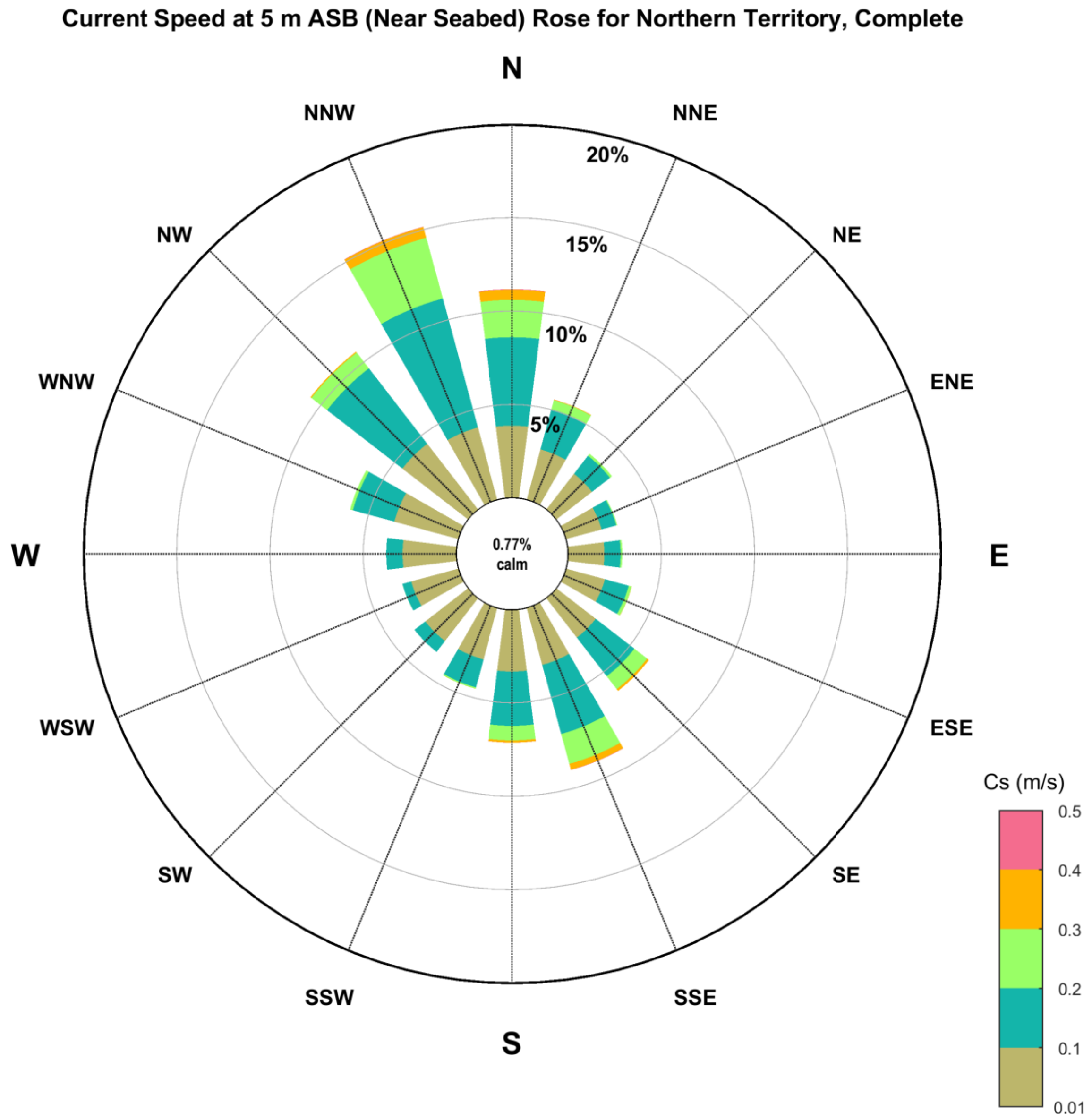


Figure 4-5: Annual near surface combined frequency of 1-minute mean current speed and direction (towards) measured at Offshore Northern Territory location (cyclones removed) (IMOS, 2020). Based on six months of data measured from August 2019 to March 2020



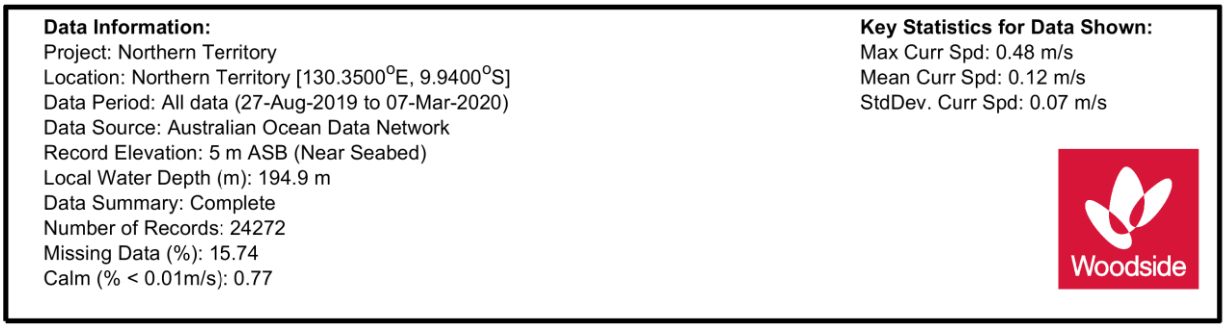


Figure 4-6: Annual near seabed combined frequency of 1-minute mean current speed and direction (towards) measured at an Offshore Northern Territory location (cyclones removed) (IMOS, 2020). Based on six months of data measured from August 2019 to March 2020

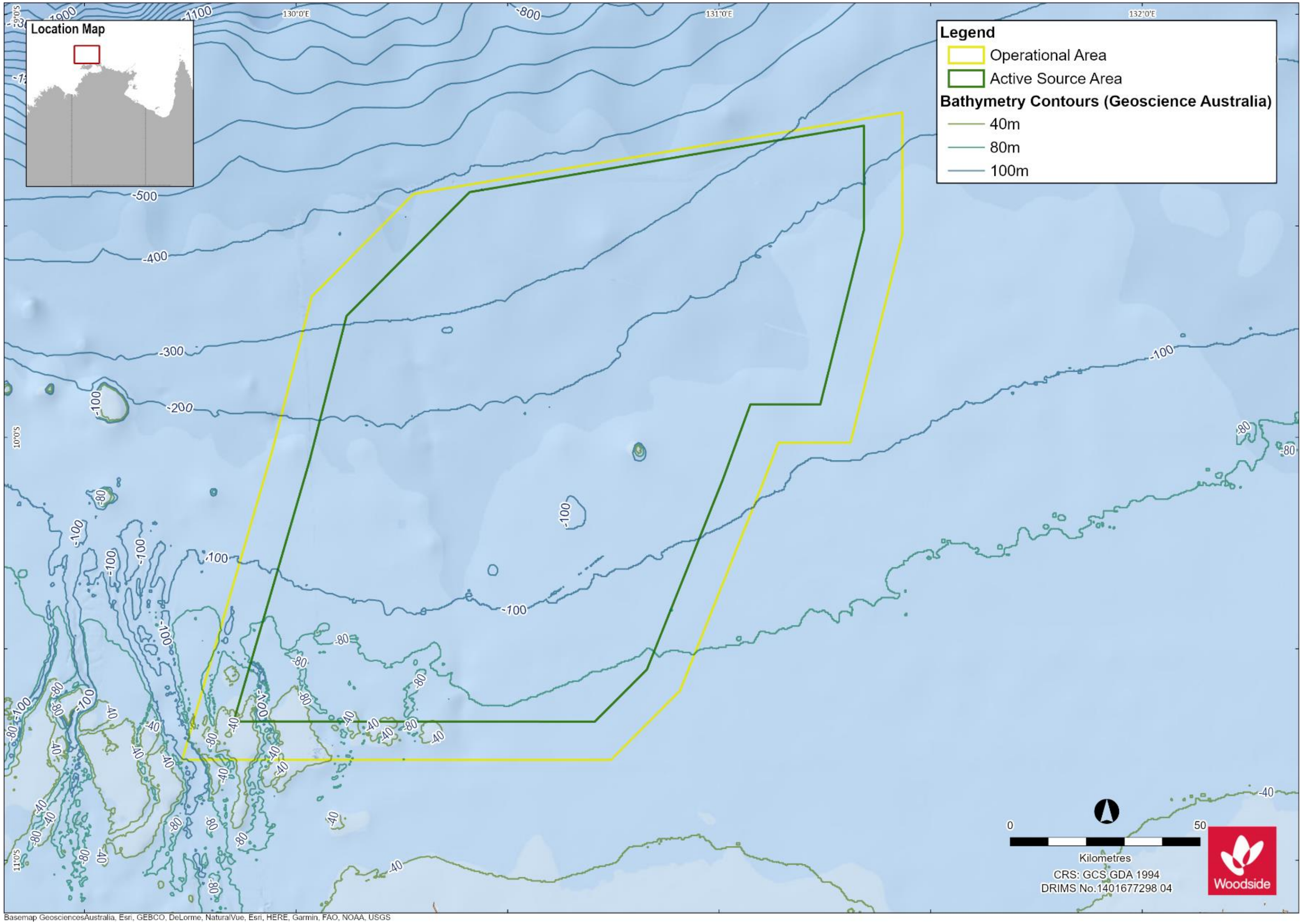


Figure 4-7: Bathymetry of the Operational Area

4.4 Habitats and Communities

4.4.1 Critical Habitat and Threatened Ecological Communities – EPBC Listed

No marine Critical Habitats or Threatened Ecological Communities (TECs) as listed under the EPBC Act are known to occur within the Operational Area and EMBA, as indicated by the EPBC Act Protected Matters Report extracted in December 2020 (**Appendix C**).

4.4.2 Marine Primary Producers

4.4.2.1 Coral Reef

Coral reef habitats have a high diversity of corals and associated fish and other species of both commercial and conservation importance. Offshore coral reef within the NMR is generally associated with shoals and banks. The shoals and banks in the region support tropical marine biota consistent with that found on emergent reef systems of the Indo West Pacific region including Ashmore Reef, Cartier Island, Seringapatam Reef and Scott Reef (all of which are located beyond the EMBA).

Coral reef habitat is known to occur within the Operational Area at Lynedoch Bank, and partial coral habitat has been recorded at Goodrich Bank (Heyward et al., 2017) (described in **Section 4.4.3.3**). Within the EMBA, coral reef habitat is known to occur at the 'Pinnacles of the Bonaparte Basin' Key Ecological Feature (KEF) (described in **Section 4.6.4.3**), Evans Shoal, Tassie Shoal and Blackwood Shoal (described in **Section 4.4.3**). Coral reef habitat may also be present along the Indonesian coastline, within the EMBA.

4.4.2.2 Seagrass Beds/Macroalgae

Seagrass beds and macroalgal habitats represent a food source for many marine species and also provide key habitats and nursery grounds for commercially harvested fish and prawns, and provide feeding grounds for dugongs and green turtles (Department of Fisheries [DoF], 2011a).

Seagrass distribution in the region is disjointed and typically found in and around inshore islands, small bays and inlets. No seagrass beds or macroalgal habitats occurs within the Operational Area, however they may be present along the Indonesian coastline within the EBMA. The nearest known seagrass habitats to the Operational Area are located around the Tiwi Islands, about 44 km south of the Operational Area (outside of the EMBA).

4.4.2.3 Mangroves

Mangrove systems provide complex structural habitats that act as nurseries for many marine species as well as nesting and feeding sites for many birds, reptiles and insects. Mangroves also maintain sediment, nutrient and water quality within habitats and minimise coastal erosion. No mangroves occur within the Operational Area; however, they may be present along the Indonesian coastline within in the EMBA. The closest known mangrove habitats are located on the coastline of the Tiwi Islands, about 44 km south of the Operational Area (outside of the EMBA).

4.4.3 Other Communities and Habitats

4.4.3.1 Plankton

Phytoplankton communities of the NMR are highly diverse (about 200 species) and are dominated by large, tropical diatom flora (single-celled algae) on the continental shelf. These are distinctly different in abundance and diversity from the oceanic single-celled algae that have two appendages (called flagella) that occur in the adjacent Coral Sea and Indian Ocean (DSEWPaC, 2012). The tropical nanoplankton of the NMR include diatoms, dinoflagellates and prymnesiophytes, and range in size from 2–20 µm. Offshore waters are dominated by the cyanobacterium *Trichodesmium* and the diatoms *Rhizosolenia* and *Thalassonema*, and deeper waters (more than 50 m) are dominated by the dinoflagellates *Dinophysis*, *Ceratium*, *Prorocentrum* and *Ceratocorys* (DSEWPaC, 2012).

Phytoplankton have marked seasonal cycles in tropical regions with higher productivity occurring during the cooler months and lower productivity in the warmer months (Blondeau-Patisser et al., 2011; Schroeder et al., 2009). Zooplankton may include organisms that complete their life cycle as plankton (e.g. copepods, euphausiids) as well as larval stages of other taxa such as fishes, corals and molluscs.

4.4.3.2 Pelagic and Demersal Fish and Shellfish Populations

The tropical waters of the Northern Territory (NT) are home to a wide variety of economically, socially and culturally important fish species. In 2012, baited camera systems (stereo-BRUVS) were deployed within the Oceanic Shoals Australian Marine Park (AMP) (Australian Institute of Marine Science [AIMS], 2015). The study recorded several shark species, including the great hammerhead (*Sphyrna mokarran*), tiger shark (*Galeocerdo cuvier*), spot-tail shark (*Carcharhinus sorrah*), grey reef shark (*Carcharhinus amblyrhynchos*), pigeye shark, blacktip shark and silky shark. Several fish species were also identified, including the giant trevally (*Caranx ignobilis*), grey mackerel (*Scomberomorus semifasciatus*), barracuda (*Sphyraena* spp.), black marlin (*Istiompax indica*) and manta ray (*Manta birostris*).

Pelagic species found within the troughs of the Timor Transition provincial bioregion include snaggle-teeth fish, hatchet fish and lantern fish (DEWHA, 2008). At least 284 demersal fish species have been found in the Timor Transition provincial bioregion, including red snappers (*Lutjanus erythropterus*) (DEWHA, 2008). Demersal species reported to be caught by recreational fishers at Evans Shoal, Tassie Shoal and Lynedoch Bank include goldband snapper, nannygai, red emperor, coral trout and rankin cod (Arafura Bluewater, 2020). Protected fish species are detailed in **Table 4-4**, whilst commercially targeted pelagic and demersal fish species are described below.

The fishes of the Arafura Sea includes 527 species from 141 families, slightly less than the number of fish families/species of the North-west Shelf (134 families, 666 species) (Russell and Houston, 1989). The majority of fishes of the Arafura Sea (111 families, 481 species) are shallow-water, benthic forms that typically inhabit water depths down to around 100 m, with the remaining families/species mainly deeper water, epipelagic forms (Russell and Houston, 1989). A few families dominate the fish fauna of the Arafura Sea; including Carangidae (e.g. trevally), Lutjanidae (snapper), Carcharinidae (whaler shark), Leiognathidae (e.g. ponyfish), Nemipteridae (coral bream), Platycephalidae (flathead), Serranidae (cod, grouper), Scorpanidae (scorpionfish), Mullidae (red mullet) and Bothidae (left-eyed flounder), containing around 34% of the total number of species (Russell and Houston, 1989). Additionally, two families are endemic to the Arafura Sea: Tetrabrachiidae (frogfish) and Leptobramidae (beach salmon) (Russell and Houston, 1989).

Commercially Targeted Fish Species

The NMR provides fishing grounds for several commercial fisheries that target a variety of demersal and pelagic fish species. Indicator species are selected from the suite of commercially targeted finfish (based on their inherent vulnerability, management importance and overall risk to sustainability) for assessing the status of the overall resource.

The NT Department of Industry, Tourism and Trade (DITT) (Fisheries) monitors the key biological fish stocks in the NT, following the national reporting framework used in the Status of Key Australian Fish Stocks Reports 2018 (Stewardson et al., 2018).

As described for each individual key indicator fish species in the Australian Fisheries Research and Development Corporation (FRDC) Status of Australian Fish Stocks (SAFS) Reports (FRDC, 2019), fish stock structures are considered in terms of both their genetic stocks and fishery management units. Biological stocks are discrete populations of a fish species, usually in a given geographical area and with limited interbreeding with other biological stocks of the same species (NT Government, 2019). The level of mixing from egg and larval dispersal is influenced by the spatial-temporal patterns of spawning relative to the prevailing oceanographic currents, the duration of the spawning period and the periodicity of spawning. For example, a species that spawns over a large portion of the continental shelf for a protracted period will very likely have a high level of egg and larval dispersal resulting in a wide spatial stock extent (Gaughan et al., 2018). This is the case with all of the key indicator fish species in NT, which spawn throughout their ranges and on multiple occasions during protracted spawning periods (Gaughan et al., 2018).

There is considerable bidirectional mixing of pelagic eggs and larvae in both directions in the NMR therefore, for species that are relatively evenly distributed throughout their range and with spawning seasons that extend over several months, there is a high propensity for alongshore mixing over large distances (Gaughan et al., 2018). The eggs and larvae released by spawning adult demersal fish in the region may disperse for several days or weeks and may travel for hundreds of kilometres or more before settling on the seabed (Newman et al., 2000; Mackie et al., 2009, 2010; Marriott et al., 2012; Berry et al., 2012; Gaughan et al., 2018). The biological stocks, therefore, represent the area where the exchange of larvae and subsequent recruitment of juvenile fish to the stocks occurs over many years (Martin et al., 2014; Gaughan et al., 2018).

Table 4-5 summarises the key indicator fish and shellfish species that are relevant to the Operational Area, the spatial extent of their biological stocks, and their reproductive biology.

Table 4-3: Key indicator fish and shellfish species for commercial fisheries relevant to the Operational Area

Species	Distribution and habitat	Biological stock range	Principal depth range	Reproduction and recruitment	Stock status	Spawning season	Relevance to EP
Demersal species							
White banana prawn (*Penaeus merguiensis*) Redleg banana prawn (*P. indicus*)	Banana prawns inhabit tropical and subtropical coastal waters. They are found over muddy and sandy bottoms in coastal waters and estuaries. Juveniles inhabit small creeks and rivers in sheltered mangrove environments.	The biological stock structure of banana prawns is uncertain. There is some evidence that there may be separate biological stocks of banana prawns within the Northern Prawn Fishery (NPF) (Commonwealth-managed); however, the boundaries of the biological stocks are unknown (FRDC, 2018; Yearsley et al., 1999). Stock status is presented at the management unit level. Relevant to the Operational Area is the stock belonging to the NPF.	White banana prawns can generally be found at depths of 16 m – 25 m but can occur to depths of 45 m. Redleg banana prawns are found at depths of 35 – 90 m (AFMA, 2021a).	Banana prawns reach reproductive maturity at about 0.5 years of age and have an average lifespan of 1-2 years (Huber, 2003; Tanimoto et al., 2006; Yearsley et al., 1999). Spawning occurs in shallow coastal waters where eggs are shed into the water after moulting and are fertilised externally. Banana prawns are serial spawners and each female can lay several egg batches each year. Females produce 100,000 – 450,000 eggs per year depending on their body size. Eggs hatch within 24 hours of fertilisation. Joseph Bonaparte Gulf is identified as a key site for redleg banana prawn spawning and recruitment, as well as fishing for the species (Loneragan et al. 2002). Recruitment of banana prawns in the NPF is highly variable and thought to be largely determined by seasonal environmental conditions, particularly rainfall (FRDC, 2021; Venables et al., 2011).	Sustainable	Spawning occurs year-round with two spawning peaks from September – November and from March – May (AFMA, 2021).	Given the known distribution and habitat depths, banana prawns may occur in the Operational Area in low concentrations, but are highly unlikely to spawn in significant numbers in the Operational Area due to the species preferred spawning location in coastal bays and gulfs. Further, peak spawning occurs outside of the proposed survey period.
Brown tiger prawn (*P. esculentus)* Grooved tiger prawn *(P. semisulcatus*)	Brown tiger prawns are endemic to tropical and subtropical waters of Australia, while grooved tiger prawns have a wider Indo–West Pacific distribution (FRDC, 2018). Adult brown tiger prawns are found over coarse sediments, while adult grooved tiger prawns are found in fine mud sediments (AFMA, 2021a). Juvenile tiger prawns are found in shallow waters, often in association with seagrass beds, and sometimes on top of coral reef platforms (AFMA, 2021a).	There is some genetic evidence of separation of brown tiger prawn stocks from the east and west coasts of Australia (FRDC, 2018; Ward et al., 2006). Stock status is presented at the management unit level. Relevant to the Operational Area is the brown tiger prawn and grooved tiger prawn stock belonging to the NPF.	Tiger prawns inhabit coastal and shelf waters up to depths of 200 m (AFMA, 2021).	Tiger prawns reach reproductive maturity at about 0.5 years of age and have a lifespan up to 2-years (Kangas et al., 2015; Somers, 1987; Yearsley et al., 1999). Spawning occurs in both inshore and offshore areas for brown tiger prawns and in offshore areas for grooved tiger prawns. Mating occurs during moulting, with the male implanting a spermatophore (sperm package) into the female's spermatheca (sperm storage organ). Eggs are shed into the water after moulting and are fertilised externally by sperm from the spermatheca. Females produce about 186,000 eggs (brown tiger prawns) and 365,000 eggs (grooved tiger prawns) per year depending on their body size. Eggs hatch within 24 hours of fertilisation.	Sustainable	Spawning occurs year-round. Brown tiger prawns have a spawning peak between July and October. Grooved tiger prawns have a spawning peak from August – September, with a secondary peak in February.	Given the known distribution and habitat depths, adult tiger prawns may occur and may spawn within the Operational Area, particularly during their August peak spawning time. However, the Operational Area is not located near key fishing or spawning grounds (e.g. Gulf of Carpentaria and Arnhem Land coast).
Goldband snapper (*Pristipomoides multidens*)	Goldband snapper are widely distributed throughout the Indo-Pacific region from Samoa to the Red Sea. In Australian waters, they are found from Cape Pasley, Western Australia (WA) across the north to Moruya, New South Wales (NSW) (NT Government, 2018a). Goldband snapper occur around offshore reefs, shoals, and areas of hard flat bottom with occasional benthos or vertical relief. Juveniles typically occur on uniform sedimentary habitat with no relief (Newman et al., 2008).	Stock status is presented at the management unit level. Relevant to the Operational Area is the stock belonging to the NT management unit.	Goldband snapper are found at depths between 50 m and 200 m (DPIRD, 2018). However, the species is more concentrated in depths from 80 m – 150 m (Allen, 1985; unpublished data cited in Newman et al., 2000).	Goldband snapper reach reproductive maturity about 4–5 years and have a lifespan of up to 28 years (Jackson et al., 2020). Goldband snapper are highly fecund, serial, broadcast spawners and they can produce several million eggs per season (Newman et al., 2008). They spawn throughout their range (DPIRD, 2019).	Sustainable	Spawning occurs between October to May (DPIRD, 2018)	Given the known distribution and habitat depths, goldband snapper are likely to occur and may spawn within the Operational Area. However, spawning occurs outside of the proposed survey period.
Saddle-tail snapper (*Lutjanus malabaricus*)	Saddle-tail snapper are widely distributed throughout the Indo-Pacific region from Fiji to the Persian Gulf and tropical Australian waters. In Australian waters, they are found from Shark Bay in WA, across northern Australia to the east coast of Queensland over a wide depth range, from coastal to offshore areas.	Stock status is presented at the management unit level. Relevant to the Operational Area is the stock belonging to the NT management unit.	The depth distribution for this species has not been well defined in the NT. This species is expected to be found between 5 m and 100 m (Salini et al., 2006).	Saddle-tail snapper reach reproductive maturity at about 9-years and have a lifespan of about 30-years (FRDC, 2018; Fry et al., 2009). There is a distinct difference in length at first maturity between the sexes, with male saddle-tail snappers first reaching sexual maturity at around 240 mm whereas females began maturing between 250 and 300 mm. Published data available on the reproductive characteristics of tropical lutjanides indicate that most species are highly fecund, serial spawners with a	Sustainable	Spawning occurs throughout the year, with a peak between September and March (Fry et al., 2009).	Given the known distribution and habitat depths, saddle-tail snapper may occur in the Operational Area and may spawn throughout their range. However, peak spawning time occurs outside of the

Species	Distribution and habitat	Biological stock range	Principal depth range	Reproduction and recruitment	Stock status	Spawning season	Relevance to EP
				protracted spawning season (Davis and West, 1993; Grimes, 1987; Kritzer, 2004; Marriot et al., 2007; Shimose, 2005). Northern Australian populations of saddle-tail snapper show a single-modal cycle in their reproductive activity (Fry et al., 2009). The species has been recorded producing up to 997,000 oocytes per batch (Fry et al., 2009). Preferred spawning depths have not been identified for this species in the region.			proposed survey period.
Crimson snapper (*Lutjanus erythropterus*)	Crimson snapper are widely distributed throughout the Indian Ocean and the tropical parts of the Western Pacific Ocean, ranging from India through the entire Malay Archipelago to China, the Philippines and Australia (Allen and Talbot 1985). In Australian waters, they are found from Shark Bay in WA to central NSW over a wide depth range, from coastal to offshore areas (NT Government, 2018).	Stock status is presented at the management unit level. Relevant to the Operational Area is the stock belonging to the NT management unit.	The depth distribution for this species has not been well defined in the NT. This species is expected to be found between 5 m and 100 m (Salini et al., 2006).	Male crimson snapper reach reproductive maturity at about 240 mm whereas females begin maturing between 250 and 300 mm. The species has a lifespan of about 40-years (FRDC, 2018; Fry et al., 2009). Published data available on the reproductive characteristics of tropical lutjanids indicate that most species are highly fecund, serial spawners with a protracted spawning season (Davis and West, 1993; Grimes, 1987; Kritzer, 2004; Marriot et al., 2007; Shimose, 2005). Northern Australian populations of crimson snapper show a single-modal cycle in their reproductive activity (Fry et al., 2009). The species has been recorded producing up to 676,100 oocytes per batch (Fry et al., 2009).	Sustainable	Spawning occurs throughout the year, with a peak between July and December (Fry et al., 2009).	Given the known distribution and habitat depths, crimson snapper may occur in the Operational Area and may spawn throughout their range, particularly during their July and August peak spawning times.
Red emperor (*L. sebae*)	Red emperor occur from the central west coast of WA to southern Queensland (Newman et al. 2018a). Red emperor are widely distributed across the continental shelf and associated with reefs, lagoons, epibenthic communities, limestone sand flats and gravel patches (Newman et al., 2008).	The reproductive biology of red emperor results in a very broad distribution of eggs and larvae, which results in genetic connectivity over a wide geographic range (Gaughan et al., 2018). There is extensive connectivity and gene flow among populations across northern Australia (Queensland to Shark Bay in WA), indicating a single genetic stock (Newman et al., 2018). There is no evidence of discrete breeding populations between regions (Gaughan et al., 2018). Stock status is presented at the management unit level. Relevant to the Operational Area is the stock belonging to the NT management unit.	Red emperor are usually found in waters between 5 and 100 m (DPIRD, 2018: NT Government, 2020)	Red emperor are highly fecund, serial, broadcast spawners. Females release numerous batches of eggs over an extended spawning period. (Newman et al., 2008; Gaughan et al., 2018). They spawn throughout their range (DPIRD, 2019). Juvenile fish are more common in nearshore waters and move offshore and recruit to the stock as they mature (Newman et al., 2008; van Herwerden et al., 2009). Fish are estimated to reach maturity after approximately 4 – 6 years (Newman et al., 2018a).	Sustainable	The species spawns for 8-10 months of the year. The main spawning season is June – December and March (peaks August – October) (DPIRD, 2018)	Given the known distribution and habitat depths, red emperor may occur in the Operational Area and may spawn throughout their range, particularly during their winter peak spawning times.
Pelagic species							
Spanish mackerel (*Scomberomorus commerson*)	Spanish mackerel are a pelagic species that are widely distributed throughout Indo-West Pacific waters. In Australia, Spanish mackerel are found from approximately Geraldton in WA to northern NSW (FRDC, 2018). Adult movements in Australian waters occur over ranges of 100 – 300 km (Mackie et al., 2010). Spanish mackerel are commonly associated with coral reefs, rocky shoals and current lines on outer reef areas and offshore water to inshore shallow water of low salinity and high turbidity (NT Government, 2020).	Stock status is presented at the management unit level. Relevant to the Operational Area is the stock belonging to the NT management unit.	Spanish mackerel are usually found in waters 1–50 m (DPIRD, 2018; NT Government, 2020).	Spanish mackerel spawning in occurs in coastal waters where they form spawning schools around inshore reefs in the north coast bioregion (Mackie et al., 2010; Lewis and Jones, 2018). They are serial spawners and alongshore dispersal of eggs maintains genetic homogeneity (Mackie et al., 2010). Females are capable of producing a batch of hundreds of thousands of eggs every 1-3 days during the spawning season, though a spawning frequency of 1.9 to 5.9 days has also been reported (McPherson, 1993; Mackie et al., 2010). Larvae are commonly associated with reef lagoonal areas, before juveniles move to estuary and foreshore nursery and feeding grounds where they tend to remain for the first year of life (McPherson, 1993; Begg et al., 2006; Mackie et al., 2010). Fish are estimated to reach maturity after approximately 2 years (FRDC, 2018).	Sustainable	September – December (peak spawning) (DPIRD, 2018).	Given the known distribution and habitat depths, Spanish mackerel may occur in the Operational Area, but are unlikely to spawn in the Operational Area due to the species preferred spawning location in shallow coastal waters. Further, peak spawning occurs outside of the proposed survey period.
Grey mackerel	Grey mackerel have a restricted distribution and are confined to the waters of southern Papua New Guinea	Stock status is presented at the management unit level. Relevant to the	Grey mackerel are usually found in water depths of about 3–	Grey mackerel have a lifespan of about 14-years, with females reaching maturity at around 2-years while males reach maturity between 1-2 years (Cameron and Begg,	Sustainable	August – January, though this is thought to be temperature	Given the known distribution and habitat depths, grey mackerel

Species	Distribution and habitat	Biological stock range	Principal depth range	Reproduction and recruitment	Stock status	Spawning season	Relevance to EP
(*Scomberomorus semifasciatus*)	and around northern Australia from the Houtman Abrolhos Islands on the west coast to northern NSW on the east coast (NT Government, 2020). Adult grey mackerel are known to commonly occur in turbid tropical and subtropical waters at approximately 3–30 m depth. This is usually in the vicinity of bottom structure in close proximity to headlands and reefs and on sandy mud and muddy sand substrates (NT Government, 2020).	Operational Area is the stock belonging to the NT management unit.	30 m (NT Government, 2020).	2002; Department of Agriculture and Fisheries, 2016). Grey mackerel grow rapidly and are highly fecund, producing approximately 250,000 oocytes per spawning (NT Government, 2020). They form spawning schools that are predictable enough both spatially and temporally to be targeted by fisheries (NT Government, 2020). Once hatched, larvae of this species move to the inner margins of coastal bays and also into estuaries (Jenkins et al., 1985). Juveniles grow rapidly in estuarine habitats and move into coastal environments as they mature.		dependent and potentially extended in northern regions (Welch et al., 2009)	are unlikely to occur in the Operational Area in significant numbers and are therefore unlikely to spawn within the Operational Area. Further, most spawning occurs outside of the proposed survey period.

4.4.3.3 Benthic Communities

The NMR consists mostly of shallow continental shelf characterised by flat terrain, with depth increasing gradually by about one metre every kilometre (DSEWPaC, 2012). Complex geomorphic features including banks, valleys, slopes and canyons are present within the Arafura Shelf and are present within the Operational Area and EMBA.

As described in **Section 4.3**, the majority of the seabed within the Operational Area can be characterised by a largely uniform slope of moderate gradient covering the mid-outer continental shelf and slope (**Figure 4-7**). Sediment within the Operational Area largely consists of sandy substrate to soft muddy sediments. Two banks are located within the Operational Area, Lynedoch Bank and Goodrich Bank (**Figure 4-9**).

In 2017, the Australian Institute of Marine Science (AIMS) developed a regional model to predict the distribution of coarse benthic habitat classes within the Oceanic Shoals Australian Marine Park (AMP—hereinafter referred to as the Oceanic Shoals Marine Park) (AIMS, 2017). The boundaries of the model partially overlaps with the Operational Area and the spatial distribution of habitat classes are shown in **Figure 4-9**. Apart from Lynedoch Bank, the model largely predicts no biota to occur within the portion of the Oceanic Shoals Marine Park that overlaps the Operational Area, with patches of burrowers and filterers potentially occurring at the southern extent of the Operational Area.

Seabed habitat in the north-west of the Operational Area was surveyed in 2015 (Jacobs 2016). The survey included eight sites in depths ranging from 211 to 309 m and found that sediment was predominantly comprised of silty sand lacking hard substrate (Jacobs 2016). Octocorals (particularly sea pens) and decapod crustaceans (mostly prawns and squat lobsters) were observed in low numbers. Bioturbation was frequently observed at these depths and attributed to the activity of polychaetes, crustaceans, bivalves, molluscs, echinoderms and potentially fish.

A number of banks and shoals exist within the Timor Sea region which are broadly characterised by tropical marine biota of the Indo West Pacific regions. Heyward et al. (2017a) investigated prominent shoals within the region using towed video surveys, including Goodrich Bank (located within the Operational Area) and Evans Shoal, Tassie Shoal, Blackwood Shoal (located within the EMBA). Jacobs (2016) also qualitatively classified habitat and biota at Lynedoch Bank, Evans Shoal and Tassie Shoal. The surveys identified benthic classes to the highest possible taxonomic classification, which broadly included hard corals, soft corals, algae, seagrass, sponges, other animals and abiotic. Heyward et al. (2017a) found that the submerged shoals featured habitats consistent with other outer shelf shoals in the North and North-west marine regions, including the Margaret Harries Banks, the Sahul Banks and the Karmt Shoals. Mid-shelf areas adjacent to banks were typically characterised by large areas of bare seabed, occasionally supporting patchy filter feeder habitats associated with limited areas of consolidated substrate. Sponges were the dominant fauna, consistent with other studies in turbid shelf areas in this region, with gorgonian soft corals generally making lesser contributions to the mixed filter feeder communities (Heyward et al., 2017). Fish abundance was below average in deeper waters and above average in shallows under 30 m and was mostly influenced by the presence of any epibenthos on the seafloor and by calcareous reef composition of the substrate (Heyward et al., 2017).

The named banks and shoals within the Operational Area and EMBA are identified in **Figure 4-8**. Several unnamed shoals occur within the wider EMBA. A string of shoals is located west of the Operational Area and within the EMBA, beginning with Tassie Shoal and ending at Echo Shoals, located about 38 km and 328 km west of the Operational Area, respectively. Several banks and shoals occur south and south-west of the Operational Area between Marie Shoal and Flat Top Bank, 16 km and 166 km from the Operational Area, respectively. Available information on the banks and shoals that have been surveyed, as described by AIMS (2017), Jacobs (2016) and Heyward et al. (2017a) is provided below.

Lynedoch Bank

Lynedoch Bank is located on the western boundary of the Timor Transition provincial bioregion and within the Active Source Area. Lynedoch Bank is characterised by a reef flat occurring in depths of about 14 m – 20 m, bordered by gentle slopes rising from depths of about 70 m – 90 m. Sand and rubble dominates the reef flat with hard corals, sponges and soft corals present (Jacobs, 2016). Hard corals were mostly categorised as branching, encrusting (i.e. low spreading) and massive (i.e. ball-shaped with stable profiles).

Jacobs (2016) found the western slope of Lynedoch Bank was inhabited by small reef fish (Family Pomacanthidae). The reef flat was inhabited by reef fish including representatives from the families Chaetodontidae, Labridae and Zanclidae. Whitetip reef sharks, a seasnake and a moray eel were also observed. The eastern slope of Lynedoch Bank was reported to have noticeably low abundance of mobile biota including fish and sharks.

Goodrich Bank

Goodrich Bank is located adjacent to the Active Source Area and within the Operational Area. Towed video surveys found Goodrich Bank to contain complex bathymetry characterised by a series of undulating banks with depth ranges between about 100 m and 15 m (AIMS, 2015). The bathymetry has been attributed to a legacy of past sea level, with strong tidally-driven currents bringing turbid water over the ridges and valleys (AIMS, 2015).

Substrate on the banks is variable and includes sand, rubble patches and limestone outcrops. The epibenthic communities found on the banks are sparse, with low-medium density filter feeders occasionally found in depths less than 60 m and in association with small scale patches of consolidated substrate. Phototrophic species, such as hard corals, are rare and only occur at the shallowest areas of the banks in waters less than 30 m (AIMS, 2015). The substrate in the valleys between the banks is primarily comprised of sand and does not support any significant benthic communities. The sparse coverage of benthic communities at Goodrich Bank is attributable to the high water turbidity causing low levels of surface light penetration (AIMS, 2015).

Marie Shoal

Marie Shoal (also known as Marie Reef) is located about 16 km south of the Operational Area and within the EMBA. The AIMS benthic habitat map provides a prediction of benthic habitats within the Oceanic Shoals AMP extrapolated for physical and environmental survey data collected in the AMP and suggests that burrowers, crinoids and filter feeder communities are expected at Marie Shoal (Heyward et al., 2017) (**Figure 4-9**). Marie Shoal is likely to attract similar fish species as other offshore shoals in the region, including reef fish from the families Chaetodontidae, Labridae and Zanclidae.

Evans Shoal

Evans Shoal is located 45 km west of the Operational Area and within the EMBA. The shoal is characterised by a large plateau area of about 43 km^2 with low vertical relief and extensive sand and rubble (Heyward et al., 2017). Four sites at Evans Shoal were surveyed by Heyward et al. (2017a). The survey found that the benthic environment at Evans Shoal is dominated by sandy bare substrates or forms of low relief algae, with varying densities of the calcareous green macroalga *Halimeda* and the small solitary coral genus *Heteropsammia* (Heyward et al., 2017). Hard coral was largely absent from the Evans Shoal plateau, however a single large bommie of *Pavona clavus* was reported in the south-western quadrant, measuring 75 m in diameter. A dense band of foliaceous coral was also recorded in multiple transects at a depth of 40 m, extending down the slope before transitioning to sparse filter feeder areas.

Tassie Shoal

Tassie Shoal is located 38 km west of the Operational Area and within the EMBA. Tassie Shoal is characterised by a small plateau area of about 5.3 km^2 containing a complex arrangement of low relief ridges and small bommies, interspersed with patches of sand and rubble (Heyward et al., 2017). The edge of the plateau is characterised by a gentle slope with sediment comprising of fine sand, coarse sand and gravel. Tassie Shoal supports highly diverse fish communities and relatively high levels of fish abundance when compared to other shoals around Australia (Heyward et al., 2017).

Three sites at Tassie Shoal were surveyed by Heyward et al. (2017). The composition of the benthic communities were reported to be similar to that of Evans Shoal, however coral cover on Tassie Shoal was more commonly ‘medium’ density rather than sparse. The epifauna at Tassie Shoal is characterised by syllid polychaetes (worms), tanaid crustaceans, foraminifera, brittlestars and fibularid echinoderms (urchins) (Jacobs, 2016). Similar to Evans Shoal, a single large bommie of the coral *Pavona clavus* was recorded on the south-western quadrant, though of a much smaller size.

Blackwood Shoal

Blackwood Shoal is located 62 km west of the Operational Area, but within the EMBA, and is characterised by a small and shallow plateau of about 0.7 km^2. Video surveys conducted in 2015 reported coral habitat was a consistent feature across the small shoal plateau, with a mean coverage of 25% (medium to high density) (Heyward et al., 2017).

Margaret Harries Bank

Margaret Harries Bank comprises a series of shoals located about 122 km west of the Operational Area at the outer extent of the EMBA. Towed video surveys conducted in 2015 identified benthic habitat dominated by limestone and hard coral outcrops, with some rubble present (Heyward et al., 2017). Forms of low relief algae were also identified, comprising varying densities of *Halimeda*.

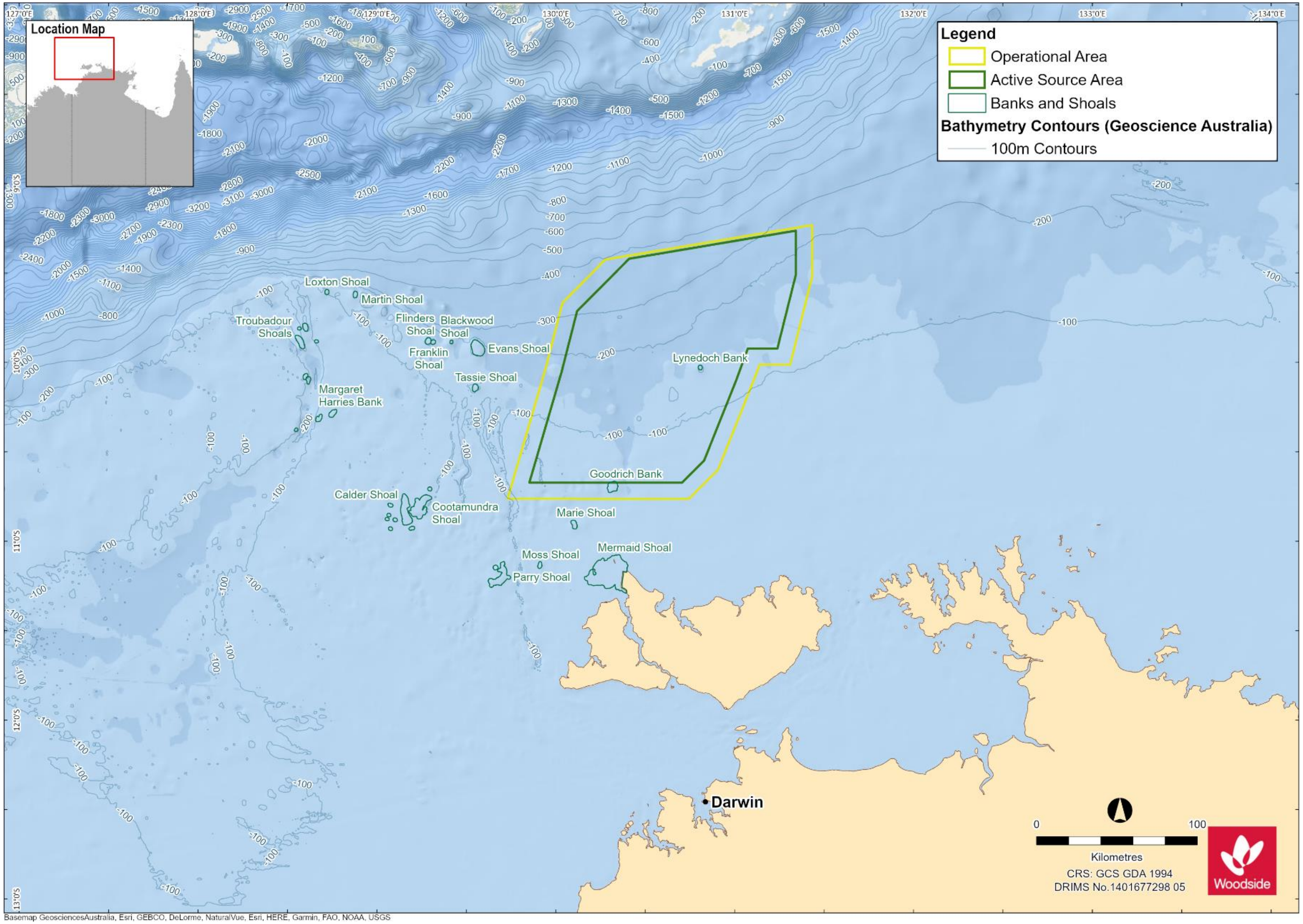


Figure 4-8: Banks and shoals located in the Operational Area and EMBA

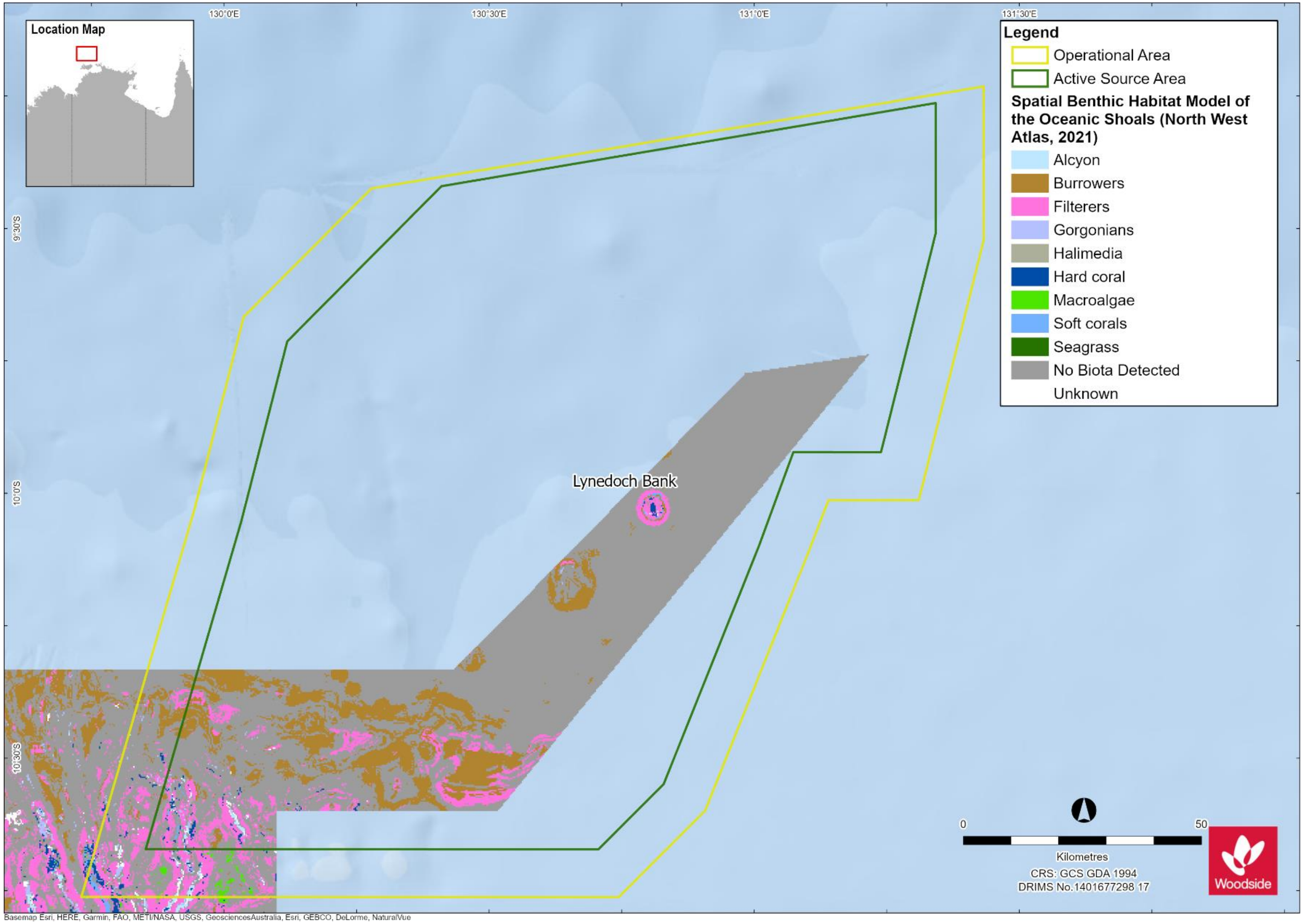


Figure 4-9: Benthic habitats of the Oceanic Shoals Marine Park (adapted from Northwest Atlas, 2021)

4.4.4 Protected Species

The EPBC Act Protected Matters Search Tool (PMST) has been used to identify listed species under the EPBC Act that may occur within the Operational Area and EMBA. The results of the search inform the assessment of impacts and risks in **Section 6.4** and **6.5**. It should be noted that the EPBC Act PMST is a general database that conservatively identifies areas in which protected species have the potential to occur.

A total of 42 listed species considered to be MNES were identified as potentially occurring within the EMBA, of which a subset of 38 species were identified as potentially occurring within the Operational Area (**Table 4-4**). The full list of marine species identified from the PMST report is provided in **Appendix C**, including several MNES that are not considered to be credibly impacted (e.g. terrestrial species within the EMBA). One conservation dependent species has also been identified as potentially occurring within the Operational Area and EMBA, the scalloped hammerhead. Species identified as potentially occurring within the Operational Area and EMBA are described in **Section 4.4.4.5**.

Table 4-4: Threatened and migratory marine species under the EPBC Act potentially occurring within the Operational Area and EMBA

Species name	Common name	Threatened status	Migratory status	Potential for occurrence	
				Operational Area	***EMBA***
Marine mammals					
Balaenoptera borealis	Sei whale	Vulnerable	Migratory	Species or species habitat likely to occur	Species or species habitat likely to occur
Balaenoptera musculus	Blue whale	Endangered	Migratory	Species or species habitat likely to occur	Species or species habitat likely to occur
Balaenoptera physalus	Fin whale	Vulnerable	Migratory	Species or species habitat likely to occur	Species or species habitat likely to occur
Megaptera novaeangliae	Humpback whale	Vulnerable	Migratory	Species or species habitat likely to occur	Species or species habitat likely to occur
Balaenoptera edeni	Bryde's whale	N/A	Migratory	Species or species habitat may occur	Species or species habitat may occur
Orcinus orca	Killer whale	N/A	Migratory	Species or species habitat may occur	Species or species habitat may occur
Physeter macrocephalus	Sperm whale	N/A	Migratory	Species or species habitat may occur	Species or species habitat may occur
Tursiops aduncus (Arafura/Timor Sea populations)	Spotted bottlenose dolphin	N/A	Migratory	Species or species habitat may occur	Species or species habitat known to occur
Dugong dugon	Dugong	N/A	Migratory	X	Species or species habitat known to occur
Sousa chinensis	Indo-Pacific humpback dolphin	N/A	Migratory	X	Species or species habitat may occur
Orcaella heinsohni	Australian snubfin dolphin	N/A	Migratory	X	Species or species habitat known to occur
Marine reptiles					
Caretta caretta	Loggerhead turtle	Endangered	Migratory	Species or species habitat likely to occur	Species or species habitat known to occur

Species name	Common name	Threatened status	Migratory status	Potential for occurrence	
				Operational Area	***EMBA***
Chelonia mydas	Green turtle	Vulnerable	Migratory	Species or species habitat known to occur	Breeding known to occur
Eretmochelys imbricata	Hawksbill turtle	Vulnerable	Migratory	Species or species habitat known to occur	Breeding known to occur
Lepidochelys olivacea	Olive Ridley turtle	Endangered	Migratory	Species or species habitat known to occur	Breeding known to occur
Dermochelys coriacea	Leatherback turtle	Endangered	Migratory	Species or species habitat likely to occur	Species or species habitat known to occur
Natator depressus	Flatback turtle	Vulnerable	Migratory	Congregation or aggregation known to occur	Breeding known to occur
Crocodylus porosus	Salt-water crocodile	N/A	Migratory	Species or species habitat likely to occur	Species or species habitat likely to occur
Fish, sharks and rays					
Carcharodon carcharias	White shark	Vulnerable	Migratory	Species or species habitat may occur	Species or species habitat may occur
Glyphis garricki	Northern river shark	Endangered	N/A	Species or species habitat may occur	Species or species habitat may occur
Glyphis glyphis	Speartooth shark	Critically endangered	N/A	Species or species habitat may occur	Species or species habitat may occur
Pristis clavata	Dwarf sawfish	Vulnerable	Migratory	Species or species habitat known to occur	Species or species habitat known to occur
Pristis pristis	Freshwater sawfish	Vulnerable	Migratory	Species or species habitat known to occur	Species or species habitat known to occur
Pristis zijsron	Green sawfish	Vulnerable	Migratory	Species or species habitat known to occur	Species or species habitat known to occur
Rhincodon typus	Whale shark	Vulnerable	Migratory	Species or species habitat may occur	Species or species habitat may occur

Species name	Common name	Threatened status	Migratory status	Potential for occurrence	
				Operational Area	*EMBA*
Anoxypristis cuspidata	Narrow sawfish	N/A	Migratory	Species or species habitat may occur	Species or species habitat known to occur
Carcharhinus longimanus	Oceanic whitetip shark	N/A	Migratory	Species or species habitat may occur	Species or species habitat may occur
Isurus paucus	Longfin mako	N/A	Migratory	Species or species habitat likely to occur	Species or species habitat likely to occur
Manta alfredi	Reef manta ray	N/A	Migratory	Species or species habitat likely to occur	Species or species habitat likely to occur
Manta birostris	Giant manta ray	N/A	Migratory	Species or species habitat likely to occur	Species or species habitat likely to occur
Isurus oxyrinchus	Shortfin mako	N/A	Migratory	X	Species or species habitat likely to occur
Seabirds and shorebirds					
Calidris canutus	Red knot	Endangered	Migratory	Species or species habitat may occur	Species or species habitat may occur
Calidris ferruginea	Curlew sandpiper	Critically endangered	Migratory	Species or species habitat may occur	Species or species habitat may occur
Numenius madagascariensis	Eastern curlew	Critically endangered	Migratory	Species or species habitat may occur	Species or species habitat may occur
Anous stolidus	Common noddy	N/A	Migratory	Species or species habitat may occur	Species or species habitat likely to occur
Calonectris leucomelas	Streaked shearwater	N/A	Migratory	Species or species habitat likely to occur	Species or species habitat known to occur
Fregata ariel	Lesser frigatebird	N/A	Migratory	Species or species habitat may occur	Species or species habitat likely to occur
Fregata minor	Great frigatebird	N/A	Migratory	Species or species habitat may occur	Species or species habitat likely to occur
Actitis hypoleucos	Common sandpiper	N/A	Migratory	Species or species habitat may occur	Species or species habitat may occur

Species name	Common name	Threatened status	Migratory status	Potential for occurrence	
				Operational Area	***EMBA***
Calidris acuminata	Sharp-tailed sandpiper	N/A	Migratory	Species or species habitat may occur	Species or species habitat may occur
Calidris melanotos	Pectoral sandpiper	N/A	Migratory	Species or species habitat may occur	Species or species habitat may occur
Pandion haliaetus	Osprey	N/A	Migratory	Species or species habitat may occur	Species or species habitat may occur
Thalasseus bergii	Greater crested tern	N/A	Migratory	X	Breeding likely to occur
Erythrotriorchis radiatus	Red goshawk	Vulnerable	N/A	X	Species or species habitat may occur
Limosa lapponica baueri	Bar-tailed godwit	Vulnerable	Migratory	X	Species or species habitat may occur
Rostratula australis	Australian painted snipe	Endangered	N/A	X	Species or species habitat may occur
Apus pacificus	Fork-tailed swift	N/A	Migratory	X	Species or species habitat likely to occur

4.4.4.1 Listed Threatened Species Recovery Plans and Conservation Advice

Conservation advice and recovery plans for listed threatened species, threat abatement plans for key threatening processes, and wildlife conservation plans for listed migratory/marine species and cetaceans, are developed and implemented under Part 13 of the EPBC Act (refer **Section 1.9.1.3.1**).

Recovery plans are enacted under the EPBC Act and remain in force until the species is removed from the threatened list. Conservation advice provides guidance on immediate recovery and threat abatement activities that can be undertaken to facilitate the conservation of a listed species or ecological community.

Table 4-5 outlines the Part 13 statutory instruments relevant to those species identified by the EPBC Protected Matters search.

A screening process was conducted to identify which of these species, and associated Part 13 statutory instruments, are relevant in the context of the assessment of impacts and risks associated with the Petroleum Activities Program. The following criteria were used for this screening:

- Overlap between Operational Area and EMBA with Habitat Critical for the survival of marine turtles, and with BIAs for any listed threatened species as reported in the PMST searches.
- Published literature, unpublished reports and/or credible anecdotal information (e.g. feedback from stakeholders) indicating species presence/occurrence within the Operational Area.
- Temporal overlap between the timing of the Petroleum Activities Program and peak periods for key behaviours (e.g. breeding, nesting, calving, resting, foraging, migration).
- An aspect associated with the activity has been identified as a key threat to the species in a Part 13 statutory instrument (e.g. anthropogenic noise, light emissions, marine debris, etc.).

For those Part 13 statutory instruments identified as relevant to the activity, the objectives, action areas and actions were considered during the assessment of impacts and risks (**Section 6.6**).

Table 4-5: Part 13 statutory instruments for EPBC listed species identified from PMST searchs

Species	EPBC Act Part 13 statutory instrument	Considered during impact / risk assessment (Y/N)	Relevant EP section
All vertebrate fauna			
All vertebrate fauna	Threat abatement plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE, 2018)	Y	**Section 6** and **Table 6-28**
Cetaceans			
Blue whale	Conservation management plan for the blue whale: *A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999* 2015-2025 (Commonwealth of Australia, 2015a)	Y	**Section 6** and **Table 6-25**
Humpback whale	Approved conservation advice for *Megaptera novaeangliae* (humpback whale) (Threatened Species Scientific Committee [TSSC], 2015c)	N	**N/A**
Sei whale	Conservation advice *Balaenoptera borealis* sei whale (TSSC, 2015a)	N	**N/A**
Fin whale	Conservation advice *Balaenoptera physalus* fin whale (TSSC, 2015b)	N	**N/A**
Marine reptiles			
Loggerhead turtle, hawksbill turtle, green turtle, olive ridley and flatback turtle	Recovery plan for marine turtles in Australia (Commonwealth of Australia, 2017a)	Y	**Section 6** and **Table 6-24**
Sharks and rays			
White shark	Recovery plan for the white shark (*Carcharodon carcharias*) (DSEWPaC, 2013)	Y	**Section 6**
Northern river shark	Approved Conservation Advice for *Glyphis garricki* (northern river shark) (DoE, 2014a)	Y	**Section 6**
Speartooth shark	Approved Conservation Advice for *Glyphis glyphis* (speartooth shark) (DoE, 2014b)	Y	**Section 6**

Species	EPBC Act Part 13 statutory instrument	Considered during impact / risk assessment (Y/N)	Relevant EP section
Dwarf sawfish	Approved Conservation Advice for *Pristis clavata* (dwarf sawfish) (DEWHA, 2009a)	Y	**Section 6**
Freshwater sawfish	Approved Conservation Advice for *Pristis pristis* (largetooth sawfish) (DoE, 2014c)	Y	**Section 6**
Green sawfish	Approved Conservation Advice for Green Sawfish (DEWHA, 2008c)	Y	**Section 6**
Northern river shark, speartooth shark, dwarf sawfish, freshwater sawfish, green sawfish	Sawfish and river shark multispecies recovery plan (DoE, 2015a)	Y	**Section 6** and **Table 6-27**
Whale shark	Conservation advice *Rhincodon typus* whale shark (TSSC, 2015d)	Y	**Section 6**
	Whale shark (*Rhincodon typus*) recovery plan 2005-2010[2] (DEH, 2005a)		
Shortfin mako	Listing Advice *Isurus oxyrinchus* shortfin mako shark (TSSC, 2014).	Y	**Section 6**
Seabirds and shorebirds			
Red knot	Conservation advice *Calidris canutus* red knot (TSSC 2016)	Y	**Section 6**
Curlew sandpiper	Conservation advice *Calidris ferruginea* curlew sandpiper (DoE, 2015c)	Y	
Eastern curlew	Conservation advice *Numenius madagascariensis* eastern curlew (DoE, 2015b)	Y	
Red goshawk	National recovery plan for the red goshawk *Erythrotiorchis radiates* (Department of Environment and Research Management [DERM], 2012)	Y	
Bar-tailed godwit	Conservation advice *Limosa lapponica bauera* bar-tailed godwit (DoE, 2016)	Y	
Australian painted snipe	Approved conservation advice for *Rostratula australis* (Australian painted snipe) (DoE, 2013)	Y	
All migratory shorebirds	Wildlife conservation plan for migratory shorebirds (Commonwealth of Australia, 2015b)	Y	

[2] While the Whale shark (*Rhincodon typus*) recovery plan ceased to be in effect on 1 October 2015, the conservation advice in this plan was considered to inform the context of the environmental risk assessment for the Petroleum Activities Program.

Species	EPBC Act Part 13 statutory instrument	Considered during impact / risk assessment (Y/N)	Relevant EP section
All migratory seabirds	Draft Wildlife Conservation Plan for Seabirds (Commonwealth of Australia, 2019)	Y	

4.4.4.2 Habitat Critical to the Survival of a Species (Habitat Critical)

In accordance with the EPBC Act Significant Impact Guidelines 1.1 – Matters of National Environmental Significance, an action is deemed to have a significant impact if there is a real chance or possibility that it will adversely affect Habitat Critical to the survival of a species.

A review of relevant recovery plans and conservation advice identified that the following Habitat Critical area overlaps the Operational Area:

- Internesting buffer Habitat Critical to the survival of flatback turtles defined by a 60 km radius around Tiwi Islands (Commonwealth of Australia, 2017a). Nesting occurs year-round with a peak from June to September.

The following Habitat Critical area overlaps with the wider EMBA:

- Internesting buffer Habitat Critical to the survival of olive ridley turtles defined by a 20 km radius around the Tiwi Islands (Commonwealth of Australia, 2017a). Nesting occurs year-round with a peak from April to August.

The overlap of the Operational Area and EMBA with Habitat Critical to the survival of a species is shown in **Figure 4-10**. Additional information on Habitat Critical areas is provided in the species-specific descriptions in **Section 4.4.4.5**.

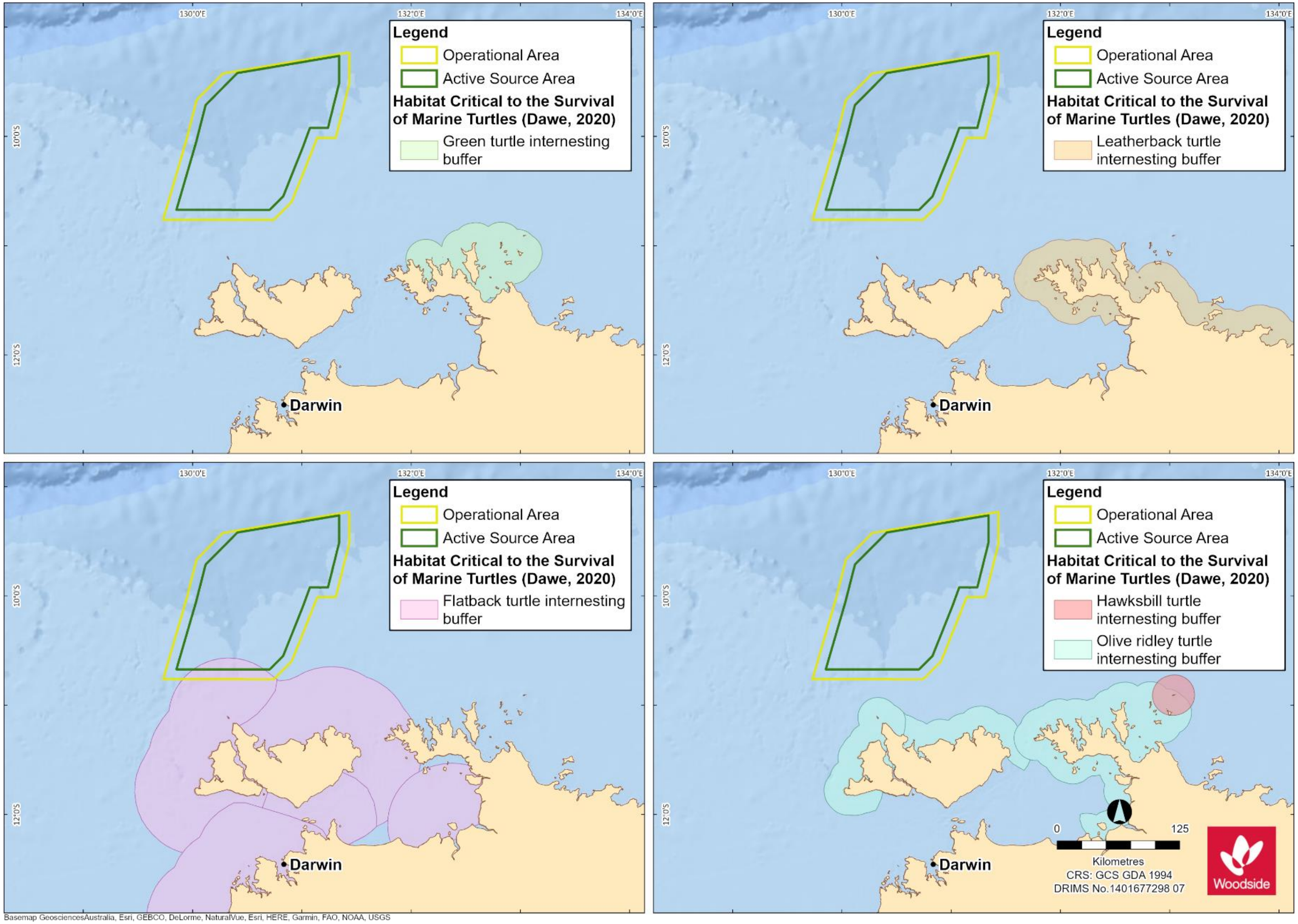


Figure 4-10: Habitat Critical to the survival of marine turtles

4.4.4.3 Biologically Important Areas (BIAs)

A review of the Department of Agriculture, Water and the Environment (DAWE) National Conservation Values Atlas (NCVA) (DAWE, 2015) identified that the following BIA overlaps the Operational Area:

- Flatback turtle internesting (likely to occur) around Melville Island and Cobourg Peninsula, defined by an 80 km internesting buffer around nesting sites.
- Seven additional BIAs were identified to overlap with the EMBA:
- Olive ridley turtle internesting (likely to occur) around Bathurst Island/Melville Island, defined by a 20 km internesting buffer around nesting sites.
- Green turtle internesting (likely to occur) north-west of Melville Island, defined by a 20 km internesting buffer around nesting sites.
- Olive ridley turtle foraging (known to occur) Joseph Bonaparte Gulf (JBG), northern JBG and western JBG depression.
- Green turtle foraging (known to occur) JBG.
- Loggerhead turtle foraging (known to occur) Western JBG depression.
- Flatback turtle foraging (known to occur) Western JBG depression.
- Crested tern breeding (known to occur) at Seagull Island, off Cape Van Diemen, north-west tip of Melville Island, defined by a 20 km buffer around both islands (foraging usually restricted to <20 m water depth).

4.4.4.4 Seasonal Sensitivities for Protected Species

Periods of the year where the Operational Area may overlap seasonally important habitat (e.g. for nesting, breeding, foraging, or migration) for protected species are presented in **Table 4-6**.

Table 4-6: Key seasonal sensitivities for protected species identified as occurring within the Operational Area.

<table>
<tr><th>Species</th><th>January</th><th>February</th><th>March</th><th>April</th><th>May</th><th>June</th><th>July</th><th>August</th><th>September</th><th>October</th><th>November</th><th>December</th></tr>
<tr><td colspan="13">Marine reptiles</td></tr>
<tr><td>Flatback turtle: Nesting</td><td></td><td></td><td></td><td></td><td></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td></td><td></td><td></td></tr>
<tr><td>Olive ridley turtle: Nesting</td><td></td><td></td><td></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Green turtle: Nesting</td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Olive ridley turtle, green turtle, loggerhead turtle and flatback turtle: Foraging</td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td></tr>
<tr><td colspan="13">Seabirds and Shorebirds</td></tr>
<tr><td>Seabird migration</td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td><td bgcolor="#FFE599"></td></tr>
</table>

Species	January	February	March	April	May	June	July	August	September	October	November	December
	Species may be present in the Operational Area											
	Peak period. Presence of animals is reliable and predictable each year											

4.4.4.5 Biology and Ecology of Protected Species

4.4.4.5.1 Marine Mammals

Sei whale

The sei whale is a baleen whale with a worldwide oceanic distribution and is expected to seasonally migrate between low latitude wintering areas and high latitude summer feeding grounds (Bannister et al., 1996; Prieto et al., 2012). There are no known mating or calving areas in Australian waters. Calving grounds are presumed to exist in low-latitudes with mating and calving potentially occurring during winter months (TSSC, 2015a). The species has a preference for deep waters, typically occurring in oceanic basins and continental slopes (Prieto et al., 2012) and exhibits a migration pathway influenced by seasonal feeding and breeding patterns. They will typically travel in small pods of three to five individuals, with some segregation by age, sex and reproductive status (DAWE, 2021). Sei whales have been infrequently recorded in Australian waters (Bannister et al., 1996) and reliable estimates of the sei whale population size in Australia waters are currently not possible due to a lack of dedicated surveys and their natural characteristics. Similarly, the extent of occurrence and area of occupancy of sei whales in Australian waters cannot be calculated due to the rarity of sighting records (DAWE, 2021).

Given the cosmopolitan nature of the species and absence of biologically important areas near the Operational Area, the species may infrequently occur within the deeper waters of the Operational Area, mainly during winter months when the species may move away from Antarctic feeding areas.

Blue whale

The blue whale is the largest of all baleen whales. There are two recognised subspecies of blue whale in the Southern Hemisphere, which are both recorded in Australian waters. These are the southern (or 'true') blue whale (*Balaenoptera musculus intermedia*) and the ‘pygmy' blue whale (*Balaenoptera musculus brevicauda*) (DAWE, 2021). In general, southern blue whales occur in waters south of 60°S and pygmy blue whales occur in waters north of 55°S (i.e. not in the Antarctic) (Department of Environment and Heritage [DEH], 2005b). Recent assessment of the distribution and population parameters of the pygmy blue whale in Australian waters found that whales in waters off the west coast of Australia utilise the full latitude range of the Indian Ocean, from northern Indonesia to the Southern Ocean (McCauley et al., 2018). This has allowed further delineation of stock structure, and this sub-population is now recognised as the Eastern Indian Ocean pygmy blue whales. On this basis, blue whales that may occur in the North Marine Region are likely to be Eastern Indian Ocean pygmy blue whales.

The East Indian Ocean pygmy blue whale undertakes an annual migration through the offshore waters of WA, completing a northbound migration through the North-west Marine Region between mid-April to early August, and southbound migration from October to January (McCauley and Jenner, 2010; McCauley and Duncan, 2011; McCauley et al., 2018; Joliffe et al., 2019; Gavrilov et al., 2018). Whales reach the northern terminus of their migration and potential breeding grounds in Indonesian waters by June (Double et al., 2014). This migration pathway is recognised by a BIA, extending from Augusta (WA) to Indonesia.

Based on acoustic data, East Indian Ocean pygmy blue whales are likely to travel alone or in small groups. Typically, solitary whales have been recorded calling on noise loggers, although larger groups of calling animals were occasionally detected. For example, 78% of pygmy blue whale calls recorded around Scott Reef between 2006 and 2009 were from lone whales, 18% were from two whales and 4% were from three or more whales (McCauley and Duncan, 2011). The maximum number of individuals calling at one time was five. Noise monitoring undertaken approximately 400 km north-east of the BIA associated with the pygmy blue whale migration corridor, and within and adjacent to the Operational Area, recorded pygmy blue whales migrating northward towards Indonesian waters in August 2014 and between late May and July 2015 (JASCO Applied Science [JASCO], 2016). No detections of the species were made during the period of their southward migration, indicating that they may utilise a different migration path (JASCO, 2016).

The defined pygmy blue whale migration BIA is located 580 km west of the Operational Area; however, given the noise monitoring data described above, pygmy blue whales may occur within the Operational Area during their northern migration. Whales are unlikely to aggregate within the waters of the Operational Area for feeding given the absence of known or possible foraging areas. They may transit the Operational Area and EMBA as individuals or small groups.

Fin whale

The fin whale is a large baleen whale with a worldwide distribution in all ocean basins between 20°S and 75°S (DEH, 2005b). Like other baleen whales, fin whales migrate annually between high latitude summer feeding grounds and lower latitude over wintering areas (Bannister et al., 1996). It is not currently possible to accurately estimate the population size of fin whales in Australian waters predominantly due to the species' behaviour and local ecology, as the proportion of time they spent at the surface varies greatly depending on these factors. In addition, natural fluctuation of fin whales in Australian waters are unknown; however, long range movements do appear to be prey-related (DAWE, 2021).

Fin whales are thought to follow oceanic migration paths and are uncommonly encountered in coastal or continental shelf waters. Australian Antarctic waters are important feeding grounds for fin whales but there are no known mating or calving areas in Australian waters (Morrice et al., 2004). There are no known BIAs for fin whales in the North Marine Region. A recent study by Aulich et al. (2019) used passive acoustic monitoring as a tool to identify the migratory movements of fin whales in Australian waters. On the west coast, the earliest arrival of these animals occurred at Cape Leeuwin in April, and between May and October they migrated along the WA coastline to the Perth Canyon, which likely acts as a way-station for feeding (Aulich et al., 2019). Some whales are found to continue migrating as far north as Dampier; however, no fin whales were recorded at the most northerly monitoring site, Scott Reef. Fin whales were last recorded in October before returning to Antarctica.

Given the known migration paths along the WA coast and absence of BIAs in the NMR, fin whales not expected to occur within the Operational Area, however individuals may transit the EMBA.

Omura's whale

The Omura's whale was first described as a new species distinct from the fin, Bryde's and Eden's whales in 2003 (Wada et al., 2003). The species is widely distributed in primarily tropical and warm-temperate locations, between 35°S and 35°N (Cerchio et al., 2019). There have been several photographic accounts and one stranding record of Omura's whales along the north-west coast of Australia from Exmouth into the Timor Sea (Cerchio et al., 2019), Additionally, there is extensive acoustic documentation of Omura's whales from Exmouth to north of Darwin, indicating year round presence of these whales off Scott's Reef, northwest of Broome and in the Joseph Bonaparte Gulf (McCauley 2009, 2014). Omura's whales were detected in the Timor Sea within and adjacent to the Operational Area from April to September, with a peak in June and July (JASCO, 2016). Whales seemed to enter the region in a south-west to north-east direction and remained during the autumn and winter months, before leaving in a north-east to south-west direction in late-October (JASCO, 2016). Therefore, Omura's whales may be encountered in the Operational Area and EMBA as individuals or small groups.

Humpback whale

The humpback whale occurs in all major oceans and primarily inhabits coastal and continental shelf waters (Reeves et al., 2002). Humpback whales travel to and from the southern Kimberley to the northern end of Camden Sound (the main breeding and calving area) in the winter and spring months (Jenner et al., 2001; Commonwealth of Australia, 2015c), after feeding in Antarctic waters during the summer months (Bannister and Hedley, 2001). This migration corridor (both north and southbound) is a defined BIA for humpback whales. Calving occurs at the northern extent of the migration corridor (outside of the EMBA for the Petroleum Activities Program). In the NT, humpback whale distribution was known from a single beached individual at the Napier Peninsula in 1981 (Chatto and Warnecke, 2000), over 280 km east of the Operational Area. More recently, humpback whales have been seen in NT waters between the Tiwi Islands and the WA border, typically between August and October (Woinarski et al., 2012). These sightings have recorded humpback whales as individuals or small groups, often including calves.

The BIA is located over 850 km south-west of the Operational Area and outside the EMBA. Humpback whales are occasionally spotted in coastal waters in the NT; however, given the well-defined migration pathway and northern terminus at Camden Sound, it is unlikely that humpback whales will occur within the deeper waters of the Operational Area at any time of the year. In addition, no humpback whales were recorded during a 12-month noise monitoring program, located within and adjacent to the Operational Area (JASCO, 2016).

Bryde's whale

The Bryde's whale is the least migratory species of its genus and is restricted geographically from the equator to approximately 40°N and S, or the 20° C isotherm (Bannister et al., 1996). Bryde's whales occur in both oceanic and inshore waters, with key localities recognised at the Abrolhos Islands and north of Shark Bay, and off Queensland (Bannister et al., 1996), however there are no defined BIAs for this species in the NCVA. Two forms are recognised: inshore and offshore Bryde's whales. It appears that the offshore form may migrate seasonally, heading towards warmer tropical waters during the winter; however, information on migration is not well known. McCauley (2011) detected Bryde's whales using noise loggers deployed around Scott Reef from 2006 to 2009.

The species has been recorded in the Timor Sea and acoustically detected from January to early October within and adjacent to the Operational Area (JASCO, 2016). Bryde's whales may therefore be encountered in the Operational Area and EMBA, however are not expected to occur in significant numbers due to the absence of important habitat.

Killer whale

The killer whale has a widespread distribution from polar to equatorial regions of all oceans and has been recorded off all states of Australia (Bannister et al., 1996). Killer whales appear to be more common in cold, deep waters; however, they have been observed along the continental slope and shelf (Bannister et al., 1996), as well as in shallow coastal areas of WA (RPS, 2010c). There are no recognised key localities or important habitats for killer whales within the Operational Area or EMBA.

The total number of killer whales in Australian waters is unknown, however, it may be that the total number of mature animals within waters around the continent is less than 10,000 (DAWE, 2021). Killer whales are known to make seasonal movements, and probably follow regular migratory routes, but no information is available for the species in Australia waters. Killer whales are top-level carnivores, and there are reports from around Australia of attacks on dolphins, juvenile humpback whales, blue whales, sperm whales, and beaked whales, dugongs and Australia sea lions (Bannister et al., 1996).

Given the wide distribution of killer whales and their preference for colder waters, the Operational Area and EMBA is unlikely to represent an important habitat for this species. Their presence is likely to be a rare occurrence and limited to a few individuals infrequently transiting the area.

Sperm whale

The sperm whale has a worldwide distribution in deep waters (greater than 200 m) off continental shelves and sometimes near shelf edges, averaging 20–30 nautical miles offshore (Bannister et al., 1996). There is limited information about sperm whale distribution in Australian waters; however, they are usually found in deep offshore waters, with more dense populations close to continental shelves and canyons (DoEE, 2019). The species may occur in severely fragmented populations. Key localities in Australia include; the southern coastline between Cape Leeuwin and Esperance, WA (Bannister et al., 1996); south-west of Kangaroo Island, South Australia (SA); deep waters off the Tasmanian west and south coasts; southern NSW; and deep waters off Stradbroke Island, Queensland (QLD) (Ceccarelli et al., 2011). There are no known BIAs for sperm whales in the NMR. In the open ocean, there is a general movement of sperm whales southwards in summer, and corresponding movement northwards in winter, particularly for males (DAWE, 2020). Detailed information about the distribution and migration patterns of sperm whales off the WA coast is not available.

Given the wide distribution of sperm whales and their preference for deeper oceanic waters, the Operational Area and EMBA is unlikely to represent an important habitat for this species. Their presence is likely to be a rare occurrence and limited to a few individuals infrequently transiting the EMBA only.

Indo-Pacific humpback dolphin

The Indo-Pacific humpback dolphin is now recognised as two distinct species: the Indo-Pacific humpback dolphin (*Sousa chinensis*) and the Australian humpback dolphin (*S. sahulensis*) (Jefferson and Rosenbaum, 2014). This EP will herein refer to the Australian humpback dolphin (*S. sahulensis*) that is known to occur in waters of the Sahul Shelf from northern Australia to New Guinea. Australian humpback dolphins are found in tropical/subtropical waters, and widely distributed in Australia along the northern coastline from Shark Bay, WA to the QLD/NSW border (Parra and Cagnazzi, 2016). Humpback dolphins inhabit shallow coastal, estuarine habitats generally in depths of less than 20 m and within 20 km from shore (Corkeron et al., 1997; Jefferson, 2000; Allen et al., 2012; Jefferson and Rosenbaum, 2014). Given their preference for shallow coastal habitats, the species may occur in coastal waters within the EMBA, but is unlikely to occur within the Operational Area.

Spotted bottlenose dolphin (Arafura/Timor Sea Populations)

The spotted bottlenose dolphin is generally considered to be a warm water subspecies of the common bottlenose dolphin. Distribution is primarily in inshore waters, often in depths of less than 10 m (Bannister et al., 1996). They are known to occur from Shark Bay, north to the western edge of the Gulf of Carpentaria. Given the distribution of spotted bottlenose dolphins and their preference for shallow coastal waters, the Operational Area is unlikely to represent an important habitat for this species. Their presence is likely to be a rare occurrence and limited to infrequent transiting of the area. The spotted bottlenose dolphin is likely to be present in nearshore and coastal waters, within the EMBA.

Australian snubfin dolphin

The Australian snubfin dolphin is primarily distributed in northern Australian waters from Broome, WA on the west coast to the Brisbane River, Queensland on the east coast (Parra et al., 2002). Most recorded sightings come from protected shallow waters, especially in close vicinity to river mouths, which implies that their expected range is the northern Sahul Shelf including the coastal waters of northern Australia and Papua New Guinea (Beasley et al., 2005), with just one sighting from Papua New Guinea (Beasley et al., 2002). Given the distribution of Australian snubfin dolphins and their preference for shallow coastal waters, the Operational Area is unlikely to represent an important habitat for this species, however, Australian snubfn dolphins are likely to be present in nearshore and coastal waters, within the EMBA.

Dugong

Dugong are large herbivorous marine mammals. Dugongs occur in tropical and subtropical waters, with a significant proportion of the world's dugong populations occurring in northern Australia's coastal waters from Shark Bay, WA to Moreton Bay, Queensland (Commonwealth of Australia, 2012). The waters of the NMR support significant populations of dugongs, with a major population of some 4,400 animals occurring in the waters offshore of the Tiwi Islands (Northern Territory Parks and Wildlife Service [PWS], 2003). Dugong distribution is correlated with seagrass habitats that dugong feed on, although water temperature has also been correlated with dugong movements and distribution (Preen et al., 1997; Preen, 2004). Dugong are known to migrate (up to hundreds of kilometres) between seagrass habitats (Sheppard et al., 2006). Given the distribution of dugong and their preference for shallow coastal waters, their presence is highly unlikely within the Operational Area due to the lack of suitable habitat (seagrass and macroalgae beds). However, significant sites for dugongs were identified approximately 85 km south-south-east of the Operational Area on the east side of the Tiwi Islands, and significant sites for dugongs and seagrass were identified approximately 22 km south of the Operational Area, partially overlapping the EMBA (ConocoPhillips, 2018). Therefore, dugongs may be present in the nearshore waters of the EMBA.

4.4.4.5.2 Marine Reptiles

Marine Turtles

Six marine turtle species were identified in the PMST as potentially occurring within the Operational Area: the green, loggerhead, hawksbill, flatback, olive ridley and leatherback turtle (**Appendix C**). Key information on marine turtles in the NMR is presented in **Table 4-7**.

Marine turtles are highly migratory during some life phases, but during others show high site fidelity. They require both terrestrial and marine habitats to fulfil different life history stages (Commonwealth of Australia, 2017a). The majority of their lives are spent in the ocean, although adult female turtles will come ashore to lay eggs in the sand above the high-water mark.

Amongst the six species of marine turtle identified above, the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017a) has defined 22 genetic stocks that nest or forage in Australian waters. Discrete genetic stocks have evolved within each marine turtle species as a result of marine turtles returning to the region from where they hatched (Commonwealth of Australia, 2017a). These genetically distinct stocks are defined by the presence of regional breeding aggregations. Stocks are composed of multiple rookeries in a region and are delineated where there is little or no overlap migration of individuals between nesting areas. Turtles from different stocks typically overlap at feeding grounds (Commonwealth of Australia, 2017a).

Nine of these genetic stocks have distributions that overlap the Operational Area, comprising five green turtle stocks, one loggerhead turtle stock, two flatback turtle stocks and one olive ridley turtle stock. Each of these genetic stocks are described below in **Table 4-7**.

The north-western area of Melville Island and Seagull Island, approximately 55 km and 43 km south of the Operational Area, respectively, are important marine turtle nesting areas, particularly for olive ridley turtles and flatback turtles (Chatto and Baker, 2008). Olive ridley and flatback turtles nest in all months between February and November, with the peak for olive ridley nesting around April/May (Chatto and Baker, 2008). The peak nesting period for flatback turtles was unable to be determined due to insufficient records (Chatto and Baker, 2008). Small numbers of green turtles and a single hawksbill turtle were also found to nest in these areas (Chatto and Baker, 2008). There is no emergent habitat within the Operational Area and therefore nesting aggregations of marine turtles do not occur. A flatback turtle internesting BIA and internesting buffer Habitat Critical to the survival of flatback turtles, extends from nesting locations at the Tiwi Islands overlaps with the Operational

Area (refer **Figure 4-10 and Figure 4-11**). Nesting occurs year-round with a peak from June to September (Commonwealth of Australia, 2017a). The BIA and Habitat Critical to the survival of flatback turtles are considered very conservative as they are based on the maximum range of internesting females.

Table 4-7: Key information on marine turtles in the NMR

Turtle species	Key seasons within the NMR	Diet	Preferred habitat	Genetic Stocks with dispersals overlapping the Operational Area
Flatback turtle	**Breeding**: September to January. **Nesting**: Year-round with a peak from June to September.	Primarily carnivorous, feeding on soft-bodied invertebrates. Juveniles eat gastropod molluscs, squid, siphonophores. Limited data indicate that cuttlefish, hydroids, soft corals, crinoids, molluscs and jellyfish are also eaten	Nearshore and offshore subtidal and soft-bottomed habitats of offshore islands.	**Arafura Sea Stock (F-Ars):** The F-Ars stock encompasses flatback turtles nesting in the western Torres Strait, around the Gulf of Carpentaria, north-east Arnhem Land, Cobourg Peninsula and into western NT. Crab Island, in the Gulf of Carpentaria, is one of the largest flatback turtle rookeries, and it is estimated that approximately 3,000 turtles nesting there per year. Other major nesting sites include Bare Sand, Field, Deliverance, and Sir Edward Pellew Islands. Minor nesting sites include the Cobourg Peninsula, Wellesley, Flinders Beach, Jardine River to Edward River and in western Torres Strait. An internesting buffer of 60 km is established around these rookeries, defined as Habitat Critical to the survival of the species. Post-hatchling and young juveniles remain on the Australian continental shelf. Little is known about the foraging habitat of juvenile and young adult turtles, although trawl captures indicate flatback turtles feed in turbid inshore (10-40 m) soft bottom habitats over the continental shelf of northern Australia (Robins, 1995). **Cape Domett Stock (F-CD):** Cape Domett is an important high-density nesting area. Combined with a smaller site at Lacrosse Island, the F-CD stock is one of the largest flatback turtle stocks in Australia. Average nesting abundance at Cape Domett is estimated at 3,250 females per year (Whiting et al., 2008). Designated Habitat Critical for the F-CD stock are the nesting locations of Cape Domett and Lacrosse Island, and an internesting buffer of 60 km around these rookeries, year-round with peak internesting activity occurring July to September. Extending further than the Habitat Critical internesting buffer, an internesting buffer BIA of 80 km is located at Cape Domett and Lacrosse Island.
Olive ridley turtle	**Breeding**: Unknown **Nesting**: Year round with a peak from April to June.	Primarily carnivorous, feeding on soft-bodied invertebrates such as sea pens, soft corals, sea cucumbers and jellyfish in depth	Benthic habitats of the continental shelf. After nesting, olive ridley turtles are known to migrate up to 1,050 km to various foraging areas (DoEE 2017h) including the pinnacles of the Bonaparte Basin and the carbonate banks and terrace system	**Northern Territory Stock (O-NT):** While the NT olive ridley turtle stock is relatively small and has a limited geographic range, it is likely that the NT has the most significant olive ridley population remaining in the Asia-Pacific region (Groom et al., 2017; Commonwealth of Australia, 2017a). A lack of long-term monitoring has precluded stock status estimates. Major rookeries are located at English Company, Wessel, Crocodile, Elcho and Tiwi islands of north-east Arnhem Land and Grant Islands, McCluer Island Group, Cobourg Peninsula, Melville Island and Bathurst Island off north-western Arnhem Land (Limpus, 2009). Minor rookeries are located along western NT, eastern Arnhem Land and Dhimurru Indigenous Protected Areas (Limpus, 2009). An internesting

Turtle species	Key seasons within the NMR	Diet	Preferred habitat	Genetic Stocks with dispersals overlapping the Operational Area
		between 15-200 m.	of the Sahul Shelf (DSEWPaC 2012a).	buffer of 20 km is established around these rookeries, defined as Habitat Critical to the survival of the species. A possible migration pathway is thought to exist between Australia and Indonesia for the O-NT stock (Commonwealth of Australia, 2017a). The foraging habitat of post-hatchling and young juvenile turtles is unknown, however juvenile and adult turtles are known to forage over soft-bottomed substrates (shallows to depths of 200 m) along the coastal zone of northern Australia (Commonwealth of Australia, 2017a;Whiting et al., 2007).
Green turtle	**Breeding**: Approximately September to December. **Nesting**: November to March. Peak period from January to March.	Primarily herbivorous, foraging on algae, seagrass and mangroves. In their pelagic juvenile stage, they feed on algae, pelagic crustaceans and molluscs.	Nearshore reef habitats in the photic zone. Juvenile and adult turtles forage within the tidal/sub-tidal habitats of offshore islands and coastal waters with coral reef, mangrove, sand, rocky reefs and mudflats where there are algal turfs or seagrass meadows present (Commonwealth of Australia, 2017). A proportion of turtles may also remain resident in the open ocean (Hatase et al., 2006).	**North-west Shelf Stock (G-NWS):** The G-NWS stock is one of the largest green turtle stocks in the world and the largest in the Indian Ocean. The G-NWS stock is estimated at approximately 20,000 individuals (DEWHA, 2012a) and the population trend for the stock is reported as stable (Commonwealth of Australia, 2017a). Major rookeries are located at Lacepedes, Montebello, Barrow, Murion and Browse islands, and the North West Cape. Post-hatchlings are likely to disperse through much of the Indian Ocean/Arafura Sea. The G-NWS stock forage primarily between Shark Bay and Adele Island (southern Kimberley), WA, although foraging extends to the Tiwi Islands and Coburg Peninsula, NT (Ferreira et al., 2020). **Ashmore Reef Stock (G-AR):** The G-AR stock nests in a localised area of the Indian Ocean in the Ashmore Reef and Cartier Island AMP areas, outside the Operational Area and EMBA. Population estimates are not available for Ashmore Reef, although annual breeding numbers are thought to be in the low hundreds (Whiting et al., 2000; Woodside, 2009). Designated Habitat Critical for the G-AR stock are the nesting locations of Ashmore Reef and Cartier Island, and an internesting buffer of 20 km radius around these rookeries year-round with peak internesting activity occurring December to January. The G-AR stock forage primarily between Port Hedland, WA and the Tiwi Islands and Coburg Peninsula, NT (Ferreira et al., 2020). **Scott-Browse Stock (G-ScBr):** The G-ScBr stock is a discrete unit known to nest at only two locations within the north-east Indian Ocean – Sandy Islet and Browse Island. There is currently very limited data available for the G-ScBr stock and therefore population numbers are unknown. Designated Habitat Critical for the G-ScBr stock are the nesting locations of Sandy Islet and Browse Island, and an internesting buffer of 20 km radius around these rookeries, for the period November to March. Summer months from late

Turtle species	Key seasons within the NMR	Diet	Preferred habitat	Genetic Stocks with dispersals overlapping the Operational Area
				November to February are the preferred breeding season for green turtles at Sandy Island (Guinea, 2009). Adult green turtles leaving Scott Reef appear to swim through Scott Reef lagoon and disperse toward the WA mainland via two distinct post-nesting migration pathways; travelling east and north toward the Bonaparte Archipelago and then north along the coast to foraging areas in the NT waters, or travelling south to Cape Leveque and then south along the coast to the Turtle Islands off the mouth of the De Grey River in the Pilbara Region (Pendoley, 2005; Guinea, 2011). The G-ScBr stock forage primarily in waters around the Bougainville Peninsula (northern Kimberley), WA, to the Tiwi Islands and Coburg Peninsula, NT, although foraging extends as far south as Eighty Mile Beach, WA (Ferreira et al., 2020). **Cobourg Stock (G-Cobourg):** The G-Cobourg stock has only recently been delineated as a separate genetic stock and there is no long-term nesting or foraging habitat data available for this stock. Major rookeries have been identified and include Black Point and Smith Point and McCluer, Croker and Lawson Islands. In addition to Cobourg Peninsula, low numbers of green turtles have been recorded nesting at the Tiwi Islands, but the genetic stock of these turtles is currently unknown (Chatto and Baker 2008). The foraging locations of post-hatchling and young juveniles is currently unknown; however, hatchlings likely disperse through waters of the Indian Ocean and Arafura Sea region. **Northern Great Barrier Reef Stock (G-nGBR):** The G-nGBR stock has major rookeries at Raine Island and Moulter Cay. Minor rookeries include Bramble Cay, Murray Island, Dauar Island, Sandbanks No. 7 and No. 8. The Torres Strait provides important foraging habitat for green turtles from this stock, although the foraging range for this stock does extend into NT waters (Groom et al., 2017). An internesting buffer of 20 km is established around these rookeries, defined as Habitat Critical to the survival of the species. Post-hatchling and young juveniles spend the first 5-10 years in oceanic waters of the southern Pacific Ocean, utilising floating seaweed rafts and opportunistically feeding on gelatinous organisms, before returning back to inshore foraging habitat.
Loggerhead turtle	**Breeding**: Approximately September to March.	Carnivorous, feeding predominantly on benthic invertebrates in	**Preferred habitat**: Nearshore and island coral reefs, bays and estuaries in tropical and warm temperate latitudes.	**Western Australia Stock (LH-WA):** The LH-WA stock is one of the largest in the world (Limpus, 2009). The population trend is reported as stable (Commonwealth of Australia, 2017a).

Turtle species	Key seasons within the NMR	Diet	Preferred habitat	Genetic Stocks with dispersals overlapping the Operational Area
	Nesting: November to March. Peak period from late December to early January.	habitats ranging from near shore to 55 m. During their post-hatchling stage, they feed on algae, pelagic crustaceans and molluscs.		Major rookeries of the LH-WA stock are located at Dirk Hartog Island, Muiron Islands and Gnarloo Bay. These areas are designated Habitat Critical for the stock and include an internesting buffer of 20 km radius around these rookeries, November to May. Dirk Hartog Island in the Shark Bay Marine Park, with an average of 122 nests per day over 2.1 km (Reinhold, 2014), is recognised as the most important loggerhead turtle rookery in WA.
Hawksbill turtle	**Breeding**: All year round. **Nesting**: All year round with peak in October to February.	Omnivorous, feeding on algae, sponges, soft corals and other soft-bodied invertebrates.	**Preferred habitat**: Nearshore and offshore reef habitats.	**N/A**
Leatherback turtle	**N/A**	Carnivorous, feeding mainly in the open ocean on jellyfish and other soft-bodied invertebrates.	**Preferred habitat**: Nearshore, coastal tropical and temperate waters.	**N/A**

* Habitat Critical to the survival of a species identified in the Recovery Plan for Marine Turtles in Australia 2017–2027 (Commonwealth of Australia, 2017a)

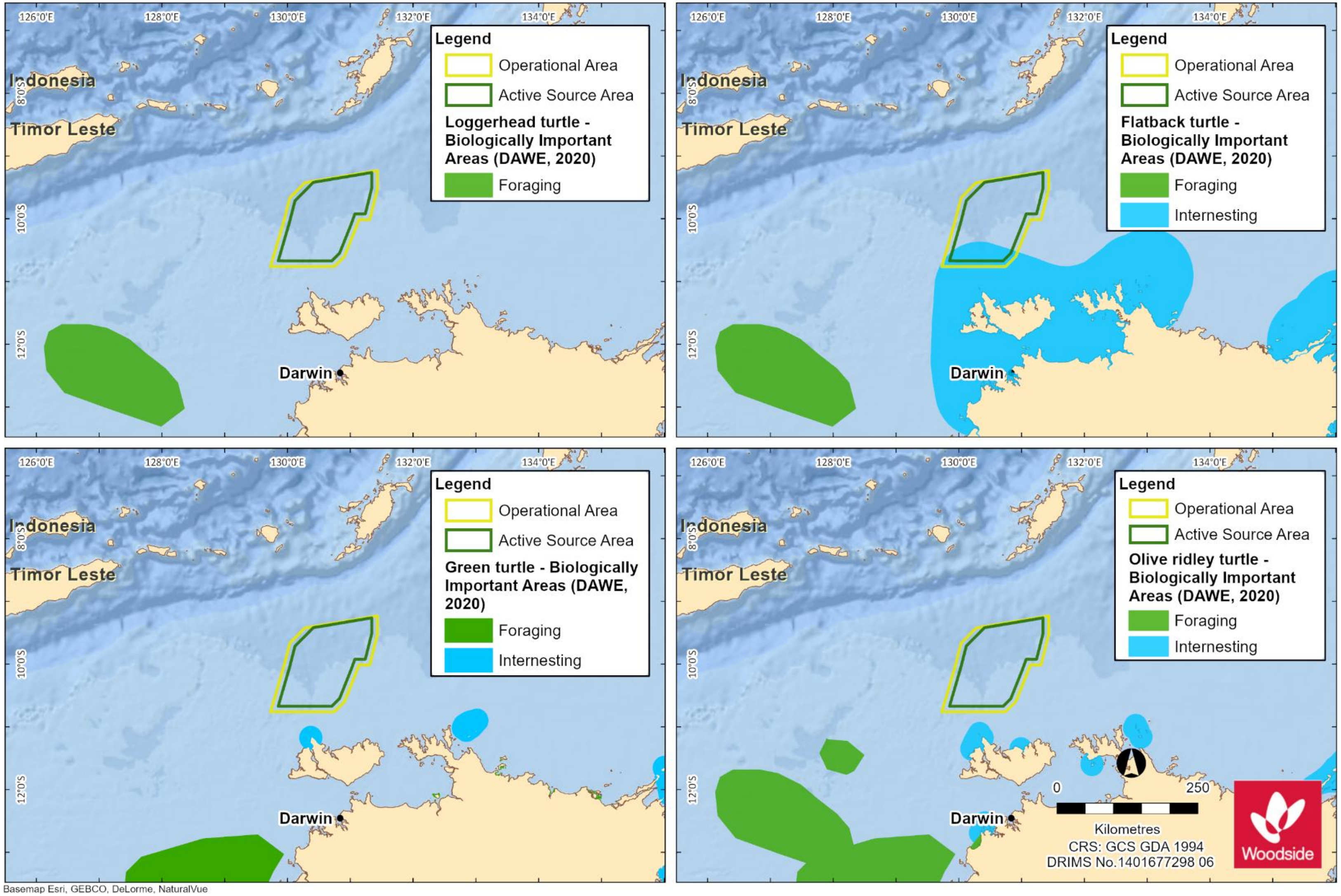


Figure 4-11: Biologically Important Areas for marine turtles

Sea snakes

The NMR is an important area for sea snakes with 19 species known to occur and a further nine species potentially occurring, all listed under the EPBC Act. Sea snakes are typically distributed in shallow inshore regions and islands; however, they can also be found at nearby islands and further offshore at atolls, including shoals and banks. The majority of sea snakes are observed in water depths ranging from 10-50 m (RPS, 2010). Very few species are known to occupy deep pelagic environments, such as those within the Operational Area.

Species exhibit habitat preferences depending on water depth, benthic habitat, turbidity and season (Heatwole and Cogger, 1993). Some species have extensive distributions and individuals may cover large distances, while other species have limited home ranges (Heatwole and Cogger, 1993). Most sea snake species tend to be found in the shallower waters to allow for increased benthic foraging time (DEWHA, 2008b). Sea snakes that reside on coral reefs do not actively disperse or migrate between reefs, however for those species that do migrate, migration is thought to be influenced by ocean currents.

Given the preference of sea snakes for shallow waters, the Operational Area is unlikely to represent an important habitat for this species and their presence is likely to be a rare occurrence of individuals.

Salt-water crocodile

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

4.4.4.5.3 Fishes and Elasmobranchs

White shark

The white shark typically occurs between the coast and the 100 m depth contour, although adults and juveniles have been recorded diving to depths of 1,000 m (Bruce et al., 2006; Bruce and Bradford, 2008). They are also known to make open ocean excursions of several hundred kilometres and can cross ocean basins (for instance from South Africa to the western coast of Australia) (Weng et al., 2007). White sharks occur from central Queensland around the south coast to north-west WA, but may occur further north on both coasts (Bonfil et al,. 2005; Bruce et al., 2006; Last and Stevens, 2009; Paterson, 1990). White sharks are often found in regions with high prey density, such as pinniped colonies (DEWHA, 2009b). Given their preference for temperate waters, lack of typical prey species and offshore location of the Operational Area, white sharks are unlikely to occur within the Operational Area. The species may be present in the EMBA.

Northern river shark

In Australia, northern river sharks are known to occur in WA and the NT, including the waters of the Joseph Bonaparte Gulf (Stevens et al., 2005; Pillans et al., 2008). The species typically inhabits rivers, estuarine systems, inshore and offshore marine habitats, though adults have only been recorded in marine environments (Pillans et al., 2009). The species has been recorded offshore in saline waters (e.g. around the Wessel Islands), although the extent to which this occurs and the distances moved is unknown (DoE, 2014, Pillans et al., 2009). The global population size of northern river sharks is unknown (Stevens et al., 2005) and the relationship between the Australian and global populations is poorly understood. Given their habitat preference for estuarine and coastal waters, northern river sharks are unlikely to occur within the Operational Area but may be present within shallower waters of the EMBA.

Speartooth shark

Speartooth sharks occur in geographically distinct locations across northern Australia. In the NT, they are found in the Van Diemen Gulf drainage, including the Adelaide River, South, East and West Alligator rivers and Murganella Creek (Field et al., 2008; Pillans et al., 2009). They have been recorded in tidal rivers and estuaries with turbid waters, fine muddy substrates and temperatures ranging from 27 to 33°C (DoE, 2014). Short-term movement patterns of juvenile speartooth sharks in the Adelaide and Wenlock rivers indicate that individuals have a tidally influenced movement pattern, moving up and downstream with the tide (Pillans et al., 2008). Due to their physiological similarities to bull sharks, it is thought that adult speartooth sharks may live outside of rivers in the coastal marine environment (Stevens et al., 2005; Pillans et al., 2008). Given their habitat preference for estuarine and coastal waters, northern river sharks are unlikely to occur within the Operational Area, but may be present within shallower waters of the EMBA.

Grey nurse shark

The grey nurse shark is found primarily in warm-temperate (from sub-tropical to cool-temperate) inshore waters around mainland continental masses (Pognoski et al., 2002). It occurs in habitats ranging from rocky inshore reefs down to around 200 m depth on the continental shelf (Pognoski et al., 2002). The species is considered rare in the NT and tends to occur further offshore than in temperate waters (Stirrat and Larson, 2006). Records indicate that a longline fishing vessel operating in waters of the Arafura Sea near Lynedoch Bank reported catches of grey nurse sharks in the 1980's (Read and Ward, 1995). A recent survey in the Barossa field observed four grey nurse sharks, including a suspected pregnant female, at a seamount approximately 15 km west of the Operational Area (Jacobs, 2016). Based on the above reports, it is possible that individual grey nurse sharks may be encountered in low numbers within the Operational Area and wider EMBA.

Oceanic whitetip shark

The oceanic whitetip shark is a circumglobal deep-water species inhabiting tropical to warm-temperate waters (Compagno, 1984). They are found from the surface to depths of about 150 m (Smith, 1997). There is very little information about these sharks in Australia, with no available population estimates or distribution trends. Given their circumglobal distribution and habitat preference, oceanic white tip sharks may occur within the EMBA.

Longfin mako shark

The longfin mako is a widely distributed but rarely encountered oceanic tropical shark found in Australian waters south to Geraldton in WA (outside the EMBA) and to at least Port Stephens in NSW (DEWHA, 2010). The longfin mako is often confused with the shortfin mako. There is very little information about these sharks in Australia, with no available population estimates or distribution trends. Longfin mako sharks may occur within the EMBA in low numbers.

Shortfin mako shark

The shortfin mako is found in tropical and warm-temperate seas in water depths up to 500 m. The species is rarely found in waters cooler than 16°C and is occasionally found close inshore where the continental shelf is narrow (Cailliet et al., 2009). The shortfin mako is widespread in Australian waters and has been recorded in offshore waters all around the continent's coastline with exception of the Arafura Sea, the Gulf of Carpentaria and Torres Strait (TSSC, 2014). Shortfin makos are also highly migratory and travel large distances. Given the absence of shortfin makos in the waters surrounding the Operational Area their occurrence is unlikely and may be limited to individuals transiting the EMBA.

Whale shark

Whale sharks have a global distribution in tropical and warm temperate waters. In Australia, they mainly occur in off the NT, Queensland and northern WA. Seasonal aggregations occur at Ningaloo Reef (March – July), Christmas Island (December – January) and the Coral Sea (November – December), and are considered to be biologically important areas linked to seasonal localised pulses of food productivity (TSSC, 2015d). Its distribution and status in waters around the NT is poorly known, although there are at least some anecdotal records (Woinarski and Larson, 2006). Consequently, there are no defined BIAs for the whale shark in NT waters. Due to the species widespread distribution and highly migratory nature, individuals may transit through the Operational Area and EMBA in low numbers.

Dwarf sawfish

The dwarf sawfish is found in Australian coastal waters extending north from Cairns around the Cape York Peninsula in Queensland to the Pilbara coast (Commonwealth of Australia, 2015e). Dwarf sawfish typically inhabit shallow (2 to 3 m) silty coastal waters and estuarine habitats, occupying relatively restricted areas and moving only small distances (Stevens et al., 2008). In the NT, it has been recorded in several catchments including the Keep River, Victoria River, Buffalo Creek and Rapid Creek (Darwin Harbour) and the South Alligator River (Thorburn et al., 2003; Peverell et al., 2004). Occasional individuals have also been taken from considerably deeper water from trawl fishing (Morgan et al., 2009). Given their preference for estuarine and coastal waters and typical depth distribution, dwarf sawfishes are unlikely to occur within the Operational Area but may be present within shallower waters of the EMBA.

Freshwater sawfish

In Australia, largetooth sawfish have been recorded in numerous drainage systems in the country's north in fresh and saline water (DoE, 2014). In the NT, this includes the Adelaide, Victoria, Daly, East and South Alligator, Goomadeer, Roper, McArthur, Wearyan and Robinson rivers. Freshwater sawfish generally inhabit river and estuarine environments during their juvenile stages and enter the marine environment as adults. They have been recorded up to 100 km offshore (DoE, 2014). Given their preference for estuarine and coastal waters and typical depth distribution, freshwater sawfishes are unlikely to occur within the Operational Area but may be present within shallower waters of the EMBA.

Green sawfish

Green sawfish were once widely distributed in coastal waters along the northern Indian Ocean, although it is believed that northern Australia may be the last region where significant populations exist (Stevens et al., 2005). Within Australia, green sawfish are currently distributed from around the Whitsundays in Queensland, across northern Australian waters to Shark Bay in WA (Commonwealth of Australia, 2015e). Green sawfish are present in coastal waters and tidal creeks and, despite records for deeper offshore waters, their range is mostly restricted to the inshore fringe with a strong association to mangroves and adjacent mudflat habitats (Commonwealth of Australia, 2015e). Given their habitat preference for estuarine and coastal waters and typical depth distribution, green sawfishes are unlikely to occur within the Operational Area but may be present within shallower waters of the EMBA.

Narrow sawfish

The narrow sawfish occurs from the northern Arabian Gulf to Australia and north to Japan. The species inhabits inshore and estuarine waters and offshore waters up to depths of 100 m (D'Anastasi et al., 2013) and are most commonly found in sheltered bays with sandy bottoms. The species is not currently listed as threatened under the EPBC Act but are currently under threatened listing assessment (due 30 October 2022), and is not included in the Sawfish and river shark Multispecies Recovery Plan (DoE, 2015a).

Narrow sawfish are commonly caught as by-catch in the Northern Prawn Fishery (NPF). A total of 1234 sawfish interactions were recorded in the NPF during 2020, an increase from 607 in 2019 (Laird, 2021). There were 798 interactions with unidentified species (65% of the total interactions). For the remaining interactions, 409 were with narrow sawfish (33%), 12 with freshwater sawfish (1%), 11 with green sawfish (<1%), and four with dwarf sawfish (<0.5%). Of the 1234 animals caught in 2020, 845 individuals (68%) were released alive. Most sawfish deaths occurred in the Melville area of the NPF (Laird, 2021), which includes all of the waters north of the Tiwi Islands and the Operational Area for the Galactic Hybrid 2D MSS.

Narrow sawfish are unlikely to be present at water depths associated with the Operational Area, however they may occur in the EMBA, particularly in nearshore estuarine environments

Reef manta ray

The reef manta ray is globally distributed in tropical and subtropical waters. It is a planktivorous species and is thought to migrate relatively long distances, travelling up to 70 km per day and moving between specific productive areas (Couturier et al., 2011; van Duinkerken, 2010). The species is commonly sighted inshore, however is also found around offshore coral reefs, rocky reefs and seamounts (Marshall et al., 2018). The Operational Area is not located in or adjacent to any known key aggregation areas for the species (e.g. feeding or breeding). Occurrence of reef manta rays within the Operational Area is likely to be infrequent and restricted to individuals transiting the EMBA.

Giant manta ray

The giant manta ray is very common in tropical waters of Australia. The giant manta ray primarily inhabits near-shore environments along productive coastlines with regular upwelling, but they appear to be seasonal visitors to coastal or offshore sites including offshore island groups, offshore pinnacles and seamounts (Marshall et al., 2011). The Operational Area is not located in or adjacent to any known key aggregation areas for the species (e.g. feeding or breeding). Occurrence of giant manta rays within the Operational Area is likely to be infrequent and restricted to individuals transiting the EMBA.

4.4.4.5.4 Seabirds and Shorebirds

Red knot

The species undertakes long distance migrations from breeding grounds in high northern latitudes, where it breeds during the boreal summer, to the southern hemisphere during the austral summer. Both Australia and New Zealand host significant numbers of red knots during their non-breeding period (Bamford et al., 2008). As with other migratory shorebirds, the species occurs in coastal wetland and intertidal sand or mudflats outside the Operational Area and EMBA. It is unlikely to occur in the Operational Area, aside from individuals occasionally transiting through during migrations, due to the lack of emergent habitat.

Crested tern

The crested tern is widespread and numerous along the NT coastline, with 20 breeding colonies reported (DSEWPaC, 2012a). The majority of these colonies are on small islands and support over 5,000 birds. The colony on Seagull Island, off the north-west tip of Melville Island supports a BIA of approximately 60,000 crested terns (Woinarski et al., 2003), which is thought to be the largest breeding colony of this species and of international significance. The breeding period for the crested term is March to July, with most eggs being laid during late April to early June (Chatto, 2001). The species forages in a range of habitats including shallow waters of lagoons, coral reefs, bays, harbours, inlets and estuaries, along shorelines, rocky outcrops and in open sea, in mangrove swamps and in offshore and pelagic waters (DSEWPaC, 2012d). Given the lack of suitable habitat, crested terns are unlikely to occur within the Operational Area; however, may occasionally be present within the EMBA.

Curlew sandpiper

In Australia, curlew sandpipers occur around the coasts while also being widespread inland, though in smaller numbers (DAWE, 2021). They mainly inhabit intertidal mudflats, sandflats and sandy beaches of sheltered coasts or shallows pools on exposed wave-cut rock platforms or coral reefs. The curlew sandpiper departs breeding grounds in Siberia between early July and August, reaching the northern shores of Australia in late August and early September (Higgins and Davies, 1996; Minton, 1996). The return north begins in March (DAWE, 2021).

Given the distribution of this coastal wetland bird species, the species is unlikely to occur within the Operational Area; however, may be present within the EMBA.

Eastern curlew

The eastern curlew is Australia's largest shorebird and is a coastal species with a continuous distribution north from Barrow Island to the Kimberley region. The species is endemic to the East Asian–Australasian Flyway. The species is a non-breeding visitor to Australia from August to March, primarily foraging on crabs and molluscs in intertidal mudflats. Due to the lack of emergent habitat, the eastern curlew is not expected to occur within the Operational Area, aside from individuals occasionally transiting the EMBA during migration periods.

Common noddy

The common noddy is the largest species of noddy found in Australian waters. The species is widespread in tropical and subtropical areas beyond Australia. This seabird typically forages in coastal waters around nesting sites, taking prey such as small fish, but may occur longer distances out to sea. Nesting occurs broadly across tropical and subtropical Australia in coastal areas, particularly on islands such as the Houtman Abrolhos Islands in WA (Johnstone et al., 2013). The common noddy is thought to undertake seasonal movements, with some nesting sites abandoned during the non-breeding season (which is protracted between spring and autumn). The species is unlikely to occur within the Operational Area, aside from individuals occasionally transiting through during migration periods. The species may occur within the EMBA.

Streaked shearwater

The streaked shearwater is most commonly found in pelagic and inshore waters of the Pacific Ocean. Within Australian waters, the species is commonly distributed from Exmouth, across northern Australia to Queensland, south to NSW (DSEWPaC 2012). Its diet consists of invertebrates and epipelagic fishes (Atlas of Living Australia, 2019). The species breeds in temperate regions of east and south-east Asia before migrating to tropical regions near the equator; however, little is known about their movements during the non-breeding period (Yamamoto et al., 2010). Given the lack of suitable habitat, crested terns are unlikely to occur within the Operational Area; however, may occasionally be present within the wider EMBA.

Lesser frigatebird

The lesser frigatebird is the most widely distributed frigatebird in Australian tropical seas and is the smallest species of frigatebird. The species is well-adapted for an aerial existence and may range considerable distances from land. Food consists largely of fish taken at the sea surface or stolen from other birds. Beyond Australia, the lesser frigatebird occurs throughout the tropical Indian Ocean, the western tropical Pacific Ocean, and the south-western tropical Atlantic Ocean. The lesser frigatebird may occur within the Operational Area and the EMBA.

Great frigatebird

Great frigatebirds are found in tropical waters globally. The species breeds on small, remote tropical and sub-tropical islands, in mangroves or bushes and occasionally on bare ground. The great frigatebird feeds on fish, squid and chicks of other bird species. Breeding is known to occur between May to June and in August (DoEE, 2019a). A BIA has been identified at Ashmore Reef and Cartier Island for the species to highlight breeding and foraging behaviours in the area (approximately 550 km away from the Operational Area).

Common sandpiper

The common sandpiper is a small, migratory sandpiper with a very large range through which it migrates annually between breeding grounds in the northern hemisphere (Europe and Asia) and non-breeding areas in the Asia-Pacific region (Bamford et al., 2008). The species congregates in large flocks and forages in shallow waters and tidal flats between spring and autumn. Specific critical habitat in Australia has not been identified due to the species' broad distribution (Bamford et al., 2008). The common sandpiper is unlikely to occur in the Operational Area or EMBA, aside from individuals occasionally transiting through during migrations, due to the lack of emergent habitat.

Sharp-tailed sandpiper

Like other species of sandpiper, the sharp-tailed sandpiper is a migratory wading shorebird and seasonally migrates long distances between breeding grounds in the northern hemisphere and over-wintering areas in the southern hemisphere (Bamford et al., 2008). The species may occur in Australia between spring and autumn. The species is unlikely to occur within the Operational Area due to the lack of suitable habitat, however it may occur in the EMBA.

Pectoral sandpiper

As with other species of sandpiper, the pectoral sandpiper breeds in the northern hemisphere during the boreal summer, before undertaking long distance migrations to feeding grounds in the southern hemisphere. The species occurs throughout mainland Australia between spring and autumn. The pectoral sandpiper prefers coastal and near-coastal environments such as wetlands, estuaries and mudflats. Given the species' preferred habitat the pectoral sandpiper is not expected to occur within the Operational Area, however it may occur in the EMBA.

Osprey

Within Australia, ospreys are most commonly found in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. In Australia, ospreys breed from April to February in individual pairs. Ospreys are mostly resident around breeding territories, foraging more widely during non-breeding season and feeding primarily on fish. Due to the lack of emergent habitat, ospreys are not expected to occur within the Operational Area; however, they may occur in the EMBA.

Red goshawk

The red goshawk is very sparsely dispersed across primarily coastal and near-coastal Australia from the Kimberley in WA to north-eastern New South Wales (DERM, 2012). In the NT, the Tiwi Islands are the stronghold for the species supporting approximately 15% of the Australian population (DERM, 2012). In the north of Australia, adult red goshawks are year-round residents, with breeding generally occurring in spring, and laying occurring from May to October (DERM, 2012). In the Tiwi Islands, red goshawks most often forage in extensive open forest and open woodlands, with over 95% of the red goshawk's diet made up of birds (DERM, 2012). Due to the lack of emergent and suitable foraging habitat, red goshawks are not expected to occur within the Operational Area; however, they may occur in nearshore waters of the EMBA surrounding the Tiwi Islands.

Bar-tailed godwit

The bar-tailed godwit has been recorded in the coastal areas of all Australian states. It is widespread in the Torres Strait and along the east and south-east coasts of Queensland, NSW and Victoria, with populations also recorded in northern Australia, from Darwin east to the Gulf of Carpentaria (DoE, 2016). The bar-tailed godwit occurs mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays, although it has also been recorded at sandy ocean beaches, rock platforms and coral reef-flats (DoE, 2016). The bar-tailed godwit does not breed in Australia and foraging usually occurs near the edge of water or in shallow water, mainly in tidal estuaries and harbours (DoE, 2016). Due to the lack of emergent and suitable foraging habitat, bar-tailed godwits are not expected to occur within the Operational Area; however, they may occur in nearshore waters of the EMBA surrounding the Tiwi Islands.

Australian painted snipe

The Australian painted snipe has a widespread distribution, mainly occurring in shallow freshwater (occasionally brackish) wetlands, such as lakes and swamps (DoE, 2013). The Australian painted snipe has been recorded in wetlands in all states and territories, and is more common in eastern Australia (DoE, 2013). Given the lack of suitable habitat, Australian painted snipes are not expected to occur within the Operational Area; however, they may occur in nearshore waters of the EMBA.

Fork-tailed swift

The fork-tailed swift is a non-breeding visitor to all states and territories of Australia (DoE, 2021). In the NT, there are widespread but scattered records in the north, including some offshore islands (DoE, 2021). The fork-tailed swift does not breed in Australia, but migrates from breeding grounds in Siberia from August to September, and arrives in Australia via the NT from mid-October, departing again by the end of April (DoE, 2021). Due to the lack of emergent habitat, fork-tailed swifts are not expected to occur within the Operational Area; however, they may occur in the EMBA.

4.5 Socio-Economic and Cultural Environment

4.5.1 European and/or Indigenous Sites of Significance

Indigenous cultural heritage sites are protected under the *Heritage Act 2011* (NT) and/or the EPBC Act. A search of the NT Government Heritage Register was undertaken for the Operational Area and EMBA. The search confirmed there are no known sites of Indigenous cultural heritage significance within the vicinity of the Operational Area or EMBA.

Indigenous Australian people have a strong continuing connection with the area that extends back some 50,000 years. Woodside acknowledges this unique connection between Aboriginal peoples and the land and sea in which the company operates. Woodside also understands that while marine resources used by Indigenous people are generally limited to coastal waters for activities such as fishing, hunting and maintenance of culture and heritage, many Aboriginal groups have a direct cultural interest in decisions affecting the management of deeper offshore waters. Woodside engaged the Tiwi Land Council as part of consultation for this EP to ensure cultural interests relevant to the activity were considered during development of this EP (**Section 5.5**).Maritime Cultural Heritage Sites

In 2018, the Australian Parliament passed the *Underwater Cultural Heritage Act 2018* (Underwater Heritage Act). The Act came into effect on 1 July 2019, replacing the *Historic Shipwrecks Act 1976*. The Underwater Heritage Act continues the protection of Australia's shipwrecks, but has also broadened to include protection to sunken aircraft and other types of underwater cultural heritage.

A search of the Australian National Shipwreck Database (DAWE, 2021), which records all known Maritime Cultural Heritage (shipwrecks, aircraft, relics and other underwater cultural heritage) in Australian waters, indicated that there are no Underwater Cultural Heritage sites within the Operational Area. The closest Underwater Cultural Heritage site is the wreck of the SS Florence D, a bulk carrier sunk off the coast of the Tiwi Islands in 1942, located 50 km south of the Operational Area, within the EMBA.

4.5.2 Jurisdictional Arrangements with Indonesia

As shown in **Figure 3-1**, the Operational Area is located in Commonwealth Waters within Australia's 200 nautical mile (nm) EEZ as defined by the "*1972 Seabed Boundaries Agreement between the Commonwealth of Australia and the Republic of Indonesia on Seabed Boundaries in the Area of the Timor and Arafura Seas*" (the Australia-Indonesia 1972 Seabed Agreement).

The northern portion of the Operational Area is located within an 'Area of Overlapping Jurisdiction' under the "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*" (the 1997 Perth Treaty). The Treaty remains unsigned by the Indonesian government and has not officially entered into force, however both Australia and Indonesia act consistently with the arrangements established under the Treaty (AFMA, 2014).

The Active Source Area and Operational Area overlap with approximately 4935 km^2 and 6043 km^2 of the ‘Area of Overlapping Jurisdiction’ respectively, which itself has a total area of 57,044 km^2. Within this area, Australia exercises seabed jurisdiction including the exploration for petroleum, and Indonesia exercises water column jurisdiction including fishing rights. Administration of petroleum rights within this area is undertaken by the National Offshore Petroleum Titles Administrator (NOPTA), and the management of environment, safety and risk from petroleum activities within this area is regulated by NOPSEMA.

The northern boundary of the Perth Treaty Area is contiguous with the seabed boundary set in the 1972 Seabed Agreement, with the seabed and waters north of this boundary being located within the Indonesian EEZ. The northern boundary of the Operational Area is located approximately 3 km south from the boundary of the Indonesian EEZ.

4.5.3 Ramsar Wetlands

Ramsar wetlands are sites that have been included on the List of Wetlands of International Importance on the basis of representativeness or uniqueness or of biodiversity values. There are no Ramsar wetlands within or adjacent to the Operational Area or EMBA. The closest Ramsar wetland occurs at the Cobourg Peninsula, about 122 km south-east of the Operational Area (outside of the EMBA).

4.5.4 Australian Commercial Fisheries

4.5.4.1 Commonwealth Managed Fisheries

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

The Information presented in this section has been predominately sourced from AFMA, Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) Fishery Status Reports and consultation with stakeholders (refer to **Section 5**).

The Commonwealth managed fisheries located within, adjacent to, or in the region of the Operational Area are outlined in **Table 4-8**.

Table 4-8: Commonwealth managed fisheries of relevance to the Petroleum Activities Program

Fishery	Management area overlaps with: Operational Area	Management area overlaps with: Socio-cultural EMBA	Potential for interaction within Operational Area	Description	
Northern Prawn Fishery (Patterson et al., 2020) (AFMA, 2021b)	✓	✓	✓	Management area:	The Northern Prawn Fishery (NPF) extends from Joseph Bonaparte Gulf across the top end to the Gulf of Carpentaria (**Figure 4-12**).
				Species targeted:	The NPF targets a range of tropical prawn species. White banana prawn (*Penaeus merguiensis*) and two species of tiger prawn (*P. esculentus* and *P.semisulcatus*) account for around 80% of the landed catch. White banana prawn is mainly caught during the day on the eastern side of the Gulf of Carpentaria, whereas redleg banana prawn (*P. indicus*) is caught during both day and night, mainly in the JBG. By-product species include endeavour prawns, scampi (*Metanephrops* spp.), bugs (*Thenus* spp.) and saucer scallops (*Amusium* spp.).
				Fishing methods:	The NPF uses otter trawl gear. Most vessels have transitioned from using twin gear to using a more efficient quad rig comprising four trawl nets.
				Fishing season(s):	The NPF operates during two seasons. The first season is from 1 April to 15 June, and during this time banana prawns are mainly caught. In the second season from 1 August to 1 December, tiger prawns are predominately caught. Either season has the potential to end early depending on the total catch.
				Fishing depth:	Fishing takes place in waters 35–70 m deep, with most fishing effort between 50 and 60 m.
				Fishing effort:	Total NPF catch in 2019 was 8,581 t, comprising 8,449 t of prawns and 132 t of by-product (by-catch) species (predominantly squid, bugs and scampi). Annual catches tend to be quite variable from year to year because of natural variability in the banana prawn component of the fishery. Most catches come from the southern and western Gulf of Carpentaria, and the nearshore waters of the Arnhem Land coast. Highest catches occur in areas near coastal seagrass beds that form the nursery habitat for tiger prawns. Daytime trawling has been prohibited in all areas during the tiger prawn season (1 August to 1 December) and therefore tiger prawns are primarily taken at night (AFMA, 2021b).

Fishery	Management area overlaps with: Operational Area	Management area overlaps with: Socio-cultural EMBA	Potential for interaction within Operational Area	Description	
					The southern extent of the Operational Area overlaps with an area identified in the ABARES Fishery Status Report 2020 (Patterson et al., 2020) as containing low fishing effort (<0.1 days/km^2) (**Figure** 4-13). Adjacent to this low fishing area and about 14 km south of the Operational Area is a relatively small area identified as containing medium fishing effort (0.1-0.25 days/km^2). A limited quantity of scampi is taken as a non-target, by-product species from a deepwater area on the edge of the Australian Fishing Zone (AFZ) north of Melville Island and is targeted during NPF prawn trawling closure periods (primarily in December to January) (AFMA, 2021c). Holders of statutory fishing rights in the NPF are permitted to collect live prawn broodstock (AFMA, 2021c). Specific broodstock collection permits are provided for under the NPF Management Plan 1995. Annually, 2-3 vessels are usually engaged in broodstock collection and can fish year-round, including during seasonal closures.
				Active licences/vessels:	52 active vessels from 52 permits in the 2019 fishing season (Patterson et al., 2020).
				Potential for interaction within Operational Area:	There is potential for fishers in the NPF during both the first (banana) and second (tiger) prawn seasons to occasionally be present within the Operational Area during the Petroleum Activities Program, in particular at the southern extent of the Operational Area where low fishing effort is reported. There is also potential for fishers to be present during prawn fishing closure periods in the north-western extent of the Operational Area while trawling deep waters for scampi. Additionally, vessels with permits for broodstock collection could be present in the southern extent of the Operational Area during the Petroleum Activities Program. The Northern Prawn Fishery Industry Pty Ltd (NPFI) were engaged during consultation for this EP (**Section 5.5**).
Southern Bluefin Tuna Fishery	✓	✓	×	Management area:	The Southern Bluefin Tuna Fishery covers the entire EEZ around Australia, out to 200 nm from the coast.
				Species targeted:	Southern bluefin tuna (*Thunnus maccoyii*).
				Fishing methods:	Pelagic longline and purse seine fishing.

Fishery	Management area overlaps with:		Potential for interaction within Operational Area	Description	
	Operational Area	Socio-cultural EMBA			
(Patterson et al., 2020)				Fishing season(s):	All year.
				Fishing depth:	Southern bluefin tuna are a pelagic species which can be found up to depths of 500 m (AFMA, 2020).
				Fishing effort:	Fishing mainly occurs in the Great Australian Bight during summer months, and off the NSW coastline during winter months (AFMA, 2020). The fishery has not been active in the Operational Area within at least the last five years. Fishing efforts for Southern Bluefin Tuna hit its peak in Australia in 1967, with a catch of around 59,281 tonnes (Commission for the Conservation of Southern Bluefin Tuna [CCSBT], 2019), since then, catch efforts have declined to around 6,074 tonnes for the Australian 2018-19 fishing season.
				Active licences/vessels:	Seven purse seine vessels, 20 longline vessels.
				Potential for interaction within Operational Area:	Although the Operational Area overlaps with the fishery management area, future interactions with the fishery are not expected given the current distribution of fishing effort. Therefore, the fishery is not considered further in this EP.
Western Skipjack Tuna Fishery (Patterson et al., 2020)	✓	✓	×	Management area:	The combined Western and Eastern Skipjack Tuna fisheries encompass the entire Australian EEZ. The Western Skipjack Tuna Fishery extends westward from the SA/Victoria (VIC) border across the Great Australian Bight and around the west coast of WA to the Cape York Peninsula.
				Species targeted:	Western Skipjack Tuna (*Katsuwonus pelamis*).
				Fishing methods:	Fishers historically used purse seine nets and pole and line.
				Fishing season(s):	The fishery is not currently active and the management arrangements for this fishery are under review.
				Fishing depth:	Western skipjack tuna are a pelagic species that can be found up to depths of 260 m (AFMA, 2020).
				Fishing effort:	Data shows fishing effort was historically concentrated offshore of the 200 m isobath off southern WA, with some effort also recorded off the central and Pilbara coasts of WA (Patterson and Stephan, 2014; Williams et al., 2016). The

Fishery	Management area overlaps with:		Potential for interaction within Operational Area	Description	
	Operational Area	Socio-cultural EMBA			
					Skipjack Tuna Fishery is not active currently and no Australian boats have fished for skipjack tuna since 2009.
				Active licences/vessels:	No active vessels have operated in the fishery since 2009 (Patterson et al., 2020).
				Potential for interaction within Operational Area:	Although the Operational Area overlaps with the fishery management area, future interactions with the fishery are not expected given there has been no active vessel since 2009. Therefore, the fishery is not considered further in this EP.
Western Tuna and Billfish Fishery (Patterson et al., 2020)	✓	✓	×	Management area:	The Western Tuna and Billfish Fishery extends to the Australian EEZ boundary in the Indian Ocean, from Cape York in QLD, through WA to the border between VIC and SA.
				Species targeted:	The fishery targets bigeye tuna (*Thunnus obesus*), yellowfin tuna (*T. albacares*), broadbill swordfish (*Xiphias gladius*) and striped marlin (*Tetrapturus audux*).
				Fishing methods:	The fishery mainly uses longline fishing gear to catch targeted species. Minor line (including handline, troll, rod and reel) is also permitted.
				Fishing season(s):	All year.
				Fishing depth:	Fishing occurs mainly off the 200 m isobath.
				Fishing effort:	Data shows fishing effort is concentrated offshore of the 200 m isobath off southern WA, with some effort also recorded off the central and Pilbara coasts off WA (Patterson and Stephan, 2014; Williams et al., 2016). The fishery has not been active in the Operational Area within at least the last five years (ABARES, 2019).
				Active licences/vessels:	Two pelagic longline vessels and two minor longline vessels (Patterson et al., 2020).
				Potential for interaction within Operational Area:	Although the Operational Area overlaps with the fishery management area, future interactions with the fishery are not expected given the current distribution of fishing effort. Therefore, the fishery is not considered further in this EP.

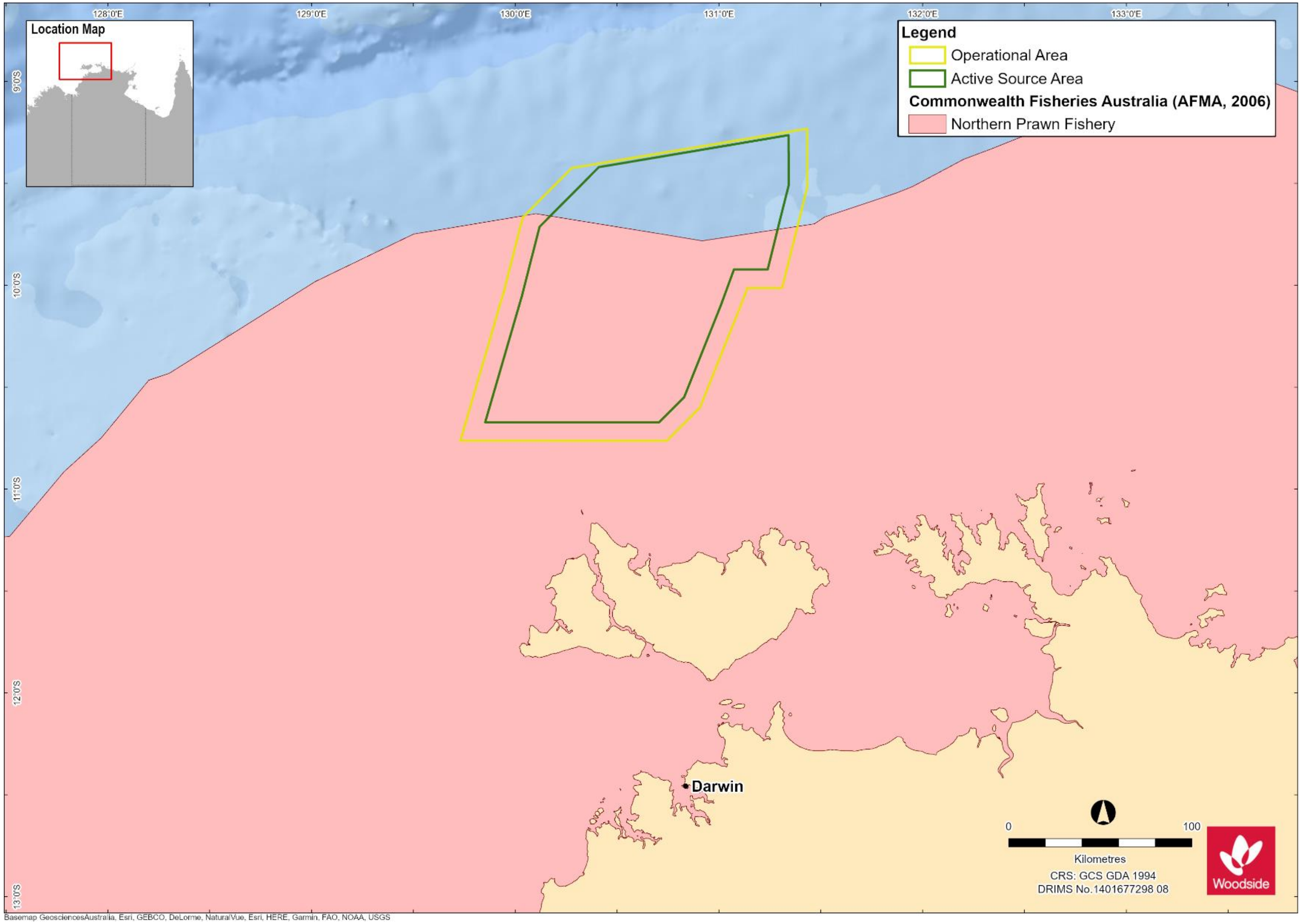


Figure 4-12: Commonwealth fisheries with potential for interaction with the Petroleum Activities Program

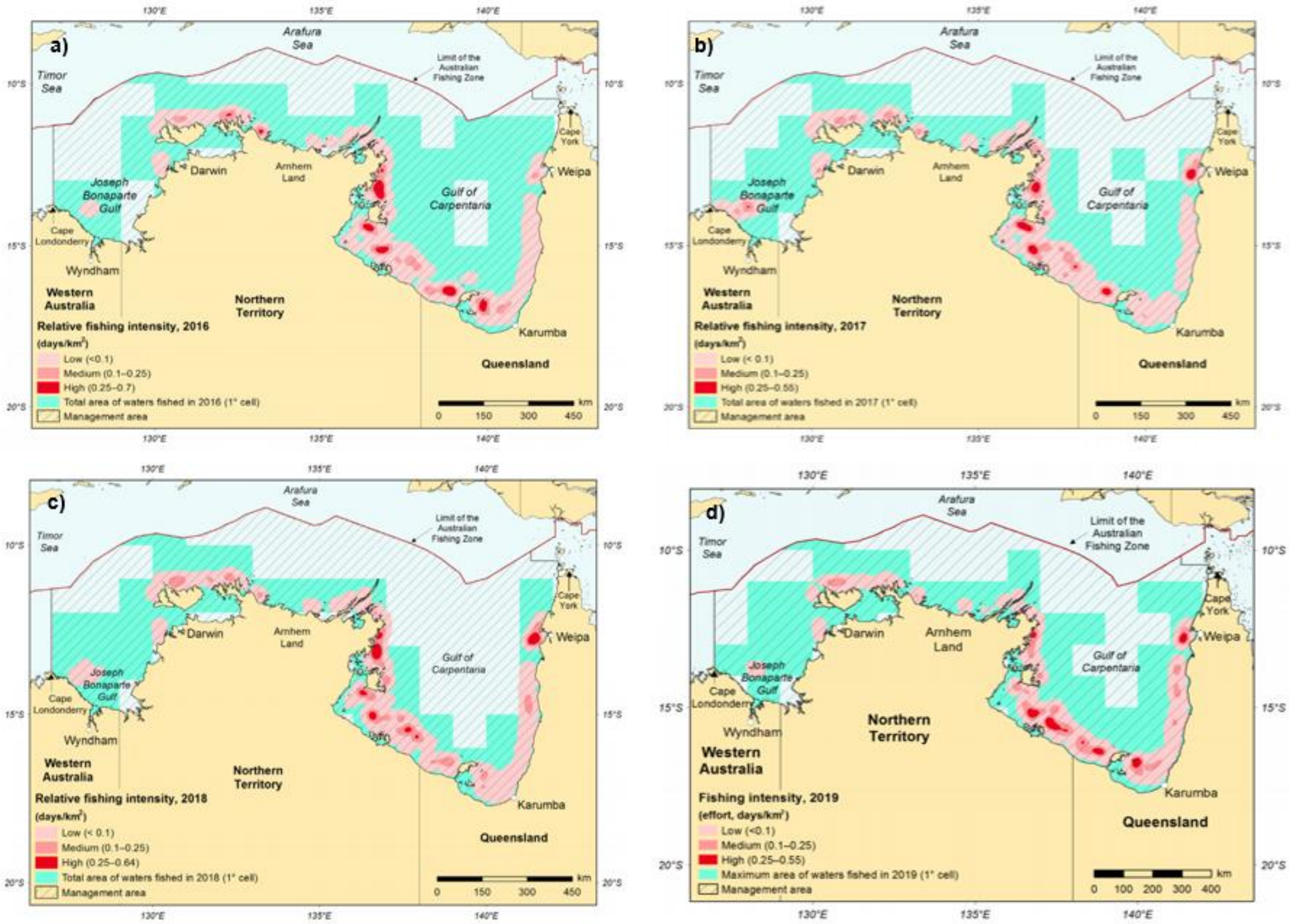


Figure 4-13: Fishing intensity in the Northern Prawn Fishery; a) 2016, b) 2017, c) 2018, d) 2019 (Patterson et al., 2017, 2018, 2019, 2020)

4.5.4.2 Northern Territory Managed Fisheries

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

The information presented in this section has been predominately sourced from NT DITT and NT Fish Stocks Report 2017 (DPIR, 2017).

Woodside also requested catch and effort data from the NT DITT (Fisheries) for NT managed fisheries identified as overlapping the Operational Area. Annual catch and effort data was requested for the 2016–2020 period at the highest available resolution (60 nm x 60 nm fishing grid blocks) (DITT, 2021). Data provided by DITT included:

- Weight (kg): a measure of fish catches in a 60 nm x 60 nm block during the period of interest.
- Licence count: a measure of the number of licences that fished in 60 nm x 60 nm block during the period of interest. Licences are transferable in some fisheries and therefore licence count does not represent vessel count.
- Fishing day count: a measure of fishing effort, represented by the number of days when one or more vessels fished in a 60 nm x 60 nm block during the period of interest.

Due to confidentiality reasons, DITT (Fisheries) was unable to release catch data for blocks where less than five licence holders fished during the period of interest (i.e. less than five licence holders per year). It is important to recognise the limitations of referring to blocks with less than five licence holders; although the number of licence holders may be less than five, a block may experience high catch. Alternatively, these blocks may experience less catch than other blocks where five or more licence holders frequent the area to fish.

In addition, Woodside has used data reported for an aggregated 5-year period (2016-2020), which greatly reduces the number of blocks in a fishery where ‘less than five licence holders’ are reported. Where a block has been visited by less than five licence holders over an entire 5-year period, it implies that fishing effort may be relatively low compared with other blocks where five or more licence holders go to fish.

The data received was analysed block-by-block to understand the distribution of fishing effort relative to the Operational Area and identify any trends in catch and effort over time. Results of the data analysis are provided in **Table 4-9** and used to inform the assessments in **Section 6.4** and **6.5.**

Table 4-9: NT managed fisheries of relevance to the Petroleum Activities Program

Fishery	Management area overlaps with:		Potential for interaction within Operational Area	Description	
	Operational Area	Socio-cultural EMBA			
Aquarium Fishery (DITT, 2016a)	✓	✓	✓	Management area:	The Aquarium Fishery management area (**Figure 4-14**) encompasses freshwater, estuarine and marine waters between the WA/NT and QLD/NT border to the outer boundary of the Australian Fishing Zone (AFZ), covering an area of 523,946 km^2. Harvesting is not permitted from a number of designated protected areas, including Doctor's Gully Aquatic Life Reserve, East Point Aquatic Reserve and Darwin Harbour, Aboriginal sacred sites, aquaculture farm leases and sanctuary zones (DPIR, 2019).
				Species targeted:	The fishery targets aquarium fishes that mostly comprises of rainbowfish (e.g. *Melanotaenia* spp.), catfish (e.g. *Neosilurus ater*) and scats (e.g. *Scatophagus argus*). The fishery also targets invertebrates including hermit crabs, snails, whelks and hard and soft corals and aquatic plants. The fishery has traditionally focused on freshwater fish, but in recent years some operators have been transitioning into the collection of marine fish.
				Fishing methods:	Collection via hand-held equipment, including nets (barrier, cast, scoop, drag and skimmer) and hand pumps. Freshwater pots are also permitted.
				Fishing season(s):	All year.
				Fishing depth:	Harvesting usually in depths less than 10 m, and occasionally in depths up to 30 m (DPIR, 2019).
				Fishing effort:	Freshwater and estuarine species are generally collected between the Adelaide and Daly rivers, while most marine species are collected within 100 km of Nhulunbuy and Darwin. From time to time activity occurs away from the major centres, including at Evans Shoal and Goodrich Bank (DPIR, 2019). A review of historic fishing data indicates that effort was reported relatively consistently between 2016 and 2020 in the fishing grid blocks (1029 and 1030) overlapping the south of the Operational Area (**Figure 4-15)**. Over this period, between 3 to 12 days of fishing per year was reported in the fishing grid blocks overlapping the Operational Area.
				Active licences/vessels:	There are 11 licences in the Aquarium Fishery and in 2018-19 there were 7 licences actively collecting marine species (DPIR, 2019).

Fishery	Management area overlaps with:		Potential for interaction within Operational Area	Description	
	Operational Area	Socio-cultural EMBA			
				Potential for interaction within Operational Area:	The majority of fishing effort in the Aquarium Fishery is focused in freshwater and nearshore marine environments, outside of the Operational Area. Occasional fishing effort has been reported at offshore locations, such as Goodrich Bank, located at the southern extent of the Operational Area (**Figure 4-15**). Therefore, there is potential for interaction with fishers in the south of the Operational Area. Licence holders in the Aquarium Fishery were engaged during consultation for this EP (**Section 5.5**).
Spanish Mackerel Fishery (DPIF, 2017c)	✓	✓	✓	Management area:	The Spanish Mackerel Fishery management area covers waters between the WA/NT and QLD/NT border from the high water mark to the outer boundary of the AFZ (**Figure 4-14**).
				Species targeted:	Spanish mackerel (*Scomberomorus commerson*). Refer to **Table 4-3** for a description of the habitat, distribution, stock structure and reproductive biology of this species.
				Fishing methods:	Commercial fishers operate using a mothership and up to two dories. It is common for fishers to troll two to four lines behind a dory and up to eight lines from a mothership using trolled lures or baited lines.
				Fishing season(s):	All year.
				Fishing depth:	The preferred fishing depth of this fishery is not specified.
				Fishing effort:	Fishing generally takes place around reefs, headlands and shoals. Majority of catch occurs off the western and eastern mainland coasts and near islands including Bathurst Island, Groote Eylandt and the Wessel Islands. A review of historic fishing data indicates that effort was reported consistently between 2016 and 2020 in the fishing grid blocks (1029, 1030 and 1031) overlapping the Operational Area (**Figure 4-16)**. Over this period, between 12 to 120 days of fishing per year was reported in the listed blocks. Majority of the fishing effort is concentrated south and west of the Operational Area (**Figure 4-16**).
				Active licences/vessels:	There are 15 licences currently issued in the fishery.

Fishery	Management area overlaps with:		Potential for interaction within Operational Area	Description	
	Operational Area	Socio-cultural EMBA			
				Potential for interaction within Operational Area:	The majority of the fishing effort in the fishery is focused off the western and eastern mainland coasts. Fishing effort has been reported consistently in the fishing grid blocks overlapping the Operational Area between 2016 and 2020. Therefore, there is potential for interactions with fishers in the Operational Area. Licence holders in the Spanish Mackerel Fishery were engaged during consultation for this EP (**Section 5.5**).
Timor Reef Fishery (Department of Primary Industries and Fisheries [DPIF], 2017f; DPIR, 2019)	✓	✓	✓	Management area:	The Timor Reef Fishery is located north-west of Darwin from the WA /NT border and to the outer boundary of the AFZ (**Figure 4-14**). This region known as the Timor Box and covers an area of approximately 31,182 km^2.
				Species targeted:	Goldband snapper (*Pristipomoides multidens*), saddle-tail snapper (*Lutjanus malabaricus*), and crimson snapper (*L. erythropterus*) are the primary species taken. Refer to **Table 4-3** for a description of the habitat, distribution, stock structure and reproductive biology of these species. Secondary species include, cods (Family Serranidae), trevally, redspot emperor (*Lethrinus lentjan*), mangrove jack (*Lutjanus argentimaculatus*) and Robinson's sea bream (*Gymnocranius grandoculus*).
				Fishing methods:	The majority of the catch is taken using baited traps; however, the fishery also uses vertical lines, finfish longlines, and drop lines attached to or free from a vessel.
				Fishing season(s):	All year.
				Fishing depth:	Fishing is typically concentrated between 80 m and 150 m.
				Fishing effort:	A review of historic fishing data indicates that effort was consistently between 2016 and 2020 in the fishing grid blocks (930, 931, 1029, 1030 and 1031) overlapping the Operational Area (**Figure 4-16**). Over this period, between 1 to 413 days of fishing per year was reported in the listed blocks. Majority of the fishing effort is concentrated to the west of the Operational Area, and in the south of the Operational Area (**Figure 4-16**).
				Active licences/vessels:	There are 15 licences currently issued in the Timor Reef Fishery. Analysis of historic fishing data (DITT, 2021) determined that between one and six licences

Fishery	Management area overlaps with:		Potential for interaction within Operational Area	Description	
	Operational Area	Socio-cultural EMBA			
					were active within the Timor Reef Fishery each year between 2016 and 2020. The number of vessels operating in the fishery is not known.
				Potential for interaction within Operational Area:	Fishing effort has been reported consistently in the fishing grid blocks overlapping the Operational Area between 2016 and 2020. Therefore, there is potential for interactions with fishers in the Operational Area. Licence holders in the Timor Reef Fishery were engaged during consultation for this EP (**Section 5.5**).
Demersal Fishery (DPIF, 2016)	✓	✓	✓	Management area:	The Demersal Fishery encompasses waters between the WA/NT and QLD/NT border from 15 nm from the low water mark to the outer boundary of the AFZ, excluding the area of the Timor Reef Fishery (**Figure 4-14**). The fishery covers an area of 356,200 km^2. Fish traps, hand lines and droplines are permitted throughout the fishery and demersal trawl nets are permitted in two defined zones (i.e. the 'Demersal Multigear Areas') – one in the Joseph Bonaparte Gulf and one across the waters comprising the western Gulf of Carpentaria and north-east NT offshore area. The Operational Area is within an area where fish traps, hand lines and droplines are permitted, and demersal trawls nets are excluded.
				Species targeted:	Target species in the Demersal Fishery Area include goldband snapper (*Pristipomoides multidens*), saddle-tail snapper (*Lutjanus malabaricus*), and crimson snapper (*L. erythropterus*). By-product species include red emperor (*L sebae*) and cods (Family Serranidae). Target species in the Demersal Multigear Area include saddle-tail snapper (*Lutjanus malabaricus*) and crimson snapper (*L. erythropterus*). By-product species include painted sweetlip (*Haemulidae* spp.), redspot emperor (*Lethrinus lentjan*) and goldband snapper. Refer to **Table 4-3** for a description of the habitat, distribution, stock structure and reproductive biology of the target species.
				Fishing methods:	Vertical lines, drop lines, finfish longlines and baited fish traps are used in the Demersal Fishery Area. Semi-demersal trawl nets, in addition to vertical lines, drop lines, finfish longlines and baited fish traps are used in the Demersal Multigear Area.

Fishery	Management area overlaps with:		Potential for interaction within Operational Area	Description	
	Operational Area	Socio-cultural EMBA			
				Fishing season(s):	All year.
				Fishing depth:	The preferred fishing depth of this fishery is not specified.
				Fishing effort:	A review of historic fishing data indicates that effort was reported consistently between 2016 and 2020 in the fishing grid blocks (930, 931, 1029 1030 and 1031) overlapping the Operational Area (**Figure 4-16)**. Over this period, between 1 to 120 days of fishing per year was reported in the listed blocks. Majority of the fishing effort is concentrated to the south and east of the Operational Area (**Figure 4-18**).
				Active licences/vessels:	There are 18 licences currently issued in the fishery. Analysis of historic fishing data determined that up to six licences were active within the fishery each year between 2016 and 2020. The number of vessels operating in the fishery is not known.
				Potential for interaction within Operational Area:	Fishing effort has been reported consistently in the fishing grid blocks overlapping the Operational Area between 2016 and 2020. Therefore, there is potential for interactions with fishers in the Operational Area. Licence holders in the Demersal Fishery were engaged during consultation for this EP (**Section 5.5**).
Offshore Net and Line Fishery (DPIF, 2021)	✓	✓	✓	Management area:	The fishery can operate in all NT waters from the low water mark to the boundary of the AFZ and covers an area of more than 522,000 km^2 (**Figure 4-14**).
				Species targeted:	Primarily target black-tip shark (*Carcharhinus limbatus*) and grey mackerel (*Scomberomorus semifasciatus*). Refer to **Table 4-3** for a description of the habitat, distribution, stock structure and reproductive biology of these species. Secondary species include hammerhead shark (*Sphyrna lewini*), bull shark (*Carcharhinus leucas*), tiger shark (*Galeocerdo cuvier*), pigeye shark (*Carcharhinus amboinensis*), lemon shark (*Negaprion brevirostris*), winghead shark (*Eusphyra blochii*) and dusky whalers (*Carcharhinus obscurus*). By-product catch includes Spanish mackerel, longtail tuna (*Thunnus tonggol*), black pomfret (*Parastromateus niger*) and other finfish.

<table>
<tr><th rowspan="2">Fishery</th><th colspan="2">Management area overlaps with:</th><th rowspan="2">Potential for interaction within Operational Area</th><th colspan="2" rowspan="2">Description</th></tr>
<tr><th>Operational Area</th><th>Socio-cultural EMBA</th></tr>
<tr><td rowspan="6"></td><td rowspan="6"></td><td rowspan="6"></td><td rowspan="6"></td><td>Fishing methods:</td><td>The following fishing methods can be used by the fishery with relevant restrictions:
• Demersal longlines may be used from the low water mark to the AFZ
• Pelagic longlines may be used three nautical miles seaward from the territorial sea baseline to the boundary of the AFZ.
• Pelagic nets can be used from two nautical miles from the low water mark to the boundary of the AFZ.</td></tr>
<tr><td>Fishing season(s):</td><td>All year.</td></tr>
<tr><td>Fishing depth:</td><td>The preferred fishing depth of this fishery is not specified.</td></tr>
<tr><td>Fishing effort:</td><td>Most fishing is done in the coastal zone within 12 nm of the coast, and immediately offshore in the Gulf of Carpentaria. Commercial fishing effort is concentrated around a few key reefs and shoals (NT Government, 2020).
A review of historic fishing data indicates that effort was reported in 2016, 2017 and 2019 in the fishing grid blocks (1029, 1030 and 1031) overlapping the Operational Area (Figure 4-16). Over this period, between 1 to 7 days of fishing per year was reported in the listed blocks. Majority of the fishing effort is concentrated to the south of the Operational Area along the NT coast (Figure 4-18).</td></tr>
<tr><td>Active licences/vessels:</td><td>The fishery has no restrictions on the number of licences issued. Analysis of historic fishing data from 2016 to 2020 determined that there was between one and seven licences active in the fishery.</td></tr>
<tr><td>Potential for interaction within Operational Area:</td><td>Fishing effort has been reported consistently in the fishing grid blocks overlapping the Operational Area between 2016 and 2020. Therefore, there is potential for interactions with fishers in the Operational Area. Licence holders in the Offshore Net and Line Fishery were engaged during consultation for this EP (Section 5.5).</td></tr>
<tr><td>Pearl Oyster Fishery</td><td>✓</td><td>✓</td><td>✗</td><td>Management area:</td><td>The fishery extends from the high-water mark to the outer boundary of the Australian fishing zone, 200 nautical miles offshore.</td></tr>
</table>

Fishery	Management area overlaps with:		Potential for interaction within Operational Area	Description	
	Operational Area	Socio-cultural EMBA			
(DITT, 2017b)				Species targeted:	The fishery targets bivalves of the genus *Pinctada* (pearl oysters). Pearl oysters are distributed within the central Indo-Pacific region, bounded by the Bay of Bengal to the west, Solomon Islands to the east, Taiwan to the north, and northern Australia to the south (Southgate et al., 2008).
				Fishing methods:	Hand collection by drift divers.
				Fishing season(s):	All year.
				Fishing depth:	Fishing efforts are restricted to water depths less than 35 m.
				Fishing effort:	Large catches of pearl oyster were taken from NT waters between 1901 and 1966. The catch peaked at 804 t in 1937 and the last significant catch was 339 t in 1957. A total of 138,000 oysters can be collected in the fishery each year; however, unlike the shallow and productive grounds in WA, relatively little fishing has occurred in the NT after the mother of pearl (MOP) fishery declined in the 1960s (DPIR, 1995). Since that time, annual catches have been very low, primarily because the market for MOP collapsed. Heavy historical fishing is considered to have depleted the stock in many areas along the NT coast (FRDC, 2018; Knuckey, 1995). Surveys conducted in the 1990s found significant numbers of large, mature individuals, indicating that recruitment was occurring, but biomass was not estimated (FRDC, 2018; Knuckey, 1995). Catches earlier this century were around 2 t (to supply niche markets) and there has been no harvest in the NT since 2008 (FRDC, 2018).
				Active licences/vessels:	There are five licences in the Pearl Oyster fishery, however no vessels have been active in the fishery since 2008 (FRDC, 2018).
				Potential for interaction within Operational Area:	Although the Operational Area overlaps with the fishery management area, future interactions with the fishery are not expected given there has been no active vessel since 2008. Therefore, the fishery is not considered further in this EP.
Coastal Line Fishery	×	✓	×	Management area:	The fishery extends along the NT coast between the high-water mark and 15 nm out from the low water mark.

Fishery	Management area overlaps with:		Potential for interaction within Operational Area	Description	
	Operational Area	Socio-cultural EMBA			
(DITT, 2017c)				Species targeted:	The fishery primarily targets black jewfish (*Protonibea diacanthus*) and golden snapper (*Lutjanus johnii).* Emperors, cods and other snappers are by-product species.
				Fishing methods:	The main fishing methods include the use of: • vertical lines, cast nets, scoop nets or gaffs can be used from the high-water mark out to 15 nm from the low water mark • drop lines and up to five fish traps can be used from two to 15 nm out from the low water mark • up to five hooks per vertical line and up to 40 hooks per drop line
				Fishing season(s):	All year.
				Fishing depth:	The preferred fishing depth of this fishery is not specified.
				Fishing effort:	Fishing effort is restricted to NT coastal waters.
				Active licences/vessels:	The fishery is restricted to 52 licences, of which all are currently allocated.
				Potential for interaction within Operational Area:	As the Operational Area does not overlap with the fishery management boundary, and that fishing effort is concentrated in NT coastal waters, no interactions with the fishery are not expected. Therefore, the fishery is not considered further in this EP.

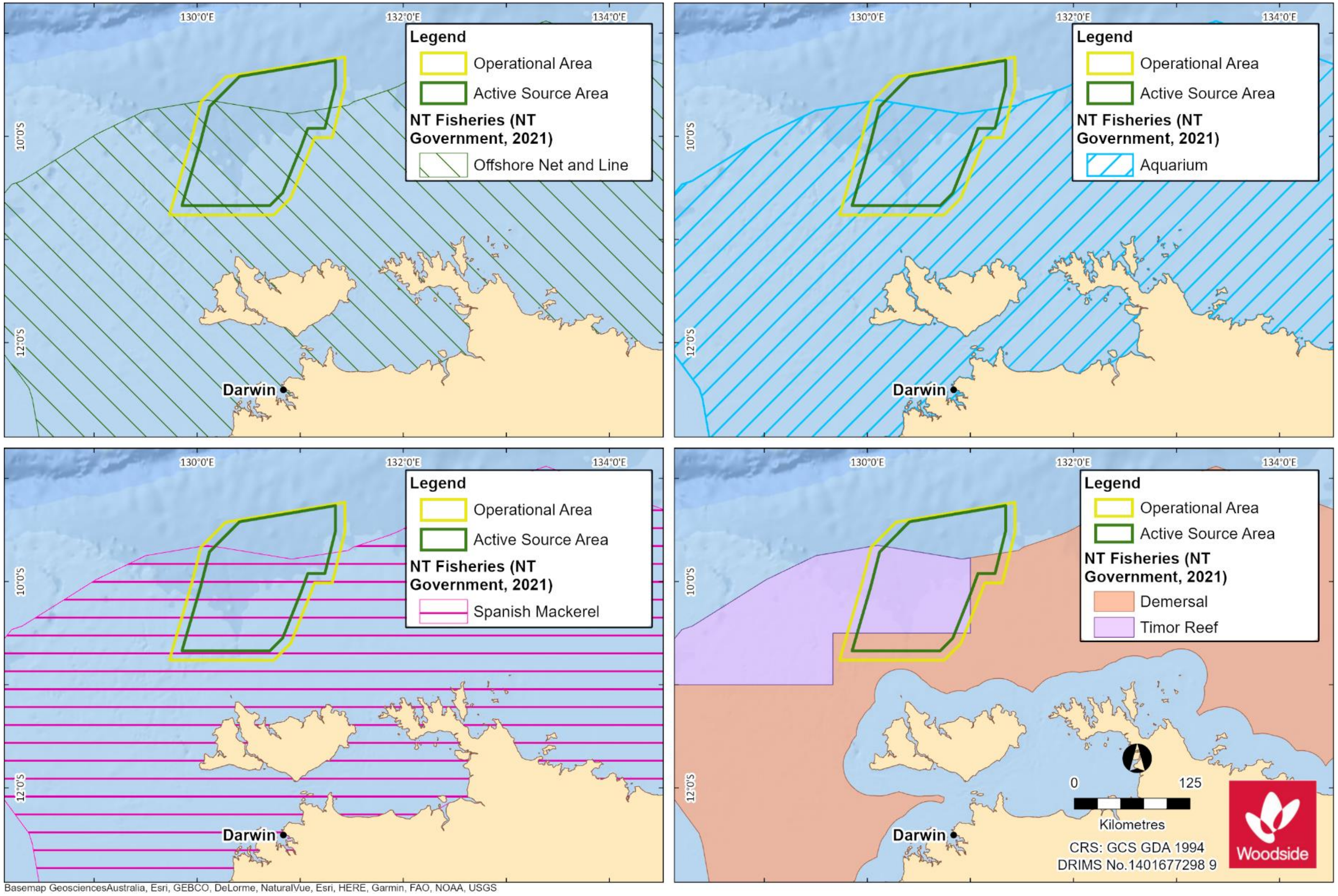


Figure 4-14: NT fisheries with potential for interaction with the Petroleum Activities Program

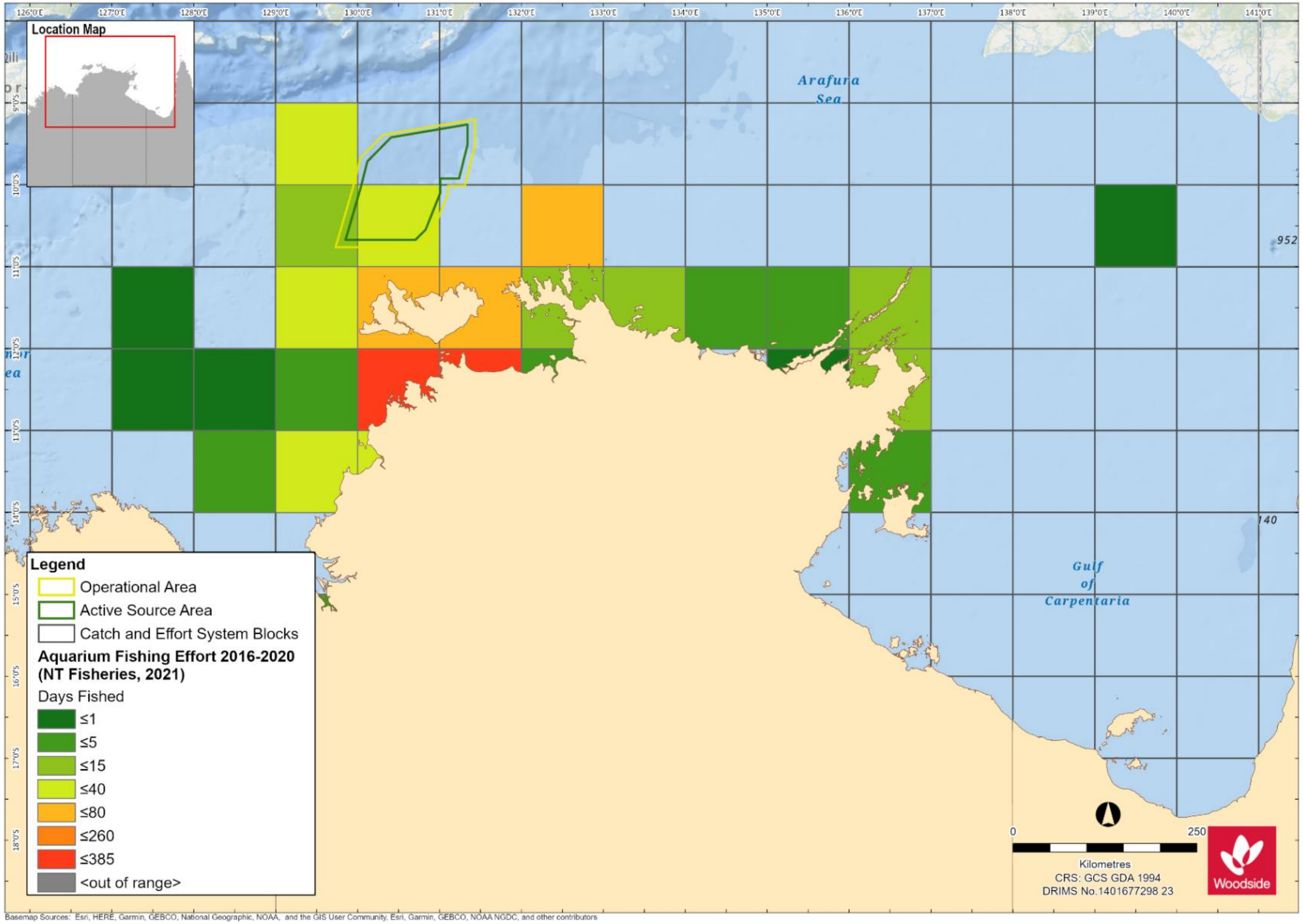


Figure 4-15: Aquarium Fishery total fishing day count (2016 to 2020)

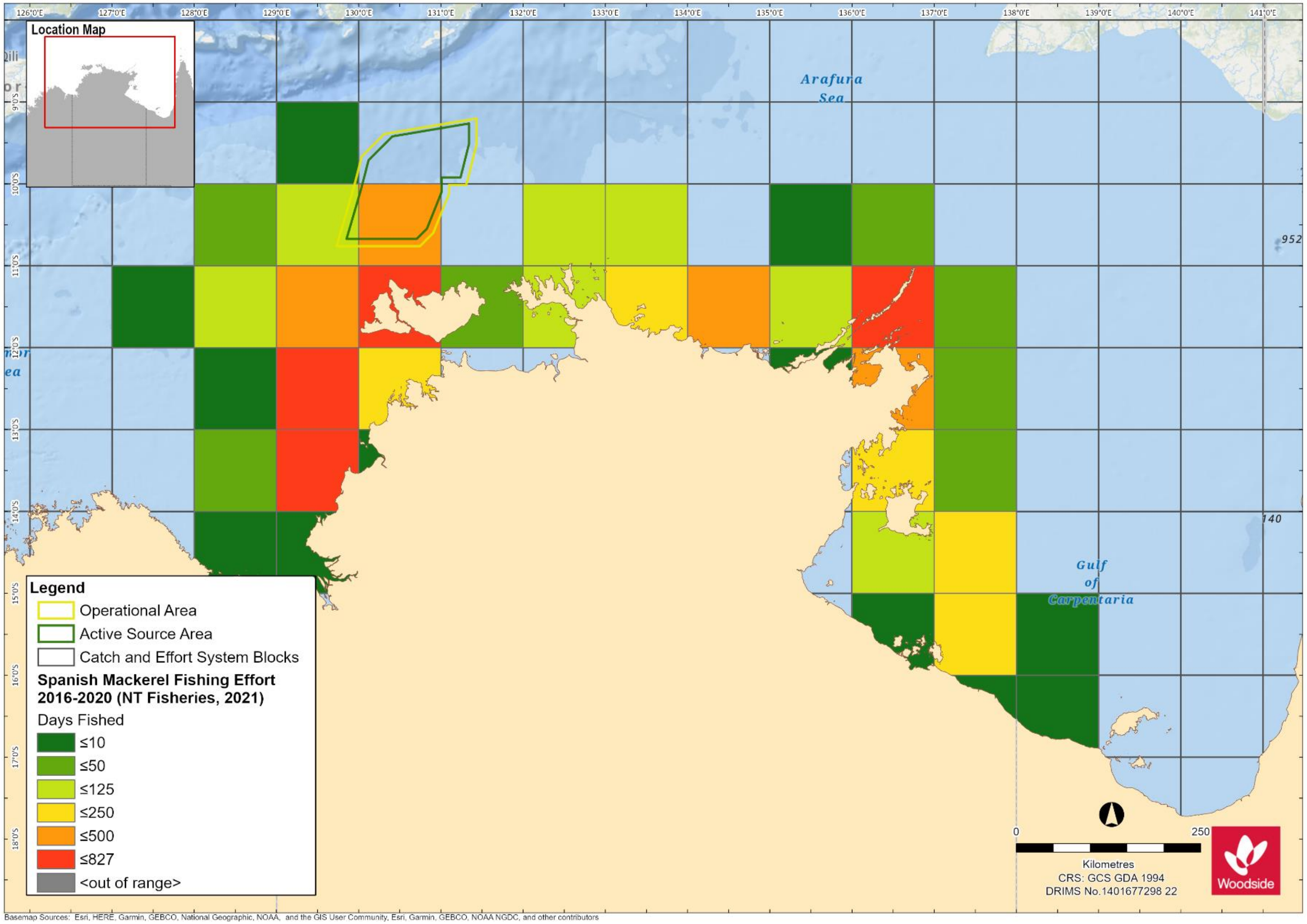


Figure 4-16: Spanish Mackerel Fishery total fishing day count (2016 to 2020)

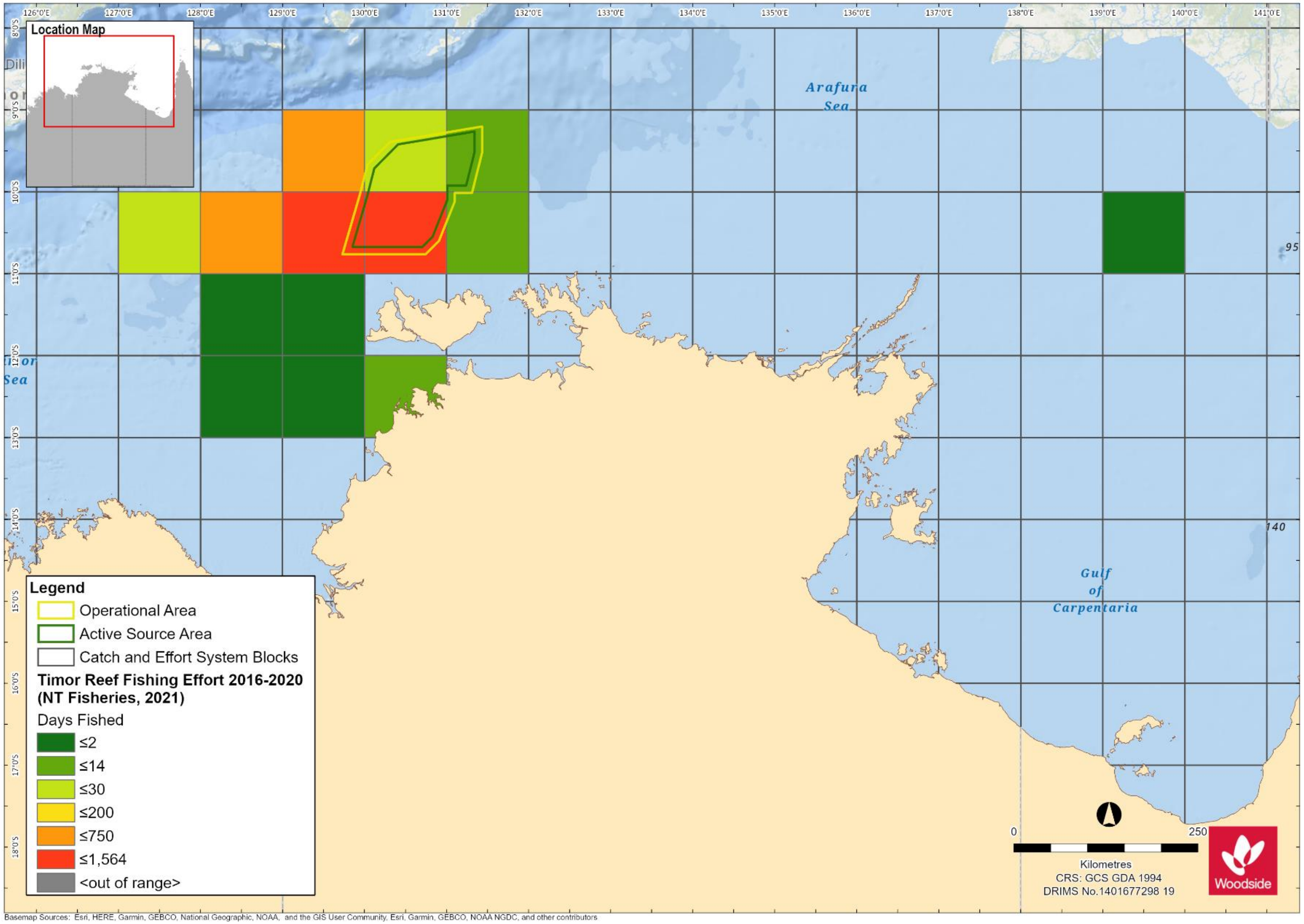


Figure 4-17: Timor Reef Fishery total fishing day count (2016 to 2020)

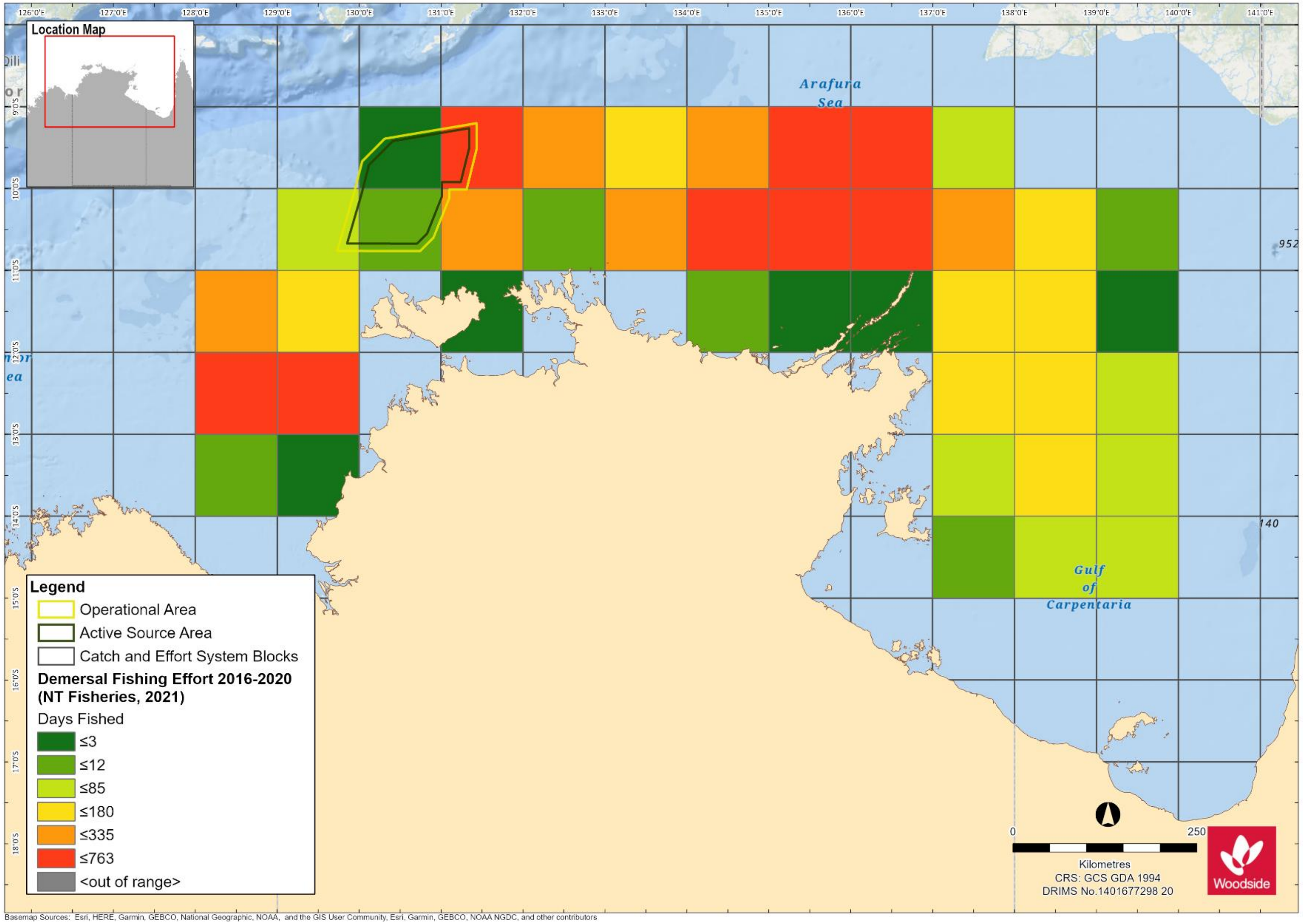


Figure 4-18: Demersal Fishery total fishing day count (2016 to 2020)

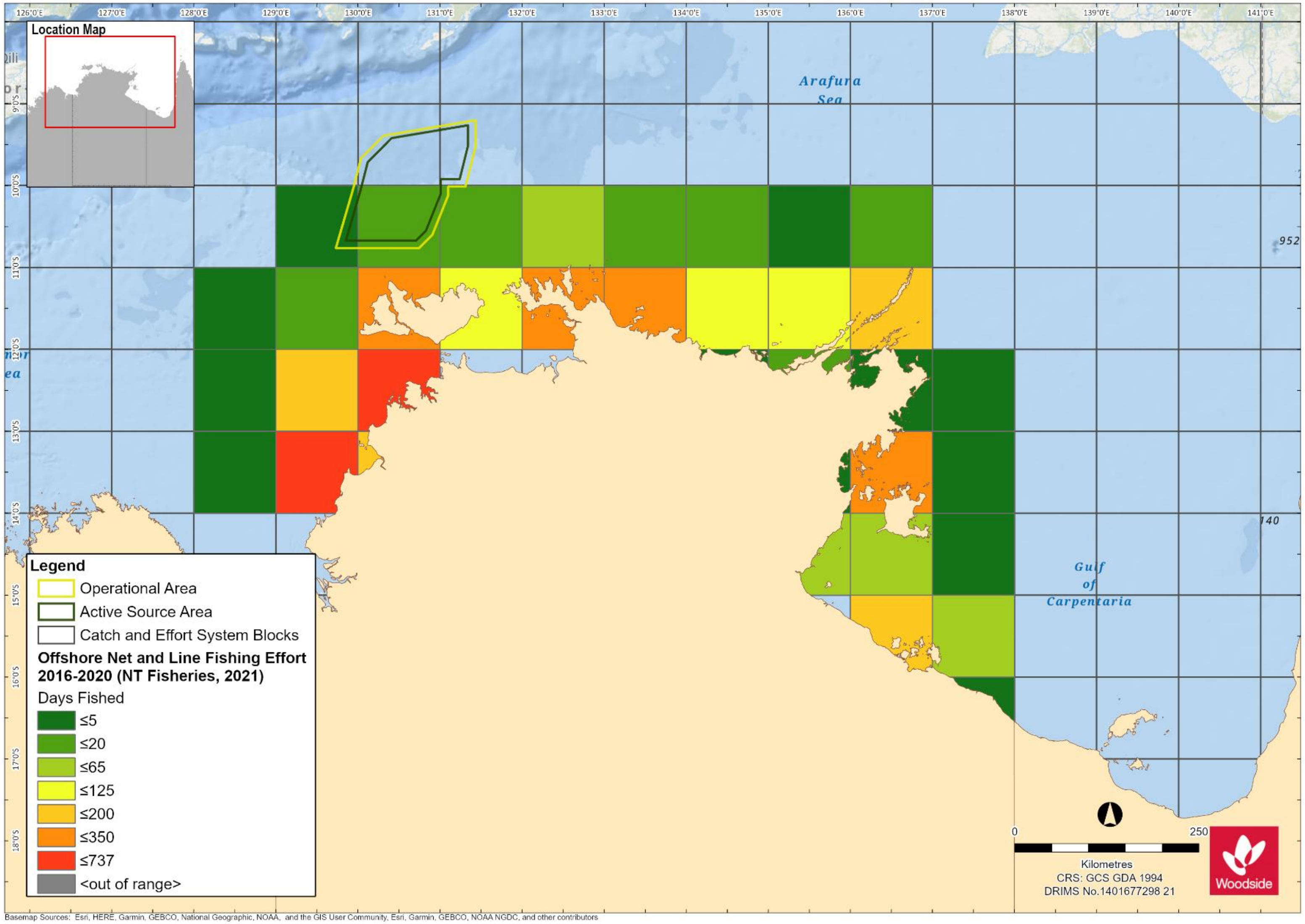


Figure 4-19: Offshore Net and Line Fishery total fishing day count (2016 to 2020)

4.5.5 Indonesian Commercial Fisheries

As described in **Section 4.5.2**, the northern portion of the Operational Area is located in the 'Area of Overlapping Jurisdiction' established under the 1997 Perth Treaty (**Figure 3-1**). Within this area, Australia exercises seabed jurisdiction including the exploration for petroleum, and Indonesia exercises water column jurisdiction including fishing rights. Therefore, it is possible that Indonesian commercial fishing vessels may be encountered in this area.

Indonesian regulations require Vessel Monitoring System (VMS) on fishing vessels exceeding 30 gross register tonnage (GRT) (averaging about 16 m or more) (Global Fishing Watch, 2020). In June 2017, the Republic of Indonesia entered into a partnership with Global Fishing Watch to deliver VMS data for all Indonesian flagged fishing vessels in a publicly available data platform. Subsequently, VMS data was made available on the Global Fishing Watch website for all Indonesian fishing vessels that are both equipped with the system and licensed to fish in Indonesian waters. Analysis of Indonesian fishing vessel tracks (vessels ≥30 GRT) in the Timor Sea since 2013 indicate the majority of offshore fishing in the region takes place about 50 km west of the Operational Area in Indonesian waters east of Evans Shoal, as well as the Timor Trough. Comparatively, Indonesian fishing vessel activity within the Operational Area is considered light, with only 5–10 vessels (>30 GRT) occasionally fishing within the waters of the Operational Area since 2013.

The VMS data delineate between six categories of fishing vessel, including drifting longlines, purse seine, trawlers, fixed gear (i.e. set longlines, set gillnets, pots and traps), squid jiggers and 'other' fishing vessels. The length and tonnage of each vessel is also provided in the data. Analysis of the data suggests that Indonesian vessels operating in the Timor Sea mostly comprise of basic longline vessels with a length of 20–40 m and weighing 25–50 GRT. In 1980, Indonesia began systematically prohibiting trawling throughout Indonesian waters (Presidential Decree 39/1980), and a total ban of trawling in the waters of Indonesia came into effect 1 January 1983 (Presidential Instruction No. 11/1982) (Food and Agriculture Organization [FAO], 2015). The government has since reopened some areas for trawling, including the Arafura Sea and the Indian Ocean around west of Sumatra and Aceh Island (FAO, 2015); however, the Timor Sea remains closed to trawling with no immediate prospect for this to change. It is noted that Indonesian fishing vessels less than 30 GRT are not equipped with VMS and may also operate in the Timor Sea. For example, handline vessels are also occasionally recorded in the region. These vessel types appear similar to various Indonesian vessels that have been sighted, rescued or apprehended by Australian border security from time to time within the region (AFMA, 2017; Australian Broadcasting Corporation [ABC], 2019; NT News, 2016).

The 'semi-enclosed' Arafura and Timor Seas, and in particular the Arafura Sea, is a recognised global hotspot for illegal, unreported and unregulated (IUU) fishing (Edyvane, 2017). While there has been significant progress in tackling IUU fishing in the Arafura Sea, especially since 2015, there have been major increases in IUU fishing in the Timor Sea, particularly in the waters of Timor-Leste, including large-scale, industrial foreign trawling operations (Edyvane, 2017).

4.5.6 Aquaculture

Aquaculture in the NT consists primarily of culturing hatchery-reared and wild-caught oysters (*Pinctada maxima*) in shallow coastal waters. There are no aquaculture activities within the Operational Area or EMBA.

4.5.7 Fisheries – Traditional

Dugong, fish and marine turtles are important components of Aboriginal culture and diet. Aboriginal people continue to actively manage their sea country in coastal waters of the NT in order to protect and manage the marine environment, its resources and cultural values. Traditional Indigenous fishers generally utilise waters within 3 nm of the coastline (NT Government, 2015) and are not considered to be active within the offshore waters of the Operational Area and EMBA.

4.5.8 Tourism and Recreational Fishing

Annual expenditure by recreational fishers and the guided fishing industry in the NT is estimated at over $100 million (NT Government, 2019). Due to the distance from shore, there is limited capacity for recreational fishers to fish in the offshore waters of the Operational Area. An online search identified that at least one charter company (Arafura Bluewater Charters) offers seasonal four to five day fishing charters to Evans Shoal, Tassie Shoal and Lynedoch Bank during the calmest times of the year and specific tides. Targeted species include mackerel, dogtooth tuna, trevally, wahoo, sailfish and marlin.

Feedback from game fishing operators (**Section 5.5**) indicated only one Darwin-based charter company had a vessel that undertook multi-day charters near the Operational Area. Feedback from that operator was that it was highly unlikely it would be in the area, though there was a possibility due to weather implications.

Excluding occasional seasonal visits to Lynedoch Bank, recreational fishers are not expected to access the waters within the Operational Area.

4.5.9 Research and Monitoring Programs

The Integrated Marine Operating System (IMOS) National Mooring Network (NMN) is a collection of mooring arrays strategically positioned in Australian coastal waters. The NMN measures physical and biological parameters. An IMOS mooring (NWSLYN) is located on Lynedoch Bank (located within the Active Source Area) and is operated by AIMS. It is understood that the instrumentation available on the mooring is retrieved and re-deployed approximately every six months to collect recorded data and maintain/calibrate instrumentation. A waverider buoy is deployed at Goodrich Bank (located within the Operational Area) to record wave height, period and direction (Bureau of Meteorology [BoM], 2021). Each record is obtained by sampling the waves for 20 minutes, with records updated hourly.

Feedback from the operator of these moorings (**Section 5.5**) indicated potential SIMOPS with the seismic survey and maintenance of the moorings, which will be managed by controls implemented in this EP (**Section 6.4.1**).

4.5.10 Shipping

The Timor Sea supports moderate levels of commercial shipping activity for vessels transiting between Australia and south-east Asia. AMSA's Automated Identification System (AIS) point density maps identify a shipping route running east to west and directly north of the Operational Area (**Figure 4-20**). This moderate density shipping route accommodates vessels transiting between Indonesia and through the waters between Cape York Peninsula and Papua New Guinea. Low density traffic also occurs to the east of the Operational Area from vessels transiting between Darwin and south-east Asia. Comparatively, very few commercial vessels transit the Operational Area, which is situated in between the common shipping routes of the region (**Figure 4-20**).

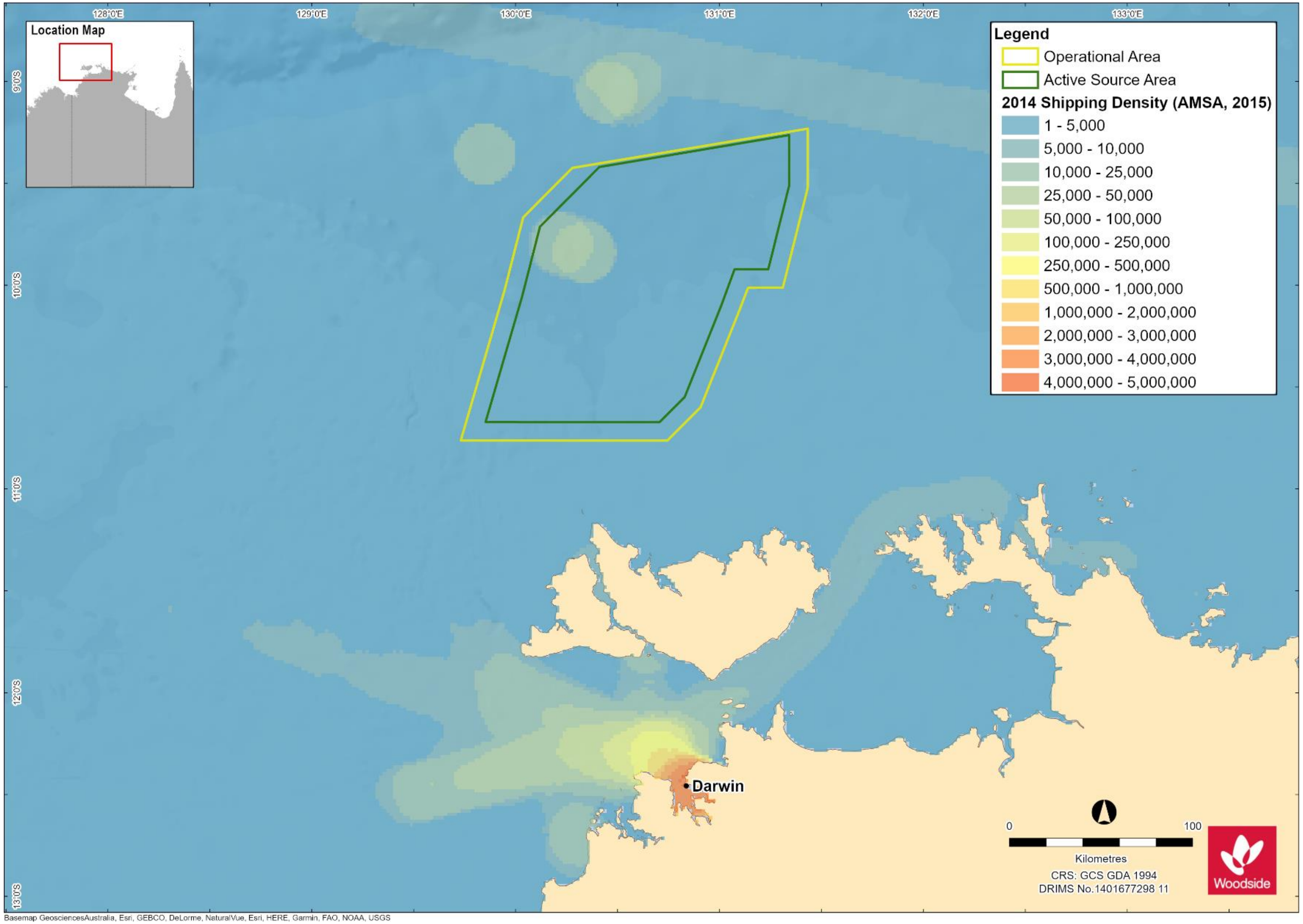


Figure 4-20: Vessel density map in the vicinity of Operational Area from 2014, derived from AMSA satellite tracking system data (vessels include cargo, LNG tanker, passenger, support and other vessels)

4.5.11 Oil and Gas Operations

There are five petroleum permits within the Operational Area, including NT/P86. The four other permits are held by Santos (NT/L1, NT/RL6, NT/P82 and NT-10-AA). Four additional permits are located within the wider EMBA, held by Santos (NT/P85, NT-10-AA) and Eni (NT/RL7 and NT/RL8) (refer to **Figure 4-21**).

There are no oil and gas production wells or facilities located within the Operational Area. The proposed Barossa Development is located in the north-west of the Operational Area, 300 km north of Darwin. The project is a joint venture between Santos and SK E&S, and includes an FPSO facility, subsea wells and production system and gas export pipeline tying into the existing Bayu-Darwin pipeline. Santos announced a final investment decision (FID) on Barossa on 31 March 2021.

Feedback from Santos (**Section 5.5**) indicated potential SIMOPS with the seismic survey and Santos' activities associated with the Barossa Development, which will be managed by controls implemented in this EP (**Section 6.4.1**).

4.5.12 Communications Infrastructure

The North West Cable System (NWCS) is a 2,000 km fibre optic cable between Port Hedland (WA) and Darwin (NT) that connects offshore oil and gas facilities in the Browse, Bonaparte and Carnarvon basins to onshore locations. The NWCS is owned and operated by Vocus Communications. The NWCS is located about 75 km south-west of the Operational Area at its closest point. An extension of the cable is planned as part of the Barossa Development (**Section 4.5.11**) to connect the FPSO with the existing NWCS. The proposed extension, known as the Bonaparte Basin Cable Loop (BBCL), is expected to transverse the Operational Area. The BBCL is anticipated to be installed by Alcatel Submarine Network (ASN). Consultation with the NWCS operator, Vocus Communications, has confirmed that the BBCL is not expected to be installed prior to commencement of or during the Woodside Galactic Hybrid 2D MSS (**Section 5.5**). Therefore, potential interaction and impacts to cable installation or operation are not considered or assessed further in the EP.

4.5.13 Defence

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

A Royal Australian Air Force (RAAF) base is located in Darwin, about 182 km south of the Operational Area. The designated defence practice areas associated with this RAAF base extend into the offshore marine waters of the NT and partially overlap the Operational Area (**Figure 4-22**). This area is known as the North Australian Exercise Area (NAXA) and is used by the RAAF and the Royal Australian Navy (RAN) for military operations including live weapons and missile firings.

The NAXA is the primary location of the KAKADU training exercise that operates every two years. The exercise involves numerous naval ships and submarines from various countries participating in the waters off Darwin and Northern Australia. Exercise KAKADU is Australia's premier international maritime exercise bringing together navies and air forces from the Asian, Pacific and Indian Ocean regions to test integration and war fighting abilities. Access will be restricted to all vessels and aircraft within the Due Regard Area (DRA) (**Figure 4-22**).

Defence advised Woodside that they will be conducting a major military exercise within the NAXA from mid-August 2022 and activities conducted within the NAXA and surrounding areas during this period are likely to be disrupted (**Section 5.5**). The Petroleum Activities Program has been scheduled to avoid any potential overlap with the scheduled exercise.

Defence also advised that unexploded ordinance (UXO) may be present on and in the sea floor of the Operational Area (**Section 5.5**). According to the Defence UXO Database, the Operational Area is located within a historic Naval Gunnery area (1090 Melville Island), and therefore may be affected by UXOs (Defence, 2021).

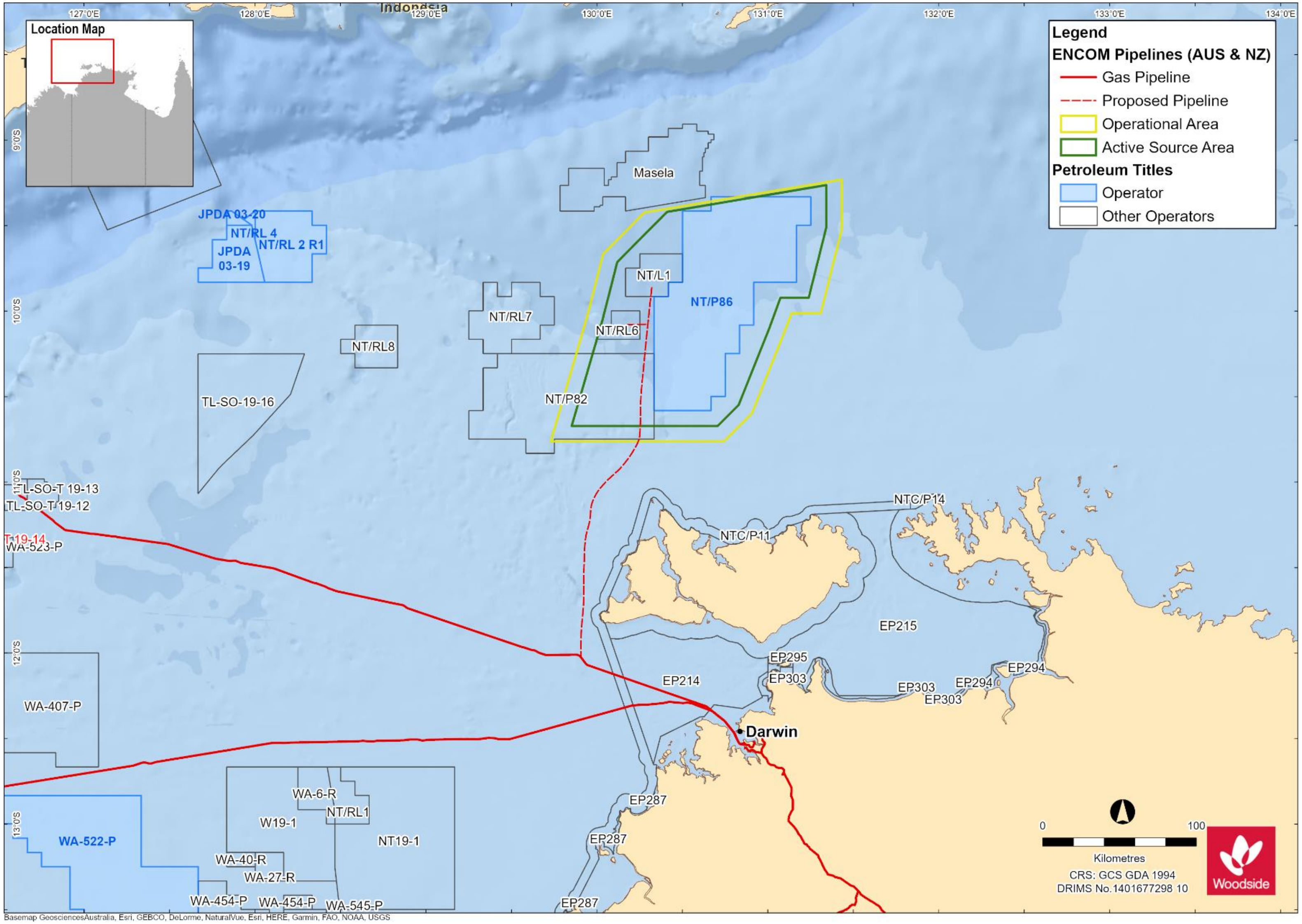


Figure 4-21: Petroleum titles and pipelines (current and proposed) with reference to the Operational Area

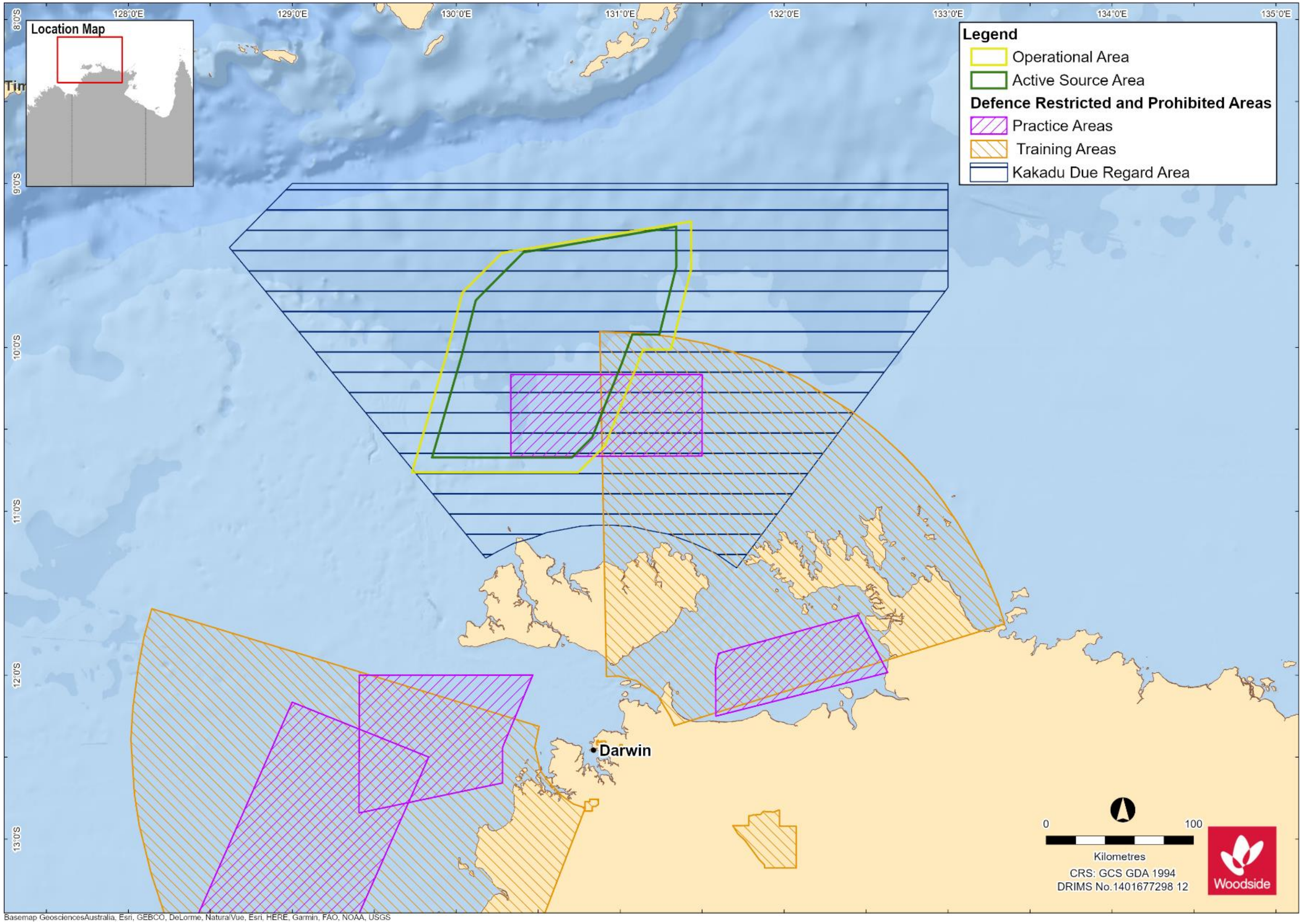


Figure 4-22: Defence restricted and prohibited areas with reference to the Operational Area

4.6 Values and Sensitivities

The NMR offshore environments contains high value or sensitive environmental assets (such as habitat and species) including Commonwealth offshore waters, as well as the wider regional context including coastal waters and habitats.

Many sensitive receptor locations are protected as part of Commonwealth and Territory managed areas and have been allocated conservation objectives (International Union for Conservation of Nature [IUCN] Protected Area Category) based on the Australian IUCN reserve management principles in Schedule 8 of the EPBC Regulations 2000.

The following section outlines the values and sensitivities of Marine Protected Areas (MPAs) and other sensitive areas overlapping the Operational Area and EMBA (listed in **Table 4-10**).

Table 4-10: Summary of established and protected places and other sensitive areas overlapping the Operational Area and EMBA

Protected places and sensitive areas	Distance from Operational Area to protected place or sensitive area (km)	IUCN category* or relevant park zone overlapping the Operational Area and/or EMBA
Australian Marine Parks (AMPs)		
Oceanic Shoals AMP	Overlaps	VI - Multiple Use Zone
		II - National Park Zone
		IV - Habitat Protection Zone
		VI - Special Purpose Zone (Trawl)
Arafura AMP	140 km east	VI – Multiple Use Zone
Key Ecological Features (KEFs)		
Shelf break and slope of the Arafura Shelf	Overlaps	N/A
Carbonate bank and terrace system of the Van Diemen Rise	Overlaps	N/A
Pinnacles of the Bonaparte Basin	130 km west	N/A
Carbonate bank and terrace system of the Sahul Shelf	230 km south-west	N/A

**Conservation objectives for IUCN categories include:*

Ia: Strict Nature Reserve

Ib: Wilderness Area

II: national Park

III: Natural Monument or Feature

IV: Habitat/Species Management Area

V: Protected Landscape

VI: Protected area with sustainable use of natural resources – allow human use but prohibits large scale development.

IUCN categories for the marine park are provided and, in brackets, the IUCN categories for specific zones within each Marine Park as assigned under the North-west Marine Parks Network Management Plan 2018 and South-west Marine Parks Network Management Plan 2018.

4.6.1 Australian Marine Parks

4.6.1.1 Oceanic Shoals Australian Marine Park

The Oceanic Shoals Marine Park covers an area of 71,743 km^2 and extends to the edge of the Australian EEZ. The Operational Area overlaps with the Multiple Use Zone (IUCN VI) portion of the AMP, while the EMBA overlaps with the National Park Zone (IUCN II), Habitat Protection Zone (IUCN IV), Multiple Use Zone (IUCN VI) and Special Purpose Zone (Trawl) (IUCN VI) (**Figure 4-23**). The DNP was engaged during consultation for this EP (**Section 5.5**).

The Oceanic Shoals AMP contains habitats, species and ecological communities associated with the Northwest Shelf Transition (Director of National Parks [DNP], 2018). Four KEFs are located within the AMP, which are all valued as unique seafloor features with ecological properties of regional significance: 'Carbonate bank and terrace systems of the Van Diemen Rise'; 'Carbonate bank and terrace systems of the Sahul Shelf'; 'Pinnacles of the Bonaparte Basin'; and 'Shelf break and slope of the Arafura Shelf' (**Section 4.6.4**).

4.6.1.2 Arafura Australian Marine Park

The Arafura AMP covers an area of 22, 924 km^2 and extends to the edge of the Australian EEZ. The EMBA overlaps with Multiple Use Zone (IUCN VI), approximately 140 km east of the Operational Area (**Figure 4-23**).

The Arafura AMP contains habitats, species and ecological communities associated with Northern Shelf Province and the Timor Transition (Director of National Parks [DNP], 2018). One KEF is located within the AMP; however, outside of the Operational Area and EMBA; 'Tributary Canyons of the Arafura Depression' (**Section 4.6.4**).

4.6.2 Territory Marine Parks and Nature Reserves

There are no NT marine parks or nature reserves within the Operational Area or EMBA. The closest NT protected area is Garig Gunak Barlu National Park, located on and around the Cobourg Peninsula, about 121 km south-east of the Operational Area and outside the EMBA (**Figure 4-23**).

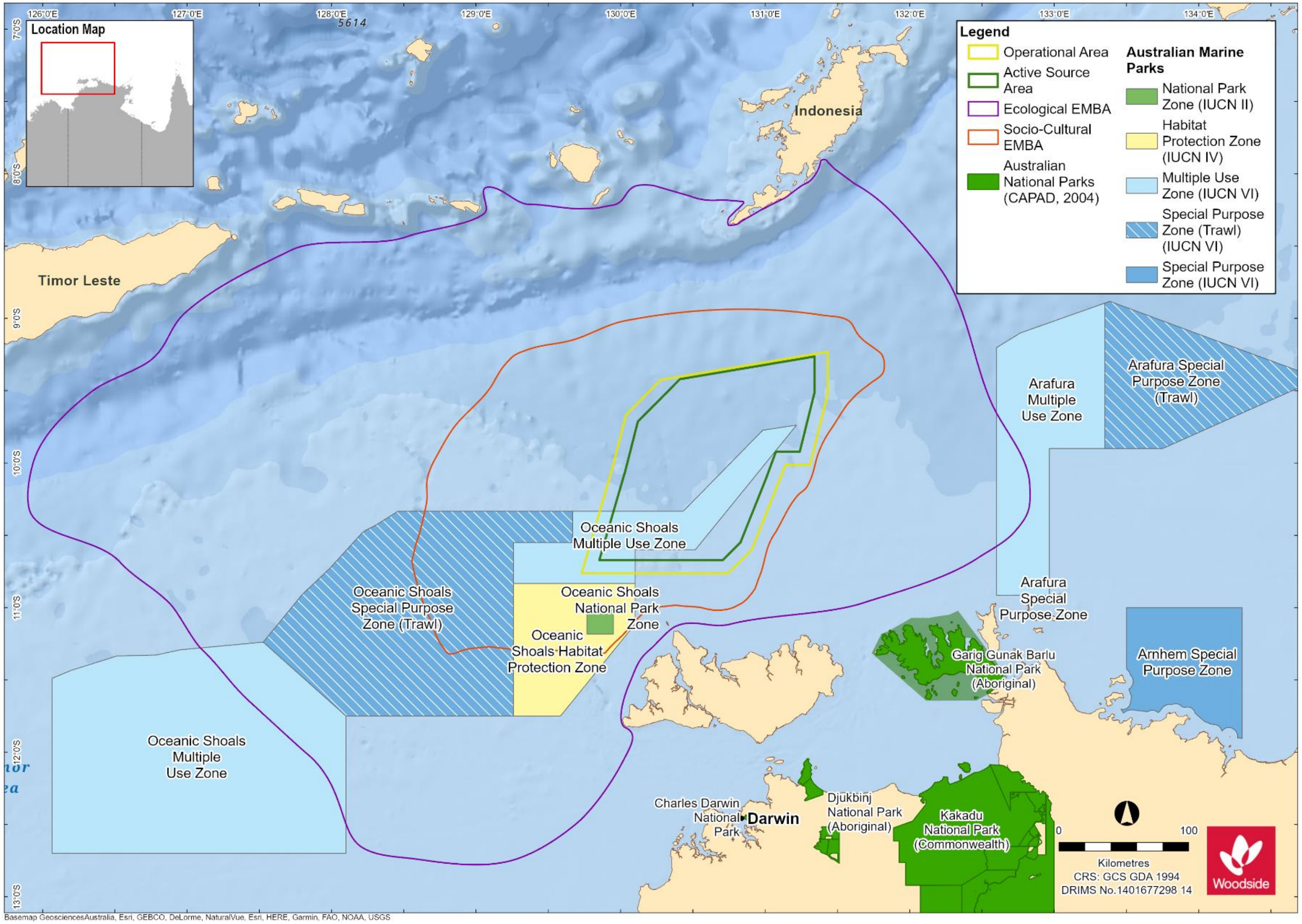


Figure 4-23: Australian Marine Parks and National Parks with reference to the Operational Area and EMBA

4.6.3 Cultural Heritage Areas

4.6.3.1 World Heritage Properties

World Heritage Properties (WHP) are heritage places that are of outstanding universal value and have been included on the United Nations Educational, Scientific and Cultural Organisation (UNESCO) managed list. There are no WHP within the Operational Area or EMBA. The closest WHP is Kakadu National Park, located over 220 km south-east of the Operational Area and outside the EMBA (**Figure 4-23**).

4.6.3.2 National Heritage Areas

National Heritage Areas are natural, historic and Indigenous places that are of outstanding national heritage value to the Australian nation. There are no National Heritage Areas within the Operational Area or EMBA. The closest National Heritage Area is Kakadu National Park, located over 220 km south-east of the Operational Area and outside the EMBA (**Figure 4-23**).

4.6.3.3 Commonwealth Heritage Areas

The Commonwealth Heritage List is a list of natural, historic and Indigenous places of heritage significance owned or controlled by the Australian Government. There are no Commonwealth Heritage Areas within the Operational Area or EMBA.

4.6.4 Key Ecological Features

4.6.4.1 Shelf break and slope of the Arafura Shelf

The ‘Shelf break and slope of the Arafura Shelf’ KEF is located towards the edge of the Australian EEZ and partially overlaps the Operational Area (**Figure 4-24**). The KEF includes an area of slope north of the Van Diemen Rise and an adjacent area of shelf extending south to the terrace edge, and bounded by the 100 m depth contour in the east (DAWE, 2020). The KEF covers an area of 10,844 km^2, of which the Operational Area overlaps with about 7,883 km^2.

The KEF is characterised by continental slope, patch reefs and hard substrate pinnacles (DAWE, 2020; Harris et al., 2005). The ‘Shelf break and slope of the Arafura Shelf’ is defined as a KEF for its ecological significance associated with productivity emanating from the slope (DAWE, 2020; Last et al. 2005). The KEF is situated in a major biogeographic crossroad where biota is largely affiliated with the Timor–Indonesian–Malay region where oceanographic processes are driven by the Indonesian Throughflow and surface wind–driven circulation resulting from the north-west monsoon (DAWE, 2020; Hooper and Ekins, 2005). Fish communities that occur in associated with the KEF represent the break between the Timor Province provincial bioregion and the Timor Transition provincial bioregion, however ecosystem processes operating in this area are largely unknown (DAWE, 2020; Last et al., 2005).

4.6.4.2 Carbonate bank and terrace system of the Van Diemen Rise

The ‘Carbonate bank and terrace system of the Van Diemen Rise’ KEF is located north-eastern side of the Joseph Bonaparte Gulf and partially overlaps with the south-west of the Operational Area (**Figure 4-24**). The KEF is considered important for its role in enhancing biodiversity and local productivity relative to its surrounds and for supporting relatively high species diversity. The KEF covers an area of 31,278 km^2, of which the Operational Area overlaps with about 2,862 km^2.

The KEF is characterised by banks, ridges and terraces with relatively high proportions of hard substrate (DAWE, 2021). Channel systems between the banks range from approximately 60–150 m to 10–40 m in depth (Anderson et al., 2011) and supports sponge and octocoral gardens by providing epifauna habitat in an otherwise flat environment (Przeslawski et al., 2011). Whilst reef-forming corals are rare throughout the Joseph Bonaparte Gulf and Timor Sea region, some locally dense hard corals were found on the banks of the Van Diemen rise during marine surveys in 2009 and 2010 (Przeslawski et al., 2011).

A study of the sponge diversity and ecology of the Van Diemen Rise identified the region as a sponge biodiversity hotspot (Przeslawski et al., 2014). Sponges were collected with a benthic sled from five geomorphic features (banks, terrace, ridge, plain and valley), resulting in the identification of 283 species. The study found that sponge diversity was generally highest further offshore and on raised geomorphic features, particularly banks. One of the sample locations in the study was approximately 8 km west of the Operational Area.

Pelagic fish such as mackerel, red snapper and a distinct gene pool of goldband snapper are found in the Van Diemen Rise (Blaber et al., 2005; Salini et al. 2006). Olive ridley turtles, sea snakes and sharks have also been reported to occur in the area (Guinea, pers. comm., 2009 [cited in DAWE, 2021]; Blaber et al., 2009).

4.6.4.3 Pinnacles of the Bonaparte Basin

The limestone pinnacles that form the ‘Pinnacles of the Bonaparte Basin’ KEF are located in the Joseph Bonaparte Gulf, the closest of which is located about 134 km west of the Operational Area but within the EMBA (**Figure 4-24**). The ‘Pinnacles of the Bonaparte Basin’ are defined as a KEF as they are a unique seafloor feature with ecological properties of regional significance.

The pinnacles within the KEF represent 40% of all pinnacles that exist in the NMR and 8% of limestone pinnacles in the Australian EEZ (Baker et al., 2008). This represents the largest concentration of pinnacles along the Australian margin, where local upwellings of nutrient-rich water attract aggregations of fish, seabirds and turtles (DNP, 2018). Rising steeply from depths of about 80 m some pinnacles emerge to within 30 m of the water surface, allowing light dependent organisms to thrive (DAWE, 2021). Communities include sessile benthic invertebrates including hard and soft corals, sponges, whips, fans, bryozoans and aggregations of demersal fish species such as snappers, emperors and groupers (Brewer et al., 2007; Nichol et al., 2013). The pinnacles are also recognised as a biodiversity hotspot for sponges as they are home to more sponge species and different communities than the surrounding seafloor (National Environmental Research Program Marine Biodiversity Hub, 2014).

4.6.4.4 Carbonate bank and terrace system of the Sahul Shelf

The ‘carbonate bank and terrace system of the Sahul Shelf’ KEF is located in the western Joseph Bonaparte Gulf and to the north of Cape Bougainville and Cape Londonderry, the closest of which is located about 235 km south-east of the Operational Area but within the EMBA (**Figure 4-24**). The KEF is considered important for its role in enhancing biodiversity and local productivity relative to its surrounds.

The carbonate banks and terrace systems provide areas of hard substrate and flat tops at depths of 150 - 300 m (DSEWPaC, 2012). Each bank occupies an area generally less than 10 km² and is separated from the next bank by narrow sinuous channels with depths up to 150 m (Brewer et al., 2007). The Sahul Banks are the single most extensive region of banks and shoals in the Australian EEZ forming a nearly continuous chain of complex submerged algal banks on the middle and outer shelf (Heap and Harris, 2008). Little is known about the banks, terraces and associated channels, but they are believed to be areas of enhanced primary productivity and biodiversity due to upwellings of cold nutrient-rich water at the heads of the channels (Brewer et al., 2007).

The banks are thought to support a high diversity of organisms including reef fish, sponges, soft and hard corals, gorgonians, bryozoans, ascidians and other sessile filter-feeders (Brewer et al., 2007). Additionally, they are known foraging areas for loggerhead, olive ridley and flatback turtles, and humpback whales, and green and freshwater sawfish are likely to occur in the area (Donovan et al., 2008).

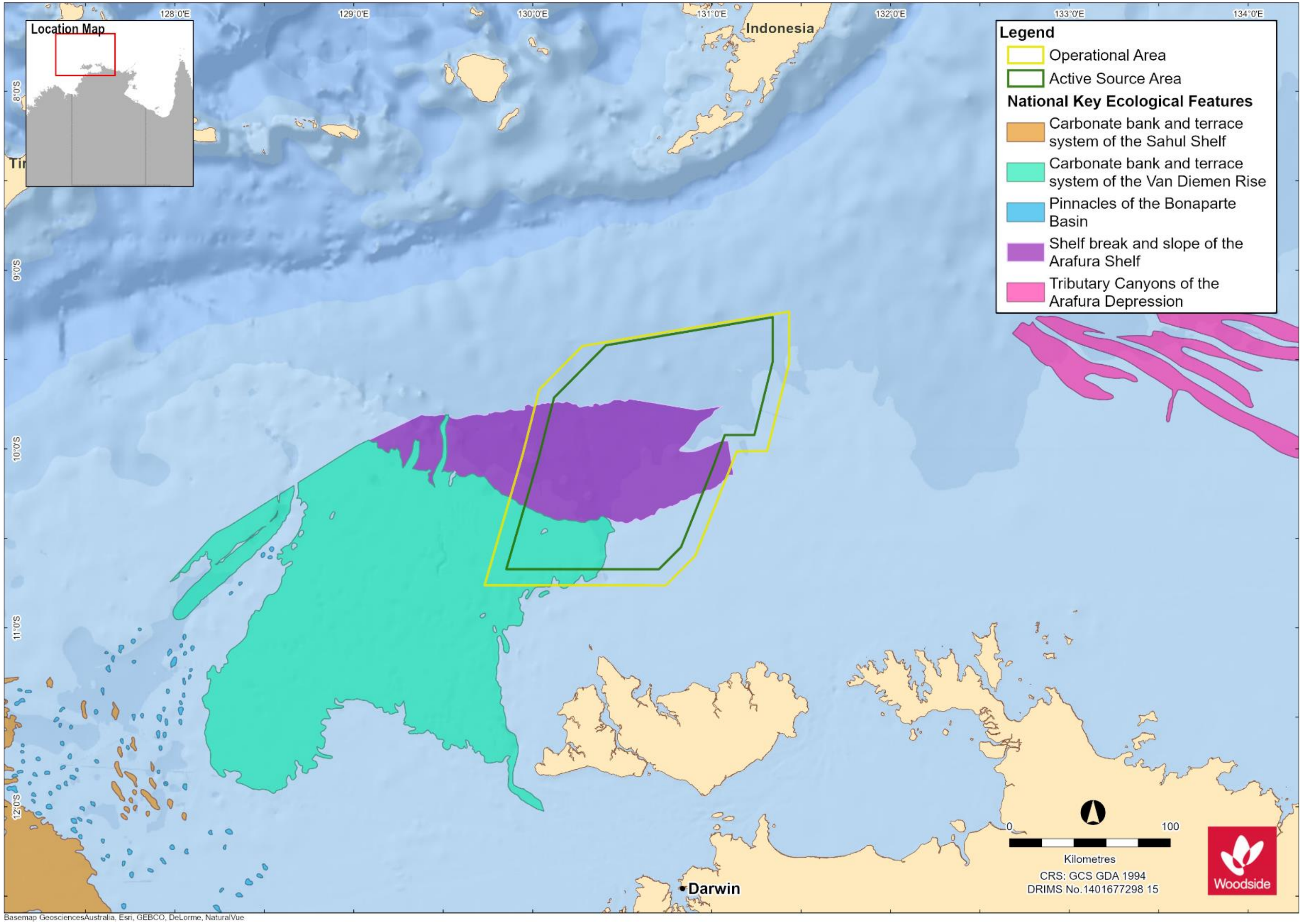


Figure 4-24: Key Ecological Features with reference to the Operational Area and EMBA

5. STAKEHOLDER CONSULTATION

5.1 Summary

Woodside is committed to consulting relevant stakeholders to ensure stakeholder feedback informs its decision making and planning for proposed petroleum activities and builds upon Woodside's extensive and ongoing stakeholder consultation for its offshore petroleum activities in the region.

5.2 Stakeholder Consultation Guidance

Woodside has followed the requirements of Subregulation 11A (1) of the Environment Regulations to identify relevant stakeholders, these being:

- Each Department or agency of the Commonwealth Government to which the activities to be carried out under the Environment Plan, or the revision of the Plan, may be relevant.
- Each Department or agency of a State or the Northern Territory Government to which the activities to be carried out under the Environment Plan, or the revision of the Plan, may be relevant.
- The Department of the responsible State Minister, or the responsible Northern Territory Minister.
- 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 Plan.
- Any other person or organisation that the Titleholder considers relevant.

Woodside's assessment of stakeholder relevance is outlined in **Table 5-1**.

5.3 Stakeholder Consultation Objectives

In support of this EP, Woodside has sought to:

- Ensure all relevant stakeholders are identified and engaged in a timely and effective manner.
- Develop and make available communications material to stakeholders that is relevant to their interests and information needs.
- Incorporate stakeholder feedback into the management of the proposed activity where practicable.
- Provide feedback to stakeholders on Woodside's assessment of their feedback and keep a record of all engagements.
- Make available opportunities to provide feedback during the life of this EP.

5.4 Stakeholder Expectations for Consultation

Stakeholder consultation for this activity has also been guided by stakeholder organisation expectations for consultation on planned activities. This guidance includes:

NOPSEMA:

GL1721 - Environment plan decision making - November 2021

GN1847 - Responding to public comment on environment plans - September 2020

GN1344 - Environment plan content requirements - September 2020

GN1488 - Oil pollution risk management - February 2021

GN1785 – Petroleum activities and Australian Marine Parks – June 2020

GL1887 – Consultation with Commonwealth agencies with responsibilities in the marine area – July 2020

NOPSEMA Bulletin #2 – Clarifying statutory requirements and good practice consultation – November 2019

Australian Fisheries Management Authority:

Petroleum industry consultation with the commercial fishing industry

Commonwealth Department of Agriculture and Water Resources:

Fisheries and the Environment – Offshore Petroleum and Greenhouse Gas Act 2006

Offshore Installations Biosecurity Guide

WA Department of Primary Industries and Regional Development:

Guidance statement for oil and gas industry consultation with the Department of Fisheries

WA Department of Transport:

Offshore Petroleum Industry Guidance Note

Woodside acknowledges that additional relevant stakeholders may be identified prior to or during the proposed activity. These stakeholders will be contacted, provided relevant information to their interests and invited to provide feedback about the proposed activity. Woodside will assess their feedback, respond to the stakeholder and incorporate feedback into the management of the proposed activity where practicable. Feedback will be assessed to determine the merit and relevancy to the activity and consideration of how existing and proposed controls can address stakeholders claims and objections where reasonably practicable.

Woodside consultation arrangements typically provide stakeholders between 30 - 45 days (unless otherwise agreed) to review and respond to proposed seismic activities where stakeholders are potentially affected. Woodside considers this consultation period provides an adequate timeframe in which stakeholders can assess potential impacts of the proposed activity and provide feedback. Woodside will continue to accept feedback from all stakeholders during the assessment of this EP and throughout the duration of the accepted EP.

Table 5-1:Assessment of Relevant Stakeholders for the Proposed Activity

Stakeholder	Relevant to activity	Reasoning
Commonwealth Government department or agency		
Australian Border Force (ABF)	Yes	Responsible for offshore border control enforcement and coordinating maritime security.
Australian Communications and Media Authority (ACMA)	Yes	Responsible for regulating communications and media in Australia. Agency to be consulted where an activity has the potential to impact submarine telecommunication cables.
Australian Fisheries Management Authority (AFMA)	Yes	Manages the Northern Prawn Fishery (NPF) and participates in joint management of the Northern Territory managed Timor Reef and Demersal fisheries via the Northern Territory Joint Fishing Authority.
Australian Hydrographic Office (AHO)	Yes	Maritime safety and responsible for Notice to Mariners and AUSCOAST warnings.
Australian Maritime Safety Authority (AMSA) – maritime safety	Yes	Statutory agency for vessel safety and navigation and legislated responsibility for oil pollution response in Commonwealth waters.
Australian Maritime Safety Authority (AMSA) – marine pollution	Yes	Statutory agency for vessel safety and navigation and legislated responsibility for oil pollution response in Commonwealth waters.
Department of Agriculture, Water and the Environment (DAWE) – fisheries	Yes	The Department provides policy advice to the Australian Government on a range of economic and environmental fisheries issues, including the conservation of the marine ecosystems and biodiversity that support commercially valuable fisheries resources. The Department requests to be consulted where an activity has the potential to impact fishing operations in Commonwealth waters.
DAWE – biosecurity (marine pests, vessels, aircraft and personnel)	Yes	DAWE administers, implements and enforces the Biosecurity Act 2015. The Department requests to be consulted where an activity has the potential to transfer marine pests. DAWE also has inspection and reporting requirements to ensure that all conveyances (vessels, installations and aircraft) arriving in Australian territory comply with international health regulations and that any biosecurity risk is managed. The Department requests to be consulted where an activity involves the movement of aircraft or vessels between Australia and offshore petroleum activities either inside or outside Australian territory.
Department of Defence (DoD)	Yes	The proposed Operational Area and Active Source Area overlap North Australia Exercise Area (NAXA), Due Regard Area (DRA) for Exercise Kakadu, and UXO area. A major military exercise typically occurs in the NAXA and DRA from mid-August to 30 September every two years. The last exercise occurred in 2020.

Stakeholder	Relevant to activity	Reasoning
Department of Foreign Affairs and Trade (DFAT)	Yes	Proposed Operational Area and Active Source Area overlap waters north of the Australian Fishing Zone, where Indonesian vessels can operate. DFAT also has responsibilities for oil spill in international waters.
Department of Industry, Science, Energy and Resources (DISER)	Yes	Department of relevant Commonwealth Minister and is required to be consulted under the OPGGS (Env) Regulations.
Director of National Parks (DNP)	Yes	Responsible for managing Australian Marine Parks (AMPs). Proposed Operational Area and Active Source Area overlap multiple use area of the Oceanic Shoals Marine Park.
NT Government department or agency		
NT Department of Industry, Tourism and Trade (NT DITT) (Petroleum)	Yes	Department of relevant Territory Minister and is required to be consulted under the OPGGS (Env) Regulations.
NT DITT Fisheries	Yes	Responsible for joint management of the Timor Reef Fishery (TRF), Demersal Fishery (DF) and Offshore Net and Line Fishery (ONLF). The Department is also responsible for the management of the Spanish Mackerel Fishery (SMF) and Aquarium Fishery (AF).
NT Department of the Environment, Parks and Water Security (NT DEPWS)	Yes	Manages oil spill response in Territory waters.
Commonwealth managed fisheries*		
Northern Prawn Fishery	Yes	The fishery has been active in the Operational Area within the last five years.
Southern Bluefin Tuna Fishery	No	The fishery has not been active in the Operational Area within at least the last five years.
Western Skipjack Tuna Fishery	No	The Skipjack Tuna Fishery is not currently active, and no Australian boats have fished for skipjack tuna since 2009.
Western Tuna and Billfish Fishery	No	The fishery has not been active in the Operational Area within at least the last five years.
NT managed fisheries*		
Aquarium Fishery	Yes	The fishery has been active in the Operational Area within the last five years.
Demersal Fishery	Yes	The fishery has been active in the Operational Area within the last five years.
Offshore Net and Line Fishery	Yes	The fishery has been active in the Operational Area within the last five years.
Pearl Oyster Fishery	No	No pearl oyster harvest in the Northern Territory since 2008.

Stakeholder	Relevant to activity	Reasoning
Spanish Mackerel Fishery	Yes	The fishery has been active in the Operational Area within the last five years.
Timor Reef Fishery	Yes	The fishery has been active in the Operational Area within the last five years.
Industry		
Inpex	Yes	Adjacent Titleholder.
Santos	Yes	Adjacent Titleholder.
Vocus Communications	Yes	Owner and Operator of the North West Cable System and proposed Bonaparte Basin Cable Loop.
Industry representative organisations		
Amateur Fishermen's Association of the Northern Territory (AFANT)	Yes	Represents the interests of amateur fishermen in the Northern Territory.
Australian Petroleum Production and Exploration Association (APPEA)	Yes	Represents the interests of oil and gas explorers and producers in Australia.
Commonwealth Fisheries Association (CFA)	Yes	Represents the interests of licence holders in Commonwealth-managed fisheries.
Demersal Fishery Licensee Committee (DFLC)	Yes	Represents the interests of licence holders in the NT-managed Demersal Fishery.
Northern Prawn Fishery Industry Pty Ltd (NPFI)	Yes	Represents the interests Northern Prawn Trawl licence holders.
NT Guided Fishing Industry Association (NTGFIA)	Yes	Represents the interests of guided fishing operators in the Northern Territory.
Northern Territory Game Fishing Association of Australia (NTGFA)	Yes	Represents the interests of game fishing operators in the Northern Territory.
Northern Territory Seafood Council (NTSC)	Yes	Represents the interests of licence holders in Northern Territory-managed fisheries.
Pearl Producers Association (PPA)	Yes	Although interactions with licence holders in the Pearl Oyster Managed Fishery are unlikely, PPA has requested to be informed of Woodside's planned activities.
Seafood Industry Australia (SIA)	Yes	Represents the interests of the Australian fishing industry.

Stakeholder	Relevant to activity	Reasoning
Timor Reef Licensee Committee (TRLC)	Yes	Represents the interests of licence holders in the NT-managed Timor Reef Fishery.
Traditional Owners		
Tiwi Land Council (TLC)	Yes	Represents the interests of the Tiwi people.
Other Stakeholders		
Research organisations – Australian Institute of Marine Science (AIMS)	Yes	Operator of the Integrated Marine Observing System (IMOS) moorings located on Lynedoch Shoal and Goodrich Bank.
Research organisations • CSIRO • Geoscience Australia • Charles Darwin University • Marine Biodiversity Hub (UTAS)	Yes	May have research operations in field undertaking diving activities.
Dive operators • Dive Air • Darwin Sub Aqua Club • Learn to Dive Darwin • Sea Darwin	Yes	May have divers in the field undertaking diving activities.
National Energy Resources Australia (NERA)	Yes	Coordinator of the Collaborative Seismic Environment Plan Project, an industry consortium focused on managing potential individual and cumulative impacts of seismic activities on stakeholders and the environment.

** Fisheries have been identified as being relevant on the basis of fishing licence overlap with the proposed Operational Area, as well as consideration of fishing effort data, fishing methods, water depth, and likelihood of fishing in the future.* ***Section 4.5.4*** *provides a detailed assessment of Commonwealth and State fisheries within or adjacent to the Operational Area.*

5.5 Stakeholder Consultation

Consultation activities conducted for the proposed activity are outlined in **Table 5-2**. Consultation was undertaken in two phases to provide stakeholders initially with the general location and timing of the survey (Phase 1: 45-day feedback period commencing 25 March 2021) and then increased definition of the activity scope once planning for the proposed activity matured (Phase 2: 30-day feedback period commencing 30 June). Woodside considers these consultation periods adequate in which stakeholders can assess potential impacts of the proposed activity and provide feedback. Several stakeholders were not considered relevant for the second phase of consultation based on feedback provided in the first phase.

Although set timeframes were noted for the two phases of consultation, engagement with stakeholders is ongoing up to, during and following all Woodside's activities. Following submission of this EP a 30-day public comment period will commence where stakeholders outside of those identified as directly relevant to the activity will also have the opportunity to provide comment on the Petroleum Activities Program.

The Consultation Information Sheet (**Appendix F**) is published on the Woodside website and includes a toll-free 1800 phone number.

Table 5-2: Stakeholder Consultation Activities

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
Australian Government department or agency				
Airservices Australia	On 6 May 2021, Woodside called Airservices Australia following feedback from Defence that a Notice to Airmen may be required for the proposed Activity.	Airservices Australia requested further detail about the proposed activity in order to provide an informed response.	On 6 May 2021, Woodside emailed Airservices Australia providing a copy of consultation material provided to Defence, as well as Defence's response provided to Woodside on 28 April 2021.	Consultation ongoing.
	On 10 May 2021, Woodside sent a follow up email.	On 10 May 2021, Airservices Australia called and confirmed a Notice to Airmen notification would not be required by vessel-based activities within civilian airspace. It provided contact details for engagement with the Office of Airspace Regulation Military which had jurisdiction for activities within restricted air space in which a Notice to Airmen may be required.	Woodside to follow up with the Office of Airspace Regulation Military.	Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
ABF	On 25 March 2021, Woodside emailed ABF advising of the proposed activity (**Appendix F**, reference 1.1) and provided a Consultation Information Sheet.	No feedback received.	No response required.	Consultation ongoing.
	On 30 June 2021, Woodside emailed ABF providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity	No feedback received.	No response required.	Woodside has addressed maritime security-related issues in **Section 6** of this EP based on previous offshore activities. Woodside considers stakeholder's interests have

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	scope (**Appendix F**, reference 1.25).			been adequately addressed and no further consultation is required.
ACMA	On 25 March 2021, Woodside emailed ACMA advising of the proposed activity (**Appendix F**, reference 1.2) and provided a Consultation Information Sheet.	On 26 March 2021, ACMA emailed Woodside advising that its advice had been escalated for an expert response.	No response required.	Woodside to inform ACMA following advice by Vocus Communications on potential offshore interactions relevant to the proposed Bonaparte Basin Cable Loop.
	On 12 April 2021, Woodside emailed ACMA advising that Vocus Communications had confirmed to Woodside it would not have any assets in the area by May 2022.	Phone call received from ACMA on 19 April 2021 confirming that the activity did not impact ACMA's interests.	No response required.	Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
AFMA	On 25 March 2021, Woodside emailed AFMA advising of the proposed activity (**Appendix F**, reference 1.3) and provided a Consultation Information Sheet, and Commercial Fishing Information Sheet.	No feedback received.	No response required.	Consultation ongoing.
	On 30 June 2021, Woodside emailed AFMA (**Appendix F**, reference 1.23) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope.	On 5 July 2021, AFMA emailed Woodside noting the importance to consult fishers with entitlements in the area, either through representative organisations or directly with licence holders. AFMA provided advice on contact details for representative organisations and processes for	No response required.	Woodside has assessed the relevancy of Commonwealth fisheries issues in **Section 4.5.4** of this EP and identified the Northern Prawn Fishery as being relevant for the proposed activity. It has provided consultation information to licence holders in this fishery and the relevant

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	Woodside also provided maps showing historic 2D and 3D surveys overlaid with the NT/P86 permit operated by Woodside. Woodside also offered upon request, the draft of the section of the Environment Plan that outlines noise impact assessment, as well the independent noise modelling report that underpinned Woodside's assessment given expected interest from stakeholders with interests in commercial fishing.	obtaining licence holder contact details.		representative organisation, the NPF Industry. This information was provided for both phases of consultation activity in March and July 2021. Consultation information has also been provided to CFA, SIA and DAWE. Woodside will provide notifications to AFMA, prior to the commencement and at the end of the activity (**PS 1.4**). Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
AHO	On 25 March 2021, Woodside emailed the AHO advising of the proposed activity (**Appendix F**, reference 1.4) and provided a Consultation Information Sheet, and shipping density map.	No feedback received.	No response required.	Consultation ongoing.
	On 30 June 2021, Woodside emailed AHO providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity	On 1 July 2021, AHO emailed Woodside noting that Woodside's email had been received by the ATO and would be registered, assessed, prioritised and validated in preparation for updating its Navigational Charting products.	No response required.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	scope (**Appendix F**, reference 1.25).	On 1 July 2021, AHO emailed Woodside noting the change in activity scope and expected to be notified closer to the activity start date.	On 3 August 2021, Woodside emailed AHO confirming it would notify AHO no less than four weeks prior to the start of the planned Activity.	Woodside notes feedback provided by AHO and AMSA for this Activity and previous consultations that it will notify the AHO no less than four working weeks before operations commence (**PS 1.1**). Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
AMSA (marine safety)	On 25 March 2021, Woodside emailed AMSA advising of the proposed activity (**Appendix F**, reference 1.4) and provided a Consultation Information Sheet, and shipping traffic density map.	On 26 March 2021, AMSA emailed Woodside requesting: • The AHO be contacted no less than four working weeks before operations commence for the promulgation of related notices to mariners. • AMSA's Joint Rescue Coordination Centre (JRCC) be notified at least 24–48 hours before operations commence • Provide updates to the AHO and JRCC should there be changes to the activity. • Vessels exhibit appropriate lights and shapes to reflect the nature of operations and comply with the International Rules of Preventing Collisions at Sea.	On 6 April 2021, Woodside responded confirming it will contact/notify: • The AHO no less than 4 weeks before operations commence • AMSA's JRCC at least 24-48 hours before operations commence • Provide updates to both the AHO and AMSA on any changes. Confirming vessels will exhibit appropriate lights and shapes to reflect the nature of operations and the obligation to comply with the International Rules for Preventing Collisions at Sea.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		AMSA provided advice on obtaining vessel traffic plots, including digital datasets and maps.		
	On 12 April 2021 Woodside sent a follow up email to AMSA, specifically seeking feedback on the potential use of AUV seismic nodes for part of the survey.	On 13 April 2021, AMSA emailed Woodside advising it had no concerns with the use of AUV seismic nodes, provided Woodside used an additional support vessel to that identified for managing interactions with other marine vessels.	No response required.	Woodside considers this adequately addresses stakeholder interests with respect to the use of AUV seismic nodes and no further consultation is required on this matter.
	On 30 June 2021, Woodside emailed AMSA (**Appendix F**, reference 1.25) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope.	On 2 July 2021, AMSA emailed Woodside providing the same advice as per its initial advice on 26 March 2021.	On 3 August 2021, Woodside responded confirming it will contact/notify: • The AHO no less than 4 weeks before operations commence • AMSA's JRCC at least 24-48 hours before operations commence • Provide updates to both the AHO and AMSA on any changes. Woodside also confirmed vessels will exhibit appropriate lights and shapes to reflect the nature of operations and the obligation to comply with the International Rules for Preventing Collisions at Sea.	Woodside has addressed AMSA's requests: • Woodside will notify AMSA's JRCC at least 24–48 hours before operations commence (**PS 1.2**). • Woodside will notify the AHO no less than four working weeks before operations commence (**PS 1.1**). Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
AMSA (marine pollution)	On 25 March 2021, Woodside emailed AMSA advising of the proposed activity (**Appendix F**, reference 1.5) and provided a Consultation Information Sheet.	No feedback received.	No response required. Woodside to provide the Oil Pollution First Strike Plan to AMSA.	Consultation ongoing.
	On 14 July 2021 (**Appendix F**, reference 1.25), Woodside emailed AMSA providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope and a copy of the Oil Pollution First Strike Plan.	No feedback received.	No response required. Woodside has provided the Oil Pollution First Strike Plan to AMSA.	Woodside has addressed oil pollution planning and response at **Appendix D**. Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
DAWE	On 25 March 2021, Woodside emailed DAWE advising of the proposed activity considering biosecurity matters (**Appendix F**, reference 1.6) and provided a Consultation Information Sheet, and fisheries map.	No feedback received.	No response required.	Consultation ongoing.
	On 30 June 2021, Woodside emailed DAWE (**Appendix F**, reference 1.23) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the	No feedback received.	No response required.	Woodside has assessed the relevancy of Commonwealth fisheries issues in **Section 4.5.4** of this EP and identified the Northern Prawn Fishery as being relevant for the proposed activity.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	confirmed 2D survey activity scope. Woodside also provided maps showing historic 2D and 3D surveys overlaid with the NT/P86 permit operated by Woodside. Woodside also offered upon request, the draft of the section of the Environment Plan that outlines noise impact assessment, as well the independent noise modelling report that underpinned Woodside's assessment given expected interest from stakeholders with interests in commercial fishing.			It has provided consultation information to licence holders in this fishery and the relevant representative organisation, the NPF Industry. This information was provided for both phases of consultation activity in March and July 2021. Consultation information has also been provided to CFA, SIA and AFMA. Woodside has addressed maritime biosecurity issues in **Section 6** of this EP based on previous offshore activities. Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
DoD	On 25 March 2021, Woodside emailed DoD advising of the proposed activity (**Appendix F**, reference 1.7) and provided a Consultation Information Sheet, and defence map.	No feedback received.	Woodside to follow up.	Consultation ongoing.
	On 12 April 2021, Woodside sent a follow up email to the DoD, specifically seeking feedback on the timing of Exercise Kakadu and the potential location of UXOs.	On 28 April 2021, DoD emailed Woodside and noting that: • A portion of the survey area was within the North Australia Exercise Area (NAXA), Defence Practice Area Melville	On 11 May 2021, Woodside emailed DoD noting its advice on the location of the survey area with the North Australia Exercise Area (NAXA), Defence Practice Area Melville Island	Woodside will commit to DoD's expectation for completion of activities in the NAXA by 16 August 2022 (**PS 2.4**).

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		Island (DPA Melville Is.) and restricted airspace. • Unexploded ordnance (UXO) may be present on and in the sea floor within the NAXA and DPA Melville Is. Woodside Energy must, therefore, inform itself as to the risks associated with conducting activities in the area (for example, the detonation of UXO). DoD additionally advised that: • All activities in the area are conducted at Woodside's own risk. • The Commonwealth of Australia, represented by the Department of Defence, takes no responsibility for: – Reporting the location and type of UXO that may be in the areas. – Identifying or removing any UXO from these areas. – Any loss or damage suffered or incurred by Woodside Energy or any third party arising out of, or directly related to, UXO in the area. DoD also required activities to be completed and clear of the NAXA and DPA Melville Island by mid-	(DPA Melville Is.) and restricted airspace. Woodside also noted its advice with respect to the location, identification, removal, or damage to equipment from unexploded ordinances. In response, Woodside confirmed: • It would include the potential presence of unexploded ordinances in its risk assessment for Activity planning. • Planned activities would be completed by mid-August 2022 to ensure activities did not interact with those of Exercise Kakadu. • Defence had been added to Activity notification protocols, which will be included in the Activity Environment Plan submitted to NOPSEMA. Woodside will notify Defence at least five weeks prior to the start of activities. • Woodside was engaging with Airservices Australia (civilian airspace) and Office of Airspace Regulation Military (restricted airspace) on activity notification protocols. A summary of this engagement and implications for potential Notifications to Airmen will be included in the Activity Environment Plan submitted to NOPSEMA.	Woodside acknowledges the potential presence of UXOs and has considered this in its risk assessment planning. Woodside has addressed DoDs expectations on notifications – Defence, restricted air space and AHO (**PS 1.1** and **1.3**). Notice to Airman was determined not required through engagement with Airservices Australia. Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		August 2022 to ensure no conflict with Exercise Kakadu. DoD also required the following notifications: • DoD five weeks prior to the commencement of activities. • Airservices Australia if Notice to Airmen notification is required for activities in Restricted Airspace. • AHO three weeks prior to the commencement of activities.	• AHO had been engaged for the Activity and was included in Woodside's Activity notification protocols. AHO will be notified four weeks prior to the start of activities.	
	On 14 May 2021, Woodside emailed the Office of Airspace Regulation seeking to understand any implications should restricted airspace be activated.	On 17 May 2021, the Office of Airspace Regulation emailed and advised the proposed activity would need to be complete by mid-August. The R230 series could be activated to the surface which would necessitate the requirement for Woodside air assets to obtain a clearance for entry. ADF airspace is unable to assist regarding UXO.	On 17 May 2021, Woodside emailed the Office of Airspace Regulation and confirmed activities will be completed by Mid August.	
	On 30 June 2021, Woodside emailed DoD (**Appendix F**, reference 1.25) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope.	No feedback received.	No response required.	Woodside considers its response to DoD on 14 May 2021 adequately addresses DoDs interests as there were no material changes to the activity relevant to the stakeholder as advised on 30 June 2021.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
				No further consultation is required.
DFAT	On 25 March 2021, Woodside emailed DFAT advising of the proposed activity (**Appendix F**, reference 1.8) and provided a Consultation Information Sheet.	No feedback received.	Woodside to follow up.	Consultation ongoing.
	On 5 May 2021, Woodside called and emailed DFAT to identify relevant department contacts with respect to potential interaction with Indonesian fishers and oil spill planning in the unlikely event of an incident.	DFAT requested Woodside to re-send consultation information and it would facilitate provision of Department contacts.	Woodside to follow up as it had not received a response.	Consultation ongoing.
	On 10 May 2021, Woodside emailed DFAT following up on its email of 5 May 2021.	On 10 May 2021, DFAT emailed Woodside advising it would revert with a response on appropriate contacts.	On 11 May 2021, Woodside emailed DFAT acknowledging its advice.	Consultation ongoing.
	On 21 May 2021, Woodside emailed DFAT following up on DFAT's advice on 10 May 2021.	On 28 May 2021, DFAT emailed Woodside advising it would revert with a response on appropriate contacts.	Woodside to follow up.	Consultation ongoing.
	On 30 June 2021, Woodside emailed DFAT (**Appendix F**, reference 1.25) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the	On 1 July 2021, DFAT emailed Woodside acknowledging receipt of its advice and would provide a response by the indicted date for providing feedback. DFAT also provided an email address for future engagements with the Department.	On 2 July 2021, Woodside emailed DFAT thanking the Department for its advice. Woodside also provided copies of its initial activity advice sent to DFAT on 25 March 2021, including a Consultation Information Sheet.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	confirmed 2D survey activity scope.		Woodside advised it sought contact details within DFAT for oil spill planning and engagement with Indonesian fishers.	
	On 16 July 2021, Woodside emailed DFAT following up on its email of 2 July 2021 seeking feedback on contact details within DFAT for oil spill planning and engagement with Indonesian fishers.	On 20 July 2021, DFAT emailed Woodside noting the responsibility of other Australian government agencies for most of the issues raised by Woodside in its email of 25 March 2021. As a result, DFAT confirmed it did not have any substantive comments on the proposal. DFAT noted it would welcome further consultation should any foreign countries be affected by the proposed activity, including any oil spill planning and response in international waters.	Woodside to follow up with DFAT following its request to be consulted on oil spill planning and impacts to the interests of foreign countries.	Consultation ongoing.
	On 23 July 2021, Woodside called DFAT to further discuss planning activities. On 23 July 2021, Woodside emailed DFAT seeking clarity on whether there were any specific contacts within DFAT that should be engaged in the event of unplanned activities where the interests of foreign countries may be impacted.	No feedback received.	Woodside to follow up.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	On 28 July 2021, Woodside called DFAT to further discuss planning activities.	On 28 July 2021, DFAT texted Woodside confirming a dedicated email address for consultation purposes and would provide a formal response by email on 29 July 2021.	On 28 July 2021, Woodside texted DFAT acknowledging its advice, also seeking clarification on the timeliness for notifications in event of unplanned events, such as marine pollution.	Consultation ongoing.
		On 29 July 2021, DFAT emailed Woodside providing a common email address for future engagements as individual officers on geographic desks are subject to change over time. DFAT confirmed it expected Woodside to consult with AMSA as required by any relevant obligations as to the timeliness of incident reporting. DFAT advised that historically AMSA had advised of any cross-boundary dimensions for marine pollution. On this basis DFAT expected that any notifications from Woodside to DFAT follow Woodside's reporting the incident to AMSA.	On 30 July 2021, Woodside emailed DFAT thanking the Department for its advice. Woodside confirmed for marine pollution notifications for the activity it would: • Verbally notify AMSA and Northern Territory departments responsible for marine pollution as soon as possible after an incident. • Follow up its AMSA notification by way of an online report via AMSA's website. • Notify other relevant government departments as soon as practicable. These notifications would include DFAT via the email address provided by DFAT if a spill was likely to enter international waters. Woodside also confirmed it would use the email address provided by DFAT to notify the Department in the unlikely event that the proposed activity affected the interests of foreign countries, such as interaction with Indonesian fishers.	Woodside includes instructions in the Notifications Table of the First Strike Plan to notify AMSA, NT Authorities in the event of a spill and, if the spill is entering international waters, to notify DFAT in the event of a spill. Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
DISER	On 25 March 2021, Woodside emailed DISER advising of the proposed activity (**Appendix F**, reference 1.1) and provided a Consultation Information Sheet.	No feedback received.	No response required.	Consultation ongoing.
	On 30 June 2021, Woodside emailed DISER (**Appendix F**, reference 1.25) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope.	No feedback received.	No response required.	Woodside has provided sufficient information and opportunity to respond. Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
DNP	On 25 March 2021, Woodside emailed DNP advising of the proposed activity considering potential risks to Australian marine Parks (**Appendix F**, reference 1.9), and provided a Consultation Information Sheet.	On 23 April 2021, DNP thanked Woodside for the information and noted that the proposed Operational Area includes the Oceanic Shoals Marine Park Multiple Use Zone, which forms part of the North Network of Marine Parks. DNP provided a link to the North Marine Park Network Management Plan, which provides information on the values of the values of the Oceanic Shoals Marine Park and allows for mining authorisation to be given through a NOPSEMA-assessed class approval. DNP also provided a link to guidance note outlining	On 14 May 2021, Woodside emailed and thanked DNP for its response and confirmed that confirm that while the Operational Area overlaps the Multiple Use Zone (IUCN VI) of the Oceanic Shoals AMP, it is outside of the National Park Zone (IUCN II) and Habitat Protection Zone (IUCN IV) and, therefore, no activities (including vessel operations, streamer deployment/recovery or AUV node deployment/repositioning) will take place in these areas. Woodside confirmed it had adopted the following controls to manage impacts specifically from the generation of underwater noise during the activity:	The Environment Plan has identified and managed all impacts and risks on Australian marine park values (including ecosystem values) to an ALARP and acceptable level and demonstrated that the activity is not inconsistent with the management plan (**Section 1.9.1.3.2**, **4.6.1** and **6**). Relevant controls adopted to manage specific impacts and risks raised during consultation include: **PS 7.1**, **5.1**, **12.1** and **19.1**. Woodside will provide notifications to DNP prior to the commencement and at

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		expectations for what aspects titleholders need to consider and evaluate when preparing Environment Plans. DNP requested Woodside ensure that the EP: • Identifies and manages all impacts and risks on Australian marine park values (including ecosystem values) to an acceptable level and considers all options to avoid or reduce them to as low as reasonably practicable. • Clearly demonstrates that the activity will not be inconsistent with the management plan. DNP noted that specific values for the Oceanic Shoals Marine Park include (but are not limited to) were: • Species listed as threatened, migratory, marine or cetacean. • Biologically important areas including foraging and interesting habitat for marine turtles. • Carbonate bank and terrace systems of the Van Diemen Rise. • Carbonate bank and terrace system of the Sahul Shelf. • Pinnacles of the Bonaparte Basin.	• Application of a 5 km exclusion zone around the outer (offshore) boundary of the Flatback Turtle Interesting Buffer Habitat Critical inside which the source cannot be discharged at full power. • Adaptive Management Measures – Turtles • Application of EPBC Policy Statement 2.1 Part A Standard Management Procedures to whales. • Application of EPBC Regulations 2000 –Part 8 Division 8.1 Interacting with cetaceans. Woodside also confirmed controls had also been adopted to manage other impacts and risks associated with the activity to a level which is acceptable and ALARP (e.g. vessel discharges and unplanned spills).	the end of the activity, as outlined in **Section 7.9.3**. Woodside will ensure DNP is made aware of any incidences within a marine park for the activity, as per the commitment in the Oil Pollution First Strike Plan (**Appendix H**). Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		• Shelf break and slope of the Arafura Shelf. DNP requested Woodside ensure that the operational area, which includes the vessel, streamer or node repositioning, does not include any activity within Oceanic Shoals Marine Park Habitat Protection or National Park Zones. DNP also provided its expectations and contact details for notification in the event of oil/gas pollution incidences which occur within a marine park or are likely to impact on a marine park.		
	On 30 June 2021, Woodside emailed DNP (**Appendix F**, reference 1.25) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope.	No feedback received.	No response required.	Woodside considers its response to DNP on 14 May 2021 adequately addresses DNPs interests as there were no material changes to the activity relevant to the stakeholder as advised on 30 June 2021. No further consultation is required.
NT Government				
NT DITT (Petroleum)	On 17 March 2021, Woodside met with the NT DITT and presented (**Appendix F**, reference 1.26) an overview of planned activities and its engagement approach with identified stakeholders.	No issues of concern were raised at the meeting. The NTDITT provided guidance on contact details for relevant government, industry and community stakeholders.	No response required ahead of formal consultation with all identified stakeholders.	No action required.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	On 26 March 2021, Woodside emailed the NT DITT advising of the proposed activity (**Appendix F**, reference 1.1) and provided a Consultation Information Sheet.	No feedback received.	No response required.	Consultation ongoing.
	On 30 June 2021, Woodside emailed NT DITT (**Appendix F**, reference 1.25) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope.	No feedback received.	No response required.	Consultation ongoing.
	On 23 July 2021, Woodside emailed NT DITT seeking advice on its expectations for pre-start and cessation of activity notifications.	On 27 July 2021, NT DITT emailed Woodside advised that it should refer to the OPGGS (Environment) Regulations 2009 for the requirements to notify the NT on its activities, particularly regulations 26(6), 26A(5) and 30.	On 3 August 2021, Woodside emailed NT DITT confirming in accordance with Regulations 26 for reportable incidents, Woodside will: • Provide a written record of reportable incidents to DITT as soon as practiable after orally reporting the incident (Regulation 26(6)) • Provide a copy of written reportable incident reports to the DITT, within seven days of the written report being provided to NOPSEMA (Regulation 26A(5). In accordance with the requirements of Regulation 30 for notification of activity commencement, Woodside confirmed it would notify DITT of the	The Environment Plan outlines requirements for reportable incidents in **Section 7.9.5**. Woodside will provide notifications to NT DITT (Petroleum) prior to the commencement and at the end of the activity, as outlined in **Section 7.9.3**.Woodside considers its initial briefing, and the provision of consultation materials for the two phases of consultation activities in March and July 2021 adequately addresses stakeholder's interests.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
			commencement of the Petroleum Activities Program at least ten days before the activity commences, and within ten days of completing the activity.	No further consultation is required.
NT DITT (Fisheries)	On 17 March 2021, Woodside met with the NT and presented (**Appendix F**, reference 1.26) an overview of planned activities and its engagement approach with identified stakeholders.	No issues of concern were raised at the meeting. Areas of interest included the use of AUV seismic nodes and the opportunity to gather benthic data during the survey to support ground-truthing of modelled benthic habitats in the region.	No response required. Woodside notes the NT DITT's interest in addressing scientific knowledge gaps in the region of the benthic environment.	Consultation ongoing.
	On 17 March 2021, Woodside emailed the NT DITT seeking guidance on its approach for engaging relevant fishery stakeholders in NT-managed fisheries. Woodside also sought guidance on the presence of charter boat/diving activities in the region.	On 19 March 2021, NT DITT provided advice for including additional stakeholders, including the Tiwi Land Council. NT DITT also advised that diving/spearfishing activity in the region would be very rare and would mainly be by recreational divers/anglers rather than charter groups.	On 19 March 2021, Woodside emailed and thanked NT DITT for its advice on stakeholder identification and charter boat/diving activities. Woodside also confirmed it would be working with its Indigenous Affairs team for engagement of the Tiwi Land Council.	Consultation ongoing.
		On 17 March 2021, NT DITT emailed Woodside advising it would check there are no missing contacts and to add the Demersal Fishery Licensee Committee.	On 17 March 2021, Woodside thanked NT DITT. On 19 March 2021, Woodside sought an update from NT DITT.	Counsulation ongoing.
		On 19 March 2021, NT DITT emailed Woodside provided the generic licencing email and advised	On 19 March 2021, Woodside advised it would follow up with the licencing contact details, and would start the	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		the organisation discussed in the meeting are relevant, and the Tiwi Island Council should be added. NT DITT advised it would be very rare divers / spearfishers would be active in the region.	engagememt process with the Tiwi Island Council.	
			On 26 March 2021, Woodside emailed NT DITT to advise Woodside is undertaking formal consultation for the Galactic Hybrid Marine Seismic Survey. Woodside asked if there is dedicated NT DITT email address or contact. Woodside asked if advice to NT DITT (Fisheries) office and AFMA sufficient to meet the consultation requirements for the NT FJA, or does it also have a dedicated contact person?	Consultation ongoing.
			On 30 March 2021, Woodside followed up with DT NITT on the generic email address and engagement of the NT FJA.	
	On 1 April 2021, Woodside emailed the NT DITT advising of the proposed activity (**Appendix F**, reference 1.10) and provided a Consultation Information Sheet, and Commercial Fishing Information Sheet.	On 7 April 2021, NT DITT emailed Woodside thanking it fo the information sheets and advised the email addresses if fisheries@nt.gov.au NT DITT advised there is not a dedicated contact for the NT FJA and to engage the Department, and management officer at AFMA for Commonwealth fisheries.	On 10 May 2021, Woodside advised an extension is fine, and advised the NT DITT of a pending decision on survey scope (2D or 3D) and definition (extent of the Acquisition Area).	Woodside to consider NT DITT feedback following a decision on survey scope.
		On 10 May 2021, the NT DITT emailed Woodside seeking a two-		

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		day extension on provision of feedback, noting it was assessing risk implications of 2D and 3D survey options.		
		On 10 May 2021, NT DITT thanked Woodside and advised different iskes with 2D or 3D would influence its response. It asked if it was better to wait the decision before providing a response.	On 10 May 2021, Woodside advised it will have more definition on the decision and extent of the acquisition area and will provide this once available.	
		On 21 May 2021, NT DITT thanked Woodside for the update and will await a decision on survey type before providing comment.	On 21 May 2021, Woodside a decision on the Galatic scope is still pending and a decision is likely in the coming weeks, at which time an update would be provided.	
	On 30 June 2021, Woodside emailed NT DITT (**Appendix F**, reference 1.23) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope. Woodside also provided maps showing historic 2D and 3D surveys overlaid with the NT/P86 permit operated by Woodside. Woodside also offered upon request, the draft of the section of the Environment Plan that outlines noise impact assessment, as well	On 30 June 2021, Woodside received a response from NT DITT that its liaison contact for consultation no longer worked for the Departnment and alternative contacts were provided.	On 30 June 2021, Woodside sent a follow-up email to NT DITT seeking a response on whether it wished to provide feedback on the proposed Activity and confirming AFMA had also been engaged.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	the independent noise modelling report that underpinned Woodside's assessment given expected interest from stakeholders with interests in commercial fishing.			
	On 3 August 2021, Woodside sent a follow-up email to NT DITT seeking a response on whether it wished to provide feedback on the proposed Activity.	On 3 August 2021, NT DITT emailed Woodside confirmed it had received Woodside's email and would attend to the enquiry/process application at the earliest opportunity.	No response required.	Woodside has identified five fisheries as being relevant for the proposed activity (**Table 5-1**) and assessed fisheries issues in **Section 4.5.4** and **Section 6** of this EP. Woodside has provided consultation information to licence holders to these fisheries and the relevant representative organisations. This information was provided for both phases of consultation activity in March and July 2021. Woodside will provide notifications to NT DITT (Fisheries) and relevant commercial fishery representative bodies and/or licence holders prior to the commencement and at the end of the activity (**PS 1.4**) Woodside considers its initial briefing, and the provision of consultation materials for two phases of consultation in March and July 2021

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
				adequately addresses stakeholder's interests. No further consultation is required.
NT DEPWS	On 17 March 2021, Woodside emailed and met with the NT DEPWS and provided an overview of planned activities and its engagement approach with identified stakeholders.	On 17 March 2021, NT DEPWS advised it was available to meet. No issues of concern were raised at the meeting.	Woodside confirmed it would engage separately on oil spill planning matters and subsequently met with the NT DEPWS on 19 March 2021.	No action required.
	On 17 March 2021, Woodside emailed the NT DEPWS seeking a meeting to discuss oil spill planning arrangements (reference 1.11). On 19 March 2021, Woodside met with NT DEPWS and provided an email summary and assumptions to inform oil spill planning and notification escalation.	On 7 April 2021, NT DEPWS provided comment on Woodside's planning assumptions, including feedback on: • NT hazard management and response arrangements. • Oil spill response plan development and resourcing.	On 7 April 2021, Woodside emailed NT DEPWS thanking for input into Woodside's planning for the proposed Activity.	Consultation ongoing
	On 14 July 2021, Woodside emailed NT DEPWS providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope.	No feedback received.	No response required.	Woodside has incorporated advice and guidance provided by DEPWS into the Oil Pollution First Strike Plan and has addressed oil pollution planning and response at **Appendix D**. Woodside considers stakeholder's interests have

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
				been adequately addressed and no further consultation is required.
Commonwealth Managed Fisheries				
Licence holders in the Northern Prawn Fishery	On 25 March 2021, Woodside emailed licence holders advising of the proposed activity (**Appendix F**, reference 1.12) and provided a Consultation Information Sheet, and Commercial Fishing Information Sheet.	No feedback received.	No response required.	Consultation ongoing.
	On 30 June 2021, Woodside emailed licence holders (**Appendix F**, reference 1.23) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope. Woodside also provided maps showing historic 2D and 3D surveys overlaid with the NT/P86 permit operated by Woodside. Woodside offered upon request, the draft of the section of the Environment Plan that outlines noise impact assessment, as well the independent noise modelling report that	No feedback received.	No response required.	Woodside has assessed the relevancy of Commonwealth fisheries issues in **Section 4.5.4** of this EP and identified the Northern Prawn Fishery as being relevant for the proposed activity. It has provided consultation information to licence holders in this fishery and the relevant representative organisation, the NPF Industry. This information was provided for both phases of consultation activity in March and July 2021. Consultation information has also been provided to CFA, SIA and AFMA. Woodside will provide notifications to relevant commercial fishery

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	underpinned Woodside's assessment given expected interest from stakeholders with interests in commercial fishing.			representative bodies and/or licence holders prior to the commencement and at the end of the activity (**PS 1.4**). Daily lookahead reports will be provided on request (**PS 1.6**) and where possible interactions are identified an operations plan will be developed (**PS 1.7**). Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
Northern Territory Managed Fisheries				
Licence holders in the Aquarium Fishery, Demersal Fishery, Offshore Net and Line Fishery, Spanish Mackerel Fishery and the Timor Reef Fishery	On 25 March 2021, Woodside mailed licence holders advising of the proposed activity (**Appendix F**, reference 1.13) and provided a Consultation Information Sheet, and Commercial Fishing Information Sheet.	No feedback received.	No response required.	Consultation ongoing.
	On 30 June 2021, Woodside mailed licence holders (**Appendix F**, reference 1.24) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition	No feedback received.	No response required.	Woodside has assessed the relevancy of Northern Territory fisheries issues in **Section 4.5.4** of this EP and identified the Aquarium Fishery, Demersal Fishery, Offshore Net and Line Fishery, Spanish Mackerel Fishery and the Timor Reef

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	line options for the confirmed 2D survey activity scope. Woodside also provided maps showing historic 2D and 3D surveys overlaid with the NT/P86 permit operated by Woodside. Woodside offered upon request, the draft of the section of the Environment Plan that outlines noise impact assessment, as well the independent noise modelling report that underpinned Woodside's assessment given expected interest from stakeholders with interests in commercial fishing.			Fishery as being relevant for the proposed activity. It has provided consultation information to licence holders in these fisheries and the relevant representative organisation, the NTSC. This information was provided for both phases of consultation activity in March and July 2021. Woodside has also met with the NTSC as part of first phase consultation activities and has sought on multiple occasions to the engage the NTSC during the second phase of consultations. Woodside will provide notifications to relevant commercial fishery representative bodies and/or licence holders prior to the commencement and at the end of the activity (**PS 1.4**). Daily lookahead reports will be provided on request (**PS 1.6**) and where possible interactions are identified an operations plan will be developed (**PS 1.7**). Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
Austral Fisheries Licence holder in the Timor Reef and Demersal Fisheries		Austral Fisheries emailed Woodside on 26 March 2021 that it had a significant Tropical Snapper fishing operation in the area indicated by the proposed seismic program. The licence holder indicated it wanted to engage in discussions at the earliest possible time. The stakeholder claimed that its experience in this area with previous seismic programs showed immediate effects on fish behaviour and longer term localised stock depletion.	On 26 March 2021, Woodside Woodside emailed Austral Fisheries and noted the stakeholder's meeting request and coordinated a meeting on 19 April 2021. Meeting was later deferred to 22 April.	Consultation ongoing.
		On 26 March 2021, emailed suggesting a time for a meeting.	On 26 March 2021, Woodside emailed advised the meeting time is fine and it would confirm attendees	
			On 1 April 2021, Woodside emailed seeking a revised time to meet.	
		On 6 April 2021, Austral Fisheries emailed advising another meeting time.		
		On 15 April 2021, Australia Fisheries emailed requesting to meet at another time.	On 15 April 2021, Woodside emailed advised it would check with the time on the proposed time and clarified the proposed meeting day.	
		On 15 April 2021, Austral Fisheries emailed Woodside confirming the day.	On 15 April 2021, Woodside emailed suggesting a different meeting time.	

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	On 22 April 2021, Woodside met with the licence holder to present (**Appendix F**, reference 1.27) further details on the survey and to understand stakeholder issues or concerns.	The licence holder confirmed it operated in the survey Operational Area and would seek compensation if impacted. The licence holder advised it would provide catch data to Woodside to support a compensation claim. The licence holder also encouraged Woodside to maintain dialogue with the NTSC to inform other fishing licence holders.	Woodside confirmed it would advise when planning was complete on the final acquisition area and type of survey (2D or 3D) to inform potential impact. Woodside advised it would also provide a composite map showing historic seismic surveys in the region by all operators, overlayed with the final acquisition area for the Galactic Hybrid Marine Seismic Survey.	Woodside to maintain engagement with the licence holder and the NTSC.
		On 21 May 2021, Woodside emailed providing an update on the Galactic survey scope, and that a decision on 2D or 3D would be made in the coming weeks.	On 21 May 2021, Austral Fisheries emailed thanking Woodside for the update.	
	On 30 June 2021, Woodside emailed the licence holder (**Appendix F**, reference 1.23) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope. Woodside also provided maps showing historic 2D and 3D surveys overlaid with the NT/P86 permit operated by Woodside. Woodside offered upon request, the draft of the section of the Environment Plan that outlines noise	No feedback received.	No response required.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	impact assessment, as well the independent noise modelling report that underpinned Woodside's assessment given expected interest from stakeholders with interests in commercial fishing.			
	On 28 July 2021, Woodside called the licence holder to follow up on its updated activity advice on 30 June 2021.	The licence holder indicated it would not be providing feedback directly but would provide feedback through its representative organisation.	Woodside notes the licence holder's feedback.	Woodside considers its initial briefing, and the provision of consultation materials for the two phases of consultation activities in March and July 2021 adequately addresses stakeholder's interests. Woodside will maintain engagement with the NTSC and provide notifications to relevant commercial fishery representative bodies and/or licence holders prior to the commencement and at the end of the activity (**PS 1.4**). Daily lookahead reports will be provided on request (**PS 1.6**) and where possible interactions are identified an operations plan will be developed (**PS 1.7**).
Industry				

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
INPEX	On 25 March 2021, Woodside emailed INPEX advising of the proposed activity (**Appendix F**, reference 1.14) and provided a Consultation Information Sheet, and Titleholder map.	On 26 March 2021, Inpex responded by way of an automated email.	No feedback received.	Consultation ongoing.
	On 30 June 2021, Woodside emailed INPEX (**Appendix F**, reference 1.25) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope.	No feedback received.	No response required.	Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
Santos	On 25 March 2021, Woodside emailed Santos advising of the proposed activity (**Appendix F**, reference 1.14) and provided a Consultation Information Sheet, and Titleholder map.	No feedback received.	Woodside to follow up given Santos' market announcement on 30 March 2021 that it had taken a Financial Investment Decision on the nearby Barossa project.	Consultation ongoing.
	On 19 April 2021, Woodside emailed Santos asking if there were likely to be activities in the region to support development of its Barossa project.	On 20 April 2021, the Santos contact forwarded the email to the relevant Santos representative.	On 23 April 2021, Woodside emailed Santos confirming its agreeance to meet and discuss management of SIMOPS activities.	Consultation ongoing.
		On 20 April 2021, the relevant Santos representative advised it had activities planned for 2021.		

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		On 22 April 2021, Santos advised drilling activities would occur and sought to meet with Woodside to discuss respective activities.		
	On 3 May 2021, Woodside and Santos held a meeting and emailed to discuss respective Activity scopes and timings, including the need for Woodside to undertake seismic activities in Santos permits NTL1, NTRL6 and NTP82.	Both parties agreed at the 3 May 2021 meeting to continue to engage, with a view to identifying and managing potential risks in the event of simultaneous operations.	Woodside acknowledges Santos' cooperation and collaborative approach to minimising activity risk.	Consultation ongoing.
		On 4 May 2021, Santos emailed advising it will plot survey lines over proposed Santos activities.	On 11 May 2021, Woodside emailed Santos thanking it for over laying anchor pattersn, and advised tow depth is between 15 – 18m. Woodside requested the layout in CAD or GIS format so we can look at planning around the drilling campaign.	
		On 4 May 2021, Santos emailed oulting concern the tie in line runs through the Barossa field and over anchor patterns.		
		On 11 May 2021, Santos advised it is not happy with a sesiimc sruevy happening within the anchor pattern. Any deviation from this would require careful planning and agreement of all parties. Asked if Woodside had already received the field layout. Advised it will take a while before planning for drilling is available.	On 12 May 2021, Woodside advised it will overlay the drilling activity and will consider how to work around the constraints.	
		On 12 May 2021, Santos thanked Woodside and requested to keep in touch.		

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	On 30 June 2021, Woodside emailed Santos (**Appendix F**, reference 1.25) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope.	No feedback received.	No response required.	Woodside will continue to engage Santos as planning for respective activities matures. Woodside will provide notifications to Santos prior to the commencement and at the end of the activity (**PS 1.4**). Daily lookahead reports will be provided on request (**PS 1.6**) and where possible interactions are identified an operations plan will be developed (**PS 1.7**).
	On 6 May 2021, Woodside emailed Santos with draft ingress agreements to undertake activities in Santos permits.	From 13 May to 2 July 2021 Santos and Woodside progressed ingress agreement.	On 8 July 2021, Woodside issued final ingress agreements to Santos for signature.	Woodside considers stakeholder's interests have been adequately addressed and will continue to engage Santos to manage potential SIMOPS.
Vocus Communications	On 25 March 2021, Woodside emailed Vocus Communications advising of the proposed activity (**Appendix F**, reference 1.15) and provided a Consultation Information Sheet.	On 25 March 2021, Vocus emailed Woodside advising that its Special Projects Team had been notified about the proposed Activity.	No response required.	Consultation ongoing.
		On 26 March 2021, Vocus emailed Woodside indicating its preliminary view was that it would not have any assets in the area by May 2022.	Woodside notes feedback from Vocus.	Woodside notes that Vocus has advised it will not have any assets in the area. Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
Industry representative organisations				

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
AFANT	On 25 March 2021, Woodside emailed AFANT advising of the proposed activity (**Appendix F**, reference 1.16) and provided a Consultation Information Sheet, and Commercial Fishing Information Sheet.	No feedback received.	No response required.	Consultation ongoing.
	On 30 June 2021, Woodside emailed AFANT (**Appendix F**, reference 1.23) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope. Woodside also provided maps showing historic 2D and 3D surveys overlaid with the NT/P86 permit operated by Woodside. Woodside offered upon request, the draft of the section of the Environment Plan that outlines noise impact assessment, as well the independent noise modelling report that underpinned Woodside's assessment given expected interest from stakeholders with interests in commercial fishing.	No feedback received.	No response required.	Woodside has provided sufficient information and opportunity to respond. Woodside will provide notifications to AFANT prior to the commencement and at the end of the activity (**PS 1.4**). Daily lookahead reports will be provided on request (**PS 1.6**) and where possible interactions are identified an operations plan will be developed (**PS 1.7**). Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
APPEA	On 25 March 2021, Woodside emailed APPEA advising of the proposed activity (**Appendix F**, reference 1.1) and provided a Consultation Information Sheet.	No feedback received.	No response required.	Consultation ongoing.
	On 30 June 2021, Woodside emailed APPEA (**Appendix F**, reference 1.25) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope.	No feedback received.	No response required.	Woodside has provided sufficient information and opportunity to respond. Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
CFA	On 25 March 2021, Woodside emailed CFA advising of the proposed activity (**Appendix F**, reference 1.16) and provided a Consultation Information Sheet, and Commercial Fishing Information Sheet.	No feedback received.	No response required.	Consultation ongoing.
	On 30 June 2021, Woodside emailed CFA (**Appendix F**, reference 1.23) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope.	No feedback received.	No response required.	Woodside has assessed the relevancy of Commonwealth fisheries issues in **Section 4.5.4** of this EP and identified the Northern Prawn Fishery as being relevant for the proposed activity. It has provided consultation information to licence holders in this fishery and the relevant

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	Woodside also provided maps showing historic 2D and 3D surveys overlaid with the NT/P86 permit operated by Woodside. Woodside offered upon request, the draft of the section of the Environment Plan that outlines noise impact assessment, as well the independent noise modelling report that underpinned Woodside's assessment given expected interest from stakeholders with interests in commercial fishing.			representative organisation, the CFA. This information was provided for both phases of consultation activity in March and July 2021. Consultation information has also been provided to SIA, DAWE and AFMA. Woodside will provide notifications to relevant commercial fishery representative bodies and/or licence holders prior to the commencement and at the end of the activity (**PS 1.4**). Daily lookahead reports will be provided on request (**PS 1.6**) and where possible interactions are identified an operations plan will be developed (**PS 1.7**). Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
DFLC	On 25 March 2021, Woodside emailed NTSC advising of the proposed activity (**Appendix F**, reference 1.18) and provided a Consultation Information Sheet, and Commercial Fishing Information Sheet. NTSC advised by email on 6 April 2021 that it had	No feedback received.	No response required.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	forwarded Woodside's consultation to the Chairs and Vice Chairs and/or the Executive Officer of the five NT managed fisheries Licensee Committee/Associations. It also advised that its response had been copied to the Chairman for the NT Demersal Fishermen's Association and the Chairman for the Timor Reef Licensee Committee			
	On 30 June 2021, Woodside emailed NTSC (**Appendix F**, reference 1.23) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope. Woodside also provided maps showing historic 2D and 3D surveys overlaid with the NT/P86 permit operated by Woodside. Woodside offered upon request, the draft of the section of the Environment Plan that outlines noise impact assessment, as well the independent noise modelling report that	No feedback received.	No response required.	Woodside has assessed the relevancy of NT fisheries issues in **Section 4.5.4** of this EP and identified the Demersal Fishery as being relevant for the proposed activity. It has provided consultation information to licence holders in this fishery and relevant representative organisations, the NTSC and the DFLC via the NTSC. This information was provided for both phases of consultation activity in March and July 2021. Consultation information has also been provided to SIA, DAWE and AFMA. Woodside will provide notifications to relevant commercial fishery

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	underpinned Woodside's assessment given expected interest from stakeholders with interests in commercial fishing. NTSC responded by email on 6 April 2021 and copied Chair of the DFLC.			representative bodies and/or licence holders prior to the commencement and at the end of the activity (**PS 1.4**). Daily lookahead reports will be provided on request (**PS 1.6**) and where possible interactions are identified an operations plan will be developed (**PS 1.7**). Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
NPFI	On 25 March 2021, Woodside emailed NPFI advising of the proposed activity (**Appendix F**, reference 1.16) and provided a Consultation Information Sheet, and Commercial Fishing Information Sheet.	On 7 April 2021, NPFI emailed Woodside seeking a shape file to overlay on fishing activity in the Northern Prawn Fishery.	On 12 April 2021, Woodside emailed and provided a shape file of the survey area and offered to meet if NPFI had interest.	Consultation ongoing.
	On 30 April 2021, Woodside emailed NPFI to follow up if further information was required. Woodside also advised NPFI it would be advised when a decision had been made on the whether the activity would be a 2D or 3D survey.	No feedback received.	No response required.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		On 10 May 2021, NPFI emailed Woodside expressing concern regarding the proposed survey and potential impacts of the survey on NPF operations and potentially, the productivity of NPF prawns and scampi species. NPFI said its records showed that there had been considerable fishing effort/catch from both NPF prawn operators and NPF scampi operators in the area of the proposed survey between 2010 and 2020. It also said that Threatened, Endangered & Protected (TEP) species, including sea snakes and sawfishes have also been reported in the area of the survey. It said that potential impacts of seismic activity and TEPs, including mitigation measures, will need to be specifically addressed in the development of the EP. NPFI was unable to provide the scampi fishery catch and effort data relating to the proposed area due to AFMA's confidentiality requirements (i.e. data from less than 5 boats is unable to be released) however its open to further consideration/discussion on the proposed survey. NPFI recommended that, should the survey proceed, timing is	On 14 May 2021, Woodside emailed NPFI noting its feedback and concerns. Woodside advised it would provide confirmation at the earliest opportunity following finalising a business decision on the scope of the survey – 2D or 3D, including a decision on the actual survey size within the Operational Area. Woodside said it would share this information when available to have a more informed discussion on the resultant overlay of the survey with the interests of licence holders.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		restricted to the survey taking place during the NPF mid-year closure (between 15 June and 1t August) to limit operational impacts on NPF operators and to minimise adjustment requirements (including in relation to loss of catch and/or increased costs due to displacement) to Woodside. NPFI noted that this approach may not minimise impacts of seismic activity on productivity impacts on fishery stock and/or the health of the marine environment.		
	On 30 June 2021, Woodside emailed NPFI (**Appendix F**, reference 1.23) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope. Woodside also provided maps showing historic 2D and 3D surveys overlaid with the NT/P86 permit operated by Woodside. Woodside offered upon request, the draft of the section of the Environment Plan that outlines noise impact assessment, as well the independent noise modelling report that	No feedback received.	No response required.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	underpinned Woodside's assessment given expected interest from stakeholders with interests in commercial fishing.			
	On 28 July 2021, Woodside called NPFI seeking feedback on the updated activity scope provided on 30 June 2021.	No feedback received.	No response required.	Consultation ongoing.
	On 29 July 2021, Woodside emailed NPFI seeking feedback on the updated activity scope.	On 29 July 2021, NPFI left a voicemail and emailed Woodside requesting a follow-up call.	Woodside to follow up.	Consultation ongoing.
	On 30 July 2021, Woodside spoke to NPFI seeking feedback on the updated activity scope.	On 30 July 2021, NPFI suggested a meeting for 4 August 2021 to discuss the updated activity scope.	Woodside to coordinate meeting.	Consultation ongoing.
	On 4 August 2021. Woodside met with NPFI and provided a presentation relevant to the stakeholder's interests (**Appendix F**, reference 1.28).	The NPFI raised no specific claims or objections with respect to the activity for licence holders in the Northern Prawn Fishery. It brought to Woodside's attention the possibility of live broodstock catch effort in the survey area and the need for establishing communications protocols for potential on water interaction (2-3 vessels annually have permits for broodstock collection, and can fish year-round). NPFI noted communication protocols would also be required if the proposed Activity overlapped	Woodside noted NPFI's expectation for communications protocols to manage on water interactions for broodstock collection and seasonal catch activities. Woodside confirmed an activity start date would be provided when available. Sawfishes had been included in the Environment Plan as part of the sawfish multi species recovery plan assessment. NPFI pointed out that this recovery plan doesn't cover the narrow sawfish. Woodside committed to further reviewing data on narrow sawfish presence/absence and	Woodside will provide notifications to relevant commercial fishery representative bodies and/or licence holders prior to the commencement and at the end of the activity (**PS 1.4**). Daily lookahead reports will be provided on request (**PS 1.6**) and where possible interactions are identified an operations plan will be developed (**PS 1.7**).Woodside to provide feedback on its assessment of the presence

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		the commencement of the tiger prawn season on 1 August 2022. NPFI sought feedback from Woodside on whether impacts and risks to sawfish (and specifically narrow sawfish) were covered in its impact assessment in the Environment Plan. It also sought advice when available for the activity start date.	distribution in the Operational Area and adjacent waters.	and potential impact to narrow sawfish. Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
NT GFIA	On 25 March 2021, Woodside called the NT GFIA to obtain contact details to provide consultation material.	No feedback received.	No response required.	Woodside to follow up.
	On 25 March 2021, Woodside emailed NT GFIA advising of the proposed activity (**Appendix F**, reference 1.16) and provided a Consultation Information Sheet, and Commercial Fishing Information Sheet.	No feedback received.	No response required.	Woodside to follow up.
	On 4 August 2021, Woodside called charter boat operators to confirm presence of guided fishing activities in the Operation Area as contact details	Feedback from operators indicated only one Darwin-based charter company had a vessel that undertook multi-day charters required to travel to the Operational Area. Feedback from that operator was that it was highly unlikely it would be in the area, though there was a possibility due to weather implications.	Woodside noted the feedback and will as precautionary measure include the charter operator in its pre-start notifications.	Charter operator to be notified 10 days prior to start of activities. Woodside will provide notifications to NT GFIA prior to the commencement and at the end of the activity (**PS 1.4**). Daily lookahead reports will be provided on request (**PS 1.6**) and where possible interactions are identified an

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
				operations plan will be developed (**PS 1.7**). Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
NT GFA	On 25 March 2021, Woodside emailed NT GFA advising of the proposed activity (**Appendix F**, reference 1.16) and provided a Consultation Information Sheet, and Commercial Fishing Information Sheet.	No feedback received.	No response required.	Consultation ongoing.
	On 30 June 2021, Woodside emailed NT GFA (**Appendix F**, reference 1.23) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope. Woodside also provided maps showing historic 2D and 3D surveys overlaid with the NT/P86 permit operated by Woodside. Woodside offered upon request, the draft of the section of the Environment Plan that outlines noise impact assessment, as well the independent noise	No feedback received.	No response required.	Woodside has provided sufficient information and opportunity to respond. Woodside will provide notifications to NT GFA prior to the commencement and at the end of the activity (**PS 1.4**). Daily lookahead reports will be provided on request (**PS 1.6**) and where possible interactions are identified an operations plan will be developed (**PS 1.7**). Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	modelling report that underpinned Woodside's assessment given expected interest from stakeholders with interests in commercial fishing.			
NTSC	On 23 March 2021, Woodside called the NTSC seeking feedback on Woodside's proposed engagement approach with licence holders in Northern Territory-managed fisheries.	No feedback received.	Woodside to follow up by email	Consultation ongoing.
	On 24 March 2021, Woodside emailed NTSC seeking feedback on Woodside's proposed engagement approach with licence holders in Northern Territory-managed fisheries (**Appendix F**, reference 1.17).	No feedback received.	Woodside to follow up by email.	Consultation ongoing.
	On 25 March 2021, Woodside emailed NTSC advising of the proposed activity (**Appendix F**, reference 1.18) and provided a Consultation Information Sheet, and Commercial Fishing Information Sheet.	No feedback received.	Woodside to follow up by email.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	On 30 March 2021, Woodside emailed the NTSC seeking contact details for its Demersal Fishery Licensee Committee and its Timor Reef Fishery Licensee Committee.	On 30 March 2021, the NTSC emailed Woodside referencing its email to Woodside on 24 March 2021 (not received by Woodside) advising it sought survey details prior to engaging by phone. The NTSC noted some stakeholders had received information from Woodside and sought feedback from Woodside on its level and method for engaging fishers. The NTSC noted it had copied the WA Fishing Industry Council (WAFIC) on its response given initiatives by WAFIC to improve communication and consultation processes between oil and gas operators and fishers. The NTSC advised it would review Woodside's consultation information and would be available after Easter for a discussion.	Woodside responded to the NTSC by email on 30 March 2021, advising that licence holders in Northern Territory-managed fisheries had been advised by mail as per contact details provided by the NT DITT (Fisheries). • Woodside also advised it had emailed information about the proposed survey to: Licence holders in the relevant Commonwealth-managed fishery (Northern Prawn) as per contact details provided by AFMA • Commonwealth Fisheries Association • Seafood Industry Australia • Northern Prawn Industry Pty Ltd • Amateur Fishermen's Association of the Northern Territory • Northern Territory - Game Fishing Association of Australia. Woodside said it awaited feedback from the NTSC after Easter, as well as addressing any gaps in Woodside's stakeholder identification process.	Consultation ongoing.
		On 6 April 2021, NTSC emailed Woodside and advised that: • Stakeholders identified by Woodside were relevant for the proposed Activity. • It had included a link to Woodside's information sheet	Woodside met with the NTSC on 16 April 2021 (**Appendix F**, Ref 1.27) and noted its distribution of Woodside consultation materials to members and the Licensee Committees/Associations. On survey water depth, Woodside advised that a buffer area would be	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		within two of its weekly member updates. • It had forwarded Woodside's information sheets to the Chairs and Vice Chairs and/or the Executive Officer of the five NT managed fisheries Licensee Committee/Associations. • Further information was sought on water depth across the survey area. • Further information was sought on noise modelling, noting member interest on modelling to have been done for longer accumulation times and the fast accumulation on first pass. • Clarification on Woodside's claim that it will be the first 3D seismic survey and the first 2D survey since the mid-2000s over the permit area. NTSC requested an overview of survey's that have occurred within the proposed area since 2005. • Clarification on whether Woodside will commit to not undertaking the survey in certain months to reduce the overlap with spawning seasons.	established around shallow water areas. Woodside provided an overview of noise modelling undertaken for the survey and offered to provide further details prior to submission of the Environment Plan. On survey overlap, Woodside committed to providing provide a composite map showing historic seismic surveys in the region by all operators, overlayed with the final acquisition area for the Galactic Hybrid Marine Seismic Survey. On survey timing, Woodside confirmed it had chosen the window for seismic acquisition based on feedback from fishing stakeholders for other regional seismic surveys, accounting for spawning timing for key target species.	

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		On 14 May 2021, NTSC requested clarification on whether further information/answers to their queries from 6 April were available.	On 14 May 2021, Woodside emailed NTSC confirming a decision on the final survey scope was imminent and that further information would be provided when available,	Consultation ongoing.
	On 30 June 2021, Woodside emailed NTSC (**Appendix F**, reference 1.23) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope. Woodside also provided maps showing historic 2D and 3D surveys overlaid with the NT/P86 permit operated by Woodside. Woodside offered upon request, the draft of the section of the Environment Plan that outlines noise impact assessment, as well the independent noise modelling report that underpinned Woodside's assessment given expected interest from stakeholders with interests in commercial fishing.	No feedback received.	Woodside to follow up by email.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	On 2 July 2021, Woodside emailed NTSC advising it had left voicemails to discuss next steps to engage NTSC members and heads of the relevant Licensee Committees on the proposed Activity.	On 14 July 2021, NTSC emailed Woodside welcoming the provision of further information as well as a response to its email of 6 April 2021.	On 15 July 2021, Woodside emailed NTSC noting that information had been sent on 30 June 2021 which had addressed some items in NTSC's email of 6 April 2021. In addition, Woodside confirmed that the Active Source Area overlapped one area with depths as shallow as 12 m – Lynedoch Bank. Woodside also confirmed Goodrich Bank, which had minimum water depths of approximately 12-13 m, was located in the southern part of the Operational Area, and was outside the Active Source Area, with no planned 2D seismic lines passing over the top of Lynedoch Bank. Woodside said that the 2D seismic lines adjacent to Lynedoch Bank would be positioned such that the seismic source will not be operated within 250 m horizontal distance of the 80 m contour of the bank. This control was is based on the noise modelling outputs and minimised the risk of impacts to site-attached fish communities inhabiting the reef flat and upper slopes of Lynedoch Bank. As per advice to NTSC on 30 June 2021, Woodside said it would make available the noise modelling report that underpinned our assessment and the relevant section of the Environment Plan prior to submission to NOPSEMA, as well as NTSC	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
			feedback on the best way to provide/discuss information with your members and relevant licensee committees. Woodside confirmed its advice on 30 June 2021 was emailed to relevant Commonwealth licence holders and a letter sent to relevant NT-managed licence holders, providing the same information and an offer to provide modelling/assessment information on request.	
	On 28 July 2021, Woodside called the NTSC as a follow up to ongoing engagement of NTSC and licensee committees.	No feedback received.	Woodside to follow up by email	Consultation ongoing.
	On 29 July 2021, Woodside emailed the NTSC following up to see if it had any further feedback	No feedback received.	No response required.	Woodside has assessed the relevancy of Northern Territory fisheries issues in **Section 4.5.4** of this EP and identified the Aquarium Fishery, Demersal Fishery, Offshore Net and Line Fishery, Spanish Mackerel Fishery and the Timor Reef Fishery as being relevant for the proposed activity. It has provided consultation information to licence holders in these fisheries and the relevant representative organisation, the NTSC. This information was provided for both phases of consultation

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
				activity in March and July 2021. Woodside will provide notifications to relevant commercial fishery representative bodies and/or licence holders prior to the commencement and at the end of the activity (**PS 1.4**). Daily lookahead reports will be provided on request (**PS 1.6**) and where possible interactions are identified an operations plan will be developed (**PS 1.7**). Woodside has also met with the NTSC as part of first phase consultation activities and has sought on multiple occasions to the engage the NTSC during the second phase of consultations. Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
PPA	On 25 March 2021, Woodside emailed PPA advising of the proposed activity (**Appendix F**, reference 1.16) and provided a Consultation Information Sheet, and Commercial Fishing Information Sheet.	On 25 March 2021, Woodside received an automated email response that the nominated PPA contact no longer worked for PPA.	On 6 April 2021 Woodside emailed an alternate contact at the PPA.	Consultation ongoing.
		On 14 April 2021, PPA emailed Woodside and requested to be kept informed of Woodside's planned activities.	No response required.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	On 30 June 2021, Woodside emailed PPA (**Appendix F**, reference 1.23) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope. Woodside also provided maps showing historic 2D and 3D surveys overlaid with the NT/P86 permit operated by Woodside. Woodside offered upon request, the draft of the section of the Environment Plan that outlines noise impact assessment, as well the independent noise modelling report that underpinned Woodside's assessment given expected interest from stakeholders with interests in commercial fishing.	No feedback received.	No response required.	Woodside has assessed the relevancy of fisheries issues in **Section 4.5.4** of this EP. Woodside will provide notifications to relevant commercial fishery representative bodies and/or licence holders prior to the commencement and at the end of the activity (**PS 1.4**). Daily lookahead reports will be provided on request (**PS 1.6**) and where possible interactions are identified an operations plan will be developed (**PS 1.7**). Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
SIA	On 25 March 2021, Woodside emailed SIA advising of the proposed activity (**Appendix F**, reference 1.16) and provided a Consultation Information Sheet, and Commercial Fishing Information Sheet.	No feedback received.	No response required.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	On 30 June 2021, Woodside emailed SIA (**Appendix F**, reference 1.23) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope. Woodside also provided maps showing historic 2D and 3D surveys overlaid with the NT/P86 permit operated by Woodside. Woodside offered upon request, the draft of the section of the Environment Plan that outlines noise impact assessment, as well the independent noise modelling report that underpinned Woodside's assessment given expected interest from stakeholders with interests in commercial fishing.	No feedback received.	No response required.	Woodside has assessed the relevancy of Commonwealth fisheries issues in **Section 4.5.4** of this EP. Woodside has consulted relevant Commonwealth and Northern Territory managed fishery stakeholders, including relevant government departments, licence holders and representative organisations. Woodside will provide notifications to relevant commercial fishery representative bodies and/or licence holders prior to the commencement and at the end of the activity (**PS 1.4**). Daily lookahead reports will be provided on request (**PS 1.6**) and where possible interactions are identified an operations plan will be developed (**PS 1.7**). Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
TRLC	On 25 March 2021, Woodside emailed NTSC advising of the proposed activity (**Appendix F**, reference 1.18) and provided a Consultation Information	No feedback received.	No response required.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	Sheet, and Commercial Fishing Information Sheet. NTSC advised by email on 6 April 2021 that it had forwarded Woodside's consultation to the Chair of the TRLC.			
	On 30 June 2021, Woodside emailed NTSC (**Appendix F**, reference 1.23) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope. Woodside also provided maps showing historic 2D and 3D surveys overlaid with the NT/P86 permit operated by Woodside. Woodside offered upon request, the draft of the section of the Environment Plan that outlines noise impact assessment, as well the independent noise modelling report that underpinned Woodside's assessment given expected interest from stakeholders with interests in commercial fishing.	No feedback received.	No response required.	Woodside has assessed the relevancy of NT fisheries issues in **Section 4.5.4** of this EP and identified the Demersal Fishery as being relevant for the proposed activity. It has provided consultation information to licence holders in this fishery and relevant representative organisations, the NTSC and the DFLC via the NTSC. This information was provided for both phases of consultation activity in March and July 2021. Consultation information has also been provided to SIA, DAWE and AFMA. Woodside will provide notifications to relevant commercial fishery representative bodies and/or licence holders prior to the commencement and at the end of the activity (**PS 1.4**). Daily lookahead reports will be provided on request (**PS 1.6**) and where possible

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	NTSC responded by email on 6 April 2021 and copied Chair of the TRLC.			interactions are identified an operations plan will be developed (**PS 1.7**). Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
Traditional owners				
TLC	On 26 March 2021, Woodside emailed TLC advising of the proposed activity (**Appendix F**, reference 1.19) and provided a Consultation Information Sheet.	On 14 April 2016, the TLC emailed Woodside acknowledging Woodside's advice about the proposed Activity. The TLC sought clarification if the survey was linked to Santos' proposed Barossa project. The TLC also sought a resource (poster size) about the survey in plain English as Woodside information sheet contained technical information may not be understood by landowners whose first language was not English. The TLC was also interested in hosting someone from Woodside to meet with colleagues at the Tiwi Land Council and Tiwi Resources for a briefing.	On 16 April 2016, Woodside called the TLC explaining than the survey was not linked to the Barossa project. Woodside also confirmed it would prepare a poster for communication with landowners. Woodside acknowledged the TLCs request for a meeting.	Consultation ongoing
	On 19 April 2021, Woodside emailed TLC advising a draft poster will be developed for feedback by the TLC.	On 19 April 2021, the TLC emailed Woodside advising it looks forward to reviewing the draft poster.	Woodside to follow up by email.	Conusultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	On 14 May 2021, Woodside met with representatives from the Tiwi Land Council and provided a presentation (**Appendix F**, reference 1.30) and draft poster for review (**Appendix F**, reference 1.31)	No concerns or objection raised at the meeting on 14 May 2021.	On 14 May 2021, Woodside emailed the TLCl, committing to providing generic seismic survey information, as well as Activity-specific information.	Consultation ongoing.
		On 14 May 2021, the Tiwi Land Council emailed Woodside noting its appreciation for engaging properly with the Tiwi Land Council.	On 17 May 2021, Woodside emailed the Tiwi Land Council with information as per its commitment of 14 May 2021.	Consultation ongoing.
	On 30 June 2021, Woodside emailed TLC (**Appendix F**, reference 1.24) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope.	No feedback received.	No response required.	Woodside has provided sufficient information and opportunity to respond. Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
Other stakeholders				
Research organisations – AIMS	On 25 March 2021, Woodside emailed AIMS advising of the proposed activity (**Appendix F**, reference 1.20) and provided a Consultation Information Sheet.	On 1 April 2021, AIMS emailed Woodside advising that two aspects of its operations will likely interact with Woodside's planned survey - in-situ moorings and a planned service trip to the moorings. AIMS provided lats and longs of the mooring locations as well as a map showing the moorings relative to the Operational Area of the survey and sought feedback from Woodside on how it proposed to	On 30 April 2021, Woodside emailed AIMS advising it had noted the locations of the research moorings and the timing of the service trip to the moorings. Woodside suggested a meeting be held to discuss respective activities following the completion of planning activities for 2D or 3D seismic acquisition.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		avoid direct interaction with the moorings. AIMS also provided indicative date for the service trip, 20-27 May 2022. AIMS provided vessel name and mooring recovery/redeployment timing in the event of SIMOPs. AIMS indicated concurrent operations could occur and was willing to provide additional information or meet if needed. AIMS sought from Woodside upon survey completion: • The survey paths near the sites, and • Time and distance of closest approach (so we can check any effect on our instruments).		
	On 30 April 2021, Woodside sent a follow up email to AIMS to coordinate a meeting.	No feedback received.	No response required.	Consultation ongoing.
	On 11 May 2021, Woodside sent a follow up email to coordinate a meeting to discuss respective activities.	On 11 May 2021, AIMS emailed Woodside providing an alternate contact for its NT activities.	Woodside to follow up with meeting request.	Consultation ongoing.
		On 14 May 2021, AIMS emailed Woodside advising it serviced moorings at Goodrich Bank and Lynedoch Bank every 6 months and would be interested to meet with Woodside's survey team.	On 14 May 2021, Woodside emailed AIMS suggesting a meeting in the week beginning 24 May 2021.	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
	On 30 June 2021, Woodside emailed AIMS (**Appendix F**, reference 1.25) providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope. Woodside also offered the opportunity to meet to discuss respective activities in the area.	No feedback received.	Woodside to follow up.	Consultation ongoing.
	On 3 August 2021, Woodside called AIMS to discuss opportunities meet and discuss respective activities in the area.	AIMS was receptive for a planning meeting.	Woodside coordinated a meeting for 5 August 2021.	Consultation ongoing.
	On 5 August 2021 Woodside met with AIMS and provided a presentation relevant to the stakeholder's interests (**Appendix F**, reference 1.29).	AIMS welcomed the meeting and provided the following information to assist Woodside with its planning activities: • AIMS' maintenance program for its oceanographic monitoring equipment was planned to start late April 2022 and be completed mid-May 2022. • The program would comprise maintenance of moorings and buoys, which are located offshore Western Australia and Northern Territory.	On 19 August 2021, Woodside emailed AIMS with its nominated contact representative for planning activities. Woodside also provided proposed communications protocols for discussion and agreement.	Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required. Woodside will maintain contact with AIMS during Activity planning and on-water activities. Woodside will provide notifications to AIMS prior to the commencement and at the end of the activity (**PS 1.4**). Daily lookahead reports will be provided on request (**PS 1.6**) and where possible interactions are identified an

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		• The program carried two transit options - Exmouth to Darwin or Darwin to Darwin - depending on travel restrictions. • As a result, servicing the IMOS mooring on Lynedoch Bank and the waverider buoy on Goodrich Bank would be at the beginning or end of the program, depending on the final transit option selected. It was agreed at the meeting that early advice from AIMS and Woodside on confirmed start dates as well as the establishment of nominated organisation contacts points would assist mutual planning activities. Further, vessel to vessel communications protocols would assist activities in the field in order to minimise on-water interactions.		operations plan will be developed (**PS 1.7**).
Research organisations • CSIRO • Geoscience Australia (GA) • Charles Darwin University • Marine Biodiversity Hub (UTAS)	On 19 July 2021, Woodside emailed research organisations (**Appendix F**, reference 1.21), specifically with respect to field activities that may include diving.	On 30 July 2021, GA emailed Woodside thanking Woodside for providing GA with an opportunity to provide feedback on the proposed Galactic Hybrid 2D Marine Seismic Survey, as it relates to diving. GA confirmed it did not conduct any diving operations and was not in a position to comment. No other stakeholder feedback received.	On 30 July 2021, Woodside emailed GA thanking GA for its feedback.	Woodside has provided sufficient information and opportunity to respond. Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
Diving Operators • Darwin Sub Aqua Club • Dive Air • Learn to Dive Darwin • Sea Darwin	On 19 July 2021, Woodside emailed Darwin-based diving operators, specifically with respect to field activities that may include diving. On 19 July 2021, Woodside emailed Darwin-based diving operators (**Appendix F**, reference 1.22), specifically with respect to field activities that may include diving.	On 19 July 2021, Dive Air emailed Woodside confirming it had no dives planned for the area. Dive Air confirmed contact details for other Darwin-based dive operators and commented that it was unlikely diving activities would take place in the survey area.	On 19 July 2021, Woodside emailed Dive Air thanking Dive Air for its advice. Woodside also sought confirmation on contact details for other dive operators identified by Woodside.	Consultation ongoing.
		On 20 July 2021, Dive Air responded by email confirming that additional operators identified by Woodside were no longer operational.	On 20 July 2021, Woodside emailed Dive Air thanking Dive Air for its feedback.	Woodside has provided sufficient information and opportunity to respond. Woodside will provide notifications to dive operators prior to the commencement and at the end of the activity (**PS 1.4**) and implement DMAC 12 guidelines where required (**PS 1.5**). Woodside considers stakeholder's interests have been adequately addressed and no further consultation is required.
NERA	Nil	On 12 April 2021, NERA emailed Woodside in its role as facilitator of the Collaborative Seismic Environment Plan Project (CESP). NERA sought to be notified of future information and notifications as the Galactic survey Operational Area overlaps the CESP operational area. NERA also sought feedback from Woodside on controls in relation to	On 16 April 2021, Woodside emailed NERA advising it had included NERA on its stakeholder list for any future information and notifications. Woodside advised it was not aware of any NOPSEMA accepted seismic surveys in this region at the proposed timing of the Galactic survey. Woodside will continue to monitor NOPSEMA's web site for accepted petroleum activities prior to and	Consultation ongoing.

Stakeholder	Information provided	Stakeholder response	Woodside response	Woodside assessment and outcome
		cumulative impacts from seismic surveys within the same region. NERA advised that the CSEP will implement that seismic acquisition will not be undertaken within 40 km of another vessel that is also acquiring data.	following the submission of our Environment Plan for assessment. In the unlikely event of two seismic surveys working in the same area at the same time Woodside confirmed it would manage this by way of a 40 km separation distance in this EP (**PS 11.1**).	
		On 23 April 2021, NERA emailed Woodside, acknowledging its response. NERA also noted that Santos and Inpex were members of the CSEP, acknowledging ongoing engagement as respective activities were developed.	Woodside notes NERA's response.	Consultation ongoing.
	On 30 June 2021, Woodside emailed NERA (**Appendix F**, ref 1.25 providing an update on the scope of the proposed activity and a map showing proposed seismic acquisition line options for the confirmed 2D survey activity scope.	On 8 July 2021, NERA emailed Woodside thanking Woodside for the update. It confirmed it had no comments and requested to be informed of updates.	Woodside notes NERA's response.	Woodside considers its response adequately addresses stakeholder interests.

6. ENVIRONMENTAL IMPACT AND RISK ASSESSMENT, PERFORMANCE OUTCOMES, STANDARDS AND MEASUREMENT CRITERIA

6.1 Overview

This section presents the impact and risk analysis and evaluation, EPOs, EPSs and MC for the Petroleum Activities Program, using the methodology described in **Section 2**.

6.2 Analysis and Evaluation

The analysis and evaluation demonstrate that the identified risks and impacts associated with the Petroleum Activities Program are reduced to ALARP, are of an acceptable level and consider all operations of the activity, including potential emergency conditions.

The risks identified during the ENVID (including decision type, current risk level, acceptability of risk and tools used to demonstrate acceptability and ALARP) have been divided into two broad categories:

- planned (routine and non-routine) activities
- unplanned events (accidents, incidents or emergency situations).

Within these categories, impact assessment groupings are based on stressor type, e.g. emissions, physical presence, etc. In all cases, the worst credible consequence was assumed.

The ENVID conducted on 20 January 2021 identified seven impacts and seven risks associated with the Petroleum Activities Program. Planned activities and unplanned events are summarised in **Table 6-1**.

The analysis and evaluation for the Petroleum Activities Program indicate that all the current environmental risks and impacts associated with the activity are reduced to ALARP and are of an acceptable level, as discussed further in **Sections 6.4** and **6.5.**

6.3 Cumulative Impacts

Woodside has assessed the cumulative impacts of the Petroleum Activities Program in relation to other petroleum activities which could realistically result in overlapping temporal and spatial extents. The potential cumulative impact of concurrent seismic activities is assessed in **Section 6.4.1** and **6.4.3**.

Table 6-1: Environmental impact analysis summary of planned and unplanned activities

Aspect	EP section	Risk rating				Acceptability of impact/risk
		Impact/consequence	Potential impact/consequence level	Likelihood	Current risk rating	
Planned activities (routine and non-routine)						
Physical presence: Interactions with other marine users	**6.4.1**	E	Social and Cultural – Slight, short-term impact (less than one year) to a community or areas/items of cultural significance	-	-	Broadly acceptable
Physical presence: Disturbance to benthic habitat from the placement of AUV nodes	**6.4.2**	F	Environment – No lasting effect (less than one month); localised impact not significant to environmental receptors.	-	-	Broadly acceptable
Routine acoustic emissions: Seismic survey equipment	**6.4.3**	E	Environment – Slight, short-term impact (less than one year) on species, habitat (but not affecting ecosystems function), physical or biological attributes.	-	-	Acceptable
Routine acoustic emissions: Vessels, helicopters, AUV nodes and mechanical equipment operation	**6.4.4**	F	Environment – No lasting effect (less than one month); localised impact not significant to environmental receptors.	-	-	Broadly acceptable
Routine atmospheric emissions: Fuel combustion	**6.4.5**	F	Environment – No lasting effect (less than one month); localised impact not significant to environmental receptors.	-	-	Broadly acceptable
Routine discharges: Bilge water, grey water, sewage, putrescible wastes and deck drainage water	**6.4.6**	F	Environment – No lasting effect (less than one month); localised impact not significant to environmental receptors.	-	-	Broadly acceptable
Routine light emissions: External lighting on project vessels	**6.4.7**	F	Environment – No lasting effect (less than one month); localised impact not significant to environmental receptors (e.g. air quality).	-	-	Broadly acceptable
Unplanned activities (accidents, incidents, emergency situations)						
Accidental hydrocarbon release: Vessel collision	**6.5.2**	D	Environment – Minor, short-term impact (one to two years) on species, habitat (but not affecting ecosystems), physical or biological attributes.	1	M	Acceptable
Accidental hydrocarbon release: Bunkering	**6.5.3**	E	Environment – Slight, short-term impact (less than one year) on species, habitat (but not affecting ecosystems function), physical or biological attributes.	2	L	Broadly acceptable
Unplanned discharge: Deck spills	**6.5.4**	F	Environment – No lasting effect (less than one month); localised impact not significant to environmental receptors (e.g. water quality).	2	L	Broadly acceptable
Unplanned discharge: Loss of solid hazardous and non-hazardous wastes (including dropped objects)	**0**	F	Environment – No lasting effect (less than one month); localised impact not significant to environmental receptors (e.g. water quality).	2	L	Broadly acceptable
Physical presence: Vessel collision/entanglement with marine fauna	**6.5.6**	E	Environment – Slight, short term local impact (less than one year) on species, habitat (but not affecting ecosystems function), physical or biological attributes.	1	L	Broadly acceptable
Physical presence: Loss or grounding of equipment	**6.5.7**	E	Environment – Slight, short term local impact (less than one year) on species, habitat (but not affecting ecosystems function), physical or biological attributes.	1	L	Broadly acceptable
Physical presence: Introduction and establishment of invasive marine species	**6.5.8**	D	Environment – Slight, short term local impact (less than one year) on species, habitat (but not affecting ecosystems function), physical or biological attributes.	0	L	Broadly acceptable

6.4 Planned Activities (Routine and Non-routine)

6.4.1 Physical Presence: Interactions with Other Marine Users

Context		
Activity Components - **Section 3.6**	Socio-Economic Environment – **Section 4.5**	Stakeholder Consultation – **Section 5**

Impact Evaluation Summary

Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcomes
Displacement of other marine users – proximity of project vessels (and submersible equipment) interacting with or displacing third party vessels							X	A	E	-	-	GP	Broadly Acceptable	EPO 1,2,3
Potential interactions with planned Defence training exercises							X							
Potential interactions with proposed oil and gas activities							X							

Description of Source of Impact

Project Vessels (including the towed seismic equipment)

The Petroleum Activities Program will be conducted using a single seismic vessel. A temporary 3 nm distance SNA will be maintained around the seismic vessel and towed array (comprising the airgun array and streamer array, which includes a header buoy, single streamer and a tail buoy) during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

The chase/support/vessel, capable of AUV and commercial seismic node deployment/retrieval (further details below), will accompany the seismic vessel to re-supply it with fuel and other logistical and operational supplies. An additional support/chase vessel may be used to manage interactions with shipping and fishing activities, if required.

AUV and Commercial Nodes

The Petroleum Activities Program will involve the deployment and use of approximately 15-20 AUV and commercial nodes in the Active Source Area. The proposed AUV nodes are cylindrical in shape with short wings on the sides for flight stabilisation and steering. They are approximately 1000 mm long and 300 mm in diameter (weights approximately 30 kg in air and 10 kg in sea water). The AUV nodes operate autonomously through the water column and are adapted to settle temporarily on the seabed and listen to/record the seismic signal. As a control the AUV nodes will be fitted with thrusters to be periodically used for propulsion, navigation assistance, managing low impact landings and assist with take-offs as required.

The AUV nodes with be paired with equivalent commercial nodes to ground truth the technology in terms of the verification seismic data recorded. As an additional control the commercial nodes may most probably be deployed and recovered by a small ROV but may also be tethered by a rope to a buoy. The commercial nodes will weigh approximately 15 kg (6.5 kg in sea water) and measure approximately 346 mm (L), by 218 mm (W) and 138 mm (H).

The nodes will be deployed on the seabed along the 20 km lengths of the three existing intersecting lines during the survey. At the end of the survey, when the streamer is recovered, the seismic vessel will re-acquire approximately 20 km lengths along these three lines for a period of between 24 to 48 hr with the same source configuration and source interval. Each AUV node is planned to have approximately five placements along these lines during this final trial period before retrieval. The area where nodes will be used (refer to **Section 3.4**) is limited to approximately 315 km^2.

Recovery devices are included within each AUV and commercial node, which will deploy inflatable air bags to raise the node to the surface if the node is unable to surface. An additional control of a ROV will also be used as a failsafe to recover the AUV nodes as required as well as deployment and recovery of the commercial nodes. The AUV nodes will be pre-programed prior to deployment and will be supported by ultra-short baseline (USBL) acoustic positioning updates from the surface vessels. The AUV units will have onboard "Health check" diagnostic capability to confirm all sensors are working as expected and where found to be in fault the AUV will surface and message the supporting vessels for retrieval.

Impact Assessment

Potential Impacts to Environmental Values

Commercial Fishing

There are a number of Commonwealth and NT managed commercial fisheries that have historically had catch/effort within the Operational Area (refer to **Section 4.5.4**). An analysis has been conducted to determine the area of overlap with historic fishing activity (effort). Accounting for the entire Operational Area is an overly conservative approach and simply provides an indication of the total area where there is potential for interactions with fishers to occur over the total duration of the activity. This is conservative because the seismic vessel will only be operating in a part of the Operational Area at any one time. Depending upon the final line plan that is acquired, parts of the Operational Area may be accessed very infrequently or not at all.

Figure 6-1 presents the 3 nm SNA applied to the total extended case indicative line plan for the Galactic 2D Hybrid MSS. This also overrepresents the area where interactions with fishers may occur as it is based on the entire survey, which may be acquired over a total of 60 days. Over the course of a single day, the area covered by the seismic survey vessel will be significantly smaller. During a 24-hour period of the survey, for example, the seismic survey vessel (travelling at a speed of 4.5 knots) will cover a total line distance of approximately 200 km. Accounting for the 3 nm (5.6 km) SNA applied around the seismic survey vessel and towed array to represent the avoidance distance typically requested of other vessels, the estimated maximum area that fishes will be requested to avoid during a single 24-hour period may be up to 2200 km^2. The 24-hour period accounts for the time when fishers may be directly displaced by the seismic vessel and towed streamers within the SNA. Fishers may not be able to relocate and return to an area quickly enough to resume fishing activities within the same 24-hour period that the seismic vessel is active in the area so it is indicative of a likely area of on-the-water disruption.

It is important to note that due to the long line lengths and broad line spacing associated with 2D seismic surveys, compared with 3D seismic surveys, the seismic survey vessel may at times traverse through an area where fishing normally occurs within a few hours, then transit a significant distance beyond this area and may not return to the same vicinity for until a day or two later.

The 315 km^2 source only AUV survey area may also restrict fishing activities. Nodes will be deployed here for the duration of the survey although survey vessel and acquisition activities within this area will mainly be limited to the start and end of the survey when the survey vessels will be present and nodes are being repositioned.

Table 6-2 presents the area of overlap with each commercial fishery that operates in the Operational Area from 24-hours of 2D line acquisition, the AUV survey area, as well as the total base case and extended case line plan examples. Based on 24-hours of 2D line acquisition, the spatial overlap ranges from 0.47% (Northern Prawn Fishery) to 7.2% (Timor Reef Fishery). Assessment of potential impacts to each of the fisheries presented in **Table 6-2** is provided below.

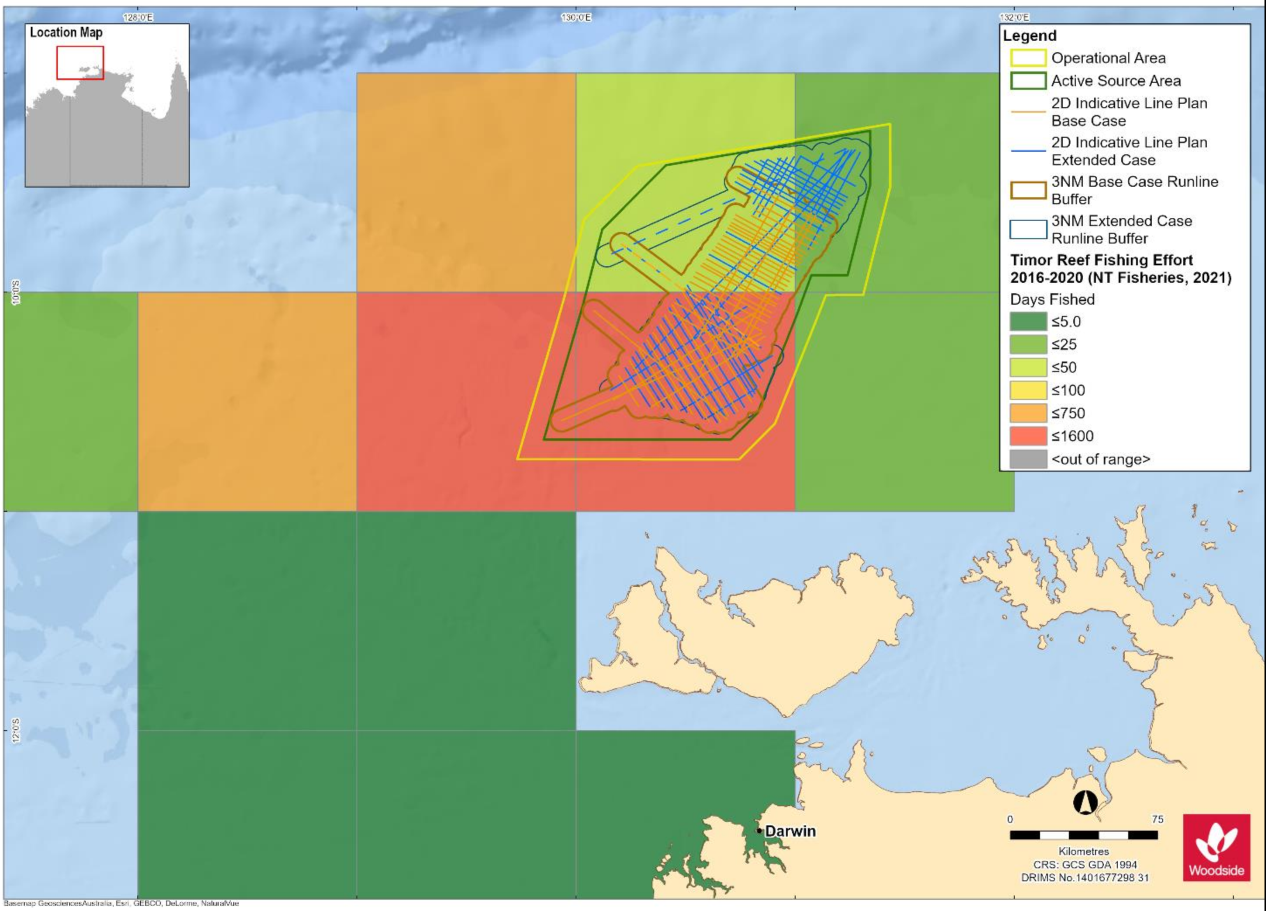


Figure 6-1: Overlap between the 3 nm SNA applied to the Galactic 2D Hybrid MSS line plans and the Timor Reef Fishery.

Table 6-2: Spatial overlap of the Galactic 2D Hybrid MSS with historic fishing effort for relevant commercial fisheries

Relevant commercial fisheries	Area of historic fishing effort (km²)*	Spatial overlap							
		AUV node survey area		24-hours acquisition		Base case lines		Extended case lines	
		km²	%	km²	%	km²	%	km²	%
Northern Prawn Fishery (Cth)	477,053	315	0.1%	2240	0.5%	6766	1.4%	7345	1.5%
Timor Reef Fishery (NT)	31,317	315	1.0%	2240	7.2%	6896	22.0%	7475	23.9%
Demersal Fishery (NT)	312,276	0	0.0%	275	0.1%	1220	0.4%	1220	0.4%
Spanish Mackerel Fishery (NT)	335,811	315	0.1%	2240	0.7%	4580	1.4%	5160	1.5%
Offshore Net and Line Fishery (NT)	325,280	315	0.1%	2240	0.7%	4580	1.4%	5160	1.6%
Aquarium Fishery (NT)	189,996	315	0.2%	2240	1.2%	4580	2.4%	5160	2.7%

* The area of fishing effort for NT-managed fisheries is based on historic data from 2016 to 2020. The area of fishing effort for Commonwealth-managed fisheries is based on the information presented in the ABARES Fishery Status Report 2020 (data is based on 2019-20 fishing season). Refer to **Section 4.5.4** for more information.

Northern Prawn Fishery (Cth)

The majority of effort in the NPF occurs in the nearshore waters of the Gulf of Carpentaria and nearshore waters north of the Tiwi Islands and the Van Diemen Gulf. The NPF operates during two seasons. The first season is from 1 April to 15 June, and during this time banana prawns are mainly caught. Conversely, during the second season from 1 August to 30 November, tiger prawns are predominately caught. Each season has the potential to end early depending on the total catch. The Galactic Hybrid 2D MSS has the potential to overlap with both fishing seasons.

The southern extent of the Operational Area overlaps with an area identified in the ABARES Fishery Status Report 2020 (Patterson et al., 2020) as containing low intensity fishing effort (<0.1 days/km2), while the rest of the Operational Area is subject to fishing by less than six vessels per year (**Figure 6-2**). Fishing generally takes place in waters 35 – 70 m deep, with most fishing effort between 50 and 60 m. The north-western portion of the Operational Area may also experience a limited amount of deepwater trawling for scampi during the prawn fishing closure periods (primarily in December to January), although acquisition in this area will likely only comprise well tie in lines and disruption will be minimal.

The base case and extended case line plan examples overlap with approximately 1.5% of the area of fishing effort, however, in a single day of acquisition, less than 0.5% of the fished area may be disrupted. Fishing effort is based on the information presented in the ABARES Fishery Status Report 2020 (Patterson et al., 2020) which is based on 60 x 60 nm blocks. As such the area of fishing effort and overlap may be overestimated, as fishing is likely limited to spatially discrete locations rather than over the entire area presented in the ABARES Fishery Status Report 2020 (Patterson et al., 2020).

Vessels operating in the fishery predominately use trawl gear and are restricted in their ability to manoeuvre. Commercial fishers may be asked to deviate from fishing grounds periodically to accommodate seismic survey operations. Commercial fishing vessels may potentially experience operational inconvenience and temporary displacement from fishing grounds within the Operational Area. However, such interactions are expected to be infrequent and short-term, due to the transient nature of the seismic vessel and the small area occupied by the seismic vessel (and SNA) at any one time. Alternative and more viable fishing grounds are available to commercial fishers in the NPF, including other sites nearby to the Operational Area (based on historic data).

The AUV node survey area, where nodes will be deployed on the seabed for the duration of the survey, is not located in an area that is typically trawled by the NPF and so this activity is not expected to present an obstruction to this fishery.

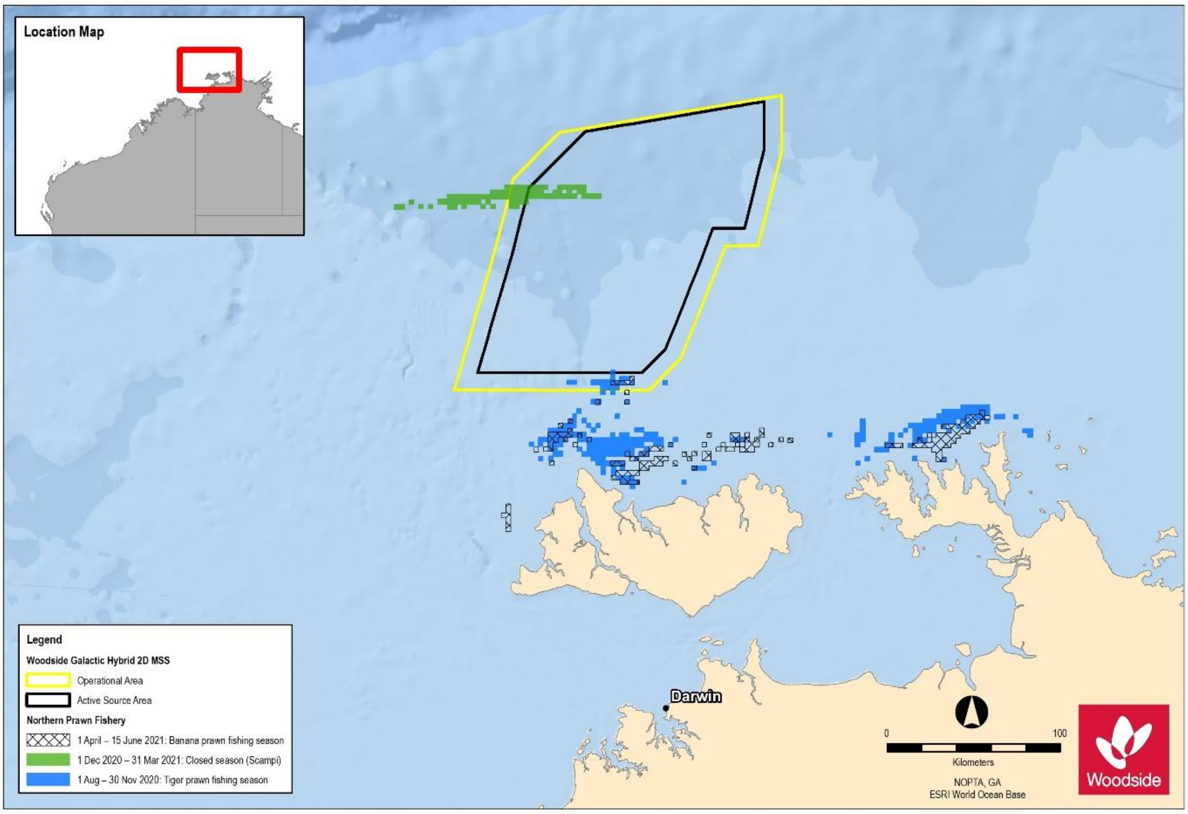


Figure 6-2: Overlap with 2020 and 2021 fishing effort for Northern Prawn Fishery (NT)

Timor Reef Fishery (NT)

Analysis of historic fishing data shows that the area of fishing effort over the NT coast is 31,317 km^2 for the period between 2016 and 2020 (**Section 4.5.4.2**). A review of historic fishing data indicates that effort was consistently between 2016 and 2020 in the fishing grid blocks overlapping the Operational Area. Over this period, between 1 to 413 days of fishing per year was reported in the listed blocks. Majority of the fishing effort is concentrated to the west of the

Operational Area, and in the central and southern parts of the Operational Area (**Figure 6-3**and **Section 4.5.4.2**). These areas include the most frequently fished parts of the fishery. Fishing effort occurs relatively consistently across each year with no identified peak periods.

The base case and extended case line plan examples overlap with approximately 22 – 24% of this area, however, in a single day of acquisition, up to a maximum of 7.2% of the fished area may be disrupted.

The southern half of the Operational Area is noted as being an area where high historical fishing effort has occurred and, therefore, it is therefore highly likely that the Galactic 2D Hybrid MSS will result in some level of interaction with fishing vessels in this fishery. However, alternative fishing grounds (with equivalent historical levels of fishing) are available to commercial fishers, including other sites to the west of the Operational Area where comparable catch and effort occurs (based on historic data).

Vessels operating in the fishery predominately use baited traps, however the fishery also uses vertical lines, finfish longlines and drop lines. Commercial fishers may be asked to deviate from fishing grounds periodically to accommodate seismic survey operations. Commercial fishing vessels may potentially experience operational inconvenience and temporary displacement from fishing grounds within the Operational Area. However, such interactions are expected to be infrequent and short-term, due to the transient nature of the seismic vessel and the small area occupied by the seismic vessel (and SNA) at any one time.

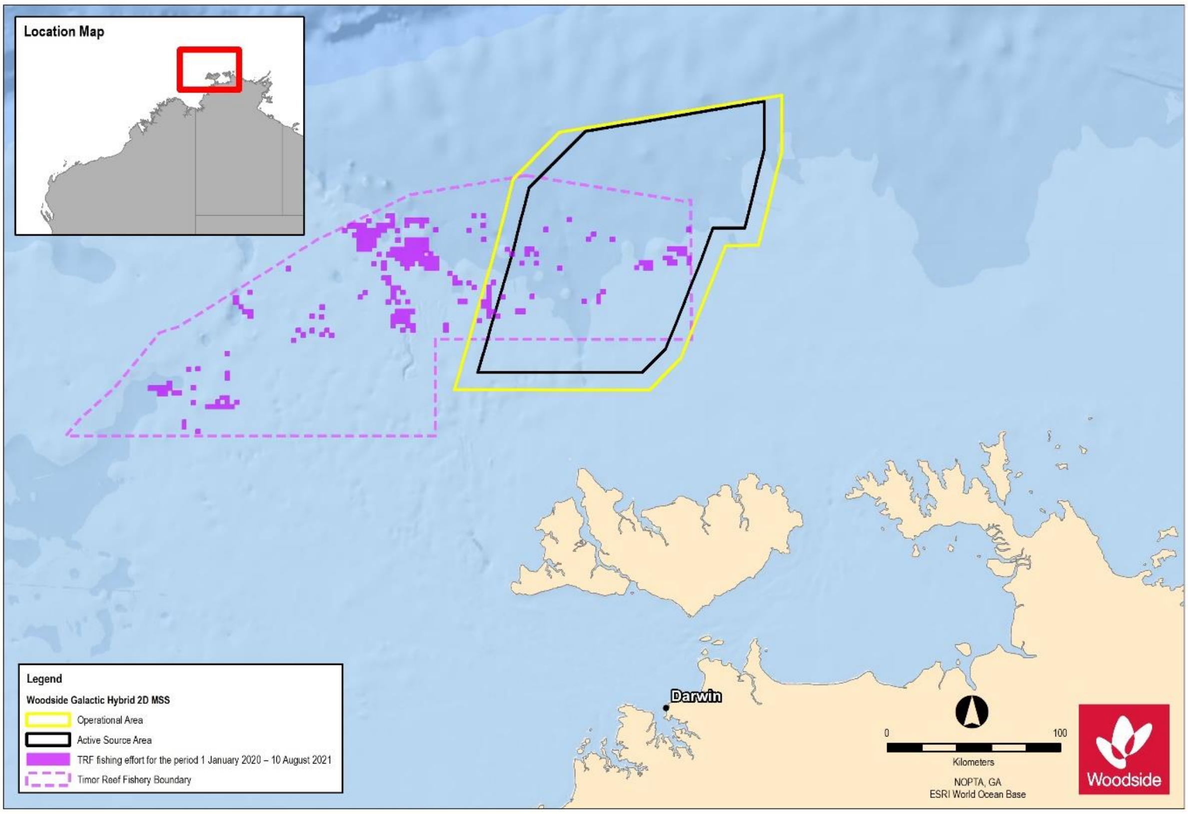


Figure 6-3: Overlap with 2020 and 2021 fishing effort for Timor Reef Fishery (NT)

Demersal Fishery (NT)

Analysis of historic fishing data shows that the area of fishing effort over the NT coast is 312,276 km^2 for the period between 2016 and 2020 (refer to **Section 4.5.4.2**). A review of historic fishing data indicates that effort was reported consistently between 2016 and 2020 in the fishing grid blocks overlapping the Operational Area. Over this period, between 1 to 120 days of fishing per year was reported in the listed blocks. The licensed area for this fishery and fishing effort is limited only to the southern and eastern edges of the Operational Area (refer to **Section 4.5.4.2**). Catch and effort varies from year to year. However, fishing effort occurs relatively consistently across each year with no identified peak periods.

The Galactic 2D Hybrid MSS will overlap with less than 1% of the area accessed by this fishery and limited disruption is expected. Any potential interactions with vessels in this fishery will be limited to short periods when the seismic vessel is transiting at the end of lines and during turns at the southern or eastern edge of the Operational Area.

Alternative and extensive fishing grounds are available to commercial fishers, including other sites nearby to the Operational Area (based on historic data). Vessels operating in the fishery predominately use vertical lines, drop lines, finfish longlines and baited fish traps. Commercial fishers may be asked to deviate from fishing grounds periodically to accommodate seismic survey operations.

Commercial fishing vessels may potentially experience operational inconvenience and temporary displacement from fishing grounds within the Operational Area. However, such interactions are expected to be infrequent and short-term, due to the transient nature of the seismic vessel and the small area occupied by the seismic vessel (and SNA) at any one time.

Spanish Mackerel Fishery (NT)

Analysis of historic fishing data shows that the area of fishing effort over the NT coast is 335,811 km^2 for the period between 2016 and 2020 (refer to **Section 4.5.4.2**). A review of historic fishing data indicates that effort was reported consistently between 2016 and 2020 in the fishing grid blocks overlapping the southern part of the Operational Area. Over this period, between 12 to 120 days of fishing per year was reported in the listed blocks. The majority of the fishing effort is concentrated south and west of the Operational Area (refer to **Section 4.5.4.2)**.

The base case and extended case line plan examples overlap with approximately 1.5% of the fished area, and in a single day of acquisition, up to a maximum of 0.7% of the fished area may be disrupted.

Alternative fishing grounds are available to commercial fishers, including other sites nearby to the Operational Area (based on historic data). Vessels operating in the fishery predominately use trolled lure or baited lines. Commercial fishers may be asked to deviate from fishing grounds periodically to accommodate seismic survey operations.

Commercial fishing vessels may potentially experience operational inconvenience and temporary displacement from fishing grounds within the Operational Area. However, such interactions are expected to be infrequent and short-term, due to the transient nature of the seismic vessel and the small area occupied by the seismic vessel (and SNA) at any one time.

Offshore Net and Line Fishery (NT)

Analysis of historic fishing data shows that the area of fishing effort over the NT coast is 325,280 km^2 for the period between 2016 and 2020 (refer to **Section 4.5.4.2**). A review of historic fishing data indicates that effort was reported in 2016, 2017 and 2019 in the fishing grid blocks overlapping the Operational Area. Over this period, only 1 to 7 days of fishing per year was reported in the listed blocks. The majority of the fishing effort is concentrated to the south of the Operational Area along the NT coast (refer to **Section 4.5.4.2**). Vessels operating in the fishery predominately use demersal or pelagic longlines or pelagic nets.

The base case and extended case line plan examples overlap with approximately 1.5% of the fished area, and in a single day of acquisition, up to a maximum of 0.7% of the fished area may be disrupted. However, given the very low level and infrequent fishing effort that has occurred in the Operational Area previously, interaction with this fishery is unlikely.

More viable fishing grounds are available to commercial fishers to the south of the Operational Area in coastal waters (based on historic data). Should any interactions occur, they are expected to be infrequent and short-term, due to the transient nature of the seismic vessel and the small area occupied by the seismic vessel (and SNA) at any one time.

Aquarium Fishery (NT)

Analysis of historic fishing data shows that the area of fishing effort over the NT coast is 189,996 km^2 for the period between 2016 and 2020 (refer to **Section 4.5.4.2**). The majority of fishing effort in the Aquarium Fishery is focused in freshwater and nearshore marine environments, outside of the Operational Area and wider EMBA. Occasional fishing effort has been reported at offshore locations, one of which is Goodrich Bank, located at the southern extent of the Operational Area.

The base case and extended case line plan examples overlap with approximately 2.5% of the fished area, however, in a single day of acquisition, up to a maximum of 1.2% of the fished area may be disrupted.

Alternative fishing grounds are available to licence holders, including other sites nearby to the Operational Area (based on historic data). Collection via hand-held equipment, including nets (barrier, cast, scoop, drag and skimmer) and hand pumps. Commercial fishers may be asked to deviate from fishing grounds periodically to accommodate seismic survey operations.

Commercial fishing vessels may potentially experience operational inconvenience and temporary displacement from fishing grounds within the Operational Area. However, such interactions are expected to be infrequent and short term, due to the transient nature of the seismic vessel and the small area occupied by the seismic vessel (and SNA) at any one time.

Indonesian Commercial Fishing

The Operational Area is located in the 'Area of Overlapping Jurisdiction' established under the 1997 Perth Treaty (as described in **Section 4.5.2**). Within this area, Australia exercises seabed jurisdiction including the exploration of petroleum, and Indonesia exercises water column jurisdiction, including fishing rights. Therefore, it is possible that Indonesian commercial fishing vessels may be encountered in this area.

Analysis of Indonesian fishing vessel tracks (vessels ≥30 GRT) in the Timor Sea since 2013 (as described in **Section 4.5.5**), indicated the majority of fishing in the region takes place about 50 km west of the Operational Area in Indonesian waters east of Evans Shoal, as well as the Timor Trough. Comparatively, Indonesian fishing vessel activity within the Operational Area is light, with only 5–10 vessels (>30 GRT) occasionally fishing within the waters since 2013.

Commercial fishing vessels may potentially experience operational inconvenience and temporary displacement from fishing grounds within the Operational Area. However, such interactions are expected to be infrequent and short-term, due to the transient nature of the seismic vessel and the small area occupied by the seismic vessel (and SNA) at any one time.

Recreational Fishing, Diving and Tourism Operations

Recreational fishers are not expected to access the waters of the Operational Area, due to the distance from shore. An online search identified one charter company offering seasonal fishing charters to Evans Shoal, Tassie Shoal and Lynedoch Bank. The potential impacts to third party vessels are expected to include short-term displacement of vessels as they make slight course alterations to avoid the project vessels (and associated towed seismic equipment in the SNA) and AUV nodes.

There are alternative locations to Lynedoch Bank that allow for good recreational fishing, including Evans Shoal and Tassie Shoal approximately 40 km from the Operational Area, as well as sites closer to Darwin or elsewhere along the Van Diemen Rise and Arafura Shelf.

Feedback from game fishing operators (**Section 5.5**) indicated only one Darwin-based charter company had a vessel that undertook multi-day charters near the Operational Area. Feedback from that operator was that it was highly unlikely it would be in the area, though there was a possibility due to weather implications. Dive charters were also contacted as part of engagement and will be provided notifications for the commencement of the activity, though highly unlikely to be present in the area.

Based on this information, there is low likelihood of the Galactic 2D Hybrid MSS disrupting recreational fishing and tourism operations. Any interactions that may occur are likely to be short term and temporary disturbances.

Research and Monitoring Programs

The IMOS NMN is a collection of mooring arrays strategically positioned in Australian coastal waters. The NMN measures physical and biological parameters. An IMOS mooring (NWSLYN) is located on Lynedoch Bank (located within the Active Source Area) and is operated by AIMS. It is understood that the instrumentation available on the mooring is retrieved and re-deployed approximately every six months to collect recorded data and maintain/calibrate instrumentation, with a service trip planned for 20-27 May 2022, concurrent with the Galactic Hybrid 2D MSS. A waverider buoy is deployed at Goodrich Bank (located within the Operational Area) to record wave height, period and direction (BoM, 2021).Each record is obtained by sampling the waves for 20 minutes, with records updated hourly.

Research organisations with a potential to conduct dive operations in the area will also be notified of activity commencement date, though highly unlikely to be present in the area.

The potential impacts to third party vessels, including AIMS, are expected to include short-term displacement of vessels as they make slight course alterations to avoid the project vessels (and associated towed seismic equipment in the SNA) and AUV nodes.

Commercial Shipping

The presence of project vessels and submersible equipment may cause temporary disruptions to commercial shipping. Consultation with AMSA confirms that low density traffic may be encountered in the Operational Area. A moderate density shipping route located north of the Operational Area accommodates vessels transiting between Indonesia through to the waters between Cape York Peninsula and Papua New Guinea.

The potential impacts are expected to include short-term displacement of vessels as they make slight course alterations to avoid the project vessels (and associated towed seismic equipment in the SNA) and AUV nodes.

Defence Training Exercises

The Operational Area overlaps with a designated defence practice area known as the North Australian Exercise Area (NAXA). The NAXA is used by the RAAF and RAN for military operations including live weapons and missile findings. The NAXA is the primary location of the KAKADU training exercise that operates biennially. The exercise involves numerous naval ships from various countries. Defence will require the Petroleum Activities Program to be completed and clear of the NAXA and DPA Melville Island by mid-August 2022 to ensure no conflict with Exercise Kakadu.

The Galactic Hybrid 2D MSS has been scheduled to allow it to occur prior to the commencement of the KAKADU training exercise. Therefore, there is no potential for interaction with Defence training exercises.

UXOs

According to the Defence UXO Database, the Operational Area overlaps with a historic Naval Gunnery area (1090 Melville Island), and therefore UXOs may be present on and in the sea floor. The AUV/commercial nodes will not be used within the historic Naval Gunnery area (1090 Melville Island) and no other equipment will contact the seabed, therefore, no impacts are expected.

Oil and Gas Activities

No oil and gas production wells or facilities are located within the Operational Area. Santos Limited (and joint venture partner SK E&S) is proposing to develop the Barossa project, located in NT/RL5, within the north-west portion of the Operational Area. The project includes an FPSO facility, subsea wells and production system and gas export pipeline tying into the existing Bayu-Darwin pipeline. Santos made the final investment decision (FID) on the Barossa Development on 31st March 2021. Potential overlap with activities associated with the Barossa project and the Galactic Hybrid 2D MSS acquisition window were identified during consultation and will be managed by ongoing engagement and controls to manage any concurrent operations.

Cumulative Assessment

Cumulative impacts from seismic surveys may occur as a result of effects experienced from previous seismic surveys, or from seismic surveys that occur concurrently on or in quick succession during the same year. It is recognised that the effects resulting from multiple seismic surveys, when considered collectively, may result in a greater level of impact or risk than the effects arising solely from the Galactic Hybrid 2D MSS.

The only group of marine users that is understood to have the potential to experience cumulative impacts from seismic surveys in this region is commercial fisheries. Therefore, assessment of cumulative impacts only considers commercial fisheries.

Previous Seismic Surveys

Commercial fishery stakeholders in the Timor Reef Fishery, NT Demersal Fishery and the Northern Prawn Fishery raised concerns during consultation regarding the proposed Galactic Hybrid 2D MSS due to claims that previous 3D seismic surveys in the region have impacted fishing activities and catch rates. The 3D marine seismic surveys that have been undertaken within the NT fisheries management unit in the last fifteen years (since 2006) are presented in **Figure 6-4** and summarised in **Table 6-3**. Past surveys have taken place in these fisheries, including the Caldita-Barossa 3D MSS (2016) and the Bethany 3D MSS (2018) which both took place in areas of the Timor Reef Fishery that are subject to relatively high levels of fishing effort. No other seismic surveys have been undertaken in the region since the Bethany 3D MSS in 2018. Fishery catch and effort data provided by the NT DITT is restricted and does not provide catch or effort data for fishery blocks where less than five licence holders fished during the period of interest (i.e. less than five licence holders per year). Therefore, it has not been possible to determine if the occurrence of past seismic surveys has materially impacted the performance of commercial fisheries. While other viable fishing grounds will have been available outside of the seismic survey areas, it is acknowledged that some temporary displacement may have occurred due to interference and disruption to fishing vessels during the periods that surveys took place.

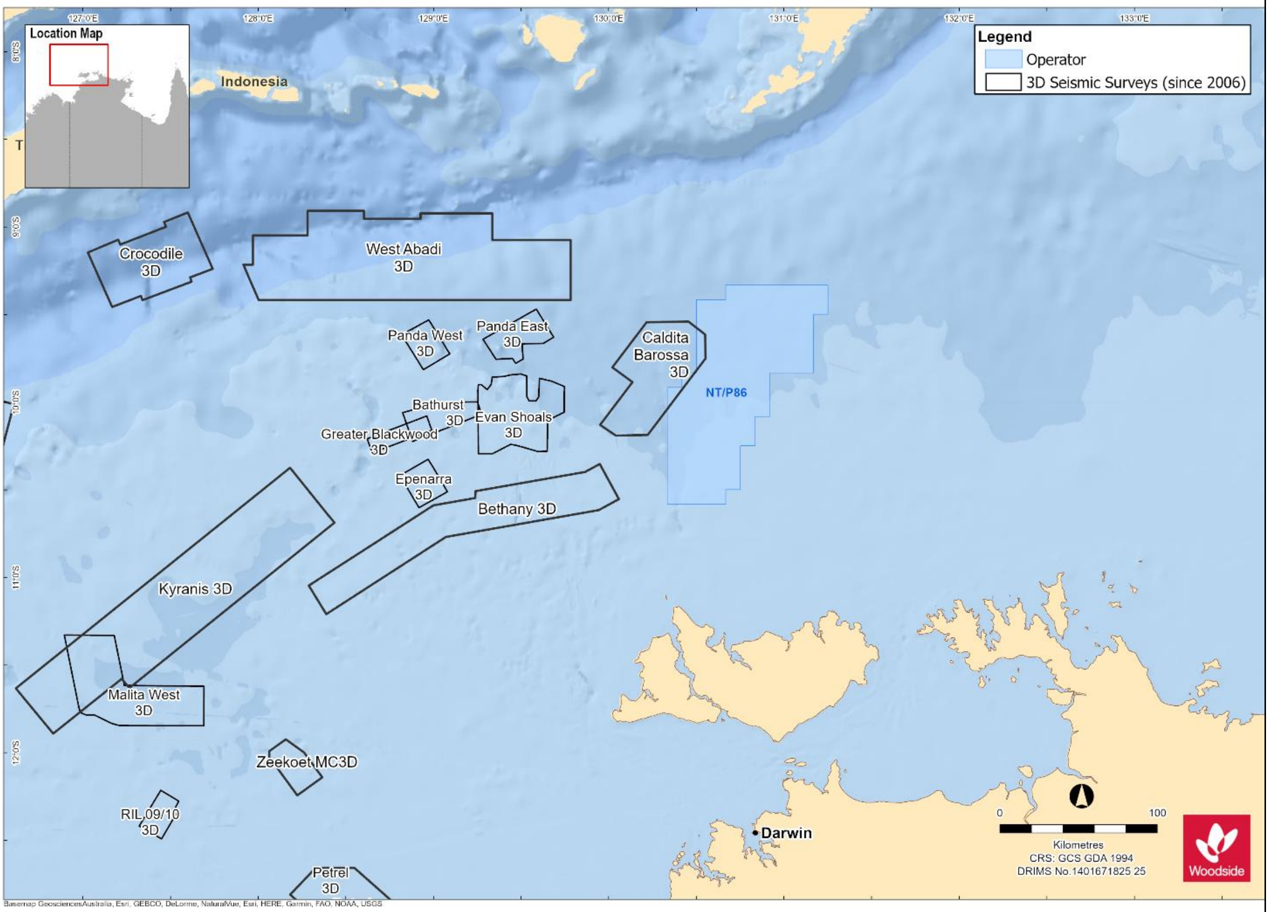


Figure 6-4: 3D seismic surveys undertaken since 2006.

Table 6-3: Previous 3D seismic surveys completed since 2006

Survey Name	Operator	Acquisition Period(s)	Spatial overlap

Evans Shoal 3D MSS	Santos	13/06-2006 – 07/12/2006	No
NT/P68 Epenarra 3D MSS	Methanol	27/09/2006 – 30/10/2006	No
Malita West 3D MSS	Total E and P Australia	03/03/2008 – 17/05/2008	No
Blackwood 3D MSS	Methanol	29/04/2008 – 19/05/2008	No
Bathurst 3D MSS	Eni Australia Limited	03/12/2011 – 05/01/2012	No
Magellan Bonaparte 3D MSS	Magellan Petroleum Pty Ltd	14/12/2012 – 28/12/2012	No
Kyranis MC 3D MSS	Fugro Multi Client Services Pty Ltd	25/07/2012 – 12/01/2013 10/12/2013 – 19/02/2013	No
Zeekoet MC 3D MSS	Fugro Multi Client Services Pty Ltd	25/01/2013 – 09/02/2013	No
Caldita-Barossa 3D MSS	ConocoPhillips	06/08/2016 – 13/10/2016	Yes
Fishburn 3D MSS	Santos	27/06/2017 – 11/07/2017	No
Zénaïde 3D MSS	Polarcus	18/01/2018 – 18/04/2018	No
Bethany 3D MSS	Santos	11/05/2018 – 21/07/2018	Yes
Beehive 3D MSS	Santos	23/07/2018 – 11/08/2018	No
Petrelex 3D MSS	Polarcus	01/12/2019 – 16/01/2020	No

Concurrent Seismic Surveys

Over the scheduled duration of the Galactic Hybrid 2D MSS the only other known seismic survey that may occur in the NT fisheries management unit within a similar timeframe is the Santos Petrel Sub-Basin SW 3D MSS (**Figure 6-5**). This survey is planned to be acquired during 1 December 2021 and 31 March 2022, with contingency to be completed the following year if planned timing is not achievable. Therefore, although the surveys will not occur at the same time, there is potential for them to be completed within two months of each other.

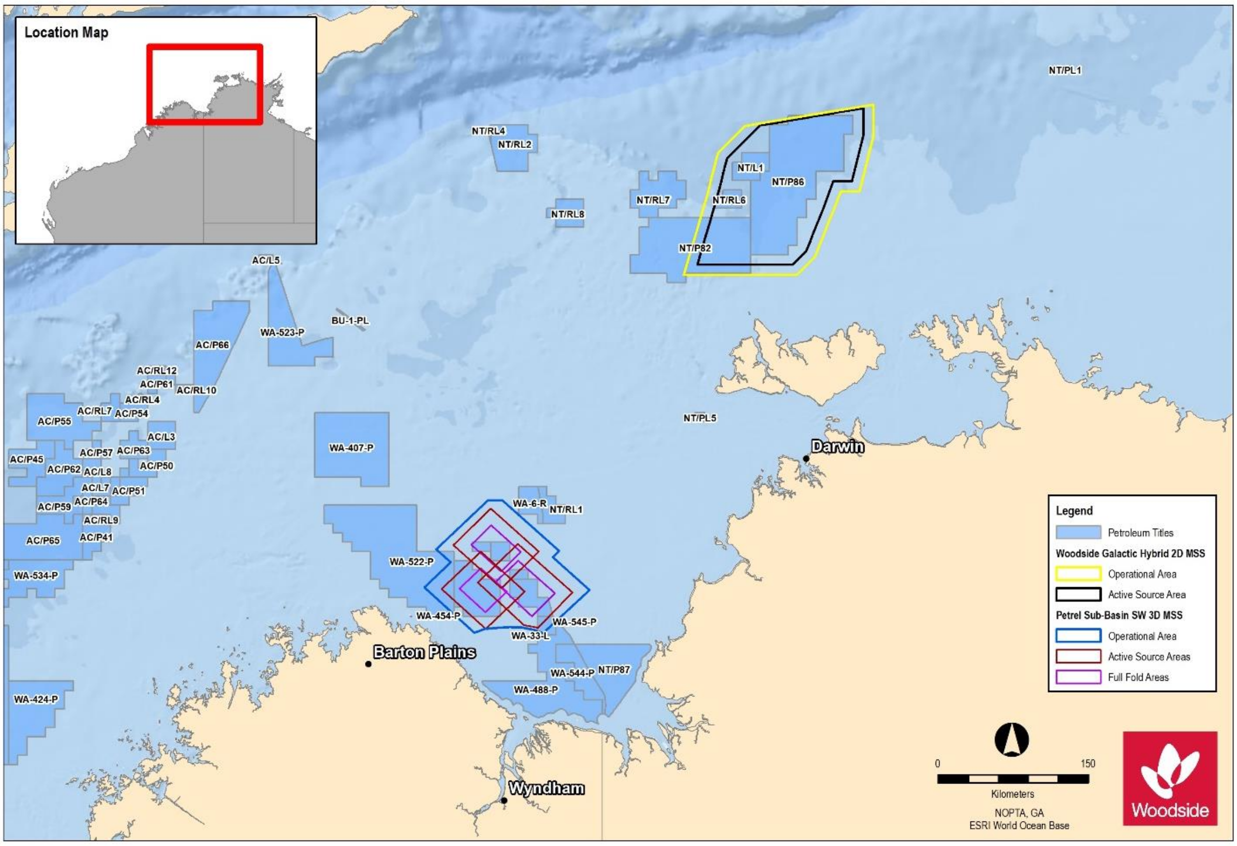


Figure 6-5: Other seismic surveys that have the potential to be acquired during the similar time period as the Galactic 2D Hybrid MSS.
The below assessment does not assess cumulative impacts from seismic surveys in the region that occur after the Galactic Hybrid 2D MSS or that have not yet submitted an Environmental Plan to NOPSEMA. The Santos Petrel Sub-Basin SW 3D MSS is located in the Joseph Bonaparte Gulf to the southwest of the Galactic Hybrid 2D MSS. The survey primarily overlaps waters offshore from WA and has very limited overlap with NT-managed fisheries, with just 1668 km² of the eastern part of its Operational Area extending into waters offshore from the NT. The survey overlaps with blocks that are fished by the NT Demersal Fishery, the NT Spanish Mackerel Fishery and the NT Offshore Net and Line Fishery. Based on the spatial overlap of one week of 3D seismic survey acquisition lines (comparable to the assessment method applied above for the Galactic Hybrid 2D MSS) the maximum spatial overlap that the Petrel Sub-Basin SW 3D MSS will have with these fisheries is 274 km², equivalent to less than 0.1% of the fished area of each fishery (Santos, 2021). The survey also overlaps areas where relatively low levels of fishing effort occur in each fishery. The Petrel Sub-Basin SW 3D MSS overlaps a significant area of the Joseph Bonaparte Gulf within the NPF fishery, however, due to a series of closure periods within the gulf and the timing of the Petrel Sub-Basin SW 3D MSS, there will be no interaction between the survey and NPF fishing activities. Given the low number of vessels accessing the Petrel Sub-Basin SW 3D MSS Operational Area compared with the broader areas over which the fishery operates, the potential for disruption is limited. There is limited potential for these two surveys to affect the same fisheries. As a result, the potential cumulative impacts to fishing activities within these fisheries arising as a result of both the Galactic Hybrid 2D MSS and Petrel Sub-Basin SW 3D MSS occurring in the region is negligible.
Summary of Potential Impacts to Environmental Values(s)
Given the adopted controls, it is considered that the physical presence of the project vessels (including towed seismic equipment) and AUV/commercial nodes will not result in a potential impact greater than slight, short-term temporary displacement of other marine users, such as shipping, commercial fisheries, recreational fishing, tourism operations, research/monitoring projects and other petroleum activities

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[3]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
None identified.				
Good Practice				
Notify AHO of activities and movements no less than four weeks before the scheduled activity commencement date.	F: Yes CS: Minimal cost. Standard practice.	Notification to AHO will enable them to generate navigation warnings (Maritime Safety Information Notifications (MSIN)) and Notices to Mariners (NTM) [including AUSCOAST warnings where relevant)]).	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 1.1**
Notify AMSA Joint Rescue Coordination Centre (JRCC) of activities and movements 24-48 hours before the scheduled activity commencement date.	F: Yes CS: Minimal cost. Standard practice.	Communication of the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of interference with other marine users.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 1.2**

[1] Qualitative measure

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[3]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Notify Defence of activities and movements no less than five weeks before the scheduled activity commencement date.	F: Yes CS: Minimal cost. Standard practice.	Communication of the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of interference with other marine users.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 1.3**
Notify relevant stakeholders identified during consultation four weeks prior to commencement and upon completion of activities.	F: Yes CS: Minimal cost. Standard practice.	Communication of the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of interference with other marine users.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 1.4**
Where potential concurrent operations with diving activities are confirmed, adhere to the following recommended requirements of the revised DMAC 12 guidelines: • Where diving and seismic activity are scheduled to occur within a distance of 45 km, Woodside will notify divers of the planned activity where practicable. • Where diving and seismic activity will occur within a distance of 30 km a joint risk assessment should be conducted, between the clients/operators involved and the seismic and diving contractors in advance of any simultaneous operations.	F: Yes CS: Minimal cost. Standard practice.	Communication of the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of interference with other marine users.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 1.5**
Provide daily lookahead reports to fisheries stakeholders and other key on-the-water stakeholders, where	F: Yes CS: Minimal cost. Standard practice.	Communication of the Petroleum Activities Program to other marine users ensures they are informed and	Benefits outweigh cost/sacrifice.	Yes **C 1.6**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[3]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
requested, notifying of planned acquisition and vessel location in upcoming 72-hour period.		aware, thereby reducing the likelihood of interference with other marine users.		
Develop an operations plan (where required) with stakeholders confirmed as having concurrent activities, including the following aspects: • communications • work programming • hazard management • emergency response.	F: Yes CS: Minimal cost. Standard practice.	Communication of the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of interference with other marine users.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 1.7**
Establish and maintain a publicly available interactive map which provides stakeholders with updated information on activities being conducted as part of the Petroleum Activities Program, including location of seismic vessel.	F: Yes. CS: Minimal cost.	Interactive map provides additional/alternate method for marine users to obtain information on the timing of activities, thereby reducing the likelihood of interference with other marine users.	Benefits outweigh cost/sacrifice.	Yes **C 1.8**
Establish and maintain a 3 nm radius SNA around the seismic vessel and towed array.	F: Yes CS: Minimal cost. Standard practice.	Presence of the SNA will reduce the likelihood of interfering with other marine users.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 2.1**
At least one dedicated chase/support vessel will be employed to assist the seismic vessel.	F: Yes CS: Minimal cost. Standard practice.	Use of a chase or support vessel to assist the seismic vessel will reduce the likelihood of an interaction with a third-party vessel.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 2.2**
Project vessels operate AIS, and tail buoy will be fitted with lights, Global Navigation Satellite System (GNSS) and virtual AIS.	F: Yes CS: Minimal cost. Standard practice.	Use of AIS on project vessels, and lights and virtual AIS and GNSS on tail buoy will reduce the likelihood of an interaction with a third-party vessel.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 2.3**
Woodside will consider evidence based claims from commercial fishing licence holders where: • There is genuine displacement from undertaking normal	F: Yes CS: Minimal to Moderate.	In the unlikely event that commercial fishers are displaced from normal fishing areas due to the operations of the petroleum activity, Woodside will	Benefits outweigh cost/sacrifice.	Yes **C 3.1**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[3]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
fishing activities that results in demonstratable economic loss. • Deployed fishing equipment has been accidentally lost or damaged by any activities under Woodside's control. • There is a loss of catch due to the seismic activity that can be demonstrated		consider claims for compensation to reduce or eliminate financial consequence of displacement.		
Professional Judgement – Eliminate				
The timing of the survey scheduled to not occur during Defence training exercises within the NAXA.	F: Yes CS: Minimal cost.	Eliminates the potential for an interaction with Defence activities.	Benefits outweigh cost/sacrifice.	Yes **C 2.4**
Limit activities to avoid peak shipping and commercial fishing activities.	F: No. Shipping occurs year-round and cannot be avoided. Concurrent operations (CONOPS) with fishing seasons cannot be eliminated as fishing activities occur consistency throughout the year, and exact timings and locations of fishing activities are not known. CS: Not considered – control not feasible.	Not considered – control not feasible.	Not considered – control not feasible.	No
Eliminate use of vessels.	F: No. The use of vessels is required to conduct the Petroleum Activities Program. CS: Not considered – control not feasible.	Not considered – control not feasible.	Not considered – control not feasible.	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[3]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Eliminate use of AUV/commercial nodes.	F: Yes. Woodside will be able to continue to acquire the seismic survey without the use of AUV and commercial nodes, given the seismic vessel will be towing streamer(s) that can listen to/record the seismic signal. However, the use of AUV and commercial nodes has the potential to improve both seismic data quality and efficiently and reduce the frequency and duration of future seismic surveys. CS: No additional costs. Inability to confirm the functionality and performance of the novel technology on a commercial-scale seismic survey.	Eliminates the potential for the AUV and commercial nodes to interfere with third party vessels.	Although the control would eliminate the potential for interaction with third party vessels, it would result in the inability for Woodside to confirm the functionality and performance of the novel technology on a commercial-scale seismic survey. Therefore, delaying Woodside's ability to advance technological advancements in acquiring seismic data.	No
Professional Judgement – Substitute				
None identified.				
Professional Judgement – Engineered Solution				
None identified.				
ALARP Statement On the basis of the environmental impact assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks of the physical presence of the project vessels and AUV/commercial nodes on other marine users, such as shipping, commercial fisheries, recreational fishing, tourism operations, research/monitoring projects and other petroleum activities. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that, given the adopted controls, physical presence of the project vessels (and associated towed seismic equipment in the SNA) and AUV and commercial nodes is unlikely to result in potential impact greater than localised and short-term concern to other marine users, such as shipping, commercial fisheries, recreational fishing, tourism operations, research/monitoring projects and other petroleum activities. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice and meet expectations of AMSA, AHO, Defence, Santos, AIMS, and relevant commercial fishery industry representative bodies and/or licence holders provided during consultation with stakeholders. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of the physical presence of the project vessels (and associated towed seismic equipment in the SNA) and AUV/commercial nodes to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 1	**C 1.1**	**PS 1.1**	**MC 1.1.1**

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
Marine users are aware of the Petroleum Activities Program.	Notify AHO of activities no less than four weeks before the scheduled activity commencement date.	Notification to AHO four weeks prior to scheduled commencement to allow for the generation of navigation warnings (MSIN and NTM [including AUSCOAST warnings where relevant])	Records demonstrate that AHO has been notified prior to commencement of the Petroleum Activities Program.
	C 1.2 Notify AMSA JRCC of activities and movements 24-48 hours before the scheduled activity commencement date.	**PS 1.2** Notification to AMSA JRCC 24-48 hours prior to the scheduled commencement date.	**MC 1.2.1** Records demonstrate that AMSA JRCC has been notified prior to commencement of the Petroleum Activities Program within the required timeframes.
	C 1.3 Notify Defence of activities and movements no less than five weeks before the scheduled activity commencement date.	**PS 1.3** Notification to Defence five weeks prior to the scheduled commencement date.	**MC 1.3.1** Records demonstrate that Defence has been notified prior to commencement of the Petroleum Activities Program within the required timeframes.
	C 1.4 Notify relevant stakeholders identified during consultation four weeks prior to commencement and upon completion of activities.	**PS 1.4** Notification to relevant stakeholders prior to commencement and upon completion of activities, including: • AFMA • NT DITT (Fisheries) • Santos • AIMS • Commercial fisheries representative bodies (CFA, DFLC, NPFI, NTSC, PPA, SIA, TRLC) and all relevant fishery licence holders • Recreational and charter fishing organisations (AFANT, NTGFIA, NT GFA) • dive operators.	**MC 1.4.1** Consultation records demonstrate that relevant stakeholders have been notified prior to commencement and upon completion of activities.
	C 1.5 Where potential concurrent operations with diving activities are identified, adhere to the following recommended requirements of the revised DMAC 12 guidelines: • Where diving and seismic activity are scheduled to occur	**PS 1.5** Relevant DMAC 12 guidelines adhered to where potential concurrent diving activities are identified.	**MC 1.5.1** Records demonstrate that relevant DMAC 12 guidelines followed where potential concurrent diving activities are identified.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	within a distance of 45 km, Woodside will notify divers of the planned activity where practicable. • Where diving and seismic activity will occur within a distance of 30 km a joint risk assessment should be conducted, between the clients/operators involved and the seismic and diving contractors in advance of any simultaneous operations.		
	C 1.6 Provide daily lookahead reports to fisheries stakeholders and other key on-the-water stakeholders, where requested, notifying of planned acquisition and vessel location in upcoming 72-hour period.	**PS 1.6** Daily lookahead reports provided to fisheries stakeholders and other key on-the-water stakeholders, where requested, during the Petroleum Activities Program.	**MC 1.6.1** Records demonstrate that fisheries stakeholders and other key on-the-water stakeholders received daily lookahead reports, where requested, during the Petroleum Activities Program.
	C 1.7 Develop an operations plan (where required) with stakeholders confirmed as having concurrent activities, including the following aspects: • communications • work programming • hazard management • emergency response.	**PS 1.7** An operations plan developed (where required) for concurrent activities confirmed within the Operational Area.	**MC 1.7.1** Records demonstrate an operations plan was developed for confirmed concurrent operations (where required).
	C 1.8 Establish and maintain a publicly available interactive map which provides stakeholders with updated information on activities being conducted as part of the Petroleum Activities Program, including location of seismic vessel.	**PS 1.8** Activity interactive map established and maintained throughout activities.	**MC 1.8.1** Records demonstrate interactive map was provided and available to stakeholders throughout activities.
EPO 2 Prevent adverse interactions between vessels and other marine users during the Petroleum Activities Program	**C 2.1** Establish and maintain a 3 nm radius SNA around the seismic vessel and towed array.	**PS 2.1** SNA established, communicated and maintained around the seismic vessel and towed array during the Petroleum Activities Program.	**MC 2.1.1** Records demonstrate that the SNA has been established and details have been communicated to approaching third-party vessels.
	C 2.2	**PS 2.2**	**MC 2.2.1**

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	At least one dedicated chase/support vessel will be employed to assist the seismic vessel.	At least one vessel employed to assist the seismic vessel mitigate interactions with third-party vessels.	Records demonstrate that a second vessel is employed for the Petroleum Activities Program.
	C 2.3 Project vessels operate AIS, and tail buoy fitted with lights, GNSS and virtual AIS.	**PS 2.3** Project vessels will operate AIS, and tail buoy will be fitted with lights, GNSS and virtual AIS.	**MC 2.3.1** Records demonstrate that project vessels operating AIS, and tail boys are fitted with lights and virtual AIS.
	C 2.4 The timing of the survey scheduled to not occur during Defence training exercises within the NAXA.	**PS 2.4** Survey will occur outside of Defence training exercises within the NAXA.	**MC 2.4.1** Records demonstrate that the survey occurs outside of Defence training exercises within the NAXA.
EPO 3 Undertake seismic acquisition in a manner that minimises impacts to commercial fishers.	**C 3.1** Woodside will consider evidence based claims from commercial fishing licence holders where: • There is genuine displacement from undertaking normal fishing activities that results in demonstrable economic loss. • Deployed fishing equipment has been accidently lost or damaged by any activities under Woodside’s control. • There is a loss of catch due to the seismic activity that can be demonstrated.	**PS 3.1** Evidence based claims from commercial fishing licence holders will be considered for compensation (**Appendix G**).	**MC 3.1.1** Records demonstrate claims received from commercial fishing licence holders are considered for compensation.

6.4.2 Physical Presence: Disturbance to Benthic Habitat from Placement of AUV and Commercial Nodes

Context		
AUV Nodes – **Section 3.6**	Physical Environment – **Section 4.3** Biological Environment – **Section 4.4**	Stakeholder Consultation – **Section 5**

Impact Evaluation Summary

Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcomes
Disturbance to seabed from placement of AUV nodes		X	X		X			A	F	-	-	GP	Broadly Acceptable	EPO 4

Description of Source of Impact

Placement of AUV and Commercial Nodes

The placement of AUV and commercial nodes on the seabed within the Active Source Area may result in temporary seabed disturbance and suspension of sediments, causing a localised increase in turbidity.

The proposed AUV nodes are cylindrical in shape with short wings on the side to stabilise flight and steering, approximately 1000 mm long and 300 mm in diameter (weights approximately 30 kg in air and 10 kg in sea water). The AUV nodes will autonomously position through the water column and settle temporarily on the seabed and listen to/record the seismic signal. As a control the AUV nodes will be fitted with thrusters to be periodically used for propulsion, navigation assistance and to manage low impact landings and assist with take-off as required.

The AUV nodes will be paired with equivalent commercial nodes to ground truth the technology in terms of the verification of seismic data recorded. As an additional control the commercial nodes may most probably be deployed and recovered by a small ROV but may also be tethered by a rope to a buoy. The commercial nodes will weigh approximately 15 kg (6.5 kg in sea water) and measure approximately 346 mm (L), by 218 mm (W) and 138 mm (H).

Approximately 15-20 AUV and commercial nodes may be deployed in the Active Source Area. The nodes will be deployed on the seabed along the 20 km lengths of the three existing intersecting lines during the survey. At the end of the survey, when the streamer is recovered, the seismic vessel will re-acquire approximately 20 km lengths along these three lines for a period of between 24 to 48-hours with the same source configuration and source interval. Each AUV node is planned to have approximately five placements along these lines during this final trial period before retrieval. The AUV nodes will be moved in a staged approach during the Petroleum Activities Program (i.e. the nodes will not be moving all at the same time, except for during deployment and retrieval). The AUV nodes are expected to be deployed for the duration of the Petroleum Activities Program. Recovery devices are included within each AUV node, which will deploy inflatable air bags to raise the node to the surface if the node is unable to surface. An additional control of a ROV will also be used as a failsafe to recover the AUV nodes as required as well as for deployment and recovery of the commercial nodes.

The AUV nodes can be positioned accurately on the seabed. If the AUV node is unable to position due to unsuitable substrate, the AUV node will automatically relocate to more suitable substrate for landing. Positioning of the AUV nodes will also be supported by USBL acoustic positioning updates from the surface vessels.

Impact Assessment

Potential Impacts to Environmental Values

Benthic Habitats
The placement of AUV and commercial nodes on the seafloor is expected to result in localised disturbance to soft sediment habitats, and localised elevated turbidity. Physical modifications to the seabed are not expected to occur. As mentioned above, the AUV nodes are able to be positioned accurately on the seabed. If the AUV node is unable to position due to unsuitable substrate (such as hard rock or coral), the AUV node will automatically relocate to more suitable substrate for landing. An additional control of a ROV will also be used as a failsafe to recover the AUV nodes as required as well as for deployment and recovery of the commercial nodes. The Operational Area is expected to consist primarily of sandy substrate and soft muddy sediments. The seabed is likely to be inhabited by a low abundance and patchy distributions of filter feeders and other epifauna. Lynedoch Bank located within the Active Source Area is characterised by a reef flat occurring in depths of about 14 m – 20 m, bordered by gentle slopes rising from depths of about 70 m – 90 m. Sand and rubble dominates the reef flat with hard corals, sponges and soft corals present (Jacobs, 2016). Similarly, Goodrich Bank located within the Operational Area (outside of the Active Source Area) is characterised by sand, rubble patches and limestone outcrops. The epibenthic communities found on the banks are sparse, with low-medium density filter feeders occasionally found in depths less than 60 m and in association with small scale patches of consolidated substrate. Phototrophic species such as hard corals are rare and only occur at the shallowest areas of the bank in waters less than 30 m (AIMS, 2015). In addition, the Operational Area partially overlaps with the Carbonate bank and terrace system of the Van Diemen Rise KEF and the Shelf break and slope of the Arafura Shelf KEF. These KEFs provide significant benthic habitat and are important areas for a number of commercial fish species. The placement of the AUV and commercial nodes on the seafloor may result in slight and short-term impacts to biota, as a result of physical disturbance and elevated turbidity that may cause the clogging of respiratory and feeding parts of filter-feeding organisms. However, elevated turbidity is expected to be very localised, short-term and temporary, and is therefore not expected to have a significant impact to environmental receptors. These impacts are expected to be highly localised around the footprint of the AUV and commercial nodes. Based on the above assessment, seabed disturbance is unlikely to impact on the ecological values of the Active Source Area and surrounding environment, including the Carbonate bank and terrace system of the Van Diemen Rise KEF and the Shelf break and slope of the Arafura Shelf KEF. The area where the nodes will be deployed does not overlap the Oceanic Shoals AMP,
Summary of Potential Impacts to Environmental Values(s)
Given the adopted controls, seabed disturbance from the Petroleum Activities Program will result in no greater than localised, short-term impacts to benthic habitat and communities with no lasting effect (i.e. Environment Impact F).

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[4]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
None identified.				
Good Practice				
Environmental monitoring of the seabed prior to and following the Petroleum Activities Program to assess any impacts to seabed.	F: Yes CS: Significant. Monitoring of the seabed would have significant additional costs to obtain and analyse data with the spatial resolution to accurately assess changes to the seabed.	The AUV and commercial nodes will only be deployed within a small area along 20 km lengths of the three intersecting survey lines.	Control grossly disproportionate. Monitoring will not reduce the consequence of any impacts to the seabed, and the costs associated with the level of monitoring required to accurately assess any impacts greatly outweighs the benefits gains.	No
Professional Judgement – Eliminate				

[4] Qualitative measure

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[4]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Eliminate use of AUV and commercial nodes.	F: Yes. Woodside will be able to continue to acquire the seismic survey without the use of AUV/commercial nodes, given the seismic vessel will be towing streamer(s) that can listen to/record the seismic signal. However, the use of AUV/commercial nodes has the potential to improve seismic data quality and reduce the duration of future seismic surveys. CS: No additional costs. Inability to confirm the functionality and performance of the novel technology on a commercial-scale seismic survey.	Adoption of this control would result in no seabed disturbance during planned activities.	Although the control would reduce the consequence of any impacts to the seabed, it would result in the inability for Woodside to confirm the functionality and performance of the novel technology on a commercial-scale seismic survey. Therefore, delaying Woodside's ability to advance technological advancements in acquiring seismic data.	No
Professional Judgement – Substitute				
None identified.				
Professional Judgement – Engineered Solution				
AUV/commercial nodes designed with appropriate tracking and monitoring systems including: • AUV nodes will be pre-programmed with the planned movements prior to deployment • sub-surface positioning can be tracked via USBL while AUV is moving • surface live positioning of AUV/commercial nodes is tracked via two GNSS systems • nodes can be monitored from vessel via health check system; if significant issues are identified buoyancy air-bag will be deployed to bring nodes to the surface and tracking systems will allow for retrieval.	F: Yes. CS: Minimal cost. Nodes are designed and built with tracking and monitoring systems.	Implementation of these controls will reduce the likelihood of nodes being lost and unable to be recovered, therefore preventing structures from remaining on the seabed in an otherwise primarily soft sediment environment.	Benefits outweigh the cost/sacrifice.	Yes **C 4.1**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[4]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
ALARP Statement On the basis of the environmental impact assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to management the impacts of seabed disturbance from the placement of AUV/commercial nodes. As no reasonable additional/alternative controls were identified that would further reduce the impacts without grossly disproportionate sacrifice, the impacts are considered ALARP.				
Demonstration of Acceptability				
Acceptability Statement The impact assessment has determined that, given the adopted controls, disturbance to the seabed from placement of AUV/commercial nodes may result in localised and short-term effects to benthic habitat and communities with no lasting effect. The adopted controls are considered consistent with industry good practice and professional judgement. On the basis of the environmental impact assessment outcomes and Woodside's criteria for acceptability outlined in **Section 2.7.2**, this is considered an acceptable level of impact.				

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 4 No disturbance to benthic communities from the placement of AUV/commercial nodes with a consequence level greater than F[5] for the duration of the Petroleum Activities Program.	**C 4.1** AUV/commercial nodes designed with appropriate tracking and monitoring systems, including: • AUV nodes will be pre-programmed with the planned movements prior to deployment • sub-surface positioning can be tracked via USBL while AUV is moving • surface live positioning of AUV/commercial nodes is tracked via two GNSS systems • nodes can be monitored from vessel via health check system; if significant issues are identified buoyancy air-bag will be deployed to bring nodes to the surface and tracking systems will allow for retrieval.	**PS 4.1** Location and status of AUVs can be tracked/monitored from vessels	**MC 4.1.1** Records demonstrate that systems are in place to track/monitor the location and status of AUVs from vessels when deployed
		PS 4.2 AUV/commercial nodes will be designed with buoyancy self-recovery devices that include air-bags deployed to facilitate surfacing where necessary	**MC 4.2.1** Records demonstrate that AUV/commercial are designed with self-recovery buoyancy air-bag devices

[5] Defined as 'No lasting effect (<1 month) or negligible impact. Localised impact not significant to environmental receptors.'

6.4.3 Routine Acoustic Emissions: Seismic Survey Equipment

Context		
Activity Components – **Section 3.6**	Physical Environment – **Section 4.3** Biological Environment – **Section 4.4** Socio-Economic Environment – **Section 4.5**	Stakeholder Consultation – **Section 5**

Impact Evaluation Summary													
Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***					
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcomes
Generation of underwater noise from seismic survey equipment					X	X	X	B	E	-	-	LGS GP	Acceptable	EPO 5, 6, 7, 8, 9, 10, 11

Description of Source of Impact

The Petroleum Activities Program will use a seismic source, consisting of an airgun array with a maximum capacity of 3500 in³, towed at a water depth of 6–8 m. The source will be used to generate acoustic pulses by periodically discharging compressed air into the water column as the vessel transits along planned survey lines within the Active Source Area. The Petroleum Activities Program will involve the acquisition of up to 4475 line km (full fold) of 2D seismic data.

At the end of the survey approximately 1-2 days will be spent performing source only run lines within a small area (source only AUV area) in the southern portion of the Active Source Area (**Section 3.4**). This activity is to gather comparative data between AUV and commercial nodes. The associated acoustic emissions will fall within the scope of the acoustic modelling conducted for the Galactic Hybrid 2D MSS and in the assessment of noise impacts below.

A 3150 in³ representative seismic source was modelled for this survey. The 3150 in³ seismic source is expected to produce far-field source levels up to a maximum of 256.4 dB re 1 μPa m (PK) and per-pulse SEL of 229.6 – 232.6 dB re 1 $\mu Pa^2 m^2 s$ (at 5-2000 Hz) in the vertical plane directly beneath the array. In the horizontal (broadside) pane, the seismic source is expected to produce far-field source levels up to a maximum of 247.6 dB re 1 μPa m (PK) and per-pulse SEL of 224.5 dB re 1 $\mu Pa^2 m^2 s$ (at 5-2000 Hz).

Impact Assessment

Background

Elevated underwater noise can affect marine fauna, including marine mammals (cetaceans), turtles and fishes in three main ways (Richardson et al.,1995; Simmonds et al., 2004):

1. By causing direct physical effects, including injury or hearing impairment. Hearing impairment may be temporary (temporary threshold shift – TTS), or permanent (PTS), with PTS generally considered to represent a form of injury.
2. Through disturbance leading to behavioural changes or displacement from important areas. The occurrence and intensity of disturbance is highly variable and depends on a range of factors relating to the animal and situation.
3. By masking or interfering with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey).

The area over which seismic sound may adversely impact marine species depends upon multiple factors including the extent of sound propagation relative to the location of receptors, and the sensitivity and range of spectral hearing of different species (Slabbekoorn et al., 2010; Popper and Hawkins, 2012).

Without adequate control measures in place, noise emitted from the seismic source used during the Petroleum Activities Program has the potential to impact a range of receptor groups, being:

- plankton
- benthic invertebrates
- fishes and elasmobranchs
- fish spawning
- cetaceans
- turtles
- seabirds and migratory shorebirds
- commercial fisheries
- tourism and recreation
- commercial divers
- marine protected areas.

Sound Metric Terminology

Sound levels and the decibel scale

The decibel (dB) scale is used to measure the amplitude or 'loudness' of a sound wave. For underwater sounds, the dB scale is denoted relative to the reference pressure of 1 micro pascal (µPa) e.g. dB re 1 µPa, whereas the reference pressure level used in air is 20 µPa, which was selected to match human hearing sensitivity. Because of these differences in reference standards, dB sound levels in air are not comparable to underwater sound levels i.e. dB sound levels underwater are much quieter than the same dB sound levels in air (Carroll et al., 2017).

Sound metrics

Marine seismic surveys emit pulses of underwater sound. These sounds are termed 'impulsive' sounds as they are brief and intermittent with rapid rise times and decay back to ambient levels (within a few seconds).

There are four main metrics used to measure and describe underwater sound pressure and energy that are applied to the assessment of these types of sound, all of which use the decibel scale (adapted from ISO/DIS 18405.2:2017):

- **Zero-to-peak sound pressure (PK)**, the greatest magnitude of the sound pressure during a specified time interval (**Figure 6-1**); unit: dB re 1 µPa; PK levels are relevant to the assessment of potential physical injury and impairment impacts to marine fauna and biota resulting from a single seismic pulse.
- **Peak-to-peak sound pressure (PK-PK),** sum of the peak compressional pressure and the peak rarefactional pressure during a specified time interval (approximately double the zero-to-peak pressure) (**Figure 6-1**); unit: dB re 1 µPa; PK-PK levels, like PK levels, are relevant to the assessment of potential physical injury and impairment impacts to marine fauna and biota resulting from a single seismic pulse.
- **Root-mean-square sound pressure level (SPL),** the time-mean-square sound pressure, in a stated frequency band, to the square of the reference sound pressure over the duration of an acoustic event (i.e. the duration of a single seismic pulse) (**Figure 6-1**); unit: dB re 1 µPa; because the SPL represents the effective sound pressure over the full duration of the acoustic event rather than the maximum instantaneous peak pressure, it is regularly used to represent the effective loudness of a sound and to assess the potential for a behavioural response from marine fauna.
- **Sound exposure level (SEL),** a measure related to the sound energy (instead of the sound pressure) in one or more pulses, or the ratio of the time-integrated squared sound pressure to the specified reference value; unit: dB re 1 $\mu Pa^2 \cdot s$; SEL is specified in terms of either a per-pulse SEL or an accumulated SEL (SEL_{cum}) from multiple pulses over a given period. SEL recognises that the effects of sound can be a function of exposure duration as well as maximum instantaneous peak pressure. SEL can therefore be considered a dose-type measurement with SEL_{cum} being used to assess dose-type impacts such as the potential for the gradual onset of temporary threshold shift (TTS) in marine fauna hearing because of prolonged exposure to high sound levels. It is standard practice for SEL_{cum} to be assessed over a summation period of 24-hours (SEL_{24h}).

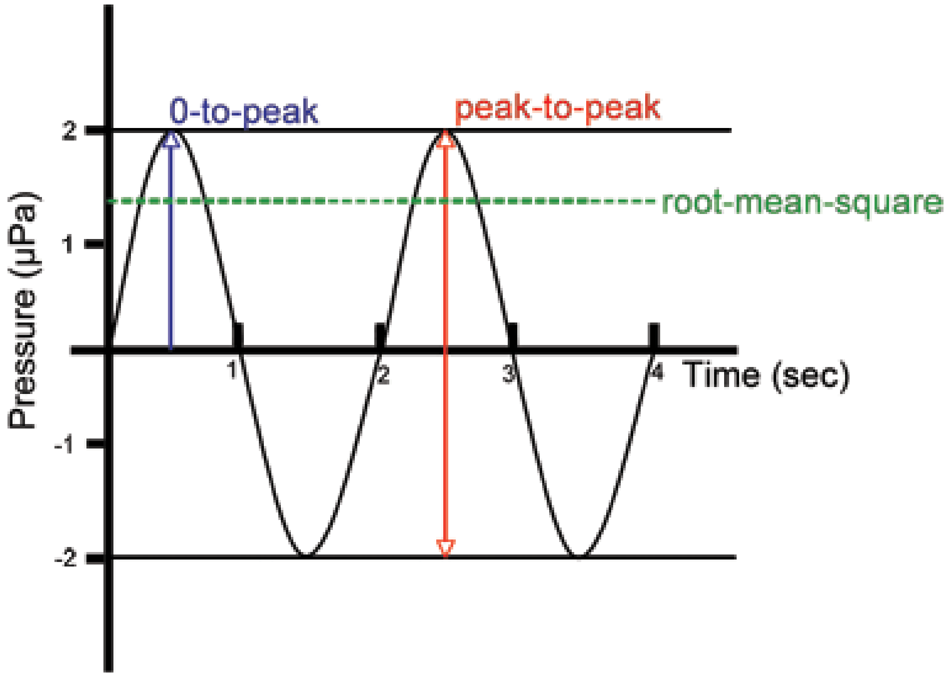


Figure 6-6: Simplified sound wave and sound pressure metrics (University of Rhode Island and Inner Space Center 2017)

Particle motion

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

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

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

Sound frequency and hearing sensitivity

Different animals are sensitive to different sound frequencies, which are measured in Hertz (Hz) and kilohertz (kHz). Therefore, if an animal is sensitive to a particular frequency range, a sound in that frequency range will seem louder to that animal than to a different animal which is less sensitive to those frequencies. For example, some large baleen whales are sensitive to very low frequency sounds (7 Hz to 35 kHz), while other toothed whales and dolphin species are considered more sensitive to mid-high frequency sounds (150 Hz to 160 kHz) with their peak hearing frequency somewhere between these frequency ranges (National Marine Fisheries Service, 2018). Therefore, how loud a sound will be perceived will differ between species.

In some cases, a sound level is specified relative to a given frequency range or is weighted according to the auditory sensitivity of an animal (e.g. low-frequency, medium-frequency and high-frequency groups of cetaceans). This has the advantage of placing the sound into a more biologically relevant context for that animal. If a frequency range or weighting is not specified, the frequency of the sound is generally referred to as "broadband" sound i.e. the sound level accounts for sound across all frequencies, noting again that a particular animal may not be able to detect all of the sound frequencies and associated energy that are emitted.

Therefore, the frequency of a sound and how sensitive different animals are to sound can make a considerable difference to how loud the sound is perceived to be and any resultant impact.

Acoustic Modelling

To assess the potential magnitude and extent of impacts from underwater noise produced during the Petroleum Activities Program, Woodside commissioned JASCO Applied Sciences (JASCO) to model sound propagation at several locations that were representative of the different water depths, bathymetry and seabed properties within the Active Source Area (Welch et al., 2020; **Appendix I**).

The objective of this acoustic modelling study was to evaluate the potential effects of sound on marine fauna including cetaceans, marine reptiles, fishes, elasmobranchs, benthic invertebrates and zooplankton, and on socio-economic receptors such as commercial fisheries and marine protected areas.

Four standalone single impulse sites were modelled for the 2D single array configuration (labelled 1A, 2A, 2B and 2C in **Figure 6-7**) and used to model one scenario for survey operations over 24-hours to assess accumulated SEL (SEL_{24h}). Water depths at these sites are: 1A 53 m; 2A 119 m; 2B 207 m; 2C 304 m. The accumulated SEL scenario assumed that a survey vessel sailed along survey lines at a maximum speed of 5 knots, with a shot point interval of 25 m. The selected locations are considered representative of a range of water depths along the survey lines that will be acquired during the Galactic Hybrid 2D MSS, and the potential sound propagation characteristics that may occur during survey acquisition.

The 2D line scenario consists of two sail lines and it was assumed that adjacent parallel lines will be acquired consecutively. During the actual survey, the 2D sail lines in the orthogonal grid may be acquired in an order where one sail line is followed by a line that lies perpendicular to it; in such instances, the distance between the lines will, for the most part, be greater than the modelled adjacent parallel lines and so the accumulated sound exposures will generally be less. Therefore, the accumulated SEL results for this scenario may be conservative (i.e. over-estimated) in some instances.

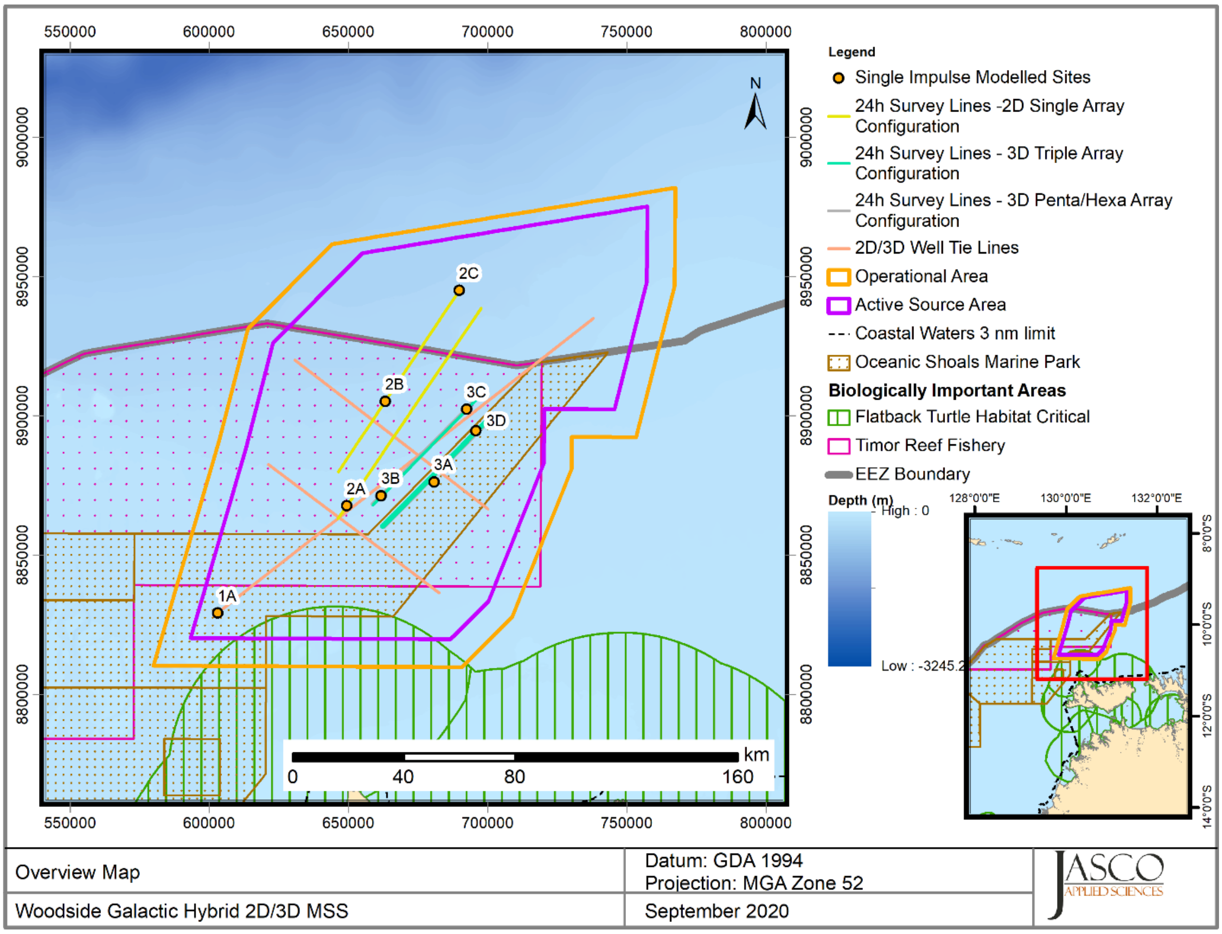


Figure 6-7: Overview of the modelled sites, acquisition lines, and features for the Galactic 2D Hybrid MSS (Welch et al., 2020)

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

- R_{max} - the maximum range to the given sound level over all azimuths
- $R_{95\%}$ - the range to the given sound level after the 5% farthest points were excluded.

The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment. In some environments a sound level contour might have small anomalous isolated fringes in which case the use of R_{max} can misrepresent the area of the region exposed to such effects. In these instances $R_{95\%}$ is considered more representative. In environments that have bathymetric features that affect sound propagation then the $R_{95\%}$ may neglect to account for these and therefore R_{max} might better represent the region of effect in specific directions. For this impact assessment the R_{max} values have been considered. In many of the impact assessments, the maximum R_{max} values resulting from the various modelling sites have been referenced (unless specified) which provides a further level of conservatism to the assessment.

The results of the acoustic modelling are presented in relation to the sound exposure thresholds relevant to each receptor group assessed below. The detailed results are provided in the acoustic modelling report (Welch et al., 2020; **Appendix I**).

Zooplankton

Species sensitivity and sound exposure thresholds

Plankton is a collective term for all marine organisms that are unable to swim against a current. This group is diverse and includes phytoplankton (plants) and zooplankton (animals), as well as fish and invertebrate eggs and larvae. There is no scientific information on the potential for noise-induced effect in phytoplankton and no functional cause-effect relationship has been established. Noise-induced effects on zooplankton, such as copepods, cladocerans, chaetognaths and euphausiids, have been investigated in a number of sound exposure experiments.

Zooplankton includes fish eggs and larvae that are transported by currents and winds and hence cannot take evasive behaviour to avoid seismic sources. With respect to the Galactic 2D Hybrid MSS, key spawning areas for commercially targeted fish species (assessed under "Fish spawning" below) have been identified as areas where zooplankton populations may be more important.

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

Parry et al. (2002) studied the abundance of plankton after exposure to airgun sounds but found no evidence of mortality or changes in catch-rate at a population-level. Other studies have also noted limited negative impacts on zooplankton, fish eggs, larvae or fry, and most have reported that impacts occur within a few metres or tens of metres from the source (Kostyuchenko, 1973; Dalen and Knutsen, 1987; Holliday et al., 1987; Kosheleva, 1992; Pearson et al., 1994; Turnpenny and Nedwell, 1994; Booman et al., 1996; Payne, 2004; Payne et al., 2009). These studies included exposures to sound pressures up to approximately 242 dB re 1 µPa, comparable to those predicted in close range to the Galactic 2D Hybrid MSS seismic source.

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

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

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

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

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

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

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

1. Why was there no attenuation of the impact with distance? There is no consistent decline in the proportion of zooplankton that are dead with increasing distance away from the airgun. The energy of the sound waves at a distance of 1.2 km is substantially lower than at the source.
2. Why was there an immediate decline in abundance? It is unclear why there would be a near immediate drop in zooplankton abundance as measured by net samples and acoustic data. If zooplankton were killed, they would not immediately sink from the surface layers, or be rapidly eaten. A drop in abundance would be more likely once the dead zooplankton either sunk to the bottom or were removed by predation. Richardson et al (2017) conclude it is difficult to explain this immediate decline in zooplankton abundance
3. Was there sufficient replication to be confident in the study findings?

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

Independently of the APPEA/CSIRO study, the International Association of Geophysical Contractors (IAGC) conducted its own review of the McCauley et al. (2017) paper. This review came to the following conclusion: "While we found the study interesting, we are also troubled by the small sample sizes, the large day-to-day variability in both the baseline and experimental data, and the large number of speculative conclusions that appear inconsistent with the data collected over a two-day period. Both statistically and methodologically, this project falls short of what would be needed to provide a convincing case for adverse effects from geophysical survey operations." (IAGC, 2017).

The second component of the CSIRO study was to estimate the spatial and temporal impact of seismic activity on zooplankton on the 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 et al., 2017).

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

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

A more recent study by Fields et al. (2019) exposed zooplankton (copepods) to seismic pulses at various distances up to 25 m from a seismic source. The source levels produced were estimated to be 221 dB re μPa²·s. The study observed an increase in immediate mortality rates of up to 30% of copepods in samples compared to controls at distances of 5 m or less from the airguns. Mortality one week after exposure was significantly higher by 9% relative to controls in the copepods placed 10 m from the airguns. Fields et al. (2019) also reported no sub-lethal effects of seismic exposure to the copepods. The findings of the study are consistent with numerous other field studies, as referenced previously, indicating that the potential effects of seismic pulses to zooplankton are limited to within approximately 10 m from the seismic source. Fields et al. (2019) note that the findings of the McCauley et al. (2017) study are difficult to reconcile with the body of other available research. The findings of the McCauley et al. (2017) study may, therefore, provide an overly conservative estimate of the potential effects of seismic pulses to zooplankton.

Impact Assessment

For this impact assessment the sound exposure thresholds for mortality/potential mortal injury (PMI) to fish eggs and larvae from Popper et al. (2014) were applied and consider both PK and SEL24h metrics (**Table** 6-4). The thresholds were based on limited data and were selected on the basis that Popper et al. (2014) note that they are likely to be conservative. While research generally suggests limited impacts to plankton beyond approximately 10 m distance from seismic sources, the precautionary Popper et al. (2014) thresholds for larval mortality / PMI have been selected to indicate the magnitude and extent of potential impacts from acquisition of the survey.

Table 6-4: Maximum predicted distances (R_{max}) to mortality/PMI thresholds in the water column for fish eggs and larvae, and zooplankton

Sound Exposure Threshold	R_{max} Distance (km)
210 dB re 1 μPa².s (SEL_{24h})	<0.02
207 dB re 1 μPa (PK)	0.18

As shown in **Table 6-4**, the maximum distance (R_{max}) to mortality/PMI thresholds for fish eggs and larvae, and zooplankton, applying the single pulse (PK) threshold from Popper et al. (2014) was 180 m.

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

The magnitude of such localised impacts is negligible and is not expected to be discernible at the regional scale when considering the large natural spatial and temporal variability and scale of plankton and spawning biomass in the NMR. In particular, phytoplankton and zooplankton biomass in the oceans can vary significantly at spatial scales ranging from hundreds of metres to hundreds of kilometres and temporal scales of hours, days, seasons and inter-annually, due to tidal and large scale currents, bathymetry, temperature, salinity, water chemistry parameters and other environmental factors (Gibbons and Hutchings, 1996; Holliday et al., 2011; McKinnon et al., 2008; Pearce et al., 2000; Sutton and Beckley, 2017). Therefore, changes in zooplankton abundance are likely to be replenished and indistinguishable from natural levels and distributions within hours of a seismic survey vessel passing.

Zooplankton – Impact Assessment Conclusion

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

Benthic Invertebrates

Species Sensitivity and Sound Exposure Thresholds

Research is ongoing into the relationship between sound and its effects on benthic invertebrates, including the relevant metrics for both effect and impact. Marine invertebrates lack a gas-filled bladder and are unable to detect the pressure component of sound waves (Parry and Gason, 2006; Carroll et al., 2017) or "hear" sound in the way that mammals and fish are able to. Instead, invertebrates detect sound by sensing the particle motion component of sound in water and seabed sediments through physiological structures such as sensory hairs, statocysts and muscles, and therefore detect sound at close range (McCauley, 1994; Parry and Gason, 2006; André et al., 2016; Roberts et al., 2016; Edmonds et al, 2016; Carroll et al., 2017; Popper and Hawkins, 2018).

Statocysts, found in a wide range of invertebrates, are utilised by animals to maintain their orientation, direct their movements through the water and may play a key role in controlling the behaviour responses of invertebrates to a wide range of stimuli. Although directly sensitive to particle motion and not to sound pressure, most available research on seismic impacts to invertebrates characterises received sound levels in terms of the sound pressure. Therefore, available literature suggests particle motion, rather than sound pressure, is a more important factor for benthic invertebrates such as crustacean and molluscs. Water depth and seismic source size are related to the particle motion levels at the seafloor, with larger arrays and shallower water being related to higher particle motion levels, thus more relevant to effects on crustaceans and bivalves (Welch et al., 2020; **Appendix I)**.

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 tens or a few hundred metres from the sound source or have been from repeated exposure at the same sound levels, which is not typical of an actual seismic survey (Carroll et al., 2017; Edmonds et al., 2016; Salgado Kent et al., 2016; Webster et al., 2018).

Studies by Christian et al. (2003), Department of Fisheries and Oceans Canada [DFO] (2004) and Payne et al. (2007, 2008) have exposed crustaceans to seismic sound levels of approximately 197–237 dB re 1 µPa PK-PK. No acute or chronic lethal or sub-lethal effects were observed in the weeks to months following exposure, with the exception of Payne et al. (2007, 2008) who noted a decrease in serum enzymes and an increase in food consumption in the weeks to months post exposure, which may indicate stress effects or potential osmo-regulatory disturbance.

Research undertaken by Day et al. (2016a, 2016b) in Australian waters, exposed captive southern rock lobster (J*asus edwardsii*) to multiple passes of a seismic source element in 10-12 m water depths. Maximum received sound exposures were 209-212 dB re 1µPa PK-PK, 186 to 190 dB re 1 µPa²·s per-pulse SEL, and SEL_{cum} of 192 to 199 dB re µPa²·s. Exposed lobsters and control lobsters were sampled up to a year post-exposure. The findings of the study are as follows:

- Exposure to seismic sound did not result in any mortalities to adult lobsters.
- Some potential sub-lethal changes in adult lobsters were observed, including some long-term impairment to lobsters' statocysts, which was also linked to a short delay in the lobsters' ability to right themselves when upturned.
- Haemocyte count (indicative of immune response function) also showed some evidence of decline over time.
- The condition or development of eggs carried by female lobsters at the time of exposure, even at close proximity directly beneath the seismic source, were not affected.

The significance of the seismic exposures and whether the sub-lethal effects may have wider ecological implications (e.g. ability to feed, avoid predators and resist disease) warrants further consideration. Day et al. (2016a, 2016b) reported that some of the control lobsters used in the experiments were collected from a marine reserve and were found to have a high level of pre-existing impairment to statocysts similar to that induced by the seismic exposure experiments. This statocyst impairment was considered to be the result of long-term exposure to shipping noise. Some experiments showed no significant differences in righting times between control and exposed lobsters, while in some instances the control lobsters demonstrated slower righting times than exposed lobsters. Lobsters with pre-existing statocyst impairment demonstrated the fastest righting times of all experiments, which Day et al. (2016a, 2016b) suggested may indicate that lobsters are able to adapt or compensate for long-term statocyst impairment. Therefore, the level of statocyst impairment resulting from seismic exposure is not clear. Monitoring of the lobster population at the same reserve where the lobsters with pre-existing statocyst impairment were taken from showed that the rock lobster population within the reserve was thriving and at carrying capacity (Green and Gardner, 2009; Kordjazi et al., 2015). Therefore, the levels of statocyst impairment reported in the Day et al. (2016a, 2016b) study appear to not be impacting on the survival of the lobster population, and any population-level survivability effects from statocyst impairment are not significant and wider ecological implications are likely to be negligible.

More recently Day et al. (2019) found that airgun exposure caused damage to the righting reflect and statocysts in rock lobsters (*Jasus edwardsii*). Following exposure equivalent to a full-scale commercial array (3,100 cui) passing within 100–500 m, lobsters showed impaired righting and significant damage to the sensory hairs of the statocyst. Reflex impairment and statocyst damage persisted up to 365 days post-exposure and did not improved following moulting. For this study, maximum measured received noise levels were 209-213 dB re 1 µPa (PK-PK).

Kosheleva (1992) identified no detectable effects to marine bivalves and gastropods (mussels and periwinkles) after exposure to a single seismic source element of source level 233 dB re 1µPa at a distance of 0.5 m or greater from the source. Conversely, Matishov (1992) reported a single scallop shell splitting in a sample of three scallops, but this was located 2 m beneath a seismic source element and therefore exposed to maximum sources levels (which is not representative of a typical commercial seismic survey).

Day et al. (2021) examined the potential impacts of seismic surveys on the larval stages of southern rock lobster (*Jasus edwardsii*) to determine whether early development and recruitment may be affected. Lobster puerulus (post-larval stage) and juveniles were held in baskets and exposed to multiple passes of a seismic source element in 10-12 m water depths. Maximum received sound exposures were 203-219 dB re 1µPa PK-PK, 181 to 190 dB re 1 µPa²·s per-pulse SEL, and SEL_{cum} of 201 to 205 dB re µPa²·s, comparable to Day et al. (2016a, 2016b) (Day et al., 2021). Lobster puerulus were randomly assigned to control (not exposed to airgun signals) or E0 (exposed to airgun signals at a nominal range of 0 m from the sail line), and juveniles were assigned to control, E0 and E500 (exposed to airgun signals at a nominal range of 500 m from the vessel sail line). The findings of the study are as follows:

- Exposure did not result in any elevated mortality for puerulus or juveniles.
- Righting was significantly impaired for all exposure treatments immediately after exposure, indicating that the range of impact extended to at least 500 m from the source (maximum range tested in the study).
- Puerelus and juvenile E0 treatment lobsters did not show the capacity for recovery, while juvenile E500 lobsters recovered from impairment after the first moult, providing evidence of a range threshold for recovery.
- Intermoult period was significantly increased in E0 juvenile lobsters, and appeared to be increased in puerulus, while juvenile E500 treatment lobsters show a moderate, non-significant increase in moult duration.
- Increased intermoult duration suggested impacted development and potentially slowed growth, and physiological stress.

Recent Australian studies (Przeslawski et al., 2016, 2018; Day et al., 2016b, 2017) have focussed on commercial scallops (*Pecten fumatus*). Przeslawski et al. (2016, 2018) examined the short-term impacts on scallops and other marine invertebrates from a 2,530 cubic inch seismic array and found no evidence of mortality or change in condition following exposure to a seismic survey. Analysis of images and samples revealed some site-specific differences in scallop abundance, size, condition and assemblages, but these were not related to seismic operations. Day et al. (2016b, 2017) exposed scallops to maximum received sound exposures of up to 213 dB re 1µPa PK-PK, 181 to 188 dB re 1 µPa².s per-pulse SEL, and SEL_{cum} of 188 to 198 dB re 1µPa².s. The study also predicted ground acceleration of up to 37.57 m/s². Day et al. (2016b, 2017) concluded that exposures did not result in any immediate mass mortalities, however, repeated exposures resulted in a chronic increase in mortality over timeframes of approximately four months post-exposure, though not beyond naturally occurring rates of mortality. Separate experiments undertaken in 2013 and 2014 yielded mortalities of 3.6-3.8% in control scallops (no seismic exposure), 9.4-11.3% mortality in scallops exposed to a single pass of the seismic source, 11.3-16.1% mortality in scallops exposed to two passes of the seismic source, and 14.8-17.5% mortality in scallops exposed to four passes of the seismic source. The mortality rates were at the low end of the range of naturally occurring mortality rates documented in the wild, which range from 11-51% with a six year mean of 38% (Day et al., 2017). A third experiment in 2015 resulted in 100% mortality to both control scallops and exposed scallops, and accordingly was attributed to other causes and not to seismic exposure (Day et al., 2016b, 2017).

Sub-lethal effects to exposed scallops were also observed by Day et al. (2016b, 2017) indicating a compromised capacity for homeostasis and potential immunodeficiency over acute (hours to days) and chronic (months) timescales post exposure. Exposures did not elicit energetically expensive behaviours (i.e. extensive swimming or long periods of valve closure), but scallops showed significant changes in some behavioural patterns during exposure (e.g. “flinch” response) and an increase in recessing into sediment following exposure (Day et al., 2017).

Published sound exposure criteria do not currently exist for acoustic impacts to invertebrates but the available literature above provides an indication of the sound levels and distances within which some impacts may occur. A range of sound levels, 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, 2016b) studies, were applied in the assessment. The Payne et al. (2008) 202 dB re 1 µPa PK-PK is considered to be associated with no impacts to benthic crustaceans (such as prawns, scampi and lobsters), whereas the 209-212 re 1 µPa PK-PK thresholds could be associated with some level of sub-lethal effects in these animals

(Welch et al., 2020; **Appendix I**). A 213 dB re 1 µPa PK-PK level is considered as representative of levels that may result in sub-lethal effects and chronic mortality in molluscs and some other invertebrates based on Day et al. (2016b, 2017).

A PK sound level of 226 dB re 1 µPa PK was applied for sponges and corals, based on a study where corals received maximum sound pressure levels of 226-232 dB re 1µPa PK-PK, but no mortality, damage to soft tissue or skeletal integrity, visible signs of stress, change in abundance or community structure was detected immediately after, and up to four months following exposure (Heyward et al., 2018b).

Impact Assessment

The benthic habitats and communities present in the Operational Area are likely to be related to the water depth. As described in **Section 4.6.4**, the Operational Area overlaps with the Shelf break and slope of the Arafura Shelf KEF and the Carbonate bank and terrace system of the Van Diemen Rise KEF (which includes Goodrich Bank). Raised geomorphic features in this region support sponges, gorgonians, and other soft corals, while low coverage of reef-forming hard corals has been found on the banks of the Van Diemen Rise (Przeslawski et al., 2011). The benthic community of the Van Diemen Rise was surveyed by Geoscience Australia and AIMS (Anderson et al., 2011). It was found that the shallower banks had the most complex benthic environment with a diverse range of corals, sponges, molluscs, crustaceans, echinoderms and fish.

A benthic habitat model developed by AIMS within the Oceanic Shoals AMP (Radford and Puotinen, 2016) extends within the Operational Area and includes Lynedoch Bank. The majority of the benthic habitat within the habitat map area overlapping the Operational Area is classified as abiotic (no epifauna present). Burrowers and crinoids have the second highest coverage and may include groups such as polychaetes, crabs, starfish, feather stars and brittle stars. Habitats categorised as filterers, gorgonians, halimeda, and hard coral have lower coverage and are limited to more structurally complex areas of the shallow banks.

Lynedoch Bank is characterised by a reef flat occurring in depths of about 14 m – 20 m, bordered by gentle slopes rising from depths of about 70 m – 90 m. Sand and rubble dominates the reef flat with hard corals, sponges and soft corals present. Hard corals are also present (Jacobs, 2016).

Goodrich Bank is characterised by a series of undulating banks with depth ranges between about 15 m and 100 m (AIMS, 2015). Substrate on the banks is variable and includes sand, rubble patches and limestone outcrops. The epibenthic communities found on the bank are sparse, with low-medium density filter feeders occasionally found in depths less than 60 m and in association with small scale patches of consolidated substrate. Sponges are the dominant fauna, with gorgonian soft corals generally making lesser contributions to the mixed filter feeder communities (Heyward et al., 2017). Phototrophic species such as hard corals are rare, due to high water turbidity causing low levels of light penetration, and only occur at the shallowest areas of the banks in waters less than 30 m (AIMS, 2015).

The substrate in the valleys between the banks is primarily comprised of sand and does not support any significant benthic communities (AIMS, 2015). Heywood et al. (2017a) examined seabed biodiversity within mid-shelf areas adjacent to the Goodrich Bank and found that sites were generally turbid with large areas of bare seabed. Patchy sponge-dominated filter feeder communities were associated with limited areas of consolidated substrates.

Sound Pressure

A range of sound exposure levels from 202 dB re 1 µPa PK-PK to 213 dB re 1 µPa PK-PK were applied in the acoustic modelling study for benthic crustaceans. Sound levels of 209-212 re 1 µPa PK-PK thresholds are potentially associated with some level of sub-lethal effects. As shown in **Table 6-5**, at a sound exposure threshold of 209 dB re 1 µPa PK-PK, the maximum predicted R_{max} distance was 263.1 m. The maximum predicted R_{max} distance associated with the 213 dB re 1 µPa PK-PK level for sub-lethal effects and chronic mortality (Day et al. 2016b, 2017) was 162.1 m.

The PK sound level at the seafloor directly underneath the seismic source was estimated at the modelled sites and compared to the sound level of 226 dB re 1 µPa PK for sponges and corals (Heyward et al., 2018), however it was not reached for the modelled seismic source and in water depths as shallow as 53 m (single impulse site 1A). Additionally, the 226 dB re 1 µPa PK reported in Heyward et al. (2018b) is not a threshold above which impacts are expected to occur, but a level at which no short-term or long-term effects were observed. Impacts to corals and sponges are not expected until significantly higher levels are exceeded, which are not predicted to occur during this survey. Therefore, no measurable impacts to corals and sponges are expected.

Table 6-5: Maximum predicted distances (R_{max}) to effect thresholds for benthic crustaceans at the seafloor

Sound Exposure Threshold (PK-PK)	R_{max} Distance (km)	Water Depth (m)
213 dB re 1 µPa	162.1	53
212 dB re 1 µPa	183.5	60
210 dB re 1 µPa	233.7	90
209 dB re 1 µPa	263.1	100
202 dB re 1 µPa	523.7	60

At received noise levels of 209 dB re µPa (PK-PK), the maximum predicted R_{max} distance for sub-lethal impacts to crustaceans is approximately 263 m, and therefore there is the potential for some crustaceans 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, therefore, impacts at a population level due to reduced fitness would be unlikely as there would be sufficient unaffected individuals to maintain the population.

Chronic mortality may also occur in a small number of organisms (e.g. bivalve molluscs) within the weeks and months following exposure to sound levels equal to or greater than 213 dB re 1 µPa PK-PK (Day et al., 2016b, 2017), within a maximum R_{max} of up to approximately 162 m from the seismic source.

The seismic source will not be operated within 250 m horizontal distance of the 80 m depth contour (isobath) of Lynedoch Bank or within 250 m horizontal distance of the 40 m depth contour of Goodrich Bank and other shoals within the south-west part of the Active Source Area (refer to impact assessment to site-attached fish assemblages below). Therefore, potential impacts to benthic invertebrates will be avoided in shallow water areas where benthic invertebrate communities are likely to be more diverse than in deeper waters.

Particle Motion

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, and as such 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, authoritative thresholds to inform the impact assessment are not defined. However, levels can be determined for pressure metrics presented in literature to assist the assessment (Welch et al., 2020; **Appendix I**).

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

For bivalves, literature does not present a sound level associated with no impact, and as particle motion is the more relevant metric, particle acceleration from the seismic source has been modelled for comparison with the results of Day et al. (2016b). The maximum particle acceleration assessed for bivalves, associated with chronic mortality in some individuals, was 37.57 m/s^2 (Welch et al., 2020; **Appendix I**). The maximum particle acceleration and velocity, as a function of horizontal range from the centre of the array in broadside directions (which generate the higher amplitude results) was modelled. The maximum distance to a particle acceleration of 37.57 m/s^2 was 15 m.

Benthic invertebrates – Impact Assessment Conclusion

Based on the above body of research and risk assessment, some benthic invertebrate species may experience sub-lethal effects or a small increase in mortality rates in the weeks or months following seismic exposure within tens or hundreds of metres from the seismic source. Should this occur, the continuous natural cycle of death, recovery and recruitment of invertebrates from adjacent sediments will occur in parallel over these same timescales, and therefore it is questionable whether any impacts from seismic exposure would be detectable from natural fluctuations in relative abundance, benthic community composition and structure. Day et al. (2017) and Payne et al. (2007, 2008) acknowledge that the changes observed in their research are likely within the range of variation that can occur from other common natural and anthropogenic stressors. The ecological implications of such impacts on benthic invertebrate communities are not expected to be significant or long-term. The seismic source will also not be operated within shallow water areas (Lynedoch Bank and Goodrich Bank) where benthic invertebrate communities are likely to be more diverse than in deeper waters.

Therefore, the potential impacts of noise emissions from the seismic source on benthic invertebrates during the acquisition of the survey, including benthic communities within the Shelf break and slope of the Arafura Shelf KEF and the Carbonate bank and terrace system of the Van Diemen Rise KEF, 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 Active Source Area.

Fishes and Elasmobranchs

Species Sensitivity and Sound Exposure Thresholds

Every species of fish studied to date is able to hear. Fish produce sounds in a wide range of context such as feeding, mating or fighting, and as a result anything that inhibits the detection of these sounds can have a negative effect on their fitness and survival (Popper and Hawkins, 2019). The majority of fish species detect sounds from <50 Hz up to 500-1500 Hz (Popper and Hawkins, 2019). A smaller number of species can detect sounds over 3 kHz, while very few species can detect ultrasound over 100 kHz (Ladich and Fay, 2013). The critical issue for understanding whether an anthropogenic sound will affect the hearing of a fish is whether it is within the hearing frequency range of the fish and loud enough to be detectable above background ambient noise.

The hearing sensitivity of fish varies depending upon the auditory structures in the inner ear (otoliths surrounded by an epithelium of hair cells) and, if present, the swim bladder (Finneran and Hastings 2000; Nedwell et al., 2004). Otoliths are sensitive only to particle motion, while the swim bladder may provide an indirect route for sound pressure to reach the inner ear. The other main mechano-reception system in fish is the lateral line system, which runs along the side of the body and is more pronounced in some groups of fish than others. The lateral line system responds to particle motion produced in the near-field of a sound source, as well as to tiny water currents set up by the motions of the fish (Nedwell et al., 2004), therefore all fish are sensitive to the particle motion component of sound at close range from a sound source. Particle motion is the most relevant metric for perceiving underwater sound for most species, but with the exception of a few species (Popper and Fay, 2011; Popper et al., 2014), there is an almost complete lack of relevant data on particle motion sensitivity in fish (Popper and Hawkins, 2018). Some more specialised fish with a swim bladder that they use for hearing are sensitive to sound pressure and are capable of detecting less intense noise and a wider range of frequencies, compared to less-specialised groups of fish (Popper et al., 2014; Carroll et al., 2017; Hawkins and Popper, 2017). The susceptibility of fish to injury from noise exposure varies depending on the species and the presence and possible role of a swim bladder in hearing.

In marine fish, the connection with the swim bladder and ability to detect sound pressure is understood to be present to some varying degree in the families Clupeidae (e.g. herrings, sardines, pilchards and shads), Gadidae (e.g. true cods such as Atlantic cod and whiting), and some nearshore/reef species relevant to tropical Australia, including some species in the families Pomacentridae (e.g. damsel fishes and clown fishes), Holocentridae (soldierfishes and squirrelfishes) and Haemulidae (e.g. grunters and sweetlips) (Nedwell et al., 2004; Braun and Grande, 2008; Popper et al., 2014; Popper and Hawkins, 2018, 2019). However, the vast majority of marine fish species do not have this hearing specialisation.

A great many fish species possess a swim bladder or other gas-filled cavity but do not have a connection with their hearing, for example various demersal snapper, emperor and cod species targeted by the NT Timor Reef Fishery and NT Demersal Fishery. Fish species that lack a gas-filled cavity altogether, include elasmobranchs (e.g. sharks and rays), some flat fishes, some tunas, and mackerels (Casper et al., 2012; Popper et al. 2014).

The sound exposure thresholds applied for fish and elasmobranchs (sharks and rays) in the acoustic modelling study and in this impact assessment are summarised in **Table 6-6** and explained in more detail in the acoustic modelling report (Welch et al., 2020; **Appendix I**). The modelling study assessed the ranges for quantitative threshold criteria based on the Popper et al. (2014) guidelines for three types of immediate effects to fish:

- mortality, including injury leading to death
- recoverable injury, including injuries unlikely to result in mortality, such as hair cell damage and minor haematoma
- TTS.

The modelling study considered single pulse (PK) and multiple pulse (SEL_{24h}) metrics for both the entire water column and seafloor in the following categories reflective of the different hearing mechanisms and sensitivity to sound:

- 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.

For this impact assessment, it is assumed that all fish can detect signals below 500 Hz and so can ‘hear’ the seismic source.

Table 6-6: Thresholds for seismic sound exposure for fish, adopted from Popper et al., (2014)

Type	Mortality and Potential Mortality Injury	Impairment			Behaviour
		Recoverable Injury	TTS	Masking	
I 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
II 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
III Fish: Swim bladder involved in hearing (primarily	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

pressure detection)					

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).

Mortality/Injury

It is noted that while thresholds for fish mortality have been included for consideration in this assessment based on the Popper et al. (2014) guidelines, no studies to date have demonstrated direct mortality of free-swimming adult fish in response to airgun emissions, even when fired at close proximity (within 1– 7 m) (DFO, 2004; Boeger et al., 2006; Popper et al., 2016; Carroll et al., 2017). Although some fish deaths have been reported during cage experiments, these were more likely caused by experimental artefacts of handling fish or confinement stress (Hassel et al., 2004). 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) did not reference an actual occurrence of this effect. At the time of developing the guidelines, no quantified data on injury and mortality from seismic sources on fish had been reviewed by the Working Group. Therefore, the Popper et al. (2014) exposure guidelines for mortality/potential mortal injury and recoverable injury for fish exposed to seismic source emissions are based solely on data from pile driving conducted on predominantly temperate, freshwater fish species. Although seismic surveys and pile driving both produce impulsive sound, their sound characteristics are markedly different; pile driving impulses result in a more rapid rise time in sound pressure than seismic pulses and it is this rapid rise time that has the greatest potential for trauma (Caltrans, 2001, 2004; Hastings and Popper, 2005; Popper et al., 2006).

Environmental Resources Management Australia (ERM) undertook a detailed literature review of potential fish mortality and physical injury as a result of exposure to seismic sources (ERM, 2017). Of the 28 studies reviewed, only three observed direct mortality and in each case, mortalities occurred to caged fish at very close proximity to the seismic source (<2 m), which is not representative of real-life exposures from seismic surveys because fish are free-swimming and are not typically exposed at such close range. The received sound levels that resulted in mortality ranged from 220 to 241 dB re 1 µPa PK, however, other studies reported no mortality or injury at levels as high as 246 dB re 1 µPa PK. Therefore, the sound exposure criteria proposed by Popper et al. (2014) for mortality and injury are considered to be highly conservative and provide a precautionary approach in the assessment of potential injury and mortality effects to fishes from exposure to underwater noise from marine seismic surveys.

Temporary Threshold Shift

Temporary hearing impairment (TTS) can occur due to fatigue and temporary changes to the epithelium (hair cells) of the inner ear and/or damage to auditory nerves innervating the ear, which has the potential to occur in some fishes exposed to intense sound pressures for prolonged periods of time (Smith et al., 2006; Popper et al., 2014; Liberman, 2015). While experiencing TTS, fishes may have a decrease in fitness in terms of communication, detecting predators or prey, and/or assessing their environment. The period over which normal hearing ability returns following the termination of a sound that causes TTS is variable, and dependent on many factors including the intensity and duration of sound exposure (e.g. Popper and Clarke, 1976; Scholik and Yan, 2001; Amoser and Ladich, 200;, Smith et al., 2004a, 2004b, 2006, 2011; Popper et al., 2005, 2007).

The impact threshold of 186 dB re 1 µPa²·s proposed by Popper et al. (2014) in **Table 6-6** is based on exposure of a freshwater fish species with a connection between the swim bladder and inner ear (more specialised hearing than the demersal and pelagic fish species likely to occur in the Galactic 2D Hybrid MSS Operational Area). Fish that showed TTS recovered to normal hearing levels within 18 – 24 hours. Given that reliable auditory frequency weightings have not been defined for the three categories of fish in the way they have for cetaceans, the 186 dB re 1 µPa²·s SEL_{24h} criteria in **Table 6-6** includes a level of conservatism as:

- The types of fish that are likely to occur in the Operational Area do not possess a direct connection between the swim bladder and the inner ear; they are therefore sensitive primarily to particle motion rather than sound pressure and may be less sensitive than the types of fish upon which the 186 dB re 1 µPa²·s threshold is derived.
- Modelled SELs are based on broadband sounds and may therefore account for more sound energy associated with frequencies that are not within the auditory ranges of the fish species likely to occur in the Operational Area.
- The main contribution of sound energy to the onset of TTS will occur over just a few hours when the source is at the closest point of approach; the 24-hour modelled accumulation period accounts for additional sound energy accumulated while the seismic source is at greater distances and potentially not audible to fishes.

It is also noted that many of the available studies on TTS are based on captive fish, whereas free-swimming fishes in the wild are likely to make some effort to avoid the intense sound pressures that contribute the most to the onset of TTS. If TTS does occur, the effects will be temporary and recoverable.

Behavioural Effects

Behavioural effects of noise on fish will vary depending on the 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 and Popper, 2017).

Responses may include avoidance behaviours, startle reactions, increased swimming speed, change in orientation, change in position in the water column, changes to schooling behaviour (e.g. tightening of school structure), and temporary avoidance of an area (Simmonds and MacLennan, 2005; McCauley et al., 2000a; Fewtrell and McCauley, 2012; Popper et al., 2014; Carroll et al., 2017). Changes in movement patterns may also temporarily divert efforts away from feeding, egg production and spawning success (Hawkins and Popper, 2017). The potential extent and duration of behavioural effects based on studies of seismic exposure are summarised below.

A degree of caution should be given when interpreting behavioural studies, given that many are conducted on captive fish which may not provide an accurate representation of responses in free-swimming fish in the wild (Popper et al., 2014; Salgado Kent et al., 2016; Carroll et al., 2017). Behavioural studies are also highly subjective. Extrapolation of observed effects on fish should also be undertaken with caution (Carroll et al., 2017). This is particularly the case given that many exposure experiments report received SPL or SEL, even though the most relevant metric for most fish species is particle motion (Popper and Hawkins, 2018, 2019). Many exposure experiments are undertaken using a single airgun and it is not clear how transferrable the behaviours and received SPL/SEL levels are to a full commercial-sized seismic array, particularly if observed behaviours are in response to particle motion close to the sound source rather than to sound pressure.

Pearson et al. (1992) exposed captive demersal rockfish to multiple 10-minute periods of seismic sound from a seismic source towed at distances of less than 215 m, which is not representative of real-life exposures to a seismic survey. Schools of rockfish were observed to exhibit a 'startle' response (shudders, flexions of the body followed by rapid swimming) at sound levels above 200-205 dB re 1µPa SPL. An 'alarm' response (change in vertical position in the water column to be closer to the seabed, short-term post-exposure behavioural changes) was found to occur above approximately 180 dB re 1µPa SPL, although it was suggested that some individuals may begin to exhibit subtle changes in behaviour and position in the water column at sound levels above 161 dB re 1µPa SPL. Changes in behaviour were found to return to normal before the end of the sound exposure or within just minutes of the sound ceasing, indicating only very short-term, transient effects and potential habituation to the disturbance.

Santulli et al. (1999) exposed caged European sea bass (a demersal species) to a 2,500 cubic inch seismic source. Limited response was observed at 2.5 km distance, a startle response was observed when the array was at a distance of approximately 800 m, but after passing within 180 m, fish behaviour appeared to return to normal within one hour.

The Scott Reef Study associated with the Woodside Maxima 3D survey reported in McCauley et al. (2008) and Miller and Cripps (2013), and summarised in Salgado-Kent et al. (2016), included a component that examined how the behaviour of caged fish exposed to seismic signals changed. The study examined the effects to fish species in the Holocentridae family, which have adaptations linking the swim bladder to the otolith system of the inner ear, as well as to bluestripe snapper, a demersal species without such a hearing adaptation, similar to the demersal species that are most likely to occur within the Galactic Hybrid 2D MSS Operational Area. Fish were exposed to either one or two passes of the active source at three distance categories (45–74 m, 105–131 m, 475–807 m). Alarm responses (including the startle response and behavioural avoidance) occurred within less than 200 m either side of the pass by, but responses were too infrequent to include in analyses. Less significant agitation levels (defined by changing swim direction) in Holocentridae increased with increasing received sound level above 155–165 dB re 1 uPa².s SEL, but agitation levels did not seem to increase with increasing received sound levels for the less sensitive bluestripe snapper (McCauley et al., 2008). Fish began to feed and behave normally again within 20-minutes after the passage of the seismic source (McCauley et al., 2008; Miller and Cripps, 2013).

McCauley et al. (2000a, 2003) reported that trials involving captive fish (of various species, including snappers, emperors, groupers, trevally, bream, herring and others) exposed to seismic sound showed a common 'startle' response (C-turns), 'alarm' responses (e.g. swimming faster, darting movements and sudden changes in school structure), or less obvious changes such as moving closer to the seabed or huddling closer together. Subtle responses such as moving closer to the seabed or changes in schooling behaviour were suggested to commence when sound levels exceeded approximately 147 - 151 dB re 1 µPa².s SEL. Similar behaviours in pink snapper and trevally were noted by Fewtrell and McCauley (2012) in response to comparable sound levels. These are minimal reactions that are likely to be an indication of awareness and perception of the sound rather than a response that could result in significant ecological impacts. More obvious startle and alarm responses were apparent in trials when received sound levels were in the order of 159-172 dB re 1 µPa².s SEL. In situations where a behavioural response was observed, fish were considered to have resumed normal behaviour within 4 – 31 minutes after cessation of the seismic activity (McCauley et al., 2000, 2003). Startle and alarm responses reduced with time, indicating some habituation to the sound. No statistically clear trends in physiological stress response were observed following exposure (McCauley et al., 2000, 2003).

Behavioural observations of two tropical snapper species and another coral reef fish species, spadefish, in field enclosures before, during and after exposure to seismic sound showed that repeated exposure resulted in increasingly less obvious startle responses (Boeger et al., 2006). This is consistent with the potential habituation suggested by McCauley et al. (2000a) and by Fewtrell and McCauley (2012).

McCauley and Salgado Kent (2007) observed the behaviour of goldband snapper in fish traps in the Timor Sea using cameras placed inside the fish traps. A seismic vessel towed two 3,090 cubic inch seismic sources. Maximum signals reached at the closest trap to each seismic pass-by were 200, 202 and 212 dB re 1 µPa PK-PK (equivalent to approximately 194, 196 and 206 dB re 1 µPa PK). No dramatic behavioural responses of fish to the passing seismic source were observed. Fish generally displayed increased activity immediately after entering a trap presumably as they searched for a way out, with this activity reducing with time. Fish that had been in a trap for some time showed increased activity levels as the operating seismic source approached but were 'quiet' when the array passed at the point of closest approach.

Bruce et al. (2018) tagged tiger flathead and two shark species, which were monitored during a seismic survey undertaken in Australian waters. Sharks moved freely in and out of the study area and exposed sharks did not show any indication of differences in behaviour or distribution compared with control areas. Minor behavioural effects were observed in exposed tiger flathead, which increased their swimming speed during the seismic survey and changed daily movement patterns after the survey but showed no significant displacement. Overall, there was little evidence for consistent behavioural responses (Bruce et al., 2018).

Paxton et al. (2017) observed temperate reef fish, including snapper and grouper species, in 33 m water depths located 7.9 km from a seismic survey line using video recordings. The authors observed fish abundance and habitat use during the evening hours for three days prior to a seismic survey and then during the evening of the day when seismic activity occurred. The authors attempted to measure sound at two other reefs in closer proximity to the survey, but the hydrophones malfunctioned. No video recordings were made at the other reefs where hydrophone measurements were attempted. No hydrophone measurements were made at the reef were video recordings took place, but maximum sound levels were estimated to be in excess of 170 dB re 1 μPa SPL. Despite no clear visual evidence of behavioural responses in fish during the seismic survey, the authors noted a 78% decline in abundance in the evening following the survey. No further recordings were made to assess when fish abundance returned to pre-exposure levels or how far they may have moved. Therefore, with limited data, it is not clear from this study if reduced abundance is attributed to the seismic sound or other natural factors such as tidal influence or food availability. However, the study may indicate a possible avoidance response and change in local abundance and distribution.

Meekan et al. (2021) undertook a large-scale experiment that quantified the impacts of exposure of an assemblage of tropical demersal emperors (family Lutjanidae), snappers (family Lethrinidae) and groupers (family Epinephelidae) targeted by commercial fisheries to a commercial-scale seismic source on the North West Shelf off Western Australia. Dominant species included spangled emperor (*Lethrinus punctulatus*), red emperor (*Lutjanus sebae*), and brownstripe snapper (*L. vitta*). A combination of Baited Remote Underwater Video Systems (BRUVS) and acoustic tagging methods were used to measure the behaviours and movements of fishes at high, medium and low exposure sites, as well as at control sites. The high, medium and low exposure sites were located at horizontal distances from the path of the seismic source of approximately 0 – 300 m, 2 – 10 km and 11 km respectively. The maximum modelled SEL values received at the high, medium and low exposure sites were in the order of 180 – 200 dB re 1 μPa^2·s, 130 – 160 dB re 1 μPa^2·s and 115 – 125 dB re 1 μPa^2·s respectively. There were no short-term (days) or long-term (months) effects of exposure on the composition, abundance, size structure, behaviour, or movement of fishes at any exposure sites. The authors suggest that it is a reasonable assumption that the behavioural responses of demersal fishes to the bait cue provided by the BRUVS are a realistic proxy of the likely response of the same species to baited hooks or traps used by the commercial fisheries that target them. The acoustic tags and telemetry found little evidence that fish were displaced by the exposure to the seismic source. Movements of tagged fish occurred over a limited area focused on two or three acoustic receivers, and there was no evidence for the departure of tagged fish after exposure. These multiple lines of evidence suggest that seismic surveys have little impact on the behaviours of demersal fishes in this environment.

Some other studies looking at the behavioural response of sound pressure-sensitive Gadidae and Clupeidae species, such as whiting, Atlantic cod and herring, have reported changes in vertical position in the water column, potential avoidance responses and short-term changes in distribution. Chapman and Hawkins (1969) observed that the depth distribution of free-ranging whiting changed in response to an intermittently discharging stationary seismic source, which resulted in fish being exposed to an estimated SPL of 178 dB re 1 μPa. The fish school responded to the sound by shifting downward, forming a more compact layer at greater depth although temporary habituation was observed after one hour of continual sound exposure (Chapman and Hawkins, 1969).

Hawkins et al. (2014) exposed free-swimming sprat (a sound pressure-sensitive Clupeidae species with a swim bladder connected to the inner ear) and Atlantic mackerel (a particle motion detecting species without a swim bladder) to playback of impulsive sound. Sprat schools were more likely to disperse laterally in response to received sound levels of approximately 135 dB re 1 μPa^2.s SEL. Mackerel schools were more likely to alter their depth in the water column in response to approximately 142 dB re 1 μPa^2.s SEL. Hawkins et al. (2014) note how the two different species seemed to respond to the sound playback at similar sound levels despite the differences in sound sensitivity of the two species, but suggested that mackerel were simply more "flighty" than sprat and therefore more likely to react. The tests were also undertaken using low sound level playback in very close proximity to the schools of fish and it is not clear how relevant the sound pressure and sound exposure levels are in relation to mackerel given that their response was likely driven by particle motion. The study location, a very small, enclosed, quiet, coastal sea lough, where fish were not accustomed to heavy disturbance from shipping and other intense sound sources is also very different from an open ocean location.

Slotte et al. (2004) monitored the effects of a 3,090 cubic inch seismic array on migrating herring (Clupeidae) and whiting (Gadidae), mapping their distribution and abundance in relation to the seismic survey lines. There was no significant evidence of immediate, near-field scaring reactions on the horizontal scale in response to acquiring survey lines, but there was some evidence that fish changed position in the water column, moving closer to the seabed. Some short-term changes in distribution were observed but weren't statistically significant; fish consistently remained within the immediate vicinity of the survey area, but in a limited number of measurements there was an indication that fish abundance was lower near to the survey area and increased with distance out to a maximum range of 37 km. However, results were inconsistent and clear trends were not observed in all cases. Slotte et al. (2004) concluded that it was not possible to determine how much abundance and distribution were attributed to the seismic survey or to the natural migration patterns and food availability of the fish, or other natural factors. Herring and whiting were found to be abundant in the survey area again after a pause in seismic acquisition and monitoring of fishes for three to four days, indicating that if any displacement did occur as a result of seismic sound exposure, the displacement was temporary (i.e. less than 3-4 days) (Slotte et al., 2004).

In similar studies, Engås et al. (1996) and Engås and Løkkeborg (2002) reported on the effects of seismic surveys on Atlantic cod and haddock (Gadidae) and found that the abundance of fish were lower in the survey area compared with areas outside of the survey area, which the authors hypothesize may be the result of an avoidance response. Some differences in abundance were still detectable within the survey area five days after the survey was completed (Engås et al., 1996; Engås and Løkkeborg, 2002).

Conversely, Peña et al. (2013) described the real-time behaviour of herring schools exposed to a full-scale 3D seismic survey, observed using sonar. No changes were observed in swimming speed, swimming direction, or school size that could be attributed to a transmitting seismic vessel as it approached from a distance of 27 km to 2 km, over a six-hour period. The unexpected lack of a response to the seismic survey was interpreted as a combination of a strong motivation for feeding by the fish, a lack of suddenness of the onset of sound, and an increased level of tolerance to seismic pulses.

Davidsen et al. (2019) investigated the effects of seismic sound exposure on the physiology and behaviour of captive Atlantic cod (*Gadus morhua*) and saithe (*Pollachius virens*) using a combination of biologgers and acoustic tags, as well as video monitoring. Experimental sound exposures were 18–60 dB above ambient. Fish were held in a large sea cage and exposed over a 3-day period. The cod exhibited reduced heart rate in response to the particle motion component of the sound from the airgun, indicative of an initial flight response. No behavioural startle response to the airgun was observed; both cod and saithe changed both swimming depth and horizontal position more frequently during sound exposure. The saithe became more dispersed in response to the elevated sound levels. The fish seemed to habituate both physiologically and behaviourally with repeated exposure. The authors concluded that sound exposures induced over the timeframes used in this study appear unlikely to be associated with long-term alterations in physiology or behaviour.

Hubert et al. (2020) exposed captive Atlantic cod to one hour of playback of seismic airgun sound pulses with a 10-second shot point interval. Cod were placed in a net pen positioned 7.8 m from the speaker. The mean peak sound pressure and particle acceleration levels at a distance of 9.7 m from the speaker were 164 dB re 1 μPa and 101 dB re 1 nm/s^2 respectively. At a distance of 16.4 m form the speaker, the mean peak sound pressure and particle acceleration levels were 158 dB re 1 μPa and 99 dB re 1 nm/s^2 respectively. These levels compare with a mean SPL of the ambient conditions in the pen of 113 dB re 1 μPa and a mean sound particle acceleration of 61 dB re 1 nm/s^2. Results indicated no strong overall pattern of change in swimming patterns or immediate, short-term behaviours during the exposure, compared to baseline periods without playback. However, several individuals changed their time spent in several behavioural states during the one-hour sound exposure. Several individuals spent more time transiting and less time being locally active or inactive. This may be indicative of changes in energy expenditure, which may be relevant if sound exposure occurs over the long-term. However, due to experimental design limitations, it was not possible to test the significance of these behavioural state trends (Hubert et al., 2020).

Van der Knaap (2021) investigated the effect of a 3.5-day, full-scale, seismic survey exposure on the movement behaviour of free-swimming Atlantic cod, using acoustic telemetry. The closest point of approach to the tagging location was 2.25 km. The study found that during the experimental survey, cod did not leave the detection area more than expected from baseline data. However, cod left more quickly than expected, from two days to two weeks after the seismic survey. Furthermore, behavioural analyses indicated that during the exposure cod decreased their activity, with time spent being locally active (moving over small distances, showing high body acceleration) becoming shorter, and time spent being inactive (moving over small distances, having low body acceleration) becoming longer. Additionally, diurnal activity cycles were disrupted with lower locally active peaks at dusk and dawn—periods when cod is known to actively feed.

The following conclusions are made regarding behavioural effects to fish from seismic airguns, based on the literature above:

- Different fish may exhibit different behavioural responses when exposed to seismic survey noise, depending on their activities, motivation and the context in which they receive sound.
- Fish may change position in the water column (i.e. move closer to the seabed) as a response to becoming aware of approaching seismic sound (e.g. Pearson et al., 1992;, McCauley et al., 2000, 2003; Slotte et al., 2004; Fewtrell and McCauley, 2012; Miller and Cripps, 2013; Davidsen et al., 2019).
- Exposure to higher sound levels at close range to a seismic source may begin to result in more noticeable startle or alarm responses, such as changes in school structure, increased swimming speed and avoidance of the sound source (e.g. Simmonds and MacLennan, 2005; McCauley et al., 2000, 2003; Fewtrell and McCauley, 2012; Popper et al., 2014; Carroll et al., 2017).
- Many exposure experiments are undertaken using a single airgun and it is not clear how transferrable the behaviours and received SPL/SEL levels are to a full commercial-sized seismic array, particularly if observed behaviours are in response to particle motion close to the sound source rather than to sound pressure.

- There is some evidence that fish may also tolerate gradual increases in sound levels and habituate to repeated sound exposures (Chapman and Hawkins, 1969; McCauley et al., 2000; Boeger et al., 2006; Fewtrell and McCauley, 2012; Peña et al., 2013; Davidsen et al., 2019).
- Many studies indicate that fishes resume normal behaviour shortly after cessation of the acoustic disturbance (within minutes / less than an hour), with no evidence of long-term changes (e.g. Wardle et al., 2001; Pearson et al., 1992; Santulli et al., 1999; McCauley et al., 2000, 2003; Fewtrell and McCauley, 2012; Miller and Cripps, 2013; Davidsen et al., 2019).
- Meekan et al. (2021) found no short-term (days) or longer-term (months) effects of seismic sound exposure on the behaviour and movement of tropical demersal snapper, emperor and grouper species off northern Australia, including some species targeted by the NT Demersal Fishery and Timor Reef Fishery.
- There is some evidence that changes in distribution may persist for longer than the initial change in behaviour, i.e. position in the water column, schooling behaviours and swim speeds may return to normal relatively quickly (within minutes or hours), but their distribution may not return to normal for hours or days. Potential changes in distribution of fish has been observed in some studies for approximately five days following sound exposure, although such changes are limited to studies that focused primarily on migrating sound pressure-sensitive types of fish with a swim bladder-ear connection (e.g. Clupeidae, Gadidae). These studies also acknowledge that it is difficult to attribute these changes in distribution directly to the seismic survey or to natural migration patterns, food availability or other natural factors (Slotte et al., 2004; Engås et al., 1996; Engås and Løkkeborg, 2002). However, it is possible that changes to the behaviour and distribution of some sound-sensitive prey species (e.g. herring, sardines) may have some indirect influence on the distribution of larger predatory fishes during the days following exposure and disturbance.
- Small changes in behaviour or disruption to diurnal activities of pressure-sensitive species of fish (Gadidae) with a swim bladder-ear connection may indicate that activities such as feeding and energy expenditure can be affected if exposed long-term (Davidsen et al. 2019; Hubert et al., 2020; Van der Knaap, 2020, 2021), although these species of fish may also habituate to the sound with repeated exposure (Davidsen et al. 2019).

Given the limited convergence in results from the available studies, the subjective nature of many assessments and the context under which fish received sound, the Popper et al. (2014) ANSI-Accredited Standards Committee Sound Exposure Guidelines for Fishes and Turtles determined that it is not possible to define exact sound level thresholds for changes in fish behaviours. Instead, Popper et al. (2014) applies relative risk criteria (**Table** 6-7). The criteria reflect the potential for substantial changes in behaviour for a large proportion of the animals exposed to a sound, which may alter distribution, and moving from preferred sites for feeding and reproduction. The criteria do not include effects on single animals or small changes in behaviour such as a startle response or minor movements. As such, Popper et al. (2014) indicate that fish without a swim bladder or with no connection between the swim bladder and the inner ear may experience substantial changes in behaviour within tens or hundreds of metres of a seismic source. These peer-reviewed and accredited sound exposure criteria are reflected in Woodside's risk assessment. It is acknowledged that some fishes with swim bladders may show varying levels of awareness of sound pressure at greater distances from the seismic source, but it is important to recognise changes in behaviour that may be of ecological significance from those that aren't.

Impact Assessment

As described in **Section 4.4.3**, the Operational Area and surrounding waters represent habitat for a range of bony fishes (teleosts) and elasmobranchs (sharks and rays), including benthic, demersal, and pelagic assemblages. These fish assemblages include demersal and pelagic species and stocks that are targeted by commercial fisheries in the region (e.g. goldband snapper, saddletail snapper, crimson snapper, red emperor, Spanish mackerel).

The Operational Area partially overlaps with the Shelf break and slope of the Arafura Shelf and Carbonate bank and terrace system of the Van Diemen Rise KEFs. Parts of these KEFs are characterised by areas of hard substrate, and are important for enhancing productivity and biodiversity, and supporting relatively high species diversity in an area otherwise dominated by soft sediment. These areas of hard substrate may represent significant habitat for both demersal and benthic fish assemblages, including "site-attached" fish assemblages. For the purpose of this risk assessment, site-attached fishes are defined as fish that rely on the benthic habitat and demonstrate a very high degree of site fidelity to the extent that they are unlikely or unable to flee an approaching seismic source and are instead likely to remain/seek refuge within habitat structures.

The EPBC Protected Matters Search (**Section 4.4.4**) identified five shark species (including the whale shark), four sawfish species and two ray species that may potentially occur within the Operational Area. The grey nurse shark has also been reported in nearby waters and therefore may occur within the Operational Area.

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

Table 6-7 presents the results of the acoustic modelling study for maximum predicted distances to mortality/PMI, recoverable injury and TTS onset in fish and fish eggs and larvae. Data is presented for both the entire water column (MOD) and at the seafloor.

Table 6-7: Summary of maximum distances to mortality/PMI, recoverable injury and TTS onset in fish, fish eggs and larvae for single pulse and SEL24h modelled scenarios

Marine Fauna Group	Potential Impact	Sound Exposure Threshold	R_{max} Distance (km)	
			MOD	Seafloor
I Fish: No swim bladder	Mortality/PMI	219 dB re 1 µPa^2·s (SEL_{24h})	<0.02	-
		213 dB re 1 µPa (PK)	0.06	0.10
	Recoverable injury	216 dB re 1 µPa^2·s (SEL_{24h})	<0.02	-
		213 dB re 1 µPa (PK)	0.06	0.10
	TTS	186 dB re 1 µPa^2·s (SEL_{24h})	0.90	0.85
II Fish: Swim bladder not involved in hearing	Mortality/PMI	210 dB re 1 µPa^2·s (SEL_{24h})	<0.02	-
		207 dB re 1 µPa (PK)	0.18	0.21
	Recoverable injury	203 dB re 1 µPa^2·s (SEL_{24h})	0.03	-
		207 dB re 1 µPa (PK)	0.18	0.21
	TTS	186 dB re 1 µPa^2·s (SEL_{24h})	0.90	0.85
III Fish: Swim bladder involved in hearing	Mortality/PMI	207 dB re 1 µPa^2·s (SEL_{24h})	<0.02	-
		207 dB re 1 µPa (PK)	0.18	0.21
	Recoverable injury	203 dB re 1 µPa^2·s (SEL_{24h})	0.03	-
		207 dB re 1 µPa (PK)	0.18	0.21
	TTS	186 dB re 1 µPa^2·s (SEL_{24h})	0.90	0.85

A dash indicates that the sound level was not reached.

The following fish types have been identified for this assessment:

- site-attached fish assemblages
- demersal fish species, including key commercial indicator species such as tropical snapper (Lutjanidae)
- pelagic fish species, including key commercial indicator species such as Spanish mackerel
- shark species, including EPBC Act-listed whale sharks.

Site-attached fish assemblages

Within the Active Source Area, key bathymetric features that are expected to provide habitats (hard substrate with epibenthos communities) with the potential to support site-attached fish assemblages are Lyndoch Bank, Goodrich Bank and other shoals within the south-west part of the Active Source Area.

Lynedoch Bank is located on the margin of the Shelf break and slope of the Arafura Shelf KEF. Lynedoch Bank is characterised by a reef flat occurring at depths of 14-26 m, bordered by a reef crest at approximately 40 m depth and gentle slopes rising from depths of around 70-90 m (Jacobs, 2016). The reef flat is predominantly sand and rubble with hard corals (mostly branching, encrusting and massive forms), sponges, soft corals and *Halimeda* spp. present (Jacobs, 2016). Small reef fish are common on the reef flat including representatives of the families Chaetodontidae, Labridae and Zanclidae, as well as reef sharks (Jacobs, 2016). On the western side of Lynedoch Bank, the bank slopes gently downwards from the reef crest at 40 m depth, flattening out at approximately 70 m depth. The slope is dominated by sand and rubble, with occasional sponges, sea stars, sea cucumbers, and reef fish (Pomacanthidae). Beyond water depths of 70 m, the slope is dominated by sand (Jacobs, 2016). On the eastern side of Lynedoch Bank, the bank slopes gently to a depth of approximately 85 m and is predominantly sand and rubble, with a low abundance of fish, sharks and other motile biota (Jacobs, 2016). The northern and southern slopes of Lynedoch Bank weren't surveyed, but bathymetry data indicates that the slope flattens out at approximately 80-90 m and sand is expected to be the dominant habitat type. Therefore, site-attached fishes at Lynedoch Bank are likely to occur primarily in water depths less than 40 m, in association with the reef crest and flat, but may occur in lower abundance to depths of approximately 80 m

There is no indication for any of the other banks and seamounts surveyed by Jacobs (2016) have significant hard/soft corals, *Halimeda* spp., or sponge communities in water depths greater than 50-60 m. Based on the separate AIMS (2015) study, on Goodrich Bank, epibenthic communities are sparse, with low-medium density filter feeders occasionally found in depths less than 60 m and in association with small scale patches of consolidated substrate. Phototropic species such as hard corals are rare in water depths shallower than 30 m, due to high turbidity (AIMS, 2015). Therefore, site-attached fishes at Goodrich Bank (and other shoals within the south-west part of the Active Source Area) are likely to occur primarily in depths shallower than 30 m, but may occur in lower abundance to slightly greater depths.

As shown in **Table 6-7**, the maximum predicted R_{max} distances to exceedance of mortality/PMI and recoverable injury thresholds of 213 dB re 1 µPa (PK) and 207 dB re 1 µPa (PK) at the seafloor for all hearing groups of fish range from approximately 59-210 m from a single impulse. Further detailed modelling of PK levels received at the seafloor was undertaken by Welch et al. (2020; **Appendix I**), including sites in water depths ranging between approximately 53 m and 110 m, representative of water depths where the seismic source may be operated in proximity to banks and shoals. The predicted SEL24 R_{max} distances to exceedance of mortality/PMI and recoverable injury thresholds for all hearing groups of fish ranges from <20 m to 30 m and, therefore, do not exceed the distances associated with single impulse PK thresholds.

Noting that there is the potential for mortality or injury to occur in site-attached fishes up to a maximum range of approximately 210 m from the seismic source, Woodside has proposed seismic source exclusion zones around the bank and shoal habitats. The seismic source will not be operated within 250 m horizontal distance of the 80 m contour of Lynedoch Bank or within 250 m horizontal distance of the 40 m contour of Goodrich Bank and other shoals within the south-west part of the Active Source Area (**Figure 6-8**). This has been based on data from the Northern Australian High Resolution Bathymetry Model (Geoscience Australia, 2021).The 250 m exclusion distance provides some additional conservatism against the reported R_{max}, noting that the Popper et al. (2014) thresholds for mortality and injury are already considered to be highly conservative, as described above.

The maximum predicted distance to the TTS threshold of 186 dB re 1 µPa (SEL_{24h}) at the seafloor was within 850 m. The potential for TTS to occur differs depending on the species of fish. The Popper et al. (2014) threshold is based on exposure experiments to different types of fish including sensitive fishes with a swim bladder mechanism involved in hearing. Most marine fish species do not have this hearing mechanism and are less sensitive to sound pressure and therefore may not experience TTS until sound exposure levels are much higher.

Fish exposed to seismic noise during the Woodside Maxima 3D survey at Scott Reef were examined for evidence of TTS. This included four species of tropical reef fishes, including the pinecone soldierfish (a sound pressure-sensitive species which has a swim bladder connection with the inner ear). None of the four species experienced any TTS following close-range exposure to 190 dB re 1 $\mu Pa^2 \cdot s$ SELcum (Hastings, 2008; Hastings and Miksis-Olds, 2012). No significant decreases were detected in the diversity and abundance of either sound pressure-sensitive or non-pressure sensitive fish species after the seismic survey compared to the long-term temporal trend before the survey (Woodside, 2011; Miller and Cripps, 2013).

Popper (2018) in his expert peer review of TTS effects in demersal fishes for the Santos Bethany 3D MSS, located to the west of the Galactic 2D Hybrid MSS Operational Area, noted:

- It is highly unlikely that there would be physical damage to fish as a result of the survey unless the animals are very close to the source (perhaps within a few metres).
- Most fish in the Bethany region (adjacent to the Galactic 2D Hybrid MSS Operational Area) are species that do not have hearing specialisations, and 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 fish 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 fish 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.

Therefore, while TTS effects in site-attached fish may occur, the potential for impacts to individuals' fitness and survival is limited and impacts to fish community structures are not expected.

Based on the qualitative approach applied in Popper et al. (2014), the likelihood of behavioural effects occurring is assessed as high within tens or hundreds of metres of the seismic source. There is a moderate likelihood of behavioural effects occurring in more sensitive fishes with a swim bladder hearing connection at distances in the order of kilometres from the seismic source. Site-attached fish communities may therefore exhibit some behavioural response for short periods while the seismic source passes a particular bank or shoal. Behaviours are likely to return to normal within minutes or hours of the seismic source passing.

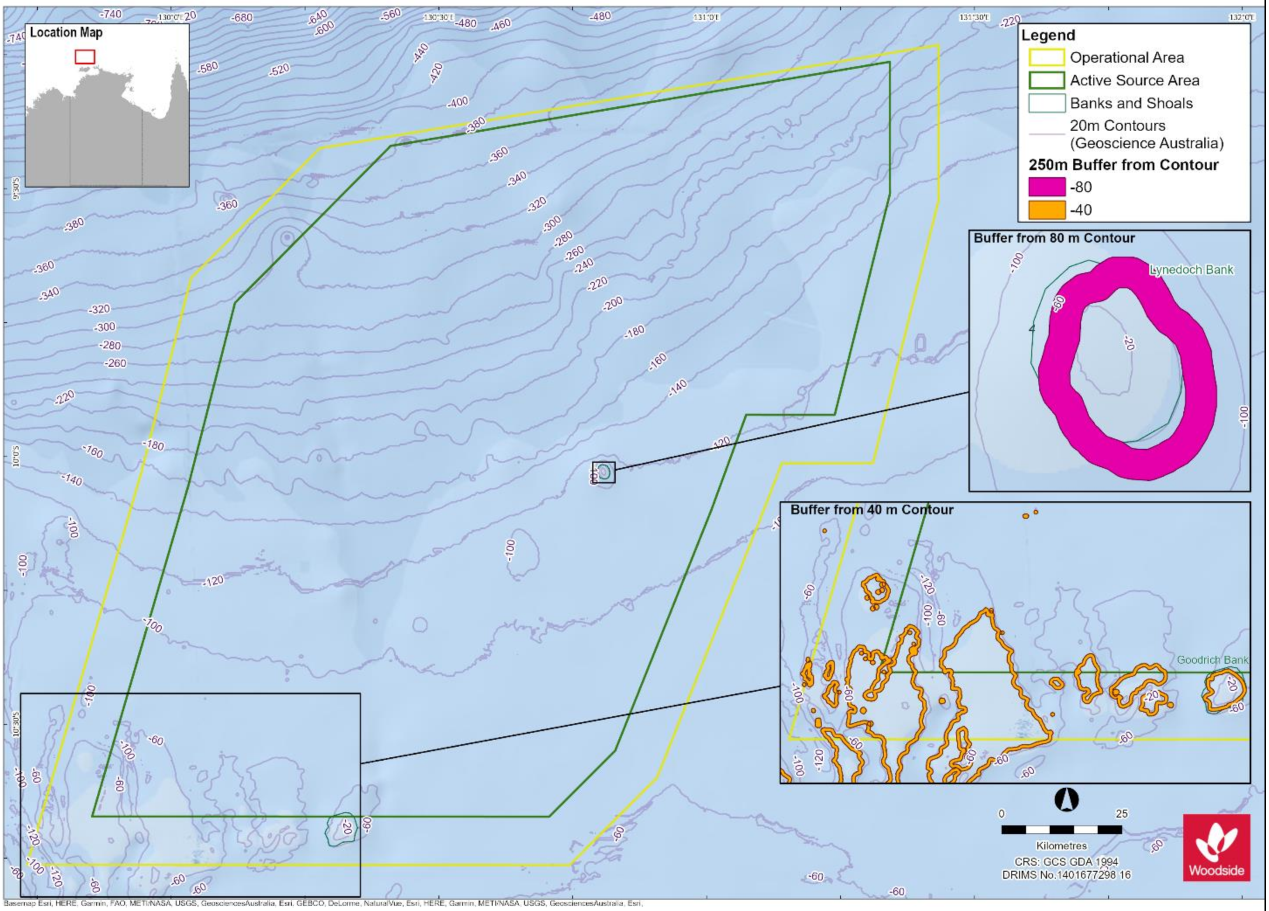


Figure 6-8: Proposed seismic source exclusion zones

Demersal fish species

The various species of demersal fish, e.g. snapper (Lutjanidae), emperor (Lethrinidae) and rock cod (Serranidae) that are characteristic of the Operational Area and are targeted by the NT Timor Reef Fishery and NT Demersal Fishery do not possess a mechanical connection between the swim bladder and the ears, and can be said to have mid to poor hearing ability (Tavolga and Wodinsky, 1963; Higgs et al., 2006; Braun and Grande, 2008; United States Department of the Navy, 2008; Popper and Hawkins, 2012; Caiger et al., 2012). Therefore, these species of fish are considered to belong to the group of fish that are primarily sensitive to particle motion with some limited sensitivity to sound pressure (Group II fishes according to the Popper et al., 2014 classification in **Table 6-6**).

As shown in **Table 6-7**, for all fish with a swim bladder both involved and not involved in hearing (Group II and III fish, which would represent most demersal fish) mortality/PMI and recoverable injury thresholds at the seafloor were reached within 210m based on the application of the PK threshold. The maximum predicted R_{max} distance to mortality/PMI and recoverable injury thresholds for fish with a swim bladder, and fish eggs and larvae within the entire water column was approximately 100 m. Therefore, injury effects could occur to demersal fish at or close to the seafloor within or adjacent to the Active Source Area. However, as discussed above, the thresholds for mortality and injury are considered highly conservative. While injury or mortality to fish in the immediate proximity of the seismic source is theoretically possible, free-swimming fish such as the demersal species that are characteristic of the Operational Area are expected to be able to avoid the seismic source as it approaches their position or ramps up during soft starts. For example, the demersal fish assemblages that are typical of the habitats in the Operational Area (predominantly snappers, emperors and cods), despite exhibiting particular habitat preferences and some fidelity to an area, can be found across a variety of habitats and are typically mobile with home ranges in the order of kilometres or tens of kilometres (Ovenden et al., 2004; Moran et al., 2004; Newman et al., 2008; Parsons et al., 2011; Harasti et al., 2015). Mortality/PMI or recoverable injury impacts to demersal fish are therefore highly unlikely to occur.

Based on the maximum predicted R_{max} distances to TTS (900 m in the water column and 850 m at the seafloor (SEL_{24h} threshold), refer to **Table 6-7**), individuals in demersal fish communities within the Active Source Area could experience TTS effects. The radii that corresponds to SEL_{24h} typically represent an unlikely worst-case scenario for SEL-based exposure since, more realistically, fish would not stay in the same location or at the same range for a period of 24-hours. Therefore, this method is highly conservative and a reported radius of SEL_{24h} criteria does not necessarily mean that animals travelling within this radius of the source will suffer hearing impairment. It is possible that some demersal fishes may not avoid the approaching seismic source completely and some level of TTS is possible, but the effects are temporary and recoverable, and the potential for such effects to have significant implications on fish fitness and survival is low.

The majority of studies relevant to behavioural responses in demersal fish species (e.g. Pearson et al., 1992; Santulli et al., 1999; McCauley et al., 2000a, 2003; McCauley and Salgado Kent, 2007; Woodside, 2011; Fewtrell and McCauley, 2012; Miller and Cripps, 2013; Bruce et al., 2018), indicate that exposure to a mobile seismic source and significant changes in behaviour are likely to be limited to durations of minutes or hours and occur within hundreds of metres of the seismic source as it passes.

Popper et al. (2014) suggest that the potential for significant behavioural impacts in the Group II category of fishes is high in the near-field (tens of metres), moderate at intermediate distances (hundreds of metres) and low in the far field (thousands of metres). Therefore, the awareness of fish to the seismic sound and any resultant behavioural responses may be limited to a few hours as the seismic source approaches from several kilometres away and passes, while significant startle or avoidance responses are more likely to be limited to a shorter period (less than an hour) when the seismic source passes close by. Consistent with the studies reviewed earlier in this section, behaviours may return to normal within less than an hour (sometimes just minutes) of the survey vessel passing.

Further, the implications for demersal fishes at a population level are expected to be limited. McCauley (1994) suggests that behavioural changes in fish may only be localised and temporary, without significant repercussions at a population level. Hawkins & Popper (2016) highlight that some responses to man-made sound may have minimal or no consequences for fish populations. For example, short-term startle responses to sounds that rapidly diminish with repeated presentation, or that do not change the overall behaviour of fish are unlikely to affect key life functions. In addition, anthropogenic sound events that are transient in nature, such as a seismic survey, and result in short-term impacts do not necessarily translate into long-term consequences to populations (Hawkins and Popper, 2016). Meekan et al. (2021) found no short-term (days) or longer-term (months) effects of seismic sound exposure on the behaviour and movement of tropical demersal snapper, emperor and grouper species off northern Australia, including groups of fishes exposed within tens of metres of the passing seismic source.

Demersal fish communities within the Operational Area may, therefore, exhibit some temporary behavioural responses to noise emissions from the seismic source; however, this is not likely to have any impact at the ecosystem level.

Pelagic fish species

Pelagic fish species likely to be present in the NMR and possibly the Operational Area include tuna and mackerel (Scrombridae), barracuda (Sphyraenidae), marlin (Istiophoridae) and trevally (Carangidae). Some species (e.g. mackerel) do not possess a swim bladder (Group I fish), while other species do (Group II and III fish). These species may be targeted in the region by the commercial mackerel fishery and also by recreational fishers/charter boats.

As shown in **Table 6-7**, the maximum predicted R_{max} distances to mortality/PMI and recoverable injury for fish with no swim bladder (Group I fish) within the entire water column was within 60 m. For all fish with a swim bladder (Group II and III fish) the maximum predicted Rmax distance to mortality/PMI within the entire water column was within 180 m. The maximum distance to the TTS threshold in the water column for all fish hearing groups (Group I, II, III) was within 900 m.

Large, pelagic, fast-swimming fish species such as mackerel, tuna and marlin 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 900 m of the operating seismic source for several hours 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. Behaviour may return to normal within minutes. However, it is acknowledged that the behaviours and distributions of the pelagic species could be affected for hours or days following exposure as a result of potential disturbance to more sound-sensitive prey species, such as herrings, sardine's, sprat and shads.

Sharks (including whale sharks and sawfishes)

Whale sharks were identified in the EPBC PMST search as potentially occurring within the Operational Area, however there are no BIAs or Habitat Critical to the survival of the species in the vicinity of the Operational Area. Furthermore, whale shark foraging is recognised to occur during September to November (refer **Section 4.4.4.5.3**), outside of the acquisition period for this seismic survey (May to August).

Four species of sawfish were identified in the PMST search as potentially occurring within the Operational Area, including the narrow sawfish. Narrow sawfish are primarily associated with inshore and estuarine waters, although they can extend to offshore waters up to 100 m depth (refer to **Section 4.4.4.5.3**). The presence of narrow sawfish in the offshore waters of the Operational Area is likely to be limited to occasional transient adults, with juveniles and pupping females remaining in nearshore habitats (Peverell, 2005).

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

As shown in **Table 6-7**, the maximum predicted R_{max} distances to mortality/PMI/recoverable injury for fish with no swim bladder (incl. sharks) within the entire water column was within 60 m. TTS thresholds across the water column for fish without a swim bladder could be reached within 900 m. It is important to appreciate that individual whale sharks would have to remain within a range of 900 m of the operating seismic source (which is also moving) for several hours to be exposed to sound levels that could cause TTS.

It is expected that the potential effects to whale sharks associated with acoustic noise will be the same as for other pelagic fish species, resulting in minor and temporary behavioural change such as avoidance. This aligns with the Popper et al. (2014) guidelines, which detail that there is the potential for high risk of behavioural impacts in fish species near the seismic source (tens of metres), moderate risk within hundreds of metres, and low risk at thousands of metres from the seismic source.

Sawfishes are recognised as primarily bottom dwellers, therefore, they are expected to be present at the seafloor. As shown in Table 6-7, the maximum predicted R_{max} distances to mortality/PMI/recoverable injury for fish with no swim bladder at the seafloor was within 100 m, and SEL_{24h} TTS thresholds could be reached within 850 m. Impacts to sawfishes as a result of the seismic survey are likely to be limited to localised and temporary behavioural disturbance. No impacts to key life stages or nursery habitats are expected, and there will limited impact to their food sources as outlined in the assessment of impacts to benthic invertebrates above. Seismic noise has not been identified as a threat to sawfishes, whale sharks (or other shark species identified that may be present in the region) in the Sawfish and river shark Multispecies Recovery Plan (Commonwealth of Australia, 2015b), Approved Conservation Advice (TSSC, 2015d) or previously in the Whale Shark Recovery Plan 2005 – 2010 (DEH, 2005a). Noise pollution is not identified as a pressure to whale sharks in the Marine Bioregional Plan for the NMR (DSEWPaC, 2012).

Fish and Elasmobranchs – Impact Assessment Conclusion

The potential impacts of noise emissions from the seismic source on fish and elasmobranchs during the acquisition of the survey are considered to be localised and of no lasting effect, and restricted to temporary behavioural changes (avoidance) in any isolated individuals that may transit the area in close proximity to the operating seismic source. Based on the timing and duration (up to 60 days) of seismic acquisition, and the proposed control measures, predicted noise levels from seismic acquisition are not considered likely to cause mortality/PMI, recoverable injury or significant TTS effects to fish communities or result in any ecologically significant impacts at a population level.

Commercial Fish Spawning

Impact Assessment

High intensity impulsive sound emitted from the seismic source has the potential to result in behavioural changes in fish or masking of fish vocalisation, which may temporarily divert efforts away from spawning aggregations, egg production and recruitment success (Hawkins and Popper, 2017). During consultation for this EP, a stakeholder in the Timor Reef Fishery claimed that their experience in this area with previous seismic programs showed immediate effects on fish behaviour and longer term localised stock depletion. This impact assessment is focused on fish spawning and recruitment for relevant key indicator commercial fish stocks.

Section 4.4.3.2 describes the key indicator species that are relevant to the Petroleum Activities Program, which include demersal species targeted by the NT Timor Reef Fishery and the NT Demersal Fishery, and Spanish mackerel targeted by the NT Spanish Mackerel Fishery. The reproductive biology of the key demersal indicator fish species results in a very broad distribution of eggs and larvae, and consequently genetic connectivity over a wide geographic range. Multiple batches of millions of pelagic eggs are released during multiple, frequent spawning events and throughout extended spawning periods (Gaughan et al., 2018).

The following assessment considers the potential magnitude of effects to fish spawning behaviours, and therefore the potential influence of the Petroleum Activities Program on recruitment success and the sustainability of key indicator fish species. The assessment considers:

- spatial-temporal analysis – to provide context on the proportion of the spawning biomass that may be exposed during the Petroleum Activities Program
- consideration of the natural variability in fish distribution, spawning biomass and recruitment
- consideration of the sustainability status of the fish stocks and fisheries.

While the focus of this assessment is on the key indicator species, the status of these stocks is used by fisheries managers as an indicator of the sustainability status within the broader suite of scalefish species exploited in the region.

Spatial-Temporal Analysis

A spatial-temporal analysis has been conducted to determine the overlap between the Petroleum Activities Program and the principal spawning ranges and periods of key commercial indicator species. The analysis provides an indication of the proportion of the spawning area and the proportion of the spawning period for each species that may be exposed to sound from the survey.

The following assessment focuses on the following commercial key indicator fish species:

- goldband snapper
- saddletail snapper
- crimson snapper
- red emperor (a commonly caught species, but not an indicator species)

- Spanish mackerel.

It is noted that number of species of tropical prawns are also targeted in the region by the Northern Prawn Fishery. White banana prawns can generally be found in coastal waters at depths of 16 m – 25 m but can occur to depths of 45 m. Redleg banana prawns are found at depths of 35 – 90 m. Spawning occurs in coastal waters and gulfs, and juveniles inhabit small creeks and rivers in sheltered mangrove environments (AFMA 2021a). Joseph Bonaparte Gulf (over 350 km south-west of the Operational Area) is identified as a key site for redleg banana prawn spawning and recruitment, as well as fishing for the species (Loneragan et al., 2002). Tiger prawns can occur to greater depths on the continental shelf (up to 200 m water depth) and spawning can occur in offshore areas as well as nearshore areas (AFMA, 2021a). Juvenile tiger prawns are found in shallow waters and recruitment of juveniles to the adult spawning stocks of both species is, therefore, likely to occur primarily from shallow coastal waters. Tiger prawns are caught in greatest numbers in the Gulf of Carpentaria, and the nearshore waters of the Arnhem Land coast (AFMA, 2021b). Some adult prawns and level of spawning activity may occur in the Operational Area, potentially in association with Lynedoch Bank, Goodrich Bank and other shallow banks on the southern boundary of the survey. However, the Petroleum Activities Program is expected to be located outside of the core coastal spawning grounds for these species (e.g. Joseph Bonaparte Gulf, Gulf of Carpentaria and Arnhem Land coast) and so prawn species have not been included in the analysis.

The following spatial-temporal analysis is not intended to provide an exact estimate of how much each species' spawning success rate will be impacted. Instead, this method demonstrates how the proportion of fishes that may be affected is relatively small compared to the larger overall adult spawning biomass, spawning area and spawning periods of each stock, which is important context for the assessment. It is important to note that a number of assumptions have been applied to the analysis in order to address uncertainty about behavioural effects to spawning fishes and provide a highly conservative and more precautionary estimate of the proportion of spawning fish stocks that may be exposed and potentially affected during the survey. These assumptions are outlined below:

1. **The spatial overlap with each stock is represented by 24-hours of 2D acquisition with a 5 km buffer applied to account for possible uncertainty about the exact range to disturbance to fish.**

   This approach accounts for an area that may be subject to sound exposure from the seismic source. Accounting for the entire Active Source Area or the entire acquisition line plan is overly conservative as it is likely to be significantly larger than the area where fish may be exposed to sound and subjected to disturbance. The 24-hour timeframe is precautionary in order to account for scientific uncertainty in relation to the duration and recovery of behavioural disturbances in fishes. Behavioural changes in the demersal fish species and mackerel in the Operational Area may return to normal within minutes or hours following exposure (e.g. Pearson et al., 1992; Santulli et al., 1999; McCauley et al., 2000a, 2003; McCauley and Salgado Kent, 2007; Woodside, 2011; Fewtrell and McCauley, 2012; Miller and Cripps, 2013; Bruce et al., 2018). Meekan et al. (2021) found no short-term (days) or longer-term (months) effects of seismic sound exposure on the behaviour and movement of tropical demersal snapper, emperor and grouper species off northern Australia, including some species caught by the NT Demersal Fishery and Timor Reef Fishery, and including groups of fishes exposed within tens of metres of the passing seismic source.

   To apply an additional level of conservatism and account for possible uncertainty about the exact range over which fish may be disturbed, a 5 km buffer has been applied to the acquisition lines to account for potential variability in the hearing of different fish species and to broadly represent where some fishes may have some awareness of sound pressure changes, noting that the key indicator demersal and pelagic fish species are primarily sensitive to particle motion effects more so than sound pressure and significant behavioural effects are more likely to be limited to within tens or hundreds of metres of the seismic source (Popper et al., 2014).

   Therefore, this 24-hour scenario provides a highly conservative reflection of the spawning area that may be exposed at any time during the survey. For example, depending upon the actual line sequence acquired, the seismic survey vessel may sail past groups of fishes at a particular location, with disturbance occurring for less than an hour, and then may sail tens or hundreds of kilometres beyond this point, turning to acquire another line, and may not pass near the same location again until days later; given the wide line spacing of 2D surveys (approximately 1.5 km to 15 km in the case of the Galactic 2D Hybrid MSS), the same area of seabed and same group of fishes may not be exposed to significant disturbances again during the entire survey.

2. **The spatial extent of the spawning areas for each key indicator fish species has been estimated based on each species' principal depth range and the NT fisheries management area.**

   As described in **Section 4.4.3.2**, genetic connectivity and the biological stocks have been confirmed across significantly larger areas (hundreds of thousands of square kilometres compared with the tens of thousands of square kilometre spawning areas considered in the analysis). The biological stocks of the key indicator species generally extend across northern Australia. The biological stock areas may be more relevant to the impact assessment from a biological perspective, however, the boundaries of the biological stocks are not clearly defined and it is noted that genetic connectivity and recruitment within the biological stock ranges occurs over multiple years of spawning and dispersion of eggs and larvae (Martin et al., 2014; Gaughan et al., 2018). In any given year or a single spawning season, the genetic connectivity between the area of seabed exposed to disturbances from the survey depends on the duration of the egg and larval dispersion phase and the oceanographic currents; connectivity and recruitment in a single season may therefore occur within and well beyond the limits of the NT fishery management unit, but potentially not across the entire biological stock area.

Therefore, to address any potential uncertainty in the biological stock ranges, the NT fishery management area has been selected to provide a conservative indication of the proportion of the stocks that may be affected in a single spawning season. As a result, the spatial overlaps accounted for in the spatial-temporal analysis are likely to significantly overestimate the percentage of spawning area of each species that may be exposed to sound from the Petroleum Activities Program.

3. **The spatial-temporal analysis is a simplistic approach that assumes that fish spawning in the area and period of exposure will definitely be compromised.**

   In reality, it is possible that fishes may continue to spawn regardless of exposure and disturbance, may move away from the seismic source and spawn at another location nearby, or, given that fish behaviours may return to normal within minutes or hours of exposure, spawning may be delayed but may occur a short time later. In either of these cases, the impact on spawning success may be negligible. However, given uncertainty about how the spawning behaviours of individual fishes and populations may be affected in response to seismic sound exposure, it is conservatively assumed that cessation of spawning could occur.

Therefore, the following analysis provides a highly conservative indication of the proportion of each indicator fish stock that may be exposed during a 24-hour period of 2D acquisition. This provides useful context for the impact assessment, but the extent and duration of actual impacts will likely be significantly smaller.

Table 6-8 presents the spatial overlap with the spawning areas of key indicator species based on each species' principal depth range and the NT fisheries management unit. In addition to the principal depth ranges of each species, Territory Natural Resources Management (2014) have previously mapped an area of high goldband snapper productivity, restricted to a narrow band of water depths of 110-120 m, based on fishing catch data in the Timor Reef Fishery. This depth range has been extended beyond the boundaries of the Timor Reef Fishery and applied to the NT fishery management area to represent the potential spatial-temporal overlap with the goldband snapper zone of high productivity across the management unit.

A temporal (duration) analysis has also been conducted to determine the maximum overlap between the timing and total potential durations of the Galactic 2D acquisition and the spawning times of key commercial indicator fish species (refer to **Table 6-9**). It is important to note that the temporal overlap may also over-represent what will likely, in reality, be a disturbance to one out of many spawning events for a very small proportion of fish effected by the passing seismic source at the time of a spawning event. For example, the above demersal fish species are serial/multiple batch broadcast spawners, releasing multiple batches of eggs into the water column over a wide area, and spawn multiple times throughout the spawning period (Newman et al., 2008; Gaughan et al., 2018).

Table 6-8: Spatial overlap with spawning ranges of key indicator fish species

Acquisition Scenario	Spatial Overlap					
	Goldband snapper (50-200 m)	Goldband snapper (110-120 m)	Saddletail Snapper (5-100 m)	Crimson Snapper (5-100 m)	Red Emperor (10-180 m)	Spanish Mackerel (0-50 m)
24-hours 2D + 5 km buffer (maximum 2000 km^2)	0.6%	7.6%	0.5%	0.5%	0.4%	0.02%
Spawning areas have been estimated based on each species' depth range and the NT fishery management area. It is important to note that genetic connectivity and the biological stocks have been confirmed across significantly larger areas, however, the NT fishery management area is a useful and conservative indicator for assessment purposes and is consistent with the fisheries management approach.						

Table 6-9: Temporal overlap with spawning periods of key indicator fish species

Acquisition Scenario	Temporal Overlap					
	Goldband snapper (Nov-May)	Goldband snapper (Nov-May)	Saddletail Snapper (Oct-Feb)	Crimson Snapper (Oct-Feb)	Red Emperor (Sep-Jun)	Spanish Mackerel (Sep-Jan)
Up to 60-day duration	14.6%	14.6%	0.0%	0.0%	19.8%	0.0%

The combined spatial-temporal overlap with the spawning areas and times of the key commercial indicator fish species is presented in Table 6-10

Table 6-10: Combined spatial-temporal overlap with spawning periods and ranges of key indicator fish species

Acquisition Scenario	Spatial-Temporal Overlap					
	Goldband snapper (50-200 m)	**Goldband snapper (110-120 m)**	**Saddletail Snapper (5-100 m)**	**Crimson Snapper (5-100 m)**	**Red Emperor (10-180 m)**	**Spanish Mackerel (0-50 m)**
2D: 24 hours + 5 km buffer spatial overlap, 60-day temporal overlap	0.09%	1.11%	0.00%	0.00%	0.09%	0.00%

As shown in **Table 6-10**, the timing of the Petroleum Activities Program (May to August) avoids the spawning periods for saddletail snapper, crimson snapper and Spanish mackerel and so spawning adults of this species will not be affected.

The spatial-temporal overlap with the goldband snapper and red emperor stocks is less than 0.1% of their NT stock range and spawning period. Even accounting for the goldband snapper zone of high productivity between 110 m and 120 m, the spatial-temporal overlap is approximately 1%.

Natural Variability in Spawning Biomass and Recruitment

To provide further context, Woodside has considered the natural levels of variability in spawning and recruitment. Spawning biomass and recruitment rates fluctuate annually, with years of elevated or reduced recruitment influencing the overall stock population (Marriott et al., 2014). Newman et al. (2003) and Marriott et al. (2014) suggest that both spawning and recruitment success can vary depending upon both environmental (e.g. water temperature, cyclones, El Nino-La Nina cycles) and anthropogenic influences (e.g. fisheries catch levels over and above natural mortality rates). Extended periods of high exploitation by fisheries can result in decreases in the spawning stock biomass and number of effective spawnings (Newman et al., 2003). For example, between 1980 and 2013, red emperor spawning biomass in the adjacent Kimberley management unit of WA generally decreased to approximately 35% of unfished (pre-1980) levels, while recruitment success fluctuated inter-annually between a minimum of approximately 150 million fish and 400 million fish (a fluctuation of approximately 250%). Similarly, goldband snapper spawning biomass declined steadily while recruitment success fluctuated inter-annually between a minimum of approximately 250,000 fish and 900,000 fish (a fluctuation of 350%). This provides an indication of the high natural inter-annual variability in the spawning and recruitment of these indicator species. The trends in spawning biomass and recruitment do not clearly reflect one another, indicating that there may also be significant variation in spawning biomass and stock recruitment success as a result of other natural factors.

In the context of this large natural variability, the potential for approximately 1% of the goldband snapper or red emperor spawning biomass in the NT management unit to be disturbed is expected to have a negligible effect. The effects of the survey are unlikely to be discernible from natural variation, given that it is only the groups of fishes exposed at a particular site and point in time that may be affected; spawning will continue undisturbed elsewhere throughout the stocks' ranges and the majority of spawning groups in the region at any point in time will be undisturbed. The affected groups of fishes will also spawn again at multiple other times during the spawning season and so discernible impacts to recruitment and populations are not expected.

The serial, broadcast spawning strategies of the indicator demersal fish species, by their very nature, offsets potential high natural embryo and larval mortality as a result of predation or other environmental factors and thereby spreads the risk or potential opportunity for larval settlement over large areas and long timeframes. Subsequent recruitment of fishes to the adult stock also occurs over extended timeframes and is ongoing. For example, with reference to goldband snapper stocks, the Australian Government's FRDC has previously noted that moderate or long-lived species such as goldband snapper are unlikely to be affected by “short-duration” environmental/climatic changes (of one or a few years), because adult stocks comprise fish that are recruited over many years (Martin et al., 2014). Therefore, in comparison, the occasional, short-term, transient and localised disturbances to groups of fish as a result of a seismic survey would have impacts many orders of magnitude smaller than regional scale environmental/climatic events that would affect entire stocks.

Fish Stock Assessments and Sustainability Status

The monitoring and assessment of commercial fish stocks in Australia is undertaken by the relevant Commonwealth or State Government agency for fisheries. Each fishery and its target species are assessed in accordance with stock sustainability reference levels and in many cases, fishery harvest strategies are developed to set appropriate allowable catch levels. The stock assessment process and objectives are consistent with the principles of ecologically sustainable development as it aims to maintain spawning stock biomass, high productivity and recruitment, as well as to ensure that impacts do not result in serious or irreversible environmental harm.

Spawning biomass is estimated based on abundance, sex and age composition derived from catch data. The target, threshold and limit levels in each stock correspond with 40%, 30% and 20% of the virgin spawning biomass (unfished levels) respectively. The target level is an aspirational and acceptable level based on stock biomass and the fishing mortality rate that fisheries managers aim to achieve to be protective of the stock. Overall, all indicator species in the NT are classed as sustainable and all evidence indicates that the biomass of the stocks is unlikely to be depleted and that recruitment is unlikely to be impaired.

Commercial Fish Spawning - Impact Assessment Conclusion

Based on the above information and the highly conservative assessment, potential disturbance to a small proportion (up to 1.11%) of the indicator fish stocks in the NT fisheries management area is not expected to result in any population level impacts. In the context of natural variability in spawning and recruitment, the stocks are expected to remain sustainable.

Cetaceans

Species sensitivity and sound exposure thresholds

Marine mammals and especially cetaceans rely on sound for important life functions including individual recognition, socialising, detecting predators and prey, navigation and reproduction (Weilgart, 2007; Erbe et al., 2015; Erbe et al., 2018). Underwater noise can affect marine mammals in various ways including interfering with communication (masking), behavioural changes, a shift in the heating threshold, physical damage and stress (Erbe, 2012; Rolland et al., 2012).

When exposed to intense or moderately intense noise levels (e.g. seismic airguns), marine mammals can experience physiological impacts such as physical damage to the auditory apparatus, for example loss of hair calls or permanently fatigued hair cell receptors, which could cause permanent or temporary loss of hearing sensitivity. While the loss of hearing sensitivity is usually strongest in the frequency range of the emitted noise, it is not limited to the frequency bands where the noise occurs but can affect a broader hearing range. This is because animals perceive sound structured by a set of auditory bandwidth filters that proportionately increase in width with frequency.

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

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 sound exposure level (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 peak pressure level (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 have been proven to cause noise-induced threshold shifts in marine mammals at high received levels. However, there is considerable individual difference in all TTS-related parameters between subjects and species tested so far. Furthermore, TTS requires relatively high noise levels and thus occurs at shorter distances compared with behavioural effects, which are likely to occur at much lower levels (Dunlop et al., 2017).

There are no published data on the sound levels that cause PTS in marine mammals. Hence, PTS effects in marine mammals should be viewed as theoretical, as they have never actually been demonstrated in either captive or wild animals.

In response to noise from seismic airguns marine mammals were observed to exhibit localised spatial avoidance and temporary displacement, however different species of cetaceans may adopt different strategies for responding to acoustic disturbance (Stone and Tasker, 2006).

The sound exposure thresholds applied for cetaceans in the acoustic modelling study, and in this impact assessment, are summarised in **Table 6-11**. Noise thresholds have been defined for both the per-pulse sound energy released (PK), as well as the total sound energy (accumulated) (SEL) that marine fauna is subjected to over a defined period of time. For recent regulatory assessments of seismic surveys the period of total sound energy integration (i.e. accumulation) has been typically defined as 24-hours; hence, this was the period used for modelling and in this assessment (SEL_{24h}). The PK and frequency-weighted accumulated SEL presented in **Table 6-11** are from the U.S. National Oceanic and Atmospheric Administration (NOAA) Technical Guidance (NMFS, 2018) for the onset of PTS and TTS in marine mammals and are consistent with a detailed review published by Southall et al. (2019). The marine mammal behavioural threshold presented in **Table 6-11** is based on the current NOAA (2019) criterion for marine mammals of 160 dB re 1 µPa sound pressure level (SPL) for impulsive sound sources.

Table 6-11: Acoustic effects thresholds applicable to cetaceans

Hearing Group	NOAA (2019)	NMFS (2018), Southall et al. (2019)

	Behaviour	PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
	Unweighted SPL ***(L_{pk}; dB re 1 µPa)***	***Weighted SEL24h*** ***(L_E,24h; dB re 1 µPa²·s)***	***PK*** ***(L_{pk}; dB re 1 µPa)***	***Weighted SEL24h*** ***(L_E,24h; dB re 1 µPa²·s)***	***PK*** ***(L_{pk}; dB re 1 µPa)***
Low-frequency (LF) cetaceans	160	183	219	168	213
High-frequency (HF) cetaceans		185	230	170	224

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

Impact Assessment

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

Based on the information presented in **Section 4.4.4**, there are no BIAs or Habitat Critical areas for cetaceans identified within the Operational Area or EMBA. However, 42 species listed under the EPBC Act (including four threatened and migratory, and five migratory cetaceans), including baleen whales, toothed whales and dolphins were identified as potentially occurring within the Operational Area and EMBA.

The four threatened cetacean species identified as potentially occurring within the Operational Area were the blue whale (Endangered), sei whale (Vulnerable), fin whale (Vulnerable) and humpback whale (Vulnerable). Of these species, the pygmy blue whale is most likely to occur within the Operational Area during their northern migration from April to August. However, the Operational Area for this survey is located 580 km from the boundary of the migration BIA, and therefore it is consequently unlikely that significant numbers of pygmy blue whales would be encountered throughout the duration of the survey. The BIA for migrating, breeding and calving humpback whales is located in the Kimberley region of WA, over 850 km south-west of the Operational Area. Therefore, it is unlikely that humpback whales will be encountered within or near the Operational Area. Other threatened species (e.g. sei, fin) may transit the region, mainly during the winter months. Similarly, other migratory species may occur within or adjacent to the Operational Area, including the Omura's whale and Bryde's whale that were detected acoustically in the Timor Sea within and adjacent to the Operational Area from April to early-November, and January to early-October, respectively (JASCO, 2016). However, the presence of all cetacean species is likely to be limited to infrequent occurrences of individuals or small groups.

High-frequency (HF) cetaceans (e.g. river dolphins, harbour porpoises) were not identified as potentially occurring within the Operational Area or EMBA, and accordingly the impact assessment is focused on low-frequency (LF) cetaceans (baleen whales). It is noted that while dugongs were identified as potentially occurring within the EMBA through a PMST search, they are not expected to occur in or around the Operational Area due to the absence of foraging BIAs, preferred water depths (<10 m) and a lack of nearby suitable habitats. Impacts to dugongs as a result of underwater sound from the seismic source are therefore not expected.

Table 6-12 presents the results of the acoustic modelling study for the maximum R_{max} distances to PTS (injury), TTS and behavioural response thresholds in LF and HF cetaceans, for all modelled source scenarios. The results for the thresholds applied for PTS and TTS consider both single pulse (PK) and weighted multiple pulse (SEL_{24h}) metrics. In accordance with NMFS (2018) recommendations, the longest distance associated with either metric is required to be applied for impact assessment.

Table 6-12: Maximum predicted horizontal distances (R_{max}) to PTS, TTS and behavioural response thresholds in cetaceans

Hearing Group	Sound Exposure Threshold	R_{max} Distance (km)
PTS		
LF cetaceans	219 dB re 1 µPa (PK)	0.03
	183 dB re 1 µPa².s (SEL_{24h})	0.38

HF cetaceans	230 dB re 1 µPa (PK)	-
	185 dB re 1 µPa².s (SEL_{24h})	-
TTS		
LF cetaceans	213 dB re 1 µPa (PK)	0.06
	168 dB re 1 µPa².s (SEL_{24h})	60.7
HF cetaceans	224 dB re 1 µPa (PK)	-
	170 dB re 1 µPa².s (SEL_{24h})	-
Behavioural Response		
LF cetaceans	160 dB re 1 µPa (SPL)	7.28
HF cetaceans		

A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

Considering the NMFS (2018) SEL_{24h} threshold criterion, LF cetaceans could reach PTS thresholds within 400 m from the nearest survey line based on the application of the multiple pulse SEL_{24h} threshold, but within 30 m based on the single pulse PK metric. For HF cetaceans, PTS thresholds could be reached within <20 m on the application of the multiple pulse SEL_{24h} threshold. For HF cetaceans, the single pulse PK PTS threshold was not reached within the limits of the modelling resolution. i.e. either the threshold will not be exceeded, or the range to exceedance will be limited to the immediate proximity of the seismic source.

For LF cetaceans, TTS thresholds could be reached within 17.2 km based on the application of the multiple pulse SEL_{24h} threshold, and within 60m based on the single pulse PK metric. HF cetaceans may reach TTS thresholds within <20 m based on the application of the multiple pulse SEL_{24h} threshold. For HF cetaceans, the single pulse PK TTS threshold was not reached within the limits of the modelling resolution.

The 24-hour SEL is a cumulative metric that reflects the doisimetric (measured dose) impact of noise levels within 24-hours, based on the conservative assumption that an animal is consistently exposed to such noise levels at a fixed position. This represents a conservative worst-case scenario. More realistically, whales would not stay in the same location and may not remain within range of the survey line for 24-hours. This would particularly be the case for an animal migrating through offshore waters that do not represent a migratory BIA or critical habitat. Therefore, a reported radius for SEL_{24h} criterion 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 (Welch et al., 2020; **Appendix I**).

It is highly unlikely that an individual whale (e.g. pygmy blue whale) would remain within a range of 400 m (maximum predicted distance for PTS for LF cetaceans, based on the SEL_{24h} metric) from the operating seismic source (which is moving) for a full 24-hour period, or even for a few hours. Should an individual remain within the range for potential impact, some recoverable TTS could occur. However, the likelihood of TTS occurring is reduced to some degree by the implementation of control measures including a shut-down zone of 500 m and a low-power zone of 2 km under Part A of the EPBC Policy Statement 2.1, which reduces the potential for close range sound exposures where the greatest sound contribution is received.

The modelling results (**Table 6-12**) show that the predicted maximum Rmax distances to PTS and TTS thresholds for LF cetaceans based on the SEL_{24h} thresholds were considerably larger than those predicted using the single pulse PK metric. Application of the 219 dB re 1 µPa (PK) PTS threshold and of the 213 dB re 1 µPa (PK) TTS threshold indicates that R_{max} radii from individual shot points would be in the range of 30-60 m, i.e. a whale would have to be within a very close distance to the source to be exposed to sound levels from a single pulse high enough to cause PTS or TTS effects. Such close proximity is highly unlikely given the shut down and low power control measures that will be in place during acquisition of the survey.

For both LF and HF cetaceans, a behavioural response could occur within 9 km of the active seismic source.

Cetaceans - Impact Assessment Conclusion

Based on the assessment above, the implementation of controls and the absence of any cetacean BIAs, the potential impacts of noise emissions from the seismic source on cetaceans during the acquisition of the survey are considered to be slight and short-term. Impacts are likely to be restricted to temporary behavioural changes (avoidance) in individuals moving through the Operational Area, with predicted noise levels from the seismic acquisition not considered likely to cause injury effects.

Marine Reptiles

Species Sensitivity and Sound Exposure Thresholds

Acute noise, or temporary exposure to loud noise, may result in the avoidance of important habitats and in some situations physical damage to turtles. However, there is a scarcity of data regarding the responses of turtles to acoustic exposure, and no studies of hearing loss due to exposure to loud sounds. Marine turtles have the best hearing sensitivity and low frequencies in the range of 100-700 Hz (Bartol and Musick, 2003; Finnernan et al., 2017), and are known to have poor auditory sensitivity (Bartol and Ketten, 2006; Dow Piniak et al., 2012). Accordingly, PTS and TTS thresholds for turtles are likely more similar to those of fishes than to marine mammals (Popper et al., 2014).

McCauley et al. (2000b) observed the behavioural response of caged sea 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 (SPL) 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 response to sea turtles by NMFS and applied in the Arctic Programmatic Environmental Impact Statement (PEIS) (NSF, 2011) and the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017a). The 175 dB re 1 µPa level from McCauley et al. (2000b) is recommended as the threshold for behavioural disturbance.

Some additional data suggest that behavioural responses occur closer to an SPL of 175 dB re 1 µPa, and TTS or PTS at even higher levels (Moein et al., 1995), but the received levels were unknown and the NSF (2011) PEIS maintained the earlier NMFS criteria levels of 166 and 180 dB re 1 µPa (SPL) for behavioural response and injury, respectively. Popper et al. (2014) suggested injury to turtles could occur for sound exposures above 207 dB re 1 µPa (PK) or above 210 dB re 1 µPa²·s (SEL24h). 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 metres) from the airgun.

The sound exposure thresholds applied for marine turtles in the acoustic modelling study, and in this impact assessment, are summarised in **Table 6-13**. The peak pressure levels (PK) and frequency-weighted accumulated sound exposure levels (SEL) presented in **Table 6-13** are as reported in Finnernan et al. (2017) for PTS and TTS effects in turtles. The behavioural response threshold presented in **Table 6-13** is based on the NMFS and applied in the Arctic Programmatic Environmental Impact Statement (PEIS) (National Science Foundation [NSF], 2011), and the behavioural disturbance threshold is based on the level reported in McCauley et al. (2000b).

Table 6-13: SPL, SEL_{24h}, and PK thresholds for acoustic effects on marine turtles

Effect Type	Criterion	Unweighted SPL (L_{pk}; dB re 1 µPa)	Weighted SEL_{24h} (L_E,24h; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)
Behavioural response	NSF (2011)	166	N/A	
Behavioural disturbance	McCauley et al. (2000a, 2000b)	175		
PTS onset thresholds* (received level)	Finneran et al. (2017)	N/A	204	232
TTS onset thresholds* (received level)			189	226

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

Impact Assessment

Without appropriate control measures in place, noise emissions from the seismic source have the potential to impact marine reptiles 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 presented in **Section 4.4.4**, the Operational Area partially overlaps with the flatback turtle interesting BIA and a Habitat Critical area, and additionally the EMBA partially overlaps the olive ridley turtle interesting BIA and Habitat Critical area. The Recovery Plan for Marine Turtles (Commonwealth of Australia, 2017a) specifies a 60 km internesting buffer for flatback turtles and a 20 km internesting buffer for olive ridley turtles. Flatback turtle nesting areas have been identified at the Tiwi Islands; however, they are not identified as major or minor important nesting areas (Commonwealth of Australia, 2017a).

The 60 km internesting buffer for flatback turtles in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017a) is based primarily on the movements of tagged internesting flatback turtles in the Pilbara region of WA, reported by Whittock et al. (2014), which found that flatback turtles may demonstrate internesting displacement distances up to 62 km from nesting beaches. However, these movements were confined to longshore movements in nearshore coastal waters or travel between island rookeries and the adjacent mainland (Whittock et al., 2014).

A more recent paper by the same authors (Whittock et al., 2016) defined suitable internesting habitat as water 0–16 m deep and within 5–10 km of the coastline, while unsuitable internesting flatback habitat was defined as waters >25 m deep and >27 km from the coastline. The primary environmental variables that influenced flatback internesting movement were bathymetry, distance from coastline, and sea surface temperature (Whittock et al., 2016). Additionally, suitable areas of internesting habitat were located close to many known flatback turtle rookeries across the region (Whittock et al., 2016). There is no evidence to date to indicate that flatback turtles swim out into deep offshore waters during the internesting period.

It is important to note that flatback turtle hatchlings do not undertake oceanic migrations offshore to deep, pelagic waters. Instead juveniles grow to maturity in shallow coastal waters close to their natal beaches (Musick and Limpus, 1996).

Additionally, four other marine turtle species and the salt-water crocodile were also identified as potentially occurring within the Operational Area. However, there are no BIAs nearby, and therefore their occurrence within or adjacent to the Operational Area is considered unlikely, as are any impacts to these species as a result of underwater sound from the seismic source.

Table 6-14 presents the results of the acoustic modelling study for the maximum Rmax distances to PTS (injury), TTS, behavioural response, and behavioural disturbance thresholds in turtles, for all modelled source scenarios. The results for the thresholds applied for PTS and TTS consider both metrics (single pulse PK and multiple pulse SEL_{24h}).

Table 6-14: Maximum predicted horizontal distances (R_{max}) to PTS, TTS, behavioural response and behavioural disturbance thresholds in turtles, for all modelled scenarios

Hearing Group	Sound Effect Threshold	R_{max} Distance (km)
Marine turtles	Behavioural Response	
	166 dB re 1 µPa (SPL)	4.04
	175 dB re 1 µPa (SPL)	1.84
	PTS	
	232 dB re 1 µPa (PK)	-
	204 dB re 1 µPa².s (SEL_{24h})	<0.02
	TTS	
	226 dB re 1 µPa (PK)	-
	189 dB re 1 µPa².s (SEL_{24h})	0.16

* A dash indicates that the threshold is not reached within the limits of the modelling resolution (20 m).

Marine turtle PTS thresholds could be reached within <20 m based on the application of the multiple pulse SEL_{24h} threshold as the single pulse PK PTS threshold was not reached within the limits of the modelling resolution. TTS thresholds could be reached within 160 m based on the application of the multiple pulse SEL_{24h} threshold as the single pulse PK PTS threshold was again not reached.

The SEL_{24h} is a cumulative metric that reflects the doisimetric 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, and represents an unlikely scenario. More realistically, marine turtles would not stay in the same location for 24-hours, but rather a shorter period, depending upon their behaviour and the proximity and movements of the source. Therefore, a reported radius for SEL_{24h} criteria does not mean that marine reptiles travelling within this radius of the source will be impaired, but rather that an animal could be exposed to the sound level associated with impairment (either PTS or TTS) if it remained in that location for 24-hours (Welch et al., 2020; **Appendix I**)

The likelihood of PTS and TTS occurring to marine turtles is reduced to a degree by the implementation of control measures including an observation zone of 500 m and a shut-down zone of 100 m under Part A of the EPBC Policy Statement 2.1, which reduces the potential for close range sound exposures where the greatest sound contribution is received. Additionally, during June to September within the flatback turtle Habitat Critical internesting Woodside will implement adaptive management measures as described below.

Based on the 166 dB re 1 µPa SPL behavioural threshold criterion (NSF, 2011) a behavioural response could occur within 4.04 km. Based on the 175 dB re 1 µPa SPL behavioural threshold criterion (McCauley et al., 2000a, 2000b) a behavioural disturbance could occur within 1.84 km. Therefore, there is the potential for sound levels to exceed the 166 dB re 1 µPa SPL behavioural threshold criterion within the parts of the Active Source Area that overlap the identified flatback turtle Habitat Critical area.

The possible seismic acquisition period (May to August) overlaps with both the flatback turtle (Arafura Sea) internesting period (peak June to September) and the olive ridley (NT) turtle internesting period (peak April to August). However, the area of potential impact is small in the context of suitable habitat, and is likely outside of the preferred internesting habitat for flatback turtles (within 5-10 km from the coastline). Additionally, turtles within the area of potential impact will not be evenly distributed and are likely to be moving in and out of the area, and similarly, the sound levels within this potential impact area with change as the seismic vessel moves throughout the survey for a period of up to 60 days.

Marine Reptiles - Impact Assessment Conclusion

Based on the assessment above and the implementation of controls, the potential impacts of noise emissions from the seismic source on marine reptiles (turtles) during the acquisition of the survey are considered to be slight and short-term. Impacts are likely to be restricted to temporary behavioural changes (avoidance) to transient turtles that may pass within 4.04 km of the seismic source, depending on the source. Turtles would be exposed to noise levels above behavioural threshold levels for a short period of time as the vessel moves through the survey area (up to 60 days).

Seabirds and migratory shorebirds

Impact Assessment

Very little is known about the effects of intense underwater sound (e.g. seismic surveys) on seabirds. However, impacts to seabirds have not been observed previously during seismic surveys (Turnpenny and Nedwell, 1994), and it is generally thought that noise produced from activities associated with seismic surveys may impact only those species of birds that spend large quantities of time underwater, either swimming or plunge diving while foraging for food (US DoIMMS, 2004). Pichegru et al. (2017) found that penguins showed a strong avoidance of their preferred foraging areas during seismic activities, foraging significantly further from the survey vessel when in operation and increasing overall foraging effort.

As outlined in **Section 4.4.4**, 12 species of birds were identified by the EPBC Act PMST as potentially occurring within the Operational Area or EMBA, including three threatened species. There are no BIAs or Habitat Critical to the survival of birds located within the Operational Area; however, the EMBA overlaps with the crested tern breeding BIA.

Birds foraging within the Operational Area have the potential to be exposed to increased sound levels generated by the operating seismic source, while diving for small pelagic fishes near the sea surface. Such behaviours may result in a startle response during diving. Birds resting on the surface of the water in proximity to the seismic vessel have limited potential to be affected by sound emissions underwater due to the limited transmission of sound energy between the water/air interface, but may be startled by seismic pulses in close proximity to the seismic source. However, given the likely avoidance response from fish and other prey species in waters immediately surrounding the seismic source, birds are unlikely to forage near the operating seismic source. In the unlikely event that birds dive and forage near the seismic source, this is likely to only affect individual birds, resulting in a startle response with the affected birds expected to move away from the area as a result.

Seabirds and migratory shorebirds – Impact Assessment Conclusion

In the absence of foraging BIAs it is not likely that seabirds and migratory shorebirds would be impacted by the seismic survey. The behaviour and distribution of some fish 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 bird species. However, it is expected that the behaviours and distribution of prey at any one time will remain largely unaffected within the Operational Area. Furthermore, it is expected that the crested tern will not be displaced from the wider areas of the breeding BIA. Therefore, impacts to seabird and migratory shorebird populations are extremely unlikely to occur.

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 Active Source Area and in adjacent waters. Additionally, seismic acquisition has the potential to affect commercial fisheries via displacement or exclusion of fishers from areas where they normally operate for all or part of the period during which the survey is being acquired. This potential impact is assessed in **Section 4.6.1.**

As described in **Section 4.5.4**, there are a number of Commonwealth and NT commercial fisheries that have historically had catch/effort within the Operational Area, as follows:

- Northern Prawn Fishery (Cth)
- Timor Reef Fishery (NT)
- Demersal Fishery (NT)
- Spanish Mackerel Fishery (NT)
- Offshore Net and Line Fishery (NT)
- Aquarium Fishery (NT).

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 (hours or days) after.

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

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

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

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

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

Meekan et al. (2021) found no short-term (days) or longer-term (months) effects of seismic sound exposure on the behaviour and movement of tropical demersal snapper, emperor and grouper species off northern Australia, including some species caught by the NT Demersal Fishery and Timor Reef Fishery, and including groups of fishes exposed within tens of metres of the passing seismic source. The authors suggest that the behavioural responses of demersal fishes to the bait cue during the study are a realistic proxy of the likely response of the same species to baited hooks or traps used by the commercial fisheries that target them. Therefore, no long-term impacts on the catchability of demersal fish species are expected.

Effects will be temporary as the seismic vessel traverses each survey line, and fish may move away as the airgun array approaches. As described above, significant behavioural responses in the key indicator demersal fish species (which primarily detect particle motion, with limited, or no sensitivity to sound pressure changes at distance from a seismic source) will likely be limited to distances of a few hundreds of metres from the operating seismic source.

Section 6.4.1 includes an analysis of the area of overlap between the area of historic fishing activity (effort) and the Petroleum Activities Program. This is based on representative 2D acquisition scenarios, which take into account periods which fishing vessel may be displaced by the seismic vessel and a 3 nm (5.6 km) SNA around the seismic vessel and towed streamers. The potential area of disturbance generally represents less than 1% of the areas fished by each fishery and limited impacts are expected. The one exception is the Timor Reef Fishery where up to 7.2% of the area of fishing effort may be subject to potential interactions with fishers during a representative 24-hour period of acquisition. It is also noted that the southern half of the Operational Area, as well as waters to the west of the Operational Area represent the areas of highest historical fishing effort in this fishery.

It is acknowledged that localised and temporary disturbances to fishing activities from seismic survey activities may occur. However, noting that behavioural impacts to target fish species will likely be limited to distances of a few hundreds of metres from the operating seismic source, with behaviours and distributions returning to normal minutes or hours (or potentially days) after, the potential acoustic disturbance to commercial fisheries and their target species is not expected to exceed the areas and durations of displacement due to the physical presence of the survey. Once the survey is complete, fish behaviours and distributions are expected to return to normal within days, if not hours.

Between one and six licences have been active within the Timor Reef Fishery each year between 2016 and 2020. Noting that historical fishing effort to the west of the Operational Area is comparable to the level of historical effort overlapped by the survey, alternative and viable fishing grounds are available to fishers during the survey. If viable catch levels can be maintained from other areas, overall annual catch rates and fishery performance are not expected to be significantly impacted. In the event that fishers experience impacts, Woodside has a co-existence approach that includes compensation (**Appendix G**). In summary, Woodside will consider claims from commercial fishing licence holders where:

- there is genuine displacement from undertaking normal fishing activities that results in economic loss
- fishing equipment has been lost or damaged by any activities under Woodside's control
- loss of catch that can be demonstrated.

Commercial Fisheries – Impact Assessment Conclusion

Based on the assessment above and the implementation of the identified control measures, the consequence of occasional short-term and localised disturbance to the target species and catch rates of commercial fisheries is Minor and the Consequence is considered to be Slight.

Tourism and Recreational Fishing

Impact Assessment

Tourism or recreational activities (e.g. fishing, diving/snorkelling) are not likely to take place within or immediately adjacent to the Operational Area due to the distance from shore. However, there is some limited capacity for recreational fishers to fish in the offshore waters of the Operational area on board fishing charters to Lynedoch Bank during the calmest times of the year and specific tides (2021 dates September to December). Targeted species include mackerel, dogtooth tuna, trevally, wahoo, sailfish and marlin – all pelagic species.

Impacts to recreationally target fish species are likely restricted to temporary behavioural changes (avoidance) in any isolated individuals that may transit the area in close proximity to the operating seismic source. Fishing charters are expected to occur outside of the seismic acquisition period (May to August, for a maximum of 60 days), and therefore it is highly unlikely that there would be any impact to recreational fishers in the Operational Area, particularly with respect to the 'catchability' of the target species.

Feedback from game fishing operators (**Section 5.5**) indicated only one Darwin-based charter company had a vessel that undertook multi-day charters near the Operational Area. Feedback from that operator was that it was highly unlikely it would be in the area, though there was a possibility due to weather implications.

Based on this information, there is low likelihood of the Galactic 2D Hybrid MSS affecting recreational fishing catch rates.

Divers

Fishing effort data for the NT Aquarium Fishery indicates that fishing may occur within the Operational Area, likely associated with Lynedoch Bank, Goodrich Bank or other bank and shoal areas on the edge of the survey.

The human auditory system is significantly less sensitive underwater than in air and is further degraded if diving equipment obstructs the ears or face (e.g. diving with a hood or full facemask). Underwater, the human ear is about 20 dB less sensitive than it is in air at low frequencies (20 Hz), increasing to 40 dB at mid-frequencies (less than 1 kHz), and increasing to 70–80 dB less sensitive at higher frequencies (Parvin, 1998). Divers who wear neoprene hoods have even higher hearing thresholds (lower sensitivity) above 500 Hz because the hood material absorbs high-frequency sounds (Sims et al., 1999). Exposure studies related to divers have typically focused on military sonar exposure, with little information on seismic survey operations, and as such care is required when considering thresholds for non-military divers, particularly for impulsive sounds such as seismic source impulses (Ainslie, 2008).

Underwater auditory threshold curves indicate that the human auditory system is most sensitive to waterborne sound at frequencies between 400 Hz to 1 kHz (Parvin et al., 1994); cited in Anthony et al., 2009), and these frequencies have the greatest potential for damage. Within the literature (all as cited in Ainslie, 2008), there is some variation in acceptable SPLs for divers.

The auditory threshold of hearing under-water was lowest at 1 kHz (70 dB re 1 µPa SPL) and increased for lower and higher frequencies to around 120 dB re 1 µPa at 20 Hz and at 20 kHz (Parvin, 1998). Fothergill et al. (2000) and Fothergill et al. (2001) conducted controlled acoustic exposure experiments on military divers under fully controlled conditions at a US Ocean Simulation Facility and an US Open water test facility. The following exposure limit for both military and recreational divers was suggested as a conservative measure: For frequencies between 100 and 500 Hz, the maximum SPL should be 145 dB re 1 µPa over a maximum continuous exposure of 100 seconds or with a maximum duty cycle of 20 per cent and a maximum daily cumulative total of three hours. The trading relation between the maximum SPL and duration was 4 dB per doubling of duration (e.g. 141 dB SPL for a 200 second exposure) (Pestorius et al., 2009).

In alignment with these studies, and considering only frequencies between 100 and 500 Hz, Parvin (2005) suggested 145 dB re 1 µPa as a safety criterion for recreational divers and swimmers. Seismic airgun sources are broadband sources, and therefore, for this assessment the most precautionary and conservative diver acoustic impact threshold is the 145 dB re 1 µPa SPL suggested by Parvin (2005). This does not imply that this level is associated with the onset of injury but represents a conservative level for protection against prolonged sound exposure for health and safety purposes.

From the acoustic modelling (Welch et al., 2020; **Appendix I**), received sound levels may exceed 145 dB re 1 µPa SPL at distances of up to 30 km.

Guidance note issued by the UK Diving Medical Advisory Committee (DMAC) "Safe Diving Distance from Seismic Surveying Operations" (DMAC, 2019) have suggested that adverse effects may be experienced by divers at distances of up to 27 km from a seismic source, similar to the 145 dB re 1 µPa SPL isopleth considered above, but do not provide any further details. DMAC (2019) recommends that where diving and seismic activity occur within 30 km of each other, a joint risk assessment should be conducted, and planning/mitigation agreed between parties. Where diving and seismic activities occur within 45 km of each other, all parties should be made aware of the planned activity. These ranges include areas around banks and shoals where divers may be present.

Marine Protected Areas

Impact Assessment

As described in **Section 4.6.1**, the Operational Area overlaps with the Oceanic Shoals Australian Marine Park Multiple Use Zone (MUZ; IUCN VI). Four KEFs are located within the AMP, including the Shelf break and slope of the Arafura Shelf and the Carbonate bank and terrace systems of the Van Diemen Rise, which partially overlap with the Operational Area.

The potential impacts to the natural values of the Oceanic Shoals Marine Park (OSMP) are summarised as follows:

- Shelf break and slope of the Arafura Shelf KEF: Biological communities located within this KEF include plankton, some coral, fish – demersal and pelagic, marine turtles and sharks. No long-term of population impacts to these species were identified in the impact assessments above, and therefore impacts to species within this KEF are considered slight and short term and limited to temporary behavioural change (avoidance).
- Carbonate bank and terrace systems of the Van Diemen Rise KEF: Biological communities located within this KEF include plankton, corals, invertebrates (sessile filter feeders associated with hard substrate and sediments of the deep channels – sponges, soft corals, sea cucumbers), fish – demersal and pelagic, marine turtles, sea snakes and sharks. No long-term of population impacts to these species were identified in the impact assessments above, and therefore impacts to species within this KEF are considered slight and short term and limited to temporary behavioural change (avoidance).
- Flatback turtle internesting BIA and Habitat Critical: The Recovery Plan for Marine Turtles in Australia 2017-2027 (Commonwealth of Australia 2017) identifies seismic noise as a threat to turtles. PTS (injury) effects will only occur at very close range of the seismic source, within 20 m, while TTS effects could occur within 160 m of the source. A behavioural response to marine turtles could occur within 4.04 km of the seismic source (refer to **Table 6-14**). However, as described in the assessment of potential impacts to marine turtles above, the Galactic Hybrid 2D MSS will implement adaptive management measures during the peak flatback turtle internesting period. The area of potential impact from noise from the seismic source is small in the context of suitable habitat, and likely outside of the preferred internesting habitat for flatback turtles, therefore impacts to internesting marine turtles are considered slight and short-term and limited to temporary behavioural changes (avoidance) to transient turtles.

The objectives of the North Marine Parks Network Management Plan are to provide for:

a) the protection and conservation of biodiversity and other natural, cultural and heritage values of marine parks in the North Network; and
b) ecologically sustainable use and enjoyment of the natural resources within marine parks in the North Network, where this is consistent with objective (a).

Objectives and rules are also prescribed for the MUZ. The objective of the MUZ is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species. No long-term impacts are predicted and the values will be conserved and protected.

Based on the predicted levels of impact to values of the Oceanic Shoals AMP, the Petroleum Activities Program is expected to be undertaken in a manner that is consistent with the management objectives for the AMP and the North Marine Park Network.

Marine Protected Areas – Impact Assessment Conclusion

Based on the proposed timing and duration (up to 60 days) of the seismic acquisition and the control measures proposed, predicted noise levels from seismic acquisition are not considered likely to cause any ecologically significant impacts to the natural values of the OSMP and the Petroleum Activities Programme is expected to be undertaken in a manner that is consistent with the management objectives for the AMP and the North Marine Park Network.

Cumulative Assessment

Previous Seismic Surveys

Cumulative impacts from successive seismic surveys in the same area can occur when timing between the surveys is less than the recovery rate of any potential receptors, which can be in the order of minutes to hours for some receptors (e.g. zooplankton and fish), or weeks to months for others (e.g. benthic invertebrates), as described above.

Ecological receptors are therefore expected to have recovered from the effects of a seismic survey within days to months of completion, with potential lethal and sublethal effects to some immobile benthic invertebrate communities considered to have the longest population recovery period. Longer term, only sublethal impacts to some benthic invertebrate organisms may persist.

A summary of the 3D marine seismic surveys that have been undertaken in the NMR and within the NT fisheries management unit in the last fifteen years (since 2006) is presented in **Table 6-15**. Given the time that has elapsed since the last survey overlapping with the Galactic Hybrid 2D MSS (the Santos Bethany 3D MSS in 2018), all receptors are expected to have recovered from the effects of previous surveys prior to commencement of the Petrel Sub-Basin SW 3D MSS. Therefore, cumulative impacts to ecological receptors are not expected to occur as a result of any of the identified previous seismic surveys in the region and the proposed Galactic Hybrid 2D MSS.

Commercial fishery stakeholders in the Timor Reef Fishery, NT Demersal Fishery and the Northern Prawn Fishery claimed during consultation that previous 3D seismic surveys in the region have impacted fishing activities and catch rates. As noted in **Section 6.4.1**, NT commercial fisheries have been exposed to past surveys in the region, however, fishery catch and effort data provided by the NT DITT is restricted and does not provide catch or effort data for fishery blocks where less than five licence holders fished during the period of interest (i.e. less than five licence holders per year). Therefore, it has not been possible to determine if the occurrence of past seismic surveys has materially impacted the performance of commercial fisheries (for example, due to disturbance of target fish species from pulses of seismic sound). It is acknowledged that some level of impact may have occurred but based on the information provided above, effects to fish species are likely to be localised (within hundreds of metres of the source) and temporary, with fish behaviours and distribution returning to normal within minutes, hours or days after a survey has ceased.

Table 6-15: Previous 3D seismic surveys completed since 2006 in the NMR

Survey Name	Operator	Acquisition Period(s)	Spatial Overlap
Evans Shoal 3D MSS	Santos	13/06-2006 – 07/12/2006	No
NT/P68 Epenarra 3D MSS	Methanol	27/09/2006 – 30/10/2006	No
Malita West 3D MSS	Total E and P Australia	03/03/2008 – 17/05/2008	No
Blackwood 3D MSS	Methanol	29/04/2008 – 19/05/2008	No
Bathurst 3D MSS	Eni Australia Limited	03/12/2011 – 05/01/2012	No
Magellan Bonaparte 3D MSS	Magellan Petroleum Pty Ltd	14/12/2012 – 28/12/2012	No
Kyranis MC 3D MSS	Fugro Multi Client Services Pty Ltd	25/07/2012 – 12/01/2013 10/12/2013 – 19/02/2013	No
Caldita-Barossa 3D MSS	ConocoPhillips	06/08/2016 – 13/10/2016	Yes
Bethany 3D MSS	Santos	11/05/2018 – 21/07/2018	Yes
Beehive 3D MSS	Santos	23/07/2018 – 11/08/2018	No
Petrelex 3D MSS	Polarcus	01/12/2019 – 16/01/2020	No

Concurrent Seismic Surveys

There are no known surveys taking place concurrently with the Galactic Hybrid 2D MSS survey. However, the Santos Petrel Sub-Basin SW 3D MSS is planned to take place during 2021 within the NMR and the NT fisheries management unit (**Section 6.4.2**). The Santos Petrel Sub-Basin SW 3D MSS is located in the Joseph Bonaparte Gulf to the south-west of the Galactic Hybrid 2D MSS. At the closest point, the Galactic Active Source Area is 316 km from the Petrel Sub-Basin SW Active Source Zone.

<u>Zooplankton</u>

Based on the maximum worst case mortality exposure suggested by McCauley et al. (2017) and modelling completed by CSIRO (Richardson et al., 2017), impacts to zooplankton are only expected to be significant within a short range (< 15 km) of seismic survey areas. Beyond 22 days of acquisition, Richardson et al. (2017) found that no further relative increase in zooplankton mortality occurs, due to recruitment of zooplankton via currents from adjacent areas, and conditions return to normal within a few days of a survey ceasing. At the regional scale, these impacts are not expected to be significant (Richardson et al., 2017). The maximum predicted distances to mortality for zooplankton during the Galactic Hybrid 2D MSS was approximately 180 m (**Table 6-4**). Further, natural mortality rate in zooplankton can be high, and therefore limited impacts are expected relative to the natural variation in zooplankton concentrations and mortality rate.

No significant, discernible cumulative impacts to zooplankton are expected to occur given the distance from the Petrel Sub-Basin SW 3D MSS and the minimum separation distance of 40 km between the Galactic Hybrid 2D MSS and any other operating seismic sources. Cumulative impacts to zooplankton communities in the NMR are therefore expected to be negligible.

Benthic Invertebrates

The maximum worst case impacts reported for invertebrates include sub-lethal impacts such as statocyst impairment, temporary reduced immune response function, temporary impaired reflexes, and potentially some chronic effects that lead to mortality of a very small number of sessile benthic invertebrates over and above natural mortality rates. Repeated exposures to seismic noise for some sessile invertebrates, such as bivalves, have been observed to result in additional chronic mortality in the weeks and months following exposure compared with invertebrates exposed to just one pass of a seismic source (i.e. an increase of approximately 2-5%) (Day et al., 2016b). However, such effects may still be within the range of naturally occurring mortality rates documented in the wild (Day et al., 2017). Therefore, given that repeat exposures will affect only a small proportion of benthic organisms, and the natural cycle of death and recruitment will occur in parallel, the impacts of repeated seismic exposure may not be detectable from natural fluctuations in benthic invertebrates.

No significant, discernible cumulative impacts to zooplankton are expected to occur given the distance from the Petrel Sub-Basin SW 3D MSS and the minimum separation distance of 40 km between the Galactic Hybrid 2D MSS and any other operating seismic sources. Cumulative impacts to benthic invertebrate communities in the NMR are therefore expected to be negligible.

Fish, Sharks and Rays

No significant, discernible cumulative impacts to fish, sharks and rays are expected to occur given the minimum separation distance of 40 km between the Galactic Hybrid 2D MSS and any other operating seismic sources, including the Petrel Sub-Basin SW 3D MSS located over 316 km away. Behavioural impacts to fish are expected to occur within tens to hundreds of metres of a seismic source (Popper et al., 2014), returning to normal within minutes to hours or days, depending on the species, hearing sensitivity and situational context.

Individual groups of fishes in each seismic survey Active Source Area may be subject to occasional behavioural disturbances, however no cumulative overlap of strong behavioural responses is expected to occur. Some changes in fish abundance and distribution could occur as a result of sound exposure from multiple operating seismic sources, although these changes are expected to return to normal within hours to days.

Cetaceans

There are no significant, discernible cumulative impacts to cetaceans, expected to occur given the minimum separation distance of 40 km between the Galactic Hybrid 2D MSS and any other operating seismic sources, including the Petrel Sub-Basin SW 3D MSS located over 316 km away. As above, combined seismic sound from two similar seismic sources at a distance of half the minimum separation distance (20 km) would be expected to result in an SPL lower than the defined behavioural response thresholds for cetaceans of 160 dB re 1μPa. Any behavioural avoidance or deviations are expected to be small relative to the long distances over which cetaceans usually travel.

Cetaceans in each seismic survey Active Source Area may be subject to occasional behavioural disturbances, however no cumulative overlap of strong behavioural responses is expected to occur.

Marine Reptiles

No significant, discernible cumulative impacts to marine turtles are expected to occur given the minimum separation distance of 40 km between the Galactic Hybrid 2D MSS and any other operating seismic sources, including the Petrel Sub-Basin SW 3D MSS located over 316 km away. Any behavioural avoidance or deviations are expected to be small relative to the long distances over which marine turtles usually travel.

Marine turtles may experience a short-term behavioural response up to approximately 4 km from the Galactic Hybrid 2D MSS operating source, based on the NMFS criterion of 166 dB re 1 μPa SPL. The Galactic Hybrid 2D MSS Operational Area is located approximately 43 km from the nearest turtle nesting beaches. Given that no significant impacts are expected impact to marine turtles as a result of the Galactic Hybrid 2D MSS and the 40 km proposed minimum separation distance, no cumulative behavioural effects to marine turtles are expected within internesting BIAs or Habitat Critical areas. Localised disturbances to marine turtles may occur in each seismic survey Active Source Area, however no significant cumulative impacts are expected.

Commercial Fisheries

Cumulative impacts to commercial fisheries may occur if multiple seismic surveys occur concurrently or in quick succession within a fishery, resulting in displacement of commercial fishing vessels or changes in catch rates due to behavioural changes in target fish or shellfish species. 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.

As outlined in **Section 6.4.1** and **Table 6-16**, the Petrel Sub-Basin SW 3D MSS has minimal or no overlap with the same commercial fisheries that are overlapped by the proposed Galactic 2D Hybrid MSS.

Table 6-16 Cumulative spatial-temporal overlap with historic fishing effort for relevant commercial fisheries

Relevant Commercial Fisheries	Spatial Overlap (%)	
	Galactic Hybrid 2D MSS	Petrel Sub-Basin SW 3D MSS
Timor Reef Fishery (NT)	24.2	0.00
Demersal Fishery (NT)	2.4	0.09
Spanish Mackerel Fishery (NT)	2.3	0.08
Offshore Net and Line Fishery (NT)	2.3	0.08
Aquarium Fishery (NT)	4.0	0.06
Northern Prawn Fishery (Cth)	1.6	0.00

Table 6-17 presents the spatial-temporal overlap of the Galactic Hybrid 2D MSS and the Petrel Sub-Basin SW 3D MSS with the principal depth ranges of key indicator fish species in the NT fisheries management unit based on the spatial overlap from a 24-hour period of acquisition. This represents potential disturbance to target catch and to spawning and recruitment.

The combined disturbance to key indicator species is expected to be up to approximately 1% of the indicator fish stocks in the NT fisheries management area. Localised disturbances to groups of fishes may occur in each seismic survey Active Source Area, which could in turn result in localised and temporary reductions in catch within each survey area, however, no cumulative impacts are expected.

Table 6-17: Spatial-temporal overlap with spawning ranges of key indicator fish species

Acquisition Scenario	Spatial-Temporal Overlap					
	Goldband snapper (50-200 m)	Goldband snapper (110-120 m)	Saddletail Snapper (5-100 m)	Crimson Snapper (5-100 m)	Red Emperor (10-180 m)	Spanish Mackerel (0-50m)
Galactic Hybrid 2D MSS	0.09%	1.11%	0.0%	0.0%	0.09%	0.0%
Petrel Sub-Basin SW 3D MSS	0.02%	0.0%	0.03%	0.03%	0.04%	0.0%
Cumulative Overlap	**0.11%**	**1.11%**	**0.03%**	**0.03%**	**0.13%**	**0.0%**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[6]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Application of EPBC Policy Statement 2.1 Part A Standard Management Procedures to whales, as outlined below: • observation zone: 3 km+ • low power zone: 2 km	F: Yes. CS: Minimal cost. Standard.	Reduces the likelihood of individual whales being within proximity of the acoustic source where PTS or TTS could occur.	Benefits outweigh cost/sacrifice.	Yes **C 5.1**

1 Qualitative measure

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[6]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
• shut-down zone: 500 m • observation and compliance reporting: − Use of vessel crew trained in marine fauna observations and monitoring for compliance to Policy Statement 2.1. − Records kept of marine fauna observations during all surveys. • pre start-up visual observation (30 minutes) • soft start procedure (30 minutes) • start-up delay procedure (if sighting occurs) • operations procedure • stop work (shut down) procedure • night-time and low visibility procedure				
Application of EPBC Act Policy Statement 2.1 Part B.1 – MMOs: • employ two dedicated MFOs to undertake observations for EPBC Act Policy Statement 2.1.	F: Yes. CS: Minimal cost. Standard practice.	Two dedicated MFOs provides improved marine fauna identification, distance estimation and implementation of EPBC Act Policy Statement 2.1. Two MFOs on board provides contingency in the event one is unavailable and for managing work shift fatigue.	Benefits outweigh cost/sacrifice.	Yes **C 5.2**
Application of EPBC Act Policy Statement 2.1 Part B.2 – Night-time/poor visibility: • additional night-time/low visibility procedures e.g. limit soft-starts only to conditions that allow visual inspection.	F: Yes. CS: Significant cost and schedule impacts due to potential delays in acquiring data. Any delays to the seismic program could result in significant cost and operational implications. It would also extend the duration of the survey,	Based on the timing and duration of the Petroleum Activities Program, the absence of significant habitat for cetaceans and the other control measures proposed, additional night-time/low visibility procedures will provide limited benefit.	Not considered – Cost outweighs limited benefit. Part B of EPBC Act Policy Statement 2.1 is intended for locations where there is an increased likelihood of	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[6]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
	increasing impacts to other receptors (e.g. fisheries).		encountering cetaceans. The Operational Area is not located near any significant cetacean habitat and cetaceans are expected in relatively low numbers.	
Application of EPBC Act Policy Statement 2.1 Part B.3 – Spotter vessel/ Aircraft	F: Yes CS: Cost of specialist aircraft with good downward visibility, or cost of an additional spotter vessel additional MFOs required on board aircraft (approximately $10 - $20K per day). Additional risks to environment through use of vessels/airplanes, increased safety risks to personnel on board additional vessels/airplanes.	Given the absence of any interaction between critical habitats (i.e. feeding, breeding, calving) or a constricted migratory pathway, no benefit is considered by implementing EPBC Policy Statement 2.1 Part B3. Given the existing controls in place the predicted impacts from seismic acquisition are not considered to be ecologically significant at a population level for whales or any other species of cetacean.	Not considered – Cost outweighs limited benefit. Part B of EPBC Act Policy Statement 2.1 is intended for locations where there is an increased likelihood of encountering cetaceans. The Operational Area is not located near any significant cetacean habitat and cetaceans are expected in relatively low numbers.	No
Application of EPBC Act Policy Statement 2.1 Part B.4 – Increased precaution zones	F: Yes CS: Potential costs and schedule impacts due to potential delays in acquiring data. Any delays to the seismic program could result in significant cost and operational implications. It would also extend the duration of the survey, increasing impacts to other receptors (e.g. fisheries).	Given the absence of any interaction between critical habitats (i.e. feeding, breeding, calving) or a constricted migratory pathway, no benefit is considered by implementing EPBC Policy Statement 2.1 Part B4. Given the existing controls in place the predicted impacts from seismic acquisition are not considered to be ecologically significant at a population level for whales or any other species of cetacean. The proposed standard observation zones are considered to be sufficient to protect against PTS and limit potential for TTS.	Not considered – Cost outweighs limited benefit. Part B of EPBC Act Policy Statement 2.1 is intended for locations where there is an increased likelihood of encountering cetaceans. The Operational Area is not located near any significant cetacean habitat and cetaceans are expected in relatively low numbers.	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[6]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Application of EPBC Act Policy Statement 2.1 Part B.5 – Passive Acoustic Monitoring (PAM): • a PAM system will be installed aboard the survey vessel to detect cetaceans	F: Yes CS: Cost of PAM system plus trained PAM operator(s) on board the vessel. To enable PAM to be utilized more efficiently, more complex PAM systems would be required with a dedicated vessel, at significant cost.	Potential to identify toothed cetaceans which do not breach the sea surface (e.g. on long dives). However, it may be difficult to detect the distance and direction of cetaceans to enable implementation of precaution zones. Only applicable to vocalising cetaceans, PAM very dependent on environmental conditions.	Not considered – Cost outweighs limited benefit. Part B of EPBC Act Policy Statement 2.1 is intended for locations where there is an increased likelihood of encountering cetaceans. The Operational Area is not located near any significant cetacean habitat and cetaceans are expected in relatively low numbers.	No
Application of EPBC Act Policy Statement 2.1 Part B.6 – Adaptive Management, e.g. • relocate to a different survey line or cease night-time operations if there are three consecutive days on which operators experience three or more whale-instigated shut down/power down situations.	F: No. Given the small 2D / 3D area that will be acquired, relocation of the seismic vessel by any meaningful distance to another part of the survey is unlikely to be possible. CS: Significant cost and schedule impacts due to potential delays in acquiring data. Any delays to the seismic program could result in significant cost and operational implications. It would also extend the duration of the survey, increasing impacts to other receptors (e.g. fisheries).	Based on the timing and duration of the Petroleum Activities Program, the absence of significant habitat for cetaceans and the other control measures proposed, adaptive management will provide limited benefit.	Not considered – control not feasible. Cost outweighs limited benefit. Part B of EPBC Act Policy Statement 2.1 is intended for locations where there is an increased likelihood of encountering cetaceans. The Operational Area is not located near any significant cetacean habitat and cetaceans are expected in relatively low numbers.	No
Good Practice				
Seismic source validation	F: Yes CS: Source modelling can be undertaken at minimal cost and relatively quickly.	If the seismic source selected for the Petroleum Activities Program is significantly different to the source modelled and assessed in Welch et al. (2020; **Appendix J**), then additional source modelling will be undertaken to confirm	Benefits outweigh cost/sacrifice.	Yes **6.1**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[6]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
		whether the sound levels are consistent with levels assessed as acceptable in this EP.		
Adaptive Management Measures – marine turtles. During June to September (flatback turtle peak internesting period), a 5 km exclusion zone will be applied around the flatback turtle internesting Habitat Critical, inside which the source cannot be operated at full power. This 5 km buffer is conservatively based on the maximum behavioural response onset distance of 4.04 km.	F: Yes CS: Potential cost and schedule impacts due to potential delays in acquiring data.	Proposed measures are considered to be a practicable alternative to no acquisition in the flatback turtle Habitat Critical during the nesting period. Proposed measures may provide benefit by limiting potential disturbance to internesting turtles during the peak nesting season.	Benefits outweigh cost/sacrifice.	Yes **C 7.1**
No operation of the seismic source within 250 m horizontal distance of the 80 m depth contour of Lynedoch Bank. No operation of the seismic source within 250 m horizontal distance of the 40 m depth contour of Goodrich Bank and other shoals within south-west part of the Active Source Area.	F: Yes CS: Cost associated with not being able to acquire data in shallow water locations.	The proposed measure provides a precautionary approach to prevent injury or mortality in site-attached fish assemblages.	Benefits outweigh cost/sacrifice.	Yes **C 8.1**
The seismic vessel will not return to acquire reacquisition shot points within 1 km horizontal distance from the 80 m depth contour of Lynedoch Bank or the 40 m depth contour at Goodrich Bank, within a 24-hour period to enable recovery of TTS in site attached fishes.	F: Yes CS: Given the broad line spacing of the 2D acquisition, line positions or the acquisition sequence can be managed such that the proposed control can be implemented without delay or significant cost to the survey.	By not returning with the specified distances of the banks and shoals, site-attached fish are able to recover from the effects of TTS. Recovery can occur before additional sound exposures occur that could increase TTS or the potential for PTS.	Benefits outweigh cost/sacrifice.	Yes **C 8.2**
Engage with facility operators, commercial diving companies, scientific research groups, and recreational dive operators. This process will adhere to the following recommended requirements of the	F: Yes CS: Minimal additional cost. Pre-survey notifications will be sent to relevant diving stakeholders.	Reduces potential health and safety risks to commercial and recreational divers	Benefits outweigh cost/sacrifice.	Yes **C 1.5**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[6]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
revised DMAC 12 guidelines: • Where diving and seismic activity are scheduled to occur within a distance of 45 km, Woodside will notify divers of the planned activity where practicable. • Where diving and seismic activity will occur within a distance of 30 km a joint risk assessment should be conducted, between the clients/operators involved and the seismic and diving contractors in advance of any simultaneous operations.				
Woodside will consider evidence based claims from commercial fishing licence holders where: • there is genuine displacement from undertaking normal fishing activities that results in demonstratable economic loss • deployed fishing equipment has been accidentally lost or damaged by any activities under Woodside's control • there is a loss of catch due to the seismic survey that can be demonstrated.	F: Yes. CS: Minimal-Moderate cost.	In the event fish behaviours and distributions are temporarily altered during and in the days immediately following the activity, control will reduce the consequence to commercial fishers impacted.	Benefits outweigh cost/sacrifice.	Yes **C 3.1**
A 40 km separation distance between the Petroleum Activities Program and any identified concurrent seismic survey.	F: Yes CS: In the event that other surveys are present in the region, a 40 km separation distance may result in delays due to vessel downtime or loss of survey area.	The Bureau of Ocean Energy Management (BOEM, 2014) published an environmental review of geological and geophysical survey activities in the south Atlantic Ocean. To minimise impacts to marine life by providing a 'corridor' between	Benefits outweigh cost/sacrifice.	Yes **C 11.1**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[6]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
		vessels, the environmental impact statement from this review included a requirement for a 40 km geographic separation distance (based on worst case scenarios) between the sources of simultaneous seismic surveys.		
Application of EPBC Policy Statement 2.1 Part A Standard Management Procedures to dolphins.	F: Yes CS: Increased costs of the survey through additional shutdowns, prolonging the survey duration. Any delays to the seismic program could result in significant cost and operational implications. It would also extend the duration of the survey, increasing impacts to other receptors (e.g. fisheries).	PTS or TTS effects to dolphins are not predicted to occur from exposure to a single impulse. PTS or TTS effects to dolphins resulting from 24-hours of exposure are predicted to be limited to within 20 m of the acquired survey lines. More realistically, dolphins would not stay in the same location for 24-hours, but rather a shorter period, depending upon their behaviour and the proximity and movements of the source. The survey is not located in an area that provides for unique or significant habitat for dolphins. Application of EPBC Policy Statement 2.1 Part A Standard Management Procedures is not expected to provide significant environmental benefit.	Not considered – Cost outweighs limited benefit.	No
Application of EPBC Policy Statement 2.1 Part A Standard Management Procedures to marine turtles.	F: Yes CS: Increased costs of the survey through additional shutdowns, prolonging the survey duration. Any delays to the seismic program could result in significant cost and operational implications. It would also extend the duration of the survey, increasing impacts to other receptors (e.g. fisheries).	PTS or TTS effects to turtles are not predicted to occur from exposure to a single impulse. PTS or TTS effects to turtles resulting from 24-hours of exposure are predicted to be limited to within 200 m of the acquired survey lines. More realistically, dolphins would not stay in the same location for 24-hours, but rather a shorter period, depending upon their	Not considered – Cost outweighs limited benefit.	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[6]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
		behaviour and the proximity and movements of the source. Application of EPBC Policy Statement 2.1 Part A Standard Management Procedures is not expected to provide significant environmental benefit.		
No operation of the seismic source in the flatback turtle internesting BIA and Habitat Critical during the internesting period (June to September).	F: No CS: There is a minor overlap between the Active Source Area and the outer extent of the defined internesting Habitat Critical. However, given the small size of the survey, and required timing of the survey, there is the potential that the survey may not be able to be acquired in a timeframe that allows for acquisition in a key area of the Active Source Area.	Provides a precautionary approach to prevent disturbance to internesting flatback turtles. The Recovery Plan for Marine Turtles in Australia specifies a precautionary approach will be applied, such that no operation of the seismic source will take place inside important internesting habitat during the nesting season. As described in the above assessment, the Petroleum Activities Program is located offshore in a location that is not expected to support significant numbers or internesting turtles.	Not considered – control not feasible. Cost outweighs limited benefit.	No
Professional Judgement – Eliminate				
None identified				
Professional Judgement – Substitute				
None identified				
Professional Judgement – Engineered Solution				
None identified				
ALARP Statement On the basis of the environmental impact assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type B), Woodside considers the adopted controls appropriate to manage the impacts and risks of noise emissions generated from seismic source. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability		
Receptor	***Acceptability Criteria and Assessment***	***Statement of Acceptability***
Migratory and threatened cetaceans	**Principles of ESD** The impact assessment has considered the relevant principles of ESD: • The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making. • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. **Internal Context** The Petroleum Activities Program is consistent with Woodside corporate policies, culture, processes, standards, structure and systems as outlined in the Demonstration of ALARP and Environmental Performance Outcomes, including: • Woodside Health, Safety and Environment Policy (**Appendix A**) • Woodside Risk Management Policy (**Appendix A**). **External Context** During stakeholder consultation no concerns specifically relating to cetaceans were raised. However, DNP requested Woodside ensure impacts and risks to AMP values were identified and managed to ALARP and acceptable levels, including impacts to species listed as threatened, migratory or cetacean. This has been addressed through the implementation of controls (**PS 5.1**, **5.2** and **6.1**) and demonstration that impacts from seismic acoustic emissions to cetaceans will be managed to levels that are ALARP and acceptable. **Other Requirements** The proposed control measures exceed the required standards and control measures set out in EPBC Policy Statement 2.1. Part A Standard Management Measures (DEWHA, 2008). The proposed control measures are not inconsistent with the requirements of recovery plans or wildlife conservation plans/advice as demonstrated in **Section 6.6**. The impact assessment has determined that seismic acquisition may be undertaken in a manner that is not inconsistent with the requirements of the Conservation Management Plan for the Blue Whale, specifically which 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*'. The pygmy blue whale migration BIA is located approximately 175 km north-west from the Active Source Area and acoustic modelling demonstrate that injury and TTS effects will not occur in the BIA. There are no known foraging areas near the Galactic Hybrid 2D MSS Operational Area. The impact assessment and proposed control measures are consistent with NOPSEMA Acoustic Impact Evaluation and Management Guideline (N-04750-IP1765 Rev2 Dec 2018).	The predicted level of impact to migratory and threatened cetaceans is considered to be of an acceptable level (E- Slight), given that: • the Petroleum Activities Program is consistent with the relevant principles of ESD • the proposed controls have considered the environmental consequence and are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the Petroleum Activities Program will be managed in a manner that is not inconsistent with management objectives for relevant WHPs, AMPs, recovery plans and conservation plans/advices • the predicted level of impact has been reduced to ALARP. **Environmental Performance Consideration** To manage impacts to migratory and threatened cetaceans to an acceptable level the following EPOs have been applied: **EPO 5**: Undertake seismic acquisition in a manner that prevents physical injury to cetaceans. **EPO 6**: Far-field source levels for the selected seismic source for the Galactic Hybrid 2D MSS are consistent with levels assessed in this EP.

<table>
<tr><th colspan="3">Demonstration of Acceptability</th></tr>
<tr><th>Receptor</th><th>Acceptability Criteria and Assessment</th><th>Statement of Acceptability</th></tr>
<tr><td></td><td>No significant or long-term impacts are expected to occur to key habitats of EPBC Act listed species included as values of the Oceanic Shoals AMP.</td><td></td></tr>
<tr><td>Migratory and threatened marine turtles</td><td>Principles of ESD
The Petroleum Activities Program is consistent with the relevant principles of ESD:
• The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making.
• Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
Internal Context
The Petroleum Activities Program is consistent with Woodside corporate policies, culture, processes, standards, structure and systems as outlined in the Demonstration of ALARP and Environmental Performance Outcomes, including:
• Woodside Health, Safety and Environment Policy (Appendix A)
• Woodside Risk Management Policy (Appendix A).
External Context
During stakeholder consultation no concerns specifically relating to turtles were raised. However, DNP requested Woodside ensure impacts and risks to AMP values were identified and managed to ALARP and acceptable levels, including impacts to species listed as threatened and/or migratory and foraging and internesting BIAs for marine turtles. This has been addressed through the implementation of controls (PS 6.1 and 7.1) and demonstration that impacts from seismic acoustic emissions to marine turtles will be managed to levels that are ALARP and acceptable.
Other requirements
The proposed control measures are not inconsistent with the applicable objectives and actions of the Recovery Plan for Marine Turtles (Commonwealth of Australia, 2017a). Specifically, controls measures will 'manage anthropogenic activities to ensure marine turtles are not displaced from identified Habitat Critical to the survival' of marine turtles and 'given that the impacts of noise are unknown, a precautionary approach [will] be applied to seismic work, such that surveys planned to occur inside important internesting habitat should be scheduled outside the nesting season'. Relevant controls have been adopted to ensure consistency with these actions such that that received noise levels from seismic acquisition are not likely to cause injury, displace any individuals from Habitat Critical or internesting BIAs, or result in any ecologically significant impacts at a population level for any species of marine turtle that may be present within or adjacent to the Operational Area during the Petroleum Activities Program.</td><td>The predicted level of impact for migratory and threatened marine turtles is considered to be of an acceptable level (E- Slight), given that:
• the Petroleum Activities Program is aligned with the relevant principles of ESD
• the proposed controls have considered the environmental consequence and are consistent with Woodside's internal policies, procedures and standards
• feedback from stakeholders has been taken into consideration
• legislative requirements/industry standards have been adopted
• the Petroleum Activities Program will be managed in a manner that is consistent with management objectives for relevant WHPs, AMPs, recovery plans and conservation plans/advices
• the predicted level of impact has been reduced to ALARP.
Environmental Performance Considerations
To manage potential impacts to migratory and threatened marine turtles to an acceptable level, the following EPOs have been applied:
EPO 6: Far-field source levels for the selected seismic source for the Galactic Hybrid 2D MSS are consistent with levels assessed in this EP.
EPO 7: Undertake seismic acquisition in a manner that prevents physical injury to marine turtles.</td></tr>
</table>

Demonstration of Acceptability		
Receptor	***Acceptability Criteria and Assessment***	***Statement of Acceptability***
	The impact assessment and proposed control measures are consistent with NOPSEMA Acoustic Impact Evaluation and Management Guideline (N-04750-IP1765 Rev2 Dec 2018). Nesting and internesting marine turtle habitats are identified as a natural value of the Oceanic Shoals AMP. No significant impacts to internesting marine turtles are predicted and the Activity will be undertaken consistent with marine park objectives.	
Migratory and threatened fishes	**Principles of ESD** The Petroleum Activities Program is consistent with the relevant principles of ESD: • The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making. • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. **Internal Context** The Petroleum Activities Program is consistent with Woodside corporate policies, culture, processes, standards, structure and systems as outlined in the Demonstration of ALARP and Environmental Performance Outcomes, including: • Woodside Health, Safety and Environment Policy (**Appendix A**) • Woodside Risk Management Policy (**Appendix A**). **External Context** During stakeholder consultation, the NPFI raised concerns regarding potential impacts to listed threatened and/or migratory sawfishes. DNP also requested Woodside ensure impacts and risks to AMP values were identified and managed to ALARP and acceptable levels, including impacts to species listed as threatened, migratory species. These concerns have been considered in this EP through consideration of the habitats and distribution of sawfish and other migratory and threatened fish species. Impacts to these species as a result of the seismic survey are likely to be limited to localised and temporary behavioural disturbance and no impacts to key life stages or nursery habitats are expected. No habitat degradation will occur and impacts and risks will be managed to levels that are ALARP and acceptable. **Other Requirements** There are no legislative requirements applicable to managing the effects of seismic surveys in relation to threatened and/or migratory fishes. Seismic noise has not been identified as a threat to any threatened or migratory fish species identified as possibly present in the region in recovery plans or wildlife conservation plans/advice.	The predicted level of impact for migratory and threatened fishes is considered to be of an acceptable level (E- Slight), given that the: • the Petroleum Activities Program is aligned with the relevant principles of ESD • the proposed controls have considered the environmental consequence and are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the Petroleum Activities Program will be managed in a manner that is consistent with management objectives for relevant WHPs, AMPs, recovery plans and conservation plans/advices • the predicted level of impact has been reduced to ALARP. **Environmental Performance Considerations** To manage potential impacts to migratory and threatened fishes to an acceptable level, the following EPOs have been applied: **EPO 6:** Far-field source levels for the selected seismic source for the Galactic Hybrid 2D MSS are consistent with levels assessed in this EP. **EPO 8**: Undertake seismic acquisition in a manner that prevents injury/mortality and

<table>
<tr><th colspan="3">Demonstration of Acceptability</th></tr>
<tr><th>Receptor</th><th>Acceptability Criteria and Assessment</th><th>Statement of Acceptability</th></tr>
<tr><td></td><td>Noise pollution is not identified as a pressure to threatened or migratory fish in the Marine Bioregional Plan for the NMR (DSEWPaC, 2012).
The impact assessment and proposed control measures are consistent with NOPSEMA Acoustic Impact Evaluation and Management Guideline (N-04750-IP1765 Rev2 Dec 2018).</td><td>reduces the potential for TTS in site-attached fish.</td></tr>
<tr><td>Fish spawning and commercial fisheries</td><td>Principles of ESD
The Petroleum Activities Program is consistent with the relevant principles of ESD:
• The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making.
• Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
Internal Context
The Petroleum Activities Program is consistent with Woodside corporate policies, culture, processes, standards, structure and systems as outlined in the Demonstration of ALARP and Environmental Performance Outcomes, including:
• Woodside Health, Safety and Environment Policy (Appendix A)
• Woodside Risk Management Policy (Appendix A).
External Context
During stakeholder consultation a stakeholder in the Timor Reef Fishery claimed that their experience in this area with previous seismic programs showed immediate effects on fish behaviour and longer term localised stock depletion.
These concerns have been considered in this EP through review of studies on the physiological and behavioural responses of fishes to seismic sound, as well as the potential spatial and temporal overlap of the survey and potential spawning areas. The Petroleum Activities Program will not result in changes to the spawning biomass or changes in recruitment of commercially important species that may be discernible from normal natural variation. The Petroleum Activities Program will not impact commercial fishery catch rates. The potential impacts of noise emissions from the seismic source on spawning of key indicator commercial fish species are considered to be slight and short-term, and the Activity is not likely to result in any ecologically significant impacts at a population level for any key indicator commercial fish species that may be spawning within or adjacent to the Operational Area during acquisition activities.
Stakeholder concerns have further been considered in this EP through the implementation of a series of controls (PS 3.1 and 6.1) and demonstration that impacts from seismic acoustic emissions to fishes will be managed to levels that are ALARP and acceptable.
Other Requirements</td><td>The predicted level of impact for fish spawning and commercial fisheries is considered to be of an acceptable level (E- Slight), given that
• the Petroleum Activities Program is aligned with the relevant principles of ESD
• the proposed controls have considered the environmental consequence and are consistent with Woodside’s internal policies, procedures and standards
• feedback from stakeholders has been taken into consideration
• legislative requirements/industry standards have been adopted
• the predicted level of impact has been reduced to ALARP.
Environmental Performance Considerations
To manage potential impacts to fish spawning and commercial fisheries to an acceptable level, the following EPOs have been applied:
EPO 6: Far-field source levels for the selected seismic source for the Galactic Hybrid 2D MSS are consistent with levels assessed in this EP.
EPO 10: Undertake seismic acquisition in a manner that minimises impacts to commercial fishers.</td></tr>
</table>

Demonstration of Acceptability		
Receptor	***Acceptability Criteria and Assessment***	***Statement of Acceptability***
	There are no legislative requirements applicable to managing the effects of seismic surveys in relation to fish spawning and commercial fisheries. Woodside acknowledges the recent Seismic Senate Inquiry Report, Making waves: the impact of seismic testing on fisheries and the marine environment, and is monitoring for changes in legislation. The proposed control measures are consistent with key mitigation strategies for seismic surveys published in the WA Department of Fisheries Guidance statement on undertaking seismic surveys in Western Australian waters (DoF, 2013) – e.g. use of soft starts; minimise the sound intensity and exposure time of surveys. Woodside has also considered DPIRD's ecological risk assessment of seismic impacts to marine finfish and invertebrates (Webster et al., 2018) during the assessment of impacts and risks to fish spawning and commercial fisheries, noting that the DPIRD risk assessment considers worst-case potential impacts to individual finfish and invertebrates assuming they do not move to avoid an approaching seismic source. This is not representative of real-life sound exposures and does not represent impacts at a population level. Woodside has, therefore, considered additional information to assess impacts to fish spawning and fish stock populations. The impact assessment and proposed control measures are consistent with NOPSEMA Acoustic Impact Evaluation and Management Guideline (N-04750-IP1765 Rev2 Dec 2018).	
AMPs	**Principles of ESD** The Petroleum Activities Program is consistent with the relevant principles of ESD: • The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making. • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. **Internal Context** The Petroleum Activities Program is consistent with Woodside corporate policies, culture, processes, standards, structure and systems as outlined in the Demonstration of ALARP and Environmental Performance Outcomes, including: • Woodside Health, Safety and Environment Policy (**Appendix A**) • Woodside Risk Management Policy (**Appendix A**). **External Context** During stakeholder consultation DNP requested Woodside Identify and manage all impacts and risks on AMP values (including ecosystem values) to an acceptable level and considers all options to avoid or reduce them to as low as reasonably practicable, as well as clearly demonstrate that the activity will not	The predicted level of impact for AMPs is considered to be of an acceptable level (E-Slight), given that: • the Petroleum Activities Program is consistent with the relevant principles of ESD • the proposed controls have considered the environmental consequence and are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the Petroleum Activities Program will not be inconsistent with the principles or management objectives of the North

Demonstration of Acceptability		
Receptor	***Acceptability Criteria and Assessment***	***Statement of Acceptability***
	be inconsistent with the North Marine Park Network Management Plan. DNP provided a list of specific values for the Oceanic Shoals AMP which overlaps the Operational Area, including (but not limited to): • species listed as threatened, migratory, marine or cetacean. • BIAs including foraging and interesting habitat for marine turtles. • KEFs including the Carbonate bank and terrace systems of the Van Diemen Rise, Carbonate bank and terrace system of the Sahul Shelf, Pinnacles of the Bonaparte Basin, Shelf break and slope of the Arafura Shelf. Impacts from seismic noise to threatened and migratory species associated with the values of the Oceanic Shoals AMP, including cetaceans, turtles, fishes and any important habitat for these species overlapping the Operational Area have been assessed above. Impacts to commercially important fish communities, including those associated with KEFs within the Oceanic Shoals AMP, have also been assessed above. Site-attached fish communities associated with shoals and banks within the Oceanic Shoals AMP have been addressed through the implementation of additional controls (**PS 8.1**, **8.2** and **6.1**) to ensure impacts to these species from seismic noise will be managed to levels that are ALARP and acceptable. DNP also requested Woodside ensure that the Operational Area, which includes the vessel, streamer or node repositioning, does not include any activity within Oceanic Shoals AMP Habitat Protection or National Park Zones. This is confirmed by the defined location of the Petroleum Activities Program (**Section 3.4**). **Other Requirements** The proposed controls and consequence level are consistent with: • Australian IUCN Reserve Management Principles and objectives of the IUCN Category VI Zone, as outlined in the North Marine Parks Network Management Plan (DNP, 2018) • the zone management categories outlined in the North Marine Parks Network Management Plan, and values of the Oceanic Shoals AMP.	Marine Parks Network Management Plan (DNP, 2018) • the Petroleum Activities Program will be undertaken in a manner that is consistent with the zone management categories outlined in the North Marine Parks Network Management Plan, and values of the Oceanic Shoals AMP • the predicted level of impact has been reduced to ALARP. **Environmental Performance Considerations** The Petroleum Activities Program will not impact the values or management objectives of AMPs or the North Marine Parks Network. The following EPOs have been applied: **EPO 5**: Undertake seismic acquisition in a manner that prevents physical injury to cetaceans. **EPO 6:** Far-field source levels for the selected seismic source for the Galactic Hybrid 2D MSS are consistent with levels assessed in this EP. **EPO 7**: Undertake seismic acquisition in a manner that prevents physical injury to marine turtles. **EPO 8**: Undertake seismic acquisition in a manner that prevents injury/mortality and reduces the potential for TTS in site-attached fish. **EPO 10:** Undertake seismic acquisition in a manner that minimises impacts to commercial fishers.
Other environmental values (ecosystems/h	**Principles of ESD** The Petroleum Activities Program is consistent with the relevant principles of ESD:	The predicted level of impact for other environmental values is considered to be of an acceptable level (E- Slight), given that:

Demonstration of Acceptability		
Receptor	***Acceptability Criteria and Assessment***	***Statement of Acceptability***
abitats, species and socio-economic)	• The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making. • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. **Internal Context** The Petroleum Activities Program is consistent with Woodside corporate policies, culture, processes, standards, structure and systems as outlined in the Demonstration of ALARP and Environmental Performance Outcomes, including: • Woodside Health, Safety and Environment Policy (**Appendix A**) • Woodside Risk Management Policy (**Appendix A**). **External Context** The impact assessment has evaluated potential for interaction with diving (e.g. NT Aquarium Fishery) and recreational fishing. Feedback from game fishing operators indicated only one Darwin-based charter company that may undertake charters near the Operational Area. Feedback from that operator was that it was highly unlikely it would be in the area, though there was a possibility due to weather implications. Stakeholder feedback has been considered in the assessment of impacts and will be managed through the implementation of controls (**PS 1.5**, **6.1** and **11.1**) and demonstration that impacts from seismic acoustic emissions to cetaceans will be managed to levels that are ALARP and acceptable. **Other Requirements** The proposed controls and consequence level are consistent with the DMAC 12 guidelines. No additional legislative requirements applicable to managing the effects of seismic surveys in relation to other identified environment values have been identified.	• the Petroleum Activities Program is aligned with the relevant principles of ESD • the proposed controls have considered the environmental consequence and are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the Petroleum Activities Program will be managed in a manner that is consistent with management objectives for relevant WHPs, AMPs, recovery plans and conservation plans/advices • the predicted level of impact has been reduced to ALARP. **Environmental Performance Considerations** To manage potential impacts to other environmental values to at or below the defined acceptable levels, the following EPOs have been applied: **EPO 6:** Far-field source levels for the selected seismic source for the Galactic Hybrid 2D MSS are consistent with levels assessed in this EP. **EPO 9**: Undertake seismic acquisition in a manner that prevents injury to any diver. **EPO 11:** Undertake seismic acquisition in a manner that reduces potential cumulative impacts resulting from the Petroleum Activities Programme and other seismic survey operations as far as reasonably practicable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 5 Undertake seismic acquisition in a manner that prevents physical injury to whales.	**C 5.1** Application of EPBC Policy Statement 2.1 Part A Standard Management Procedures to whales, as outlined below: • observation zone: 3 km+ • low power zone: 2 km • shut-down zone: 500 m • observation and compliance reporting: − Use of vessel crew trained in marine fauna observations and monitoring for compliance to Policy Statement 2.1. − Records kept of marine fauna observations during all surveys. • pre start-up visual observation (30 minutes) • soft start procedure (30 minutes) • start-up delay procedure (if sighting occurs) • operations procedure • stop work (shut down) procedure • night-time and low visibility procedure.	**PS 5.1** Compliance with EPBC Policy Statement 2.1 – Part A Standard Management Procedures.	**MC 5.1.1** Records demonstrate compliance with Policy Statement 2.1 Part A.
	C 5.2 Application of EPBC Policy Statement 2.1 Part B.1 – MFOs: • employ two dedicated MFOs to undertake observations for EPBC Act Policy Statement 2.1.	**PS 5.2** Two dedicated MFOs will be employed to undertake observations for EPBC Act Policy Statement 2.1.	**MC 5.2.1** Records demonstrate two dedicated MFOs are on board and undertake observations in accordance with EPBC Act Policy Statement 2.1.

EPO 6 Far-field source levels for the selected seismic source for the Galactic Hybrid 2D MSS are consistent with levels assessed in this EP.	**C 6.1** Seismic source validation	**PS 6.1** In the event that a seismic source is selected for the Galactic Hybrid 2D MSS that is significantly different to the modelled source[7], additional acoustic source modelling will be undertaken using the JASCO AASM model to confirm that the far-field horizontal source level specifications of the seismic source selected for the Galactic Hybrid 2D MSS are comparable to those assessed in this EP.	**MC 6.1.1** Acoustic source modelling report for selected seismic source
EPO 7 Undertake seismic acquisition in a manner that prevents physical injury to marine turtles	**C 7.1** Adaptive Management Measures – Turtles. During June to September, a 5 km exclusion zone will be applied around the flatback turtle internesting Habitat Critical, inside which the source will not be operated at full power.	**PS 7.1** Adaptive Management Measures – Turtles implemented. During June to September, a 5 km exclusion zone will be applied around the flatback turtle internesting Habitat Critical, inside which the source will not be operated at full power.	**MC 7.1.1** Records demonstrate compliance with marine turtle adaptive management measures as described.
EPO 8 Undertake seismic acquisition in a manner that prevents injury/mortality and reduces the potential for TTS in site-attached fish	**C 8.1** No operation of the seismic source within 250 m horizontal distance of the 80 m depth contour of Lynedoch Bank. No operation of the seismic source within 250 m horizontal distance of the 40 m depth contour of Goodrich Bank and other shoals within south-west part of the Active Source Area.	**PS 8.1** No operation of the seismic source within 250 m horizontal distance of the 80 m depth contour of Lynedoch Bank. No operation of the seismic source within 250 m horizontal distance of the 40 m depth contour of Goodrich Bank and other shoals within south-west part of the Active Source Area.	**MC 8.1.1** Survey records demonstrate that the seismic source has not been operated within the described exclusion zones.
	C 8.2 The seismic vessel will not return to acquire reacquisition shot points within 1 km horizontal distance from the 80 m depth contour at Lynedoch Bank or the 40 m depth contour at Goodrich Bank, within a 24-hour period to enable recovery of TTS in site attached fishes.	**PS 8.2** The seismic vessel will not return to acquire reacquisition shot points within 1 km horizontal distance from the 80 m depth contour at Lynedoch Bank or the 40 m depth contour at Goodrich Bank, within a 24-hour period to enable recovery of TTS in site attached fishes.	**MC 8.2.1** Survey records demonstrate compliance with the described performance standard.
EPO 9 Undertake seismic acquisition in a manner that prevents injury to any diver	**C 1.5** See **Section 6.4.1**	**PS 1.5** See **Section 6.4.1**	**MC 1.5.1** See **Section 6.4.1**

EPO 10 Undertake seismic acquisition in a manner that minimises impacts to commercial fishers	**C 3.1** See **Section 6.4.1**	**PS 3.1** See **Section 6.4.1**	**MC 3.1.1** See **Section 6.4.1**
EPO 11 Undertake seismic acquisition in a manner that reduces potential cumulative impacts resulting from the Petroleum Activities Programme and other seismic survey operations as far as reasonably practicable.	**C 11.1** A 40 km separation distance between the Petroleum Activities Program and any identified concurrent seismic survey.	**PS 11.1** A 40 km separation distance between the Petroleum Activities Program and any identified concurrent seismic survey.	**MC 11.1.1** Records demonstrate compliance with the 40 km separation distance. Records demonstrate consultation with other seismic companies of seismic surveys and titleholders with acreage within 40 km of the Operational Area prior to commencement of the activity.

[7] "Significantly different" is defined as a difference of 3 dB or greater than the modelled peak source pressure levels in the broadside, endfire and vertical directions (see Table 9 in Welch et al., 2020; **Appendix I**), as determined by seismic contractor in-house modelling of their proposed array (e.g. Gundalf, Nucleus+ outputs).

6.4.4 Routine Acoustic Emissions: Vessels, Helicopters, AUV and Commercial Nodes and Mechanical Equipment Operation

Context		
Project Vessels – **Section 3.6.5** Helicopters – **Section 3.6.6** AUV Nodes **– Section 3.6.3.2**	Physical Environment – **Section 4.3** Biological Environment – **Section 4.4**	Stakeholder Consultation – **Section 5**

Impact Evaluation Summary

Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcomes
Generation of noise from project vessels, helicopters, AUV nodes and mechanical equipment during normal operations (excluding seismic survey equipment).						X		A	F	-	-	LCS GP	Broadly acceptable	EPO 12

Description of Source of Impact

During the Petroleum Activities Program, both atmospheric and underwater noise will be generated from the project vessels (seismic vessel and support vessel(s)), helicopters and AUV nodes during normal operations.

Project Vessels

Project vessels will generate noise, due to the operation of thruster engines, propeller cavitation, on-board machinery etc. These noises will contribute to and have the potential to exceed ambient noise levels which range from around 90 dB re 1 µPa (root square mean sound pressure level (rms SPL)) under very calm, low wind conditions, to 120 dB re 1µPa (rms SPL) under windy conditions (McCauley, 2005).

The sound level and frequency characteristics ('signature') of discernible ships depend on their size, number of propellers, number and type of propeller blades, blade biofouling condition and machinery/transmission maintenance condition. In general, the larger the ship the louder the source level and the lower its frequency. A typical support vessel's peak frequency or band ranges from 1–500 Hz at a peak source level of 170-190 dB re 1 µPa at 1 m. It is expected that similar noise levels will be generated by vessels used for this Petroleum Activities Program.

Helicopters

Helicopter engines and rotor blades are recognised as a source of noise emissions, which may constitute a source of environmental risk resulting in behavioural disturbance to marine fauna. Helicopter activities may occur in the Operational Area, including the landing and take-off of helicopters on the seismic vessel helideck. Sound emitted from helicopter operations is typically below 500 Hz (Richardson et al., 1995). The peak received level diminishes with increasing helicopter altitude, but the duration of audibility often increases with increasing altitude. Richardson et al. (1995) reports that helicopter sound is audible in air for four minutes before it passed over underwater hydrophones, but detectable underwater for only 38 seconds at 3 m depth and 11 seconds at 18 m depth. Noise levels reported for a Bell 212 helicopter during fly-over was reported at 162 dB re 1 µPa and for Sikorsky-61 is 108 dB re 1 µPa at 305 m (Simmonds et al., 2004).

AUV and commercial nodes

Approximately 15-20 AUV and commercial nodes may be deployed within the Active Source Area to collect seismic data. The nodes will be deployed on the seabed along the 20 km lengths of the three existing intersecting lines during the survey. At the end of the survey, when the streamer is recovered, the seismic vessel will re-acquire approximately 20 km lengths along these three lines for a period of between 24 to 48 hr with the same source configuration and source interval. Each AUV node is planned to have approximately five placements along these lines during this final trial period before retrieval.

The AUV nodes use current AUV technology similar to Slocum gliders – these are autonomous vehicles that pump oil between an internal reservoir within the vehicle's housing and an external bladder to move up and down through the water column by changing buoyancy. While generally considered quiet, Slocum gliders produce self-noise in two ways; rudder noise produced by an electric servo-motor that controls the glider's rudder, and pump noise generated by the buoyancy engine pumping oil to and from the external bladder reservoir and glider housing to initiate dives and ascents (Haxel et al., 2019). Haxel et al. (2019) investigated the self-noise produced by a Teledyne Webb Research Slocum G2 glider in an open ocean environment. Short-duration rudder noise was most prominent within the frequency bands of <1 kHz and 2.6-4.4 kHz, with an increase in noise levels up to 30 dB re 1 µPa²/Hz in these frequency bands (Haxel et al. 2019). Pump noise was characterised by long duration, high amplitude, impulse-like spikes covering the entire frequency range of the recording (Hazel et al. 2019). Küsel et al. (2017) report pump noise at sound levels up to around 135 dB re 1 µPa at 1 m.

Positioning of the AUV nodes will be supported by USBL acoustic positioning updates from the surface vessels. USBL transponders typically emit pulses of medium frequency sound, generally within the range 21 to 31 kHz. The estimated SPL would be 180 to 206 dB re 1 µPa at 1 m (Jiménez-Arranz et al., 2017). Transmissions are not continuous but consist of short 'chirps' with a duration that ranges from 3 to 40 milliseconds every one to five seconds.

The AUV nodes will be paired with equivalent commercial nodes to ground truth the technology in terms of the verification of seismic data recorded. Nodes do not produce significant noise when stationay and would emit similar noise to an ROV when in motion. As an additional control the commercial nodes may most probably be deployed and recovered by a small ROV but may also be tethered by a rope to a buoy. The ROV will generate low level noise from the electric motors when in operation, mainly when launching and recovering the nodes.

Impact Assessment

Potential Impacts to Environmental Values

Receptors

The Operational Area is located in water depths ranging from approximately 11 m to 405 m. The fauna associated with these areas will be predominantly pelagic species of fish, with the potential for the transient presence of other species such as cetaceans, turtles and whale sharks (refer to **Section 4.4.4.5**).

The Operational Area partially overlaps with the internesting BIA and Habitat Critical area for the flatback turtle. The 80 km internesting buffer for flatback turtles in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017a) is considered very conservative. A more recent study by Whittock et al. (2016) defined suitable internesting habitat as water 0–16 m deep and within 5–10 km of the coastline, while unsuitable internesting flatback habitat was defined as waters >25 m deep and >27 km from the coastline. The primary environmental variables that influenced flatback internesting movement were bathymetry, distance from coastline, and sea surface temperature (Whittock et al., 2016). There is no evidence to date to indicate that flatback turtles swim out into deep offshore waters during the internesting period. Additionally, suitable areas of internesting habitat were located close to many known flatback turtle rookeries across the region (Whittock et al., 2016). It is important to note that flatback turtle hatchlings do not undertake oceanic migrations offshore to deep, pelagic waters. Instead juveniles grow to maturity in shallow coastal waters close to their natal beaches (Musick and Limpus, 1996). Therefore, the Operational Area is unlikely to represent important habitat for marine turtles. The occurrence of all marine turtle species within the Operational Area is expected to be limited to infrequent occurrences of transitory individuals.

No BIAs for any cetacean species were identified to occur within the EMBA. However, pygmy blue whales, Omura's whales and Bryde's whales may occur within the Operational Area throughout the duration of the survey. Although, the presence of all cetacean species is likely to be limited to infrequent occurrences of individuals or small groups.

In addition, the Operational Area does not represent important habitat for whale sharks. However, due to the species widespread distribution and highly migratory nature, individuals may transit through the Operational Area.

Potential Impact of Noise

As described in **Section 6.4.3**, elevated underwater noise can affect marine fauna, including cetaceans, fish, turtles, sharks and rays, in three main ways (Richardson et al., 1995; Simmonds et al., 2004):

- by causing direct physical effects on hearing or other organs. Hearing loss may be temporary (temporary threshold shift [TTS]; referred to as auditory fatigue), or permanent threshold shift (PTS; injury)
- by masking or interfering with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey)
- through disturbance leading to behavioural changes or displacement from important areas (e.g. BIAs). The occurrence and intensity of disturbance is highly variable and depends on a range of factors relating to the animal and situation.

The potential impacts associated with noise emissions from the seismic equipment are presented in **Section 6.4.3**, detail on impacts specific to noise from project vessels, AUV nodes and helicopters are provided below.

Project Vessels

Noise generated by the project vessels is expected to be up to 190 dB re 1 µPa at 1 m. The potential for received levels to exceed weighted thresholds defined for PTS or TTS for marine mammals is considered not credible due to propagation and reduction of sound from the source. Behavioural response thresholds for marine mammals are estimated to be exceeded out to several kilometres from the project vessels.

Marine fauna associated with the Operational Area will be predominantly pelagic and demersal species of fish, with species such as whale sharks, rays, marine turtles and cetacean species (such as pygmy blue whales, Omura's whale and Bryde's whale) transiting through the Operational Area. Therefore, potential impacts from vessel noise are likely to be restricted to temporary avoidance behaviour to individuals, and are therefore considered localised with no lasting effect.

Currently, there are no quantitative sound exposure thresholds for behavioural responses in marine turtles resulting from continuous noise sources. As outlined above, although the Operational Area overlaps with the flatback turtle internesting BIA and Habitat Critical internesting buffer around nesting locations on the Tiwi Islands, marine turtles are not expected to be in the area in high numbers even during nesting and internesting periods. Therefore, impacts to marine turtles from project vessels are expected to be negligible. Other fauna associated with the Operational Area will be predominantly pelagic species of fish, with migratory species such as whale sharks and rays transiting through the Operational Area; these species may be similarly affected by noise from project vessels.

Compliance with EPBC Regulation 2000 – Part 8 Interacting with Cetaceans to reduce the likelihood of collisions with cetaceans (i.e. vessels are to travel slower) may also further incidentally reduce the noise generated by vessels close to cetaceans and marine turtles—slower vessel speeds may reduce underwater noise.

In summary, potential impacts from vessel noise are likely to be restricted to temporary avoidance behaviour of individuals transiting through the Operational Area with no lasting effect. Individuals may deviate slightly from their activities, but are expected resume normal behaviours as they move away from the activities.

Helicopters

Helicopter engines and rotor blades are a potential source of noise emissions, which may result in behavioural disturbance to marine fauna. Water has a very high acoustic impedance contrast compared to air, and the sea surface is a strong reflector of noise energy (i.e. very little noise energy generated above the sea surface crosses into and propagates below the sea surface (and vice versa) – most is reflected). The angle at which the sound path meets the surface influences the transmission of noise energy from the atmosphere through the sea surface; angles ±>13° from vertical are almost entirely reflected (Richardson et al., 1995). Given this, and the typical characteristics of helicopter flights within the Operational Area (duration, frequency, altitude and air speed), the opportunity for underwater noise levels that may result in behavioural disturbance are considered to be highly unlikely. Note: Helicopter noise during approach, landing and take-off is more likely to propagate through the sea surface due to the reduced air speed and lower altitude. However, helicopter noise during approach, landing and take-off will be mingled with underwater noise generated by the vessel hosting the helipad (e.g. thruster noise and machinery noise). Additionally, approach, landing and take-off are relatively short phases of the flight, resulting in little opportunity for underwater noise to be generated.

Given the standard flight profile of a helicopter transfer, maintenance of a more than 500 m horizontal separation from cetaceans (as per EPBC Regulations), and the predominantly seasonal presence of individual whales within the Operational Area, interactions between helicopters and cetaceans that result in behavioural impacts are considered to be highly unlikely. In the highly unlikely event that cetaceans are disturbed by helicopters, responses are expected to consist of short-term behavioural responses, such as increased swimming speed; the consequence of such disturbance is considered to have no lasting effect.

Although unlikely, turtles may be present in low numbers within the Operational Area and may be exposed to helicopter noise when on the sea surface (e.g. when basking or breathing). Typical startle responses occur at relatively short ranges (tens of metres) (Hazel et al., 2007) and, as such, startle responses during typical helicopter flight profiles are considered remote. If a turtle has a behavioural response to the presence of a helicopter, it is expected to exhibit diving behaviour, which has no lasting effect.

The Operational Area may be occasionally visited by seabirds and/or migratory shorebirds, however the area does not contain any emergent land that could be used as roosting or nesting habitat. The closest emergent land is 40 km south of the Operational Area (Tiwi Islands). There are no BIAs for any bird species located within the Operational Area, however the EMBA overlaps with a crested tern breeding BIA at Seagull Island. Given the expected low density of seabirds and/or migratory shorebirds within the Operational Area, the relative infrequency of helicopter flights and lack of lasting effect of potential behavioural responses to helicopter noise, impacts would be unlikely, localised and temporary, and result in no lasting effect.

AUV and commercial nodes

Self-noise produced by the AUVs may be audible to marine fauna at very close range to the AUVs, but with source levels in the order of around 135 dB re 1 µPa at 1 m, no significant disturbance is expected. Minor changes in behaviour in fish and other marine fauna that may occur within metres of an AUV may just as easily occur in response to the sight of an approaching AUV as much as the noise it produces. Such responses are expected to be incidental and insignificant.

ROV motor noise is not well documented but is likely to be low-level and no significant disturbance is expected. For example, Stimpert and Madrigal (2019) reported that noise recorded during a number of underwater mobile survey

techniques was dominated by the signal of the baseline positioning system rather than motor noise from the AUV, ROV or human-operated vehicle (HOV). USBL noise levels from the surface vessels may produce higher noise levels, albeit at frequencies that are above the auditory range of most fish species. Mid-frequency cetaceans are the fauna group most likely to be able to detect the 21 to 31 kHz frequencies. With source levels of 180 to 206 dB re 1 µPa at 1 m, and assuming spherical spreading of underwater noise within close range of the source, behavioural responses may be limited to a few tens of meters. Stimpert and Madrigal (2019) found that noise from the baseline positioning system associated with an AUV was not detectable at low frequencies, while SPLs in the mid frequency range were approximately 140 dB re 1 µPa at a distance of 29 m and 120 dB re 1 µPa at a distance of 423 m. Relative to the high magnitude impulsive sound produced by the seismic source and continuous noise produced by the vessel engines, noise from AUV nodes and supporting USBL operations are expected to be insignificant.
Summary of Potential Impacts to environmental value(s)
Given the adopted controls, it is considered that noise generated by project vessels, AUV nodes and helicopters will not result in a potential impact greater than slight, short-term temporary disruption to a small portion of the population for any marine fauna species exposed, with no lasting effects.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[8]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
EPBC Regulations 2000 –Part 8 Division 8.1 Interacting with cetaceans including the following measures: • project vessels will not travel greater than 6 knots within 300 m of a cetacean or turtle (caution zone) • project vessels will not approach closer than 50 m for a dolphin or turtle and/or 100 m for a whale (with the exception of animals bow riding) • if the cetacean or turtle shows signs of being disturbed, project vessels will immediately withdraw from the caution zone at a constant speed of less than 6 knots • vessels will not travel greater than 8 knots within 250 m of a whale shark and not allow the vessel to approach closer than 30 m of a whale shark.	F: Yes CS: Minimal reduction in vessel speed and manoeuvrability resulting in minimal delay	By managing the interactions with cetaceans and restricting the proximity between vessels and cetaceans, impacts from vessel-generated noise are reduced.	Control is a legislative requirement – must be adopted	Yes **C 12.1**

[8] Qualitative measure

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)*** [8]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Exception: The above requirement does not apply to project vessels operating under limited/constrained manoeuvrability including but not limited to seismic vessel towing equipment and acquiring data, and in the event of an emergency				
Good Practice				
None identified.				
Professional Judgement – Eliminate				
Eliminate generation of noise from vessels and AUV nodes.	F: No. The generation of noise from project vessels and AUV nodes cannot be eliminated due to operating requirements. CS: Inability to conduct the Petroleum Activities Program.	Not considered – control not feasible.	Not considered – control not feasible.	No
Eliminate use of vessels.	F: No. The use of vessels is required to conduct the Petroleum Activities Program. CS: Not considered – control not feasible.	Not considered – control not feasible.	Not considered – control not feasible.	No
Eliminate use of AUV/ commercial nodes.	F: Yes. Woodside would be able to continue to acquire the seismic survey without the use of AUV/commercial nodes, given the seismic vessel will be towing streamer(s) that can listen to/record the seismic signal. However, the use of AUV/commercial nodes has the potential to improve both seismic data quality and efficiently, and reduce the frequency and duration of future seismic surveys. CS: No additional costs. Inability to confirm the functionality and performance of the novel technology on a commercial-scale seismic survey.	Eliminates the potential for the AUV/commercial nodes to add to the noise levels generated by the Petroleum Activities Program.	Although the control would eliminate the potential for noise to be generated by the AUV nodes, it would result in the inability for Woodside to test the functionality and performance of the novel technology on a commercial-scale seismic survey. Therefore, delaying Woodside's ability to advance technological advancements in acquiring seismic data.	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)*** [8]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Conduct the Petroleum Activities Program away from sensitive receptors	F: No. The location of the petroleum activities is determined by the predicted location of hydrocarbons and the legislative requirement to explore for hydrocarbons CS: Requirement to conduct activity.	Not considered – control not feasible.	Not considered – control not feasible.	No
Professional Judgement – Substitute				
Variation of the timing of the Petroleum Activities Program to avoid marine turtle nesting periods (June to September).	F: Yes. Avoidance of turtle nesting periods is technically feasible. CS: Significant cost and schedule delays in acquiring data and securing the seismic vessel for specific timeframes.	Negligible reduction in consequence given the duration and nature of the activity, the localised effects of noise produced by vessels, helicopters and AUV nodes and the 43 km distance from turtle nesting beaches.	Grossly disproportionate. Implementation of the control requires considerable cost sacrifice for minimal environmental benefit.	No
Professional Judgement – Engineered Solution				
None identified.				
ALARP Statement On the basis of the environmental impact assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks of project vessel noise emissions. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that, given the adopted controls, project vessel noise disturbance are unlikely to result in a potential impact greater than localised and temporary disruption to a small proportion of the population, with no lasting effects, and no impact on critical habitat or activity. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice and meet the requirements of Part 8 (Division 8.1) of the EPBC Regulations 2000. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of vessel noise emissions to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 12 Minimise impacts of noise generated from the Petroleum Activities Program on threatened and migratory cetacean species listed under the EPBC Act in the Operational Area	**C 12.1** EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans including the following measures: • project vessels will not travel greater than 6 knots within 300 m of a cetacean or turtle (caution zone) • project vessels will not approach closer than 50 m for a dolphin or turtle and/or 100 m for a whale (with the exception of animals bow riding) • if the cetacean or turtle shows signs of being disturbed, project vessels will immediately withdraw from the caution zone at a constant speed of less than 6 knots • vessels will not travel greater than 8 knots within 250 m of a whale shark and not allow the vessel to approach closer than 30 m of a whale shark. ***Exception:*** The above requirement does not apply to project vessels operating under limited/constrained manoeuvrability including but not limited to seismic vessel towing equipment and acquiring data, and in the event of an emergency.	**PS 12.1** Compliance with EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans and application of these regulations to whale sharks and marine turtles.	**MC 12.1.1** Records demonstrate compliance with the EPBC Regulations 2000 (Part 8 Division 8.1) and application of these regulations to whale sharks and marine turtles.

6.4.5 Routine Atmospheric Emissions: Fuel Combustion

Context		
Project Vessels – **Section 3.6.5** Helicopters – **Section 3.6.6**	Physical Environment – **Section 4.3**	Stakeholder Consultation – **Section 5**

Impact Evaluation Summary														
Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcomes
Exhaust emissions from internal combustion engines and incinerators on project vessels and helicopters within the Operational Area.				X				A	F	-	-	LCS	Broadly Acceptable	EPO 13

Description of Source of Impact
Atmospheric emissions will be generated by the project vessels from internal combustion engines (including all equipment and generators) and incineration activities (including onboard incinerators) during the Petroleum Activities Program. Emissions will include SO_2, NO_x, ozone depleting substances, CO_2, particulates and volatile organic compounds (VOCs).

Impact Assessment
Potential Impacts to Environmental Values
Fuel combustion has the potential to result in localised, temporary reduction in air quality. Potential impacts include a localised reduction in air quality and contribution to greenhouse gas emissions. Given the short duration and exposed location of project vessels (which will lead to the rapid dispersion of the low volumes of atmospheric emissions), the potential impacts are expected to be localised and of no lasting effect.
Summary of Potential Impacts to Environmental Values(s)
Given the adopted controls, it is considered that the release of a small volume of greenhouse gases will not result in a potential impact greater than a temporary impact to local air quality with no lasting effect.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)*** [9]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Marine Order 97 (Marine Pollution Prevention – Air Pollution), which details requirements for: • International Air Pollution Prevention (IAPP) Certificate,	F: Yes CS: Minimal cost	Legislative requirements to be followed may reduce the consequences of air pollution.	Control based on legislative requirements – must be adopted	Yes **C 13.1**

[9] Qualitative measure

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)*** [9]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
required by vessel class • use of low sulphur fuel (shall not exceed 0.50% m/m) • Ship Energy Efficiency Management Plan, where required by vessel class • onboard incinerator to comply with Marine Order 97.				
Good Practice				
None identified.				
Professional Judgement – Eliminate				
Do not combust fuel.	F: No. There are no vessels that do not use internal combustion engines. CS: Not considered, control not feasible.	Not considered, control not feasible.	Not considered, control not feasible.	No
Professional Judgement – Substitute				
None identified.				
Professional Judgement – Engineered Solution				
None identified.				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the potential impacts of release of atmospheric emissions within the Operational Area. As no reasonable additional/alternative controls were identified that would further reduce the impacts without grossly disproportionate sacrifice, the impacts are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that, given the adopted controls, atmospheric emissions during the Petroleum Activities Program will not result in a potential impact greater than a temporary decrease in local air quality with low impact to the environment or human health and no lasting effects. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice. Therefore, Woodside considers the adopted controls appropriate to manage the impacts of the described emissions within the Operational Area to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 13 Fuel combustion emissions and incineration during the Petroleum Activities Program will be in compliance with marine order requirements to restrict emissions to those necessary to perform the activity.	**C 13.1** Marine Order 97 (Marine Pollution Prevention – Air Pollution) which details requirements for: • International Air Pollution Prevention (IAPP) Certificate, required by vessel class • use of low sulphur fuel (shall not exceed 0.50% m/m) • Ship Energy Efficiency Management Plan, where required by vessel class • onboard incinerator to comply with Marine Order 97.	**PS 13.1** Project vessels compliant with Marine Order 97 (marine pollution prevention – air pollution) to restrict emissions to those necessary to perform the activity. Vessel marine assurance process conducted prior to contracting vessels, to ensure suitability and compliance with vessel combustion certification/ Marine Order requirements.	**MC 13.1.1** Records demonstrate compliance with Marine Order 97.

6.4.6 Routine Discharge: Bilge Water, Grey Water, Sewage, Putrescible Wastes and Deck Drainage Water

Context		
Project Vessels – **Section 3.6.5**	Physical Environment – **Section 4.3** Biological Environment – **Section 4.4**	Stakeholder Consultation – **Section 5**

Impact Evaluation Summary

Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcomes
Routine discharge of sewage, grey water and putrescible wastes to marine environment from project vessels within the Operational Area			X		X			A	F	-	-	LC S	Broadly acceptable	EPO 14
Routine discharge of deck and bilge water to marine environment from project vessels within the Operational Area			X		X			A	F	-	-			

Description of Source of Impact

The project vessels routinely generate/discharge:

- Small volumes of treated sewage, putrescible wastes and grey water to the marine environment (impact assessment based on approximate discharge of 15 m^3 per vessel per day), using an average volume of 75 L/person/day and a maximum of 200 persons on board. However, it is noted that vessels such as support vessels will have considerably less persons on board.
- Routine/periodic discharge of relatively small volumes of bilge water. Bilge tanks on the project vessels receive fluids from many parts of the vessel. Bilge water can contain water, oil, detergents, solvents, chemicals, particles and other liquids or solids.
- Variable water discharge from project vessel decks directly overboard or via deck drainage systems. Water sources could include rainfall events and/or from deck activities such as cleaning/wash-down of equipment/decks.

Routine discharges generated from the Petroleum Activities Program have the potential to cause temporary and localised reduction in water quality.

Environmental risk relating to the disposal/discharges above regulated levels or incorrect disposal/discharge of waste would be unplanned (non-routine/accidental) and are addressed in **Section 6.5.5.**

Impact Assessment

Potential Impacts to Environmental Values

The main environmental impact associated with ocean disposal of sewage and other organic wastes (i.e. putrescible waste) is eutrophication. Eutrophication occurs when the addition of nutrients, such as nitrates and phosphates, causes adverse changes to the ecosystem, such as oxygen depletion and phytoplankton blooms. Other contaminants of concern occurring in these discharges may include ammonia, E. coli, faecal coliform, volatile and semi-volatile organic compounds, phenol, hydrogen sulphide, metals, surfactants and phthalates.

Woodside monitored sewage discharges at its Torosa-4 Appraisal Drilling campaign which demonstrated that a 10 m^3 sewage discharge reduced to about 1% of its original concentration within 50 m of the discharge location. In addition to this, monitoring at distances of 50, 100 and 200 m downstream of the platform and at five different water depths

confirmed that discharges were rapidly diluted 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 (Woodside Energy Limited, 2011). Mixing and dispersion would be further facilitated in deep offshore waters, consistent with the location of the Operational Area, through regional wind and large scale current patterns resulting in the rapid mixing of surface and near surface waters where sewage discharges may occur. Studies investigating the effects of nutrient enrichment from offshore sewage discharges indicate that the influence of nutrients in open marine areas is much less significant than that experienced in enclosed areas (McIntyre and Johnston, 1975). Furthermore, open marine waters do not typically support areas of increased ecological sensitivity, due to the lack of nutrients in the upper water column and lack of light penetration at depth. Therefore, presence of receptors, such as fish, reptiles, birds and cetaceans, in significant numbers within the Operational Area is unlikely. Research also suggests that zooplankton composition and distribution are not affected in areas associated with sewage dumping grounds (McIntyre and Johnston, 1975). Plankton communities are expected to rapidly recover from any such short-term, localised impact, as they are known to have naturally high levels of mortality and a rapid replacement rate. Other discharges outlined, which may include other non-organic contaminants (e.g. bilge water), will be rapidly diluted through the same mechanisms as above and are expected to be in very small quantities and concentrations as to not pose any significant risk to any relevant receptors. As such, no significant impacts from the planned discharges that are listed above are anticipated because of the minor quantities involved, the expected localised mixing zone and high level of dilution into the open water marine environment of the Operational Area. The Operational Area is more than 12 nm from land, which exceeds the 12 nm exclusion zones required under the relevant Marine Orders.
Summary of Potential Impacts to Environmental Values(s)
Given the adopted controls, it is considered that routine discharges described will not result in a potential impact greater than localised contamination not significant to environmental receptors, with no lasting effect.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)*** [10]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Marine Orders 95 – pollution prevention – Garbage (as appropriate to vessel class), which requires putrescible waste and food scraps to pass through a macerator so it is capable of passing through a screen with no opening wider than 25 mm.	F: Yes CS: Minimal cost. Standard practice.	No reduction in consequence would result.	Controls based on legislative requirements – must be adopted.	Yes **C 14.1**
Marine Orders 96 - pollution prevention – sewage (as appropriate to vessel class), specifically: • a valid International Sewage Pollution Prevention (ISPP) Certificate, as required by vessel class • an ASMA approved sewage treatment plant	F: Yes CS: Minimal cost. Standard practice.	No reduction in consequence would result.	Controls based on legislative requirements – must be adopted.	Yes **C 14.2**

[10] Qualitative measure

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)*** [10]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
• sewage commuting and disinfecting system • a sewage holding tank sized appropriately to contain all generated waste (black and grey water) • discharge of sewage which is not comminuted or disinfected will only occur at a distance of more than 12 nm from the nearest land • discharge of sewage which is comminuted or disinfected using a certified approved sewage treatment plant will only occur at a distance of more than 3 nm from the nearest land • discharge of sewage will occur at a moderate rate while the vessel is proceeding (>4 knots), to avoid discharges in environmentally sensitive areas.				
Marine Orders 91 – oil (as relevant to vessel class) requirements, which include mandatory measures for the processing of oily water prior to discharge: • machinery space bilge/oily water shall have International Maritime Organisation (IMO) approved oil filtering equipment (oil/water separator) with an on-line monitoring device to measure Oil in Water (OIW) content to be less	F: Yes CS: Minimal cost. Standard practice.	No reduction in consequence would result.	Controls based on legislative requirements – must be adopted.	Yes **C 14.3**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)*** [10]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
than 15 ppm prior to discharge • IMO approved oil filtering equipment shall also have an alarm and an automatic stopping device or be capably of recirculating in the event that OIW concentration exceeds 15 ppm • a deck drainage system shall be capable of controlling the content of discharges for areas of high risk of fuel/oil/grease or hazardous chemical contamination • there shall be a waste oil storage tank available, to restrict oil discharges • in the event that machinery space bilge discharges cannot meet the oil content standard of <15 ppm without dilution or be treated by an IMO approved oil/water separator, they will be contained on-board and disposed of onshore • a valid IOPP Certificate, as required by vessel class.				
Good Practice				
None identified.				
Professional Judgement – Eliminate				
Storage, transport and treatment/ disposal onshore treatment of sewage, greywater, putrescible and bilge wastes.	F: No. Would present additional safety and hygiene hazards resulting from the storage, loading and transport of the waste material. CS: Not considered – control not feasible.	Not considered – control not feasible.	Not considered – control not feasible.	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)*** ***10***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Professional Judgement – Substitute				
None identified.				
Professional Judgement – Engineered Solution				
None identified.				
ALARP Statement On the basis of the environmental impact assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts of planned routine discharges from the project vessels. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that, given the adopted controls, planned (routine) discharges from projects vessels are unlikely to result in a potential impact greater than a temporary contamination above background levels and/or national/international quality standards and/or known biological effect concentrations outside a localised mixing zone with no lasting effect. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice and meet legislative requirements under Marine Orders 91, 95 and 96. Therefore, Woodside considers the adopted controls appropriate to manage the impacts of these discharges to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 14 No impact to water quality greater than a consequence level of F[11] from discharge of sewage, greywater, putrescible wastes, bilge and deck drainage to the marine environment during the Petroleum Activities Program.	**C 14.1** Marine Orders 95 – pollution prevention – Garbage (as appropriate to vessel class), which requires putrescible waste and food scraps to pass through a macerator so it is capable of passing through a screen with no opening wider than 25 mm.	**PS 14.1** Project vessels compliant with Marine Orders 95 – pollution prevention – Garbage.	**MC 14.1.1** Records demonstrate project vessels are compliant with Marine Orders 95 – pollution prevention (as appropriate to vessel class).
	C 14.2 Marine Orders 96 - pollution prevention – sewage (as appropriate to vessel class) specifically: • a valid International Sewage Pollution Prevention (ISPP) Certificate, as required by vessel class • an ASMA approved sewage treatment plant	**PS 14.2** Project vessels compliant with Marine Order 96 - pollution prevention – sewage (as appropriate to vessel class).	**MC 14.2.1** Records demonstrate project vessels are compliant with Marine Orders 96 - pollution prevention – sewage (as appropriate to vessel class).

[11] Defined as 'No lasting effect (<1 month) or negligible impact. Localised impact not significant to environmental receptors.'

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	• sewage commuting and disinfecting system • a sewage holding tank sized appropriately to contain all generated waste (black and grey water) • discharge of sewage which is not comminuted or disinfected will only occur at a distance of more than 12 nm from the nearest land • discharge of sewage which is comminuted or disinfected using a certified approved sewage treatment plant will only occur at a distance of more than 3 nm from the nearest land • discharge of sewage will occur at a moderate rate while the vessel is proceeding (>4 knots), to avoid discharges in environmentally sensitive areas.		
	C 14.3 Marine Orders 91 – oil (as relevant to vessel class) requirements, which include mandatory measures for the processing of oily water prior to discharge: • machinery space bilge/oily water shall have International Maritime Organisation (IMO) approved oil filtering equipment (oil/water separator) with an on-line monitoring device to measure Oil in Water (OIW) content to be less than 15 ppm prior to discharge • IMO approved oil filtering equipment shall also have an alarm and an automatic stopping device or be capably	**PS 14.3** Deck drainage and bilge water will be discharged to meet the oil content standard of <15 ppm without dilution	**MC 14.3.1** Records demonstrate discharge specification met for project vessels.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	of recirculating in the event that OIW concentration exceeds 15 ppm • a deck drainage system shall be capable of controlling the content of discharges for areas of high risk of fuel/oil/grease or hazardous chemical contamination • there shall be a waste oil storage tank available, to restrict oil discharges • in the event that machinery space bilge and deck drainage discharges cannot meet the oil content standard of <15 ppm without dilution or being treated by an IMO approved oil/water separator, they will be contained on-board and disposed of onshore • a valid IOPP Certificate, as required by vessel class.		

6.4.7 Routine Light Emissions: External Lighting on Project Vessels

Context		
Project Vessels – **Section 3.6.5**	Physical Environment – **Section 4.3** Biological Environment – **Section 4.4**	Stakeholder Consultation – **Section 5**

Impact Evaluation Summary														
Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcomes
Routine light emissions from project vessels within the Operational Area.						X		A	F	-	-	LC S GP	Broadly acceptable	NA

Description of Source of Impact
Routine light emissions include light sources that alter the ambient light conditions in an environment. Project vessels (including the seismic vessel) will routinely use external lighting to navigate and conduct safe operations at night throughout the Petroleum Activities Program. External light emissions from project vessels are typically managed to maintain good night vision for crew members. Vessel lighting will also be used to communicate the vessel's presence to other marine users (i.e. navigation/warning lights). Lighting is required for safely operating project vessels and cannot reasonably be eliminated. The vessels that may be required for the Petroleum Activities Program in the Operational Area are outlined in **Section 3.6.5**. External lighting is located on the vessel decks, with most external lighting directed towards working areas such as the main decks. These areas are typically <20 m above sea level for a seismic survey vessel. Lighting from vessels may appear as a direct light source from an unshielded lamp with direct line of sight to the observer or through sky glow. Direct lighting falling upon a surface is referred to as light spill. Sky glow is the diffuse glow caused by light that is screened from view, but through reflection and refraction creates a glow in the atmosphere. The distance at which direct light and sky glow may be visible from the source depends on the characteristics of vessel lighting (including height above sea level) and environmental conditions (e.g. cloud cover).

Impact Assessment
Potential Impacts to Environmental Values
Receptors that have important habitat within a 20 km radius of the Operational Area were considered for the impact assessment, based on recommendations of the National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (NLPG). The 20 km threshold provides a precautionary limit based on observed effects of sky glow on marine turtle hatchlings, demonstrated to occur at 15–18 km, and fledgling seabirds grounded in response to artificial light 15 km away (NLPG, 2020). Light emissions can affect fauna in two main ways: • Behaviour: Many species are adapted to natural levels of lighting and the natural changes associated with the day and night cycle as well as the night-time phases of the moon. However, artificial lighting has the potential to create a constant level of light at night that can override these natural levels and cycles. • Orientation: Species such as marine turtles and birds may also use lighting from natural sources to orient themselves in a certain direction at night. If an artificial light source is brighter than a natural source, the artificial light may override natural cues, leading to disorientation. The fauna within and immediately adjacent to the Operational Area are predominantly pelagic fish and zooplankton, with a low abundance of transient species such as marine turtles, whale sharks, cetaceans and migratory shorebirds

and seabirds. As described in **Section 4.4.4.5.2** and shown in **Figure 4-11**, the Operational Area overlaps the internesting buffer 'habitat critical for the survival of the species' for flatback turtles around the Tiwi Islands. Additionally, the southern boundary of the Operational Area is located ~19 km north of an internesting buffer habitat critical for olive ridley turtles around the Tiwi Islands. However, as outlined below, internesting adult female turtles are not impacted by artificial light emissions, and it is more relevant to consider separation distances between light sources and nesting habitat critical for turtles——the nesting locations as identified in Table 6 of the marine turtle Recovery Plan (Commonwealth of Australia, 2017). At the closest point, the Operational Area is located ~40 km from the nearest nesting location for both flatback and olive ridley turtles, which are the beaches on Seagull Island (off north-west tip of Melville Island).

Marine Turtles – Hatchlings

Turtle hatchlings emerge from the nest and orient towards the sea. After entering the water, hatchlings use a combination of cues (wave direction and currents) to orient and travel into offshore waters. Impacts to the sea-finding behaviour of hatchlings are more common for light sources behind a beach, as lighting offshore will orient emerging hatchlings towards the sea. Artificial light at close distances can also impact hatchling dispersal once they are in the water. Light spill may 'entrap' hatchling swimming behaviour, reducing the success of their seaward dispersion and potentially increasing their exposure to predators via silhouetting (Salmon et al., 1992).

As described above, the nearest turtle nesting site to the Operational Area is Seagull Island (~40 km south). The distance between the highest lights on the survey vessel and the edge of visibility, or the visible horizon, was calculated using a manual calculation that takes atmospheric refraction into consideration (Young's method) as expressed by the formula $d = 3.86\sqrt{h}$, where 'd' is the distance to the visible horizon, and 'h' is the light source height in metres. For a height of 20 m, the distance to the visible horizon is ~17 km – i.e. anything beyond this distance is below the horizon and direct light would not be visible. Therefore, direct light from the survey vessel will not reach the closest nesting location. There is a remote possibility that sky glow from vessel operational lighting could be visible at the closest nesting location under certain conditions (e.g. heavy cloud cover at night).

However, there is no published or anecdotal evidence that sky glow from offshore vessels causes any behavioural impacts (i.e. not biologically relevant) to emerging hatchlings on nesting beaches, particularly at a distance of ~40 km.

Since the Operational Area is located >40 km from turtle nesting locations in the region, the risk of significant numbers of dispersing hatchlings becoming attracted to direct light or sky glow from project vessels is not considered credible. This is supported by the findings of a desktop lighting impact assessment for the Scarborough Project, conducted by Pendoley Environmental (PENV, 2020). At a range of >40 km, the density of dispersing hatchlings is expected to be low and very few individuals will be at risk of attraction For any isolated individuals potentially attracted to light spill from project vessels, following sunrise, any effect of these light sources on hatchlings will be eliminated allowing dispersal behaviour to resume. Any impacts to hatchling turtles from artificial light will be limited to possible short-term behavioural impacts to isolated individual hatchlings offshore, with no lasting effect to the species.

Marine Turtle – Adults

Although individuals undertaking behaviours such as internesting, migration, mating (adults) or foraging (adults and pelagic juveniles) may occur within Operational Area, marine turtles do not use light cues to guide these behaviours. Furthermore, there is no evidence, published or anecdotal, to suggest that internesting, mating, foraging or migrating turtles are impacted by light from offshore vessels. As such, light emissions from the vessels are unlikely to result in displacement of, or behavioural changes to individuals in these life stages (PENV, 2020).

Artificial lighting may affect where nesting adult turtles emerge onto the beach, the success of nest construction, whether nesting is abandoned, and the seaward return of adults (Salmon et al., 1995a, 1995b; Salmon and Witherington, 1995). Such lighting is typically from residential and industrial development at the coastline, rather than offshore from nesting beaches. As described above, the beaches on Seagull Island (~40 km from the Operational Area) are the closest turtle nesting location. Direct light from project vessels will not be visible to nesting adult turtles, but there is a remore possibility that sky glow from vessel operational lighting to be visible. However, nesting females are not considered highly vulnerable to disorientation due to artificial light (PENV, 2020) and it is highly unlikely that sky glow from the Petroleum Activities Program could cause disruption to sea-finding behaviour post nesting. As such, vessel light sources will not discourage females from nesting, or affect nest site selection, and therefore will not displace females from nesting habitat.

There is no emergent habitat within the Operational Area and therefore nesting aggregations of marine turtles would not be expected. A flatback turtle internesting BIA and Habitat Critical internesting buffer, extending from nesting locations at the Tiwi Islands overlaps with the Operational Area. Nesting occurs year-round with a peak from June to September (Commonwealth of Australia, 2017a). The 80 km internesting buffer for flatback turtles in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017a) is considered very conservative. A more recent study by Whittock et al. (2016) defined suitable internesting habitat as water 0–16 m deep and within 5–10 km of the coastline, while unsuitable internesting flatback habitat was defined as waters >25 m deep and >27 km from the coastline. The primary environmental variables that influenced flatback internesting movement were bathymetry, distance from coastline, and sea surface temperature (Whittock et al., 2016). There is no evidence to date to indicate that flatback turtles swim out into deep offshore waters during the internesting period. Additionally, suitable areas of internesting habitat were located close to many known flatback turtle rookeries across the region (Whittock et al., 2016). It is important to note that flatback turtle hatchlings do not undertake oceanic migrations offshore to deep, pelagic waters. Instead juveniles grow to maturity in shallow coastal waters close to their natal beaches (Musick and Limpus, 1996).

Therefore, the presence of marine turtles in the Operational Area is likely to be limited to individuals temporarily transiting the area. As such, light emissions from project vessels are unlikely to result in more than localised behavioural disturbance to isolated transient individuals, with no lasting effect to the species.

Seabirds and Migratory Shorebirds

Artificial lighting can attract and disorient seabird species resulting in species behavioural changes (e.g. circling light sources or disrupted foraging), injury or mortality near the light source as a result of collision (Longcore and Rich, 2004; Gaston et al., 2014). The Operational Area may be occasionally visited by seabirds and migratory shorebirds; however, there is no emergent land that could be used for roosting or nesting habitat within the Operational Area. The nearest shoreline is the Tiwi Islands (43 km south of the Operational Area). In addition, the Operational Area does not overlap with any BIAs or critical habitat for any bird species.

The risk associated with collision from seabirds and shorebirds attracted to the light is considered to be low, given the slow moving speed of project vessels within the Operational Area. Impacts are expected to be limited to temporary behavioural disturbance to isolated individuals, with no lasting effect or displacement from important habitat.

Other Marine Fauna

Lighting from project vessel activities in the Operational Area may result in the localised aggregation of fish around the vessel. These aggregations of fish due to light are considered localised and temporary. Any long-term changes to fish species composition or abundance is considered highly unlikely. Any localised impacts to marine fish are not expected to impact on any commercial fishers in the area. Krill or plankton may also aggregate around the source of light. These aggregations of fish, krill or plankton would be confined to a small area. Based on the short duration and localised nature of the Petroleum Activities Program, these aggregations are not expected to attract pygmy blue whales, humpback whales or whale sharks.

Summary of Potential Impacts to Environmental Values(s)

Light emissions from project vessels will not result in an impact greater than a localised and temporary disturbance to marine fauna in the vicinity of the Operational Area with no lasting effect to any species (i.e. Environmental Impact – F).

Demonstration of ALARP

Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)*** [12]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
None identified.				
Good Practice				
Implement NLPG (2020) light management actions relevant to the activity during bird migration/nesting and turtle nesting/hatching periods, including: • extinguish outdoor/deck lights not necessary for safety and/or navigation at night • use available block-out blinds on portholes and windows not necessary for safety and/or navigation at night • manage seabird landings appropriately and report interactions.	F: Yes, however a minimum level of lighting is required on vessels for safety. CS: Minimal cost. Standard practice	No reduction in consequence given: • the Operational Area is located over 40 km from the nearest turtle and seabird nesting beaches (i.e. aligned with NLPG 20 km precautionary limit) • nesting females are not affected by artificial lighting from offshore vessels (PENV, 2020), so any isolated individuals out at the furthest extent of the internesting BIA / Habitat Critical will not be affected by lighting on project vessels • the Operational Area does not overlap with any seabird or	Disproportionate. Implementation of the control provides limited / no environmental benefit.	No

[12] Qualitative measure

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)*** [12]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
		migratory shorebird BIAs.		
Professional Judgement – Eliminate				
Restrict the Petroleum Activities Program to daylight hours, eliminating the need for external work lights	F: Yes. Restricting the Petroleum Activities Program to daylight hours is technically feasible, although not considered to be reasonably practicable. CS: Significant cost sacrifice. Limiting the survey to daylight hours would significantly increase the duration of the survey, and therefore result in further potential for interference with other marine users (in particular commercial fisheries).	Negligible reduction in consequence given the duration and nature of the activity.	Grossly disproportionate. Implementation of the control requires considerable cost sacrifice for minimal environmental benefit.	No
Variation of the timing of the Petroleum Activities Program to avoid turtle nesting periods (June to September)	F: Yes. Avoidance of turtle nesting periods is technically feasible. CS: Significant cost and schedule delays in acquiring data and securing the seismic vessel for specific timeframes.	Negligible reduction in consequence given the duration and nature of the activity.	Grossly disproportionate. Implementation of the control requires considerable cost sacrifice for minimal environmental benefit.	No
Substitute external lighting with light sources designed to minimise impacts and marine turtles (as per NLPG 2020 management actions): • use flashing/intermittent lights instead of fixed beam • use motion sensors to turn lights on only when needed • use luminaires with spectral content appropriate for the species present • avoid high intensity light of any colour.	F: Yes. Replacement of external lighting with lighting appropriate for turtles is technically feasible, although is not considered to be practicable. CS: Significant cost sacrifice. The retrofitting of all external lighting on vessels would result in considerable cost and time expenditure. Considerable logistical effort to source sufficient inventory of the range of light types onboard vessels.	Given the potential impacts to turtles during this activity are insignificant, implementation of this control would not result in a reduction in consequence.	Grossly disproportionate. Implementation of the control requires considerable cost sacrifice for minimal environmental benefit. The cost/sacrifice outweighs the benefit gained.	No
Professional Judgement – Substitute				
None identified.				
Professional Judgement – Engineered Solution				

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)*** [12]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
None identified.				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the potential impacts from routine light emissions from project vessels within the Operational Area to be ALARP. This includes consideration of the nature of light emissions for the duration of the Petroleum Activities Program, and the requirements for external lighting for safe operations. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that routine light emissions from project vessels may result in impacts limited to temporary behavioural disturbance to marine fauna within a localised area and with no lasting effect on any species. Further opportunities to reduce the impacts have been investigated above. As demonstrated in **Section 6.6**, the residual impacts of routine light emissions from project vessels in the Operational Area are not inconsistent with the relevant objectives and actions of any applicable recovery plans or threat abatement plans. Regard has been given to relevant conservation advice and wildlife conservation plans during the assessment of potential impacts and the NLPG were taken into consideration during the impact evaluation. Therefore, Woodside considers standard operations appropriate to manage the impacts and risks of routine light emissions to a level that is broadly acceptable.

6.5 Unplanned Activities (Accidents, Incidents, Emergency Situations)

6.5.1 Quantitative Spill Risk Assessment Methodology

Quantitative hydrocarbon spill modelling was undertaken by RPS (2021), on behalf of Woodside, using a three-dimensional (3D) hydrocarbon spill trajectory and weathering model, SIMAP (Spill Impact Mapping and Analysis Program), which is designed to simulate the transport, spreading and weathering of specific hydrocarbon types under the influence of changing meteorological and oceanographic forces.

A stochastic modelling scheme was followed in this study, whereby SIMAP was applied to repeatedly simulate the defined credible spill scenarios using different samples of current and wind data. These data samples were selected randomly from an historic time-series of wind and current data representative of the study area. Results of the replicate simulations were then statistically analysed and mapped to define contours of percentage probability of contact at identified thresholds around the hydrocarbon release point.

The model simulates surface releases and uses the unique physical and chemical properties of a hydrocarbon type to calculate rates of evaporation and viscosity change, including the tendency to form oil in water emulsions. Moreover, the unique transport and dispersion of surface slicks and in-water components (entrained and dissolved) are modelled separately. Thus, the model can be used to understand the wider potential consequences of a spill, including direct contact of hydrocarbons due to surface slicks (floating hydrocarbon) and exposure of organisms to entrained and dissolved aromatic hydrocarbons in the water column.

During each simulation, the SIMAP model records the location (by latitude, longitude and depth) of each of the particles (representing a given mass of hydrocarbons) on or in the water column, at regular time steps. For any particles that contact a shoreline, the model records the accumulation of hydrocarbon mass that arrives on each section of shoreline over time, less any mass that is lost to evaporation and/or subsequent removal by current and wind forces.

The collective records from all simulations are then analysed by dividing the study region into a 3D grid. For surface hydrocarbons (floating oil), the sum of the mass in all hydrocarbon particles located within a grid cell, divided by the area of the cell, provides hydrocarbon concentration estimates in that grid cell at each model output time interval. For entrained and dissolved aromatic hydrocarbon particles, concentrations are calculated at each time step by summing the mass of particles within a grid cell and dividing by the volume of the grid cell. The process is also subject to the application of spreading filters that represent the expected mass distribution of each distinct particle. The concentrations of hydrocarbons calculated for each grid cell, at each time step, are then analysed to determine whether concentration estimates exceed defined threshold concentrations.

All hydrocarbon spill modelling assessments undertaken by RPS undergo initial sensitivity modelling to determine appropriate time to add to the simulation after the cessation of the spill. The amount of time following the spill is based on the time required for the modelled concentrations to practically drop below threshold concentrations anywhere in the model domain in the test cases. This assessment is done by post-processing the sensitivity test results and analysing time-series of median and maximum concentrations in the water and on the surface.

6.5.1.1 Hydrocarbon Characteristics

As part of the risk identification process, Woodside identified the range of credible hydrocarbon spill scenarios that may occur from the Petroleum Activities Program. These scenarios are considered in the risk assessments of accidental hydrocarbon spill scenarios (refer to **Section 6.5.2**).

The characteristics of the hydrocarbons, used as the basis for the modelling studies used to inform the assessment, are summarised in **Table 6-18**.

Table 6-18: Hydrocarbon characteristics

Hydrocarbon Type	Initial Density (g/cm^3)	Viscosity (cP)	Component BP (°C)	Volatiles <180 °C	Semi volatiles 180–265 °C	Low Volatility (%) 265–380 °C	Residual (%) >380 °C	Aromatic (%) of whole oil <380 °C BP
				Non-Persistent			Persistent	
Marine diesel	0.829 @ 25 °C	4.0 @ 25 °C	% of total	6.0	34.6	54.4	5.0	3.0
			% aromatics	1.8	1.0	0.2	-	-

6.5.1.2 Environment that May Be Affected and Hydrocarbon Contact Thresholds

The outputs of the quantitative hydrocarbon spill modelling are used to assess the environmental risk if a credible hydrocarbon spill scenario occurred, by delineating which areas of the marine environment could be exposed to hydrocarbon levels exceeding the adopted hydrocarbon threshold concentrations (see **Table 6-19**). The summary of all the locations where hydrocarbon thresholds could be exceeded by any of the simulations modelled is defined as the ‘environment that may be affected’ (EMBA; **Section 3.1**), which is driven by the worst-case credible hydrocarbon spill scenario. For this Petroleum Activities Program the worst-case credible hydrocarbon spill scenario is a vessel collision resulting in fuel tank rupture (see **Section 6.5.2**).

As the weathering of different fates of hydrocarbons (surface, entrained and dissolved) differs due to the influence of the metocean mechanism of transportation, the EMBA combines the potential spatial extent of the different hydrocarbon fates. Note, no shoreline accumulation of hydrocarbons above threshold concentrations resulted from the modelled worst-case credible spill.

The EMBA covers a larger area than that which will be affected during any single spill event, as the model was run for a variety of weather and metocean conditions (200 simulations in total at two release locations). The EMBA therefore represents the total extent of all the locations where the adopted hydrocarbon thresholds could be exceeded from all modelling runs. Given the EMBA comprises the results of many individual simulations, the total area covered at the thresholds has been smoothed to create a continuous boundary for the purpose of describing the environment within it. Due to the size of the Operational Area and the location of the two spill release locations, the spill modelling outputs were extrapolated to all corners of the Operational Area to define the widest possible EMBA.

A conservative approach for defining thresholds for the EMBA was used by adopting the guideline impact thresholds (NOPSEMA, 2019) for floating, entrained, dissolved and accumulated hydrocarbons. An additional threshold has been included to define the boundary within which socio-cultural impacts may occur, based on surface hydrocarbons at 1 g/m² impacting the visual amenity of the marine environment. These hydrocarbon thresholds are presented in **Table 6-19**. Hydrocarbon contact below the defined thresholds may occur outside the EMBA and socio-cultural EMBA; however, the effects of these low exposure values will be limited to temporary exceedance of water quality triggers. The area within which this may occur in the event of a worst-case credible spill is presented in Appendix D: Figure 5-1.

Table 6-19: Summary of thresholds applied to the quantitative hydrocarbon spill risk modelling results

Hydrocarbon Type	EMBA				Socio-cultural EMBA	
	Surface hydrocarbon (g/m^2)	Dissolved hydrocarbon (ppb)	Entrained hydrocarbon (ppb)	Accumulated hydrocarbon (g/m^2)	Surface hydrocarbon (g/m^2)	Accumulated hydrocarbon (g/m^2)
Marine Diesel	10 g/m^2	50 ppb	100 ppb	100 g/m^2	1 g/m^2	10 g/m^2

6.5.1.3 Scientific Monitoring

A planning area for scientific monitoring is also described in **Section 5.5** of the Oil Spill Preparedness and Response Mitigation Assessment (**Appendix D**). This planning area has been defined with reference to the low exposure entrained value of 10 ppb detailed in NOPSEMA Bulletin #1 Oil Spill Modelling (2019). This low exposure threshold is based on the potential for exceeding water quality triggers.

A scientific monitoring program would be activated following a Level 2 or 3 unplanned hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors. This would consider receptors at risk (ecological and socio-economic) for the entire predicted EMBA and in particular, any identified Pre-emptive Baseline Areas (PBAs) for the worst-case credible spill scenario(s) or other identified unplanned hydrocarbon releases associated with the operational activities.

6.5.2 Accidental Hydrocarbon Release: Vessel Collision

Context		
Project Vessels – **Section 3.6.5**	Physical Environment – **Section 4.3** Biological Environment – **Section 4.4** Socio-Economic Environment – **Section 4.5**	Stakeholder Consultation – **Section 5**

Impact Evaluation Summary														
Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Hydrocarbon release to the marine environment due to a vessel collision (between Project vessels or third party vessels)			X		X	X	X	A	D	1	M	LCS GP	Acceptable	EPO 15

Description of Source of Risk

Background

A seismic vessel can have a fuel capacity in excess of 1,000 m^3 that is distributed into multiple isolated tanks. Individual marine diesel tanks are typically less than 500 m^3 in volume; however for the purposes of a conservative indication of the risks associated with a vessel collision for the Petroleum Activities Program, Woodside has assumed a largest marine diesel tank volume of 650 m^3 for a seismic vessel.

At least one support vessel will accompany the seismic vessel during the Petroleum Activities Program. The marine diesel storage capacity of a support vessel can also be in the order of 1,000 m^3 (total), distributed into multiple isolated tanks, typically located mid-ship, and can range in typical size of 22-105 m^3.

In the unlikely event of a vessel collision involving a Project vessel during the Petroleum Activities Program, the vessel will have the capability to pump marine diesel from a ruptured tank to a tank with spare volume in order to reduce the potential volume of fuel released to the environment.

Project vessels (seismic vessel and support vessel(s)) will be present in the Operational Area for the duration of the Petroleum Activities Program. This presence in the area will result in a navigational hazard for other marine users within the immediate area of the vessel (as discussed in **Section 6.4.1**).

Industry Experience

Registered vessels or foreign flag vessels in Australian waters are required to report events to the Australian Transport Safety Bureau (ATSB), AMSA or Australian Search and Rescue.

From a review of the ATSB marine safety and investigation reports, one vessel collision occurred in 2011–2012 that resulted in a spill of 25–30 L of oil into the marine environment as a result of a collision between a tug and activity support vessel off Barrow Island. Two other vessel collisions occurred in 2010, one in the port of Dampier, where an activity support vessel collided with a barge being towed. Minor damage was reported and no significant injury to personnel or pollution occurred. The second 2010 vessel collision involved a vessel under pilot control in port connected with a vessel alongside a wharf causing it to sink. No reported pollution resulted from the sunken vessel. These incidents demonstrate the likelihood of only minor volumes of hydrocarbons being released during the highly unlikely event of a vessel collision occurring.

From 2010 to 2011, the ATSB's annual publication defines the individual safety action factors identified in marine accidents and incidents: 42% related to navigation action (2011). Of those, 15% related to poor communication and 42% related to poor monitoring, checking and documentation. The majority of these related to the grounding instances.

Credible Spill Scenario

For a vessel collision to result in the worst-case scenario of a hydrocarbon spill from the vessel potentially impacting an environmental receptor, several factors must align as follows:

- The identified causes of vessel interaction must result in a collision.
- The collision must have enough force to penetrate the vessel hull.
- The collision must be in the exact location of the fuel tank.
- The fuel tank must be full, or at least of volume which is higher than the point of penetration.

The probability of the chain of events described above aligning, to result in a breach of fuel tanks resulting in a spill that could potentially affect the marine environment is considered remote. Given the offshore location of the Operational Area, vessel grounding is not considered a credible risk.

The environmental risk analysis and evaluation undertaken identified and assessed a range of potential scenarios that could result in a loss of vessel structural integrity resulting in damage to fuel storage tank(s) and a loss of marine diesel to the marine environment. These scenarios are summarised in **Table 6-20**. The scenarios consider damaged to single and multiple fuel storage tanks in the Project vessels due to various combinations of vessel-to-vessel scenarios.

The scenarios considered comprised of a collision of the support vessel and the seismic vessel with each other or with a third party vessel (i.e. commercial shipping, other petroleum related vessels and commercial fishing vessels). The likelihood of a collision was assessed as being remote, given standard vessel operations and equipment in place to prevent collision at sea, the standby role of a support vessel (low vessel speed) and its operation in close proximity to the seismic vessel (SNA), and the construction and placement of storage tanks. For the purposes of this assessment a worst-case instantaneous loss of 650 m³ from a diesel tank has been considered.

Table 6-20: Assessment of potential vessel spill scenarios

Scenario	Hydrocarbon Volumes	Preventative and Mitigation Controls	Credibility	Max. Possible Volume loss (m³)
Breach of support vessel fuel tanks due to collision with seismic vessel	Support vessel has multiple tanks typically ranging between 22 m³ and 105 m³ each.	Typically double wall, tanks which are located mid-ship (not bow or stern). Vessels are not anchored and steam at low speeds when relocating within the Operational Areas or providing stand-by cover. Normal maritime procedures would apply during such vessel movements.	**Credible** Collision of support vessel with seismic vessel could potentially result in a release from a fuel tank.	105 m³
Breach of seismic vessel fuel tanks due to collision with support vessel	Seismic vessel has multiple marine diesel tanks typically ranging between 22 m³ and 500 m³ each.	Typically double wall, tanks which are located mid-ship (not bow or stern). Vessels are not anchored and steam at low speeds when relocating within the Operational Areas or providing stand-by cover. Normal maritime procedures would apply during such vessel movements.	**Credible** Collision of seismic vessel with support vessel could potentially result in a release from a fuel tank.	650 m³
Breach of fuel tanks due to Project vessel collision with third party vessel (including commercial shipping/fisheries)	Support vessel has multiple tanks typically ranging between 22 m³ and 105 m³ each. Seismic vessel has multiple marine	Typically double wall, tanks which are located mid-ship (not bow or stern). Vessels operating in the vicinity of the SNA will be tracked	**Credible** Collision of a Project vessel with a third party vessel could potentially result in a	650 m³

	diesel tanks typically ranging between 22 m³ and 500 m³ each.	on radar and alerted to the presence of the seismic vessel via Notice to Mariners and AUSCOAST warnings.	release from a fuel tank.	

Quantitative Hydrocarbon Risk Assessment

Modelling was undertaken by RPS, on behalf of Woodside, to determine the fate of marine diesel released from a vessel collisions within the Operational Area. The modelling assessed the extent of a marine diesel spill with a volume of 650 m³ for all seasons, using a historic sample of wind and current data in the region. Due to the size of the Operational Area, stochastic modelling was conducted at 2 possible release sites, which were carefully selected based on proximity to shorelines and sensitive receptors. A total of 200 simulations were modelled with each simulation tracked for 35 days.

Hydrocarbon Characteristics

Marine diesel is a mixture of both volatile and persistent hydrocarbons. Predicted weathering of marine diesel, based on typical conditions in the region, indicates that approximately 50% by mass would be expected to evaporate over the first day or two (refer to **Figure 6-9**). After this time the majority of the remaining hydrocarbon is entrained into the upper water column. In calm conditions, entrained hydrocarbons are likely to resurface. Seven days following the spill, approximately 45–50% would evaporate, 40–45% would entrain and approximately 10% would decay and a small proportion would be dissolved (refer to **Figure 6-9**).

Given the environmental conditions experienced in the Operational Area, marine diesel is expected to undergo rapid spreading and this, together with evaporative loss, is likely to result in a rapid dissipation of the spill. Marine diesel distillates tend not to form emulsions at the temperatures found in the region. The characteristics of the marine diesel used in the modelling are provided in **Table 6-18.**

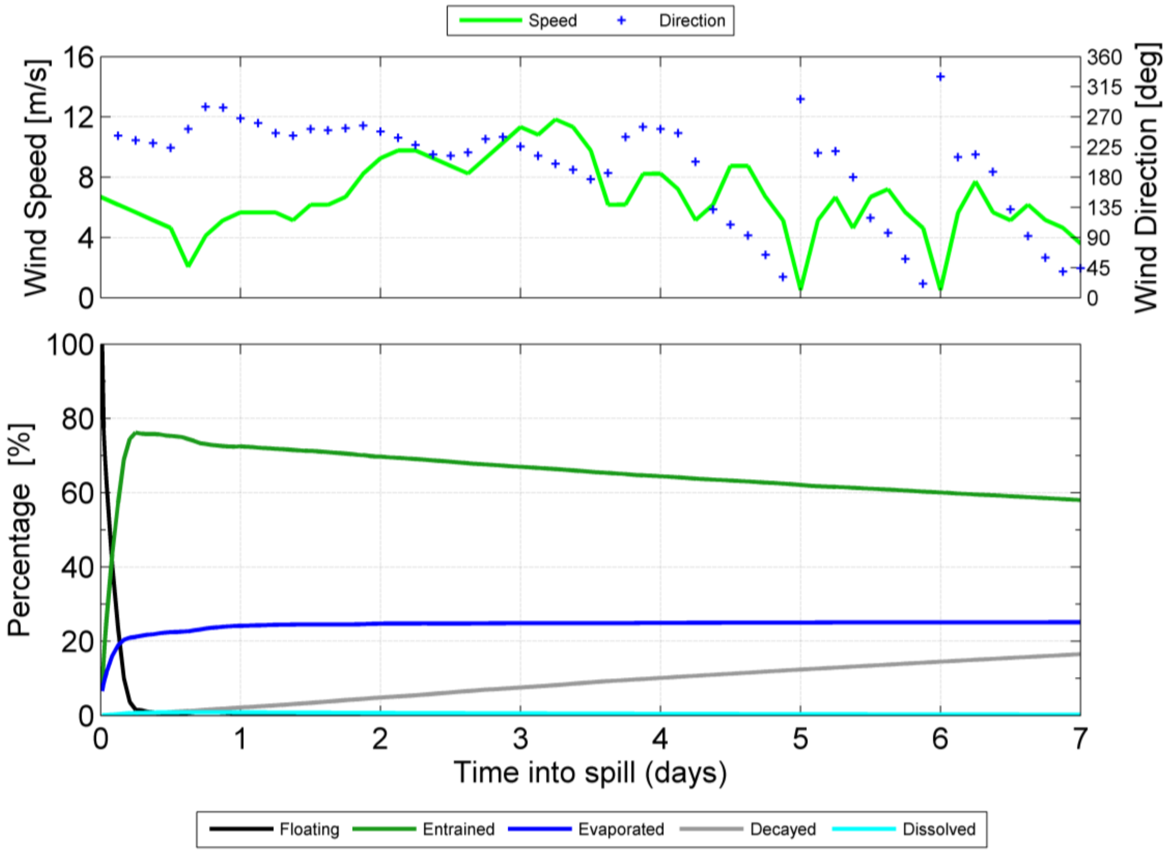


Figure 6-9: Proportional mass balance plot representing the weathering of marine diesel spilled onto the water surface as a one-off release (50 m3 over one hour) and subject to variable wind at 27 °C water temperature and 25 °C air temperature

Impact Assessment

Potential Impacts Overview

Environment that May Be Affected

The overall EMBA for the Petroleum Activities Program is based on stochastic modelling, which compiles data from 200 hypothetical worst-case spills under a variety of weather and metocean conditions (as described in **Section 6.5.1**). Due to the size of the Operational Area, stochastic modelling was conducted at two possible release sites, which were carefully selected based on proximity to shorelines and sensitive receptors. The spill modelling outputs were extrapolated to all corners of the Operational Area to define the widest possible EMBA. Therefore, the EMBA covers a larger area than the area that would be affected during any one single spill event, and thus represents the total extent of all the locations where hydrocarbon thresholds could be exceeded. The worst-case distances and probabilities of contact to receptor locations have been chosen as a conservative approach.

As the weathering of different fates of hydrocarbons (surface, entrained and dissolved) differs due to the influence of the metocean transport mechanism, a different EMBA is discussed for each fate.

Surface hydrocarbons

Quantitative hydrocarbon spill modelling results for surface hydrocarbons are shown in **Table 6-21**. The modelling indicates that the spill would be localised and confined to open water, extending up to approximately 125 km (at or above the 10 g/m^3 impact threshold) from the release location.

A socio-cultural EMBA for surface hydrocarbons which includes the threshold for visible surface hydrocarbons of 1 g/m^2 may extend up to approximately 230 km from the release site.

Entrained hydrocarbons

Quantitative hydrocarbon spill modelling results for entrained hydrocarbons are shown in **Table 6-21**. If a vessel collision scenario occurred, the plume of entrained hydrocarbons would form down-current of the release location, with the trajectory dependent on the prevailing current conditions at the time. The modelling indicates that locations exposed to entrained hydrocarbons at or above the threshold concentration of 100 ppb are restricted to offshore areas up to approximately 449 km from the release site.

In the event that this vessel collision scenario occurred, the probability of contact by entrained oil at concentrations above 100 ppb is predicted to be approximately 53% at Lynedoch Bank and 55% at the Oceanic Shoals AMP.

Dissolved hydrocarbons

Quantitative hydrocarbon spill modelling results for dissolved hydrocarbons are shown in **Table 6-21**. The modelling indicates that locations exposed to dissolved hydrocarbons at or above the threshold concentration of 50 ppb are restricted to offshore areas up to approximately 114 km from the release site.

In the event that this vessel collision scenario occurred, the probability of contact by dissolved oil at concentrations above 50 ppb is predicted to be approximately 18% at Lynedoch Bank and 22% at the Oceanic Shoals AMP.

Accumulated hydrocarbons

Quantitative hydrocarbon spill modelling results for accumulated hydrocarbons are shown in **Table 6-21**. Accumulated hydrocarbons above threshold concentrations (>100 g/m^2) were not predicted by the modelling to occur. Floating oil at concentrations equal to or greater than 1 g/m^2 are not predicted to contact any shoreline receptors.

Summary of Potential Impacts to Environmental Values

Table 6-21 presents the full extent of the EMBA, i.e. the sensitive receptors and their locations that may be exposed to hydrocarbons (surface, entrained and dissolved) at or above the set threshold concentrations in the unlikely event of a marine diesel spill from a vessel collision during the Petroleum Activities Program. Some receptors included in **Table 6-21** do not have a predicted probability of hydrocarbon contact (i.e. Indonesia), due to extrapolation of the spill modelling results to each corner of the Operational Area for defining the EMBA**.** Details of these receptors are outlined in **Section 4.4**. The potential biological and ecological impacts of an accidental hydrocarbon release as a result of a vessel collision during the Petroleum Activities Program are presented in the following sections.

Table 6-21: Key receptor locations and sensitivities potentially contacted above impact thresholds by the vessel collision scenario with summary hydrocarbon spill contact (table cell values correspond to probability of contact [%])

Environmental setting	Location/ name	Environmental, Social, Cultural, Heritage and Economic aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure (WM0000PG10055394))																													Maximum predicted probability of hydrocarbon contact (>1% probability)[13]				
		Physical		*Biological*																						*Socio-Economic and Cultural*									
		Water Quality	*Sediment Quality*	*Marine Primary Producers*			*Other Communities/Habitats*								*Protected Species*									*Other Species*											
		Open water – pristine	*Marine sediment – pristine*	*Coral reef*	*Seagrass beds/macroalgae*	*Mangroves*	*Spawning/nursery areas*	*Open water – productivity/upwelling*	*Non biogenic coral reefs*	*Offshore filter feeders and/or deep-water benthic communities*	*Nearshore filter feeders*	*Sandy shores*	*Estuaries/tributaries/creeks/lagoons (including mudflats)*	*Rocky shores*	*Cetaceans – migratory whales*	*Cetaceans – dolphins and porpoises*	*Dugongs*	*Pinnipeds (sea lions and fur seals)*	*Marine turtles (including foraging and internesting areas and significant nesting beaches)*	*Seasnakes*	*Whale sharks*	*Sharks and rays*	*Sea birds and/or migratory shorebirds*	*Pelagic fish populations*	*Resident/demersal fish*	*Fisheries – commercial*	*Fisheries – traditional*	*Tourism and Recreation*	*Protected Areas/Heritage – European and Indigenous/Shipwrecks*	*Offshore Oil and Gas Infrastructure (topside and subsea)*	*Surface hydrocarbon (≥1 g/m²)*	*Surface hydrocarbon (≥10 g/m²)*	*Entrained hydrocarbon (≥100 ppb)*	*Dissolved aromatic hydrocarbon (≥50 ppb)*	*Accumulated hydrocarbons (>100 g/m²)*
Offshore[14]	Oceanic Shoals AMP	✓	✓	✓			✓	✓		✓						✓			✓	✓		✓		✓	✓	✓	✓	✓	✓		100	100	55	21.5	NA
	Arafura AMP	✓	✓	✓			✓	✓		✓						✓			✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		-	-	0.5	-	NA
Submerged Shoals and Banks	The Boxers Area (Goodrich Bank, Marie Shoal, Moss Shoal, Parry Shoal)	✓	✓	✓			✓			✓						✓			✓	✓		✓		✓	✓	✓	✓	✓	✓		8.5	3.5	46	-	NA
	Lynedoch Bank	✓	✓	✓			✓			✓						✓			✓	✓		✓		✓	✓	✓	✓	✓	✓		58.5	46.5	53	18	NA
	Timor Sea (Margaret Harries Bank, Tassie Shoal, Evans Shoal, Blackwood Shoal, Franklin Shoal, Flinders Shoal, Martin	✓	✓	✓			✓			✓						✓			✓	✓		✓		✓	✓	✓	✓	✓			1	-	14.5	-	NA

[13] Note: the probability is based on stochastic modelling of 200 hypothetical worst-case spills under a variety of weather and metocean conditions.
[14] Note: hydrocarbons cannot accumulate on open ocean, submerged receptors, or receptors not fully emergent.

Environmental setting	Location/ name	Environmental, Social, Cultural, Heritage and Economic aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure (WM0000PG10055394))																													Maximum predicted probability of hydrocarbon contact (>1% probability)[13]				
		Physical		*Biological*																						*Socio-Economic and Cultural*									
		Water Quality	*Sediment Quality*	*Marine Primary Producers*			*Other Communities/Habitats*								*Protected Species*									*Other Species*											
		Open water – pristine	*Marine sediment – pristine*	*Coral reef*	*Seagrass beds/macroalgae*	*Mangroves*	*Spawning/nursery areas*	*Open water – productivity/upwelling*	*Non biogenic coral reefs*	*Offshore filter feeders and/or deep-water benthic communities*	*Nearshore filter feeders*	*Sandy shores*	*Estuaries/tributaries/creeks/lagoons (including mudflats)*	*Rocky shores*	*Cetaceans – migratory whales*	*Cetaceans – dolphins and porpoises*	*Dugongs*	*Pinnipeds (sea lions and fur seals)*	*Marine turtles (including foraging and internesting areas and significant nesting beaches)*	*Seasnakes*	*Whale sharks*	*Sharks and rays*	*Sea birds and/or migratory shorebirds*	*Pelagic fish populations*	*Resident/demersal fish*	*Fisheries – commercial*	*Fisheries – traditional*	*Tourism and Recreation*	*Protected Areas/Heritage – European and Indigenous/Shipwrecks*	*Offshore Oil and Gas Infrastructure (topside and subsea)*	*Surface hydrocarbon (≥1 g/m²)*	*Surface hydrocarbon (≥10 g/m²)*	*Entrained hydrocarbon (≥100 ppb)*	*Dissolved aromatic hydrocarbon (≥50 ppb)*	*Accumulated hydrocarbons (>100 g/m²)*
	Shoal, Loxton Shoal, Troubadour Shoal)																																		
	Cootamundra and Calder shoals	✓	✓	✓			✓			✓						✓			✓	✓		✓		✓	✓	✓	✓	✓			-	-	6	-	NA
	Echo Shoals	✓	✓	✓			✓			✓						✓			✓	✓		✓		✓	✓	✓	✓	✓			-	-	0.5	-	NA
	Sunrise Bank and Sunset Shoal	✓	✓	✓			✓			✓						✓			✓	✓		✓		✓	✓	✓	✓	✓			-	-	1.5	-	NA
Islands and Mainland (nearshore waters)	Indonesia (Pulau Adanar, Pulau Yamdena)	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		-	-	-	-	-

*Note, the EMBA has been defined by extrapolating the spill modelling results (for the different hydrocarbon fates) to each corner of the Operational Area. Therefore, some receptors (i.e. Indonesia) do not have a predicted probability of hydrocarbon contact.

Summary of Potential Impacts to Environmental Values(s)
Summary of potential impacts to protected species
Marine Mammals (cetaceans and dugong)
Marine mammals that have direct physical contact with surface, entrained or dissolved aromatic hydrocarbons may suffer surface fouling, ingestion of hydrocarbons (from prey, water and sediments), aspiration of oily water or droplets, and inhalation of toxic vapours (Deepwater Horizon [DWH] Natural Resource Damage Assessment Trustees, 2016). This may result in the irritation of sensitive membranes such as the eyes, mouth, digestive and respiratory tracts and organs, impairment of the immune system, neurological damage (Helm et al., 2015), reproductive failure, adverse health effects (e.g. lung disease, poor body condition) and potentially mortality (DWH Natural Resource Damage Assessment Trustees, 2016). In a review of cetacean observations relating to a number of large-scale hydrocarbon spills, Geraci (1988) found little evidence of mortality associated with hydrocarbon spills. However, it was concluded that exposure to oil from the DWH resulted in increased mortality to cetaceans in the Gulf of Mexico (DWH Natural Resource Damage Assessment Trustees, 2016). Geraci (1988) did identify behavioural disturbance (i.e. avoiding spilled hydrocarbons) in some instances for several species of cetacean, suggesting that cetaceans have the ability to detect and avoid surface slicks. However, observations during spills have recorded larger whales (both mysticetes and odontocetes) and smaller delphinids travelling through and feeding in oil slicks. During the DWH spill, cetaceans were routinely seen swimming in surface slicks offshore (and nearshore) (Achinger Dias et al., 2017). Impacts to cetaceans depends on the exposure pathway; with exposure to entrained oil and surface slicks not expected to result in significant impacts due to the relatively volatile, non-persistent nature of the hydrocarbons. Direct toxic effects from external exposure are not expected to occur, although mucous membranes and eyes may become irritated. Indirect toxic effects, such as hydrocarbon ingestion through accumulation in prey, may occur. Baleen whales feeding within entrained hydrocarbon plumes may ingest hydrocarbons, potentially resulting in toxic effects (particularly fresh hydrocarbons near the release location). Four threatened and migratory, and four migratory cetacean species were identified by a search of the EPBC Act Protected Matters Database, as potentially occurring in the EMBA (refer to **Section 4.4.4**). No BIAs for any cetacean species were identified to occur within the EMBA. However, pygmy blue whales, Omura's whales and Bryde's whales may occur within the Operational Area throughout the duration of the survey. Although, the presence of all cetacean species is likely to be limited to infrequent occurrences of individuals or small groups. The dugong was also identified by a search of the EPBC Act Protected Matters Database, as potentially occurring in the EMBA (refer to **Section 4.4.4**). The dugong is known to inhabit protected shallow coastal areas, and feed on seagrass in waters less than 10 m. The presence of the species in the EMBA is expected to be limited to infrequent occurrences of individuals or small groups. Surface and entrained hydrocarbons above threshold concentrations are not predicted to impact nearshore waters of the Tiwi Islands and/or Northern Territory. Impacts to nearshore coastal waters of Indonesia are discussed below. A loss of marine diesel from a vessel collision could result in a disruption to individual marine mammals transiting the EMBA. Such disruption could include behavioural impacts (e.g. avoidance of impacted areas), sub-lethal biological effects (e.g. skin irritation, irritation from ingestion or inhalation) and, in rare circumstances, death. However, such disruptions or impacts are not predicted to impact on the overall population viability of the species within the EMBA.
Marine Reptiles
Marine Turtles Adult sea turtles exhibit no avoidance behaviour when they encounter hydrocarbon slicks (National Oceanic and Atmospheric Administration, 2010). Contact with surface slicks, or entrained hydrocarbon, can therefore, result in hydrocarbon adherence to body surfaces (Gagnon and Rawson, 2010) causing irritation of mucous membranes in the nose, throat and eyes leading to inflammation and infection (National Oceanic and Atmospheric Administration, 2010). Oiling can also irritate and injure skin which is most evident on pliable areas such as the neck and flippers (Lutcavage et al., 1995). A stress response associated with this exposure pathway includes an increase in the production of white blood cells, and even a short exposure to hydrocarbons may affect the functioning of their salt gland (Lutcavage et al., 1995). Hydrocarbons in surface waters may also impact turtles when they surface to breathe and inhale toxic vapours. Their breathing pattern, involving large 'tidal' volumes and rapid inhalation before diving, results in direct exposure to petroleum vapours which are the most toxic component of the hydrocarbon spill (Milton and Lutz, 2003). This can lead to lung damage and congestion, interstitial emphysema, inhalant pneumonia and neurological impairment (National Oceanic and Atmospheric Administration, 2010). Contact with entrained hydrocarbons can result in hydrocarbon adherence to body surfaces (Gagnon and Rawson, 2010) causing irritation of mucous membranes in the nose, throat and eyes leading to inflammation and infection (Gagnon and Rawson, 2010). The Operational Area partially overlaps with the internesting BIA and Habitat Critical area for the flatback turtle. The timing of the Petroleum Activities Program (May to August) overlaps with the peak nesting period for the species (June to September).

Summary of Potential Impacts to Environmental Values(s)
The 80 km internesting buffer for flatback turtles in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017a) is considered very conservative. A more recent study by Whittock et al. (2016) defined suitable internesting habitat as water 0–16 m deep and within 5–10 km of the coastline, while unsuitable internesting flatback habitat was defined as waters >25 m deep and >27 km from the coastline. The primary environmental variables that influenced flatback internesting movement were bathymetry, distance from coastline, and sea surface temperature (Whittock et al., 2016). There is no evidence to date to indicate that flatback turtles swim out into deep offshore waters during the internesting period. Additionally, suitable areas of internesting habitat were located close to many known flatback turtle rookeries across the region (Whittock et al., 2016). It is important to note that flatback turtle hatchlings do not undertake oceanic migrations offshore to deep, pelagic waters. Instead juveniles grow to maturity in shallow coastal waters close to their natal beaches (Musick and Limpus, 1996). Due to the absence of potential nesting habitat and location offshore, the Operational Area is unlikely to represent important habitat for marine turtles (approximately 43 km from the Tiwi Islands). It is however acknowledged that the EMBA overlaps BIAs for several species of marine turtle (refer to **Section 4.4.4**). In the event of a vessel collision, a marine diesel spill may have a minor disruption to a small portion of the population; however, there is no threat to overall population viability. **Seasnakes** Impacts to seasnakes from direct contact with hydrocarbons are likely to result in similar physical effects to those recorded for marine turtles and may include potential damage to the dermis and irritation to mucus membranes of the eyes, nose and throat (International Tanker Owners Pollution Federation [ITOPF], 2011). They may also be impacted when they return to the surface to breathe and inhale the toxic vapours associated with the hydrocarbons, resulting in damage to their respiratory system. In general, seasnakes frequent the waters of the continental shelf area around offshore islands and potentially submerged shoals (water depths <100 m; see Submerged Shoals below) and while individuals may be present in the EMBA (refer to **Section 4.4.4**), their abundance is not expected to be high given the offshore location of the activity. Therefore, a hydrocarbon spill may have a minor disruption to a portion of the population but there is no threat to overall population viability. **Crocodiles** Impacts to crocodiles from direct contact with hydrocarbons are likely to result in similar physical effects to those recorded for marine turtles and may include potential damage to the dermis and irritation to mucus membranes of the eyes, nose and throat (ITOPF, 2011). They may also be impacted when they return to the surface to breathe and inhale the toxic vapours associated with the hydrocarbons, resulting in damage to their respiratory system. The salt-water crocodile was identified by the PMST as potentially occurring in the EMBA. The species has a tropical distribution that extends across the northern coastline of Australia. The salt-water crocodile is typically found in coastal waters and estuaries. While individuals may be present in the EMBA (refer to **Section 4.4.4**), their abundance is not expected to be high given the offshore location of the activity. Therefore, a hydrocarbon spill may have a minor disruption to a small number of individuals but there is no threat to overall population viability.
Sharks and Rays
Impacts to sharks and rays may occur through direct contact with hydrocarbons and contaminate the tissues and internal organs either through direct contact or via the food chain (consumption of prey). In the offshore environment, it is probable that pelagic shark species are able to detect and avoid surface waters underneath hydrocarbon spills by swimming into deeper water or away from the affected areas. Therefore, any impact on sharks and rays is predicted to be minor and only a temporary disruption. Hydrocarbon contact may affect whale sharks through ingestion (entrained/dissolved hydrocarbons), particularly if feeding. No defined BIAs for the whale shark are located within the EMBA (refer to **Section 4.4.4**). Due to the species widespread distribution and highly migratory nature, individuals may transit through the Operational Area and EMBA in low numbers. Therefore, individual whale sharks that have direct contact with hydrocarbons within the spill affected area may be impacted but the consequences to migratory whale shark populations are likely to be minor.

Summary of Potential Impacts to Environmental Values(s)
Seabirds and/or Migratory Shorebirds
As outlined in **Section 4.4.4**, 12 species of seabirds and/or migratory shorebirds were identified by the PMST as potentially occurring within the EMBA, including three threatened species. There are no BIAs for any bird species located within the Operational Area, however the EMBA overlaps with a crested tern breeding BIA at Seagull Island. Seabirds generally do not exhibit avoidance behaviour to floating hydrocarbons. Physical contact of seabirds with surface slicks is by several exposure pathways, primarily, immersion, ingestion and inhalation. Such contact with hydrocarbons may result in plumage fouling and hypothermia (loss of thermoregulation), decreased buoyancy and potential to drown, inability to fly or feed, anaemia, pneumonia and irritation of eyes, skin, nasal cavities and mouths (Australian Maritime Safety Authority, 2013; International Petroleum Industry Environmental Conservation Association, 2004) and result in mortality due to oiling of feathers or the ingestion of hydrocarbons. Longer-term exposure effects that may potentially impact seabird populations include a loss of reproductive success (loss of breeding adults) and malformation of eggs or chick (Australian Maritime Safety Authority, 2013). The extent of the EMBA for a surface slick may result in impacts on feeding habitat, however this is not expected to result in a threat to the overall population viability of seabirds or shorebirds. Accumulated hydrocarbons above threshold concentrations (>100 g/m^2) were not predicted to occur. Floating oil at concentrations equal to or greater than 1 g/m^2 are not predicted to contact any shoreline receptors. Therefore, no impacts are expected to important nesting habitat.
Summary of potential impacts to other habitats and communities
Benthic Fauna Communities
Benthic fauna communities associated within the submerged shoals and banks located in the EMBA (refer to **Section 4.4.3.3**) may be exposed to entrained hydrocarbons above threshold concentrations (>100 ppb). The modelling indicates that locations exposed to entrained hydrocarbons at or above the threshold concentration of 100 ppb are restricted to offshore areas up to approximately 449 km from the release site. Dissolved hydrocarbons above threshold concentrations (>50 ppb) are restricted to offshore areas approximately 114 km from the release site. Therefore, submerged shoals and banks located in the EMBA are expected to have some contact with entrained and dissolved hydrocarbons. A loss of marine diesel from a vessel collision may result in a small area of seabed and associated epifauna and infauna exposed to hydrocarbons.
Plankton and Fish Communities
There is potential for plankton communities to be impacted by a marine diesel spill where entrained hydrocarbons thresholds are exceeded; however, communities are expected to recover quickly (weeks/months) due to high population turnover (ITOPF, 2011). With the relatively small EMBA and the fast population turn-over of open water plankton populations, it is considered that any potential impacts will be low and temporary in nature. Fish populations in the open water offshore environment of the Operational Area and EMBA are highly mobile and can move away from a marine diesel spill. The spill-affected area will likely be confined to the upper surface layers. It is therefore unlikely that fish populations would be exposed to hydrocarbon contamination. Fish populations are likely to be distributed over a wide geographical area so impacts on populations or species level are considered to be negligible. Combined with these factors and the relatively small EMBA and the rapid dispersion of marine diesel, it is considered that any potential impacts will be negligible.

Summary of Potential Impacts to Environmental Values(s)
Spawning/Nursery Areas
Fish (and other commercially targeted taxa) in their early life stages (eggs, larvae and juveniles) are at their most vulnerable to lethal and sub-lethal impacts from exposure to hydrocarbons, particularly if a spill coincides with spawning seasons or if a spill reaches nursery areas close to the shore (e.g. seagrass and mangroves) (ITOPF, 2011). Fish spawning (including for commercially targeted species such as snapper and mackerel) mostly occurs in nearshore waters at certain times of the year and nearshore waters are also inhabited by higher numbers of juvenile fishes than offshore waters. Modelling indicated that in the unlikely event of a marine diesel spill there is potential for entrained hydrocarbons to occur in the surface water layers above threshold concentrations in the shallow areas of the Operational Area (i.e. Lynedoch Bank and Goodrich Bank). This, and the potential for possible lower concentration exposure for dissolved aromatic hydrocarbons, have the potential to result in lethal and sub-lethal impacts to a certain portion of fish larvae in affected areas, depending on concentration and duration of exposure and the inherent toxicity of the hydrocarbon. Losses of fish larvae in worst affected areas are unlikely to be of major consequence to fish stocks compared with significantly larger losses through natural predation, and the likelihood that most nearshore areas would be exposed is low (i.e. not all areas in the region would be affected). This is supported by a recent study in the Gulf of Mexico which used juvenile abundance data, from shallow-water seagrass meadows, as indices of the acute, population-level responses of young fishes to the Deepwater Horizon spill. Results indicated that there was no change to the juvenile cohorts following this spill. Additionally, there were no significant post-spill shifts in community composition and structure, nor were there changes in biodiversity measures (Fodrie and Heck, 2011). Any impacts to spawning and nursery areas are expected to be slight and short term, as would flow on effects to adult fish stocks into which larvae are recruited.
Coral Reef Habitat
The quantitative spill risk assessment indicates there would be potential for entrained hydrocarbons above threshold concentrations (>100 ppb) to contact a number of shallow submerged shoals and banks (refer to **Table 6-21**), and therefore exposure to subtidal coral reef habitat. Exposure to entrained hydrocarbons has the potential to result in lethal or sub-lethal toxic effects to corals and other sensitive sessile benthos within the upper water column, including subtidal corals. Mortality in a number of coral species is possible and this would result in the reduction of coral cover and change in the composition of coral communities. Sub-lethal effects to corals may include polyp retraction, changes in feeding, bleaching (loss of zooxanthellae), increased mucous production resulting in reduced growth rates and impaired reproduction (Negri and Heyward, 2000). In the unlikely event of a marine diesel spill occurring at the time of coral spawning at potentially affected coral locations or in the general peak period of biological productivity, there is potential for a reduction in successful fertilization and coral larval survival due to the sensitivity of coral early life stages to hydrocarbons (Negri and Heyward, 2000). Such impacts are likely to result in the failure of recruitment and settlement of new population cohorts. In addition, some non-coral species may be affected via direct contact with entrained hydrocarbons, resulting in sub-lethal impacts and in some cases mortality. This is with particular reference to the early life-stages of coral reef animals (reef attached fishes and reef invertebrates), which can be relatively sensitive to hydrocarbon exposure. Coral reef fish are site attached, have small home ranges and as reef residents they are at higher risk from hydrocarbon exposure than non-resident, more wide-ranging fish species. The exact impact on resident coral communities will be entirely dependent on actual hydrocarbon concentration, duration of exposure and water depth of the affected communities. The modelling indicates that locations exposed to entrained hydrocarbons at or above the threshold concentration of 100 ppb are restricted to offshore areas up to approximately 449 km from the release site. Dissolved hydrocarbons above threshold concentrations (>50 ppb) were restricted to offshore areas approximately 114 km from the release site. . Therefore, submerged shoals and banks located in the EMBA are expected to have some contact with entrained and dissolved hydrocarbons. If coral habitats within the EMBA are exposed to hydrocarbons, coral community live cover, structure and composition is predicted to reduce, manifested by loss of corals and associated sessile biota. Recovery of these impacted areas relies on coral larvae from neighbouring coral communities that have either not been affected or only partially impacted.
Indonesia (Pulau Adanar, Pulau Yamdena)
The spill modelling predicted no contact above threshold concentrations in nearshore waters of Indonesia. However, the extrapolated EMBA (as discussed in **Section 6.5.1.2**) shows that there is potential for entrained hydrocarbons above threshold concentrations (>100 ppb) to contact nearshore waters of Indonesia. Based on the spill modelling results and the distance of the Operational Area to Indonesia, the time for hydrocarbons to contact nearshore waters of Indonesia can be estimated at 20 days. At this time period, the hydrocarbons are expected to be highly weathered (refer to Figure 6-9). Impacts to receptors in nearshore waters of Indonesia are discussed below. **Seagrass Beds / Macroalgae**

Summary of Potential Impacts to Environmental Values(s)
Entrained hydrocarbons have the potential to contact shallow subtidal and intertidal communities in Indonesia. The variety of habitat and communities types, from the upper subtidal to the intertidal zones support a high diversity of marine life and are utilised as important foraging and nursery grounds by a range of invertebrate and vertebrate species. Seagrass and macroalgal beds occurring in the intertidal and subtidal zone may be susceptible to impacts from entrained hydrocarbons. Toxicity effects can also occur due to absorption of soluble fractions of hydrocarbons into tissues (Runcie et al., 2010). The potential for toxicity effects of entrained hydrocarbons may be reduced by weathering processes that should serve to lower the content of soluble aromatic components before contact occurs. Exposure to entrained hydrocarbons may result in mortality, depending on actual entrained aromatic hydrocarbon concentration received and duration of exposure. Physical contact with entrained hydrocarbon droplets could cause sub-lethal stress, causing reduced growth rates and a reduction in tolerance to other stress factors (Zieman et al., 1984). Impacts on seagrass and macroalgal communities are likely to occur in areas where hydrocarbon threshold concentrations are exceeded. **Mangroves** Mangrove habitat and associated mudflats at Indonesia, have the potential to be exposed to entrained hydrocarbons above threshold concentrations (refer to **Table 6-21**). Hydrocarbons deposited on the aerial roots of mangroves can block the pores used to breathe or interfere with the trees' salt balance resulting in sub-lethal and potential lethal effects. Mangroves can be impacted by entrained hydrocarbons that may adhere to the sediment particles. In low energy environments such as in mangroves, deposited sediment-bound hydrocarbons are unlikely to be removed naturally by wave action and may be deposited in layers by successive tides (National Oceanic and Atmospheric Administration, 2014). Entrained hydrocarbon impacts may include sub-lethal stress and mortality to certain sensitive biota in these habitats, including infauna and epifauna. Larval and juvenile fish, and invertebrates that depend on these shallow subtidal and intertidal habitats as nursery areas, may be directly impacted due to the loss of habitats and/or lethal and sub-lethal in-water toxic effects. This may result in mortality or impairment of growth, survival and reproduction (Heintz et al., 2000). In addition, there is the potential for secondary impacts on shorebirds, fish, sea turtles, rays, and crustaceans that utilise these intertidal habitat areas for breeding, feeding and nursery habitat purposes. **Coral Reef Habitat** Entrained hydrocarbons have the potential to contact coral reef habitat at Indonesia (refer to **Table 6-21**). Impacts to coral reef habitats are discussed above.
Key Ecological Features
KEFs potentially impacted by a marine diesel spill from a vessel collision event are: • Shelf break and slope of the Arafura Shelf • Carbonate bank and terrace system of the Van Diemen Rise • Pinnacles of the Bonaparte Basin • Carbonate bank and terrace system of the Sahul Shelf. These KEFs are primarily defined by seabed geomorphological features and are described to identify the potential for increased biological productivity and, therefore, ecological significance. The consequences of a marine diesel spill from a vessel collision may impact the values of the KEFs affected (for the values of each KEF see **Section 4.6.4**). Potential impacts include: the contamination of sediments, impacts to benthic fauna and associated impacts to demersal fish populations and reduced biodiversity as described above and below. Most of the KEFs within the EMBA have relatively broad-scale distributions and are unlikely to be significantly impacted.
Summary of potential impacts to water quality
Water quality would be affected due to hydrocarbon contamination which is described in terms of the biological effect concentrations. These are defined by the EMBA descriptions for each of, entrained and dissolved hydrocarbon fates and their predicted extent (refer to **Table 6-21**). Furthermore, water quality is predicted to have minor long-term and/or significant short-term hydrocarbon contamination above background and/or national/international quality standards.
Summary of potential impacts to marine sediment quality

Summary of Potential Impacts to Environmental Values(s)
Entrained hydrocarbons (at or above the defined thresholds) are predicted to potentially contact submerged shoals and banks in the region (refer to **Table 6-21)**. Such hydrocarbon contact may lead to reduced marine sediment quality by several processes, such as adherence to sediment and deposition on seabed habitat.
Summary of potential impacts to protected areas (including AMPs)
The quantitative spill risk assessment results indicate that the open water environment protected within the Oceanic Shoals AMP and Arafura AMP may be affected by the released hydrocarbons (refer to **Table 6-21**). It is noted that there are no State or Territory protected areas within the EMBA. The Oceanic Shoals AMP has the potential to be contacted by surface hydrocarbons (100% probability), entrained hydrocarbons (55% probability), and dissolved hydrocarbons (21.5% probability) at or above the defined ecological effect concentrations (10 g/m^2, 100 ppb and 50 ppb respectively). The Arafura AMP has the potential to be contacted by entrained hydrocarbons (0.5% probability) at or above the defined ecological effect concentration of 100 ppb. Surface hydrocarbons and entrained hydrocarbons above concentration thresholds (10 g/m^2 and 50 ppb, respectively) were not predicted by the modelling to occur at the Arafura AMP. Impact on the values of the Oceanic Shoals AMP and Arafura AMP (refer to **Section 4.6.1**) are discussed in the relevant sections above for ecological and physical values and below for socio-economic and cultural values. Additionally, such hydrocarbon contact may alter stakeholder understanding and/or perception of the protected marine environment, given these represent areas largely unaffected by anthropogenic influences and contain biological diverse environments.
Summary of potential impacts to socio-economic and cultural values
Fisheries – Commercial
Fish exposure to hydrocarbon can result in ‘tainting’ of their tissues. Even very low levels of hydrocarbons can impart a taint or ‘off’ flavour or smell in seafood. Tainting is reversible through the process of depuration which removes hydrocarbons from tissues by metabolic processes, although it is dependent upon the magnitude of the hydrocarbon contamination. Fish have a high capacity to metabolise these hydrocarbons while crustaceans (such as prawns) have a reduced ability (Yender et al., 2002). Seafood safety is a major concern associated with spill incidents. Therefore, actual or potential contamination of seafood can affect commercial and recreational fishing and can impact seafood markets long after any actual risk to seafood from a spill has subsided (Yender et al., 2002). A spill would result in the establishment of an exclusion zone around the spill affected area. There would be a temporary prohibition on fishing activities for a period of time and subsequent potential for economic impacts to affected commercial fishing operators A loss of marine diesel result from a vessel collision is unlikely to cause significant direct impacts on the target species of Commonwealth, NT and Indonesian commercial fisheries within the defined EMBA. Further details are provided below. **Commonwealth Fisheries** The predicted EMBA resulting from a marine diesel spill may impact on the area fished by the Northern Prawn Fishery (refer to **Section 4.5.4**). This fishery generally targets banana and tiger prawns using trawl gear. Fishing generally takes place in waters 35 – 70 m deep, with most fishing effort between 50 and 60 m. The relatively small spill-affected area and temporary nature of the predicted marine diesel spill would infer that it is unlikely the hydrocarbon concentrations in the upper surface layers would lead to potential exposure of prawns to contamination. **NT Fisheries** The predicted EMBA resulting from a marine diesel spill may impact on the area fished by a number of State fisheries (refer to **Section 4.5.4**). These fisheries generally use a range of gear types and operate from shallow inshore water to water depths up to 200 m, targeting demersal and pelagic finfish species. In the unlikely event of a marine diesel spill, there is the potential for the targeted fish species to be exposed to entrained hydrocarbons in the water column. However, the potential for direct impact would be reduced as target species such as snapper are likely to avoid the surface water layer underneath oil slicks. The relatively small spill-affected area and temporary nature of the predicted marine diesel spill would infer that it is unlikely the hydrocarbon concentrations in the upper surface layers would lead to potential exposure of pelagic fish to contamination. Demersal species (such as finfish) have limited mobility and therefore, will not be able to easily move away from a spill. Mortality/sub-lethal effects may impact demersal fish located close to the release location. **Indonesian Fisheries** The predicted EMBA resulting from a marine diesel spill may impact on the area fished by Indonesian commercial fishing vessels. The Operational Area is located in the ‘Area of Overlapping Jurisdiction’ established under the 1997 Perth Treaty (as described in **Section 4.5.5**). Within this area, Australia exercises seabed jurisdiction including the exploration of petroleum, and Indonesia exercises water column jurisdiction, including fishing rights. Indonesian fishing vessels generally use a range of gear types, targeting demersal and pelagic finfish species. In the unlikely event of a marine

Summary of Potential Impacts to Environmental Values(s)
diesel spill, there is the potential for the targeted fish species to be exposed to entrained hydrocarbons in the water column.
Fisheries – Traditional
No designated traditional fisheries have been identified to occur within the EMBA. It is recognised that indigenous communities fish in the shallow coastal and nearshore waters of the Tiwi Islands, however no impacts to these environments are predicted to occur.
Tourism and Recreational Activities
Limited recreational fishing and tourism activities take place in the offshore waters of the EMBA. A loss of marine diesel from a vessel collision may lead to exclusion of marine nature-based tourist activities, resulting in a loss of revenue for a small number of operators. Recreational fishing activities may experience operational inconvenience as vessels may be required to deviate course to avoid the affected area or seek alternative fishing grounds.
Research and Monitoring Programs
An IMOS mooring (NWSLYN) is located on Lynedoch Bank (located within the Active Source Area) and is operated by AIMS. It is understood that the instrumentation available on the mooring is retrieved and re-deployed approximately every 6-months to collect recorded data and maintain/calibrate instrumentation. In addition, a waverider buoy is deployed at Goodrich Bank (located within the Operational Area) to record wave height, period and direction. A loss of marine diesel from a vessel collision may lead to exclusion of vessels servicing the mooring and/or interference with the instrumentation (and recorded data) available on the mooring/buoy.
Offshore Oil and Gas Activities
No oil and gas production wells or facilities are located within the EMBA. Santos Limited (and joint venture partner SK E&S) is proposing to develop the Barossa project, located in NT/RL5, within the north-west portion of the Operational Area. Santos made the FID on the Barossa Development on 31st March 2021. No activities associated with the Barossa project are currently proposed to occur during the Galactic Hybrid 2D MSS acquisition window. Therefore, no impacts are predicted to occur to offshore oil and gas activities.
Commercial Shipping
Low density traffic is expected to occur in the EMBA, with the exception of a moderate density shipping route located north of the Operational Area. This route accommodates vessels transiting between Indonesia through to the waters between Cape York Peninsula and Papua New Guinea. A loss of marine diesel from a vessel collision may lead to exclusion of commercial shipping, resulting in operational inconvenience as vessels may be required to deviate course from intended routes.
Cultural Heritage
No World Heritage Properties, Commonwealth Heritage Areas or National Heritage Areas were identified in the EMBA. A search of the Australian National Shipwreck Database (**Section 4.5.1**), which records all known Maritime Cultural Heritage (shipwrecks, aircraft, relics and other underwater cultural heritage) in Australian waters, indicated that there are no Underwater Cultural Heritage sites within Operational Area, and one shipwreck within the EMBA. However, impacts to cultural heritage values are expected to be negligible.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Comply with Marine Order 30 (prevention of collisions) 2016, including: • adherence to steering and sailing rules including	F: Yes. CS: Minimal cost. Standard practice.	Legislative requirement to reduce the likelihood of interference with other marine users resulting in a collision.	Controls based on legislative requirements – must be adopted	Yes **C 15.1**

[15] Qualitative measure

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
maintaining lookouts (e.g. visual, hearing, radar, etc.), proceeding at safe speeds, assessing risk of collision and taking action to avoid collision (monitoring radar) • adherence to navigation light display requirements, including visibility, light position/shape appropriate to activity • adherence to navigation noise signals as required.				
Comply with Marine Order 27 (Safety of navigation and radio equipment) 2016, including: • navigational systems and equipment mentioned in Regulations 19 and 20 of Chapter V of SOLAS for the vessel are type approved and installed on board vessels • navigational systems and equipment mentioned in Regulations 7 to 11 of Chapter IV of SOLAS are installed on board vessels • navigational systems and equipment are maintained in working order • navigational activities and incidents of importance to safety of navigation on the vessel are recorded.	F: Yes. CS: Minimal cost. Standard practice.	Legislative requirement to reduce the likelihood of interference with other marine users resulting in a collision.	Controls based on legislative requirements – must be adopted	Yes **C 15.2**
Comply with Marine Order 21 (safety and emergency arrangements) 2020, including:	F: Yes. CS: Minimal cost. Standard practice.	Legislative requirement to reduce the likelihood of interference with other marine users resulting in a collision.	Controls based on legislative requirements – must be adopted	Yes **C 15.3**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[15]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
• adherence to minimum safe manning levels • maintenance of navigation equipment in efficient working order • navigational systems and equipment required are those specified in Regulation 19 of Chapter V of SOLAS • AIS that provides other users with information about the vessel's identity, type, position, course, speed, navigational status and other safety-related data.				
Good Practice				
Notify AHO of activities and movements no less than four weeks before the scheduled activity commencement date.	F: Yes CS: Minimal cost. Standard practice.	Notification to AHO will enable them to generate navigation warnings (Maritime Safety Information Notifications (MSIN)) and NTM [including AUSCOAST warnings where relevant)]).	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 1.1**
Notify AMSA JRCC of activities and movements 24-48 hours before the scheduled activity commencement date.	F: Yes CS: Minimal cost. Standard practice.	Communication of the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of a collision with a third party vessel.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 1.2**
Notify Defence of activities and movements no less than five weeks before the scheduled activity commencement date.	F: Yes CS: Minimal cost. Standard practice.	Communication of the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of a collision with a third party vessel.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 1.3**
Notify relevant stakeholders identified during consultation four weeks prior to commencement and	F: Yes CS: Minimal cost. Standard practice.	Communication of the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 1.4**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
upon completion of activities.		reducing the likelihood of a collision with a third party vessel.		
Provide daily lookahead reports to fisheries stakeholders and other key on-the-water stakeholders, where requested, notifying of planned acquisition and vessel location in upcoming 72-hour period.	F: Yes CS: Minimal cost. Standard practice.	Communication of the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of a collision with a third party vessel.	Benefits outweigh cost/sacrifice.	Yes **C 1.6**
Develop an operations plan (where required) with stakeholders confirmed as having concurrent activities, including the following aspects: • communications • work programming • hazard management • emergency response.	F: Yes CS: Minimal cost. Standard practice.	Communication of the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of a collision with a third party vessel.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 1.7**
Establish and maintain a 3 nm radius SNA around the seismic vessel and towed array.	F: Yes CS: Minimal cost. Standard practice.	Presence of the SNA will reduce the likelihood of a collision with a third party vessel.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 2.1**
At least one dedicated chase/support vessel will be employed to assist the seismic vessel.	F: Yes CS: Minimal cost. Standard practice.	Use of a chase or support vessel to assist the seismic vessel will reduce the likelihood of a collision with a third party vessel.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 2.2**
Project vessels to operate AIS, and tail buoy will be fitted with lights, GNSS and virtual AIS.	F: Yes CS: Minimal cost. Standard practice.	Use of AIS on project vessels, and lights and virtual AIS and GNSS on tail buoy will reduce the likelihood of a collision with a third party vessel.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 2.3**
In the event of a spill, emergency response activities implemented in accordance with the OPEP (**Table 7-4**).	F: Yes CS: Costs associated with implementing response strategies, vary dependant on nature and scale of spill event. Standard practice.	Potentially reduces consequence by implementing response to reduce impacts to the marine environment.	Control based on regulatory requirement – must be adopted.	Yes **C 15.4**
Arrangements supporting the activities in the OPEP will be tested to ensure they can be implemented as planned (**Table 7-4**).	F: Yes CS: Moderate costs associated with exercises. Standard practice.	No change to impact or risk, however, ensures OPEP can be implemented in the event of a hydrocarbon spill thereby potentially	Control based on regulatory requirement – must be adopted.	Yes **C 15.5**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
		reducing the consequence.		
Mitigation: Oil spill response.	Refer to **Appendix D**.			
Professional Judgement – Eliminate				
Eliminate use of vessels.	F: No. The use of vessels is required to conduct the Petroleum Activities Program. CS: Not considered – control not feasible.	Not considered – control not feasible.	Not considered – control not feasible.	No
Professional Judgement – Substitute				
None identified.				
Professional Judgement – Engineered Solution				
None identified.				
Risk Based Analysis				
A quantitative spill risk assessment was undertaken (see detail above).				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the communications protocol that will be in place between the project vessels (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks of an unplanned loss of hydrocarbon resulting from vessel collision. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that an accidental hydrocarbon release as a result of a vessel collision represents a moderate current risk rating and may result in minor, short-term impact (1-2 years) on species, habitat (but not affecting ecosystem function), physical or biological attributes and communities. Relevant recovery plans and conservation advice have been considered during the impact assessment, and the Petroleum Activities Program is not considered to be inconsistent with the overall recovery objectives and actions of these recovery plans and conservation advice. The adopted controls are considered consistent with industry legislation, codes and standards, good practice and professional judgement and meet the requirements and expectations of Australian Marine Orders, AMSA and AHO identified during impact assessment and stakeholder consultation. On the basis of the environmental impact assessment outcomes and Woodside's criteria for acceptability outlined in **Section 2.7.2**, this is considered an acceptable level of risk.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 15 No release of hydrocarbons to the marine environment due to a vessel collision with a consequence level greater than D[16] during the Petroleum Activities Program.	**C 15.1** Comply with Marine Order 30 (prevention of collisions) 2016, including: • adherence to steering and sailing rules including maintaining lookouts (e.g. visual, hearing, radar, etc.), proceeding at safe speeds, assessing risk of collision and taking action to avoid collision (monitoring radar) • adherence to navigation light display requirements, including visibility, light position/shape appropriate to activity • adherence to navigation noise signals as required.	**PS 15.1** Project vessels compliant with Marine Order 30 (prevention of collisions) 2016 (which requires vessels to be visible at all times).	**MC 15.1.1** Records demonstrate compliance with standard maritime safety procedures (Marine Orders 21, 27 and 30).
	C 15.2 Comply with Marine Order 27 (Safety of navigation and radio equipment) 2016, including: • navigational systems and equipment mentioned in Regulations 19 and 20 of Chapter V of SOLAS for the vessel are type approved and installed on board vessels • navigational systems and equipment mentioned in Regulations 7 to 11 of Chapter IV of SOLAS are installed on board vessels • navigational systems and equipment are maintained in working order • navigational activities and incidents of importance to safety of navigation on the vessel are recorded.	**PS 15.2** Project vessels compliant with Marine Order 27 (Safety of navigation and radio equipment) 2016.	

[16] Defined as 'Minor, short-term impact (one to two years) on species, habitat (but not affecting ecosystem function), physical or biological attributes'.

	C 15.3 Comply with Marine Order 21 (safety and emergency arrangements) 2020, including: • adherence to minimum safe manning levels • maintenance of navigation equipment in efficient working order • navigational systems and equipment required are those specified in Regulation 19 of Chapter V of SOLAS • AIS that provides other users with information about the vessel's identity, type, position, course, speed, navigational status and other safety-related data.	**PS 15.3** Project vessels compliant with Marine Order 21 (safety of navigation and emergency procedures) 2016.	
	C 15.4 In the event of a spill, emergency response activities implemented in accordance with the OPEP (**Table 7-4**).	**PS 15.4** In the event of a spill the OPEP requirements are implemented.	**MC 15.4.1** Completed incident documentation shows requirements of OPEP were implemented in the event of a spill.
	C 15.5 Arrangements supporting the activities in the OPEP will be tested to ensure they can be implemented as planned (**Table 7-4**).	**PS 15.5.1** Exercises/tests will be conducted in alignment with the frequency identified in **Table 7-5**.	**MC 15.5.1** Testing of arrangement records confirm that emergency response capability has been maintained.
		PS 15.5.2 Woodside's procedure demonstrates a minimum level of trained personnel, for core roles in the OPEP, are maintained.	**MC 15.5.2** Emergency Management dashboard confirms that minimum level of personnel trained for core OPEP roles are available.
	C 1.1 See **See Section 6.4.1**	**PS 1.1** See **Section 6.4.1**	**MC 1.1.1** See **Section 6.4.1**
	C 1.2 See **Section 6.4.1**	**PS 1.2** See **Section 6.4.1**	**MC 1.2.1** See **Section 6.4.1**
	C 1.3 See **Section 6.4.1**	**PS 1.3** See **Section 6.4.1**	**MC 1.3.1** See **Section 6.4.1**
	C 1.4 See **Section 6.4.1**	**PS 1.4** See **Section 6.4.1**	**MC 1.4.1** See **Section 6.4.1**
	C 1.6 See **Section 6.4.1**	**PS 1.6** See **Section 6.4.1**	**MC 1.6.1** See **Section 6.4.1**
	C 2.1 See **Section 6.4.1**	**PS 2.1** See **Section 6.4.1**	**MC 2.1.1** See **Section 6.4.1**

	C 2.2 See **Section 6.4.1**	**PS 2.2** See **Section 6.4.1**	**MC 2.2.1** See **Section 6.4.1**
Detailed preparedness and response performance outcomes, standards and measurement criteria for the Petroleum Activities Program are provided in **Appendix D**.			

6.5.3 Accidental Hydrocarbon Release: Bunkering

Context		
Project Vessels – **Section 3.6.5**	Physical Environment – **Section 4.3** Biological Environment – **Section 4.4**	Stakeholder Consultation – **Section 5**

Impact Evaluation Summary

Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcomes
Loss of hydrocarbons to the marine environment from bunkering/refuelling of seismic vessel			x		x	x	x	A	E	1	L	LCS GP	Broadly Acceptable	EPO 16

Description of Source of Risk

Credible Scenario

Bunkering of marine diesel between the support vessel(s) and the seismic vessel may occur within the Operational Area.

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

- Partial or total failure of a bulk transfer hose or fittings during bunkering, due to operational stress or other integrity issues could spill marine diesel to the deck and/or into the marine environment. This would be in the order of less than 200 L, based on the likely volume of a bulk transfer hose (assuming a failure of the dry break and complete loss of hose volume).
- Partial or total failure of a bulk transfer hose or fittings during bunkering, combined with a failure in procedure to shutoff fuel pumps, for a period of up to five minutes, resulting in approximately 8 m^3 marine diesel loss to the deck and/or into the marine environment.

Quantitative Spill Risk Assessment

Woodside commissioned RPS APASA to model a surface spill volume of 8 m^3 in the offshore waters of northwest Western Australia. The results of these models have indicated that exposure to surface hydrocarbons above the 10 g/m^2 threshold is limited to the immediate vicinity of the release site, with little potential to extend beyond 1 km. Therefore, it is considered that exposure to threshold concentrations from an 8 m^3 surface spill from bunkering activities would be well within the EMBA for the vessel collision scenario detailed in **Section 6.5.2**. Given this, the offshore location of the Operational Area, and the fact that the same hydrocarbon type is involved for both scenarios, specific modelling for an 8 m^3 marine diesel release was not undertaken for this Petroleum Activities Program.

Hydrocarbon Characteristics

Refer to **Section 6.5.1.1** for a description of the characteristics of marine diesel, including detail on the predicted fate and weathering of a spill to the marine environment.

Impact Assessment

Potential Impacts to Environmental Values

Previous modelling studies for 8 m^3 marine diesel releases, spilt at the surface as result of bunkering activities, indicated that the potential for exposure to surface hydrocarbons exceeding 10 g/m^2 was confined to within the immediate vicinity (approximately 1 km) of the release sites. Therefore, it is considered that there is no potential for contact with sensitive receptor locations above surface (10 g/m^2), entrained (100 ppb) or dissolved (50 ppb) threshold concentrations from an 8 m^3 spill of marine diesel within the Operational Area.

Summary of Potential Impacts to Environmental Values(s)
The potential biological and ecological impacts associated with a much larger hydrocarbon spill (650 m^3) are presented in **Section 6.5.2**, further detail on impacts specific to a spill of marine diesel from a bunkering loss are provided below. The biological consequences of such a small volume spill on identified open water sensitive receptors relate to the potential for minor impacts to megafauna, plankton and fish populations (surface and water column biota) that are within the spill affected area and no impacts to commercial fisheries and/or benthic habitats are expected. Refer to **Section 6.5.2** (potential impacts of unplanned hydrocarbon release to the marine environment from vessel collision) for the detailed potential impacts; however, the extent of the EMBA associated with a marine diesel spill from loss during bunkering will be much reduced in terms of spatial and temporal scales, and hence, potential impacts from bunkering are considered slight and short-term.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[17]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Marine Order 91 (marine pollution prevention – oil) 2014 which requires a Ship Oil Pollution Emergency Plan (SOPEP)/ Spill Monitoring Programme Execution Plan (SMPEP) (as appropriate to vessel class).	F: Yes CS: Minimal cost. Standard Practice.	Reduces the likelihood of a spill entering the marine environment. Although no significant reduction in consequence could result, the overall risk is reduced.	Controls based on legislative requirements – must be adopted.	Yes **C 16.1**
Good Practice				
Bunkering equipment controls: • all hoses that have a potential environmental risk following damage or failure shall be linked to the vessel's preventative maintenance system • all bulk transfer hoses shall be tested in accordance with Original Equipment Manufacturer recommendations and re certified as required • there shall be dry-break couplings and flotation on fuel hoses • there shall be an adequate number of appropriately stocked, located and maintained spill kits.	F: Yes CS: Minimal cost. Standard practice.	Reduces the likelihood of a spill occurring. Although no significant reduction in consequence could result, the overall risk is reduced.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 16.2**
Ensure Contractor procedures include	F: Yes	Reduces the likelihood of a spill occurring.	Benefits outweigh cost/sacrifice.	Yes **C 16.3**

[17] Qualitative measure

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[17]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
requirements to be implemented during bunkering/refuelling operations, including: • a completed Permit to Work and/or Job Safety Analysis (JSA) shall be implemented for the hydrocarbon bunkering/refuelling operation • gauges, hoses, fittings and the sea surface shall be visually monitored during the operation • hoses shall be visually inspected as per vessel procedures prior to commencement • bunkering/refuelling will commence in daylight hours. If the transfer is to continue into darkness, the JSA risk assessment must consider lighting and the ability to determine if a spill has occurred • hydrocarbons shall not be transferred in marginal weather conditions.	CS: Minimal cost. Standard practice.	Although no significant reduction in consequence could result, the overall risk is reduced.	Control is also standard practice.	
No bunkering/refuelling operations undertaken within 10 km (horizontal distance) of the 20 m depth contour of Lynedoch Bank, Goodrich Bank and other shallow shoals in the SW corner of the Operational Area (unless under emergency conditions).	F: Yes CS: Moderate cost associated with relocating vessels for bunkering.	By implementing the exclusion, the potential for entrained and dissolved hydrocarbons to contact the shallow banks and shoals is reduced.	Benefits outweigh cost/sacrifice.	Yes **C 16.4**
No bunkering/refuelling operations undertaken within the Oceanic Shoals AMP (unless under emergency conditions)	F: Yes CS: Moderate cost associated with relocating vessels for bunkering.	By avoiding the AMP, the likelihood of a spill entering the AMP is reduced.	Benefits outweigh cost/sacrifice.	Yes **C 16.5**
Mitigation: Oil spill response.	Refer to **Appendix D**.			
Professional Judgement – Eliminate				

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[17]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Seismic vessel brought into port to refuel.	F: No. Does not eliminate the fuel transfer risk. It is not operationally practical to transit the seismic vessel back to port for refuelling, based on the frequency of the refuelling requirements and distance from the nearest port (Darwin Port 194 km). CS: Significant due to schedule delay and vessel transit costs and day rates.	Eliminates the risk in the Operational Area; however, moves risk to another location. Therefore, no overall benefit.	Disproportionate. The cost/sacrifice outweighs the benefit gained.	No
Professional Judgement – Substitute				
None identified				
Professional Judgement – Engineered Solution				
None identified.				
Risk Based Analysis				
A quantitative spill risk assessment was undertaken (see details above).				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts and risks of a bunkering spill. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement Loss of hydrocarbons to marine environment during bunkering has been evaluated as having a low current risk rating that is unlikely to result in potential impact greater than minor and temporary exceedance over national/international water quality standards and a localised, minor and temporary disruption to a small proportion of the population and no impact on critical habitat or activity of protected species. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice. As demonstrated in **Section 6.6**, the residual risk of unplanned hydrocarbon release from bunkering is not inconsistent with the relevant objectives and actions of any applicable recovery plans or threat abatement plans, based on the adopted controls. Regard has been given to relevant conservation advice and wildlife conservation plans during the assessment of potential risks. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of the described emissions to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 16 No unplanned loss of hydrocarbons to the marine environment from bunkering greater than a consequence level E[18]	**C 16.1** Marine Order 91 (marine pollution prevention – oil) 2014, requires SOPEP/SMPEP (as	**PS 16.1** Appropriate initial responses prearranged and drilled in case of a hydrocarbon spill, as appropriate to vessel class.	**MC 16.1.1** Records demonstrate compliance with Marine Order 91.

[18] Defined as ‘Slight, short-term impact (< 1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes’.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
during the Petroleum Activities Program.	appropriate to vessel class).		
	C 16.2 Bunkering equipment controls: • all hoses that have a potential environmental risk following damage or failure shall be linked to the vessel's preventative maintenance system • all bulk transfer hoses shall be tested in accordance with Original Equipment Manufacturer recommendations and re certified as required. • there shall be dry-break couplings and flotation on fuel hoses • there shall be an adequate number of appropriately stocked, located and maintained spill kits.	**PS 16.2.1** Damaged equipment is replaced prior to failure.	**MC 16.2.1** Records confirm the vessel bunkering equipment is subject to systematic integrity checks.
		PS 16.2.2 Minimised inventory loss in the event of a failure.	**MC 16.2.2** Records confirm presence of dry break couplings and flotation on fuel hoses.
		PS 16.2.3 Ensure adequate resources are available to allow implementation of the SOPEP.	**MC 16.2.3** Records confirm presence of spill kits.
	C 16.3 Ensure Contractor procedures include requirements to be implemented during bunkering/refuelling operations, including: • a completed Permit to Work and/or JSA shall be implemented for the hydrocarbon bunkering/refuelling operation • gauges, hoses, fittings and the sea surface shall be visually monitored during the operation • hoses shall be visually inspected as per vessel procedures prior to commencement • bunkering/refuelling will commence in daylight hours. If the transfer is to continue	**PS 16.3** Compliance with Contractor procedures for managing bunkering/refuelling operations.	**MC 16.3.1** Records demonstrate bunkering/refuelling undertaken in accordance with contractor bunkering procedures.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	into darkness, the JSA risk assessment must consider lighting and the ability to determine if a spill has occurred • hydrocarbons shall not be transferred in marginal weather conditions.		
	C 16.4 No bunkering/refuelling operations undertaken within 10 km (horizontal distance) of the 20 m depth contour of Lynedoch Bank, Goodrich Bank and other shallow shoals in the SW corner of the Operational Area (unless under emergency conditions).	**PS 16.4** Bunkering / fuelling activities not undertaken within 10 km horizontal distance of the 20 m depth contour of Lynedoch Bank, Goodrich Bank and other shallow shoals in the SW corner of the Operational Area (unless under emergency conditions).	**MC 16.4.1** Records demonstrate no bunkering/refuelling operations undertaken within 10 km (horizontal distance) of the 20 m depth contour of Lynedoch Bank, Goodrich Bank and other shallow shoals in the SW of the Operational Area (unless under emergency conditions).
	C 16.5 No bunkering/refuelling operations undertaken within the Oceanic Shoals AMP (unless under emergency conditions)	**PS 16.5** Bunkering/refuelling not undertaken within the Oceanic Shoals AMP (unless under emergency conditions)	**MC 16.5.1** Records demonstrate no bunkering/refuelling operations undertaken within an AMP (unless under emergency conditions).
Detailed oil spill preparedness and response performance outcomes, standards and measurement criteria for the Petroleum Activities Program are presented in **Appendix D.**			

6.5.4 Unplanned Discharge: Deck Spills

Context		
Project Vessels – **Section 3.6.5**	Physical Environment – **Section 4.3** Biological Environment – **Section 4.4**	Stakeholder Consultation – **Section 5**

Impact Evaluation Summary														
Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcomes
Accidental discharge of hydrocarbons/ chemicals from Project vessel deck activities and equipment (e.g. cranes and winches) within the Operational Area			x			x		A	F	2	L	LCS GP	Broadly Acceptable	EPO 17

Description of Source of Risk
Deck spills can result from spills from stored hydrocarbons/chemicals or equipment. Project vessels typically store hydrocarbon/chemicals in various volumes. Storage areas are typically set up with effective primary and secondary bunding to contain any deck spills. Releases from equipment are predominantly from the failure of hydraulic hoses, which can either be located within bunded areas or outside of bunded or deck areas (e.g. over water on cranes). Woodside's operational experience demonstrates that spills are most likely to originate from hydraulic hoses and have been less than 100 L, with an average volume <10 L.

Impact Assessment
Potential Impacts to Environmental Value(s)
No significant impacts from the accidental discharges described are anticipated in the offshore/open water locations of the Operational Area, because of the minor quantities involved (<10 L), the limited duration of vessel activities during the Petroleum Activities Program, and high level of dilution into the open water marine environment of the Operational Area. The biological consequences of such a small volume spill on identified open water sensitive receptors relate to a minor potential for toxicity impacts to plankton and fish populations (surface and water column biota) and localised reduction in water quality within a small spill affected area. No impacts are predicted to benthic habitat communities in the Operational Area.
Summary of Potential Impacts to Environmental Value(s)
Given the adopted controls, it is considered that minor hydrocarbon/harmful chemical spills to the marine environment will not result in a potential impact to water quality greater than localised contamination above background levels, quality standards or known effect concentrations, and will not result in a potential impact greater than localised and temporary disruption to a small proportion of the population with no impact on critical habitat or activity.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[19]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				

[19] Qualitative measure

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[19]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Marine Order 91 (marine pollution prevention—oil) 2014, requires Shipboard Oil Pollution Emergency Plan (SOPEP) (as appropriate to vessel class).	F: Yes. CS: Minimal cost. Standard practice.	Legislative requirements to be followed reduce the likelihood of an unplanned release. The consequence is unchanged.	Controls based on legislative requirements – must be adopted.	Yes **C 16.1**
Good Practice				
Bulk chemical and fuel storage areas are bunded or secondarily contained when they are not being handled/moved temporarily	F: Yes. CS: Minimal cost. Standard practice.	Reduces the likelihood of contaminated deck drainage water being discharged to the marine environment.	Benefits outweigh cost/sacrifice. Control is also standard practice.	Yes **C 17.1**
Maintain and locate spill kits in close proximity to hydrocarbon storage areas and deck areas for use to contain and recover deck spills.	F: Yes. CS: Minimal cost. Standard practice.	Reduces the likelihood of a deck spill from entering the marine environment. The consequence is unchanged.	Benefits outweigh cost/sacrifice.	Yes **C 17.2**
Professional Judgement – Eliminate				
None identified.				
Professional Judgement – Substitute				
None identified				
Professional Judgement – Engineered Solution				
Below-deck storage of all hydrocarbons and chemicals.	F: Not feasible. During operations there is a need to keep small volumes near activities and within equipment requiring use of hydrocarbons and chemicals and can result in increased risk of leaks from transfers via hose or smaller containers. CS: Not considered – control not feasible.	Not considered – control not feasible.	Not considered – control not feasible.	No
A reduction in the volumes of chemicals and hydrocarbons stored onboard the vessel.	F: Yes. Increases the risks associated with transportation and lifting operations. CS: Project delays if required chemicals not on board. Increases the risks associated with transportation and lifting operations.	No reduction in likelihood or consequence since chemicals will still be required to enable activities to occur.	Disproportionate. The cost/sacrifice outweighs the benefit gained.	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[19]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks of the potential unplanned accidental deck spills described above. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The risk assessment has determined that an unplanned minor discharge of hydrocarbons/chemicals as a result of minor deck spills represents a low current risk rating that is unlikely to result in potential impact greater than localised and temporary disruption to a small proportion of the population and no impact on critical habitat or activity. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are consistent with the most relevant regulatory guidelines and good oil-field practice/industry best practice. The potential impacts and risks are considered acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of minor unplanned deck spills to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 17 No unplanned spills to the marine environment from deck activities greater than a consequence level of F[20] during the Petroleum Activities Program.	**C 16.1** See **Section 6.5.3**	**PS 16.1** See **Section 6.5.3**	**MC 16.1.1** See **Section 6.5.3**
	C 17.1 Bulk chemical and fuel storage areas are bunded or secondarily contained when they are not being handled/ moved temporarily.	**PS 17.1** Failure of primary containment in storage areas does not result in loss to the marine environment.	**MC 17.1.1** Records confirms all bulk chemicals and fuel are stored in bunded/ secondarily contained areas when not being handled/moved temporarily.
	C 17.2 Maintain and locate spill kits in close proximity to hydrocarbon storage areas and deck areas for use to contain and recover deck spills.	**PS 17.2** Spill kits to be available for use to clean up deck spills.	**MC 17.2.1** Records confirms spill kits are present, maintained and suitably stocked.

[20] Defined as 'No lasting effect (<1 month). Localised impact not significant to environmental receptor'.

6.5.5 Unplanned Discharge: Loss of Solid Hazardous and Non-Hazardous Wastes (including Dropped Objects)

Context		
Activity Components – **Section 3.6**	Physical Environment – **Section 4.3** Biological Environment – **Section 4.4**	Stakeholder Consultation – **Section 5**

Impact Evaluation Summary

Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcomes
Accidental loss of hazardous or non-hazardous wastes (including dropped objects) to the marine environment (excludes sewage, grey water, putrescible waste and bilge water).			X		X	X		A	F	2	L	LCS GP	Broadly Acceptable	EPO 18

Description of Source of Impact

The project vessels will generate a variety of solid wastes including packaging and domestic wastes such as aluminium cans, bottles, paper and cardboard. Hence, there is the potential for solid wastes to be lost overboard to the marine environment. Wastes on-board are managed in accordance with the on-board waste management plan. Some wastes may be incinerated. Based on industry experience, waste items lost overboard are typically wind-blown rubbish such as container lids, cardboard etc. Such losses typically have occurred during back loading activities, periods of adverse weather and incorrect waste storage.

Impact Assessment

Potential Impacts to Environmental Values

The potential impacts of solid wastes accidentally discharged to the marine environment include direct pollution and contamination of the environment and secondary impacts relating to potential contact of marine fauna with wastes, resulting in entanglement or ingestion and leading to injury and death of individual animals. Several migratory and threatened species were identified as occurring within the Operational Area, including cetaceans, marine turtles and whale sharks. However, these species are expected to be transient as there are no known key aggregation areas. However, the temporary or permanent loss of waste materials into the marine environment is highly unlikely to have a significant environmental impact, based on the types, size and frequency of wastes that could occur during the limited time the vessels will be in the Operational Area and the transient nature of the species present. Given this, impacts will have no lasting effect on any species or water quality.

Summary of Potential Impacts to Environmental Values(s)

Given the adopted controls, it is considered that the accidental discharge of solid waste described will result in localised impacts not significant to environmental receptors, with no lasting effect.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)*[21]**	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Marine Order 95 – marine pollution prevention—garbage (as appropriate to vessel class), prescribes matters necessary to give effect to Annex V of MARPOL, which prohibits the discharge of all garbage into the sea, except as provided otherwise.	F: Yes. CS: Minimal cost. Standard practice.	Legislative requirements to be followed reduces the likelihood of an unplanned release. The consequence is unchanged.	Controls based on legislative requirements – must be adopted.	Yes **C 18.1**
Good Practice				
Project vessel waste arrangements, which require: • dedicated waste segregation bins • records of all waste to be disposed, treated or recycled • waste streams to be handled and managed according to their hazard and recyclability class.	F: Yes. CS: Minimal cost. Standard practice.	Reduces the likelihood of an unplanned release. The consequence is unchanged.	Benefit outweighs cost sacrifice.	Yes **C 18.2**
Lost waste/dropped objects will be recovered, where safe and practicable. Where safe and practicable for this activity, will consider: • risk to personnel to retrieve object • whether the location of the object is in recoverable water depths • object's proximity to subsea infrastructure • ability to recover the object (i.e. nature of object, lifting equipment and suitable weather).	F: Yes, however it may not always be practicable. Assessed on a case by case situation. CS: Minimal cost. Standard practice.	No reduction in likelihood, as this is an unplanned event. Since the equipment may be recovered, a reduction in consequence is possible.	Benefit outweighs cost sacrifice.	Yes **C 18.3**
Professional Judgement – Eliminate				
None identified.				
Professional Judgement – Substitute				

[21] Qualitative measure

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[21]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
None identified.				
Professional Judgement – Engineered Solution				
None identified.				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks of accidental discharges of waste. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that, given the adopted controls, accidental discharge of solid waste represents a low current risk rating that is unlikely to result in a potential impact above localised, not significant to environmental receptors with no lasting effects. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice and meet legislative requirements (Marine Order 95). Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of these discharges to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 18 No unplanned releases of solid hazardous or non-hazardous waste to the marine environment greater than a consequence level of F[22] during the Petroleum Activities Program.	**C 18.1** Marine Order 95 – marine pollution prevention—garbage (as appropriate to vessel class), prescribes matters necessary to give effect to Annex V of MARPOL, which prohibits the discharge of all garbage into the sea, except as provided otherwise.	**PS 18.1** Project vessels compliant with Marine Order 95.	**MC 18.1.1** Records demonstrate project vessels are compliant with Marine Order 95.
	C 18.2 Project vessel waste arrangements, which require: • dedicated waste segregation bins • records of all waste to be disposed, treated or recycled • waste streams to be handled and managed according to their hazard and recyclability class.	**PS 18.2** Waste will be managed in accordance with the project vessel waste arrangements.	**MC 18.2.1** Records demonstrate compliance against project vessel waste arrangements.
	C 18.3 Lost waste/dropped objects will be recovered,	**PS 18.3** Waste dropped to the marine environment will be	**MC 18.3.1** Records detail the recovery attempt

[22] Defined as ‘No lasting effect (<1 month) or negligible impact. Localised impact not significant to environmental receptors’.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	where safe and practicable. Where safe and practicable for this activity, will consider: • risk to personnel to retrieve object • whether the location of the object is in recoverable water depths • object's proximity to subsea infrastructure • ability to recover the object (i.e. nature of object, lifting equipment and suitable weather).	recovered where safe and practicable to do so.	consideration and status of any waste lost to the marine environment.

6.5.6 Physical Presence: Vessel Collision/Entanglement with Marine Fauna

Context		
Project Vessels – **Section 3.6.5**	Biological Environment – **Section 4.4**	Stakeholder Consultation – **Section 5**

Impact Evaluation Summary

Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcomes
Accidental collision between project vessels and threatened and/or migratory marine fauna within the Operational Area.						x		A	E	1	L	LCS GP	Broadly Acceptable	EPO 19
Entanglement of threatened and/or migratory marine fauna with towed seismic equipment within the Operational Area.						x								

Description of Source of Risk

Project Vessels

The project vessels operating in and around the Operational Area may present a potential hazard to cetaceans and other protected marine fauna such as whale sharks and marine reptiles. Vessel movements can result in collisions between the vessel (hull and propellers) and marine fauna, potentially resulting in superficial injury, serious injury that may affect life functions (e.g. movement and reproduction) and mortality. The factors that contribute to the frequency and severity of impacts due to collisions vary greatly due to vessel type, vessel operation (specific activity, speed), physical environment (e.g. water depth) and the type of animal potentially present and their behaviours.

The seismic vessel will be transiting at low speeds (4 to 5 knots) during seismic acquisition. The support vessel(s) generally travel at higher speeds.

Seismic Equipment

The 2D seismic vessel will tow seismic equipment (comprising the acoustic source, header buoy, single streamer and tail buoy) within the Operational Area. The seismic vessel will tow a single streamer that will extend over 12 to 12.5 km behind the seismic vessel. The streamer will be towed at a depth of approximately 15 to 20 m. The seismic source will be towed at a depth of approximately 6 to 8 m.

The seismic equipment has the potential to present an entrapment/entanglement risk to marine fauna (in particular marine turtles). Anecdotally, there has been no reported cases of marine fauna becoming entangled in seismic equipment in Australian waters.

Impact Assessment

Potential Impacts to Environmental Values

Vessel disturbance is a key threat to a number of migratory and threatened species identified as occurring within Operational Area, including cetaceans, marine turtles and whale sharks. Relevant conservation actions outlined in these plans are listed in **Section 6.6.**

Cetaceans

Cetaceans are naturally inquisitive marine mammals. The reaction of cetaceans to the approach of a vessel is quite variable. Some species remain motionless when close to a vessel, while others are known to be curious and often approach ships that have stopped or are slow moving, although they generally do not approach and sometimes avoid faster moving ships (Richardson et al., 1995). The Whale and Dolphin Conservation Society (WDCS, 2006), indicates that some cetacean species, such as humpback whales, can detect and change course to avoid a vessel.

Collisions between vessels and marine mammals occur more frequently in areas where high vessel traffic and important habitat coincide (WDCS, 2006). In Australia, the majority of vessel strikes to known species involved humpback, southern right whale and sperm whales, in descending order (Peel et al., 2016). Van Warebeek et al. (2007) report just five blue whale ship strikes in the Southern Hemisphere. No vessel strike collisions were reported in the Northern coast of Australia (Peel et, al. 2016). The behaviour exhibited by whales prior to vessel collision varies, with some reported as being asleep/unmoving prior to the collision (Peel et al., 2016) and others displaying a 'last-second flight response' (Laist et al., 2001). Individual cetaceans engaged in behaviours such as feeding, mating or nursing may also be more vulnerable to vessel collisions when distracted by these activities (Commonwealth of Australia, 2017b).

The likelihood of vessel/whale collision being lethal is influenced by vessel speed—the greater the speed at impact, the greater the risk of mortality (Jensen and Silber, 2004; Laist et al., 2001). Vanderlaan and Taggart (2007) found that the chance of lethal injury to a large whale as a result of a vessel strike increases from about 20% at 8.6 knots to 80% at 15 knots. Project vessels within the Operational Area are likely to be travelling <8 knots, therefore, the chance of a vessel collision with protected species resulting in a lethal outcome is considered unlikely, as fauna can move away from project vessels.

The Operational Area does not overlap with any cetacean BIAs or critical habitat. However, pygmy blue whales, Omura's whales and Bryde's whales may occur within the Operational Area throughout the duration of the survey. Although, the presence of all cetacean species is likely to be limited to infrequent occurrences of individuals or small groups.

According to the data of Vanderlaan and Taggart (2007), it is estimated that the risk of lethal injury to a large whale as a result of a vessel strike is less than 10% at a speed of 4 knots. Vessel-whale collisions at this speed are uncommon and, based on reported data contained in the NOAA database (Jensen and Silber, 2004) there only two known instances of collisions when the vessel was travelling at less than 6 knots; both of these were from whale-watching vessels that were deliberately positioned amongst whales. Given the duration of activities within the Operational Area and the slow speeds at which project vessels operate, collisions with cetaceans are considered highly unlikely.

Marine Turtles

Marine turtles are at potential risk from vessel strike and entanglement with towed seismic equipment. Hazel and Gyuris (2006) reviewed vessel strike data from 1999-2002 on the Queensland east coast and found that during that period at least 65 turtles were killed annually as a result of collisions with vessels. Green turtles, followed by loggerhead turtles comprised the majority of vessel related records, and 72% of cases were adult or sub-adult turtles (Hazel and Gyuris, 2006). In Australian waters, all species of marine turtle have been involved in vessel strikes (DoEE, 2016).

The effect of vessel speed and turtle flee response can be significant. A study by Hazel et al. (2007) found that 60% of green turtles fled from vessels travelling at 2.2 knots (4 km/h) while only 4% fled from vessels travelling at 10.2 knots (19 km/h). When fleeing 75% of turtles moved away from the vessel's track, 8% swam along the vessel track and 18% crossed in front of the vessel. The study concluded that most turtles would be unlikely to avoid vessels travelling at speeds greater than around 2.2 knots (Hazel et al., 2007; Commonwealth of Australia, 2017a). Furthermore, the relatively small size of turtles and the significant time spent below the surface makes their observation by vessel operators extremely difficult or impossible. Green turtles observed by Hazel et al. (2009) generally only exposed the dorsal-anterior part of the head above the surface of the water and never for longer than two seconds.

There is no published literature on marine turtle entanglement with seismic equipment during seismic surveys; however, Nelms et al. (2016) state that they received anecdotal reports of turtle entrapments in tail buoys and airgun strings during several offshore seismic surveys off the west coast of Africa. Additionally, there is evidence of marine turtles becoming entangled in discarded seismic cable (Duncan et al., 2018).

The Operational Area partially overlaps with the internesting BIA and Habitat Critical area for the flatback turtle. The timing of the Petroleum Activities Program (May to August) overlaps with the peak nesting period for the species (June to September).

The 80 km internesting buffer for flatback turtles in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017a) is considered very conservative. A more recent study by Whittock et al. (2016) defined suitable internesting habitat as water 0–16 m deep and within 5–10 km of the coastline, while unsuitable internesting flatback habitat was defined as waters >25 m deep and >27 km from the coastline. The primary environmental variables that influenced flatback internesting movement were bathymetry, distance from coastline, and sea surface temperature (Whittock et al., 2016). There is no evidence to date to indicate that flatback turtles swim out into deep offshore waters during the internesting period. Additionally, suitable areas of internesting habitat were located close to many known flatback turtle rookeries across the region (Whittock et al., 2016). It is important to note that flatback turtle hatchlings do not undertake oceanic migrations offshore to deep, pelagic waters. Instead juveniles grow to maturity in shallow coastal waters close to their natal beaches (Musick and Limpus, 1996).

Due to the absence of potential nesting habitat and location offshore, the Operational Area is unlikely to represent important habitat for marine turtles. The occurrence of all species of marine reptiles within the Operational Area is

expected to be limited to infrequent occurrences of transitory individuals. Given the duration of activities within the Operational Area and the slow speeds at which project vessels operate, collisions or entanglement with transiting marine turtles are considered highly unlikely. ***Whale Sharks*** Whale sharks are at risk from vessel strikes when feeding at the surface or in shallow waters (where there is limited option to dive). The Operational Area does not represent important habitat for the species (refer to **Section 4.4.4**). Due to the species widespread distribution and highly migratory nature, individuals may transit through the Operational Area. Given the duration of activities within the Operational Area and the slow speeds at which project vessels operate, collisions with transiting individual whale sharks are considered highly unlikely.
Summary of Potential Impacts to Environmental Value(s)
Given the adopted controls, it is considered that if a collision or entanglement were to occur, it will not result in a potential impact greater than slight, short-term impact on the species (i.e. Environment Impact – E).

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[23]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans, including the following measures[24]: • Project vessels will not travel faster than six knots within 300 m of a cetacean or turtle (caution zone) • Project vessels will not approach closer than 50 m for a dolphin or turtle and/or 100 m for a whale (with the exception of animals bow riding). • If the cetacean or turtle shows signs of being disturbed, project vessels will immediately withdraw from the caution zone at a constant speed of less than six knots. • Vessels will not travel faster than eight knots within 250 m of a whale shark and not allow the vessel to approach closer than 30 m of a whale shark.	F: Yes. CS: Minimal cost. Standard practice.	Implementation of these controls will reduce the likelihood of a collision between a cetacean, whale shark or turtle occurring. The consequence of a collision is unchanged.	Controls based on legislative requirements – must be adopted.	Yes **C 12.1**

[23] Qualitative measure
[24] For safety reasons, the distance requirements below are not applied for a vessel holding station or with limited manoeuvrability, e.g. loading, back-loading, bunkering, close standby cover for overside working and emergency situations.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[23]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Exception: the above requirement does not apply to project vessels operating under limited/constrained manoeuvrability including but not limited to seismic vessel towing equipment and acquiring data, and in the event of an emergency.				
Good Practice				
None identified.				
Professional Judgement – Eliminate				
Eliminate use of vessels.	F: No. The use of vessels is required to conduct the Petroleum Activities Program. CS: Not considered – control not feasible.	Not considered – control not feasible.	Not considered – control not feasible.	No
Professional Judgement – Substitute				
Variation of the timing of the Petroleum Activities Program to avoid marine turtle nesting periods (June to September).	F: Yes. Avoidance of turtle nesting periods is technically feasible. CS: Significant cost and schedule delays in acquiring data and securing the seismic vessel for specific timeframes.	Negligible reduction in consequence given the duration and nature of the activity.	Grossly disproportionate. Implementation of the control requires considerable cost sacrifice for minimal environmental benefit.	No
The use of dedicated MFOs on support vessel(s) for the duration of the Petroleum Activities Program to watch for whales and provide direction on and monitor compliance with Part 8 of the EPBC Regulations.	F: Yes. Vessel bridge crews may maintain watch during operations. CS: Additional cost of MFOs considered unnecessary.	Given support vessel bridge crews already maintain a constant watch during operations, additional MFOs would not significantly further reduce the risk.	Grossly disproportionate. Implementation of the control requires considerable cost sacrifice for minimal environmental benefit.	No
Professional Judgement – Engineered Solution				
None identified.				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks of potential vessel collision/entanglement with protected marine fauna. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement

Demonstration of Acceptability
The impact assessment has determined that, given the adopted controls, vessel collision/entanglement with marine fauna represents a low risk rating that is unlikely to result in a potential impact to fauna greater than slight and short term, with no population-level effects. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice and meet the requirements of Part 8 (Division 8.1) of the EPBC Act Regulations 2000. The residual risk of vessel collision with marine fauna is not inconsistent with the relevant objectives and actions of any applicable recovery plans or threat abatement plans (refer to **Section 6.6**), based on the adopted controls. Regard has been given to relevant conservation advice during the assessment of potential risks. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of vessel collision with marine fauna to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 19 No vessel strikes with marine fauna (whales, whale sharks and turtles) with a consequence level greater than E[25] during the Petroleum Activities Program.	**C 12.1** EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans, including the following measures[26]: • project vessels will not travel faster than six knots within 300 m of a cetacean or turtle (caution zone). • project vessels will not approach closer than 50 m for a dolphin or turtle and/or 100 m for a whale (with the exception of animals bow-riding). • if the cetacean or turtle shows signs of being disturbed, project vessels will immediately withdraw from the caution zone at a constant speed of less than six knots. • vessels will not travel faster than eight knots within 250 m of a whale shark and not allow the vessel to approach closer than 30 m of a whale shark. ***Exception***: the above requirement does not apply to project vessels operating under limited/constrained manoeuvrability including but not limited to seismic vessel towing equipment	**PS 12.1** See **Section 6.4.4**	**MC 12.1.1** See **Section 6.4.4**
		PS 12.2 All vessel strike incidents with cetaceans, whale sharks and marine turtles will be reported in the National Ship Strike Database (as outlined in the Conservation Management Plan for the Blue Whale—A Recovery Plan under the EPBC Act 1999, Commonwealth of Australia, 2015a).	**MC 12.2.1** Records demonstrate reporting of cetacean, whale sharks and marine turtles ship strike incidents to the National Ship Strike Database.

[25] Defined as 'Slight, short-term impact (< 1 year) on species, habitat (but not affecting ecosystems function), physical or biological attributes.'

[26] For safety reasons, the distance requirements below are not applied for a vessel holding station or with limited manoeuvrability, e.g. loading, back-loading, bunkering, close standby cover for overside working and emergency situations.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	and acquiring data, and in the event of an emergency.		

6.5.7 Physical Presence: Loss or Grounding of Equipment

Context		
Activity Components – **Section 3.6**	Biological Environment – **Section 4.4** Socio-Economic Environment – **Section 4.5**	Stakeholder Consultation – **Section 5**

Impact Evaluation Summary

Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcomes
Physical loss or grounding of seismic equipment (i.e. streamers, acoustic source and AUV nodes).					x		x	A	E	1	L	LCS GP	Broadly Acceptable	EPO 20

Description of Source of Risk

The Petroleum Activities Program will be conducted using a seismic vessel. The seismic vessel will tow seismic equipment (comprising the acoustic source, header buoy, single streamer and tail buoy). The seismic vessel will tow a single streamer (that will extend approximately 12 to 12.5 km behind the seismic vessel). The streamer will be towed at a depth of approximately 15-20 m. The seismic source will be towed at a depth of approximately 6 to 8 m. The streamers will be fitted with streamer recovery devices (SRDs) that will automatically deploy inflatable air bags to raise the streamer to the service for retrieval.

In addition, approximately 15-20 AUV and commercial nodes may be deployed in the Active Source Area. The proposed AUV nodes are cylindrical in shape, with short wings on the sides for flight stabilisation and steering, at approximately 1000 m long and 300 mm in diameter (weights approximately 30 kg in air and 10 kg in sea water). The AUV nodes operate autonomously through the water column and are adapted to settle temporarily on the seabed and listen to/record the seismic signal. As a control the AUV nodes will be fitted with thrusters to be periodically used for propulsion, navigation assistance, managing low impact landings and assist with take-offs as required.

The AUV nodes will be paired with equivalent commercial nodes to ground truth the technology in terms of the verification of seismic data recorded. As an additional control the commercial nodes may most probably be deployed and recovered by a small ROV but may also be tethered by a rope to a buoy. The commercial nodes will weigh approximately 15 kg (6.5 kg in sea water) and measure approximately 346 mm (L), by 218 mm (W) and 138 mm (H).

The nodes will be deployed on the seabed along the 20 km lengths of the three existing intersecting lines during the survey. At the end of the survey, when the streamer is recovered, the seismic vessel will re-acquire approximately 20 km lengths along these three lines for a period of between 24 to 48 hr with the same source configuration and source interval. Each AUV node is planned to have approximately five placements along these lines during this final trial period before retrieval. The AUV nodes are expected to be deployed for the duration of the Petroleum Activities Program. Recovery devices are included within each AUV node, which will deploy inflatable air bags to raise the node to the surface if the node is unable to surface. An additional control of a ROV will also be used as a failsafe to recover the AUV nodes as required as well as for deployment and recovery of the commercial nodes. Loss of this equipment has the potential to cause minor physical disturbance to seabed and benthic communities, and temporary disturbance to marine users (i.e. commercial fishers).

Impact Assessment

Potential Impacts to Environmental Values

Benthic Habitat and Communities In the unlikely event of loss or grounding of seismic equipment during the Petroleum Activities Program, potential environmental effects would be limited to physical impacts to the seabed and benthic communities. During normal operations, it is considered highly unlikely for streamers to sink and impact the seabed, given the tow depth of streamers (>15 m) and the application of depth control built into the design (SRDs). Similarly, the AUV nodes will be fitted with recovery devices. The Operational Area is expected to consist primarily of sandy substrate and soft muddy sediments. The seabed is likely to be inhabited by a low abundance and patchy distributions of filter feeders and other epifauna. Lynedoch Bank located within the Active Source Area is characterised by a reef flat occurring in depths of about 14 m – 20 m, bordered by gentle slopes rising from depths of about 70 m – 90 m. Sand and rubble dominates the reef flat with hard corals, sponges and soft corals present (Jacobs, 2016). Similarly, Goodrich Bank located within the Operational Area (outside of the Active Source Area) is characterised by sand, rubble patches and limestone outcrops. The epibenthic communities found on the banks are sparse, with low-medium density filter feeders occasionally found in depths less than 60 m and in association with small scale patches of consolidated substrate. Phototrophic species such as hard corals are rare and only occur at the shallowest areas of the bank in waters less than 30 m (AIMS, 2015). In addition, the Operation Area partially overlaps with the Carbonate bank and terrace system of the Van Diemen Rise KEF and the Shelf break and slope of the Arafura Shelf KEF. These KEFs provide significant benthic habitat, and are important areas for a number of commercial fish species. Given the size of seismic equipment, only a relatively small area of the seabed would be disturbed and lasting impacts are not expected. Impacts to benthic habitats such as the shelf, slope and bank habitats of the KEFs are not expected. **Commercial Fisheries and Other Marine Users** In the unlikely event that equipment is lost, commercial fisheries and other marine users of the Operational Area may be required to make minor diversions to avoid the equipment, until it can be retrieved (if possible). The potential for such interactions will be limited to a short period of time while the equipment is retrieved (if possible). Should disruption occur, it is expected to affect individual users and cause a temporary disruption through avoidance of a highly localised area. Given the nature and size of the equipment to be used during the survey, lost equipment may result in a minor navigational hazard. Therefore, anticipated impacts are expected to be low.
Summary of Potential Impacts to Environmental Value(s)
Given the adopted controls, it is considered that a loss of seismic equipment (i.e. seismic streamers, acoustic source and AUV/commercial nodes) to the seabed will not result in a potential impact greater than localised disruption to a small area of the seabed, a small portion of the benthic population and no impact on critical habitat or activity.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[27]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Comply with Marine Order 21 (safety and emergency arrangements) 2020, including: • adherence to minimum safe manning levels • maintenance of navigation equipment in efficient working order • navigational systems and equipment required are those specified in Regulation 19 of Chapter V of SOLAS • AIS that provides other users with information about the vessel's identity, type, position, course, speed,	F: Yes. CS: Minimal cost. Standard practice.	Legislative requirement to reduce the likelihood of interference with other marine users resulting in a collision.	Controls based on legislative requirements – must be adopted	Yes **C 15.3**

[27] Qualitative measure

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[27]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
navigational status and other safety-related data.				
Good Practice				
Deploy, retrieve and operate streamers as per predetermined procedures, including: • streamers will only be deployed in suitable sea state in accordance with contractors Matrix of Permitted Operations (MOPO) or similar.	F: Yes. CS: Minimal cost. Standard practice.	Implementing this control will reduce the likelihood of equipment grounding or loss. The consequence is unchanged.	Benefit outweighs cost/ sacrifice.	Yes **C 20.1**
Streamers fitted with steering devices in the form of remote controlled wings/fins, and real-time monitoring equipment.	F: Yes. CS: Minimal cost. Standard practice.	Implementing this control will reduce the likelihood of equipment grounding or loss. The consequence is unchanged.	Benefit outweighs cost/ sacrifice.	Yes **C 20.2**
Activate pressure-activated SRDs within streamers and AUVs/commercial nodes in the event of loss, to bring the equipment to the surface.	F: Yes. CS: Minimal cost. Standard practice.	Implementing this control will reduce the likelihood of equipment grounding or loss. The consequence is unchanged.	Benefit outweighs cost/ sacrifice.	Yes **C 20.3**
Lost equipment will be recovered, where safe and practicable. Where safe and practicable for this activity, will consider: • risk to personnel to retrieve object • whether the location of the equipment is in recoverable water depths • equipment's proximity to subsea infrastructure • ability to recover the equipment (i.e. nature of equipment, lifting equipment and suitable weather).	F: Yes, however it may not always be practicable. Assessed on a case by case situation. CS: Minimal cost. Standard practice.	No reduction in likelihood, as this is an unplanned event. Since the equipment may be recovered, a reduction in consequence is possible.	Benefit outweighs cost/ sacrifice.	Yes **C 20.4**
AUV/commercial nodes designed with appropriate tracking and monitoring systems including: • AUV nodes will be pre-programmed with the planned movements prior to deployment • sub-surface positioning can be tracked via USBL while AUV is moving	F: Yes. CS: Minimal cost.	Implementation of these controls will reduce the likelihood of nodes being lost and unable to be recovered, therefore preventing structures from remaining on the seabed in an otherwise primarily soft sediment environment.	Benefits outweigh the cost/sacrifice.	Yes **C 4.1**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[27]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
• surface live positioning of AUV/commercial nodes is tracked via two GNSS systems • nodes can be monitored from vessel via health check system; if significant issues are identified buoyancy air-bag will be deployed to bring nodes to the surface and tracking systems will allow for retrieval.				
Professional Judgement – Eliminate				
None identified.				
Professional Judgement – Substitute				
Use modified short marine towed streamer(s) (approximately 1.5 to 3 km in length).	F: No. CS: Shorter streamers result in a significant loss of data, especially in deeper waters.	Not considered – control not feasible.	Not considered – control not feasible.	No
Professional Judgement – Engineered Solution				
None identified.				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks to benthic communities from the loss of seismic equipment to the seabed. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that, given the adopted controls, potential loss of seismic equipment to the seabed represent a consequence to benthic community/habitat structure limited to no lasting effect. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks to marine sediment from loss of seismic equipment to an acceptable level.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 20 No loss or grounding of seismic equipment (i.e. streamers, acoustic source and AUV/commercial nodes) with a consequence level greater	**C 15.3** See **Section 6.5.2**	**PS 15.3** See **Section 6.5.2**	**MC 15.1.1** See **Section 6.5.2**
	C 20.1 Deploy, retrieve and operate streamers as per predetermined procedures, including:	**PS 20.1** Seismic vessel compliance with predetermined procedures on deployment, retrieval and operation of streamers.	**MC 20.1.1** Records confirm that seismic vessel hold procedures for streamer deployment, retrieval and operation.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
than E[28] for the duration of the Petroleum Activities Program.	• Streamers will only be deployed in suitable sea state in accordance with contractors MOPO or equivalent.		**MC 20.1.2** Daily report demonstrates that streamers were deployed in accordance with contractors MOPO, or equivalent.
	C 20.2 Streamers fitted with steering devices in the form of remote controlled wings/fins, and real-time monitoring equipment.	**PS 20.2** Ability to control streamer depth and location of streamer in relation to the seabed is known at all times.	**MC 20.2.1** Records confirm streamers are fitted with steerable wings/fins, and real-time monitoring equipment.
	C 20.3 Activate pressure-activated SRDs within streamers in the event of loss, to bring the equipment to the surface.	**PS 20.3** Streamers fitted with SRDs.	**MC 20.3.1** Records confirm streamers are fitted with pressure-activated SRDs.
	C 20.4 Lost equipment will be recovered, where safe and practicable. Where safe and practicable for this activity, will consider: • risk to personnel to retrieve object • whether the location of the equipment is in recoverable water depths • equipment's proximity to subsea infrastructure • ability to recover the equipment (i.e. nature of equipment, lifting equipment and suitable weather).	**PS 20.4** Lost equipment recovered where safe and practicable to do so.	**MC 20.4.1** Records detail the equipment lost to the marine environment.
	C 4.1 See **Section 6.4.2**	**PS 4.1** See **Section 6.4.2**	**MC 4.1.1** See **Section 6.4.2**
		PS 4.2 See **Section 6.4.2**	**MC 4.2.1** See **Section 6.4.2**

[28] Defined as 'Slight, short-term impact (< 1 year) on species, habitat (but not affecting ecosystems function), physical or biological attributes.'

6.5.8 Physical Presence: Introduction and Establishment of Invasive Marine Species

Context		
Project Vessels – **Section 3.6.5**	Physical Environment – **Section 4.3** Biological Environment – **Section 4.4**	Stakeholder Consultation – **Section 5**

Impact Evaluation Summary

Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcomes
Introduction and establishment of invasive marine species (IMS)					X	X	X	A	D	0	L	LCS GP	Broadly Acceptable	EPO 21

Description of Source of Risk

During the Petroleum Activities Program, vessels and submersible equipment have the potential to introduce IMS to the Operational Area.

Vessels

Vessels will be transiting to and from the Operational Area, potentially including traffic mobilising from international waters. There is the potential for project vessels to transfer IMS from either international waters, Australian waters or coastal waters into the Operational Area.

All vessels are subject to some level of marine fouling. Organisms attach to the vessel hull, particularly in areas where organisms can find a good attachment surface (e.g. seams, strainers and unpainted surfaces) or where turbulence is lowest (e.g. niches, sea chests, etc.). Commercial vessels typically maintain anti-fouling coatings to reduce the build-up of fouling organisms. Organisms can also be drawn into ballast tanks during onboarding of ballast water required to maintain safe operating conditions.

Project vessels have the potential to introduce IMS to the Operational Area through marine biofouling (containing IMS) on vessels, as well as within high-risk ballast water exchange. Cross-contamination between vessels can also occur (e.g. IMS translocated between project vessels) during times when vessels need to be alongside each other.

Submersible Equipment

Submersible equipment required for the activity (seismic array, AUV and commercial nodes, ROV) is transported to and used within the Operational Area. There is the potential that this equipment may be used on other projects before being used on this activity. As a consequence, there is the potential for IMS translocation.

Impact Assessment

Potential Impacts to Environmental Values

IMS are a subset of Non-indigenous Marine Species (NIMS) that have been introduced into a region beyond their natural biogeographic range, resulting in impacts to social/cultural, human health, economic and/or environmental values. NIMS are species that have the ability to survive, reproduce and establish founder populations. However, not all NIMS introduced into an area will thrive or cause demonstrable impacts. The majority of NIMS around the world are relatively benign and few have spread widely beyond sheltered ports and harbours. NIMS are only considered IMS when they result in impacts to environmental values and/or have social/cultural, economic and/or human health impacts.

Once introduced, IMS may prey on local species (which had previously not been subject to this kind of predation and therefore not have evolved protective measures against the attack), they may outcompete indigenous species for food, space or light and can also interbreed with local species, creating hybrids such that the endemic species is lost. These changes to the local marine environment result in changes to the natural ecosystem.

IMS have also proven economically damaging to areas where they have been introduced and established. Such impacts include direct damage to assets (fouling of vessel hulls and infrastructure) and depletion of commercially harvested marine life (e.g. shellfish stocks). IMS have proven particularly difficult to eradicate from areas once established. If the introduction is detected early, eradication may be effective but is likely to be expensive, disruptive and, depending on the method of eradication, harmful to other local marine life.

Potential IMS have historically been introduced and translocated around Australia by a variety of natural and human means, including marine fouling and ballast water. Potential IMS vary from one region to another depending on various environmental factors such as water temperature, salinity, nutrient levels and habitat type, which dictate their survival and invasive capabilities. IMS typically require hard substrate in the photic zone; therefore, requiring shallow waters to become established. Highly-disturbed, shallow-water environments such as shallow coastal waters, ports and marinas are more susceptible to IMS colonisation, whereas IMS are generally unable to successfully establish in deep-water ecosystems and open-water environments where the rate of dilution and the degree of dispersal are high (Williamson and Fitter, 1996; Paulay et al., 2002; Geiling, 2014).

Project vessels and submersible equipment required to undertake the Petroleum Activities Program have the potential to introduce IMS into the Operational Area. Due to the shallow water depths (minimum of 11 m) and presence of submerged banks/shoals within the Operational Area (and surrounding environment), settlement and establishment of IMS is credible. However, the likelihood is considered remote, given the open-water environment of the Operational Area, distance from shorelines and/or critical habitat and the control measures proposed to be implemented (as outlined below).

Summary of Potential Impacts to Environmental Value(s)

In support of Woodside's assessment of the risks and consequences of IMS introduction associated with the Petroleum Activities Program, Woodside conducted a risk and impact evaluation of the different aspects of an IMS translocation. The results of this assessment are presented in **Table 6-22.**

As a result of this assessment, Woodside has assessed the potential consequence and likelihood after implementing the identified controls. This assessment concluded that the highest potential consequence is a 'D' and the likelihood is 'Remote' (0), resulting in an overall 'Low' risk.

Table 6-22: Evaluation of risks and impacts from marine pest translocation

IMS Introduction Location	Credibility of Introduction	Consequence of Introduction	Likelihood
Introduced to the Operational Area and establishment on the seafloor.	***Credible*** There is potential for the introduction and establishment of IMS on the seafloor in the Operational Area	***Environment – Credible*** The translocation of IMS from a colonised project vessel to the shallow environments of the Operational Area (i.e. Lynedoch Bank and Goodrich Bank) is considered credible. The establishment of IMS in the shallow environments of the Operational Area would potentially have major consequences on a valued ecosystem.	***Remote (0)*** Given the existing Woodside and legislative controls in place that minimise the introduction of IMS it is considered that the likelihood for IMS to become established is remote.
Introduced to the Operational Area and establishment on a project vessel.	***Credible*** There is potential to transfer marine pests between project vessels within the Operational Area	***Environment – not credible*** The translocation of IMS from a colonised project vessel to another vessel via natural dispersion is not credible. This is because of the open-water environment of the Operational Area and distance from shorelines and/or critical habitat. On this basis there is no credible environmental risk.	***Remote (0)*** Interactions between project vessels will be limited during the Petroleum Activities Program, with a 3nm SNA around the seismic vessel, and interactions limited to short periods of time alongside (i.e. during bunkering activities). It is important to note that there is no direct contact between project vessels during

			these activities. Spread of marine pests via ballast water in these open ocean environments is not considered credible due to the lack of suitable habitat for settlement and establishment.
Transferred between project vessels and from project vessels to other marine environments beyond the Operational Area (i.e. transfer IMS from seismic vessel to a support vessel and then to another environment).	***Not Credible*** The risk is considered so remote that it is not considered credible for the purposes of the activity. As described above, the transfer of IMS between project vessels was already considered remote, given the offshore open ocean environment. Project vessels will be located in an offshore, open ocean environment, where IMS survival is implausible. Furthermore, this marine pest, once transferred, would need to survive on a new vessel that has good hygiene (i.e. has been through Woodside's risk assessment process), and survive the transport back from the Operational Area to shore. If it survived this trip, it would then need conditions conducive to establishing a viable population in nearshore waters to which the infected vessel travels.		

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS*** [29]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Project vessels will manage their ballast water using one of the approved ballast water management options, as outlined in the Australian Ballast Water Management Requirements.	F: Yes. CS: Minimal cost. Standard practice.	Reduces the likelihood of transferring marine pests between project vessels within the Operational Area. No change in consequence would occur.	Controls based on legislative requirements under the *Biosecurity Act 2015* – must be adopted.	Yes **C 21.1**
Good Practice				
Woodside's IMS risk assessment process[30] will be applied to the project vessels and relevant immersible equipment undertaking the Petroleum Activities Program. Assessment will consider these risk factors: For vessels: • vessel type • recent IMS inspection and cleaning history,	F: Yes. CS: Minimal cost. Good practice implemented across all Woodside Operations.	Identifies potential risks and additional controls implemented accordingly. In doing so, the likelihood of transferring marine pests between project vessels within the Operational Area is reduced. No change in consequence would occur.	Benefits outweigh cost/sacrifice.	Yes **C 21.2**

[29] Qualitative measure
[30] Woodside's IMS risk assessment process was developed with regard to the national biofouling management guidelines for the petroleum production and exploration industry and guidelines for the control and management of a ships' biofouling to minimise the transfer of invasive aquatic species (IMO Guidelines, 2011).

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS [29]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
including for internal niches • out-of-water period before mobilisation • age and suitability of antifouling coating at mobilisation date • internal treatment systems and history • origin and proposed area of operation • number of stationary/slow speed periods >7 days • region of stationary or slow periods • type of activity – contact with seafloor. For immersible equipment: • region of deployment since last thorough clean, particularly coastal locations • duration of deployments • duration of time out of water since last deployment • transport conditions during mobilisation • post-retrieval maintenance regime. Based on the outcomes of each IMS risk assessment, management measures commensurate with the risk (such as treating internal systems, IMS inspections or cleaning) will be implemented to minimise the likelihood of IMS being introduced.				
Professional Judgement – Eliminate				

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS[29]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Do not discharge ballast water during the Petroleum Activities Program.	F: No. Ballast water discharges are critical for maintain vessel stability. Given the nature of the Petroleum Activities Program, the use of ballast (including the potential discharge of ballast water) is considered to be a safety-critical requirement. CS: Not assessed, control not feasible.	Not assessed, control not feasible.	Not assessed, control not feasible.	No
Eliminate use of vessels including the seismic vessel and support vessel(s).	F. No. Given that vessels must be used to complete the Petroleum Activities Program, there is no feasible means to eliminate the source of risk. CS. Loss of the project.	Not assessed, control not feasible.	Not assessed, control not feasible.	No
Professional Judgement – Substitute				
Source project vessels based in Australia only.	F. Potentially. Limiting activities to only use local project vessels could potentially pose a significant risk in terms of the time and duration of sourcing a vessel, as well as the ability of the local vessel to perform the tasks. While the project will attempt to source support vessels locally, it is not always possible. Availability cannot always be guaranteed. There are limited project vessels based in Australian waters and sourcing Australian-based vessels only will cause increases in cost due to pressures of vessel availability. CS: Significant cost and schedule impacts due to supply restrictions.	Sourcing vessels from within Australia will reduce the likelihood of IMS introduction from outside Australian waters; however, it does not reduce the likelihood of introducing species native to Australia but alien to the Operational Area. It also does not prevent the translocation of IMS that have established elsewhere in Australia. Therefore, the consequence is unchanged.	Disproportionate. Sourcing vessels from Australian waters may result in a slight reduction in the likelihood of introducing IMS to the Operational Area, however it does not completely eliminate the risk. Furthermore, the potential cost of implementing this control could be high, given the potential supply issues associated with only locally sourcing vessels.	No
IMS inspection of all vessels	F: Yes CS. Significant cost and schedule impacts. In addition, Woodside's IMS risk assessment process is seen to be more cost-effective as this control allows Woodside to manage the introduction of IMS through biofouling, while targeting efforts and	Inspection of all vessels for IMS would reduce the likelihood of IMS being introduced to the Operational Area. However, this reduction is unlikely to be significant, given the other control measures implemented. No	Disproportionate. The cost/sacrifice outweighs the benefit gained, as other controls that are proposed to be implemented achieve ALARP position.	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS*** [29]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
	resources to the areas of greatest concern.	change in consequence would occur.		
Professional Judgement – Engineered Solution				
None identified.				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the risks and consequences of IMS introduction. As no reasonable additional/alternative controls were identified that would further reduce the risks and consequences without disproportionate sacrifice, the risks and consequences are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement
The impact assessment has determined that, given the adopted controls, introduction of IMS to the Operational Area through ballast water or biofouling on vessels or in-water equipment represents a low residual risk that has a remote likelihood of resulting in a potential impact greater than minor and short term (one to two years) to a small proportion of the benthic community. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of introducing IMS to the Operational Area to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 21 No introduction and establishment of invasive marine species into the Operational Area with a consequence level greater than D[31] as a result of the Petroleum Activities Program.	**C 21.1** Project vessels will manage their ballast water using one of the approved ballast water management options, as outlined in the Australian Ballast Water Management Requirements.	**PS 21.1** Project vessels will manage ballast water in accordance with Australian Ballast Water Management Requirements.	**MC 21.1.1** Ballast Water Records System maintained by vessels which verifies compliance against Australian Ballast Water Management Requirements.
	C 21.2 Woodside's IMS risk assessment process[32] will be applied to project vessels and relevant immersible equipment undertaking the Petroleum Activities Program. Assessment will consider these risk factors: For vessels: • vessel type	**PS 21.2.1** Before entering the Operational Area, project vessels and relevant immersible equipment are determined to be low risk[33] of introducing IMS of concern, and maintain this low risk status to mobilisation.	**MC 21.2.1** Records of IMS risk assessments maintained for all project vessels and relevant immersible equipment entering the Operational Area or IMS management area to undertake the Petroleum Activities Program.
		PS 21.2.2	**MC 21.2.3**

[31] Defined as 'Minor, short-term impact (one to two years) on species, habitat (but not affecting ecosystem function), physical or biological attributes'.
[32] Woodside's IMS risk assessment process was developed with regard to the national biofouling management guidelines for the petroleum production and exploration industry and guidelines for the control and management of a ships' biofouling to minimise the transfer of invasive aquatic species (IMO Guidelines, 2011).
[33] Low risk of introducing IMS of concern is defined as either no additional management measures required or, management measures have been applied to reduce the risk.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	• recent IMS inspection and cleaning history, including for internal niches • out-of-water period before mobilisation • age and suitability of antifouling coating at mobilisation date • internal treatment systems and history • origin and proposed area of operation • number of stationary/slow speed periods >7 days • region of stationary or slow periods • type of activity – contact with seafloor. For immersible equipment: • region of deployment since last thorough clean, particularly coastal locations • duration of deployments • duration of time out of water since last deployment • transport conditions during mobilisation • post-retrieval maintenance regime. Based on the outcomes of each IMS risk assessment, management measures commensurate with the risk (such as treating internal systems, IMS inspections or cleaning) will be implemented to minimise the likelihood of IMS being introduced.	In accordance with Woodside's IMS risk assessment process, the IMS risk assessments will be undertaken by an authorised environment adviser who has completed relevant Woodside IMS training or by qualified and experienced IMS inspector.	Records confirm that the IMS risk assessments undertaken by an Environment Adviser or IMS inspector (as relevant).

6.6 Recovery Plan and Threat Abatement Plan Assessment

As described in **Section 2.8**, NOPSEMA will not accept an EP that is inconsistent with a recovery plan or threat abatement plan for a listed threatened species or ecological community. This section describes the assessment that Woodside has undertaken to demonstrate that the Petroleum Activities Program is not inconsistent with any relevant recovery plans or threat abatement plans. For the purposes of this assessment, the relevant Part 13 statutory instruments (recovery plans and threat abatement plans) are:

- Recovery Plan for Marine Turtles in Australia 2017–2027 (Commonwealth of Australia, 2017a).
- Conservation Management Plan for the Blue Whale 2015–2025 (Commonwealth of Australia, 2015a).
- Recovery Plan for the Grey Nurse Shark (Commonwealth of Australia, 2014).
- Sawfish and River Shark Multispecies Recovery Plan (Commonwealth of Australia, 2015b).
- Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans 2018 (Commonwealth of Australia, 2018).

Table 6-23 lists the objectives and (where relevant) the action areas of these plans, and also describes whether these objectives/action areas are applicable to government, the Titleholder, and/or the Petroleum Activities Program. For those objectives/action areas applicable to the Petroleum Activities Program, the relevant actions of each plan have been identified, and an evaluation has been conducted as to whether impacts and risks resulting from the activity are clearly inconsistent with that action or not. The results of this assessment against relevant actions are presented in **Table 6-24, Table 6-25, Table 6-26, Table 6-27** and **Table 6-28**.

Table 6-23: Identification of applicability of recovery plan and threat abatement plan objectives and action areas

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	***Titleholder***	***Petroleum Activities Program***
Marine Turtle Recovery Plan			
Long-term Recovery Objective: Minimise anthropogenic threats to allow for the conservation status of marine turtles to improve so they can be removed from the EPBC Act threatened species list	Y	Y	Y
Interim Recovery Objectives			
1. Current levels of legal and management protection for marine turtle species are maintained or improved, both domestically and throughout the migratory range of Australia's marine turtles	Y		
2. The management of marine turtles is supported	Y		
3. Anthropogenic threats are demonstrably minimised	Y	Y	Y
4. Trends in nesting numbers at index beaches and population demographics at important foraging grounds are described	Y	Y	
Action Areas			
A. Assessing and addressing threats			
A1. Maintain and improve efficacy of legal and management protection	Y		
A2. Adaptively manage turtle stocks to reduce risk and build resilience to climate change and variability	Y		
A3. Reduce the impacts of marine debris	Y	Y	Y
A4. Minimise chemical and terrestrial discharge	Y	Y	Y
A5. Address international take within and outside Australia's jurisdiction	Y		
A6. Reduce impacts from terrestrial predation	Y		
A7. Reduce international and domestic fisheries bycatch	Y		
A8. Minimise light pollution	Y	Y	Y
A9. Address the impacts of coastal development/infrastructure and dredging and trawling	Y	Y	
A10. Maintain and improve sustainable Indigenous management of marine turtles	Y		
B. Enabling and measuring recovery			

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	***Titleholder***	***Petroleum Activities Program***
B1. Determine trends in index beaches	Y	Y	Y
B2. Understand population demographics at key foraging grounds	Y		
B3. Address information gaps to better facilitate the recovery of marine turtle stocks	Y	Y	Y
Blue Whale Conservation Management Plan			
Long-term recovery objective: Minimise anthropogenic threats to allow for their conservation status to improve so that they can be removed from the EPBC Act threatened species list	Y	Y	Y
Interim Recovery Objectives			
1. The conservation status of blue whale populations is assessed using efficient and robust methodology	Y		
2. The spatial and temporal distribution, identification of biologically important areas, and population structure of blue whales in Australian waters is described	Y	Y	Y
3. Current levels of legal and management protection for blue whales are maintained or improved and an appropriate adaptive management regime is in place	Y		
4. Anthropogenic threats are demonstrably minimised	Y	Y	Y
Action Areas			
A. Assessing and addressing threats			
A.1: Maintain and improve existing legal and management protection	Y		
A.2: Assessing and addressing anthropogenic noise	Y	Y	Y
A.3: Understanding impacts of climate variability and change	Y		
A.4: Minimising vessel collisions	Y	Y	Y
B. Enabling and Measuring Recovery			
B.1: Measuring and monitoring population recovery	Y		
B.2: Investigating population structure	Y		
B.3: Describing spatial and temporal distribution and defining biologically important habitat	Y	Y	Y

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	***Titleholder***	***Petroleum Activities Program***
Grey Nurse Shark Recovery Plan			
Overarching Objective			
To assist the recovery of the grey nurse shark in the wild, throughout its range in Australian waters, with a view to: • improving the population status, leading to future removal of the grey nurse shark from the threatened species list of the EPBC Act. • ensuring that anthropogenic activities do not hinder the recovery of the grey nurse shark in the near future, or impact on the conservation status of the species in future.	Y	Y	Y
Specific Objectives			
1. Develop and apply quantitative monitoring of the population status (distribution and abundance) and potential recovery of the grey nurse shark in Australian waters	Y		
2. Quantify and reduce the impact of commercial fishing on the grey nurse shark through incidental (accidental and/or illegal) take, throughout its range	Y		
3. Quantify and reduce the impact of recreational fishing on the grey nurse shark through incidental (accidental and/or illegal) take, throughout its range	Y		
4. Where practicable, minimise the impact of shark control activities on the grey nurse shark	Y		
5. Investigate and manage the impact of ecotourism on the grey nurse shark	Y		
6. Manage the impact of aquarium collection on the grey nurse shark	Y		
7. Improve understanding of the threat of pollution and disease to the grey nurse shark	Y	Y	Y
8. Continue to identify and protect Habitat Critical to the survival of the grey nurse shark and reduce the impact of threatening processes within these areas	Y	Y	
9. Continue to develop and implement research programs to support the conservation of the grey nurse shark	Y	Y	
10. Promote community education and awareness in relation to grey nurse shark conservation and management	Y		
Sawfish and River Shark Multispecies Recovery Plan			

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	***Titleholder***	***Petroleum Activities Program***
Primary Objective			
To assist the recovery of sawfish and river sharks in Australian waters with a view to: • improving the population status leading to the removal of the sawfish and river shark species from the threatened species list of the EPBC Act • ensuring that anthropogenic activities do not hinder recovery in the near future, or impact on the conservation status of the species in the future	Y	Y	Y
Specific Objectives			
1. Reduce and, where possible, eliminate adverse impacts of commercial fishing on sawfish and river shark species	Y		
2. Reduce and, where possible, eliminate adverse impacts of recreational fishing on sawfish and river shark species	Y		
3. Reduce and, where possible, eliminate adverse impacts of Indigenous fishing on sawfish and river shark species	Y		
4. Reduce and, where possible, eliminate the impact of illegal, unregulated and unreported fishing on sawfish and river shark species	Y		
5. Reduce and, where possible, eliminate adverse impacts of habitat degradation and modification on sawfish and river shark species	Y	Y	Y
6. Reduce and, where possible, eliminate any adverse impacts of marine debris on sawfish and river shark species noting the linkages with the Threat Abatement Plan for the Impact of Marine Debris on Vertebrate Marine Life	Y	Y	Y
7. Reduce and, where possible, eliminate any adverse impacts of collection for public aquaria on sawfish and river shark species	Y		
8. Improve the information base to allow the development of a quantitative framework to assess the recovery of, and inform management options for, sawfish and river shark species	Y		
9. Develop research programs to assist conservation of sawfish and river shark species	Y	Y	
10. Improve community understanding and awareness in relation to sawfish and river shark conservation and management	Y		

EPBC Act Part 13 Statutory Instrument	Applicable to:		
	Government	***Titleholder***	***Petroleum Activities Program***
Marine Debris Threat Abatement Plan			
Objectives			
1. Contribute to long-term prevention of the incidence of marine debris	Y	Y	
2. Understand the scale of impacts from marine plastic and microplastic on key species, ecological communities and locations	Y	Y	Y
3. Remove existing marine debris	Y		
4. Monitor the quantities, origins, types and hazardous chemical contaminants of marine debris, and assess the effectiveness of management arrangements for reducing marine debris	Y		
5. Increase public understanding of the causes and impacts of harmful marine debris, including microplastic and hazardous chemical contaminants, to bring about behaviour change	Y		

Table 6-24: Assessment against relevant actions of the Marine Turtles Recovery Plan

Part 13 Statutory Instrument	Relevant Action Areas/Objectives	Relevant Actions	Evaluation	EPO, Controls and PS
Marine Turtle Recovery Plan	**Action Area A3**: Reduce the impacts from marine debris	**Action**: Support the implementation of the Marine Debris Threat Abatement Plan (TAP) Priority actions at stock level: • G-NWS – Understand the threat posed to this stock by marine debris • G-AR, O-NT – Liaise at a regional scale to address and reduce the source of marine debris in Australian waters. • G-ScBr, G-nBr, F-CD – no relevant actions • F-Ars – Determine important habitat areas and compare marine debris hotspots. • G-Cobourg – Understand the risk of entanglement • LH-WA – Determine the extent to which marine debris is impacting loggerhead turtles	Refer **Section 6.5.5** **Not inconsistent assessment**: The assessment of accidental release of solid hazardous and non-hazardous wastes has considered the potential risks to marine turtles.	**EPO 18** **C 18.1, 18.2, 18.3** **PS 18.1, 18.2, 18.3**
	Action Area A4: Minimise chemical and terrestrial discharge	**Action**: Ensure spill risk strategies and response programs adequately include management for marine turtles and their habitats, particularly in reference to 'slow to recover habitats', e.g. nesting habitat, seagrass meadows or coral reefs Priority actions at stock level: • G-NWS, G-AR, G-Cobourg, F-CD – Ensure that spill risk strategies and response programs include management for turtles and their habitats • G-ScBr, G-nBr, F-Ars – No relevant actions • LH-WA, O-NT – Ensure that spill risk strategies and response programs include management for turtles and their habitats, particularly in reference to slow to recover habitats, e.g. seagrass meadows or corals	Refer **Sections 6.5.2, 6.5.3** and **6.5.4** **Not inconsistent assessment**: The assessment of accidental release of chemicals / hydrocarbons has considered the potential risks to marine turtles. Spill risk strategies and response program include management measures for turtles and their nesting habitats.	Refer **Section 7.10.** Detailed oil spill preparedness and response performance outcomes, standards and measurement criteria for the Petroleum Activities Program are present in **Appendix D.**

Part 13 Statutory Instrument	Relevant Action Areas/Objectives	Relevant Actions	Evaluation	EPO, Controls and PS
	Action Area A8: Minimise light pollution	**Action**: Artificial light within or adjacent to Habitat Critical to the survival of marine turtles will be managed such that marine turtles are not displaced from these habitats Priority actions at stock level: • G-NWS – as above • G-AR, G-ScBr, G-Cobourg, G-nBr – no relevant actions • LH-WA, F-Ars, F-CD, O-NT – no relevant actions	Refer **Section 6.4.7.** **Not inconsistent assessment**: The assessment of light emissions has considered the potential impacts to marine turtles. Internesting, mating, foraging or migrating turtles are not impacted by light from offshore vessels. Vessel light emissions will not result in displacement of adult females or hatchlings from nesting Habitat Critical to the survival of marine turtles. The closest nesting beaches designated as Habitat Critical for flatback turtles are located >40 km from the southern boundary of the Operational Area.	N/A
	Action Area B1: Determine trends at index beaches	**Action**: Maintain or establish long-term monitoring programs at index beaches to collect standardised data critical for determining stock trends, including data on hatchling production Priority actions at stock level: • G-NWS, GnBr, F-Ars, F-CD – Continue long-term monitoring of index beaches • G-AR – No relevant actions • G-Cobourg – Initiate long-term monitoring of nesting turtle abundance and index beaches • G-ScBr, O-NT – Establish a long-term monitoring program at index beaches • LH-WA – Continue long-term monitoring of nesting and foraging populations	**Not inconsistent assessment**: Woodside contributes to Action Area B1 via its support of the Ningaloo Turtle Program[34].	N/A
	Action Area B3: Address information gaps to better facilitate the recovery of marine turtle stocks	**Action**: Understand the impacts of anthropogenic noise on marine turtle behaviour and biology Priority actions at stock level: • G-NWS – Given this is a relatively accessible stock that is likely to be exposed to	Refer **Section 6.4.3** and **6.4.4.** **Not inconsistent assessment**: The assessment of acoustic emissions has considered the potential impacts to flatback and olive ridley turtles. Vessel and seismic acoustic emissions could cause localised and	**EPO 6, 7** **C 6.1, 7.1** **PS 6.1, 7.1**

34 http://www.ningalooturtles.org.au/media_reports.html

Part 13 Statutory Instrument	Relevant Action Areas/Objectives	Relevant Actions	Evaluation	EPO, Controls and PS
		anthropogenic noise – Investigate the impacts of anthropogenic noise on turtle behaviour and biology and extrapolate findings from the North West Shelf stock to other stocks • G-AR, LH-WA, O-NT – no relevant actions • F-Ars – identify high priority mitigation areas	short-term behavioural disturbance to isolated transient individuals, which is unlikely to result in displacement of adult turtles from internesting or nesting Habitat Critical to the survival of marine turtles.	

Assessment Summary

The Marine Turtle Recovery Plan has been considered during the assessment of impacts and risks, and the Petroleum Activities Program is not considered to be inconsistent with the relevant actions of this plan.

Table 6-25: Assessment against relevant actions of the Blue Whale Conservation Management Plan

Part 13 Statutory Instrument	Relevant Action Areas/Objectives	Relevant Actions	Evaluation	EPO, Controls and PS
Blue Whale Conservation Management Plan	**Action Area A.2**: Assessing and addressing anthropogenic noise	**Action 2**: Assessing the effect of anthropogenic noise on blue whale behaviour **Action 3**: Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to use the area without injury, and is not displaced from a foraging area	Refer **Section 6.4.3.** **Not inconsistent assessment**: The assessment of acoustic emissions has considered the potential impacts to pygmy blue whales.	N/A
	Action Area A.4: Minimising vessel collisions	**Action 3**: Ensure the risk of vessel strikes on blue whales is considered when assessing actions that increase vessel traffic in areas where blue whales occur and, if required, appropriate mitigation measures are implemented	Refer **Section 6.5.6.** **Not inconsistent assessment**: The assessment of vessel collision with marine fauna has considered the potential risks to pygmy blue whales. If the Petroleum Activities Program overlaps with the northern migration, individuals may deviate slightly from migratory route, but will continue on their migration to possible breeding grounds in Indonesian waters. Vessel collisions with pygmy blue whales are highly unlikely to occur, given the very slow vessel speeds and presence of MFOs.	**EPO 19** **C 12.1** **PS 12.1 and 12.2**
	Action Area B.3: Describing spatial and temporal distribution and defining biologically important habitat	**Action 2**: Identify migratory pathways between breeding and feeding grounds **Action 3**: Assess timing and residency within Biologically Important Areas	**Not inconsistent assessment**: Woodside contributes to Action Area B3 via its support of targeted research initiatives (e.g. satellite tracking of pygmy blue whale migratory movements[35]).	N/A
Assessment Summary The Blue Whale Conservation Management Plan has been considered during the assessment of impacts and risks, and the Petroleum Activities Program is not considered to be inconsistent with the relevant actions of this plan.				

[35] Double, M.C., Andrews-Goff, V., Jenner, K.C.S., Jenner, M.-N., Laverick, S.M., Branch, T.A., Gales, N.J., 2014. Migratory movements of pygmy blue whales (*Balaenoptera musculus brevicauda*) between Australia and Indonesia as revealed by satellite telemetry. PloS One 9, e93578

Table 6-26: Assessment against relevant actions of the Grey Nurse Shark Recovery Plan

Part 13 Statutory Instrument	Relevant Action Areas/Objectives	Relevant Actions	Evaluation	EPO, Controls and PS
Grey Nurse Shark Recovery Plan	**Objective 7**: Improve understanding of the threat of pollution and disease to the grey nurse shark	**Action 7.1**: Review and assess the potential threat of introduced species, pathogens and pollutants	Refer **Sections 0** and **6.4.6.** **Not inconsistent assessment:** This EP includes an assessment of the impacts from accidental release of solid waste as well as planned vessel discharges on marine species.	N/A
			Refer **Sections 6.5.2, 6.5.3** and **6.5.4**. **Not inconsistent assessment:** The assessment of accidental release of chemicals / hydrocarbons has considered the potential risks to grey nurse sharks.	Refer **Section 7.10.** Detailed oil spill preparedness and response performance outcomes, standards and measurement criteria for the Petroleum Activities Program are present in **Appendix D**.
Assessment Summary The Grey Nurse Recovery Plan has been considered during the assessment of impacts and risks, and the Petroleum Activities Program is not considered to be inconsistent with the relevant actions of this plan.				

Table 6-27: Assessment against relevant actions of the Sawfish and River Shark Multispecies Recovery Plan

Part 13 Statutory Instrument	Relevant Action Areas/Objectives	Relevant Actions	Evaluation	EPO, Controls and PS
Sawfish and River Shark Recovery Plan	**Objective 5**: Reduce and, where possible, eliminate adverse impacts of habitat degradation and modification on sawfish and river shark species	**Action 5c**: Identify risks to important sawfish and river shark habitat and measures needed to reduce those risks	Refer **Sections 6.5.2, 6.5.3** and **6.5.4** **Not inconsistent assessment**: The assessment of accidental release of chemicals / hydrocarbons has considered the potential risks to sawfish and river shark.	Refer **Section 7.10.** Detailed oil spill preparedness and response performance outcomes, standards and measurement criteria for the Petroleum Activities Program are present in **Appendix D.**
	Objective 6: Reduce and, where possible, eliminate any adverse impacts of marine debris on sawfish and river shark species	**Action 6a**: Assess the impacts of marine debris including ghost nets, fishing gear and plastics on sawfish and river shark species	Refer **Section 6.5.5.** **Not inconsistent assessment:** The assessment of accidental release of solid hazardous and non-hazardous wastes has considered the potential risks to sawfish and river sharks.	**EPO 18** **C 18.1, 18.2, 18.3** **PS 18.1, 18.2, 18.3**
Assessment Summary The Sawfish and River Shark Multispecies Recovery Plan has been considered during the assessment of impacts and risks, and the Petroleum Activities Program is not considered to be inconsistent with the relevant actions of this plan.				

Table 6-28: Assessment against relevant actions of the Marine Debris Threat Abatement Plan

Part 13 Statutory Instrument	Relevant Action Areas/Objectives	Relevant Actions	Evaluation	EPO, Controls and PS
Marine Debris TAP	**Objective 2:** Understand the scale of marine plastic and microplastic impact on key species, ecological communities and locations	**Action 2.04**: Build understanding related to plastic and microplastic pollution	Refer **Section 6.5.5.** **Not inconsistent assessment**: The assessment of the accidental release of solid hazardous and non-hazardous wastes has considered the potential risks to the marine environment. Controls have been implemented to reduce the likelihood of accidental release of solid wastes for the duration of the Petroleum Activities Program.	**EPO 18** **C 18.1, 18.2, 18.3** **PS 18.1, 18.2, 18.3**
Assessment Summary The Marine Debris TAP has been considered during the assessment of impacts and risks, and the Petroleum Activities Program is not considered to be inconsistent with the relevant actions of this plan.				

7. IMPLEMENTATION STRATEGY

7.1 Overview

Regulation 14 of the Environment Regulations requires an EP to contain an implementation strategy for the activity. The implementation strategy for the Petroleum Activities Program confirms fit-for-purpose systems, practices and procedures are in place to direct, review and manage the activities so that environmental risks and impacts are continually being reduced to ALARP and are acceptable, and that EPOs and EPSs outlined in this EP are achieved.

Woodside, as Operator, is responsible for ensuring that the Petroleum Activities Program is managed in accordance with this implementation strategy and the WMS (see **Section 1.8**).

7.2 Systems, Practice and Procedures

All operational activities are planned and carried out in accordance with relevant legislation and internal environment standards and procedures identified in this EP (**Section 2.2**).

Processes are implemented to verify controls to manage environmental impacts and risks to:

- a level that is ALARP and acceptable
- meet EPOs
- comply with EPSs defined in this EP.

The systems, practices and procedures that will be implemented are listed in the EPSs contained in this EP. Document names and reference numbers may be subject to change during the statutory duration of this EP; this is managed through a change register and management of change process.

7.3 Roles and Responsibilities

Key roles and responsibilities for Woodside and contractor personnel relating to implementing, managing and reviewing this EP are described in **Table 7-1**. Roles and responsibilities for oil spill preparation and response are outlined in **Appendix D** and the *Woodside Oil Pollution Emergency Arrangements (Australia)*.

Table 7-1: Roles and Responsibilities

Title (role)	Environmental Responsibilities
Office-based Personnel	
Woodside Survey Operations Project Manager	• Verify relevant Environmental Approvals for the activities exist before commencing activity. • Monitor and manage the activity so it is performed as per the relevant standards and commitments in this EP. • Notify the Woodside Environment Adviser in a timely manner of any scope changes. • Liaise with regulatory authorities as required. • Review this EP as necessary and manage change requests. • Ensure all project and support vessel crew members complete a Project (Including HSE) induction. • Verify that contractors meet environmental related contractual obligations. • Liaise with contractors to ensure communication and understanding of environment requirements as outlined in this EP. • Confirm environmental incident reporting meets regulatory requirements (as outlined in this EP) and Woodside's HSE Reporting and Investigation Procedure. • Monitor and close out corrective actions identified during environmental monitoring or audits. • Track compliance with performance outcomes and performance standards as per the requirements of this EP.
Woodside Environmental Adviser	• Prepare environmental component of relevant Induction Package. • Review compliance with performance outcomes and performance standards as per the requirements of this EP. • Ensure relevant Environmental Approvals for the activities exist before commencing activity. • Input to environmental component of relevant Induction Package. • Assist with the review, investigation and reporting of environmental incidents as required. • Assist environmental monitoring and inspections/audits are performed as per the requirements of this EP as required. • Liaise with relevant regulatory authorities as required. • Assist in preparing required external regulatory reports, in line with environmental approval requirements and Woodside incident reporting procedures. • Provide advice to relevant Woodside personnel and contractors to help them understand their environment responsibilities. • Support the Survey Operations Project Manager in ensuring communications and understanding of environment requirements as outlined in this EP. • Provide environmental support for activities through regular enegagement with WSR.
Woodside Corporate Affairs Adviser	• Prepare and implement the Stakeholder Consultation Plan for the Petroleum Activities Program. • Report on stakeholder consultation. • Continuously liaise and provide notification as required as outlined in the EP.

Woodside Marine Assurance Superintendent	• Source and conduct relevant audit and inspection to confirm vessels comply with relevant Marine Orders and Woodside Marine Charters Instructions requirements.
Woodside Corporate Incident Coordination Centre (CICC) Duty Manager	On receiving notification of an incident, the Woodside CICC Duty Manager shall: • Establish and take control of the Incident Management Team and establish an appropriate command structure for the incident. • Assess the situation, identify risks and actions to minimise the risk. • Communicate impact, risk and progress to the Crisis Management Team and stakeholders. • Develop the Incident Action Plan (IAP) including objectives for action. • Approve, implement and manage the IAP. • Communicate within and beyond the incident management structure. • Manage and review safety of responders. • Address the broader public safety considerations. • Conclude and review activities.
Vessel-based Personnel	
Vessels Master	• Ensure the vessel management system and procedures are implemented. • Ensure personnel commencing work on the vessel receive an environmental induction that meets the relevant requirements specified in this EP. • Ensure personnel are competent to perform the work they have been assigned. • Verify SOPEP drills are conducted as per the vessel's schedule. • Ensure the vessel Emergency Response Team has been given sufficient training to implement the SOPEP. • Ensure any environmental incidents or breaches of relevant EPOs or PSs detailed in this EP, are reported immediately to the Party Chief and Woodside Site Representative. • Ensure corrective actions for incidents or breaches are developed, communicated to the Woodside Site Representative, and tracked to close-out in a timely manner. Ensure close-out of actions is communicated to the Woodside Site Representative.
Party Chief / Manager	• Understand and manage environmental aspects of the seismic operations per this EP and approval conditions. • Provide copies of documents, records, reports and certifications (as requested by Woodside) in a timely manner to assist in compliance reporting. • Ensure any environmental incidents or breaches of EPOs or PSs detailed in this EP, are reported immediately to the Woodside Site Representative and Woodside Survey Operations Project Manager.

It is the responsibility of all Woodside employees and contractors to implement the Woodside Corporate Health, Safety and Environment Policy (refer to **Appendix A**) in their areas of responsibility and that the personnel are suitably trained and competent in their respective roles.

7.4 Training and Competency

Woodside as part of its contracting process assesses a proposed Contractor's environmental management system to determine the level of consistency with the standard AS/NZ ISO 14001:2016. This assessment is conducted for the Petroleum Activities Program as part of the tendering / vendor selection process. The assessment determines whether there is an organisational structure that clearly defines the roles and responsibilities for key positions. The assessment also determines whether there is an up-to-date training matrix that defines any corporate and site/activity-specific environmental training and competency requirements.

All crew will be aware of their roles and responsibilities regarding environmental risks throughout the Petroleum Activities Program. As a minimum, environmental awareness training is required for all personnel, detailing awareness and compliance with the Contractor's environmental policy and environmental management system.

7.4.1 Inductions

Inductions are provided to all relevant personnel (e.g. Contractors and Company representatives) before mobilising to or on arrival at the activity location. The induction covers the HSE requirements and environmental information specific to the activity location. Attendance records are maintained.

The Petroleum Activities Program induction may cover information about:

- description of the activity
- ecological and socio-economic values of the activity location
- regulations relevant to the activity
- Woodside's Environmental Management System – Health Safety and Environment Policy
- EP importance/structure/implementation/roles and responsibilities
- main environmental aspects/hazards and potential environmental impacts and related performance outcomes
- oil spill preparedness and response
- monitoring and reporting on performance outcomes and standards using measurement criteria
- incident reporting.

7.4.2 Petroleum Activity Specific Environmental Awareness

Before the Petroleum Activities Program begins, a Woodside Project Manager will hold a pre-activity meeting with all relevant personnel. The pre-activity meeting provides an opportunity to reiterate specific environmental sensitivities or commitments associated with the activity. Attendance lists are recorded and retained.

During operations, regular HSE meetings will be held on the seismic vessel and support vessel(s). During these meetings, environmental incidents are reviewed and awareness material presented. Attendance lists are recorded and retained.

Additional materials are to be provided to project personnel as required to facilitate/support compliance with performance standards and collection of data related to measurement criteria.

7.4.3 Management of Training Requirements

All personnel on the vessels are required to be competent to perform their assigned positions. This may be in the form of external or 'on the job' training. The vessel Safety Training Coordinator (or equivalent) is responsible for identifying training needs, keeping records of training undertaken, and identifying minimum training requirements.

7.5 Monitoring, Auditing, Management of Non-conformance and Review

7.5.1 Monitoring

Woodside and its Contractors will conduct a program of periodic monitoring during the Petroleum Activities Program – starting at mobilisation and continuing through the duration of the activity to activity completion. This information will be collected using the tools and systems outlined below, developed based on the environmental performance outcomes, controls, standards and measurement criteria in this EP. The tools and systems will collect, as a minimum, the data (evidence) referred to in the measurement criteria in **Section 6.4** and **6.5** and **Appendix D.**

The collection of this data (against the measurement criteria) will form part of the permanent record of compliance maintained by Woodside. It will form the basis for demonstrating that the environmental performance outcomes and standards are met, which will be summarised in a series of routine reporting documents.

7.5.1.1 Source-Based Impacts and Risks

The tools and systems to monitor environmental performance, where relevant, will include:

- daily reports, which include leading indicator compliance
- periodic review of waste management and recycling records
- use of Contractor's risk identification program that requires personnel to record and submit safety and environment risk observation cards on a routine basis (frequency varies with contractor)
- collection of evidence of compliance with the controls detailed in the EP relevant to offshore activities by the Woodside Site Representative (other compliance evidence is collected onshore)
- environmental discharge reports that record volumes of planned and unplanned discharges to ocean and atmosphere
- monitoring of progress against key performance indicators
- internal auditing and assurance program as described in **Section 7.5.2**

Throughout this activity, Woodside will continuously identify new source-based risks and impacts through the Monitoring and Auditing systems and tools described above and in **Section 7.5.1.1.**

7.5.1.2 Management of Knowledge

Review of knowledge relevant to the existing environment is undertaken in order to identify changes relating to the understanding of the environment or legislation that supports the risk and impact assessments for EPs (in-force and in-preparation). Relevant knowledge is defined as:

- Environmental science supporting the description of the existing environment
- Socio-economic environment and stakeholder information
- Environmental legislation.

The frequency and documentation of reviews, communication of relevant new knowledge and consideration of management of change are documented in the WMS Environment Plan Guideline.Under the Oil Spill Scientific Monitoring Program preparedness, an annual review and update to the environmental baseline studies database is completed and documented. Periodic location-focused environmental studies and baseline data gap analyses are completed and documented. Any subsequent studies scoped and executed as a result of such gap analysis are managed by the Environment Science Team and tracked via the Corporate Environment Baseline Database.

7.5.1.3 Management of Newly Identified Impacts and Risks

New sources of receptor based impacts and risks identified through monitoring and auditing systems and tools and the Woodside Environment Knowledge Management System will be assessed using the Change Management Process (refer to **Section 7.6**).

7.5.2 Auditing

Environmental performance auditing will be performed to:

- Identify potential new, or changes to existing environmental impacts and risk, and methods for reducing those to ALARP.
- Confirm that mitigation measures detailed in this EP are effectively reducing environmental impacts and risk, that mitigation measures proposed are practicable and provide appropriate information to verify compliance.
- Confirm compliance with the environmental performance outcomes and performance standards detailed in this EP.

The internal audits/inspections and reviews, combined with the ongoing monitoring described in **Section 7.5.1**, and collection of evidence for measurement criteria are used to assess environmental performance outcomes and standards.

As part of Woodside's EMS and/or assurances processes, activities are periodically selected for environmental audits as per Woodside's internal auditing process. Audit, inspection and review findings relevant to continuous improvement of environmental performance are tracked through the Environmental Commitments and Actions Register (ECAR). This ECAR is used to track compliance with EP commitments, including any findings and corrective actions.

Non-conformances identified will be reported and/or tracked in accordance with **Section 7.5.3**.

7.5.2.1 Marine Assurance

Marine assurance is undertaken in accordance with the Marine Offshore Vessel Assurance Procedure (Woodside Doc No: W0000PV1400355151). The marine assurance process is managed by the Marine Assurance Team of the Marine Services.

The processes and procedures used are based on industry standards and consideration of guidelines and recommendations from recognised industry organisations such as Oil Companies International Marine Forum and International Maritime Contractors Association.

The Marine Offshore Vessel Assurance Procedure defines the marine offshore assurance activities applicable for all vessels chartered directly by or on behalf of Woodside. The procedure is mandatory for all vessels hired for Woodside operations, including for short-term hires (less than three months in duration).

The Marine Offshore Vessel Assurance Procedure ensures all vessel operators and vessels chartered only operate seaworthy vessels that meet the requirements for a defined scope of work, and are managed with a robust safety management system. The marine offshore vessel assurance process is multi-faceted and encompasses:

- offshore vessel safety management system assessment (OVMSA)
- offshore vessel inspection database (OVID) inspection or similar
- project support for tender review and evaluation, pre/post contract award.

OVID inspections are objective in nature and reflect what was observed while conducting the inspection. The inspection provides observations as opposed to non-conformances. Woodside will maintain records of the marine assurance review.

Where an OVID inspection and/or OVMSA verification review is not available, and all reasonable efforts based on time and resource availability to complete an OVID inspection and/or OVMSA verification review are undertaken (i.e. short-term vessel hire), the Marine Assurance Specialist Offshore may approve using an alternate means of inspection as defined in the Marine Offshore Vessel Assurance Procedure, known as a risk assessment.

7.5.2.2 Risk Assessment

Woodside conducts a risk assessment of vessels where either an OVMSA Verification Review and/or an OVID inspection cannot be completed (i.e. short term vessel hire). This is not a regular occurrence and is typically used when the requirements of the assurance process are unable to be met or the processes detailed are not applicable to a proposed vessel(s). The Marine Vessel Risk Assessment will be conducted by the Marine Assurance Superintendent, or the nominated deputy, where the vessel meets the short term hire prerequisites.

The risk assessment is a semi-quantitative method of determining what further assurance process activity, if any, is required to assure a vessel for a particular task or role. The process compares the level of management control a vessel is subject to against the risk factors associated with the activity or role.

Several factors are assessed as part of a vessel risk assessment, including:

- Management control factors:
  - Company audit score (i.e. management system)
  - vessel HSE incidents
  - vessel Port State Control deficiencies
  - instances of Port State Control vessel detainment
  - years since previous satisfactory vessel inspection
  - age of vessel
  - contractors’ prior experience operating for Woodside.
- Activity risk factors:
  - people health and safety risks (a function of the nature of the work and the area of operation)
  - environmental risks (a function of environmental sensitivity, activity type and magnitude of potential environment damage (e.g. largest credible oil spill scenario))
  - value risk (likely time and cost consequence to Woodside if the vessel becomes unusable)
  - reputation risk
  - exposure (i.e. exposure to risk based on duration of project)
  - industrial relations risk.

The acceptability of the vessel or requirement for further vessel inspections or audits is based on the ratio of vessel score to activity risk. If the vessel management control is not deemed to appropriately manage activity risk, a satisfactory company audit and/or vessel inspection may be required before awarding work.

The risk assessment is valid for the period a vessel is on hire and for the defined scope of work.

7.5.3 Management of Non-conformance

Woodside classifies non-conformances with environmental performance outcomes and standards in this EP as environmental incidents. Woodside employees and contractors are required to report all environmental incidents, and these are managed as per Woodside's Health, Safety and Environment Event Reporting and Investigation Procedure (Woodside Doc No. WM0000PG9905421).

An internal computerised database called First Priority is used to record and report these incidents. Details of the event, immediate action taken to control the situation, investigation outcomes and corrective actions to prevent reoccurrence are all recorded. Corrective actions are monitored using First Priority and closed out in a timely manner.

Woodside uses a consequence matrix for classification of environmental incidents, with the significant categories being A, B and C (as detailed in **Section 2.6.1**). Detailed investigations are completed for all categories A, B, C and high potential environmental incidents.

7.5.4 Review

7.5.4.1 Management Review

Within the Environment function, senior management regularly monitors and reviews environmental performance and the effectiveness of managing environmental risks and performance. Within each Function and Business Unit Leadership Team, managers regularly review environmental performance, including through HSE Review meetings.

Risks are also reviewed before the activity commences, including operational, safety and environmental risks of the Petroleum Activities Program, to support continuous improvement as outlined in the Woodside Risk Management Framework (refer to **Section 2.4.1**).

7.5.4.2 Learning and Knowledge Sharing

Learning and knowledge sharing occurs via a number of different methods including:

- HSE meetings
- event investigations
- event bulletins
- post-activity review, including the review of environmental incidents as relevant
- ongoing communication with seismic vessel operators
- formal and informal industry benchmarking
- cross-asset learnings.

7.6 EP Management of Change and Revision

Management of changes are managed in accordance with Woodside's Environmental Approval Requirements Australia Commonwealth Guideline. Management of changes relevant to this EP, concerning the scope of the activity description (**Section 3**) including: review of advances in technology at stages where new equipment may be selected such as vessel contracting; changes in understanding of the environment, DAWE EPBC Act listed threatened and migratory species status, Part 13 statutory instruments (recovery plans, threat abatement plans, conservation advice, wildlife conservation plans) and current requirements for AMPs; and potential new advice from external stakeholders (**Section 5**), will be managed in accordance with Regulation 17 of the Environment Regulations.

Risk will be assessed in accordance with the environmental risk management methodology (**Section 2.2**) to determine the significance of any potential new environmental impacts or risks not provided for in this EP. Risk assessment outcomes are reviewed in compliance with Regulation 17 of the Environment Regulations.

Minor changes where a review of the activity and the environmental risks and impacts of the activity do not trigger a requirement for a formal revision under Regulation 17 of the Environment Regulations, will be considered a 'minor revision'. Minor administrative changes to this EP, where an assessment of the environmental risks and impacts is not required (e.g. document references, phone numbers, etc.), will also be considered a 'minor revision'. Minor revisions as defined above will be made to this EP using Woodside's document control process. Minor revisions will be tracked in an MOC Register to ensure visibility of cumulative risk changes, as well as enable internal EP updates/reissuing as required. This document will be made available to NOPSEMA during regulator environment inspections.

7.7 OPEP Management of Change and Revision

Relevant documents from the OPEP (**Section 7.10** and **Table 7-4)** will be reviewed in the following circumstances:

- implementation of improved preparedness measures
- a change in the availability of equipment stockpiles
- a change in the availability of personnel that reduces or improves preparedness and the capacity to respond
- the introduction of a new or improved technology that may be considered in a response for this activity
- to incorporate, where relevant, lessons learned from exercises or events
- if national or state response frameworks and Woodside's integration with these frameworks changes.

Where changes are required to the OPEP, based on the outcomes of the reviews described above, they will be assessed against Regulation 17 to determine if resubmission of the EP, including the OPEP, is required (see **Section 7.6**).

Changes with potential to influence minor or technical changes to the OPEP are tracked in management of change records, project records and incorporated during internal updates of the OPEP or the five-yearly revision.

Woodside will maintain the following records:

- Woodside's HSPU Testing of Arrangements Register
- Woodside Internal Equipment Maintenance Register
- OPEP current and available.

Activity OPEPs will be revised at a minimum every five years in accordance with the Woodside Hydrocarbon Spill Preparedness and Response Procedure.

7.8 Record Keeping

Compliance records (outlined in Measurement Criteria in **Sections 6.4** and **6.5**) will be maintained. Record keeping will be in accordance with Regulation 15(7) that addresses maintaining records of emissions and discharge volumes. The records are maintained in the daily seismic reports.

7.9 Reporting

To meet the environmental performance outcomes and standards outlined in this EP, Woodside reports at a number of levels. These reporting arrangements are outlined below.

7.9.1 Routine Reporting (Internal)

7.9.2 Daily Progress Reports and Meetings

Daily reports for seismic activities are prepared and issued to key Company support personnel by relevant managers responsible for the activity. The report provides performance information about seismic activities, heath, safety and environment, and current and planned work activities.

Meetings between key personnel are used to transfer information, discuss incidents, agree plans for future activities and develop plans and accountabilities for resolving issues.

7.9.2.1 Regular HSE Meetings

Regular HSE meetings are held with the offshore and Perth-based Project Manager and advisers (as required) to address HSE incidents and initiatives. Minutes of these meetings are produced and distributed as appropriate.

7.9.2.2 Performance Reporting

Daily, weekly and monthly performance reports are developed. These reports cover a number of subject matters, including:

- HSE incidents (including high potential incidents and those related to this EP) and recent activities
- corporate Key Performance Indicator targets, which include environmental metrics
- outstanding actions as a result of audits or incident investigations
- technical high and low lights.

7.9.3 Routine Reporting (External)

7.9.3.1 Start and End Notifications of the Petroleum Activities Program

In accordance with Regulation 29, Woodside will notify NOPSEMA and NT DITT (Petroleum) of the commencement of the Petroleum Activities Program at least ten days before the activity commences, and will notify NOPSEMA within ten days of completing the activity. Woodside will also notify the Director of National Parks when the EP is accepted by NOPSEMA and at least 10 days prior to activities occurring within the Oceanic Shoals AMP and upon completion of the activity.

7.9.3.2 Environmental Performance Review and Reporting

In accordance with applicable environmental legislation for the activity, Woodside is required to report information on environmental performance to the appropriate regulator. Regulatory reporting requirements are summarised in **Table 7-2.**

Table 7-2: Routine external reporting requirements

Report	Recipient	Frequency	Content
Monthly Recordable Incident Report (**Appendix E**)	NOPSEMA	Monthly, by the 15th of each month.	Details of recordable incidents that have occurred during the Petroleum Activities Program for the previous month (if applicable).
Environmental Performance Report	NOPSEMA	After completion all activity close-out actions and documentation. Within three months of completing the activity.	In accordance with the Environment Regulations, the report will address compliance with environmental performance outcomes and performance standards outlined in this EP.

7.9.3.3 End of the Environment Plan

The EP will end when Woodside notifies NOPSEMA that the Petroleum Activities Program has ended and all of the obligations identified in this EP have been completed, and NOPSEMA has accepted the notification, in accordance with Regulation 25A of the Environment Regulations.

7.9.4 Incident Reporting (Internal)

It is the responsibility of the Woodside Project Manager to ensure reporting of environmental incidents meets Woodside and regulatory reporting requirements as detailed in the Woodside Health, Safety and Environment Event Reporting and Investigation Procedure and this section of this EP.

7.9.5 Incident Reporting (External) – Reportable and Recordable

7.9.5.1 Reportable Incidents

Definition

A reportable incident is defined under Regulation 4 of the Environment Regulations as '*an incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage*'.

A reportable incident for the Petroleum Activities Program is:

- an incident that has caused environmental damage with a Consequence Level of Moderate (C) or above (as defined under Woodside's Risk Table; refer to **Figure 2-4**)
- an incident that has the potential to cause environmental damage with a Consequence Level of Moderate (C) or above (as defined under Woodside's Risk Table – refer to **Figure 2-4**).

The environmental risk assessment (**Section 6**) for the Petroleum Activities Program identifies those risks with a potential consequence level of C+ for environment. The incidents that have the potential to cause this level of impact include accidental hydrocarbon release resulting from a vessel collision.

Any such incidents represent potential events which would be reportable incidents. Incident reporting is performed with consideration of NOPSEMA (2014) guidance stating, 'if in doubt, notify NOPSEMA', and assessed on a case-by-case basis to determine if they trigger a reportable incident as defined in this EP and by the Regulations.

Notification

NOPSEMA will be notified of all reportable incidents, according to the requirements of Regulations 26, 26A and 26AA of the Environment Regulations. Woodside will:

- report all reportable incidents to the regulator (orally) ASAP, but within two hours of the incident or of its detection by Woodside

- provide a written record of the reported incident to NOPSEMA, the National Offshore Petroleum Titles Administrator (NOPTA) and the Department of the responsible Territory Minister (DITT) ASAP after orally reporting the incident
- complete a written report for all reportable incidents using a format consistent with the NOPSEMA Form FM0831 – Reportable Environmental Incident (**Appendix E**) which must be submitted to NOPSEMA ASAP, but within three days of the incident or of its detection by Woodside
- provide a copy of the written report to the NOPTA and DITT, within seven days of the written report being provided to NOPSEMA
- AMSA will be notified of oil spill incidents ASAP after their occurrence, and DAWE notified if MNES are to be affected by the oil spill incident.

7.9.5.2 Recordable Incidents

Definition

A recordable incident is defined under Regulation 4 of the Environment Regulations as an incident arising from the activity that *'breaches an environmental performance outcome or environmental performance standard, in the EP for the petroleum activity, and is not a reportable incident'*.

Any breach of the environmental performance outcomes or standards (presented within **Section 6.4** and **6.5**) will be raised as an incident and managed as per the notification and reporting requirements outlined below and the Woodside Health, Safety and Environment Event Reporting and Investigation Procedure.

Notification

NOPSEMA will be notified of all recordable incidents, according to the requirements of Regulation 26B(4), no later than 15 days after the end of the calendar month using the NOPSEMA Form – Recordable Environmental Incident Monthly Summary Report detailing:

- all recordable incidents that occurred during the calendar month
- all material facts and circumstances concerning the recordable incidents that the operator knows or is able, by reasonable search or enquiry, to find out
- any action taken to avoid or mitigate any adverse environment impacts of the recordable incidents
- the corrective action that has been taken, or is proposed to be taken, to prevent similar recordable incidents
- the action that has been taken, or is proposed to be taken, to prevent a similar incident occurring in the future

7.9.5.3 Other External Incident Reporting Requirements

In addition to notifying of and reporting environmental incidents defined under the Environment Regulations and Woodside requirements, **Table 7-3** describes the incident reporting requirements that also apply in the Operational Area.

For oil spill incidents, other agencies and organisations will be notified as appropriate to the nature and scale of the incident, as per procedures and contact lists in the Woodside Oil Pollution Emergency Arrangements (Australia) and Oil Pollution First Strike Plan (refer to **Appendix I**).

Table 7-3: External Incident Reporting Requirements

Event	Responsibility	Notifiable party	Notification requirements	Contact	Contact detail
Any marine incidents during Petroleum Activities Program	Vessel Master	AMSA	Incident Alert Form 18 as soon as reasonably practicable* Within 72 hours after becoming aware of the incident, submit Incident Report Form 19	AMSA	reports@amsa.gov.au
Oil pollution incidents in Commonwealth waters	Vessel Master	AMSA RCC	Without delay as per *Protection of the Sea Act*, part II, section 11(1), AMSA RCC notified verbally via the national emergency 24-hour notification contact of the hydrocarbon spill; follow up with a written Pollution Report ASAP after verbal notification	AMSA RCC	Phone: 1800 641 792 or +61 2 6230 6811 AFTN: YSARYCYX
Any oil pollution incident which has the potential to enter a National Park or requires oil spill response activities to be conducted within a National Park	Woodside	DAWE	Reported verbally, ASAP	Director of National Parks	Phone: 02 6274 2220
Activity causes unintentional death of or injury to fauna species listed as Threatened or Migratory under the EPBC Act	Woodside	DAWE	Within seven days of becoming aware	Secretary of the DAWE	Phone: 1800 803 772 Email: protected.species@environment.gov.au

The pollution activities should also be reported to AMSA via RCC Australia by the Vessel Master are:

- Any loss of significant plastic material (e.g. streamers).
- Garbage disposed of in the sea within 12 nm of land (garbage includes food, paper, bottles, etc.).
- Any loss of hazardous materials.
- For oil spill incidents, other agencies and organisations will be notified as appropriate to the nature and scale of the incident as per procedures and contact lists in the Oil Pollution Emergency Arrangements (Australia) and the Galactic Hybrid 2D MSS Oil Pollution First Strike Plan (refer to **Appendix I**).
- External incident reporting requirements under the OPGGS (Safety) Regulations, including under sub-regulation 2.42, notices and reports of dangerous occurrences will be reported to NOPSEMA under the approved activity safety cases.

7.10 Emergency Preparedness and Response

7.10.1 Overview

Under Regulation 14(8), the implementation strategy must contain an Oil Pollution Emergency Plan (OPEP) and provide for updating the OPEP. Regulation 14(8AA) outlines the requirements for the OPEP which must include adequate arrangements for responding to and monitoring oil pollution.

A summary of how this EP and supporting documents address the various requirements of Environment Regulations relating to oil pollution response arrangements is shown in **Table 7-4**.

Table 7-4: Oil pollution and preparedness and response overview

Content	Environment Regulations Reference	Document/Section Reference
Details of (oil pollution response) control measures that will be used to reduce the impacts and risks of the activity to ALARP and an acceptable level	Regulation 13(5), (6), 14(3)	Oil Spill Preparedness and Response Mitigation Assessment (**Appendix D**)
Describes the OPEP	Regulation 14(8)	EP: Woodside's oil pollution emergency plan has the following components: • Woodside Oil Pollution Emergency Arrangements (Australia) • Oil Pollution First Strike Plan (**Appendix I**) • Oil Spill Preparedness and Response Mitigation Assessment (**Appendix D**) In accordance with Regulation 31 of the Environmental Regulations the Woodside Oil Pollution Emergency Arrangements (Australia) was provided with the Julimar Phase 2 Drilling and Subsea Installation EP, accepted by NOPSEMA on 8 November 2019.
Details the arrangements for responding to and monitoring oil pollution (to inform response activities), including control measures	Regulation 14(8AA)	Oil Spill Preparedness and Response Mitigation Assessment (**Appendix D**) • Oil Pollution First Strike Plan (**Appendix I**)

Content	Environment Regulations Reference	Document/Section Reference
Details the arrangements for updating and testing the oil pollution response arrangements	Regulation 14(8), (8A), (8B), (8C)	EP: **Section 7.10** Oil Spill Preparedness and Response Mitigation Assessment (**Appendix D**)
Details of provisions for monitoring impacts to the environment from oil pollution and response activities	Regulation 14(8D)	Oil Spill Preparedness and Response Mitigation Assessment **(Appendix D)**
Demonstrates that the oil pollution response arrangements are consistent with the national system for oil pollution preparedness and control	Regulation 14(8E)	Oil Pollution Emergency Arrangements (Australia)

7.10.2 Emergency Response Training

Regulation 14(5) requires that the implementation strategy includes measures to ensure that employees and contractors have the appropriate competencies and training (**Table 7-5**). Woodside has conducted a risk-based training needs analysis on positions required for effective oil spill response. Following the mapping of training to Woodside identified competencies, training was then mapped to positions based on their required competencies.

Table 7-5: Minimum levels of competency for key IMT positions

IMT Position	Minimum Competency
Corporate Incident Coordinate Centre (CICC) Leader	• Incident and Crisis Leadership Development Program (ICLDP) • Oil Spill Response Skills Enhancement Course (OSREC – internal course) • Participation in L2 oil spill exercise (initial) • Participation in L2 oil spill exercise (refresher)
Security & Emergency Manager Duty Manager	• ICLDP • OSREC • IMO2 or equivalent spill response specialist level with an oil spill response organisation (OSRO) • Participation in L2 oil spill exercise (initial) • Participation in L2 oil spill exercise (refresher)
Operations, Planning, Logistics, Safety	• OSREC • ICC Fundamentals Course (internal course) • Participation in L2 oil spill exercise (initial) • Participation in L2 oil spill exercise (refresher)
Environment Coordinator	• ICC Fundamentals • OSREC • IMO2 or equivalent spill response specialist level with an OSRO • Participation in L2 oil spill exercise (initial) • Participation in L2 oil spill exercise (refresh
Note on competency/equivalency	
In 2018 Woodside undertook a review of incident and crisis systems, processes and tools to assess whether these were fit-for purpose and has rolled out a change to the Incident and Crisis Management training and the oil spill response training requirements for both ICC and field-based roles. The revised ICC Fundamentals training Program and Incident and Crisis Leaders Development Program (ICLDP) align with the performance requirements of the *PMAOMIR320 – Manage Incident Response Information* and *PMAOM0R418 - Coordinate Incident Response.*	

Regarding training specific equivalency:

- ICLDP is mapped to *PMAOM0R418* (and which is equivalent to IMOIII when combined with Woodside's OSREC course) and ensures broader incident management principles aligned with Australasian Inter-service Incident Management System (AIIMS).
- The revised ICC Fundamentals Course is mapped to *PMAOMIR320* (and which is equivalent to IMOII). The blended learning program offers modules aligned to IMOIII, IMOII, IMOI and AMOSC Core Group Training Oil Spill Response Organisation Specialist Level training.
- OSREC involves the completion of two (2) online AMSA Modules (Introduction to National Plan and Incident management; and Introduction to oil spills) as well as elements of IMOI and IMOII tailored to Woodside specific OSR capabilities.
- Woodside Learning Services (WLS) are responsible for collating and maintaining personnel training records. The HSP Dashboard reflects the competencies required for each oil spill role (IMT/operational).

7.10.3 Emergency Response Preparation

The Corporate Incident Coordination Centre (CICC), based in Woodside's head office in Perth, is the onshore coordination point for an offshore emergency. The CICC is staffed by an appropriately skilled team available on call 24-hours a day. The purpose of the team is to coordinate rescues, minimise damage to the environment and facilities, and to liaise with external agencies. A description of Woodside's Incident Command Structure and arrangements is further detailed in the Woodside OPEA (Australia). Roles and responsibilities for facility emergency response are outlined in the Woodside Oil Pollution Emergency Arrangements (Australia).

Woodside will have an Emergency Response Plan (ERP) in place relevant to the Petroleum Activities Program. The ERP provides procedural guidance specific to the asset and location of operations to control, coordinate and respond to an emergency or incident. The ERP will contain instructions for vessel emergency, medical emergency, search and rescue, reportable incidents, incident notification, contact information and activation of the contractor's emergency centre and Woodside Communication Centre (WCC).

In an emergency of any type, the Vessel Master will assume overall onsite command and act as the Incident Controller (IC). All persons aboard the vessel will be required to act under the IC's directions. The vessel will maintain communications with the onshore Project Manager and/or other emergency services. Emergency response support can be provided by the Contractor's emergency centre or WCC if requested by the IC.

The seismic vessel will have on-board equipment for responding to emergencies including medical, firefighting and hydrocarbon spill response equipment.

7.10.4 Oil and Other Hazardous Materials Spill

A significant hydrocarbon spill during the Petroleum Activities Program is unlikely, but should such an event occur, it has the potential to cause serious environmental and reputational damage if not managed properly. The Woodside Oil Pollution Emergency Arrangements (Australia) document, supported by the Oil Pollution First Strike Plan (**Appendix I**) which provides tactical response guidance to the activity/area. Spill response for this Petroleum Activities Program is described further in **Appendix D**.

The Security and Emergency Management Function is responsible for the management of Woodside's hydrocarbon spill response equipment, and for the maintenance of hydrocarbon spill preparedness and response documentation. In the event of a major spill, Woodside will request that AMSA (administrator of the National Plan) supports Woodside through advice and access to equipment, people and liaison. The interface and responsibilities, as defined under the National Plan, are described in the Woodside Oil Pollution Emergency Arrangements (Australia) document. AMSA and Woodside have a Memorandum of Understanding (MOU) in place to support Woodside in the event of an oil spill.

The seismic vessel and support vessel(s) will have a SOPEP in accordance with the requirements of MARPOL 73/78 Annex I. These plans outline responsibilities, specify procedures and identify resources available in a hydrocarbon or chemical spill from vessel activities. The Oil Pollution First Strike Plan is intended to work in conjunction with the SOPEPs and provides immediate actions required to commence a response if hydrocarbons are released to the marine environment.

Woodside has established environmental performance outcomes, performance standards and measurement criteria to be used for oil spill response during the Petroleum Activities Program, as detailed in **Appendix D**.

7.11 Emergency and Spill Response

Woodside categorises incidents in relation to response requirements as follows:

- **Level 1 Incident** – A Level 1 incident can be resolved through the use of existing resources, equipment and personnel. A Level 1 incident is contained, controlled and resolved by site/regionally based teams using existing resources and functional support services.
- **Level 2 Incident** – A Level 2 incident is characterised by a response that requires external operational support to manage the incident. It is triggered in the event the capabilities of the tactical level response are exceeded. This support is provided to the activity via the activation of all, or part of, the responsible ICC.
- **Level 3 Incident** – A Level 3 incident or crisis is identified as a critical event that seriously threatens the organisation's People, the Environment, company Assets, Reputation, Livelihood or essential Services. At Woodside, the Crisis Management Team (CMT) manages the strategic impacts in order to respond to and recover from the threat to the company (material impacts, litigation, legal and commercial, reputation, etc.). The CICC may also be activated as required to manage the operational response to the Level 3 Incident.

7.11.1 Emergency and Spill Response Drills and Exercises

Personnel holding responsibilities in a response will test the arrangements supporting the activities OPEP to ensure they are effective and communicated. Testing of Woodside's capability to respond to incidents will be conducted in alignment with the Emergency and Crisis Management Procedure. The scope, frequency and objective of these tests is described in **Table 7-6.** These arrangements are conducted in accordance with Regulation 14 (8B) of the OPGGS (Environment) Regulations 2009.

The company emergency response testing regime is aligned to existing or developing risks associated with Woodside's operations and activities. Corporate hazards/risks outlined in the corporate risk register, respective Safety Cases or project Risk Registers, are the key reference point for emergency management and crisis management exercising schedule development. External participants may be invited to attend crisis exercises and may include government agencies, specialist service providers, hydrocarbon spill response organisations or industry members with which Woodside has mutual aid arrangements.

The objective is to exercise procedures, skills and teamwork of the Emergency Response and Command Teams in their ability to respond to emergency situations. After each exercise, the team holds a debrief session, during which the exercise is reviewed and reported. Any lessons learnt or areas for improvement are identified and incorporated into emergency procedures where appropriate.

Spill response exercise reports and key participants will be maintained in the Woodside IMS system.

Table 7-6: Testing of response capability

Response Category	Scope	Response Testing Frequency	Response Testing Objective
Level 1 Response	Exercises are project-/ activity-specific	One Level 1 'First Strike' drill conducted within two weeks of activity commencement.	• Comprehensive exercises test elements of the Oil Pollution First Strike Plan (**Appendix I**). • Emergency drills are scheduled to test other aspects of the Emergency Response Plan.
Level 2 Response	Exercises are vessel specific	A minimum of one Emergency Management exercise per campaign.	• Testing both the facility IMT response and/or that of the CICC following handover of incident control.
Level 3 Response	Exercises are relevant to all Woodside assets	The number of CMT exercises conducted each year is determined by the Chief Executive Officer, in consultation with the Vice President of Security and Emergency Management.	• Test Woodside's ability to respond to and manage a crisis level incident.

7.11.2 Hydrocarbon Spill Response Testing of Arrangements

Woodside is required to test hydrocarbon spill response arrangements as per regulations 8B and 8C of the Environment Regulations. Woodside's arrangements for spill response are common across its Australian operating assets and activities to ensure the controls are consistent. The overall objective of testing these arrangements is to ensure that Woodside maintains an ability to respond to a hydrocarbon spill, specifically to:

- ensure relevant responders, contractors and key personnel understand and practise their assigned roles and responsibilities
- test response arrangements and actions to validate response plans
- ensure lessons learned are incorporated into Woodside's processes and procedures and improvements are made where required.

If new response arrangements are introduced, or existing arrangements significantly amended, additional testing is undertaken accordingly. Additional activities or activity locations are not anticipated to occur; however, if they do, testing of relevant response arrangements will be undertaken as soon as practicable.

In addition to the testing of response capability described in **Section 7.11.2**, up to eight formal exercises are planned annually, across Woodside, to specifically test arrangements for responding to a hydrocarbon spill to the marine environment.

7.11.2.1 Testing of Arrangements Schedule

Woodside's Testing of Arrangements Schedule (**Figure 7-1**) aligns with international good practice for spill preparedness and response management; the testing is compatible with the IPIECA Good Practice Guide and the Australian Emergency Management Institute Handbook. If a spill occurs, enacting these arrangements will underpin Woodside's ability to implement a response across its petroleum activities. **Figure 7-1** shows a condensed snapshot of Woodside's 5-year rolling Testing of Arrangements Schedule.

HSP TESTING OF ARRANGEMENTS SCHEDULE
WOODSIDE ID: 10058092

5 YEAR ROLLING SCHEDULE

Arrangement	Support Agency / Company	Area to be tested
1	WEL	Personnel
2	WEL	Equipment
3	WEL	Vessel aquistion - internal processes
4	AMOSC	Equipment
5	AMOSC	Personnel
6	OSRL	Equipment
7	OSRL	Personnel
8	Worley Parsons	Equipment
9	Worley Parsons	Personnel
10	ERM	Equipment
11	ERM	Personnel
12	Jacobs	Equipment
13	Jacobs	Personnel
14	AMSA	Equipment
15	AMSA	Personnel
16	DOT (Department of Transport)	Equipment
17	DOT (Department of Transport)	Staging Area Support
18	WEL	Predictive Modelling - Rapid Assessment Tool
19	RPS APASA	Predictive Modelling
20	KSAT	Satellite remote sensing
21	Bristows	Aircraft
22	MSRC	Personnel
23	Sci Aero	Equipment and Personnel
24	Centurion	Logistics Support
25	Harold E Holt	Support and Access
26	Fergusons	Equipment
27	Swires	Equipment
28	Toll Mermaid	Staging Area Support
29	Norwest Air Works	Dispersant Aircraft (access and support)
30	Exmouth Aerodrome	Dispersant Aircraft (access and support)
31	Broome International Airport	Dispersant Aircraft (access and support)
32	Learmonth Airport	Dispersant Aircraft (access and support)
33	Exmouth Freight and Logistics	Logistics Support
34	Veolia	Equipment and Personnel
35	ERS	Equipment and Personnel

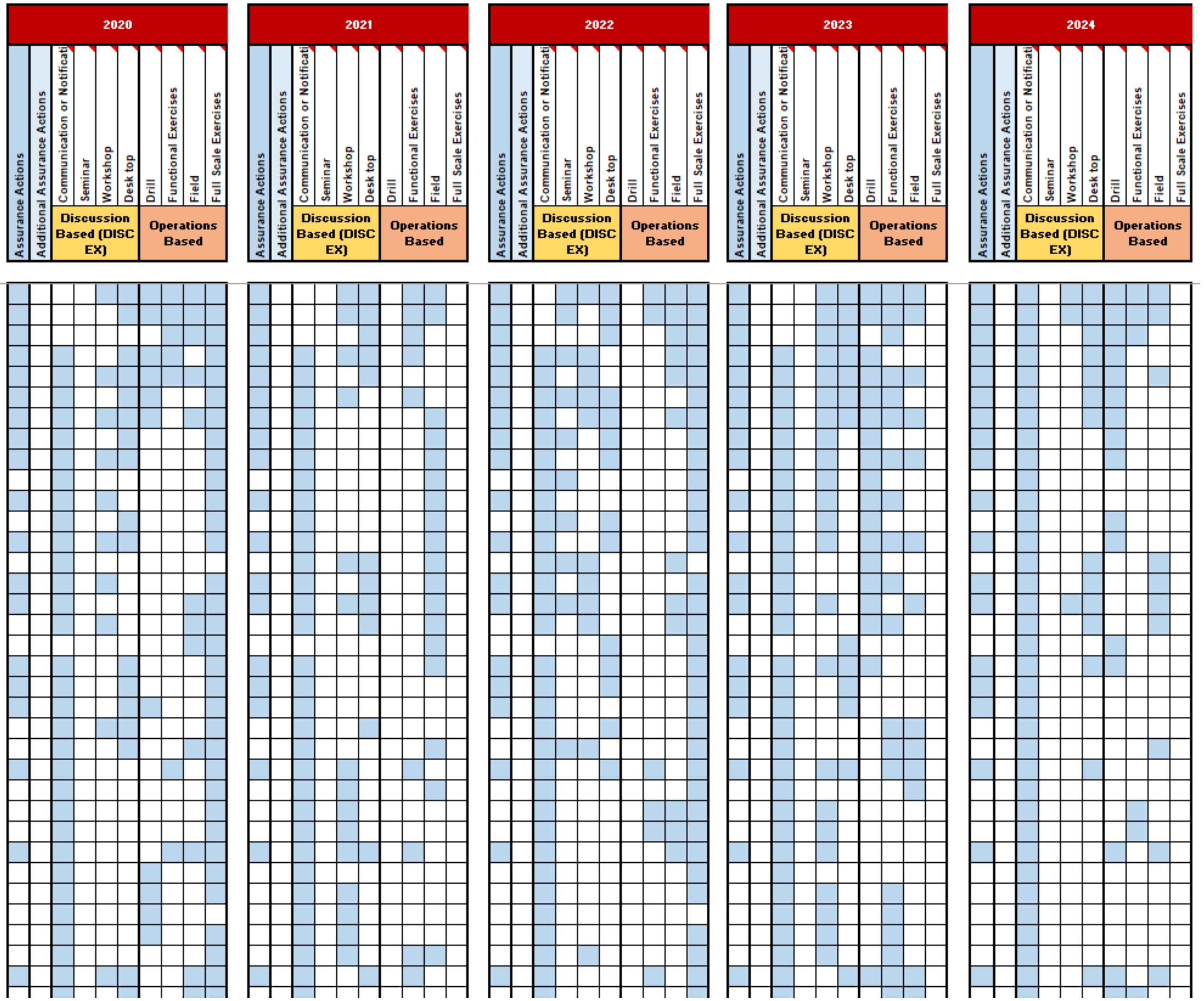


Figure 7-1: Indicative 5-yearly testing of arrangements schedule

(Snapshot of a selection of oil spill response arrangements tested annually; Note: schedule is subject to change, additional detail is included in the live document)

Numbered hydrocarbon spill arrangements listed in the rows of the schedule are taken from the support plans and operational plans described in Section 1.4 of **Appendix D**. Each arrangement has a support agency/company and an area to be tested (e.g. capability, equipment and personnel). For example, an arrangement could be to test Woodside's personnel capability for conducting scientific monitoring, or the ability of the Australian Marine Oil Spill Centre to provide response personnel and equipment. About 75 hydrocarbon spill preparedness arrangements are tested annually across the eight planned exercises, as described above.

The vertical columns under each year in **Figure 7-1** relate to an individual exercise or additional assurance actions that are conducted over the 5-year rolling schedule. The sub-heading for the column describes the standard method of testing (e.g. discussion exercise, desktop exercise), and the blue cells indicate the arrangements that could be tested for each method.

Arrangements in the schedule are tested at least once a year; however, some arrangements may be tested across multiple exercises (e.g. critical arrangements) or via other 'additional assurance' methods outside the formal Testing of Arrangements Schedule that also constitute sufficient evidence of testing of arrangements (e.g. audits, no-notice drills, internal exercises, assurance drills) (refer to the first and second vertical columns for each year in **Figure 7-1**).

7.11.2.2 Exercises, Objectives, and KPIs

Exercises are designed to cumulatively provide assurance for all arrangements within Woodside's Testing of Arrangements Schedule annually across all facilities. Exercise-initiating scenarios are derived from the worst-case credible scenarios as described in the relevant facility's First Strike Plans.

Objectives and KPIs for each exercise are determined by reviewing:

- the Testing of Arrangements Schedule, which identifies which arrangements can be tested for each testing method (**Section 7.11.2.1**)
- the objectives and KPIs master generic plan, which summarises generic objectives and KPIs that could be tested for specific response strategies, based on industry good practice guidance (i.e. IPIECA) for testing oil spill arrangements
- the oil spill ALARP commitments register, which summarises all spill response commitments from accepted EPs (e.g. timings, numbers) for different response strategies, and considers priority commitments and worst-cast spill scenarios
- actions undertaken from recommendations from previous exercises, where relevant.

The required capabilities, number of personnel, equipment, and timeframes (i.e. arrangements) form specific KPIs during an exercise. Where this is the case, the ALARP commitments register indicates the specific response strategy performance standards to use/test the arrangements against. Where relevant the most stringent performance standard across all in-force EPs is used as the KPI. After each exercise, a report is produced that includes recommendations for improvements, which are then converted to actions and tracked in the Testing of Arrangements Register.

Additional assurance actions are also routinely undertaken outside formal exercises (e.g. response audits, no-notice drills), which support testing of these arrangements. Evidence and outcomes from additional assurance actions are used, where relevant, to support testing individual arrangements, including from external sources (e.g. evidence of suppliers testing their own arrangements).

7.12 Severe Weather Preparation

The activity is scheduled to occur outside of the typical cyclone season (November to April), however cyclones have been known to develop outside of season, between July and October. The seismic vessel contractor must have a Severe Weather Procedure, or equivalent, in place outlining the processes and procedures that would be implemented during a severe weather event.

The seismic vessel will receive daily forecasts. If a severe weather event is forecast, the path and its development will be plotted and monitored using the forecast data. If there is the potential for the severe weather event to affect the Petroleum Activities Program, the Severe Weather Procedure will be actioned.

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9. LIST OF TERMS AND ACRONYMS

Acronym	Description
@	At
~	Approximately
<	Less/fewer than
>	Greater/more than
≤	Less than or equal to
≥	Greater than or equal to
°C	Degrees Celsius
24/7	24 hours a day, seven days a week
2D	Two-dimensional
3D	Three-dimensional
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABC	Australian Broadcasting Corporation
ACN	Australian Company Number
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AHS	Australian Hydrographic Service
AIIMS	Australasian Inter-service Incident Management System
AIMS	Australian Institute of Marine Science
AIS	Automated Identification System
ALARP	As low as reasonably practicable
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment and Conservation Council
API	American Petroleum Institute
APPEA	Australian Petroleum Production and Exploration Association
AR	Ashmore Reef
ArS	Arafura Sea
ASAP	As soon as possible
AS/NZS	Australian Standard/New Zealand Standard
ATSB	Australian Transport Safety Bureau
AUV	Autonomous Underwater Vehicle
BBCL	Bonaparte Basin Cable Loop
BIA	Biologically Important Area
BOEM	Bureau of Ocean Energy Management
BoM	Bureau of Meteorology
BP	Boiling Point
CCSBT	Commission for the Conservation of Southern Bluefin Tuna

Acronym	Description
CD	Cape Domett
CICC	Corporate Incident Communication Centre
cm	Centimetre
cm^3	Cubic centimetre
CMT	Crisis Management Team
CO	Carbon monoxide
CO_2	Carbon dioxide
CONOPS	Concurrent operations
COO	Chief Operations Officer
cP	Viscosity
CS	Cost/sacrifice
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cth	Commonwealth
CV	Company Values
DAWE	Commonwealth Department of Agriculture, Water and the Environment
dB re 1 µPa	Decibels relative to one micropascal; the unit used to measure the intensity of an underwater sound
DEH	Former Commonwealth Department of the Environment and Heritage (now DoEE)
DERM	Queensland Department of Environment and Resource Management
DEWHA	Former Commonwealth Department of the Environment, Water, Heritage and the Arts (now DoEE)
DFO	Department of Fisheries and Oceans Canada
DITT	Northern Territory Department of Industry, Tourism and Trade
DMAC	UK Diving Medical Advisory Committee
DNP	Director of National Parks
DNV	Det Norske Veritas
DoE	Commonwealth Department of Environment
DoEE	Commonwealth Department of the Environment and Energy
DoT	Western Australian Department of Transport
DPIF	Northern Territory Department of Primary Industries and Fisheries
DPIR	Northern Territory Department of Primary Industry and Resources
DPIRD	Western Australian Department of Primary Industries and Regional Development
DRA	Due Regard Area
DRIMS	Document Retrieval Integrated Management System
DSEWPaC	Former Commonwealth Department of Sustainability, Environment, Water, Population and Communities (now DoEE)
DWH	Deepwater Horizon
ECAR	Environmental Commitments and Actions Register
EEZ	Exclusive Economic Zone
EMBA	Environment that may be affected

Acronym	Description
ENVID	Environment Identification (study)
EP	Environment Plan
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EPO	Environmental Performance Outcome
EPS	Environment Performance Standard
ERM	Environmental Resource Management (Australia)
ERP	Emergency Response Plan
ESD	Ecologically Sustainable Development
F	Control Feasibility
FAO	Food and Agriculture Organization
FID	Final investment decision
FPSO	Floating production, storage, and offtake
FRDC	Fisheries Research and Development Corporation
g	Gram
GMEM	Gippsland Marine Environmental Monitoring
GNSS	Global Navigation Satellite System
GP	Good Practice
GPS	Global Positioning System
GRT	Gross register tonnage
HAZID	Hazard identification (study)
HF	High-frequency
HSE	Health, Safety, and Environment
IAGC	International Association of Geophysical Contractors
IAP	Incident Action Plan
IAPP	International Air Pollution Prevention
IC	Incident Controller
ICLDP	Incident and Crisis Leadership Development Program
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IMO	International Maritime Organisation
IMOS	Integrated Marine Operating System
IMS	Invasive Marine Species
IPIECA	International Petroleum Industry Environmental Conservation Association
ISO	International Organization for Standardization
ISPP	International Sewage Pollution Prevention
ITF	Indonesian Throughflow
ITOPF	International Tanker Owners Pollution Federation Ltd
IUCN	International Union for the Conservation of Nature
IUU	Illegal, Unreported and Unregulated (fishing)
JASCO	JASCO Applied Sciences

Acronym	Description
JBG	Joseph Bonaparte Gulf
JRCC	Joint Rescue Coordination Centre
JSA	Job Safety Analysis
KEF	Key Ecological Feature
kg	Kilogram
kHz	Kilohertz
km	Kilometre
kn	Knot
KPI	Key Performance Indicator
L	Litre
LCS	Legislation, Codes and Standards
LF	Low-frequency
LNG	Liquefied Natural Gas
LP	Low Pressure
LT	Low Temperature
m	Metre
m/s	Metres per second
m^2	Square metre
m^3	Cubic metre
MARPOL	The International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978.
MC	Measurement Criteria
MDO	Marine Diesel Oil
MF	Mid-frequency
mg	Milligram
ml	Millilitre
MNES	Matters of National Environmental Significance
MoC	Management of Change
MOD	Maximum over depth
MODU	Mobile Offshore Drilling Unit
MOPO	Manual of Permitted Operation
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MSIN	Maritime Safety Information Notifications
MSS	Marine Seismic Survey
MUZ	Multiple Use Zone
N/A	Not Applicable
NAXA	North Australian Exercise Area
NCVA	National Conservation Values Atlas

Acronym	Description
n.d.	No date
nGBR	Northern Great Barrier Reef
NIMS	Non-indigenous Marine Species
NLPG	National Light Pollution Guidelines for Wildlife (Including Marine Turtles, Seabirds and Migratory Shorebirds)
nm	Nautical mile
NMFS	National Marine Fisheries Service (US)
NMN	National Mooring Network
NMR	North Marine Region
NOAA	National Oceanic and Atmospheric Administration (US)
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NOPTA	National Offshore Petroleum Titles Administrator
NO_X	Oxides of nitrogen
NPF	Northern Prawn Fishery
NRC	National Research Council
NSF	National Science Foundation
NSW	New South Wales
NT	Northern Territory
NTM	Notices to Mariners
NWCS	North West Cable System
NWS	North West Shelf
OIW	Oil in water
OPEA	Oil Pollution Emergency Arrangements
OPEP	Oil Pollution Emergency Plan
OPGGS Act	Commonwealth *Offshore Petroleum and Greenhouse Gas Storage Act 2006*
OSMP	Oceanic Shoals Marine Park
OSPRMA	Oil Spill Preparedness and Response Mitigation Assessment
OSREC	Oil Spill Response Skills Enhancement Course
OSRO	Oil spill response organisation
OVID	Offshore vessel inspection database
OVMSA	Offshore vessel safety management system assessment
PAM	Passive Acoustic Monitoring
PEIS	Arctic Programmatic Environmental Impact Statement
PENV	Pendoley Environmental
PJ	Professional Judgement
PK	Zero-to-peak sound pressure
PK-PK	Peak-to-peak sound pressure
PMI	Potential mortal injury
PMST	Protected Matters Search Tool

Acronym	Description
ppb	Parts per billion
ppm	Parts per million
PTS	Permanent threshold shift
QLD	Queensland
RAAF	Royal Australian Air Force
RAN	Royal Australian Navy
RBA	Risk-based Analysis
RCC	Rescue Coordination Centre
rms	Root Mean Square
ROV	Remotely operated vehicle
SA	South Australia
SAFS	Status of Australian Fish Stocks
Sc-Br	Scott-Browse
SEL	Sound Exposure Level
SIMAP	Spill Impact Mapping and Analysis program
SMP	Scientific Monitoring Program
SMPEP	Spill Monitoring Programme Execution Plan
SNA	Safe Navigation Area
SOPEP	Ship Oil Pollution Emergency Plan
SPL	Sound Pressure Level
SV	Societal Value
SW	South-west
T	Tonne
TAP	Threat Abatement Plan
TSSC	Threatened Species Scientific Committee
TTS	Temporary threshold shift
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organisation
US	United States
USBL	Ultra-short baseline (acoustic positioning system)
UXO	Unexploded ordinance
VIC	Victoria
VMS	Vessel Monitoring System
VOC	Volatile Organic Compound
WA	Western Australia
WAFIC	Western Australian Fishing Industry Council
WCC	Woodside Communication Centre
WDCS	Whale and Dolphin Conservation Society
WEL	Woodside Energy Limited

Acronym	Description
WHP	World Heritage Property
WMS	Woodside Management System

APPENDIX A WOODSIDE HEALTH, SAFETY AND ENVIRONMENT AND RISK MANAGEMENT POLICIES

WOODSIDE POLICY

Health, Safety and Environment Policy

OBJECTIVES

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

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

PRINCIPLES

Woodside will achieve this by:

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

APPLICATION

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

Updated by the Board in April 2021

WOODSIDE POLICY

Woodside

Risk Management Policy

OBJECTIVES

Woodside recognises that risk is inherent in our business and the effective management of risk is vital to deliver our strategic objectives, continued growth and success. We are committed to managing risks in a proactive and effective manner as a source of competitive advantage.

Our approach protects us against potential negative impacts, enables us to take risk for reward and improves our resilience against emerging risks. The objective of our risk management framework is to provide a single consolidated view of risks across the company to understand our full risk exposure and prioritise risk management and governance.

The success of our approach lies in the responsibility placed on everyone at all levels to proactively identify, assess and treat risks relating to the objectives they are accountable for delivering.

PRINCIPLES

Woodside achieves these objectives by:

- Applying a structured and comprehensive framework for the identification, assessment and treatment of current risks and response to emerging risks;
- Ensuring line of sight of financial and non-financial risks at appropriate levels of the organisation;
- Demonstrating leadership and commitment to integrating risk management into our business activities and governance practices;
- Recognising the value of stakeholder engagement, best available information and proactive identification of potential changes in external and internal context;
- Embedding risk management into our critical business processes and control framework;
- Understanding our exposure to risk and tolerance for uncertainty to inform our decision making and assure that Woodside is operating with due regard to the risk appetite endorsed by the Board; and
- Evaluating and improving the effectiveness and efficiency our approach.

APPLICATION

The Managing Director of Woodside is accountable to the Board of Directors for ensuring this policy is effectively implemented.

Managers are responsible for promoting and applying the Risk Management Policy. Responsibility for the effective application of this policy rests with all Woodside employees, contractors and joint venturers engaged in activities under Woodside operational control.

This policy will be reviewed regularly and updated as required.

Revised by the Woodside Petroleum Ltd Board on 4 December 2020.

APPENDIX B RELEVANT REQUIREMENTS

This appendix refers to Commonwealth Legislation related to the project.

Commonwealth Legislation	Legislation Summary
Air Navigation Act 1920 • *Air Navigation Regulations 1947* • *Air Navigation (Aerodrome Flight* • *Corridors) Regulations 1994* • *Air Navigation (Aircraft Engine* • *Emissions) Regulations 1995* • *Air Navigation (Aircraft Noise)* • *Regulations 1984* • *Air Navigation (Fuel Spillage) Regulations 1999*	This Act relates to the management of air navigation.
Australian Maritime Safety Authority Act 1990	This Act establishes a legal framework for the Australian Maritime Safety Authority (AMSA), which represents the Australian Government and international forums in the development, implementation and enforcement of international standards including those governing ship safety and marine environment protection. AMSA is responsible for administering the Marine Orders in Commonwealth waters.
Australian Radiation Protection and Nuclear Safety Act 1998	This Act relates to the protection of the health and safety of people, and the protection of the environment from the harmful effects of radiation.
Biosecurity Act 2015 • *Quarantine Regulations 2000* • *Biosecurity Regulation 2016* • *Australian Ballast Water Management Requirements 2017*	This Act provides the Commonwealth with powers to take measures of quarantine, and implement related programs as are necessary, to prevent the introduction of any plant, animal, organism or matter that could contain anything that could threaten Australia's native flora and fauna or natural environment. The Commonwealth's powers include powers of entry, seizure, detention and disposal. This Act includes mandatory controls on the use of seawater as ballast in ships and the declaration of sea vessels voyaging out of and into Commonwealth waters. The Regulations stipulate that all information regarding the voyage of the vessel and the ballast water is declared correctly to the quarantine officers.
Environment Protection and Biodiversity Conservation Act 1999 • *Environment Protection and Biodiversity Conservation Regulations 2000*	This Act protects matters of national environmental significance (NES). It streamlines the national environmental assessment and approvals process, protects Australian biodiversity and integrates management of important natural and culturally significant places. Under this Act, actions that may be likely to have a significant impact on matters of NES must be referred to the Commonwealth Environment Minister.
Environment Protection (Sea Dumping) Act 1981 • *Environment Protection (Sea Dumping) Regulations 1983*	This Act provides for the protection of the environment by regulating dumping matter into the sea, incineration of waste at sea and placement of artificial reefs.
Industrial Chemicals (Notification and Assessment Act) 1989 • *Industrial Chemicals (Notification and Assessment) Regulations 1990*	This Act creates a national register of industrial chemicals. The Act also provides for restrictions on the use of certain chemicals which could have harmful effects on the environment or health.

Commonwealth Legislation	Legislation Summary
National Environment Protection Measures (Implementation) Act 1998 • *National Environment Protection Measures (Implementation) Regulations 1999*	This Act and Regulations provide for the implementation of National Environment Protection Measures (NEPMs) to protect, restore and enhance the quality of the environment in Australia and ensure that the community has access to relevant and meaningful information about pollution. The National Environment Protection Council has made NEPMs relating to ambient air quality, the movement of controlled waste between states and territories, the national pollutant inventory, and used packaging materials.
National Greenhouse and Energy Reporting Act 2007 • *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015*	This Act and associated Rule establishes the legislative framework for the NGER scheme for reporting greenhouse gas emissions and energy consumption and production by corporations in Australia.
Navigation Act 2012 • *Marine order 12 – Construction – subdivision and stability, machinery and electrical installations* • *Marine order 30 - Prevention of collisions* • *Marine order 47 - Mobile offshore drilling units* • *Marine order 57 - Helicopter operations* • *Marine order 60 - Floating offshore facilities* • *Marine order 91 - Marine pollution prevention—oil* • *Marine order 93 - Marine pollution prevention—noxious liquid substances* • *Marine order 94 - Marine pollution prevention—packaged harmful substances* • *Marine order 96 - Marine pollution prevention—sewage* • *Marine order 97 - Marine pollution prevention—air pollution*	This Act regulates navigation and shipping including Safety of Life at Sea (SOLAS). The Act will apply to some activities of the MODU and project vessels. This Act is the primary legislation that regulates ship and seafarer safety, shipboard aspects of marine environment protection and pollution prevention.
Offshore Petroleum and Greenhouse Gas Storage Act 2006 • *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* • *Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011* • *Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009*	This Act is the principal Act governing offshore petroleum exploration and production in Commonwealth waters. Specific environmental, resource management and safety obligations are set out in the Regulations listed.
Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 • *Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995*	This Act provides for measures to protect ozone in the atmosphere by controlling and ultimately reducing the manufacture, import and export of ozone depleting substances (ODS) and synthetic greenhouse gases, and replacing them with suitable alternatives. The Act will only apply to Woodside if it manufactures, imports or exports ozone depleting substances.

Commonwealth Legislation	Legislation Summary
Protection of the Sea (Powers of Intervention) Act 1981	This Act authorises the Commonwealth to take measures for the purpose of protecting the sea from pollution by oil and other noxious substances discharged from ships and provides legal immunity for persons acting under an AMSA direction.
Protection of the Sea (Prevention of Pollution from Ships) Act 1983 *Protection of the Sea (Prevention of Pollution from Ships) (Orders) Regulations 1994* • *Marine order 91 - Marine pollution prevention—oil* • *Marine order 93 - Marine pollution prevention—noxious liquid substances* • *Marine order 94 - Marine pollution prevention—packaged harmful substances* • *Marine order 95 - Marine pollution prevention—garbage* • *Marine order 96 - Marine pollution prevention—sewage* *Maritime Legislation Amendment (Prevention of Air Pollution from Ships) Act 2007* MARPOL Convention	This Act relates to the protection of the sea from pollution by oil and other harmful substances discharged from ships. Under this Act, discharge of oil or other harmful substances from ships into the sea is an offence. There is also a requirement to keep records of the ships dealing with such substances. The Act applies to all Australian ships, regardless of their location. It applies to foreign ships operating between 3 nautical miles (nm) off the coast out to the end of the Australian Exclusive Economic Zone (200 nm). It also applies within the 3 nm of the coast where the State/Northern Territory does not have complementary legislation. All the Marine Orders listed, except for Marine Order 95, are enacted under both the *Navigation Act 2012* and the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*. This Act is an amendment to the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*. This amended Act provides the protection of the sea from pollution by oil and other harmful substances discharged from ships.
Protection of the Sea (Harmful Antifouling Systems) Act 2006 • *Marine order 98—(Marine pollution prevention—anti-fouling systems)*	This Act relates to the protection of the sea from the effects of harmful anti-fouling systems. It prohibits the application or reapplication of harmful anti-fouling compounds on Australian ships or foreign ships that are in an Australian shipping facility.

APPENDIX C EPBC ACT PROTECTED MATTERS SEARCH REPORTS

Australian Government

Department of Agriculture, Water and the Environment

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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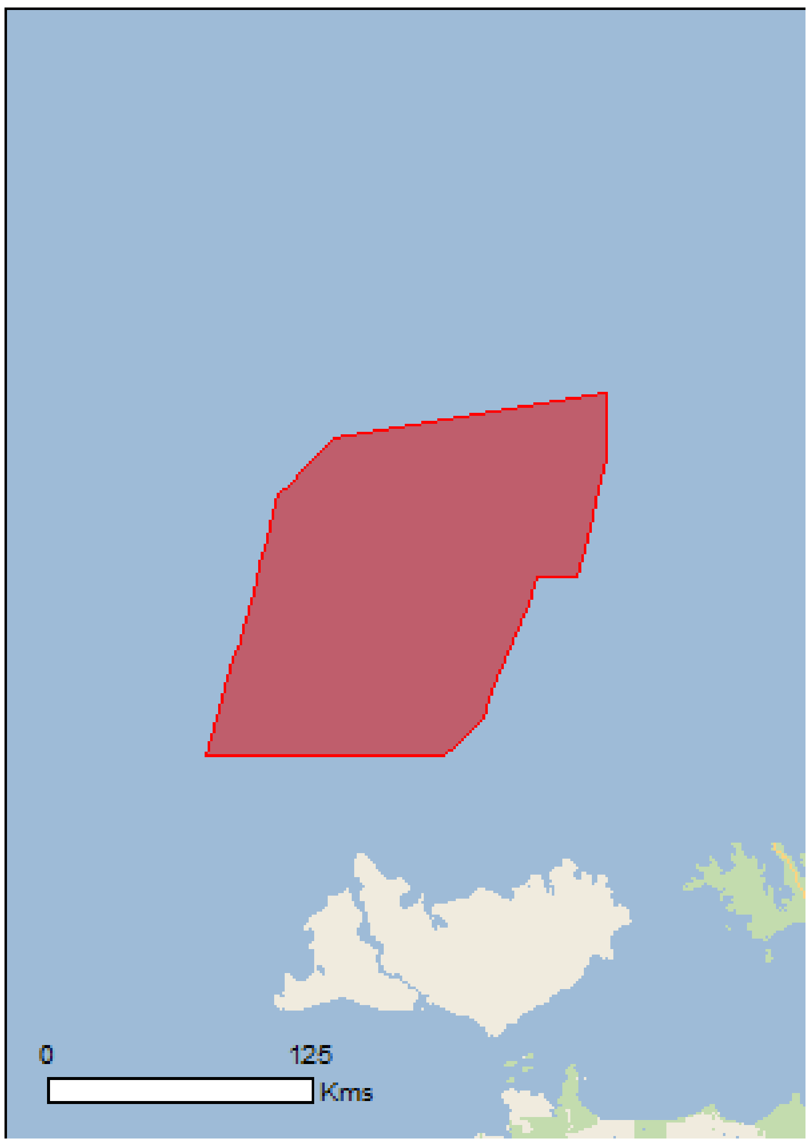

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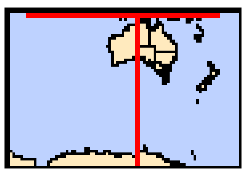

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	20
Listed Migratory Species:	36

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	66
Whales and Other Cetaceans:	23
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	1

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	None
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	2

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea
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

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Sharks		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Glyphis garricki Northern River Shark, New Guinea River Shark [82454]	Endangered	Species or species habitat may occur within area
Glyphis glyphis Speartooth Shark [82453]	Critically Endangered	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat may occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Migratory Marine Species		

Name	Threatened	Type of Presence
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat may occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Carcharhinus longimanus Oceanic Whitetip Shark [84108]		Species or species habitat may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat likely to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area

Name	Threatened	Type of Presence
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat may occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Fish		
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis coggeri Slender-necked Seasnake [25925]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis inornatus Plain Seasnake [1107]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Hydrophis pacificus Large-headed Seasnake, Pacific Seasnake [1112]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Parahydrophis mertoni Northern Mangrove Seasnake [1090]		Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans

[Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area

Name	Status	Type of Presence
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Delphinus delphis Common Dolphin, 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
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat may occur within area

Name	Status	Type of Presence
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat may occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
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
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
Carbonate bank and terrace system of the Van	North
Shelf break and slope of the Arafura Shelf	North

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

-9.5081 130.1951,-9.5612 130.1424,-9.6142 130.0897,-9.6672 130.0371,-9.7397 130.0185,-9.8122 130.0,-9.8846 129.9815,-9.9571 129.963,-10.0296 129.9444,-10.111 129.9207,-10.1924 129.897,-10.2738 129.8733,-10.3552 129.8496,-10.4366 129.8258,-10.5179 129.8021,-10.5993 129.7784,-10.6807 129.7547,-10.7621 129.7309,-10.7622 129.8154,-10.7622 129.8998,-10.7622 129.9843,-10.7623 130.0687,-10.7623 130.1531,-10.7624 130.2376,-10.7624 130.322,-10.7625 130.4064,-10.7625 130.4909,-10.7626 130.5753,-10.7626 130.6598,-10.7627 130.7442,-10.7083 130.7986,-10.6538 130.853,-10.5994 130.9073,-10.5189 130.9395,-10.4384 130.9717,-10.3579 131.0038,-10.2774 131.036,-10.1969 131.0681,-10.1163 131.1003,-10.0129 131.1402,-10.0126 131.2404,-10.0126 131.3105,-9.9306 131.331,-9.8486 131.3514,-9.7666 131.3719,-9.6846 131.3924,-9.6026 131.4128,-9.5206 131.4333,-9.4433 131.4332,-9.366 131.4332,-9.2886 131.4332,-9.2319 131.4331,-9.4246 130.278,-9.4551 130.2477,-9.5081 130.1951

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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EPBC Act Protected Matters Report

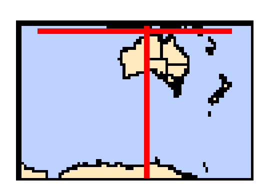
This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

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: 10/05/21 10:22:27

Coordinates
Buffer: 0.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	24
Listed Migratory Species:	46

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:	79
Whales and Other Cetaceans:	26
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	5

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)	5

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea
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
North-west

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus		
Red Goshawk [942]	Vulnerable	Species or species habitat may occur within area
Limosa lapponica baueri		
Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	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
Rostratula australis		
Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat likely to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding 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
Glyphis glyphis Speartooth Shark [82453]	Critically Endangered	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Carcharhinus longimanus Oceanic Whitetip Shark [84108]		Species or species habitat may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species

Name	Threatened	Type of Presence
		habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding 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	Breeding known to occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Cecropis daurica Red-rumped Swallow [80610]		Species or species habitat may occur within area
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]		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
Limosa lapponica Bar-tailed Godwit [844]		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 known to occur within area
Thalasseus bergii Greater Crested Tern [83000]		Breeding likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely 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

Name	Threatened	Type of Presence
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
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
Limosa lapponica Bar-tailed Godwit [844]		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 known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Sterna bergii Crested Tern [816]		Breeding likely 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 area
Corythoichthys haematopterus Reef-top Pipefish [66201]		Species or species habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
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
Festucalex cinctus Girdled Pipefish [66214]		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 cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys parvicarinatus Short-keel Pipefish, Short-keeled Pipefish [66230]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat likely to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding 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 inornatus Plain Seasnake [1107]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Hydrophis pacificus Large-headed Seasnake, Pacific Seasnake [1112]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Parahydrophis mertoni Northern Mangrove Seasnake [1090]		Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		

Name	Status	Type of Presence
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
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
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 known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat known to occur within area

Name	Status	Type of Presence
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Australian Marine Parks [Resource Information]

Name	Label
Arafura	Multiple Use Zone (IUCN VI)
Oceanic Shoals	Habitat Protection Zone (IUCN IV)
Oceanic Shoals	Multiple Use Zone (IUCN VI)
Oceanic Shoals	National Park Zone (IUCN II)
Oceanic Shoals	Special Purpose Zone (Trawl) (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
Carbonate bank and terrace system of the Van	North
Pinnacles of the Bonaparte Basin	North
Shelf break and slope of the Arafura Shelf	North
Carbonate bank and terrace system of the Sahul	North-west
Pinnacles of the Bonaparte Basin	North-west

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-8.3911 130.7395,-8.2018 130.8318,-8.1856 130.5832,-8.0628 130.1062,-8.2233 129.9767,-8.2176 129.3347,-8.0574 129.0971,-8.2867 129.0282,-8.4852 128.3702,-8.4781 127.7645,-8.9623 126.9583,-9.2747 126.7866,-9.4772 126.368,-9.802 126.0037,-10.1493 125.919,-10.3838 125.8982,-10.6773 126.5082,-10.9236 126.8364,-11.2422 127.0771,-12.1997 127.9735,-12.61 128.1538,-12.6975 128.2675,-12.7762 129.2136,-12.6145 129.5423,-12.3247 129.8905,-11.88 130.08,-11.8115 129.9698,-11.3092 130.1624,-11.1019 130.4375,-11.101 130.7293,-11.0277 131.4749,-10.6353 132.5372,-10.3143 132.82,-9.9641 132.7992,-9.508 132.5442,-8.9013 132.3436,-8.3663 131.9839,-7.9205 131.4228,-8.3911 130.7395

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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APPENDIX D OIL SPILL PREPAREDNESS AND RESPONSE MITIGATION ASSESSMENT

Oil Spill Preparedness and Response Mitigation Assessment for Galactic Hybrid Marine Seismic Survey

Security and Emergency Management
Hydrocarbon Spill Preparedness

September 2021
Revision 0

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EXECUTIVE SUMMARY

Woodside Energy Ltd (Woodside) has developed its oil spill preparedness and response position for the Galactic Hybrid Marine Seismic Survey, hereafter known as 'the activity'.

This document demonstrates that the risks and impacts from an unplanned hydrocarbon release, and the associated response operations, are controlled to As Low as Reasonably Practicable (ALARP) and Acceptable levels. It achieves this by evaluating response options to address the potential environmental impacts resulting from an unplanned loss of hydrocarbon containment associated with the activity described in the Environment Plan (EP). This document then outlines Woodside's decisions and techniques for responding to a hydrocarbon release event and the process for determining its level of hydrocarbon spill preparedness.

A summary of the key facts and references to additional detail within this document are presented in Table 0-1.

Table 0-1: Summary of the key details for assessment

<table>
<tr><th>Key details of assessment</th><th colspan="3">Summary</th><th>Reference to additional detail</th></tr>
<tr><td>Credible Scenario-01</td><td colspan="3">Credible Scenario 1 (CS-01): Hydrocarbon release at surface caused by vessel collision
A short-term (instantaneous) uncontrolled surface release of 650 m³ of Marine Diesel due to a vessel collision at release Site 1 (10° 45' 57.58'' S, 130° 44' 33.63'' E). 5% residual component of 32.5 m³</td><td>Section 2.2</td></tr>
<tr><td>Credible Scenario-02</td><td colspan="3">Credible Scenario 2 (CS-02): Hydrocarbon release at surface caused by vessel collision
A short-term (instantaneous) uncontrolled surface release of 650 m³ of Marine Diesel due to a vessel collision at release Site 2 (10° 2' 7.83'' S, 130° 49' 28.79'' E). 5% residual component of 32.5 m³</td><td>Section 2.2</td></tr>
<tr><td>Hydrocarbon Properties</td><td colspan="3">Marine Diesel (API 37.2)
In general, about 6% of the oil mass should evaporate within the first 12 hours (BP < 180 °C); 35% should evaporate within the first 24 hours (180 °C < BP < 265 °C); and 54% should evaporate over several days (265 °C < BP < 380 °C). Approximately 5% of the oil is shown to be persistent. Under calm conditions the majority of the remaining oil on the water surface will weather at a slower rate due to being comprised of the longer-chain compounds with higher boiling points. Evaporation of the residual compounds will slow significantly, and they will then be subject to more gradual decay through biological and photochemical processes.</td><td>Section 6.5 of the EP
Appendix A of the First Strike Plan (Link)</td></tr>
<tr><td rowspan="4">Modelling Results</td><td colspan="3">A quantitative, stochastic assessment has been undertaken for credible spill scenarios to help assess the environmental risk of a hydrocarbon spill.
Multiple replicate simulations were completed for CS-01 and CS-02 to account for trends and variations in the trajectory and weathering of spilled oil, with an even number of replicates completed using samples of metocean data that commenced within each calendar quarter. For each scenario a total of 200 replicate simulations were run over an annual period (50 per quarter).</td><td rowspan="4">Section 2.3</td></tr>
<tr><td></td><td>CS-01</td><td>CS-02</td></tr>
<tr><td>Minimum time to shoreline impact (above 100 g/m²)</td><td>No contact</td><td>No contact</td></tr>
<tr><td>Largest volume ashore at any single Response Priority Area (RPA) (above 100 g/m²)</td><td>No contact</td><td>No contact</td></tr>
</table>

	Largest total shoreline accumulation (above 100 g/m²) all shorelines	No contact	No contact	
Net Environmental Benefit Analysis	Monitor and evaluate, vessel source control if feasible and oiled wildlife response (if required) are all identified as potentially having a net environmental benefit (dependent on the actual spill scenario) and are carried forward for further assessment.			Section 4
ALARP Evaluation of Selected Response Techniques	The evaluation of the selected response techniques shows the proposed controls reduced the risk to an ALARP and Acceptable level for the risks presented in Sections 2 and 3, without the implementation of considered additional, alternative or improved control measures.			Section 6

1 INTRODUCTION

1.1 Overview

Woodside Energy Ltd (Woodside) has developed its oil spill preparedness and response position for the Galactic Hybrid Marine Seismic Survey, hereafter known as 'the activity'. This document outlines Woodside's decisions and techniques for responding to a hydrocarbon loss of containment event and the process for determining its level of hydrocarbon spill preparedness.

1.2 Purpose

This document, together with the documents listed below, meet the requirements of the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Environment Regulations) relating to hydrocarbon spill response arrangements.

- Galactic Hybrid Marine Seismic Survey Environment Plan (EP)
- Oil Pollution Emergency Arrangements (OPEA) (Australia)
- Galactic Hybrid Marine Seismic Survey Oil Pollution Emergency Plan (OPEP) including:
  - First Strike Plan (FSP)
  - relevant Operational Plans
  - relevant Tactical Response Plans (TRPs)
  - relevant Supporting Plans
  - Data Directory.

The purpose of this document is to demonstrate that the risks and impacts from an unplanned hydrocarbon release and the associated response operations are controlled to As Low as Reasonably Practicable (ALARP) and Acceptable levels.

1.3 Scope

This document demonstrates that the risks and impacts from an unplanned hydrocarbon release, and the associated response operations, are controlled to As Low as Reasonably Practicable (ALARP) and Acceptable levels. It achieves this by evaluating response options to address the potential environmental risks and impacts resulting from an unplanned loss of hydrocarbon containment associated with the activity described in the EP. This document then outlines Woodside's decisions and techniques for responding to a hydrocarbon release event and the process for determining its level of hydrocarbon spill preparedness. It should be read in conjunction with the documents listed in Table 1-1. The location of the activity is shown in Figure 3-1 of the EP.

1.4 Oil spill response document overview

The documents outlined in Table 1-1 and Figure 1-1 are collectively used to manage the preparedness and response for a hydrocarbon release.

The Oil Pollution First Strike Plan (FSP) (Link) contains a pre-operational Net Environmental Benefit Analysis (NEBA) summary, outlining the selected response techniques for this activity. Relevant Operational Plans to be initiated for associated response techniques are identified in the FSP and relevant forms to initiate a response are appended to the FSP.

The process to develop an Incident Action Plan (IAP) begins once the Oil Pollution FSP is underway. The IAP includes inputs from the Monitor and Evaluate (ME) operations and the pre-operational NEBA (Section 4). Planning, coordination and resource management are initiated by the Incident Management Team (IMT). In some instances, technical specialists may be utilised to provide expert advice. The planning may also involve liaison officers from supporting government agencies.

During each operational period, field reports are continually reviewed to evaluate the effectiveness of response operations. In addition, the operational NEBA is continually reviewed and updated to ensure the response techniques implemented continue to result in a net environmental benefit (Section 4).

The response will continue as described in Section 5 until the response termination criteria have been met.

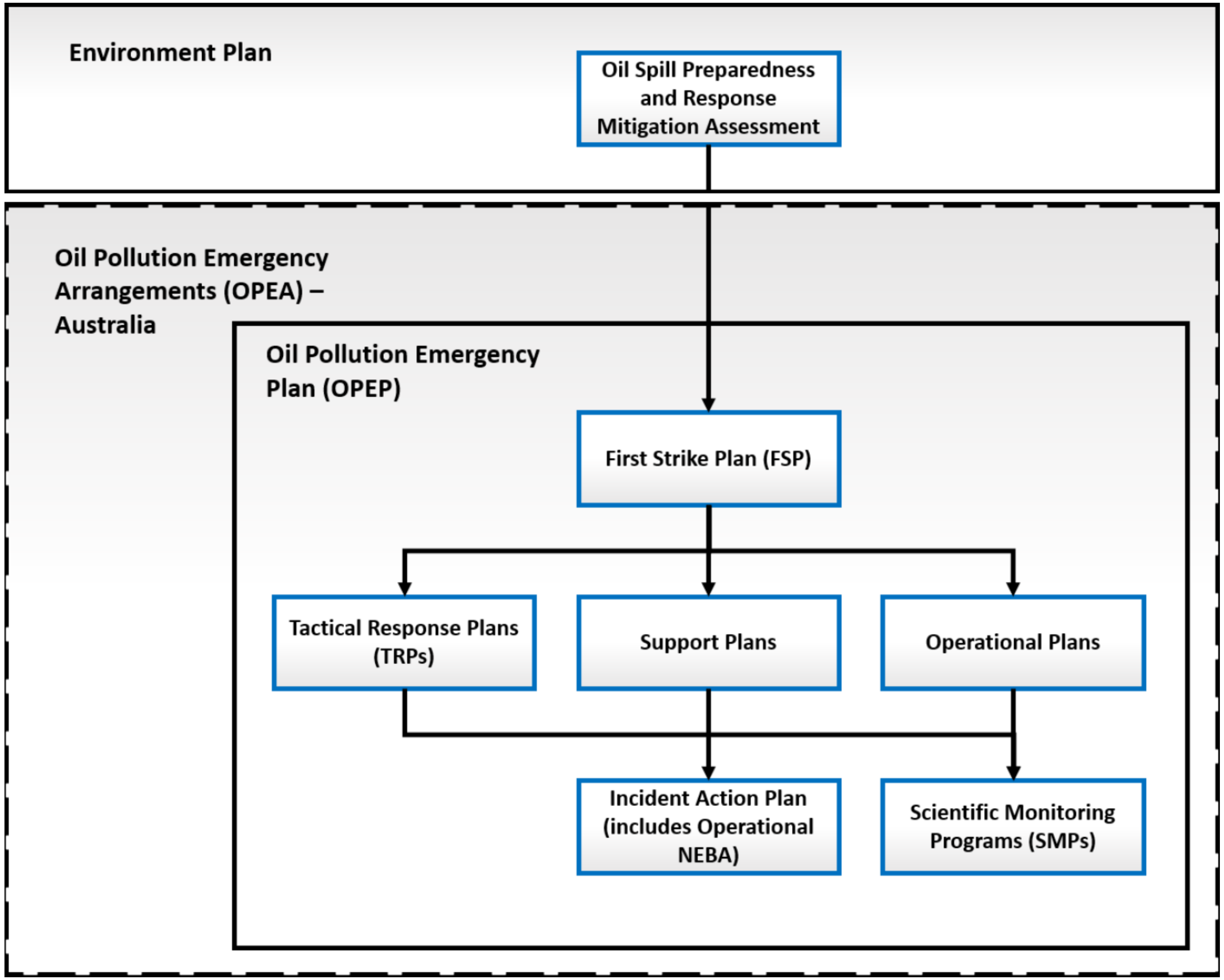


Figure 1-1: Woodside hydrocarbon spill document structure

Table 1-1: Hydrocarbon spill preparedness and response – document references

Document	Document overview	Stakeholders	Relevant information	Document subsections (if applicable)
Galactic Hybrid Marine Seismic Survey Environment Plan (EP)	Demonstrates that potential adverse impacts on the environment associated with the Galactic Hybrid Marine Seismic Survey (during both routine and non-routine operations) are mitigated and managed to As Low As Reasonably Practicable (ALARP) and will be of an acceptable level.	NOPSEMA Woodside internal	EP Section 6 (Identification and evaluation of environmental risks and impacts, including credible spill scenarios) EP Section 6 (Performance outcomes, standards and measurement criteria) EP Section 7 (Implementation strategy – including emergency preparedness and response) EP Section 7 (Reporting and compliance)	
Oil Pollution Emergency Arrangements (OPEA) Australia	Describes the arrangements and processes adopted by Woodside when responding to a hydrocarbon spill from a petroleum activity.	Regulatory agencies Woodside internal	All	
Oil Spill Preparedness and Response Mitigation Assessment for the Galactic Hybrid Marine Seismic Survey (this document)	Evaluates response options to address the potential environmental impacts resulting from an unplanned loss of hydrocarbon containment associated with the activity described in the EP.	Regulatory agencies Corporate Incident Control Centre (CICC): Control function in an ongoing spill response for activity-specific response information.	All performance outcomes, standards and measurement criteria related to hydrocarbon spill preparedness and response are included in this document.	

Document	Document overview	Stakeholders	Relevant information	Document subsections (if applicable)
Galactic Hybrid Marine Seismic Survey Oil Pollution First Strike Plan (FSP)	Facility specific document providing details and tasks required to mobilise a first strike response. Primarily applied to the first 24 hours of a response until a full Incident Action Plan (IAP) specific to the event is developed. Oil Pollution First Strike Plans are intended to be the first document used to provide immediate guidance to the responding Incident Management Team (IMT).	Site-based IMT for initial response, activation and notification. CICC for initial response, activation and notification. CICC: Control function in an ongoing spill response for activity-specific response information.	Initial notifications and reporting required within the first 24 hours of a spill event. Relevant spill response options that could be initiated for mobilisation in the event of a spill. Recommended pre-planned tactics. Details and forms for use in immediate response. Activation process for oil spill trajectory modelling, aerial surveillance and oil spill tracking buoy details.	
Operational Plans	List the actions required to activate, mobilise and deploy personnel and resources to commence response operations. Includes details on access to equipment and personnel (available immediately) and steps to mobilise additional resources depending on the nature and scale of a release. Relevant operational plans will be initially selected based on the Oil Pollution First Strike Plan; additional operational plans will be activated depending on the nature and scale of the release.	CICC: Operations and Logistics functions for first strike activities. CICC: Planning Function to help inform the IAP on resources available.	Locations from where resources may be mobilised. How resources will be mobilised. Details of where resources may be mobilised to and what facilities are required once the resources arrive. Details on how to implement resources to undertake a response.	Operational Monitoring Vessel Shipboard Oil Pollution Emergency Plan (SOPEP) Oiled Wildlife Response Scientific Monitoring

Document	Document overview	Stakeholders	Relevant information	Document subsections (if applicable)
Tactical Response Plans	Provides options for response techniques in selected RPAs. Provides site, access and deployment information to support a response at the location.	CICC: Planning Function to help develop IAPs, and Logistics Function to assist with determining resources required.	Indicative response techniques. Access requirements and/or permissions. Relevant information for undertaking a response at that site. Where applicable, may include equipment deployment locations and site layouts.	Modelling predicts no shoreline impact at response thresholds (100 g/m^2). During a spill event, if operational monitoring predicts shoreline impact at threshold, Tactical Response Plans would be drafted for relevant site based upon the Northern Territory (NT) Operational Sector maps included in ANNEX E: Operational Sector Maps.
Support Plans	Support Plans detail Woodside's approach to resourcing and the provision of services during a hydrocarbon spill response.	CICC: Operations, Logistics and Planning functions.	Strategy for mobilising and managing additional resources outside of Woodside's immediate preparedness arrangements.	Marine Logistics People and Global Capability Surge Labour Requirement Plan Health and Safety Aviation IT (First Strike Response) IT (Extended Response) Communications (First Strike Response) Communications (Extended Response) Stakeholder Engagement Accommodation and Catering Waste Management Guidance for Oil Spill Claims Management (Land based) Security Support Plan Hydrocarbon Spill Responder Health Monitoring Guideline

2 RESPONSE PLANNING PROCESS

This document details Woodside's process for identifying potential response options for the hydrocarbon release scenarios, identified in the EP. Figure 2-1 outlines the interaction between Woodside's response, planning/preparedness and selection process.

This structure has been used because it shows how the planning and preparedness activities inform a response and provides indicative guidance on what activities would be undertaken, in sequential order, if a real event were to occur. The process also evaluates alternative, additional and/or improved control measures specific to the activity.

The Galactic Hybrid Marine Seismic Survey First Strike Plan then summarises the outcome of the response planning process and provides initial response guidance and a summary of ongoing response activities, if an incident were to occur.

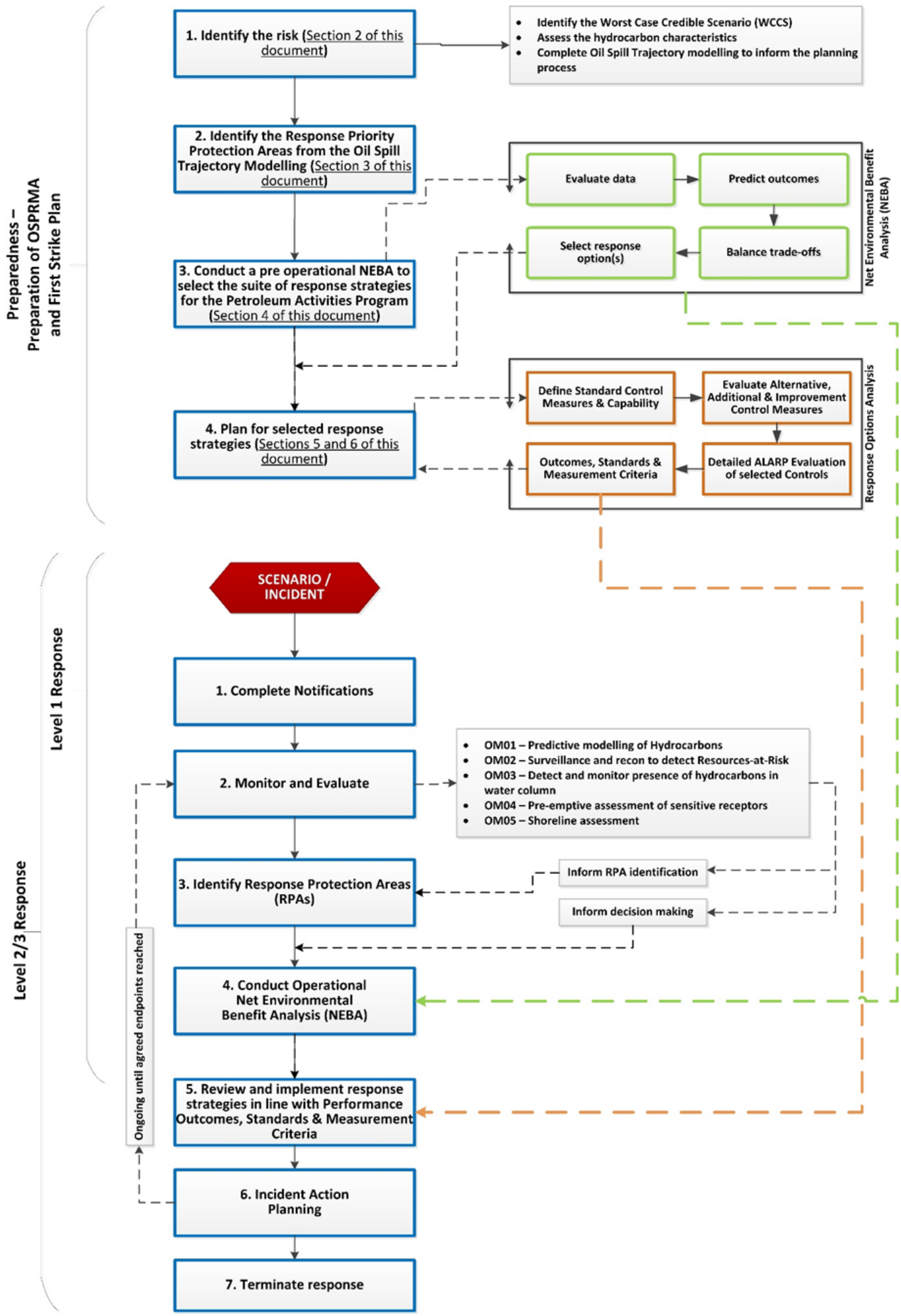


Figure 2-1: Response planning and selection process

2.1 Response planning process outline

This document is expanded below to provide additional context on the key steps in determining capability, evaluating ALARP and hydrocarbon spill response requirements.

Section 1. INTRODUCTION

Section 2. RESPONSE PLANNING PROCESS

- identification of worst-case credible scenario(s) (WCCS)
- spill modelling for WCCS.

Section 3. IDENTIFY RESPONSE PROTECTION AREAS (RPAs)

- areas predicted to be contacted at concentration >100 g/m².

Section 4. NET ENVIRONMENTAL BENEFIT ANALYSIS (NEBA)

- pre-operational NEBA (during planning/ALARP evaluation): this must be reviewed during the initial response to an incident to ensure its accuracy
- selected response techniques prioritised and carried forward for ALARP assessment.

Section 5. HYDROCARBON SPILL ALARP PROCESS

- determines the response need based on predicted consequence parameters
- details the environmental performance of the selected response options based on need
- sets the environmental performance outcomes, environmental performance standards and measurement criteria.

Section 6. ALARP EVALUATION

- evaluates alternative, additional, and improved options for each response technique to demonstrate the risk has been reduced to ALARP
- provides a detailed ALARP assessment of selected control measure options against:
  - predicted cost associated with implementing the option
  - predicted change to environmental benefit
  - predicted effectiveness / feasibility of the control measure.

Section 7. ENVIRONMENTAL RISK ASSESSMENT OF SELECTED RESPONSE TECHNIQUES

- evaluation of impacts and risks from implementing selected response options.

Section 8. ALARP CONCLUSION

Section 9. ACCEPTABILITY CONCLUSION

2.1.1 Response planning assumptions

IMT Call-out/ Notification	Contract Activation	Response Option Mobilisation	Response Option Deployment	Response Option Effectiveness
This is the time taken from call-out to mobilise the IMT to the designated Incident Control Centre	This is the time taken once the IMT has been mobilised to activate specific contracts for resources (SFRT, FWADC, AMOSC, AMSA, OSRL, etc)	This is the time taken to mobilise resources from home location to laydown/staging area (expected to be airport or sea port) close to response area	This is the time taken to deploy resources from laydown/staging area (expected to be airport or sea port) to response area/field	This relates to the performance of equipment/response option as well as required personnel resourcing (Specialists/Supervisors + support personnel)
Approx 2-4 hours	Approx 2-4 hours	Response Technique specific	Field/Location specific	Response Strategy specific

Figure 2-2: Response planning assumption – timing, resourcing and effectiveness

2.2 Environment plan risk assessment (credible spill scenarios)

Potential hydrocarbon release scenarios from the activity have been identified during the risk assessment process (Section 6 of the EP). Further descriptions of risk, impacts and mitigation measures (which are not related to hydrocarbon preparedness and response) are provided in Section 6 of the EP. Two unplanned events or credible spill scenarios for the activity have been selected as representative for the type, source and incident/response level and are considered to be the WCCS for this activity.

Table 2-1 presents the credible scenarios and WCCS for the activity. These credible scenarios are then used for response planning purposes, as any other scenario would be of a lesser scale and extent. By demonstrating capability to manage the response to the WCCS, Woodside assumes other scenarios that are smaller in nature and scale can also be managed by the same capability. Response performance measures have been defined based on a response to the WCCS.

Two vessel collision scenarios (CS-01 and CS-02) have been modelled and are considered to determine the WCCS for response planning purposes given that they are instantaneous, surface releases of Marine Diesel. The location of CS-01 was selected as the closest point to the Tiwi Islands within the operational areas. The location of CS-02 was selected as the closest point to Lynedoch Bank. Modelling of both scenarios predicts that the WCCS will not result in shoreline accumulation at response thresholds. The locations of the two credible scenarios are shown in Figure 2-3.

Table 2-1: Activity credible spill scenarios

Credible Scenario No.	Scenario selected for planning purposes	Scenario description	Maximum credible volume released (liquid m³)[1]	Incident Level	Hydrocarbon (HC) type	Residual proportion	Residual volume (liquid m³)	Key credible scenarios informing response planning
CS-01	Yes	Hydrocarbon release caused by vessel collision – Site 1 (10° 45' 57.58'' S, 130° 44' 33.63'' E)	650 m^3	2	Marine Diesel	5.0%	32.5 m^3	An instantaneous surface release of Marine Diesel at the Galactic Hybrid Marine Seismic Survey location (Site 1) due to a vessel collision
CS-02	Yes	Hydrocarbon release caused by vessel collision – Site 2 (10° 2' 7.83'' S, 130° 49' 28.79'' E)	650 m^3	2	Marine Diesel	5.0%	32.5 m^3	An instantaneous surface release of Marine Diesel at the Galactic Hybrid Marine Seismic Survey location (Site 2) due to a vessel collision

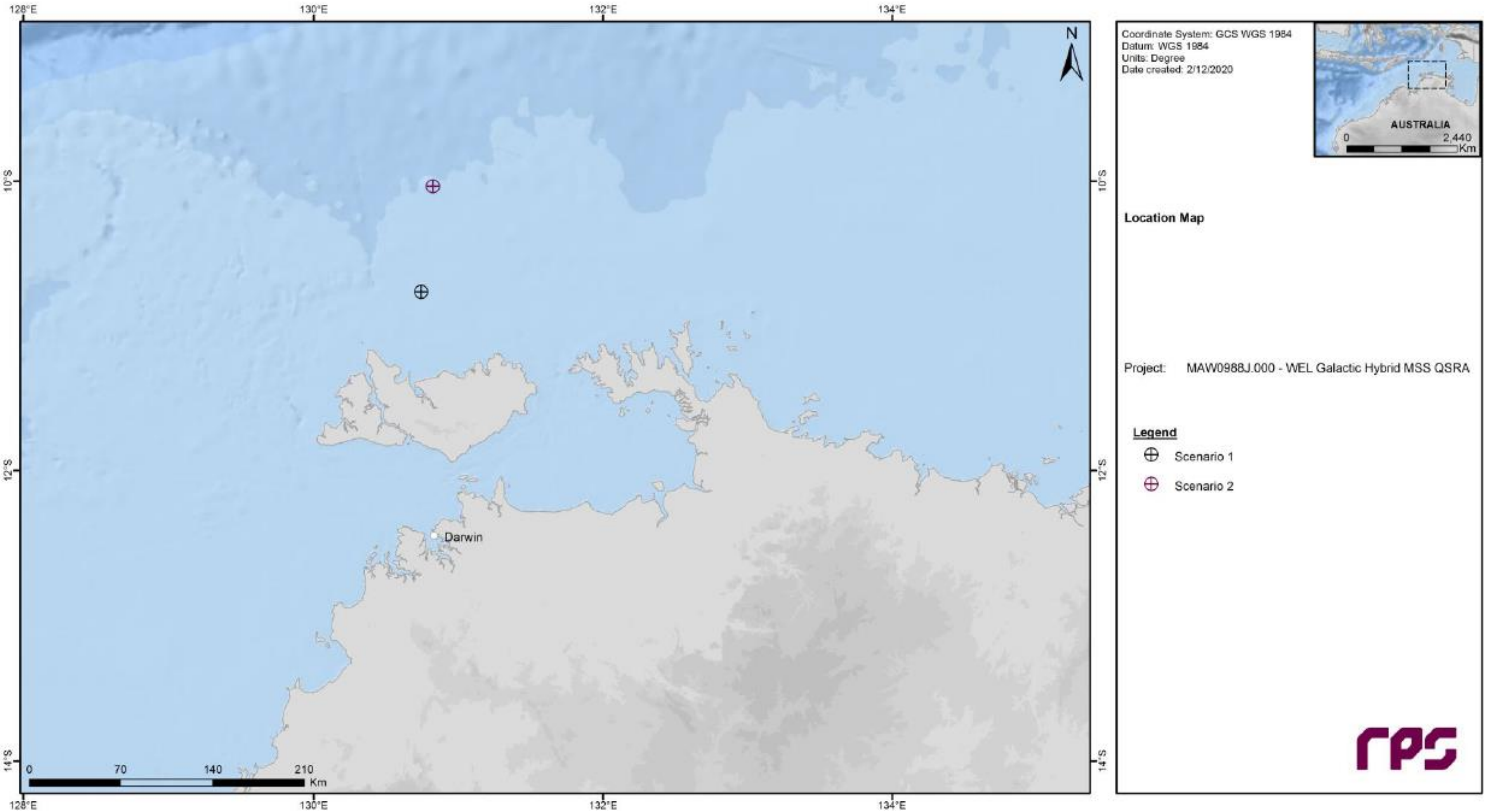


Figure 2-3: Locations of Credible Scenario-01 and Credible Scenario-02

2.2.1 Hydrocarbon characteristics

Hydrocarbon characteristics, including modelled weathering data and ecotoxicity, are included in Section 6.7 of the EP.

Marine diesel

Marine Diesel Oil is typically classed as an International Tanker Owners Federation (ITOPF) Group I/II oil. Group I/II oils are non-persistent and tend to dissipate completely through evaporation within a few hours and do not normally form emulsions.

Marine diesel is a mixture of volatile and persistent hydrocarbons with low proportions of highly volatile and residual components. In general, about 6% of the oil mass should evaporate within the first 12 hours (BP < 180 °C); 35% should evaporate within the first 24 hours (180 °C < BP < 265 °C); and 54% should evaporate over several days (265 °C < BP < 380 °C). Approximately 5% of the oil is shown to be persistent. The aromatic content of the oil is approximately 3%.

If released in the marine environment and in contact with the atmosphere (i.e. a surface spill), at the modelled sea temperature of 27°C and air temperature of 25°C (which are representative of the conditions in this region), it is predicted that approximately 41% by mass of this oil would evaporate over the first couple of days depending upon the prevailing conditions, with further evaporation slowing over time. The heavier (low volatility) components of the oil tend to entrain into the upper water column due to wind-generated waves but can subsequently resurface if wind-waves abate. Therefore, the heavier components of this oil can remain entrained or on the sea surface for an extended period, with associated potential for dissolution of the soluble aromatic fraction.

For both modelled scenarios (CS-01 and CS-02), it is predicted that 32.5 m^3 of Marine Diesel would remain after weathering.

2.3 Hydrocarbon spill modelling

Oil spill trajectory modelling (OSTM) tools are used for environmental impact assessment and during response planning to understand spatial scale and timeframes for response operations. Woodside recognises that there is a degree of uncertainty related to the use of modelling data and has subsequently utilised conservative approaches to volumes, weathering, spatial areas, timing and response effectiveness to scale capability to need.

The Oil Spill Model and Response System (OILMAP) and Integrated Oil Spill Impact Model System (SIMAP) models are both used for stochastic and deterministic trajectory modelling. They have been developed over three decades of planning, exercises, actual responses, several peer reviews, and validation studies. OILMAP was originally derived from the United States Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Type A model (French et al. 1996), for assessing marine transport, biological impact and economic impact that was also used under the United States Oil Pollution Act 1990 Natural Resource Damage Assessment (NRDA) regulations. Notable spills where the model has been used and validated against actual field observations include, Exxon Valdez (French McCay 2004), North Cape Oil Spill (French McCay 2003), along with an assessment of 20 other spills (French McCay and Rowe, 2004). In addition, test spills designed to verify fate, weathering and movement algorithms have been conducted regularly and in a range of climate conditions (French and Rines 1997; French et al. 1997; Payne et al. 2007a and 2007b; French McCay et al. 2007).

Further to this, the algorithms have been updated using the latest findings from the Macondo/Deepwater Horizon well blowout in the Gulf of Mexico and validated according to the Deepwater Horizon (DWH) oil spill in support of the Natural Resource Damage Assessment (NRDA) (Spaulding et al. 2015; French McCay et al. 2015, 2016). Finally, the OILMAP and SIMAP models have been used extensively in Australia to prosecute pollution offences, predict discharge locations and likely spill volumes based on weathering and surveillance observations, and has been used as expert witness evidence in Australian court proceedings, aiding the prosecution to determine spill quantum estimates.

2.3.1 Stochastic modelling

Stochastic modelling has been completed for the scenario outlined in Table 2-1. A quantitative, stochastic assessment has been undertaken for the credible spill scenario to help assess the environmental consequences of a hydrocarbon spill.

Multiple replicate simulations were completed for CS-01 and CS-02 to account for trends and variations in the trajectory and weathering of spilled oil, with an even number of replicates completed using samples of metocean data that commenced within each calendar quarter. For each scenario a total of 200 replicate simulations were run over an annual period (50 per quarter). Further details relating to the assessments for the scenarios can be found in Section 6.7 of the EP.

2.3.1.1 Environmental impact thresholds – EMBA and hydrocarbon exposure

The outputs of the stochastic spill modelling are used to assess the potential environmental impact from the credible scenarios. The stochastic modelling results are used to delineate areas of the marine and shoreline environment that could be exposed to hydrocarbon levels exceeding environmental impact threshold concentrations. The summary of all the locations where hydrocarbon thresholds could be exceeded by any of the simulations modelled is defined as the Environment that May Be Affected (EMBA) and is discussed further in Section 4 of the EP. As the weathering of different fates of hydrocarbons (surface, entrained and dissolved) differs due to the influence of the metocean mechanism of transportation, a different EMBA is presented for each fate within the EP.

A conservative approach – adopting accepted contact thresholds for impacts on the marine environment – is used to define the EMBA. These hydrocarbon thresholds are presented in Table 2-2 and described in Section 6.7 of the EP.

Table 2-2: Summary of thresholds applied to the stochastic hydrocarbon spill modelling to determine the EMBA and environmental impacts

Threshold (Marine Diesel)	Description
10 g/m²	Surface hydrocarbon
100 ppb	Entrained hydrocarbon (ppb)
50 ppb	Dissolved aromatic hydrocarbon (ppb)
100 g/m²	Shoreline accumulation

2.3.2 Deterministic modelling

Deterministic modelling is undertaken where initial stochastic modelling has indicated that floating oil is present at an impact threshold of 50 g/m^2 and/or where there is shoreline accumulations at an impact threshold of 100 g/m^2. The deterministic modelling outputs are then used to scale the required capability for the offshore (containment and recovery and dispersant) and/or shoreline responses.

Whilst the stochastic modelling indicates that there is some floating oil at 50 g/m^2 for both CS-01 (up to 37 km from the release location) and CS-02 (up to 44 km from the release location), the use of containment and recovery and surface dispersant are not deemed appropriate for spills of Marine Diesel. Deterministic modelling was therefore not undertaken for either CS-01 or CS-02 and stochastic modelling has been used to scale the response.

2.3.3 Response planning thresholds for surface and shoreline hydrocarbon exposure

Thresholds to determine the EMBA are used to predict and assess environmental impacts and inform the scientific monitoring plan (SMP); however, they do not appropriately represent the thresholds at which an effective response can be implemented. Additional response thresholds are used for response planning and to determine areas where response techniques would be most effective.

In the event of an actual response, modelling would be reviewed for suitability and additional modelling would be conducted using real-time data and field information to inform Incident Management Team decisions.

The modelling outputs are presented at response planning thresholds for surface hydrocarbons for the WCCS. Surface spill concentrations are expressed as grams per square metre (g/m²). The thresholds used are derived from oil spill response planning literature and industry guidance and are summarised in the next subsections.

2.3.3.1 Surface hydrocarbon concentrations

Table 2-3: Surface hydrocarbon thresholds for response planning

Surface hydrocarbon concentration (g/m²)	Description	Bonn Agreement Oil Appearance Code (BAOAC)	Mass per area (g/m²)
>10	Predicted minimum threshold for commencing operational monitoring [1]	Code 3 – Dull metallic colours	5 to 50
50	Predicted minimum floating oil threshold for containment and recovery and surface dispersant application [2]	Code 4 – Discontinuous true oil colour	50 to 200
100	Predicted optimum floating oil threshold for containment and recovery and surface dispersant application	Code 5 – Continuous true oil colour	>200
Shoreline hydrocarbon concentration (g/m²)	**Description**	**National Plan Guidance on Oil Contaminated Foreshores**	**Mass per area (g/m²)**
100	Predicted minimum shoreline accumulation threshold for shoreline assessment operations	Stain	>100
250	Predicted minimum threshold for commencing shoreline clean-up operations	Level 3 - Thin Coating	200 to 1000

The surface thickness of oil at which dispersants are typically effective is approximately 100 g/m². However, substantial variations occur in the thickness of the oil within the slick, and most fresh crude oils spread within a few hours, so that overall the average thickness is 0.1 mm (or approximately 100 g/m²) (International Tanker Owners Pollution Federation [ITOPF], 2011). Additionally, the recommended rate of application for surface dispersant is typically one-part dispersant to 20 or 25 parts of spilled oil. These figures assume a 0.1 mm slick thickness, averaged over the thickest part of the spill, to calculate a litres/hectare application rate from vessels and aircraft. In practice, this can be difficult to achieve as it is not possible to accurately assess the thickness of the floating oil.

Stochastic modelling confirmed that the majority (95%) of hydrocarbons released into the marine environment in the WCCS (CS-01 and CS-02) would evaporate within the first few days. The highly volatile nature of Marine Diesel means that the WCCS would not result in hydrocarbon accumulation at a surface thickness at which dispersants would be effective.

Some degree of localised over-dosage and under-dosage is inevitable in dispersant response. An average oil layer thickness of 0.1 mm is often assumed, although the actual thickness can vary over a wide range (from less than 0.0001 mm to more than 1 mm) over short distances (International Petroleum Industry Environment Conservation Association [IPIECA], 2015a).

Guidance from the Australian Maritime Safety Agency (AMSA, 2015) indicates that spreading of spills of Group II or III products will rapidly decrease slick thickness over the first 24 hours of a spill

[1] Operational monitoring will be undertaken from the outset of a spill whether or not this threshold has been reached. Monitoring is needed throughout the response to assess the nature of the spill, track its location and inform the need for any additional monitoring and/or response techniques. It also informs when the spill has entered Territory Coastal Waters and control of the incident passes to NT Authorities or AMSA.

[2] At 50 g/m², containment and recovery and surface dispersant application operations are not expected to be particularly effective. This threshold represents a conservative approach to planning response capability and containing the spread of surface oil.

resulting in the potential requirement of up to a ten-fold increase in capability on day 2 to achieve the same level of performance.

Further guidance from the European Maritime Safety Authority (EMSA) states that spraying the ‘metallic’ looking area of an oil slick (BAOAC 3, approximately 5 to 50 µm) with dispersant from spraying gear designed to treat an oil layer 0.1 mm (100 µm) thick, will inevitably cause dispersant over-treatment by a factor of 2 to 20 times (EMSA, 2012).

Therefore, dispersant application should be concentrated on the thickest areas of an oil slick and Woodside intends on applying surface dispersants to only BAOAC 4 and 5. Spraying areas of oil designated as BAOAC Code 4 (Discontinuous true oil colour) with dispersant will, on average, deliver approximately the recommended treatment rate of dispersant.

Spraying areas of oil designated as BAOAC Code 5 with dispersant (Continuous true oil colour and more than 0.2 mm thick) will, on average, deliver approximately half the recommended treatment rate of dispersant. Repeated application of these areas of thicker oil, or increased dosage ratios, will be required to achieve the recommended treatment rate of dispersant (EMSA, 2012).

Guidance from the National Oceanic and Atmospheric Administration (NOAA) in the United States is found in the document: Characteristics of Response Techniques: A Guide for Spill Response Planning in Marine Environments 2013 (NOAA, 2013). This guide outlines advice for response planning across all common techniques, including surface dispersant spraying and containment and recovery. It states that oil thickness can vary by orders of magnitude within distinct areas of a slick, thus the actual slick thickness and oil distribution of target areas are crucial for determining response method feasibility. Further to this, ITOPF also states that in terms of oil spill response, sheen can be disregarded as it represents a negligible quantity of oil, cannot be recovered or otherwise dealt with to a significant degree by existing response techniques, and is likely to dissipate readily and naturally (ITOPF, 2014a, 2014b).

Figure 2-4 from AMSA’s Identification of Oil on Water – Aerial Observation and Identification Guide (AMSA, 2014) shows expected percent coverage of surface hydrocarbons as a proportion of total surface area. Wind-rows, heavy oil patches and tar balls, for example, must be considered, as they influence oil encounter rates, chemical dosages and ignition potential. Each method has different thickness thresholds for effective response.

From this information and other relevant sources (Allen and Dale, 1996; EMSA, 2012; Spence, 2018) the surface threshold of 50 g/m² was chosen as an average/equilibrium thickness (50 g/m² as an average is 50% coverage of 0.1 mm Bonn Agreement Code 4 – discontinuous true oil colour, or 25% coverage of 0.2 mm Bonn Agreement Code 5 – continuous true oil colour, which would represent small patches of thick oil or wind-rows).

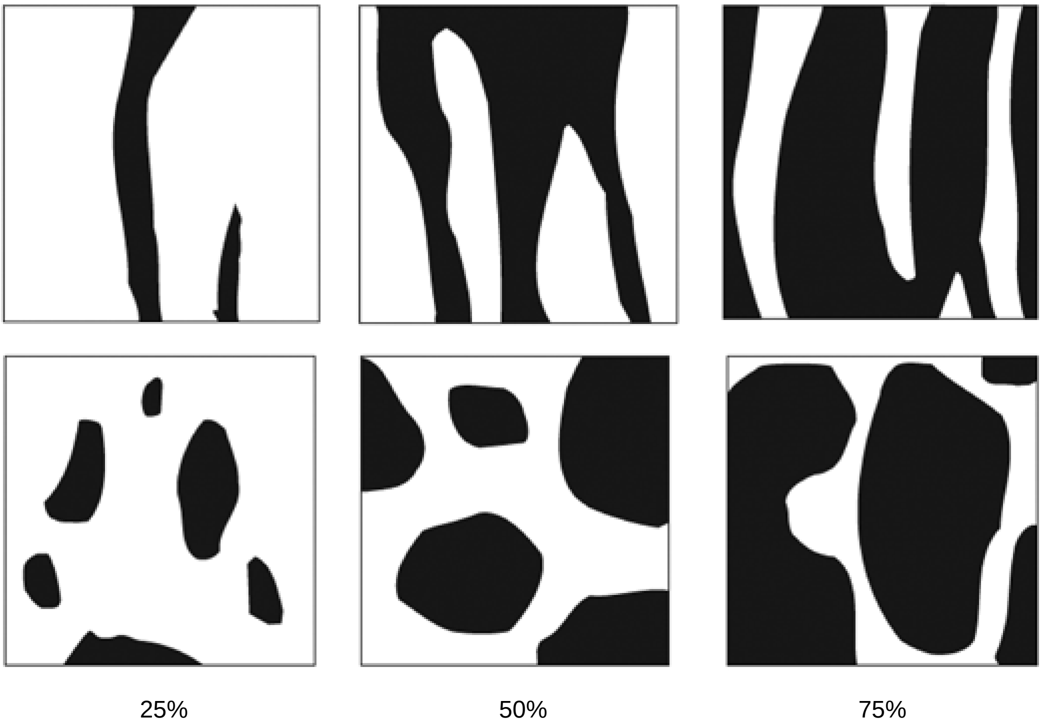


Figure 2-4: Proportion of total area coverage (AMSA, 2014)

Figure 2-5 illustrates the general relationships between on-water response techniques and slick thickness. Wind-rows, heavy oil patches and tar balls, for example, must be considered, as they influence oil encounter rates, chemical dosages and ignition potential. Each method has different thickness thresholds for effective response.

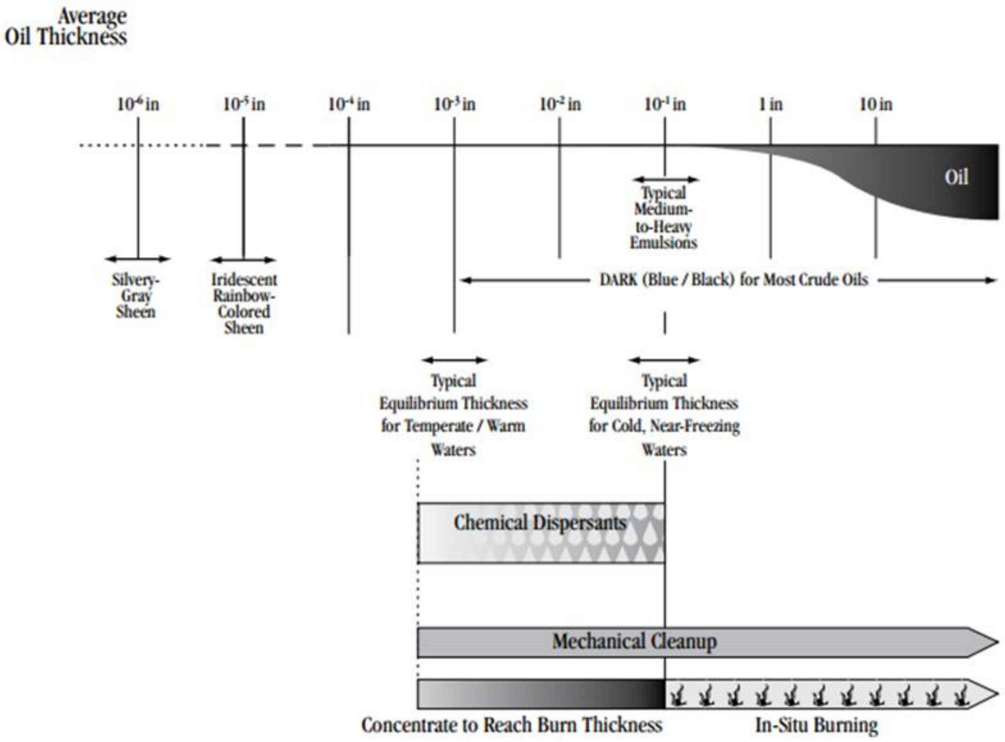


Figure 2-5: Oil thickness versus potential response options (from Allen and Dale, 1996)

Wind and waves influence the feasibility of mechanical clean-up operations, dropping the effectiveness significantly because of entrainment and/or splash-over as short period waves develop beyond two to three feet (0.6 to 0.9 m) in height. Waves and wind can also be limiting factors for the safe operation of vessels and aircraft.

2.3.3.2 Surface hydrocarbon viscosity

Table 2-4: Surface hydrocarbon viscosity thresholds

Surface viscosity (cSt)	Description	European Maritime Safety Authority	Viscosity at sea temperature (cSt)
5,000*	Predicted optimum viscosity for surface dispersant operations	Generally possible to disperse	500 to 5000
10,000*	Predicted maximum viscosity for effective surface dispersant operations	Sometimes possible to disperse	5,000 to 10,000

* Measured at sea surface temperature

Further to the required thickness for surface dispersant application and containment and recovery to be deployed effectively as outlined above, changes to viscosity will also limit the treatment of offshore response techniques. As outlined in the EMSA Manual on the Applicability of Oil Spill Dispersants (EMSA, 2012), guidance around changes to viscosity and likely effectiveness of surface dispersant application is provided.

This includes the following statements: "*It has been known for many years that it is more difficult to disperse a high viscosity oil than a low or medium viscosity oil. Laboratory testing had shown that the effectiveness of dispersants is related to oil viscosity, being highest for modern "Concentrate, UK Type 2/3" dispersants at an oil viscosity of about 1000 or 2000 mPa.s (1000 to 2000 cSt) and then declining to a low level with an oil viscosity of 10,000 mPa.s (10,000 cSt). It was considered that some generally applicable viscosity limit, such as 2000 or 5000 mPa.s (2000 to 5000 cSt), could be applied to all oils.*"

However, modern oil spill dispersants are generally effective up to an oil viscosity of 5000 mPa.s (5000 cSt) or more, and their performance gradually decreases with increasing viscosity; oils with a viscosity of more than 10,000 are, in most cases, no longer dispersible. Guidance from CEDRE (EMSA, 2012) also indicates that products with a range of 500 to 5000 cSt at sea temperature are generally possible to disperse, while 5000 to 10,000 cSt at sea temperature above pour point are sometimes possible to disperse, with products beyond 10,000 cSt at sea temperature below pour point are generally impossible to disperse.

To support decision making and response planning, a threshold of 10,000 cSt at sea temperature was chosen as a conservative estimate of maximum viscosity for surface dispersant spraying operations.

The thresholds described above are compared with the modelling results for the WCCS (Table 2-5).

2.3.4 Spill modelling results

Details of the scenario and selected stochastic modelling inputs are included along with modelling results in Table 2-5. The selected results used to represent the WCCS are based on response thresholds:

- Minimum time to commencement of hydrocarbon accumulation at any shoreline receptor (at a threshold of 100 g/m^2).
- Minimum time to floating hydrocarbon contact with the offshore edge(s) of any shoreline receptor polygon (at a threshold of 10 g/m^2).
- Maximum cumulative hydrocarbon volume accumulated at any individual shoreline receptor.
- Maximum cumulative hydrocarbon volume accumulated across all shoreline receptors contacted by accumulated hydrocarbons (including those contacted at <100 g/m^2 accumulation concentration).
- Minimum time to entrained/dissolved hydrocarbon contact with the offshore edges of any receptor polygon (at a threshold of 100 ppb).

The volumes presented in Table 2-5 have been used to determine appropriate level of response.

Table 2-5: Worst case credible scenario modelling results

Response parameter	Modelled results	
	CS-01	**CS-02**
Maximum continuous liquid hydrocarbon release rate and duration	Hydrocarbon release caused by a vessel collision (Site 1 – 10° 45' 57.58" S, 130° 44' 33.63" E) Surface release of 650 m^3 of Marine Diesel	Hydrocarbon release caused by a vessel collision (Site 2 – 10° 2' 7.83" S, 130° 49' 28.79" E) Surface release of 650 m^3 of Marine Diesel
Maximum residual surface hydrocarbon after weathering	5% residual component, 32.5 m^3 of Marine Diesel	5% residual component, 32.5 m^3 of Marine Diesel
Stochastic modelling results		
Minimum time to commencement of hydrocarbon accumulation at any shoreline receptor (at a threshold of 100 g/m^2)	No contact	No contact
Minimum time to floating hydrocarbon contact with the offshore edge(s) of any shoreline receptor polygon (at a threshold of 10 g/m^2)	1.67 days at The Boxers Area	1 hour at Oceanic Shoals MP 1 hour at Lynedoch Bank
Maximum cumulative hydrocarbon volume accumulated at any individual shoreline receptor	No contact	No contact
Maximum cumulative hydrocarbon volume accumulated across all shoreline receptors contacted by accumulated hydrocarbons (including those contacted at <100 g/m^2 accumulation concentration)	No contact	No contact
Minimum time to entrained hydrocarbon contact with the offshore edges of any receptor polygon (at a threshold of 100 ppb)	1.58 days at The Boxers Area	1 hour at Oceanic Shoals MP 1 hour at Lynedoch Bank

From analysis of the results, modelling predicts the following:

- Hydrocarbon release caused by a vessel collision (CS-01 and CS-02):
  - Whilst both Credible Scenarios result in some surface hydrocarbon at the 50 g/m^2 threshold, the use of surface dispersant and containment and recovery are not deemed feasible for Marine Diesel due to rapid spreading and weathering as a result of the local metocean conditions, together with its highly volatile nature. The use of dispersant would unnecessarily add chemicals to the marine environment. Furthermore, the volatile nature of Marine Diesel is also likely to lead to unsafe conditions in the vicinity of fresh hydrocarbon.
  - The sensitive features, including shoals and banks, that are present within contacted RPA polygons shown in Table 2-5 are all permanentently submerged features with a minimum water depth of 11 m and upon which floating oil will not accumulate. Whilst modelling predicts that entrained oil may make contact with these features, entrained oil is not used to scale the response planning as it cannot be recovered from the water columnn. It is, however, used to inform the spatial scale of the Scientific Monitoring Program (SMP).
  - Response operations cannot be implemented if the safety of response personnel cannot be guaranteed. Safety circumstances that limit the execution of this control measure include volatile concentrations of hydrocarbons in the atmosphere, high winds (> 20 knots), waves and/or sea states (> 1.5 m waves) and high ambient temperatures.

3 IDENTIFY RESPONSE PROTECTION AREAS

In a response, operational monitoring programs – including trajectory modelling and vessel/aerial observations – would be used to predict Response Protection Areas (RPAs) that may be impacted. For the purposes of planning and appropriately scaling a response, modelling has been used to identify RPAs as outlined in Figure 3-1.

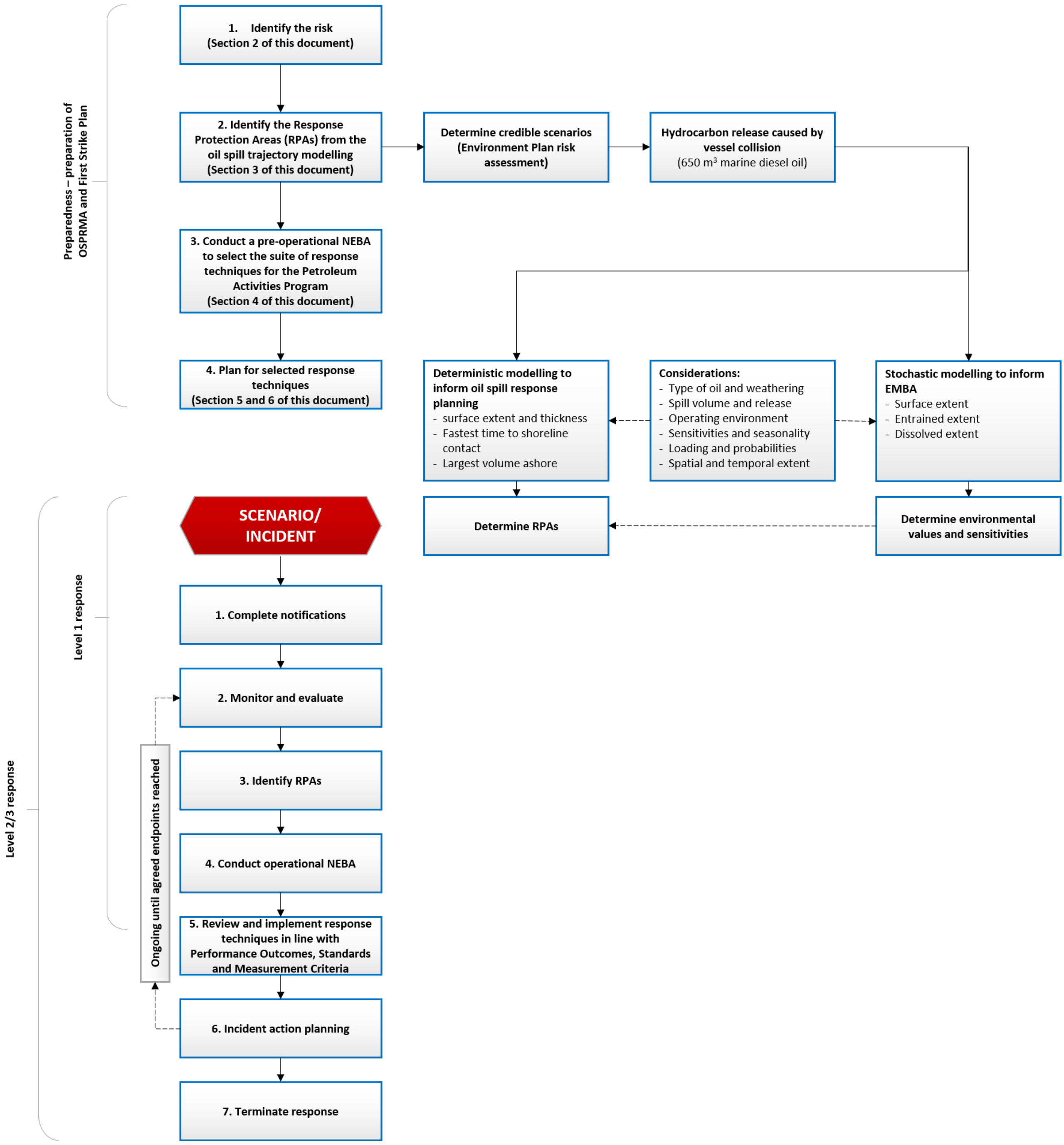


Figure 3-1: Identify Response Protection Areas flowchart

3.1 Identified sensitive receptor locations

Section 4 of the EP includes the list of sensitive receptor locations that have been identified by stochastic modelling as meeting the requirements of:

- receptors with the potential to incur surface, entrained or shoreline accumulation contact above environmental impact thresholds
- receptors within the EMBA which meet:
  - a number of priority protection criteria/categories
  - International Union of Conservation of Nature IUCN marine protected area categories
  - high conservation value habitat and species
  - important socio-economic/heritage value.

3.2 Response protection areas

RPAs are selected on the basis of their environmental (ecological, social, economic, cultural and heritage) values and sensitivities and considering the minimum response thresholds (detailed in Section 2.3.3.1) together with the ability to conduct a response.

Based on the stochastic modelling selected for this activity, contact from floating hydrocarbons above 50 g/m^2 is predicted for Commonwealth Waters only for CS-01, and, Commonwealth Waters, Oceanic Shoals MP and Lynedoch Bank receptor polygons for CS-02. Floating hydrocarbons above 10 g/m^2 is predicted for the offshore edges of Oceanic Shoals MP, Goodrich Bank, Marie Shoal and The Boxers Area for CS-01, and for Oceanic Shoals MP and Lynedoch Bank for CS-02. Modelling shows there is no accumulation above 100 g/m^2 on any shoreline thus there are no shoreline RPAs selected for this activity.

Whilst the stochastic modelling indicates the presence floating oil at 50 g/m^2 for both scenarios (which is ordinarily a trigger for undertaking deterministic modelling), containment and recovery and surface dispersant are not deemed appropriate for spills of Marine Diesel and thus deterministic modelling was not required for response scaling.

During a real spill event, however, operational monitoring techniques (OM01, OM02, OM03, OM04 and OM05) would be deployed as required from the outset of the spill to track the spill trajectory and deduce if any RPAs are at risk of impact. TRPs will be drafted in advance for any RPAs with a contact time of <14 days.

Any additional sensitive receptors are presented in the existing environment description (Section 4 of the EP) and impact assessment section (Section 6 of the EP) for the spill scenario. The pre-operational NEBA (Section 4) considers the results from the stochastic modelling to ensure all feasible response techniques are considered in the planning phase, therefore additional receptors are also included in the pre-operational NEBA.

4 NET ENVIRONMENTAL BENEFIT ANALYSIS

A Net Environmental Benefit Analysis (NEBA) is a structured process to consider which response techniques are likely to provide the greatest net environmental benefit (IPIECA, 2015b).

The NEBA process typically involves the four key steps outlined in Figure 4-1: evaluate data, predict outcomes, balance trade-offs and select response options. These steps are followed in the planning/preparedness process and would also be followed in a response.

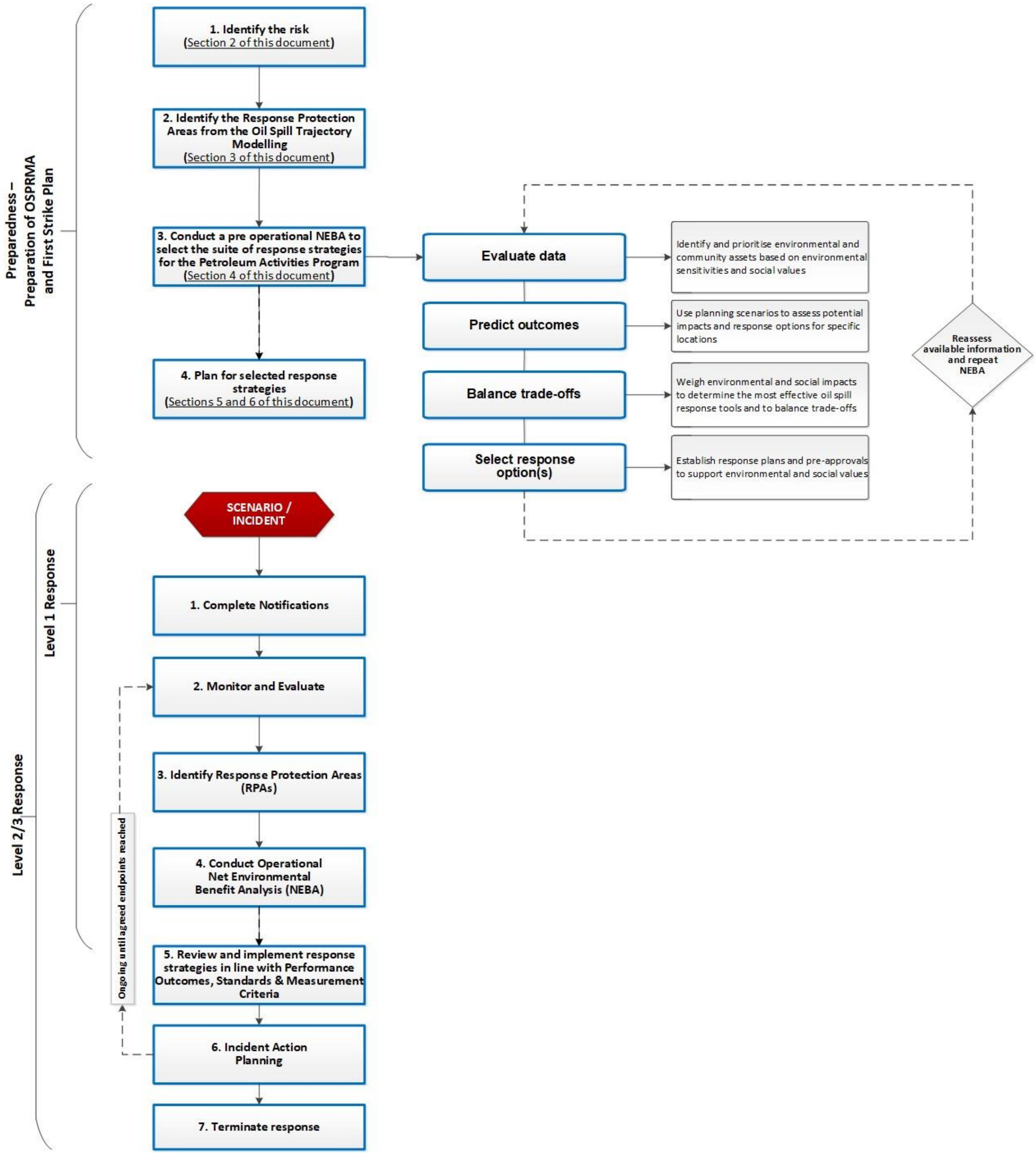


Figure 4-1: Net Environmental Benefit Analysis flowchart

4.1 Pre-operational/strategic NEBA

The pre-operational NEBA identifies positive and negative impacts to sensitive receptors from implementing the response techniques. Feasibility is considered by assessing the receptors potentially impacted above response thresholds (Section 2.3.3) and the surface concentrations (Section 2.3.3.1) from the deterministic modelling (deterministic modelling not undertaken as stochastic modelling confirmed no shoreline impact above thresholds).

Completing a pre-operational NEBA is a key response planning control that reduces the environmental risks and impacts of implementing the selected response techniques. Comprehensive details of the pre-operational NEBA for this activity are contained in ANNEX A: Net Environmental Benefit Analysis Detailed Outcomes.

4.2 Stage 1: Evaluate data

Woodside identifies and prioritises environmental and community assets based on environmental sensitivities and social values, informed through the use of trajectory modelling. Interpretation of stochastic oil spill modelling determines the EMBA for the release, which defines the spatial area that may be potentially impacted by the activity activities.

4.2.1 Defining the scenario(s)

Woodside uses scenarios identified from the risk assessment in the EP to assess potential impacts and response options for specific locations. The overall WCCS is then used for this pre-operational NEBA. Outlier locations with potential environmental impacts, selected from the stochastic modelling may also be included for assessment. Response thresholds and modelling are then used to assess the feasibility/effectiveness and scale of the response.

Table 4-1: Scenario summary information

Scenario summary information (CS-01)	
Scenario	Hydrocarbon release at surface caused by vessel collision – Site 1
Location (WGS 84)	Lat: 10° 45' 57.58" S Long: 130° 44' 33.63" E
Oil Type	Marine diesel
Fate and Weathering	6% of the oil mass should evaporate within the first 12 hours (BP < 180 °C) 35% should evaporate within the first 24 hours (180 °C < BP < 265 °C) 54% should evaporate over several days (265 °C < BP < 380 °C)
Volume and duration of release	650 m³ (instantaneous)
Scenario summary information (CS-02)	
Scenario	Hydrocarbon release at surface caused by vessel collision – Site 2
Location (WGS 84)	Lat: 10° 02' 07.83" S Long: 130° 49' 28.79" E
Oil Type	Marine diesel
Fate and Weathering	6% of the oil mass should evaporate within the first 12 hours (BP < 180 °C) 35% should evaporate within the first 24 hours (180 °C < BP < 265 °C) 54% should evaporate over several days (265 °C < BP < 380 °C)
Volume and duration of release	650 m³ (instantaneous)

4.2.1.1 Hydrocarbon characteristics

Marine diesel

Marine Diesel Oil is classed as an ITOPF Group I/II oil. It is a mixture of volatile and persistent hydrocarbons with low percentages of highly volatile and residual components. Evaporation rates will be significant, given the moderate proportion of volatile compounds in the oil (41%). The low-volatility fraction of the oil (54%) will take longer durations of the order of days to evaporate, and the residual fraction of 5% is expected to persist in the environment until degradation processes occur. Considering the spill volume, there is a low potential for dissolution of soluble aromatic compounds. For the reasons described in Sections 2.3.2 and 3.2, together with the above information,deterministic modelling was not undertaken.

4.2.2 Determining potential response options

The available response techniques based on current technology can be summarised under the following headings:

- monitor and evaluate (including operational monitoring)
- source control via vessel SOPEP
- surface dispersant application:
  - aerial dispersant application
  - vessel dispersant application
- mechanical dispersion
- in-situ burning
- containment and recovery
- shoreline protection and deflection:
  - protection
  - deflection
- shoreline clean-up:
  - Phase 1 – Mechanical clean-up
  - Phase 2 – Manual clean-up
  - Phase 3 – Final polishing
- oiled wildlife response (including hazing)

Support functions may include:

- waste management
- scientific monitoring.

An assessment of which response options are feasible for the scenarios is included in Table 4-2. These options are evaluated against each scenario's parameters, including oil type, volume and characteristics, prevailing weather conditions, logistical support, and resource availability to determine their deployment feasibility.

A shortlist of the feasible response options is then carried forward for the ALARP assessment with a justification for the exclusion of other response techniques included in Section 4.2.3. This assessment will typically result in a range of available options, that are deployed at different areas (at-source, offshore, nearshore and onshore) and times through the response. The NEBA process assists in prioritising which options to use where and when and timings throughout the response.

Table 4-2: Response technique evaluation – loss of Marine Diesel fuel (vessel collision) (CS-01 and CS-02)

Response Technique	Effectiveness	Feasibility	Decision	Rationale for the decision
Hydrocarbon: Marine Diesel				
Monitor and Evaluate	Will be effective in tracking the location of the spill, informing if/when it has entered Territory Coastal Waters, predicting potential impacts and triggering further monitoring and response techniques as required. Monitoring techniques include: • OM01 Predictive modelling of hydrocarbons to assess resources at risk – used throughout spill. 'Ground-truthed' using the outputs of all other monitoring techniques. • OM02 Surveillance and reconnaissance to detect hydrocarbons and resources at risk – from outset of spill. • OM03 Monitoring of hydrocarbon presence, properties, behaviour and weathering in water – from outset of spill. • OM04 Pre-emptive assessment of sensitive receptors at risk – triggered once OM01, OM02 and OM03 inform if any RPAs are at risk. • OM05 Shoreline assessment – triggered once OM02, OM03 and OM04 inform if any RPAs have been impacted.	Monitoring of a Marine Diesel spill is a feasible response technique and outputs will be used to guide decision making on the use of other monitoring/response techniques and whether the spill passes into Territory Coastal Waters and thus control of the incident moves to NT authorities. Monitoring of a Marine Diesel spill is a feasible response technique and outputs will be used to guide decision making on the use of other monitoring/response techniques and providing information to regulatory agencies. Practicable techniques that could be used for this scenario include OM01, OM02 and OM03. Modelling does not predict impact of any shoreline receptors at threshold, however, OM04 and OM05 would be utilised if any sensitive shoreline receptors are deemed to be at risk of impact.	Yes	Monitoring and Evaluate is an essential element of oil spill response and will be necessary to: • validate trajectory and weathering models • determine the behaviour of the diesel in the water • determine the location and state of the slick • provide forecasts of spill trajectory • determine whether the diesel is dispersing naturally or not • determine appropriate response techniques • determine effectiveness of response techniques • confirm impact pathways to receptors • determine if/when the spill crosses into Territory Coastal Waters and thus control of the spill passes to Northern Territory authorities.
Source control via vessel SOPEP	Controlling the spill of diesel at source would be the most effective way to limit the quantity of hydrocarbon entering the marine environment.	A spill of diesel from a vessel collision will be instantaneous and source control will be limited to what the vessel or facility can safely achieve whilst responding to the incident.	Yes	Ability to stop the spill at source will be dependent upon the specific spill circumstances and whether or not it is safe for response personnel to access/isolate the source of the spill.
Surface dispersant application	Dispersants are not considered effective when applied on thin surface films such as Marine Diesel as the dispersant droplets tend to pass through the surface films without binding to the hydrocarbon.	Marine diesel is prone to rapid spreading and evaporation and is not suitable for surface dispersant application. Furthermore, the volatile nature of Marine Diesel is also likely to lead to unsafe conditions in the vicinity of fresh hydrocarbon thus this response technique is deemed inappropriate.	No	The application of dispersant to Marine Diesel is unnecessary as the diesel will rapidly evaporate and disperse naturally and would thus unnecessarily introduce additional chemicals to the marine environment. Any additional entrainment would also increase exposure of subsea species and habitats to hydrocarbons.
Containment and recovery	Containment and recovery has an effective recovery rate of 5 to 10% when a hydrocarbon encounter rate of 25 to 50% is achieved at BAOAC 4 and 5. It has the potential to reduce the magnitude, probability of, extent of, contact with and accumulation of hydrocarbons on shoreline receptors. It also has the potential to reduce the magnitude and extent of contact with submerged receptors by entrained/dissolved hydrocarbons.	Marine diesel, prone to rapid spreading and evaporation and is deemed unsuitable for effective containment and recovery operations, particularly with the predicted residue of 32.5 m^3. Furthermore, the volatile nature of Marine Diesel is also likely to lead to unsafe conditions in the vicinity of the hydrocarbon thus this response technique is deemed inappropriate.	No	Containment and recovery would be an inappropriate response technique as it requires the spilled hydrocarbon to be BAOAC 4 or 5 with a 50 to 100% coverage of 100 g/m^2 to 200 g/m^2 which is a spill of diesel is unlikely to achieve. In addition to the safety issues, most of the spilled diesel would have been subject to rapid evaporation and natural dispersion prior to the commencement of containment and recovery operations.
In-situ burning	In-situ burning is only effective where minimum slick thickness can be achieved.	Use of in-situ burning as a response technique for Marine Diesel is unfeasible as the minimum slick thickness cannot be attained due to rapid spreading and evaporation. In addition, there is a limited window of opportunity in which this technique can be applied (prior to evaporation of the flammable volatiles) which is unlikely to be achieved. Furthermore, entering a volatile environment to undertake this technique would be unsafe for response personnel and its use would unnecessarily cause an increase in the release of atmospheric pollutants.	No	Marine diesel characteristics are not appropriate for the use of in-situ burning and would unnecessarily cause an increase the release of atmospheric pollutants and may also result in burned residue sinking to the seabed.
Mechanical dispersion	Mechanical dispersion involves the use of a vessel's prop wash and/or fire hose to target surface hydrocarbons to achieve dispersion into the water column. However, this technique is of limited benefit in an open ocean environment where wind and wave action are likely to deliver similar advantages.	Although the technique is feasible, highly volatile hydrocarbons are likely to weather, spread and evaporate quickly. The volatile nature of the oil likely to lead to unsafe conditions in the vicinity of fresh hydrocarbon. Additionally, any vessel used for mechanical dispersion activities would be contaminated by the hydrocarbon and could potentially cause secondary contamination of unimpacted areas when exiting the spill area. The decontamination of a vessel used for mechanical dispersion activities would result in additional quantities of oily waste requiring appropriate handling and treatment.	No	Given the limited benefit of mechanical dispersion over natural wind and wave action, secondary contamination and waste issues, and the associated safety risk of implementing the response for this activity, this strategy is deemed unsuitable.

Response Technique	Effectiveness	Feasibility	Decision	Rationale for the decision
Shoreline protection and deflection	Shoreline protection and deflection can be effective at preventing contamination of at-risk areas.	A Marine Diesel spill would be prone to rapid spreading and evaporation and the Galactic Hybrid Marine Seismic Survey modelling predicts that no shoreline receptors will be contacted at threshold. Furthermore, the volatile nature of Marine Diesel is also likely to lead to unsafe conditions in the vicinity of the hydrocarbon. Monitor and evaluate will, however, be deployed from the outset of a spill to track the spill location and fate in real-time.	No	In addition to the safety issues and the rapid spreading and evaporation of the diesel, the modelling undertaken predicts that no shoreline receptors would be contacted by floating oil concentrations at impact or response thresholds.
Shoreline clean-up	Shoreline clean-up is an effective means of hydrocarbon removal from contaminated shorelines. To be optimally effective, a threshold of 250 g/m² is needed before a realistic shoreline clean-up response can be executed.	A Marine Diesel spill would be prone to rapid spreading and evaporation and the Galactic Hybrid Marine Seismic Survey modelling predicts that no shoreline receptors will be contacted at threshold (100 g/m²) – any minor contact is significantly below any threshold concentration that would allow a response to be feasible. Furthermore, the volatile nature of Marine Diesel is also likely to lead to unsafe conditions in the vicinity of the hydrocarbon. Monitor and evaluate will, however, be deployed from the outset of a spill to track the spill location and fate in real-time.	No	In addition to the safety issues and the rapid spreading and evaporation of Marine Diesel, the modelling undertaken predicts that no shoreline receptors would be contacted at threshold concentrations required for feasible and effective clean-up.
Oiled wildlife response	Oiled wildlife response is an effective response technique for reducing the overall impact of a spill on wildlife. This is mostly achieved through hazing to prevent additional fauna from being contaminated and through rehabilitation of fauna already subject to contamination.	Due to the likely volatile atmospheric conditions surrounding a Marine Diesel spill, response options would be limited to hazing to ensure the safety of response personnel. Monitor and evaluate will, however, be deployed from the outset of a spill to track the spill location and fate in real-time. Thus, in the event that wildlife are at risk of contamination, oiled wildlife response will be undertaken in accordance with the Wildlife Response Operational Plan as and where required. In addition, any rehabilitation would only be undertaken by trained specialists.	Yes	The modelling undertaken predicts that no sensitive areas will be impacted thus it is unlikely that this technique would be required. However, if operational monitoring predicts that fauna are at risk of contamination, oiled wildlife response will be undertaken as and where needed.

4.2.3 Exclusion of response techniques

Response techniques that are not feasible for all scenarios for this activity are detailed in the subsections below and are excluded from further assessment within this document.

4.2.3.1 Surface dispersant application

Dispersants are not considered effective when applied on thin surface films such as Marine Diesel, as the dispersant droplets tend to pass through the surface films without binding to the hydrocarbon, making it unsuitable for effective treatment and unnecessarily adding chemicals to the marine environment. A Marine Diesel spill is also expected to dissipate rapidly on the surface and become entrained due to local metocean conditions. Furthermore, the volatile nature of Marine Diesel is also likely to lead to unsafe conditions in the vicinity of fresh hydrocarbon thus this response technique is deemed inappropriate.

4.2.3.2 Containment and recovery

A Marine Diesel spill would rapidly evaporate and spread too thinly to allow this response technique to be effective and thus only result in a marginal reduction in surface slicks. Furthermore, the volatile nature of Marine Diesel is also likely to lead to unsafe conditions in the vicinity of the hydrocarbon.

4.2.3.3 In-situ burning

Marine Diesel is not suitable for in situ burning due to rapid evaporation, minimum thickness requirements and window of opportunity. It would unnecessarily cause an increase in the release of atmospheric pollutants and may also result in burned residue sinking to the seabed. Furthermore, the volatile nature of Marine Diesel is also likely to lead to unsafe conditions in the vicinity of the hydrocarbon.

4.2.3.4 Mechanical dispersion

Mechanical dispersion involves the use of a vessel's propeller wash and/or fire hose to target surface hydrocarbons to achieve dispersion into the water column. However, this technique is of limited benefit in an open ocean environment where wind and wave action are likely to deliver similar advantages. Additionally, any vessel used for mechanical dispersion activities would be contaminated by the hydrocarbon and could potentially cause secondary contamination of unimpacted areas when exiting the spill area. The decontamination of a vessel used for mechanical dispersion activities would result in additional quantities of oily waste requiring appropriate handling and treatment. Furthermore, the volatile nature of Marine Diesel is also likely to lead to unsafe conditions in the vicinity of the hydrocarbon.

4.2.3.5 Shoreline protection and deflection

The modelling undertaken predicts that a diesel spill would be prone to rapid spreading and evaporation with no shoreline impact at the response threshold of 100 g/m^2. Furthermore, the volatile nature of Marine Diesel is also likely to lead to unsafe conditions in the vicinity of the hydrocarbon.

4.2.3.6 Shoreline clean-up

The modelling undertaken predicts that a diesel spill would be prone to rapid spreading and evaporation with no shoreline impact at the response threshold. Furthermore, the volatile nature of Marine Diesel is also likely to lead to unsafe conditions in the vicinity of the hydrocarbon.

4.3 Stage 2: Predict outcomes

Woodside uses planning scenarios to assess potential impacts and response options for specific locations. Locations with potential environmental impacts, selected from the stochastic modelling are included for assessment. Response thresholds and deterministic modelling are then used to assess the feasibility/effectiveness of a response.

4.4 Stage 3: Balance trade-offs

Woodside considers environmental impacts and response effectiveness/feasibility to determine the most effective oil spill response tools and balance trade-offs, using an automated NEBA tool. The tool considers potential benefits and impacts associated with a response at sensitive receptors and then considers the effectiveness/feasibility of the response to select the response techniques carried forward to the ALARP assessment. The NEBA can be found in ANNEX A: Net Environmental Benefit Analysis Detailed Outcomes.

4.5 Stage 4: Select best response options

To select the response technique, all the other stages in the NEBA process are considered and used to establish response plans and any pre-approvals to support protection of identified environmental and social values.

The response techniques implemented may vary according to a particular spill. The hydrocarbon type released and the sensitivities of the receptors (both ecological and socio-economic) may influence the response. The pre-operational NEBA broadly evaluates each response technique and supports decisions on whether they are feasible and of net environmental benefit. Response techniques that are not feasible or beneficial are rejected at this stage and not progressed to planning.

Further risks and impacts from implementing these selected response options are outlined in Section 0.

Table 4-3: Selection and prioritisation of response techniques

Response planning scenario	Key characteristics for response planning (times are minimum times to contact for first receptor and/or shoreline impacted above response threshold)	Feasibility of response techniques									Summary outline of preferred response technique
		Monitor and evaluate	Source control via vessel SOPEP	Surface dispersant application	Mechanical dispersion	In situ burning	Containment and recovery	Shoreline protection and deflection	Shoreline clean-up	Oiled wildlife response	
CS-01 – Hydrocarbon release caused by a vessel collision (surface): 650 m³ of Marine Diesel fuel released instantaneously (residual component of 32.5 m³)	No shoreline impact at threshold. No floating oil >50 g/m² at any offshore receptor	Yes	Yes	No	No	No	No	No	No	Yes	Monitor and evaluate. Initiate vessel source control if safe and feasible. Plan for oiled wildlife response and implement if oiled wildlife is observed.
CS-02 – Hydrocarbon release caused by a vessel collision (surface): 650 m³ of Marine Diesel fuel released instantaneously (residual component of 32.5 m³)	No shoreline impact at threshold. Fastest time for floating oil at an offshore receptor >50 g/m²: • Oceanic Shoals MP (1 hour) • Lynedoch Bank (1 hour)	Yes	Yes	No	No	No	No	No	No	Yes	Monitor and evaluate. Initiate vessel source control if safe and feasible. Plan for oiled wildlife response and implement if oiled wildlife is observed.

From the NEBA undertaken on the WCCS (CS-01 and CS-02 – hydrocarbon release caused by a vessel collision), the primary response techniques are:

- Monitor and evaluate
- Source control via vessel SOPEP
- Oiled wildlife response

Support functions may include:

- Waste management
- Scientific Monitoring Programmes.

5 HYDROCARBON SPILL ALARP PROCESS

Woodside's hydrocarbon spill ALARP process is aligned with guidance provided by NOPSEMA in *Guidance Note GN1488* (2021) and is set out in the 'Woodside Hydrocarbon Spill Oil Spill Preparedness and Response Mitigation Assessment (OSPRMA) Development Guidelines' (Link).

From the identified response planning need and pre-operational NEBA, Woodside conducts a structured, semi-quantitative hydrocarbon spill process which has the following steps:

1. Considers the Response Planning Need identified in terms of surface area (km²) and available surface hydrocarbon volumes (m³) against existing Woodside capability
2. Considers alternative, additional, and improved options for each response technique/control measure by providing an initial and, if required, detailed evaluation of:
   - predicted cost associated with adopting the control measure
   - predicted change/environmental benefit
   - predicted effectiveness/feasibility of the control measure.
3. Evaluates the risks and impacts of implementing the proposed response techniques, and any further control measures with associated environmental performance to manage these additional risks and impacts.

Woodside considers the risks and impacts from a hydrocarbon spill to have been reduced to ALARP when:

1. a structured process for identifying and considering alternative, additional, and improved options has been completed for each selected response technique
2. the analysis of alternate, additional, and improved control measures meets one of the following criteria:
   - all identified, reasonably practicable control measures have been adopted, or
   - no identified reasonably practicable additional, alternative and/or improved control measures would provide further overall increased proportionate environmental benefit, or
   - no reasonably practical additional, alternative, and/or improved control measures have been identified.
3. where an alternative, additional and/or improved control measure is adopted, a measurable level of environmental performance has been assigned
4. higher order impacts/risks have received more comprehensive alternative, additional, and improved control measure evaluations and do not just compare the cost of the adopted control measures to the costs of an extreme or clearly unreasonable control measure
5. cumulative effects have been analysed when considered in combination across the whole activity.

The response technique selection is based on the risk assessment conducted in the EP. The risk assessment identifies the type of oil, volume of release, duration of release, predicted fate, weathering and the EMBA (along with other requirements such as time to impact and predicted volumes ashore). Modelling is then used to inform the NEBA and the prioritisation of suitable response options. The scale of the response techniques selected in the pre-operational NEBA is informed through the assessment of results from the modelling.

For the purpose of the ALARP assessment, the following terms and definitions have been used:

- Response techniques are considered the control measures that reduce consequences from hydrocarbon spill events. The terms 'response technique' and 'control measure' are used interchangeably.
- Cost is defined as the time, effort and/or trouble taken in financial, safety, design/storage/installation, capital/lease, and/or operations/maintenance terms to adopt a control measure.
- Where the predicted change to environmental impact is compared against standard environmental values and sensitivities impacts using positive or negative criteria from the NEBA Impact Ranking Classification Guidance in ANNEX A: Net Environmental Benefit Analysis Detailed Outcomes.

5.1 Monitor and evaluate (including operational monitoring)

Monitor and evaluate includes the gathering and evaluation of data to inform the oil spill response planning and operations. It includes fate and trajectory modelling, spill tracking, weather updates and field observations. This response option is deployed in some capacity for every event.

Table 5-1 provides the operations monitoring plans that support the successful execution of this response technique for this activity.

Table 5-1: Description of supporting operational monitoring plans

ID	Title
OM01	Predictive modelling of hydrocarbons to assess resources at risk
OM02	Surveillance and reconnaissance to detect hydrocarbons and resources at risk
OM03	Monitoring of hydrocarbon presence, properties, behaviour and weathering in water
OM04	Pre-emptive assessment of sensitive receptors at risk
OM05	Shoreline assessment

Woodside maintains an *Operational Monitoring Operational Plan* (Link). The primary mobilisation base for initial monitoring activities would be Darwin with additional resources being mobilised from Perth if required.

5.1.1 Response need based on predicted consequence parameters

The following statements identify the key parameters upon which a response need can be based:

- Operational monitoring will be undertaken from the outset of a spill. This is needed to assess the nature of the spill and track its location. The data collected from the operational monitoring will inform the need for any additional operational monitoring, deployment of response techniques and may assist post-spill scientific monitoring. It also informs if/when the spill has entered Territory Coastal Waters and control of the incident passes to Northern Territory authorities.
- Modelling confirmed no shoreline impact at response threshold levels (100 g/m^2) for accumulated hydrocarbons.
- The shortest time for floating oil to contact the offshore edge of a receptor polygon at a concentration of >10 g/m^2 is 1.67 days (40 hours) at The Boxers Area (CS-01) and, at a concentration of >50 g/m^2 is 1 hour at Oceanic Shoals MP and Lynedoch Bank (CS-02). These receptor polygons are situated offshore, and sensitive features remain submerged at all times.
- The time to contact for entrained hydrocarbons greater than 100 ppb for CS-01 is 38 hours at The Boxers Area and, for CS-02, 1 hour at Oceanic Shoals MP and Lynedoch Bank.
- Arrangements for support organisations who provide specialist services or resources should be tested regularly.
- Plans, procedures and support documents need to be in place for Operational and Support functions. These should be reviewed and updated regularly.
- The duration of the spill would be instantaneous with response operations extending until the hydrocarbon discharge has ceased, surface hydrocarbons are no longer visible, and no additional response or clean-up of wildlife or habitats is predicted.
- The location, trajectory and fate of the spill will be verified by real-time spill tracking via modelling, direct observation and remote sensing (OM01, OM02, OM03, OM04 and OM05) as required.

5.1.2 Environmental performance based on need

Table 5-2: Environmental performance – Monitor and Evaluate

Environmental Performance Outcome		To gather information from multiple sources to establish an accurate common operating picture (COP) as soon as possible and predict the fate and behaviour of the spill to validate planning assumptions and adjust response plans as appropriate to the scenario.		
Control measure		**Performance Standard**		**Measurement Criteria (Section 5.7)**
1	Oil spill trajectory modelling	1.1	Initial modelling available within six hours using the Rapid Assessment Tool.	1, 3B, 3C, 4
		1.2	Detailed modelling available within four hours of APASA receiving information from Woodside.	
		1.3	Detailed modelling service available for the duration of the incident upon contract activation.	
2	Tracking buoy	2.1	Tracking buoy located on the seismic vessel and/or support vessel and ready for deployment 24/7.	1, 3A, 3C, 4
		2.2	Deploy tracking buoy from the seismic vessel and/or a support vessel within two hours as per the FSP.	1, 3A, 3B, 4
		2.3	Contract in place with service provider to allow data from tracking buoy to be received 24/7 and processed.	1, 3B, 3C, 4
		2.4	Data received to be uploaded into Woodside COP daily to improve the accuracy of other monitor and evaluate techniques.	1, 3B, 4
3	Satellite imagery	3.1	Contract in place with third-party provider to enable access and analysis of satellite imagery. Imagery source/type requested on activation of service.	1, 3C, 4
		3.2	Third-party provider will confirm availability of an initial acquisition within two hours.	1, 3B, 3C, 4
		3.3	First image received with 24 hours of Woodside confirming to third-party provider its acceptance of the proposed acquisition plan.	1
		3.4	Third-party provider to submit report to Woodside per image. Report is to include a polygon of any possible or identified slick(s) with metadata.	1
		3.5	Data received to be uploaded into Woodside COP daily to improve accuracy of other monitor and evaluate techniques.	1, 3B, 4
		3.6	Satellite Imagery services available and employed during response.	1, 3C, 4
4	Aerial surveillance	4.1	Two trained aerial observers available to be deployed by day 1 from resource pool.	1, 2, 3B, 3C, 4
		4.2	One aircraft available for two sorties per day, available for the duration of the response from day 1.	1, 3C, 4
		4.3	Observer to compile report during flight as per first strike plan. Observers report available to the IMT within two hours of landing after each sortie.	1, 2, 3B, 4
5	Hydrocarbon detections in water	5.1	Activate third-party service provider as per First Strike Plan. Deploy resources within three days: • three specialists in water quality monitoring • two monitoring systems and ancillaries • one vessel for deploying the monitoring systems with a dedicated winch, A-frame or Hiab and ancillaries to deploy the equipment.	1, 2, 3C, 3D, 4
		5.2	Water monitoring services available and employed during response	1, 3C, 4
		5.3	Preliminary results of water sample as per contractor's implementation plan within seven days of receipt of samples at the accredited lab.	

Environmental Performance Outcome		To gather information from multiple sources to establish an accurate common operating picture (COP) as soon as possible and predict the fate and behaviour of the spill to validate planning assumptions and adjust response plans as appropriate to the scenario.		
Control measure		**Performance Standard**		**Measurement Criteria (Section 5.7)**
		5.4	Daily fluorometry reports as per service provider's implementation plan will be provided to IMT to validate modelling and monitor presence/absence of entrained hydrocarbons.	
		5.5	Use of Autonomous Underwater Vehicles (AUVs) for hydrocarbon presence and detection may be used as a contingency if the operational NEBA confirms conventional methods are unsafe or not possible.	1, 2, 3C, 4
6	Pre-emptive assessment of sensitive receptors	6.1	10 days prior to any impact predicted by OM01/02/03, and in agreement with NT authorities (for Level 2/3 incidents), deployment of 2 specialists from resource pool in establishing the status of sensitive receptors.	1, 2, 3B, 3C, 4
		6.2	Daily reports provided to IMT on the status of the receptors to prioritise Response Protection Areas (RPAs) and maximise effective utilisation of resources.	1, 3B, 4
7	Shoreline assessment	7.1	10 days prior to any impact predicted by OM01/02/03, and in agreement with NT authorities (for Level 2/3 incidents), deployment of 1 specialist(s) in SCAT from resource pool for each of the Response Protection Areas (RPAs) with predicted impacts	1, 2, 3B, 3C, 4
		7.2	SCAT reports provided to IMT daily detailing the assessed areas to maximise effective utilisation of resources	1, 3B, 4
		7.3	Shoreline access routes with the least environmental impact identified will be selected by a specialist in SCAT operations.	1
8	Management of environmental impact of the response risks	8.1	If vessels are required for access, anchoring locations will be selected to minimise disturbance to benthic habitats. Where existing fixed anchoring points are not available, locations will be selected to minimise impact to nearshore benthic environments with a preference for areas of sandy seabed where they can be identified.	1
		8.2	Shallow draft vessels will be used to access remote shorelines to minimise the impacts associated with seabed disturbance on approach to the shorelines	

The control measures and capability of Woodside and its third-party service providers are shown to support Monitor and Evaluate activities up to and including the identified WCCS. This is demonstrated by the following:

- Woodside has a documented, structured and tested capability for Monitor and Evaluate operations including internal trajectory modelling capabilities, tracking buoys located offshore and contracted aerial observation platforms with access to trained observers.
- Woodside and its third-party service providers ensure there is sufficient capability for the duration of the response.
- Woodside has assessed the existing capability available and considered potential alternative, additional and improved control measures. Where control measures have been selected and implemented, they are included in Section 6.1.
- The health and safety, financial, capital and operations/maintenance costs of implementing the alternative, additional or improved control measures identified and not carried forward are considered clearly disproportionate to the environmental benefit gained and/or not reasonably practicable for this activity.

The Monitor and Evaluate capability outlined in this section is part of the response developed to manage potential risks and impacts associated with the scenarios to ALARP. There are no further additional, alternative and improved control measures other than those implemented that would provide further benefit.

5.2 Source Control via Vessel SOPEP

Vessel source control will be conducted, where feasible and in accordance with MARPOL 73/78 Annex I [3], by the Vessel Master under the Shipboard Oil Pollution Environment Plan (SOPEP) triggered by any loss of containment from the activity's vessels.

The SOPEP provides guidance to the Master and Officers on board the vessel with respect to the extra steps to be taken when an unexpected pollution incident has occurred or is likely to occur. The SOPEP contains all information and operational instructions required by IMO Resolution MEPC.54 (32) adopted on 6 March 1992, as amended by resolution MEPC.86 (44) adopted on 13 March 2000.

Its purpose is to set in motion the necessary actions to stop or minimise oil discharge and mitigate its effects and outlines responsibilities, pollution reporting requirements, procedures and resources needed in the event of a hydrocarbon spill from vessel activities.

In the event of the WCCS vessel collision event (CS-01 or CS-02), the vessel master may engage precautionary marine manoeuvres to avoid collision or commence pumping operations to transfer Marine Diesel and thus minimise the release.

5.2.1 Environmental performance based on need

Woodside has established control measures, environmental performance outcomes, performance standards and measurement criteria to be used for vessel-source oil spill response during the activity which are detailed in Section 6.7 of the EP. The Vessel Master's roles and responsibilities are described in EP Section 7.3.

Performance standards for each contracted activity vessel are detailed in the vessel's specific SOPEP.

These standards ensure that sufficient resources are available and are adequately tested to ensure implementation of the SOPEP in the event of a hydrocarbon spill.

[3] Marpol 73/78 Annex I entry into force in Australia, 2 Oct 1983

5.3 Oiled wildlife response (including hazing)

Woodside would implement a response in accordance with the *Oiled Wildlife Operational Plan*. This plan includes the process for the IMT to mobilise resources depending on the nature and scale of the spill. Oiled wildlife operations would be implemented with advice and assistance from the Oiled Wildlife Advisor from the Department of the Environment, Parks and Water Security (DEPWS).

Oiled wildlife response will be also be undertaken in accordance with the Northern Territory Oiled Wildlife Response Plan which was developed by the Australian Marine Oil Spill Centre (AMOSC) on behalf of Titleholder Members ConocoPhillips (now Santos), INPEX and Shell Australia in 2019 (NT OWRP). The NT OWRP aligns with the legislative requirements as listed in Table 5-3:

Table 5-3: Legislation of relevance for oiled wildlife response in the Northern Territory

Legislation	Jurisdiction	Purpose	Authority
Environmental Protection Amendment Act (2003)	Commonwealth	Management of Australia's environment	Department of Environment and Energy (DoEE)
Environmental Protection and Biodiversity Conservation Act (1999)	Commonwealth	Management of Australia's environment and biodiversity values	DoEE
Environmental Protection and Biodiversity Conservation Act (2000)	Commonwealth	Management of Australia's environment and biodiversity values	DoEE
Aboriginal Land Act (2013)	Northern Territory	An Act that provides for access to Aboriginal land, certain roads bordered by Aboriginal land and the seas adjacent to Aboriginal land	Department of. Infrastructure, Planning and Logistics (DIPL)
Northern Territory Environment Protection Authority Act (2018)	Northern Territory	An Act to establish the Northern Territory Environment Protection Authority, and for related purposes	Department of Environment, Parks and Water Security (DEPWS) NOTE: formerly Department of Environment and Natural Resources
Parks and Wildlife Commission Act (2013)	Northern Territory	An Act to establish a Commission to establish and manager, or assist in the management of, parks, reserves, sanctuaries and other land, conservation and sustainable use of wildlife, to establish land holding corporation in connection with those purposes, and for related purposes. This Act establishes the DEPWS as the lead agency for OWR in the Northern Territory	Department of Tourism and Culture (DTC)
Territory Parks and Wildlife Conservation Act (2014)	Northern Territory	An Act to make provision for and in relation to the establishment of Territory Parks and other Parks and Reservices and the study, protection, conservation and sustainable utilisation of wildlife	DTC NOTE: DEPWS is responsible for Part IV (Divisions 1 to 5) of the Act

If there is a net environmental benefit, oiled wildlife operations will be conducted 24 hours per day to reduce the time for rehabilitation and release of oiled wildlife. Hazing and pre-emptive capture techniques to keep non-oiled animals away from contaminated habitat in instances where it is deemed appropriate will be conducted in accordance with the NT OWRP (AMOSC, 2019), specifically vessels used in hazing/pre-emptive capture will approach fauna at slow speeds to ensure animals are not directed towards the oil and deterrence/hazing and pre-emptive capture will only be conducted if Woodside has licensed authority from DEPWS and approval from the Incident Controller.

Shoreline access will be considered as part of the operational NEBA. Vehicular access would be restricted on dunes, turtle nesting beaches and in mangroves. Woodside would work under the direction of DEPWS to engage local, trained personnel to support and manage oiled wildlife operations, and also retains its own team of specialist personnel, including trained and competent responders in Exmouth and Dampier, who would be made available to support operations. Additional personnel would be sourced through Woodside's arrangements to support an oiled wildlife response as required.

5.3.1 Response need based on predicted consequence parameters

The following statements identify the key parameters upon which a response need can be based:

- Modelling predicts that no shoreline impact above thresholds will occur.
- The offshore location of the release site is expected to initially result in low numbers of at-risk or impacted wildlife.
- It is estimated that an oiled wildlife response would be between Level 1 and 3, as defined in the NT OWRP (AMOSC, 2019).

Table 5-4: Key at-risk species potentially in open ocean waters

Species	Open ocean
Marine turtles (including foraging and inter-nesting areas and significant nesting beaches)	x
Whale sharks	✓
Seabirds and/or migratory shorebirds	✓
Cetaceans – migratory whales	✓
Cetaceans – dolphins and porpoises	✓
Dugongs	x
Sharks and rays	✓

The oiled wildlife response technique targets key wildlife populations at risk within Commonwealth open waters and the nearshore waters as described in Section 4 of the EP. Responding to oiled wildlife consists of nine key stages, as described in Table 5-5.

Table 5-5: Oiled wildlife response stages per NT OWRP (AMOSC, 2019)

Stage	Description
Stage 1: Wildlife first strike response	IMT and Wildlife Division (WD) must: • Implement the measures within the NT OWRP (AMOSC, 2019) • Assess the situation as soon as possible • Provide advice to relevant agencies in relation to the wildlife assets at risk • Determine potential response level (1-6) • Determine WD Division Commander to determine and monitor the level of the response
Stage 2: Mobilisation of wildlife resources	OWR personnel, equipment and facilities mobilised for any event will be determined by the circumstances. IMT and WD will request the use of available OWR First Strike Kits from the equipment custodians.
Stage 3: Wildlife reconnaissance	Reconnaissance to ground-truth and identify potentially affected animals via aerial survey, vessel survey, shoreline survey
Stage 4: Prevention	Prevention of wildlife oiling is preferred outcome for a spill scenario. Methods include deterrence/hazing and pre-emptive capture.
Stage 5: Wildlife rescue and staging	Comprises different phases including: search and capture; stabilisation of oiled casualties; and transportation to oiled wildlife facilities.
Stage 6: Record keeping	Accurate and complete records are required for purposes of impact assessment, evaluation/ lessons learnt; and substantiation of any claims for compensation. Records must include: total number of animals affected; species; age; and origin.
Stage 7: Oiled wildlife response treatment facility	Treatment facilities comprise triage, washing and rehabilitation centres. No dedicated land-based facilities are currently established in the Northern Territory but the NT OWRP (AMOSC, 2019) identifies suitable facilities which may be used with the permission of the respective owners. Facilities may include sports clubs, showgrounds, ovals and warehouses. **90% of coastal land in the Northern Territory is Aboriginal Land thus consultation and permission for access will be required from the Aboriginal traditional owner groups.** A vessel-based 'on-water' facility may be required to enable stabilisation of oiled wildlife if transportation to a suitable treatment facility is >2 hours. Land-based staging sites are listed in Appendix A of the NT OSRP (AMOSC, 2019) which include: Wadeye, Darwin, Tiwi Islands, Black Point and Croker Island. These may need varying levels of modification prior to OWR use.
Stage 8: Wildlife rehabilitation	Comprises: triage, cleaning, rehabilitation, mortalities/ euthanising, and release and monitoring
Stage 9: Oiled wildlife response termination	Decision to demobilise the OWR will be undertaken in accordance with Woodside's EP and when the WD Commander considers that all wildlife affected by the spill have been treated accordingly. This decision will be made in consultation with the IC, Wildlife Adviser (WA), WD Commander and DEPWS Wildlife Commander.

Reconnaissance and primary response would be done during operational monitoring and surveillance activities. Where marine fauna are observed on water or transiting near or within the spill area, observations would be recorded through surveillance records.

Staging sites would be established as forward bases for vessel-based field teams. Once recovered to a staging site, wildlife would be transported to the designated oiled wildlife facility or a temporary holding centre (before being transported to the oiled wildlife facility). Temporary holding centres are required when there is significant distance between a staging site and the oiled wildlife facility to enable stabilisation of oiled animals. The oiled wildlife facility is the primary location where animals would be housed and treated. Sites proposed for staging a regional oiled wildlife response in Wadeye, Darwin, Tiwi Islands, Black Point and Croker Island have been identified in the NT OWRP (AMOSC, 2019). These may need varying levels of modification prior to OWR use.

To deploy a response that is appropriate to the nature and scale of the event, as well as scalable over time, Woodside would implement an oiled wildlife response in consultation with DEPWS and use the capability outlined in the NT OWRP (AMOSC, 2019), with additional capability if required (e.g. volunteers) accessible through Woodside's *People and Global Capability Surge Labour Requirement Plan*.

The NT OWRP (AMOSC, 2019) provides indicative oiled wildlife response levels (Table 5-6) and the resources likely to be needed at each increasing level of response (Table 5-7).

Table 5-6: Indicative oiled wildlife response level (adapted from the NT OWRP, 2019)

OWRP Level	Duration of OWR	Birds general	Birds complex*	Dolphins/ whales	Pinnipeds/ dugongs	Mammals terrestrial
Level 1	< 3 days	1 to 2/day or < 5 total	No complex birds	None	None	None
Level 2	> 4 to 14 days	1 to 5/day or < 20 total	No complex birds	None	None	None
Level 3	> 4 to 14 days	5 to 10/day or < 50 total	1 to 5/day or < 10 total	None	< 5 seals	<5
Level 4	> 14 days	5 to 10/day or < 200 total	5 to 10/day	< 5, or known habitats affected	5 to 50 seals	5-50 mammals
Level 5	> 14 days	10 to 100/day or > 200 total	10 to 50/day	> 5 dolphins	> 50 seals	> 50 mammals
Level 6	> 14 days	> 100/day	10 to 50/day	> 5 dolphins	> 50 seals	> 50 mammals
*Threatened species, protected by treaty, or special feeders						

Table 5-7: NT OWR response level and personnel numbers (adapted from the NT OWRP (AMOSC, 2019)

<table>
<tr><th>Category</th><th>Role</th><th>Level 1</th><th>Level 2</th><th>Level 3</th><th>Level 4</th><th>Level 5</th><th>Level 6</th></tr>
<tr><td rowspan="11">Strategic</td><td>Oiled Wildlife Advisor</td><td>1^{+1}</td><td>1^{+1}</td><td>1^{+1}</td><td>1^{+1}</td><td>1^{+1}</td><td>1^{+1}</td></tr>
<tr><td>WD Coordinator**</td><td rowspan="10"></td><td rowspan="5">1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Operations Officer**</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Logistics Officer**</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Planning Officer</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Finance/ Admin Officer</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Communications Officer</td><td rowspan="5">1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Situation Officer</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Supply/ Resource Officer</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Safety Officer</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Volunteer Coordinator</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td rowspan="6">Staging Area Facilities</td><td>Wildlife Staging Manager</td><td rowspan="6">1</td><td rowspan="6">1</td><td>1</td><td>1</td><td>2</td><td>2</td></tr>
<tr><td>Wildlife Staging Area/ Intake Team</td><td>3</td><td>3</td><td>6</td><td>8</td></tr>
<tr><td>Wildlife Facilities Manager</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Trades Assistants</td><td>1</td><td>2</td><td>3</td><td>3</td></tr>
<tr><td>Wildlife Housekeeper</td><td>1</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>Wildlife Security</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td rowspan="5">Reconnaissance</td><td>Wildlife Reconnaissance Officer</td><td rowspan="5">1</td><td rowspan="5">1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Aviation Supervisor</td><td rowspan="3">1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Vessel Supervisor</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Shoreline Supervisor</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Reconnaissance Team</td><td>2</td><td>4</td><td>6</td><td>8</td></tr>
<tr><td rowspan="4">Rescue</td><td>Wildlife Rescue Officer</td><td rowspan="4">2</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Exposure Modification Officer</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Field Collection Team</td><td>3</td><td>6</td><td>9</td><td>22</td><td>22</td></tr>
<tr><td>Wildlife Transport Officer</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td rowspan="9">Rehabilitation</td><td>Triage Officer</td><td rowspan="9">2</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Triage Team</td><td>1</td><td>4</td><td>5</td><td>5</td><td>6</td></tr>
<tr><td>Wildlife Veterinarian*</td><td rowspan="2">1</td><td>1</td><td>3</td><td>3</td><td>3</td></tr>
<tr><td>Wildlife Veterinarian Technician*</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Stabilisation Officer</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Wildlife Rehabilitation Officer</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Facilities Team</td><td>3</td><td>4</td><td>6</td><td>8</td><td>8</td></tr>
<tr><td>Washing/ drying personnel</td><td>4</td><td>6</td><td>10</td><td>15</td><td>15</td></tr>
<tr><td>Recovery/ release personnel***</td><td>3</td><td>8</td><td>10</td><td>20</td><td>20</td></tr>
<tr><td colspan="2">Total number of personnel</td><td>7</td><td>26</td><td>59</td><td>78</td><td>116</td><td>122</td></tr>
<tr><td colspan="2">Notes</td><td colspan="6">* 1 person per facility/ ** may have deputy
1^{+1} = in an industry spill there may be two oiled wildlife advisors (1 Territory and 1 industry)</td></tr>
</table>

5.3.2 Environmental performance based on need

Table 5-8: Environmental performance – oiled wildlife response

Environmental Performance Outcome		Oiled Wildlife Response is conducted in accordance with the Northern Territory Oiled Wildlife Response Plan (NT OWRP) (AMOSC, 2019) to ensure it is conducted in accordance with legislative requirements of the Northern Territory (see Table 5-3)		
Control measure		**Performance Standard**		**Measurement Criteria (Section 5.7)**
9	Wildlife response equipment	9.1	Contracted capability to treat 100 individual fauna for immediate mobilisation	1, 3A, 3B, 3C, 4
		9.2	Contracted capability to treat up to an additional 250 individual fauna within a five-day period.	
		9.3	National plan access to additional resources under the guidance of the DEPWS (up to a Level 3 oiled wildlife response as specified in the NT OWRP), with the ability to treat about 600 individual fauna by the time hydrocarbons contact the shoreline.	1, 3C, 4
		9.4	Vessels used in hazing/pre-emptive capture will approach fauna at slow speeds to ensure animals are not directed towards the hydrocarbons.	1, 3A, 3B, 4
		9.5	Facilities for the rehabilitation of oiled wildlife are operational 24/7 as per NT OWRP.	1, 3A, 4
10	Wildlife responders	10.1	Two Oiled Wildlife Response Team Members to undertake oiled wildlife operations who have completed an Oiled Wildlife Response Management course	1, 2, 3B
		10.2	Wildlife responders to be accessed through resource pool and additional agreements with specialist providers	1, 2, 3A, 3B, 3C, 4
		10.3	Oiled wildlife operations (including hazing) would be implemented with advice and assistance from the Oiled Wildlife Advisor from the DEPWS and in accordance with the processes and methodologies described in the NT OWRP and the relevant regional plan.	1
		10.4	Open communication line to be maintained between IMT and infield operations to ensure awareness of progress against plan(s)	1, 3A, 3B
11	Management of environmental impact of the response risks	11.1	All oiled wildlife response sites zoned and marked before operations commence to prevent secondary contamination and minimise the mixing of clean and oiled waste.	1, 3A, 3B

The resulting wildlife response capability has been assessed against the WCCS. The range of techniques provide an ongoing approach to response if operational monitoring predicts any RPAs will be impacted.

- Under optimal conditions, during the subsea or surface release the capability available meets the need identified.
- It indicates that the wildlife response capability has the following expected performance:
  - Mobilisation and deployment of approximately two wildlife collection teams by week one for an open ocean response.
  - Mobilisation and deployment of one central wildlife treatment and rehabilitation centre at a suitable location in accordance with NT OWRP (AMOSC, 2019).

Wildlife collection operations are not predicted to be required based on modelling results indicating that no shoreline impact at threshold levels will occur. In the event of a spill, one oiled wildlife response team will maintain contact with personnel managing the operational monitoring response.

The oiled wildlife response team will remain on standby for mobilisation and deployment in the event that oiled wildlife are observed.

Woodside would establish a wildlife collection point at the response location identified for oiled wildlife collection and sorting. From these locations, recovered wildlife would be transported to a central treatment location, as listed in the NT OWRP (AMOSC, 2019) which include: Wadeye, Darwin, Tiwi Islands, Black Point and Croker Island.

5.4 Waste management

Waste management is considered a support technique to wildlife response. Waste generated and collected during the response that will require handling, management and disposal may consist of:

- liquids (hydrocarbons and contaminated liquids) collected during wildlife response, and/or
- solids/semi-solids (oily solids, garbage, contaminated materials) and debris (e.g. seaweed, sand, woods, and plastics) collected during wildlife response.

Expected waste volumes during an event are likely to vary depending on oil type, volume released, response techniques employed and how weathering of hydrocarbons. Waste management, handling and capacity should be scalable to ensure continuous response operations can be maintained.

All waste management activities will follow the *Northern Territory Waste Management and Pollution Control Act 1998* and the waste will be managed to minimise final disposal volumes. Waste treatment techniques will consider contaminated solids treatment to allow disposal to landfill and solids with high concentrations of hydrocarbon will be treated and recycled where possible or used in clean fill if suitable.

The waste products would be transported from response locations to the nearest suitable staging area/waste transfer station for treatment, disposal or recycling. Waste will be transferred with appropriately licensed vehicles. Containers will be available for temporary waste storage and will be:

- labelled with the waste type
- provided with appropriate lids to prevent waste being blown overboard
- bunded if storing liquid wastes.
- processes will be in place for transfers of bulk liquid wastes and include:
  - inspection of transfer hose undertaken prior to transfer
  - watchman equipped with radio visually monitors loading hose during transfer
  - tank gauges monitored throughout operation to prevent overflow.

The *Oil Spill Preparedness Waste Management Support Plan* details the procedures, capability and capacity in place between Woodside and its primary waste services contractor to manage waste volumes generated from response activities.

5.4.1 Response need based on predicted consequence parameters

Modelling predicts that there will be no floating oil at recoverable threshold concentrations and no shoreline impact at feasible clean-up threshold concentrations, thus the only waste management consideration will be for oiled wildlife response.

Table 5-7: Response Planning Assumptions – Waste Management

Response planning assumptiopns: Waste management	
Waste loading per m^3 oil recovered (multiplier)	Oiled wildlife response – approximately 1 m^3 of oily liquid waste generated for each wildlife unit cleaned.

5.4.2 Environmental performance based on need

Table 5-8: Environmental Performance – Waste Management

Environmental Performance Outcome		To minimise further impacts, waste will be managed, tracked and disposed of in accordance with laws and regulations.		
Control measure		**Performance Standard**		**Measurement Criteria (Section 5.7)**
12	Waste management	12.1	Contract with waste management services for transport, removal, treatment and disposal of waste.	1, 3A, 3B, 3C, 4
		12.2	Recovered hydrocarbons and wastes will be transferred to licensed treatment facility for reprocessing or disposal.	
		12.3	Teams will segregate liquid and solid wastes at the earliest opportunity.	
		12.4	Waste management provider support staff available year-round to assist in the event of an incident with waste management as detailed in contract.	
		12.5	Open communication line to be maintained between IMT and waste management services to ensure the reliable flow of accurate information between parties.	1, 3A, 3B
		12.6	Waste management to be conducted in accordance with Australian laws and regulations.	1, 3A, 3B, 3C, 4
		12.7	Waste management services available and employed during response.	

The resulting waste management capability has been assessed against the WCCS. The range of techniques provide an ongoing approach to waste management at identified RPAs.

Given that modelling predicts that there will be no floating oil at recoverable threshold concentrations and no shoreline impact at feasible clean-up threshold concentrations, the only waste management requirements will be for oiled wildlife response and the capability available therefore exceeds the need identified.

- Woodside's waste service provider in the Northern Territory can provide immediate access to capacity to treat up to 120 m^3 waste. Additional waste storage can be accessed via third-party OSR service providers in the region. The waste management requirements are within Woodside's and its service providers' existing capacity.
- Woodside has assessed the existing capability available and considered potential alternative, additional and improved control measures. Where control measures have been selected and implemented, they are included in Section 6.4.
- The health and safety, financial, capital and operations/maintenance costs of implementing the alternative, additional or improved control measures identified and not carried forward are considered clearly disproportionate to the environmental benefit gained and/or not reasonably practicable for this activity.
- The waste management capability outlined in this section is part of the response developed to manage potential risks and impacts associated with the scenarios to ALARP, and there are no further additional, alternative and improved control measures other than those implemented that would provide further benefit.

5.5 Scientific monitoring

A scientific monitoring program (SMP) would be activated following a Level 2 or 3 unplanned hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors. This would consider receptors at risk (ecological and socio-economic) for the entire predicted Environment that Maybe Affected (EMBA) and in particular, any identified Pre-emptive Baseline Areas (PBAs) for the credible spill scenario(s) or other identified unplanned hydrocarbon releases associated with the activity (refer to Table 2-1 Activity credible spill scenarios and Table 4-1 WCCS).

The outputs of the stochastic hydrocarbon spill modelling were used to assess the environmental risk of the hydrocarbon affected area as delineated by the ecological impact EMBA and social-cultural EMBA based on exceedance of environmental and social-cultural hydrocarbon threshold concentrations (refer to Table 2-2, Section 2.3.1.1 and see Section 6 of the EP for further information on applicable thresholds and the EMBAs). The Petroleum Activities Program vessel collision marine diesel spills (CS-01 and CS-02) scenario (CS-01) have been modelled and considered to determine the WCCS for the SMP planning purposes and is the basis of the SMP approach presented in this section.

It should be noted that the resulting SMP receptor locations may differ from the Response Protection Areas (RPAs) as discussed in Section 3 of this document due to the applicability of different hydrocarbon threshold levels. The SMP would be informed by the data collected via the operational monitoring program (OMP) studies, however, it differs from the OMP in being a long-term program independent of, and not directing, the operational oil spill response or monitoring of impacts from response activities (refer to Section 5.1 Monitor and Evaluate) for the operational monitoring overview.

Key objectives of the Woodside oil spill scientific monitoring program are:

- Assess the extent, severity and persistence of the environmental impacts from the spill event.
- Monitor subsequent recovery of impacted key species, habitats and ecosystems.

The SMP comprises ten targeted environmental monitoring programs to assess the condition of a range of physical-chemical (water and sediment) and biological (species and habitats) receptors including Environment Protection and Biodiversity Conservation Act (EPBC Act 1999) listed species, environmental values associated with protected areas and socio-economic values, such as fisheries. The ten SMPs are as follows:

- SM01 – Assessment of the presence, quantity and character of hydrocarbons in marine waters (linked to OM01 to OM03)
- SM02 – Assessment of the presence, quantity and character of hydrocarbons in marine sediments (linked to OM01 and OM05)
- SM03 – Assessment of impacts and recovery of subtidal and intertidal benthos
- SM04 – Assessment of impacts and recovery of mangroves/saltmarsh habitat
- SM05 – Assessment of impacts and recovery of seabird and shorebird populations
- SM06 – Assessment of impacts and recovery of nesting marine turtle populations
- SM07 – Assessment of impacts to pinniped colonies including haul-out site populations
- SM08 – Desktop assessment of impacts to other non-avian marine megafauna
- SM09 – Assessment of impacts and recovery of marine fish (linked to SM03)
- SM10 – Assessment of physiological impacts to important fish and shellfish species (fish health and seafood quality/safety) and recovery.

These SMPs have been designed to cover all key tropical and temperate habitats and species within Australian waters and broader, if required. A planning area for scientific monitoring is also identified to acknowledge potential hydrocarbon contact below the environmental threshold concentrations and beyond the EMBA. This planning area has been set with reference to the entrained low exposure value of 10 ppb detailed in NOPSEMA Bulletin #1 Oil Spill Modelling (2019), as shown in Figure 5-1.

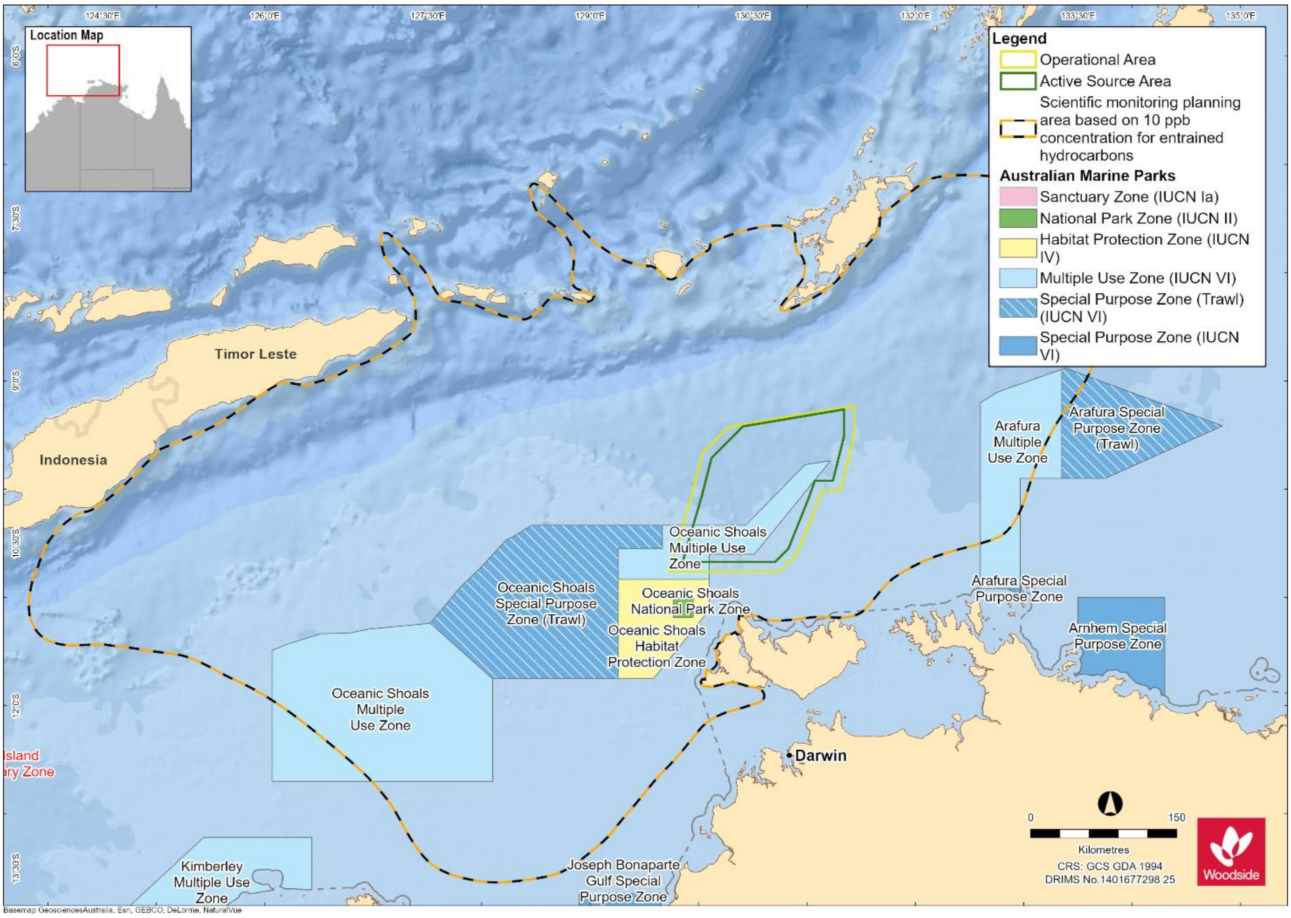


Figure 5-1: The planning area for scientific monitoring based on the area potentially contacted by the low (below ecological impact) entrained hydrocarbon threshold of 10 ppb in the event of the credible spill scenario (CS-01 and CS02).

NOTE: Figure 5-1 represents the overall combined extent of the oil spill model outputs based on a total of 100 replicate simulations over an annual period for CS-01 and CS-02 and therefore represents the largest spatial boundaries of 200 oil spill combinations, and not the spatial extent of a single spill.

5.5.1 Scientific monitoring deployment considerations

Scientific Monitoring Deployment Considerations	
Existing baseline studies for sensitive receptor locations predicted to be affected by a spill	Pre-emptive Baseline Areas (PBAs) of the following two categories: • PBAs within the predicted < 10-day hydrocarbon contact time prediction: As part of this assessment, the approach was to conduct a desktop review of available and appropriate baseline data for key receptors for locations (if any) that are potentially impacted within ten days of a spill (based on the EMBA). Then investigate the need to conduct baseline data collection to address data gaps and demonstrate spill response preparedness (refer to Annex D). In the scenario, that baseline data needs are identified, planning for baseline data acquisition is typically commenced pre-PAP and execution of studies undertaken with consideration of weather, receptor type, seasonality and temporal assessment requirements. • PBAs predicted > 10 days' time to predicted hydrocarbon contact in the event of an unplanned hydrocarbon release (for the worse case spill scenarios). As part of this assessment, a desktop review is conducted of available and appropriate baseline data for key receptors for locations (if any) that are potentially impacted >10 days' time of a hydrocarbon spill event and documented (refer to Section 5.5.2). In the event of a spill, the SMP activation (as per the Galactic Hybrid Marine Seismic Survey First Strike Plan) directs the SMP team to follow the steps outlined in the SMP Operational Plan. The steps include: checking the availability and type of existing baseline data, with particular reference to any Pre-emptive Baseline Areas (PBAs) identified as >10 days to hydrocarbon contact. Such information is used to identify response phase PBAs and plan for the activation of SMPs for pre-emptive (i.e. pre-hydrocarbon contact) baseline assessment.
Pre-emptive Baseline in the event of a spill	Activation of SMPs in order to collect baseline data at sensitive receptor locations with predicted hydrocarbon contact time > 10 days (refer to Section 5.5.2) and the process (as documented in ANNEX C: Oil Spill Scientific Monitoring Program).
Survey platform suitability and availability	In the event of the SMP activation, suitable survey platforms are available and can support the range of equipment and data collection methodologies to be implemented in nearshore and offshore marine environments.
Trained personnel to implement SMPs suitable and available	Access to trained personnel and the sampling equipment contracted for scientific monitoring via a dedicated scientific monitoring program standby contract.
Met-ocean conditions	The following met-ocean conditions have been identified as the field operational limits for implementing SMPs: • waves < 1 m for nearshore systems • waves < 1.5 m for offshore systems • winds < 20 knots • daylight operations only. SMP implementation will be planned and managed according to HSE risk reviews and the met-ocean conditions on a day to day basis by SMP operations.

5.5.2 Response planning assumptions

Response Planning Assumptions	
Pre-emptive Baseline Areas (PBAs)	Pre-emptive Baseline Areas (PBAs) identified through the application of defined hydrocarbon impact thresholds during the Quantitative Spill Risk Assessment process and a consideration of the minimum time to contact at receptor locations fall into two categories: • PBAs for which baseline data exist or are planned for and data collection may commence pre-activity (≤ 10 days minimum time to contact), where identified as a gap. • PBAs (> 10 days minimum time to contact) for which baseline data may be collected in the event of an unplanned hydrocarbon release. In the event of a spill, response phase PBAs are prioritised for SMP activities based on vulnerability (i.e. time to contact and environmental sensitivity) and potential impacts from hydrocarbon contact and as well as the identified need to acquire baseline data. Time to hydrocarbon contact of > 10 days has been identified as a minimum timeframe within which it is feasible to plan and mobilise applicable SMPs and commence collection of baseline (pre-hydrocarbon contact) data, in the event of an unplanned hydrocarbon release from the Galactic Hybrid Marine Seismic Survey operations. Pre-emptive Baseline Areas for the Galactic Hybrid Marine Seismic Survey operations are identified and listed in ANNEX D: Monitoring Program and Baseline Studies for the Petroleum Activities Program, Table D-1. The PBAs together with the situational awareness (from the operational monitoring) are the basis for the response phase SMP planning and implementation.
Pre-spill	A review of existing baseline data for receptor locations (refer to ANNEX D) with potential to be contacted by entrained hydrocarbons at or above environmental thresholds within ≤ 10 days, relating to the WCCS CS-01 and CS-02 (release of Marine Diesel due to vessel collision) for the Galactic Hybrid Marine Seismic Survey has identified the following: • Lynedoch Bank • Oceanic Shoals • Goodrich Bank • Marie Shoal • Blackwood Shoal • Evans Shoal • Tassie Shoal • Flinders Shoal • Franklin Shoal • Margaret Harris Shoal • The Boxers All the Australian Marine Parks (AMPs) are located in offshore waters where hydrocarbon exposure is possible on surface waters and in the upper layers of the water column. • Oceanic Shoals

<table>
<tr><th colspan="2">Response Planning Assumptions</th></tr>
<tr><td>In the Event of a Spill</td><td>Receptor locations with > 10 days to hydrocarbon contact, as well as the wider area, will be investigated and identified by the SMP team (in the Environment Unit of the ICC) as the spill event unfolds and as the situational awareness provided by the OMPs permits delineation of the spill affected area (for example, updates to the spill trajectory tracking). The full list is presented in ANNEX D: Monitoring Program and Baseline Studies for the Petroleum Activities Program, based on the activity credible spill scenario(s) (Table 2-1).

To address the initial focus in a response phase SMP planning situation, receptor locations predicted to be contacted between > 10 days have been identified as follows:
• Mermaid Shoal
• Troubadour Shoals

The unfolding spill affected area predictions and confirmation of appropriate baseline data will determine the selection of receptor locations and SMPs to be activated in order to gather pre-emptive (pre-hydrocarbon contact) data. The timing of SMP activation and mobilisation of the individual SMPs to undertake data collection will be decided and documented by the Woodside SMP team following the process outlined in the SMP Operational Plan.

In the event key receptors within geographic locations that are potentially impacted after 10 days following a spill event or commencement of the spill and where adequate and appropriate baseline data is not available, there will be a response phase effort to collect baseline data for the following purposes:
i. Priority will be given to the collection of baseline data for receptors predicted to be within the spill affected area prior to hydrocarbon contact. The process is initiated with the investigation of available baseline and time to hydrocarbon contact (> 10 days which is sufficient time to mobilise SMP teams and acquire data before hydrocarbon contact). With reference to the Galactic Hybrid Marine Seismic Survey operations, priority would be focused on Mermaid Shoal.
ii. Highly sensitive and/or valued habitats and communities of the shoals will be prioritised for pre-emptive baseline surveys over open water areas of AMPs.
iii. Collect baseline data for receptors predicted to be outside the spill affected area so reference datasets for comparative analysis with impacted receptor types can be assessed post-spill.</td></tr>
<tr><td>Baseline Data</td><td>A summary of the spill affected area and receptor locations as defined by the EMBA for the activity WCCS CS-01 and CS-02 are presented Section 2.3.1.

The key receptors at risk by location and corresponding SMPs based on the EMBA for the activity are presented in ANNEX D, Table D1. This matrix maps the receptors at risk with their location and the applicable SMPs that may be triggered in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors. Receptor locations and applicable SMPs are colour coded to highlight possible time to contact based on receptor locations identified as PBAs.

The status of baseline studies relevant to the activity are tracked by Woodside through the maintenance of a Corporate Environment Environmental Baseline Database (managed by the Woodside Environmental Science team), as well as accessing external databases such as the Department of Water and Environmental Regulation (WA) Index of Marine Surveys for Assessment (IMSA)[4] (refer to ANNEX C: Oil Spill Scientific Monitoring Program).</td></tr>
</table>

5.5.3 Summary – scientific monitoring

The resulting scientific monitoring capability has been assessed against the activity credible spill scenario. The range of techniques provide an ongoing approach to monitoring operations to assess and evaluate the scale and extent of impacts. All known reasonably practicable control measures have been adopted with the cost and organisational complexity of these options determined to be moderate and the overall delivery effectiveness determined to be medium. The SMP's main objectives can be met, with no additional, alternative or improved control measures providing further benefit.

[4] https://biocollect.ala.org.au/imsa#max%3D20%26sort%3DdateCreatedSort

5.5.4 Response planning: need, capability and gap – scientific monitoring

The receptor locations identified in ANNEX D: Monitoring Program and Baseline Studies for the Petroleum Activities Program provide the basis of the SMPs likely to be selected and activated. Once the Woodside SMP Delivery team and the SMP standby contractor have been stood up and the exact nature and scale of the spill becomes known, the SMPs to be activated will be confirmed as per the process set out in the SMP Operational Plan.

Scope of SMP Operations in the event of a hydrocarbon spill:

Receptor locations of interest for the SMP during the response phase are:

- Any shoal or bank with predicted hydrocarbon contact <10 days (such as the Oceanic shoals)
- Any shoal or bank with predicted hydrocarbon contact >10 days (such as Mermaid Shoal and Troubadour Shoals) with preference to target Mermaid, as closest to coastal sensitivities.

Documented baseline studies are available for the shoal and bank receptor locations including Lynedoch Bank and the Oceanic shoals (ANNEX D: Monitoring Program and Baseline Studies for the Petroleum Activities Program, Table D-2). The SMP technique; however, would still deploy SMP teams to maximise the opportunity to collect pre-emptive data at sensitive receptor locations, potentially locations such as Mermaid Shoal not immediately exposed to hydrocarbons. The exact locations where hydrocarbon contact occurs may be unpredictable, SM01 would be mobilised as a priority to be able to detect hydrocarbons and track the leading edge of the spill to verify where hydrocarbon contact occurs which will assist with where SMP resources are prioritised to obtain pre-emptive baseline data.

The ALARP assessment for the SMP (Section 6.4) considers alternate, additional, and/or improved control measures on each selected response technique.

5.5.5 Environmental performance based on need

Table 5-9: Scientific monitoring

Environmental Performance Outcome		Woodside can demonstrate preparedness to stand up the SMP to quantitatively assess and report on the extent, severity, persistence and recovery of sensitive receptors impacted from the spill event		
Control measure		Performance Standard	Measurement Criteria	
13	• Woodside has an established and dedicated SMP team comprising the Environmental Science Team and additional Environment Advisers within the HSE Function.	13.1	SMP team comprises a pool of competent Environment Advisers (stand up personnel) who receive training regarding the SMP, SMP activation and implementation of the SMP on an annual basis	• Training materials. • Training attendance registers. • Process that maps minimum qualification and experience with key SMP role competency and a tracker to manage availability of competent people for the SMP team including redundancy and rostering.
14	• Woodside has a SMP standby contractor to provide scientific personnel to resource a base capability of one team per SMP (SM01 to SM10, see ANNEX C: Oil Spill Scientific Monitoring Program, Table C-2) as detailed in Woodside's SMP standby contractor Implementation Plan, to implement the oil spill scientific monitoring programs. The availability of relevant personnel is reported to Woodside on a monthly basis via a simple report on the base-loading availability of people for each of the SMPs comprising field work for data collection (SMP resourcing report register). • In the event of a spill and the SMP is activated, the base-loading availability of scientific personnel will be provided by SMP standby contractor for the individual SMPs and where gaps in resources are identified, SMP standby contractor/Woodside will seek additional personnel (if needed) from other sources including Woodside's Environmental Services Panel.	14.1	Woodside maintains the capability to mobilise personnel required to conduct scientific monitoring programs SM01 to SM10 (except desktop based SM08): • Personnel are sourced through the existing standby contract with SMP standby contractor, as detailed within the SMP Implementation Plan. • Scientific Monitoring Program Implementation Plan describes the process for standing up and implementing the scientific monitoring programs. • SMP team stand up personnel receive training regarding the stand up, activation and implementation of the SMP on an annual basis.	• OSPU Internal Control Environment tracks the quarterly review of the Oil Spill Contracts Master. • SMP resource report of personnel availability provided by SMP contractor on monthly basis (SMP resourcing report register). • Training materials. • Training attendance registers. • Competency criteria for SMP roles. • SMP annual arrangement testing and reporting.
15	• Roles and responsibilities for SMP implementation are captured in ANNEX C: Oil Spill Scientific Monitoring Program (Table C-1) and the SMP team (as per the organisational structure of the ICC) is outlined in SMP Operational Plan. Woodside has a defined Crisis and Incident Management structure including Source Control, Operations, Planning and Logistics functions to manage a loss of well control response. • SMP Team structure, interface with SMP standby contractor (standby SMP contractor) and linkage to the ICC is presented in ANNEX C: Oil Spill Scientific Monitoring Program, Figure C-1. • Woodside has a defined Command, Control and Coordination structure for Incident and Emergency Management that is based on the AIIMS framework utilised in Australia. • Woodside utilises an online Incident Management Information System (IMIS) to coordinate and track key incident management functions. This includes specialist modelling programs, geographic information systems (GIS), as well as communication flows within the Command, Control and Coordination structure. • SMP activated via the First Strike Plan • Step by step process to activation of individual SMPs provided in the SMP Operational Plan • All decisions made regarding SMP logged in the online IMS (SMP team members trained in using Woodside's online Incident Management System) • SMP component input to the ICC Incident Action Plan (IAP) as per the identified ICC timed sessions and the SMP IAP logged on the online IMIS. • Woodside Environmental Science Team provide awareness training on the activation and stand-up of the Scientific Monitoring Programme (SMP) for the Environment Advisers in Woodside who are listed on the SMP team on an annual basis. • Woodside Environmental Science Team provide awareness training on the activation and stand-up of the Scientific Monitoring Program (SMP) for the SMP standby provider. • Woodside Environmental Science Team co-ordinates an annual SMP arrangement testing exercise which the SMP standby contractor. SMP standby contractor the SMP arrangements (people and equipment availability) tested annually since 2016.	15.1	• Woodside has established an SMP organisational structure and processes to stand up and deliver the SMP.	• SMP Oil Spill Scientific Monitoring Operational Plan. • SMP Implementation Plan. • SMP annual arrangement testing and reporting.

Environmental Performance Outcome		Woodside can demonstrate preparedness to stand up the SMP to quantitatively assess and report on the extent, severity, persistence and recovery of sensitive receptors impacted from the spill event		
Control measure		**Performance Standard**	**Measurement Criteria**	
16	• Chartered and mutual aid vessels. • Suitable vessels would be secured from the Woodside support vessels, regional fleet of vessels operated by Woodside and other operators and the regional charter market. • Vessel suitability will be guided by the need to be equipped to operate grab samplers, drop camera systems and water sampling equipment (the individual vessel requirements are outlined in the relevant SMP methodologies (refer to ANNEX C: Oil Spill Scientific Monitoring Program, Table C-2). • Nearshore mainland waters could use the same approach as for open water. Smaller vessels may be used where available and appropriate. Suitable vehicles and machinery for onshore access to nearshore SMP locations would be provided by Woodside's transport services contract and sourced from the wider market. • Dedicated survey equipment requirements for scientific monitoring range from remote towed video and drop camera systems to capture seabed images of benthic communities to intertidal/onshore surveying tools such as quadrats, theodolites and spades/trowels, cameras and binoculars (specific survey equipment requirements are outlined in the relevant SMP methodologies (refer to ANNEX C: Oil Spill Scientific Monitoring Program, Table C-2)). Equipment would be sourced through the existing SMP standby contract with SMP standby contractor for SMP resources and if additional surge capacity is required this would be available through the other Woodside Environmental Services Panel Contractors and specialist contractors. SMP standby contractor can also address equipment redundancy through either individual or multiple suppliers. MoUs are in place with one marine sampling equipment companies and one analytical laboratory (SMP resourcing report register). • Availability of SMP equipment for offshore/onshore scientific monitoring team mobilisation is within one week to ten days of the commencement of a hydrocarbon release. This meets the SMP mobilisation lead time that will support meeting the response objective of 'acquire, where practicable, the environmental baseline data prior to hydrocarbon contact required to support the post-response SMP.	16.1	Woodside maintains standby SMP capability to mobilise equipment required to conduct scientific monitoring programs SM01 to SM10 (except desktop based SM08): • Equipment is sourced through the existing standby contract with SMP standby contractor, as detailed within the SMP Implementation Plan.	• OSPU Internal Control Environment tracks the quarterly review of the Oil Spill Contracts Master. • SMP standby monthly resource reports of equipment availability provided by SMP contractor (SMP resourcing report register). • SMP annual arrangement testing and reporting.
17	Woodside's SMP approach addresses the pre-activity acquisition of baseline data for Pre-emptive Baseline Areas (PBAs) with ≤ 10 days if required following a baseline gap analysis process. Woodside maintains knowledge of Environmental Baseline data through: • Documentation of annual reviews of the Woodside Baseline Environmental Studies Database, and any specific activity baseline gap analyses. • Accessing external databases such as the Department of Water and Environmental Regulation (WA) Index of Marine Surveys for Assessment (IMSA) (refer to ANNEX C: Oil Spill Scientific Monitoring Program.	17.1	• Annual reviews of environmental baseline data. • Activity specific Pre-emptive Baseline Area baseline gap analysis.	• Annual review/update of Woodside Baseline Environmental Studies Database. • Desktop review to assess the environmental baseline study gaps completed prior to EP submission. • Accessing baseline knowledge via the SMP annual arrangement testing.
Environmental Performance Outcome		SMP plan to acquire response phase monitoring targeting pre-emptive baseline data achieved		
Control measure		**Performance Standard**	**Measurement Criteria**	
18	Woodside's SMP approach addresses: • scientific data acquisition for PBAs > 10 days to hydrocarbon contact and activated in the response phase, and • transition into post-response SMP monitoring.	18.1	**Pre-emptive Baseline Area (PBA) baseline data acquisition in the response phase** If baseline data gaps are identified for PBAs predicted to have hydrocarbon contact in > 10 days, there will be a response phase effort to collect baseline data. Priority in implementing SMPs will be given to receptors where pre-emptive baseline data can be acquired or improved. SMP team (within the Environment Unit of the ICC) contribute SMP component of the ICC Planning Function in development of the IAP.	• Response SMP plan. • Woodside's online Incident Management System Records. • SMP component of the Incident Action Plan.
		15.2	**Post Spill contact** For the receptors contacted by the spill where baseline data is available, SMPs programs to assess and monitor receptor condition will be implemented post spill (i.e. after the response phase)	• SMP planning document. • SMP Decision Log. • Incident Action Plans (IAPs).

Environmental Performance Outcome		Woodside can demonstrate preparedness to stand up the SMP to quantitatively assess and report on the extent, severity, persistence and recovery of sensitive receptors impacted from the spill event		
Control measure		**Performance Standard**	**Measurement Criteria**	
Environmental Performance Outcome		Implementation of the SMP (response and post-response phases)		
Control measure		**Performance Standard**		**Measurement Criteria**
19	• Scientific monitoring will address quantitative assessment of environmental impacts of a level 2 or 3 spill or any release event with the potential to contact sensitive environmental receptors. The SMP comprises ten targeted environmental monitoring programs. • SMP supporting documentation: 1. Oil Spill Scientific Monitoring Operational Plan; (2) SMP Implementation Plan and (3) SMP Process and Methodologies Guideline. • The Oil Spill Scientific Monitoring Operational Plan details the process of SMP selection, input to the IAP to trigger operational logistic support services. Methodology documents for each of the ten SMPs are accessible detailing equipment, data collection techniques and the specifications required for the survey platform support. • The SMP standby contractor holds a Woodside SMP implementation plan detailing activation processes, linkage with the Woodside SMP team and the general principles for the planning and mobilisation of SMPs to deliver the individual SMPs activated. Monthly resourcing report are issued by the SMP standby contractor (SMP resourcing report register). All SMP documents and their status are tracked via SMP document register.	19.1	Implementation of SM01 SM01 will be implemented to assess the presence, quantity and character of hydrocarbons in marine waters during the spill event in nearshore areas	Evidence SM01 has been triggered: • Documentation as per requirements of the SMP Operational Plan. • Woodside's online Incident Management System Records. • SMP component of the IAP. • SMP data records from field.
		19.2	**Implementation of SM02-SM10** SM02-SM10 will be implemented in accordance with the objectives and activation triggers as per ANNEX C: Oil Spill Scientific Monitoring Program, Table C-2.	Evidence SMPs have been triggered: • Documentation as per requirements of the SMP Operational Plan. • Woodside's online Incident Management System Records. • SMP component of the IAP. • SMP Data records from field.
		19.3	**Termination of SMP plans** The Scientific Monitoring Program will be terminated in accordance with termination triggers for the SMP's detailed in ANNEX C: Oil Spill Scientific Monitoring Program, Table C-2, and the Termination Criteria Decision-tree for Oil Spill Environmental Monitoring (ANNEX C: Oil Spill Scientific Monitoring Program, Figure C-3)	Evidence of Termination Criteria triggered: • Documentation and approval by relevant stakeholders to end SMPs for specific receptor types.

5.6 Incident management system

The Incident Management System (IMS) is both a control measure and a measurement criterion. As a control measure the IMS function is to prompt, facilitate and record the completion of three key response planning processes detailed below. As a measurement criterion, the IMS records the evidence of the timeliness of all response actions included in the environmental performance standards and the plans used of the activity.

As the IMS does not directly remove hydrocarbons spilt into the marine environment there is no direct relationship to the response planning need.

5.6.1 Incident action planning

The ICC will be required to collect and interpret information from the scene of the incident to determine support requirements to the site-based IMT, develop an incident action plan (IAP) and assist the IMT with the execution of that plan. The site-based IC may request the ICC to complete notifications internally within Woodside, to stakeholders and government agencies as required. Depending on the type and scale of the incident either the ICC DM or IC will be responsible for ensuring the development of the IAP. Incident Action Planning is an ongoing process that involves continual review to ensure techniques to control the incident are appropriate to the situation at the time.

5.6.2 Operational NEBA process

In the event of a response, Woodside will confirm that the response techniques adopted at the time of Environment Plan/ Oil Pollution Emergency Plan (EP/ OPEP) acceptance remain appropriate to reduce the consequences of the spill. This process verifies that there is a continuing net environmental benefit associated with continuing the response technique through the operational NEBA process. The process also manages the environmental risks and impacts of response techniques during the spill response. An operational NEBA will be undertaken throughout the response, for each operational period.

The operational NEBA will consider the risks and benefits of conducting the response and the response activity. For example, if vessels are required for access to nearshore or onshore areas, anchoring locations will be selected to minimise disturbance to benthic habitats. Vessel cleanliness would be commensurate with the receiving environment. The operational NEBA will consider the risks and benefits of conducting other response techniques.

The operational NEBA process is also used to terminate a response. Using data from operational and scientific monitoring activities, the response to a hydrocarbon spill will be terminated in accordance with the termination process outlined in the Oil Pollution Emergency Arrangements (Australia). In effect the operational NEBA will determine whether there is a net environmental benefit to continue response operations.

5.6.3 Stakeholder engagement process

Woodside will ensure stakeholders are engaged during the spill response in accordance with internal standards. This process requires that Woodside will:

- Undertake all required notifications (including Aboriginal and Torres Strait Islander traditional landowners and government notifications) for stakeholders in the region (identified in the First Strike Plan). This includes notification to mariners to communicate navigational hazards introduced through response equipment and personnel.
- In the event of a response, identify and engage with relevant stakeholders and continually assess and review.

5.6.4 Environmental performance based on need

Table 5-10: Environmental performance – incident management system

Environmental Performance Outcome		To support the effectiveness of all other control measures and monitor/record the performance levels achieved.		
Control measure		**Performance Standard**		**Measurement Criteria (Section 5.7)**
20	Operational NEBA	20.1	Confirm that the response techniques adopted at the time of acceptance remain appropriate to reduce the consequences of the spill within 24 hours.	1, 3A
		20.2	Record the evidence and justification for any deviation from the planned response activities.	
		20.3	Record the information and data from operational and scientific monitoring activities used to inform the NEBA.	
21	Stakeholder engagement	21.1	Prompt and record that all notifications (including government notifications) for stakeholders in the region are made.	
		21.2	In the event of a response, identification of relevant stakeholders will be re-assessed throughout the response period.	
		21.3	Undertake communications in accordance with: • Woodside Crisis Management Functional Support Team Guideline – Reputation • External Communication and Continuous Disclosure Procedure • External Stakeholder Engagement Procedure	
22	Personnel required to support any response	22.1	Action planning is an ongoing process that involves continual review to ensure techniques to control the incident are appropriate to the situation at the time.	1, 3B
		22.2	A duty roster of trained and competent people will be maintained to ensure that minimum manning requirements are met all year round.	3C
		22.3	Immediately activate the IMT with personnel filling one or more of the following roles: • Operations Duty Manager • D&C Duty Manager • Operations Coordinator • Deputy Operations Coordinator • Planning Coordinator • Logistics (materials, aviation, marine and support positions) • Management Support • Health and Safety Advisor • Environment Duty Manager • People Coordinator • Public Information Coordinator • Intelligence Coordinator • Finance Coordinator.	1, 2, 3B, 3C, 4
		22.4	Collect and interpret information from the scene of the incident to determine support requirements to the site-based IMT, develop an Incident Action Plan (IAP) and assist with the execution of that plan.	
		22.5	S&EM advisors will be integrated into ICC to monitor performance of all functional roles.	

Environmental Performance Outcome		To support the effectiveness of all other control measures and monitor/record the performance levels achieved.		
Control measure		**Performance Standard**		**Measurement Criteria (Section 5.7)**
		22.6	Continually communicate the status of the spill and support Woodside to determine the most appropriate response by delivering on the responsibilities of their role.	
		22.7	Follow the OPEA, Operational Plans, FSPs, support plans and the IAPs developed.	1, 2, 3A, 4
		22.8	Contribute to Woodside's response in accordance with the aims and objectives set by the Duty Manager.	1, 2, 3B, 3C, 4

5.7 Measurement criteria for all response techniques

Woodside ensures compliance with environmental performance outcomes and standards through four primary mechanisms. The aforementioned performance tables identify which of these four mechanisms monitors the readiness and records the effectiveness and performance of the control measures adopted.

1. The Incident Management System

The (IMS supports the implementation of the Emergency and Crisis Management Procedure. The IMS provides a near real-time, single source of information for monitoring and recording an incident and measuring the performance of those control measures.

The Emergency and Crisis Management Procedure defines the management framework, including roles and responsibilities, to be applied to any size incident (including hydrocarbon spills). The organisational structure required to manage an incident is developed in a modular fashion and is based on the specific requirements of each incident. The structure can be scaled up or down.

The Incident Action Plan (IAP) process formally documents and communicated the:

- incident objectives
- status of assets
- operational period objectives
- response techniques (defined during response planning)
- effectiveness of response techniques.

The information captured in the IMS (including information from personal logs and assigned tasks/close outs) confirms the response techniques implemented remain appropriate to reduce the consequences of the spill. The system also records all information and data that can be used to support the site-based IMT, development and the execution of the IAP.

2. The S&EM Competency Dashboard

The S&EM competency dashboard records the number of trained and competent responders that are available across Woodside, and some external providers, to participate in a response.

This number varies depending on expiry of competency certificates, staff attrition, internal rotations, leave and other absences. As such the Dashboard is designed to identify the minimum manning requirements and to identify sufficient redundancy to cater for the variances listed above.

Figure 5-2 shows the minimum manning numbers for the different hydrocarbon spill response roles and the number of qualified persons against those roles.

Woodside's pool of trained responders is composed of but not limited to personnel from the following organisations:

- Woodside internal
- Australian Marine Oil Spill Centre (AMOSC) core group
- AMOSC
- Oil Spill Response Limited (OSRL)
- Marine Spill Response Corporation (MSRC)
- AMSA
- Woodside contracted workforce.

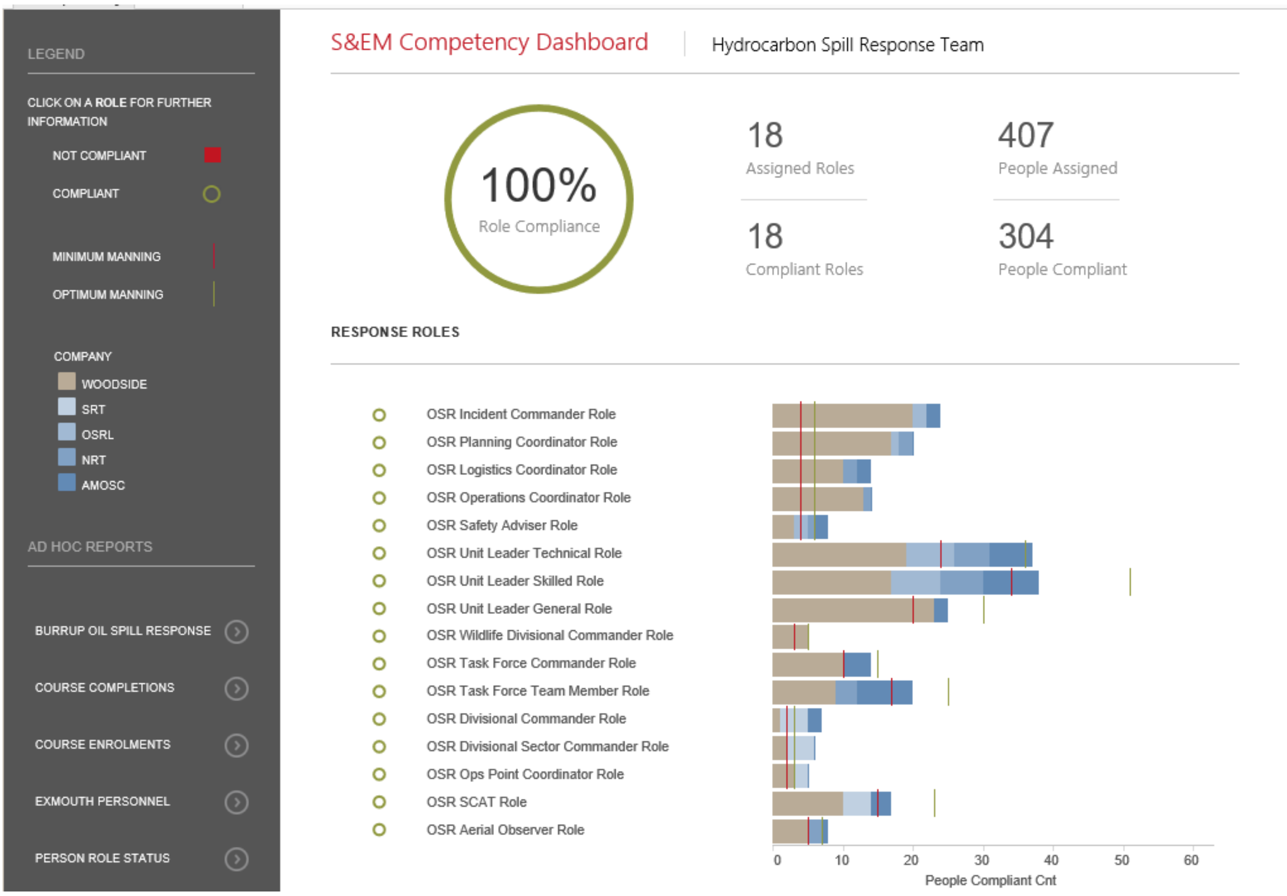
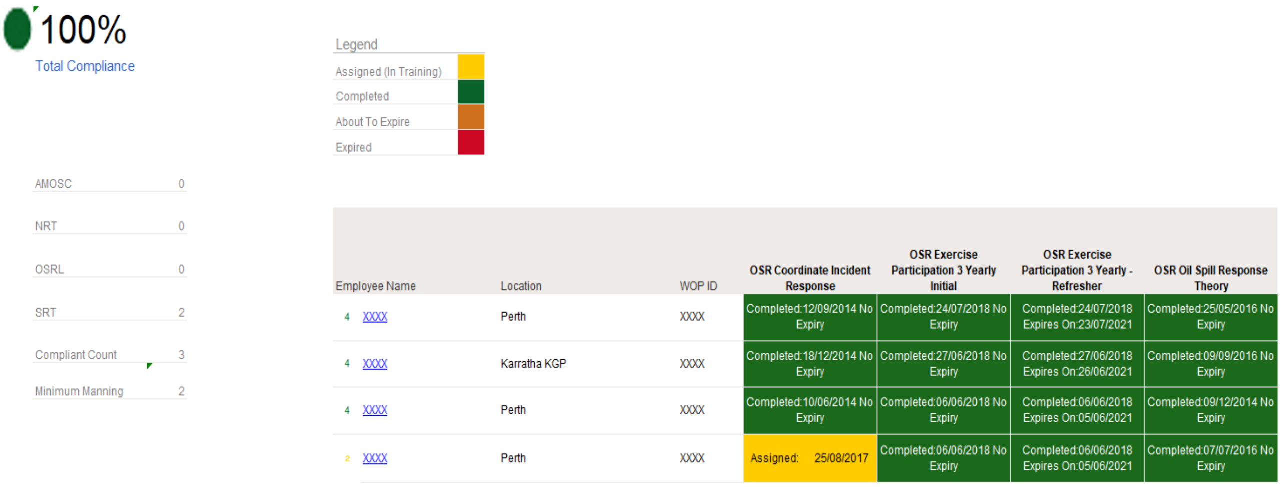


Figure 5-2: Example screen shot of the HSP competency dashboard

The Dashboard is one of Woodside's key means of monitoring its readiness to respond. It also and shows that Woodside can meet the requirements of the environmental performance standard that relate to filling certain response roles.

Figure 5-3 shows deeper dive into the Ops Point Coordinator role and the training modules required to show competence.



Employee Name	Location	WOP ID	OSR Coordinate Incident Response	OSR Exercise Participation 3 Yearly Initial	OSR Exercise Participation 3 Yearly - Refresher	OSR Oil Spill Response Theory
4 XXXX	Perth	XXXX	Completed:12/09/2014 No Expiry	Completed:24/07/2018 No Expiry	Completed:24/07/2018 Expires On:23/07/2021	Completed:25/05/2016 No Expiry
4 XXXX	Karratha KGP	XXXX	Completed:18/12/2014 No Expiry	Completed:27/06/2018 No Expiry	Completed:27/06/2018 Expires On:26/06/2021	Completed:09/09/2016 No Expiry
4 XXXX	Perth	XXXX	Completed:10/06/2014 No Expiry	Completed:06/06/2018 No Expiry	Completed:06/06/2018 Expires On:05/06/2021	Completed:09/12/2014 No Expiry
2 XXXX	Perth	XXXX	Assigned: 25/08/2017	Completed:06/06/2018 No Expiry	Completed:06/06/2018 Expires On:05/06/2021	Completed:07/07/2016 No Expiry

Figure 5-3: Example screenshot for the Ops Point Coordinator role

3. The Hydrocarbon Spill Preparedness ICE Assurance Process

The Hydrocarbon Spill Response Team has developed a Hydrocarbon Spill Preparedness and Response Internal Control Environment (ICE) process to align and feed into the Woodside Management System Assurance process for hydrocarbon spill. The process tracks compliance over four key control areas:

1. **Plans –** Ensures all plans (including: Oil Pollution Emergency Arrangements, first strike plans, operational plans, support plans and tactical response plans) are current and in line with regulatory and internal requirements.
2. **Competency** – Ensures the competency dashboard is up to date and there are the minimum competency numbers across ICC, CMT and hydrocarbon spill response roles. The hydrocarbon spill training plan and exercise schedule, including testing of arrangements is also tracked. The Testing of Arrangements (TOA) register tracks the testing of all hydrocarbon spill response arrangements, key contracts and agreements in place with internal and external parties to ensure compliance.
3. **Capability** – Tracks and monitors capability that could be required in a hydrocarbon incident, including but not limited to integrated fleet[5] vessel schedule, dispersant availability, rig/vessels monitoring, equipment stockpiles, tracking buoy locations and the CICC duty roster.
4. **Compliance and Assurance** – Ensures all regulator inspection outcomes are actioned and closed out, the global legislation register is up to date and that the key assurance components are tracked and managed. Assurance activities (including Audits) conducted on memberships with key Oil Spill Response Organisations (OSROs) including AMOSC and OSRL are also tracked and recorded in the ICE.

The ICE assurance process records how each commitment listed in the performance tables above is managed to ensure ongoing compliance monitoring. The level of compliance can be reviewed in real time and is reported on a monthly basis through the S&EM Function.

The completion of the assurance checks (over and above the ICE process) is also applied via the Woodside Integrated Risk and Compliance System (WiRCs) and subject to the requirements of Woodside's Provide Assurance Procedure.

4. The Hydrocarbon Spill Preparedness and Response Procedure

This procedure sets out how to plan and prepare for a liquid hydrocarbon spill to the marine environment. (Note, this procedure does not apply to scenarios relating to gas releases in the marine environment).

This procedure details the:

- Requirement for an OPEP to be developed, maintained, reviewed, and approved by appropriate regulators (where applicable) including:
  - defining how spill scenarios are developed on an activity specific basis
  - developing and maintaining all hydrocarbon spill related plans
  - ensuring the ongoing maintenance of training and competency for personnel
  - developing the testing of spill response arrangements
  - maintaining access to identified equipment and personnel.
- planning for hydrocarbon spill response preparedness

[5] The Integrated fleet consists of vessels from multiple operators that have been contracted to Woodside to undertake a number of duties including hydrocarbon spill response.

- accountabilities for hydrocarbon spill response preparedness
- spill training requirements
- requirements for spill exercising/testing of spill response arrangements
- Spill equipment and services requirements.

The procedure also details the roles and responsibilities of the dedicated Woodside Hydrocarbon Spill Preparedness team. This team is responsible for:

- assuring Woodside hydrocarbon spill responders meet competency requirements
- establishing the competency requirements, annual training schedule and a training register of trained personnel
- establishing and maintaining the total numbers of trained personnel required to provide an effective response to any hydrocarbon spill incident
- ensuring equipment and services contracts are maintained
- establishing OPEPs
- establishing OPEAs
- determining priority response receptors
- determining ALARP
- ensuring compliance and assurance is undertaken in accordance with external and internal requirements.

6 ALARP EVALUATION

This section should be read in conjunction with Section 5 which is the capability planned for this activity.

6.1 Monitor and evaluate – ALARP assessment

Alternative, Additional and Improved options have been identified and assessed against the base capability described in Section 5 with those that have been selected for implementation highlighted in green. Items highlighted in red have been considered and rejected on the basis that they are not feasible, the costs are clearly disproportionate to the environmental benefit, and/or the option is not reasonably practical. Control measures where there is not a clear justification for their inclusion or exclusion may be subject to a detailed ALARP assessment.

6.1.1 Monitor and evaluate – control measure options analysis

Woodside's existing level of capability is based on internal and third-party resources that are available 24 hours, 7 days per week. The capability presented below is displayed as ranges to incorporate operational factors such as weather, crew/vessel/aircraft/vehicle location and duties, survey or classification society inspection requirements, overflight/port/quarantine permits and inspections, crew/pilot duty and fatigue hours, re-fuelling/re-stocking provisions, and other similar logistic and operational limitation that are beyond Woodside's direct control.

6.1.1.1 Alternative control measures

Alternative Control Measures considered

Alternative, including potentially more effective and/or novel control measures are evaluated as replacements for an adopted control

Option considered	Environmental consideration	Feasibility	Approx. Cost	Assessment conclusions	Implemented
Aerostat (or similar inflatable observation platform) for localised aerial surveillance.	Lead time to Aerostat surveillance is disproportionate to the environmental benefit. The system also provides a very limited field of visibility around the vessel it is deployed from.	Long lead time to access (>10 days). Each system would require an operator to interpret data and direct vessels accordingly.	Purchase cost per system approx. A$300,000.	This option is not adopted as the minimal environmental benefit gained is disproportionate to the cost and complexity of its implementation.	No
Alternate analysis technologies and methods such as gravimetric, colorimetric, infra-red and UV absorption for OM03.	Due to time, limitations on sampling, equipment, methodology and analysis, the technique does not provide an environmental benefit compared to alternative available technologies.	• Gravimetric (Involves lab analysis so cannot be done on location, maybe completed with field samples in laboratory), • Colorimetric (requires chemical addition and catalysts no standard method, needs specialist training), • Infra-red (droplet size too small for infra-red analysis). • Hydrocarbons need to be extracted from water for test, therefore requires a laboratory test), and • UV absorption (Similar technology to fluorometers which are more widely available in Australia) were evaluated but all have limitations that do not improve the environmental benefit.	NA	This strategy is not considered feasible, therefore no further ALARP assessment is conducted.	No

6.1.1.2 Additional control measures

Additional Control Measures considered

Additional control measures are evaluated in terms of them reducing an environmental impact or an environmental risk when added to the existing suite of control measures

Option considered	Environmental consideration	Feasibility	Approx. Cost	Assessment Conclusions	Implemented
Additional personnel trained to use systems for OM01.	Current arrangement provides an environmental benefit in the availability of trained personnel facilitating access to monitoring data used to inform all other response techniques. No improvement required.	No improvement can be made, all personnel in technical roles e.g. intelligence unit are trained and competent on the software systems. Personnel are trained and exercised regularly. Use of the software and systems forms part of regular work assignments and projects.	Cost for training in-house staff would be approx. A$25,000.	This option is not adopted as the current capability meets the need.	No
Additional satellite tracking buoys to enable greater area coverage.	Increased capability does not provide an environmental benefit compared to the disproportionate cost in having an additional contract in place.	Tracking buoy will be on vessel, additional needs are met from Woodside owned stocks in King Bay Supply Facility (KBSF) and Exmouth or can be provided by service provider in a timely manner.	Cost for an additional satellite tracking buoy would be A$200 per day or A$6,000 to purchase.	This option is not adopted as the current capability meets the need, but additional units are available if required.	No
Additional trained aerial observers.	Current capability meets need. WEL has access to a pool of trained, competent observers at strategic locations to ensure timely and sustainable response. Additional observers are available through current contracts with AMOSC and OSRL.	Current capability meets need. WEL has a pool of trained, competent observers at strategic locations to ensure timely and sustainable response. Additional observers are available through current contracts with AMOSC and OSRL Aviation standards and guidelines ensure all aircraft crews are competent for their roles. WEL maintains a pool of trained and competent aerial observers with various home base locations to be called upon at the time of an incident. Regular audits of oil spill response organisations ensure training and competency is maintained.	Cost for additional trained aerial observers would be A$2,000 per person per day.	This option is not adopted as the current capability meets the need, but additional observers are available via response contractors if required.	No

6.1.1.3 Improved control measures

Improved Control Measures considered *Improved control measures are evaluated for improvements they could bring to the effectiveness of adopted control measures in terms of functionality, availability, reliability, survivability, independence and compatibility*					
Option considered	**Environmental consideration**	**Feasibility**	**Approx. Cost**	**Assessment conclusions**	**Implemented**
Faster turnaround time from modelling contractor.	Improved control measure does not provide an environmental benefit compared to the disproportionate cost in having an additional contract in place.	External contractor on ICC roster to be called as soon as required. However initial information needs to be gathered by ICC team to request an accurate model. External contractor has person on call to respond from their own location.	Modelling service with a faster activation time would be achieved via membership of an alternative modelling service at an annual cost of A$50,000 for 24-hour access plus an initial A$5,000 per modelling run.	This option is not adopted as the minimal environmental benefit gained is disproportionate to the cost and complexity of its implementation.	No
Night-time aerial surveillance.	The risk of undertaking the aerial observations at night is disproportionate to the limited environmental benefit. The images would be of low quality and no visual cross reference verification is possible and as such the variable is not adopted.	Flights will only occur when deemed safe by the pilot. The risk of night operations is disproportionate to the benefit gained, as images from sensors (IR, UV, etc.). will be low quality. Flight time limitations will be adhered to.	No improvement can be made without risk to personnel health and safety and breaching Woodside's golden rules.	This option is not adopted as the safety considerations outweigh any environmental benefit gained.	No
Faster mobilisation time (for water quality monitoring).	Due to the restriction on accessing the spill location on day 1 there is no environmental benefit in having vessels available from day 1. The cost of having dedicated equipment and personnel is disproportionate to the environmental benefit. The availability of vessels and personnel meets the response need.	Operations are not feasible on day 1 as volatility has potential to cause health and safety concerns within the first 24 hours of the response. Current Woodside arrangements allow for water quality monitoring to commence by day 3. Shortening the timeframes for vessel availability would require dedicated response vessels on standby in Darwin and would accelerate the initiation of monitoring by 1 day.	Cost for purchase of equipment approx. A$200,000. Ongoing costs per annum for cost of hire and pre-positioning for life of asset/activity would be larger than the purchase cost. Dedicated equipment and personnel, living locally and on short notice to mobilise. The cost would be approx. A$1 million per annum, which is disproportionate to the incremental benefit this would provide, assets are already available on day 1. 2 integrated fleet vessels are available from day 1; however, these could be tasked with other operations.	This option is not adopted as the area could not be accessed earlier due to safety considerations. Additionally, the cost and complexity of implementation outweighs the benefits.	No

6.1.2 Selected control measures

Following review of alternative, additional and improved control measures as outlined above, the following controls were selected for implementation for the activity.

- Alternative:
  - None selected.
- Additional:
  - None selected.
- Improved:
  - None selected.

6.2 Source Control via Vessel SOPEP – ALARP Assessment

Alternative, Additional and Improved options have been assessed against the base capability described in Section 5 with those that have been selected for implementation highlighted in green. Items highlighted in red have been considered and rejected on the basis that they are not feasible, the costs are disproportionate to the environmental benefit, and/or the option is not reasonably practical. Control measures where there is not a clear justification for their inclusion or exclusion may be subject to a detailed ALARP assessment.

6.2.1 Source Control via Vessel SOPEP – Control Measure Options Analysis

6.2.1.1 Alternative control measures

Alternative Control Measures considered *Alternative, including potentially more effective and/or novel control measures are evaluated as replacements for an adopted control*				
Option considered	**Environmental consideration**	**Feasibility**	**Approx. Cost**	**Implemented**
No reasonably practical alternative control measures identified.				N/A

6.2.1.2 Additional Control Measures

Additional Control Measures considered *Additional control measures are evaluated in terms of them reducing an environmental impact or an environmental risk when added to the existing suite of control measures*				
Option considered	**Environmental consideration**	**Feasibility**	**Approx. Cost**	**Implemented**
No reasonably practical additional control measures identified.				N/A

6.2.1.3 Improved Control Measures

Improved Control Measures considered *Improved control measures are evaluated for improvements they could bring to the effectiveness of adopted control measures in terms of functionality, availability, reliability, survivability, independence and compatibility*				
Option considered	**Environmental consideration**	**Feasibility**	**Approx. Cost**	**Implemented**
No reasonably practical improved control measures identified.				N/A

6.2.1.4 Selected control measures

Following review of alternative, additional and improved control measures, the following controls were selected for implementation for the activity.

- Alternative
  - None selected
- Additional
  - None selected
- Improved
  - None selected

6.3 Oiled wildlife response – ALARP assessment

Alternative, Additional and Improved options have been identified and assessed against the base capability described in Section 5 with those that have been selected for implementation highlighted in green. Items highlighted in red have been considered and rejected on the basis that they are not feasible, the costs are clearly disproportionate to the environmental benefit, and/or the option is not reasonably practical. Control measures where there is not a clear justification for their inclusion or exclusion may be subject to a detailed ALARP assessment.

6.3.1 Existing capability – wildlife response

Woodside's existing level of capability is based on internal and third-party resources that are available 24 hours, 7 days per week. The capability presented below is displayed as ranges to incorporate operational factors such as weather, crew/vessel/aircraft/vehicle location and duties, survey or classification society inspection requirements, overflight/port/quarantine permits and inspections, crew/pilot duty and fatigue hours, re-fuelling/re-stocking provisions, and other similar logistic and operational limitation that are beyond Woodside's direct control.

6.3.2 Wildlife response – control measure options analysis

6.3.2.1 Alternative control measures

Alternative Control Measures considered *Alternative, including potentially more effective and/or novel control measures are evaluated as replacements for an adopted control*					
Option considered	**Environmental consideration**	**Feasibility**	**Approximate Cost**	**Assessment conclusions**	**Implemented**
Direct contracts with service providers	This option duplicates the capability accessed through AMOSC and OSRL and would compete for the same resources. Does not provide a significant increase in environmental benefit.	These delivery options provide increased effectiveness through more direct communication and control of specialists. However, no significant net benefit is anticipated.	Duplication of capability - already subscribed to through contracts with AMOSC and OSRL	This option is not adopted as the existing capability meets the need.	No

6.3.2.2 Additional control measures

Additional Control Measures considered *Additional control measures are evaluated in terms of them reducing an environmental impact or an environmental risk when added to the existing suite of control measures*					
Option considered	**Environmental consideration**	**Feasibility**	**Approximate Cost**	**Assessment conclusions**	**Implemented**
Additional wildlife treatment systems	The selected delivery options provide access to call-off contracts with selected specialist providers. The agreements ensure these resources can be mobilised to meet the required response objectives, commensurate with the progressive nature of environmental impact and the time available to monitor hydrocarbon plume trajectories. Provides response equipment and personnel by Day 3. The additional cost in having a dedicated oiled wildlife response (equipment and personnel) in place is disproportionate to environmental benefit. These selected delivery options provide capacity to carry out an oiled wildlife response if contact is predicted and to scale up the response if required to treat widespread contamination. Current capability meets the needs required and there is no additional environmental benefit in adopting the improvements.	Although hydrocarbon contact above threshold concentrations with offshore waters is expected from day one, given the low likelihood of such an event occurring and the low environmental benefit of an offshore response, the cost of implementing measures to reduce the mobilisation time is considered disproportionate to the benefit. Additionally, the remote offshore location of the release site with no predicted contact of shoreline receptors provides sufficient opportunity for the ongoing monitoring and surveillance operations to inform the scale of the response. Numbers of oiled wildlife are expected to be low in the remote offshore setting of the oiled wildlife response, given the distance from known aggregation areas. Oiled wildlife response capacity would be addressed for open Commonwealth waters through the AMOSC arrangements, as informed by operational monitoring. The cost and organisational complexity of this approach is moderate, and the overall delivery effectiveness is high.	Additional wildlife response resources could total A$1,700 per operational site per day.	This option is not adopted as the existing capability meets the need.	No
Additional trained wildlife responders	Current numbers meet the needs required and additional personnel are available through existing contracts with oil spill response organisations and environmental panel contractors. Numbers of oiled wildlife are expected to be low in the remote offshore setting of the oiled wildlife response, given the distance from known aggregation areas. The potential environmental benefit of training additional personnel is expected to be low.	The capability provides the capacity to treat approximately 600 wildlife units (primarily avian fauna) by day six, with additional capacity available from OSRL. Additional equipment and facilities would be required to support ongoing response, depending on the scale of the event and the impact to fauna. Materials for holding facilities, portable pools, enclosures and rehabilitation areas would be sourced as required.	Additional wildlife response personnel cost A$2,000 per person per day.	This option is not adopted as the existing capability meets the need.	No

6.3.2.3 Improved control measures

Improved Control Measures considered *Improved control measures are evaluated for improvements they could bring to the effectiveness of adopted control measures in terms of functionality, availability, reliability, survivability, independence and compatibility*					
Option considered	**Environmental consideration**	**Feasibility**	**Approximate Cost**	**Assessment conclusions**	**Implemented**
Faster mobilisation time for wildlife response.	Response time is limited by specialist personnel mobilisation time. Current timing is sufficient for expected first shoreline impact. This control measure provides increased effectiveness through faster mobilisation of specialists. However, no significant net environmental benefit is expected due to shoreline stranding times. The cost of having dedicated equipment and personnel available to respond faster is considered grossly disproportionate to the environmental benefit.	Pre-positioning vessels or equipment would reduce mobilisation time for oiled wildlife response activities. However, given the effectiveness of an oiled wildlife response is expected to be generally low, an earlier response would provide a marginal increase in environmental benefit. The selected delivery options provide the capacity to mobilise an oiled wildlife response capable of treating up to 600 wildlife from at least Day 6 and exceeds the maximum estimated Level three OWR response thought to be applicable. This delivery option provides the maximum expertise pooled across the participating operators, backed up by the international resources provided by OSRL. The availability of vessels and personnel meets the response need.	Wildlife response packages to preposition at vulnerable sites identified through the deterministic modelling cost A$700 per package per day.	This option is not adopted as the existing capability meets the need.	No

6.3.3 Selected control measures

Following review of alternative, additional and improved control measures, the following controls were selected for implementation for the activity.

- Alternative
  - None selected.
- Additional
  - None selected.
- Improved
  - None selected.

6.4 Waste management – ALARP assessment

Alternative, Additional and Improved options have been identified and assessed against the base capability described in Section 5 with those that have been selected for implementation highlighted in green. Items highlighted in red have been considered and rejected on the basis that they are not feasible, the costs are clearly disproportionate to the environmental benefit, and/or the option is not reasonably practical. Control measures where there is not a clear justification for their inclusion or exclusion may be subject to a detailed ALARP assessment.

6.4.1 Existing capability – waste management

Woodside's existing level of capability is based on internal and third-party resources that are available 24 hours, 7 days per week. The capability presented below is displayed as ranges to incorporate operational factors such as weather, crew/vessel/aircraft/vehicle location and duties, survey or classification society inspection requirements, overflight/port/quarantine permits and inspections, crew/pilot duty and fatigue hours, re-fuelling/re-stocking provisions, and other similar logistic and operational limitation that are beyond Woodside's direct control.

6.4.2 Waste management – control measure options analysis

6.4.2.1 Alternative control measures

Alternative Control Measures considered *Alternative, including potentially more effective and/or novel control measures are evaluated as replacements for an adopted control*					
Option considered	**Environmental consideration**	**Feasibility**	**Approximate Cost**	**Assessment conclusions**	**Implemented**
No reasonably practical alternative control measures identified.					

6.4.2.2 Additional control measures

Additional Control Measures considered *Additional control measures are evaluated in terms of them reducing an environmental impact or an environmental risk when added to the existing suite of control measures*					
Option considered	**Environmental consideration**	**Feasibility**	**Approximate Cost**	**Assessment conclusions**	**Implemented**
Increased waste storage capability	The procurement of waste storage equipment options on the day of the event will allow immediate response and storage of collected waste. The environmental benefit of immediate waste storage is to reduce ecological consequence by safely securing waste, allowing continuous response operations to occur.	Access to Veolia's storage options provides the resources required to store and transport sufficient waste to meet the need. Access to waste contractors existing facilities enables waste to be stockpiled and gradually processed within the regional waste handling facilities. Additional temporary storage equipment is available through existing third-party contracts and arrangements with OSRL. Existing arrangements meet identified need for the activity.	Cost for increased waste disposal capability would be approximately A$1,300 per m^3. Cost for increased onshore temporary waste storage capability would be approximately A$40 per unit per day.	This option is not adopted as the existing capability meets the need.	No

6.4.2.3 Improved control measures

Improved Control Measures considered *Improved control measures are evaluated for improvements they could bring to the effectiveness of adopted control measures in terms of functionality, availability, reliability, survivability, independence and compatibility*					
Option considered	**Environmental consideration**	**Feasibility**	**Approximate Cost**	**Assessment conclusions**	**Implemented**
Faster response	The environmental benefit from successful waste storage will reduce pressure on the treatment and disposal facilities reducing ecological consequences by safely securing waste. In addition, waste storage and transport will allow continuous response operations to occur. This delivery option would increase known available storage, eliminating the risk of additional resources not being available at the time of the event. However, the environmental benefit of Woodside procuring additional waste storage is considered minor as the risk of additional storage not being available at the time of the event is considered low and existing arrangements provide adequate storage to support the response.	The credible scenario for this activity does not predict any shoreline impact and at-sea response is not appropriate for a spill of Marine Diesel thus waste storage needs will be minimal. Woodside has access to stockpiles of temporary waste storage equipment in Darwin through existing contracts and arrangements. For a prolonged response, Woodside would mobilise waste storage equipment from its stockpile in Exmouth and from third-party service providers.	The incremental benefit of having a dedicated local Woodside owned stockpile of waste equipment and transport is considered minor and cost is considered disproportionate to the benefit gained given there is no predicted shoreline impact.	This option is not adopted as the existing capability meets the need.	No

6.4.3 Selected control measures

Following review of alternative, additional and improved control measures, the following controls were selected for implementation for the activity.

- Alternative
  - None selected.
- Additional
  - None selected.
- Improved
  - None selected.

6.5 Scientific monitoring – ALARP assessment

Alternative, Additional and Improved options have been identified and assessed against the base capability described in Section 5 with those that have been selected for implementation highlighted in green. Items highlighted in red have been considered and rejected on the basis that they are not feasible, the costs are clearly disproportionate to the environmental benefit, and/or the option is not reasonably practical. Control measures where there is not a clear justification for their inclusion or exclusion may be subject to a detailed ALARP assessment.

6.5.1 Existing capability – scientific monitoring

Woodside's existing level of capability is based on internal and third-party resources that are available 24 hours, seven days per week. The capability presented below is displayed as ranges to incorporate operational factors such as weather, crew/vessel/aircraft/vehicle location and duties, survey or classification society inspection requirements, overflight/port/quarantine permits and inspections, crew/pilot duty and fatigue hours, re-fuelling/re-stocking provisions, and other similar logistic and operational limitation that are beyond Woodside's direct control.

6.5.2 Scientific monitoring – control measure options analysis

6.5.2.1 Alternative control measures

Alternative Control Measures considered

Alternative, including potentially more effective and/or novel control measures are evaluated as replacements for an adopted control

Ref	Control Measure Category	Option considered	Implemented	Environmental Consideration	Feasibility/Cost
SM01	System	Analytical laboratory facilities closer to the likely spill affected area	No	SM01 water quality monitoring requires water samples to be transported to NATA rated laboratories in Perth or interstate. Consider the benefit of laboratory access and transportation times to deliver water samples and complete lab analysis. There is a time lag from collection of water samples to being in receipt of results and confirming hydrocarbon contact to sensitive receptors). The environmental consideration of having access to suitable laboratory facilities in Exmouth or Karratha to carry out the hydrocarbon analysis would provide faster turnaround in reporting of results only by a matter of days (as per the time to transport samples to laboratories).	Laboratory facilities and staff available at locations closer to the spill affected area can reduce reporting times only to a moderate degree (days) with associated high costs of maintaining capability and do not improve the environmental benefit.
SM01	System	Dedicated contracted SMP vessel (exclusive to Woodside)	No	Would provide faster mobilisation time of scientific monitoring resources, environmental benefit associated with faster mobilisation time would be minor compared to selected options.	Chartering and equipping additional vessels on standby for scientific monitoring has been considered. The option is reasonably practicable but the sacrifice (charter costs and organisational complexity) is significant, particularly when compared with the anticipated availability of vessels and resources within in the required timeframes. The selected delivery provides capability to meet the scientific monitoring objectives, including collection of pre-emptive data where baseline knowledge gaps are identified for receptor locations where spill predictions of time to contact are > 10 days. The effectiveness of this alternative control (weather dependency, availability and survivability) is rated as very low. The cost and organisational complexity of employing a dedicated response vessel is considered disproportionate to the potential environmental benefit by adopting this delivery option.

6.5.2.2 Additional control measures

Additional Control Measures considered

Additional control measures are evaluated in terms of them reducing an environmental impact or an environmental risk when added to the existing suite of control measures

Ref	Control Measure Category	Option considered	Implemented	Environmental Consideration	Feasibility / Cost
SM01	System	Determine baseline data needs and provide implementation plan in the event of an unplanned hydrocarbon release	Yes	Address resourcing needs to collect post spill (pre-contact) baseline data as spill expands in the event of a loss of well control from the activity.	Woodside relies on existing environmental baseline for receptors which have predicted hydrocarbon contact (above environment threshold) < 10 days and acquiring pre-emptive data in the event of a loss of well control from the activities based on receptors predicted to have hydrocarbon contact > 10 days. Ensure there is appropriate baseline for key receptors for all geographic locations that are potentially impacted < 10 days of spill event, where practicable. Address resourcing needs to collect pre-emptive baseline as spill expands in the event of a hydrocarbon release from the activities.

6.5.2.3 Improved control measures

No reasonably practicable improved control measures identified.

6.5.3 Selected control measures

Following review of alternative, additional and improved control measures as outlined above, the following controls were selected for implementation for the activity.

- Alternative
  - None selected.
- Additional
  - Determine baseline data needs and activate SMPs for any identified PBAs in the event of an unplanned hydrocarbon release.
- Improved
  - None selected.

6.5.4 Operational plan

Key actions from the Scientific Monitoring Program Operational Plan for implementing the response are outlined below in Table 6-1.

Table 6-1: Scientific monitoring program operational plan actions

Responsibility	Action
Activation	
Perth ICC Planning (ICC Planning – Environment Unit)	Mobilises SMP Lead/Manager and SMP Coordinator to the ICC Planning function.
Perth ICC Planning (ICC Planning – Environment Unit) (SMP Lead/Manager and SMP Coordinator)	Constantly assesses all outputs from OM01, OM02 and OM03 (Section 5 and Annex B) to determine receptor locations and receptors at risk. Confirm sensitive receptors likely to be exposed to hydrocarbons, timeframes to specific receptor locations and which SMPs are triggered. Reviews baseline data for receptors at risk.
Perth ICC Planning (ICC Planning – Environment Unit) (SMP Lead/Manager and SMP Coordinator)	SMP coordinator stands up SMP Standby contractor. Stands up subject matter experts, if required.
Perth ICC Planning (ICC Planning – Environment Unit) (SMP Lead/Manager, SMP Coordinator, SMP Standby contractor)	Establishes if, and where, pre-contact baseline data acquisition is required. Determines practicable baseline acquisition program based on predicted timescales to contact and anticipated SMP mobilisation times. Determines scope for preliminary post-contact surveys during the Response Phase. Determines which SMP activities are required at each location based on the identified receptor sensitivities.
Perth ICC Planning (ICC Planning – Environment Unit) (SMP Lead/Manager, SMP Coordinator, SMP Standby contractor)	If response phase data acquisition is required, stands up the contractor SMP teams for data acquisition and instruct them to standby awaiting further details for mobilisation from the IMT.

Responsibility	Action
Perth ICC Planning (ICC Planning – Environment Unit) (SMP Lead/Manager, SMP Coordinator, SMP Standby contractor)	SMP contractor, SMP standby contractor, to prepare the Field Implementation Plan. Prepares and obtains sign-off of the Response Phase SMP work plan and Field Implementation Plan. Updates the IAP.
Perth ICC Planning (ICC Planning – Environment Unit) (SMP Lead/Manager, SMP Coordinator, SMP Standby contractor)	Liaises with ICC Logistics, and determines the status and availability of aircraft, vessels and road transportation available to transport survey personnel and equipment to point of departure. Engages with SMP standby contractor, SMP Manager and ICC Logistics to establish mobilisation plan, secure logistics resources and establish ongoing logistical support operations, including: • vessels, vehicles and other logistics resources • vessel fit-out specifications detailed in the Scientific Monitoring Program Operational Plan • equipment storage and pick-up locations • personnel pick-up/airport departure locations • ports of departure • land based operational centres and forward operations bases • accommodation and food requirements.
Perth ICC Planning (ICC Planning – Environment Unit) (SMP Lead/Manager, SMP Coordinator, SMP Standby contractor)	Confirms communications procedures between Woodside SMP team, SMP standby contractor, SMP Team Leads and Operations Point Coordinator.
Mobilisation	
Perth ICC Logistics	Engages vessels and vehicles and arranges fitting out as specified by the mobilisation Plan Confirms vessel departure windows and communicates with the Jacob's SMP Manager. Agrees SMP mobilisation timeline and induction procedures with the Division and Sector Command Point(s).
Perth ICC Logistics	Coordinates with SMP standby contractor to mobilise teams and equipment according to the logistics plan and Sector induction procedures.
SMP Survey Team Leads	SMP Survey Team Leader(s) coordinates on-ground/on-vessel mobilisations and support services with the Sector Command point(s).

6.5.5 ALARP and acceptability summary

ALARP and Acceptability Summary		
Scientific Monitoring		
ALARP Summary	X	All known reasonably practicable control measures have been adopted
	X	Additional Measures: Determine baseline data needs and activate SMPs for any identified PBAs in the event of an unplanned hydrocarbon release
		No reasonably practical additional, alternative, and/or improved control measure exists
	The resulting scientific monitoring capability has been assessed against the worst credible spill scenarios. The range of techniques provide an ongoing approach to monitoring operations to assess and evaluate the scale and extent of impacts. All known reasonably practicable control measures have been adopted with the cost and organisational complexity of these options determined to be Moderate and the overall delivery effectiveness considered Medium. The SMP's main objectives can be met, with the addition of one alternative control measures to provide further benefit.	
Acceptability Summary	• The control measures selected for implementation manage the potential impacts and risks to ALARP. • In the event of a hydrocarbon spill for the activity, the control measures selected, meet or exceed the requirements of Woodside Management System and industry best-practice. • Throughout the activity, relevant Australian standards and codes of practice will be followed to evaluate the impacts from a hydrocarbon release. • The level of impact and risk to the environment has been considered with regards to the principles of ESD; and risks and impacts from a range of identified scenarios were assessed in detail. The control measures described consider the conservation of biological and ecological diversity, through both the selection of control measures and the management of their performance. The control measures have been developed to account for credible case scenarios, and uncertainty has not been used as a reason for postponing control measures.	
On the basis from the ALARP assessment, above and the risk assessment for an unplanned hydrocarbon release of the Galactic Hybrid Marine Seismic Survey EP, Woodside considers the adopted controls discussed, manage the impacts and risks associated with implementing scientific monitoring activities to a level that is ALARP and acceptable.		

7 ENVIRONMENTAL RISK ASSESSMENT OF SELECTED RESPONSE TECHNIQUES

The implementation of response techniques may modify the impacts and risks identified in the EP and response activities can introduce additional impacts and risks from response operations themselves. Therefore, it is necessary to complete an assessment to ensure these impacts and risks have been considered and specific measures are put in place to continually review and manage these further impacts and risks to ALARP and Acceptable levels. A simplified assessment process has been used to complete this task which covers the identification, analysis, evaluation and treatment of impacts and risks introduced by responding to the event.

7.1 Identification of impacts and risks from implementing response techniques

Each of the control measures can modify the impacts and risks identified in the EP, specifically:

- atmospheric emissions
- routine and non-routine discharges
- physical presence, proximity to other vessels (shipping and fisheries)
- routine acoustic emissions vessels
- lighting for night work/navigational safety
- invasive marine species
- collision with marine fauna
- disturbance to seabed.

These impacts and risks have been previously assessed within the scope of the EP. Refer to the EP for details regarding how these risks are being managed. They are not discussed further in this document.

Additional impacts and risks associated with the control measures not included within the scope of the EP include:

- vessel operations and anchoring
- human presence
- waste management
- additional stress or injury caused to wildlife.

7.2 Analysis of impacts and risks from implementing response techniques

Table 7-1 compares the adopted control measures for this activity against the environmental values that can be affected when they are implemented.

Table 7-1: Analysis of risks and impacts

	Environmental Value						
	Soil and Groundwater	Marine Sediment Quality	Water Quality	Air Quality	Ecosystems/ Habitat	Species	Socio-Economic
Monitor and evaluate		✓	✓		✓	✓	
Source control (vessel)		✓	✓	✓	✓	✓	✓
Oiled Wildlife					✓	✓	
Scientific Monitoring	✓	✓	✓	✓	✓	✓	✓
Waste management	✓	✓		✓	✓	✓	✓

7.3 Evaluation of impacts and risks from implementing response techniques

7.3.1 Vessel operations

During the implementation of response techniques, where water depths allow, it is possible that response vessels will be required to anchor (e.g. during shoreline surveys). The use of vessel anchoring will be minimal and likely to occur when the impacted shoreline is inaccessible via road. Anchoring in the nearshore environment of sensitive receptor locations will have the potential to impact coral reef, seagrass beds and other benthic communities in these areas. Recovery of benthic communities from anchor damage depends on the size of anchor and frequency of anchoring. Impacts would be highly localised (restricted to the footprint of the vessel anchor and chain) and temporary, with full recovery expected.

7.3.2 Human presence

Human presence for shoreline assessment or oiled wildlife response may lead to the compaction of sediments and damage to the existing environment especially in sensitive locations such as mangroves and turtle nesting beaches. However, any impacts are expected to be localised with full recovery expected.

7.3.3 Waste generation

Implementing the selected response techniques will result in the generation of the following waste streams that will require management and disposal:

- Liquids (recovered oil/water mixture), recovered from oiled wildlife response.
- Semi-solids/solids (oily solids), collected during oiled wildlife response.
- Debris (e.g. seaweed, sand, woods, plastics), collected during oiled wildlife response.

If not managed and disposed of correctly, wastes generated during the response have the potential for secondary contamination similar to that described above, impacts to wildlife through contact with or ingestion of waste materials and contamination risks if not disposed of correctly onshore.

7.3.4 Additional stress or injury caused to wildlife

Additional stress or injury to wildlife could be caused through:

- capturing wildlife
- transporting wildlife

- stabilisation of wildlife
- cleaning and rinsing of oiled wildlife
- rehabilitation (e.g. diet, cage size, housing density)
- release of treated wildlife.

Inefficient capture techniques have the potential to cause undue stress, exhaustion or injury to wildlife, additionally pre-emptive capture could cause undue stress and impacts to wildlife when there are uncertainties in the forecast trajectory of the spill. During the transportation and stabilisation phases there is the potential for additional thermoregulation stress on captured wildlife. Additionally, during the cleaning process, it is important that personnel undertaking the tasks are familiar with the relevant techniques to ensure that further injury and the removal of water proofing feathers are managed and mitigated. Finally, during the release phase it’s important that wildlife is not released back into a contaminated environment.

7.4 Treatment of impacts and risks from implementing response techniques

In respect of the impacts and risks assessed, the following treatment measures have been adopted. It must be recognised that this environmental assessment is seeking to identify how to maintain the level of impact and risks at levels that are ALARP and of an acceptable level rather than exploring further impact and risk reduction. It is for this reason that the treatment measures identified in this assessment will be captured in Operational Plans, Tactical Response Plans, and/or First Strike Plans.

7.4.1 Vessel operations and access to the nearshore environment

- Where existing fixed anchoring points are not available, locations will be selected to minimise impact to nearshore benthic environments with a preference for areas of sandy seabed where they can be identified (PS 8.1).
- Shallow draft vessels will be used to access remote shorelines to minimise the impacts associated with seabed disturbance on approach to the shorelines (PS 8.2).

7.4.2 Human presence

- Shoreline access route (foot, car, vessel and helicopter) with the least environmental impact identified will be selected by a specialist in SCAT operations (PS 7.3).

7.4.3 Waste generation

- All oiled wildlife response sites zoned and marked before operations commence to prevent secondary contamination and minimise the mixing of clean and oiled waste (PS 11.1)

7.4.4 Additional stress or injury caused to wildlife

- Oiled wildlife operations (including hazing) would be implemented with advice and assistance from the Oiled Wildlife Advisor from the DEPWS and in accordance with the processes and methodologies described in the NT OWRP (AMOSC, 2019) and the relevant regional plan (PS 10.3).

8 ALARP CONCLUSION

An analysis of alternative, additional and improved control measures has been undertaken to determine their reasonableness and practicability. The tables in Section 6 document the considerations made in this evaluation. Where the costs of an alternative, additional, or improved control measure have been determined to be clearly disproportionate to the environmental benefit gained from its adoption it has been rejected. Where this is not considered to be the case the control measure has been adopted.

The risks from a hydrocarbon spill have been reduced to ALARP because:

- Woodside has a significant hydrocarbon spill response capability to respond to the WCCS through the control measures identified.
- New and modified impacts and risks associated with implementing response techniques have been considered and will not increase the risks associated with the activity.
- A consideration of alternative, additional, and improved control measures identified any other control measures that delivered proportionate environmental benefit compared to the cost of adoption for this activity, ensuring:
  - all known, reasonably practicable control measures have been adopted
  - no additional, reasonably practicable alternative and/or improved control measures would provide further environmental benefit
  - no reasonably practical additional, alternative, and/or improved control measure exists.
- A structured process for considering alternative, additional, and improved control measures was completed for each control measure.
- The evaluation was undertaken based on the outputs of the WCCS so that the capability in place is sufficient for all other scenarios from this activity.
- The likelihood of the WCCS spill has been ignored in evaluating what was reasonably practicable.

9 ACCEPTABILITY CONCLUSION

Following the ALARP evaluation process, Woodside deems the hydrocarbon spill risks and impacts have been reduced to an acceptable level by meeting all of the following criteria:

- Techniques are consistent with Woodside's processes and relevant internal requirements including policies, culture, processes, standards, structures and systems.
- Levels of risk/ impact are deemed acceptable by relevant persons (external stakeholders) and are aligned with the uniqueness of, and/or the level of protection assigned to the environment, its sensitivity to pressures introduced by the activity, and the proximity of activities to sensitive receptors, and have been aligned with Part 3 of the EPBC Act.
- Selected control measures meet requirements of legislation and conventions to which Australia is a signatory (e.g. MARPOL, the World Heritage Convention, the Ramsar Convention and the Biodiversity Convention). In addition to these, other non-legislative requirements met include:
  - Australian IUCN reserve management principles for Commonwealth marine protected areas and bioregional marine plans
  - National Water Quality Management Strategy and supporting guidelines for marine water quality)
  - conditions of approval set under other legislation
  - national and international requirements for managing pollution from ships
  - national biosecurity requirements.
- Industry standards, best practices and widely adopted standards and other published materials have been used and referenced when defining acceptable levels. Where these are inconsistent with mandatory/legislative regulations, explanation has been provided for the proposed deviation. Any deviation produces the same or a better level of environmental performance (or outcome).

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11 GLOSSARY AND ABBREVIATIONS

11.1 Glossary

Term	Description / Definition
ALARP	Demonstration through reasoned and supported arguments that there are no other practicable options that could reasonably be adopted to reduce risks further.
Availability	The availability of a control measure is the percentage of time that it is capable of performing its function (operating time plus standby time) divided by the total period (whether in service or not). In other words, it is the probability that the control has not failed or is undergoing a maintenance or repair function when it needs to be used.
Control	The means by which risk from events is eliminated or minimised.
Control effectiveness	A measure of how well the control measures perform their required function.
Control measure (risk control measure)	The features that eliminate, prevent, reduce or mitigate the risk to environment associated with activity.
Credible spill scenario	A spill considered by Woodside as representative of maximum volume and characteristics of a spill that could occur as part of the activity.
Dependency	The degree of reliance on other systems in order for the control measure to be able to perform its intended function.
Environment that may be affected	The summary of quantitative modelling where the marine environment could be exposed to hydrocarbons levels exceeding hydrocarbon threshold concentrations.
Incident	An event where a release of energy resulted in or had (with) the potential to cause injury, ill health, damage to the environment, damage to equipment or assets or company reputation.
Major Environment Event	The events with potential environment, reputation, social or cultural consequences of category C or higher (as per Woodside's operational risk matrix) which are evaluated against credible worst-case scenarios which may occur when all controls are absent or have failed.
Performance outcome	A statement of the overall goal or outcome to be achieved by a control measure.
Performance standard	The parameters against which [risk] controls are assessed to ensure they reduce risk to ALARP. A statement of the key requirements (indicators) that the control measure has to achieve in order to perform as intended in relation to its functionality, availability, reliability, survivability and dependencies.
Preparedness	Measures taken before an incident in order to improve the effectiveness of a response.
Reasonably practicable	... a computation ... made by the owner, in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time or trouble) [showing whether or not] that there is a gross disproportion between them ... made by the owner at a point of time anterior to the accident. (Judgement: Edwards v National Coal Board [1949])
Receptors at risk	Physical, biological and social resources identified as at risk from hydrocarbon contact using oil spill modelling predictions.
Receptor areas	Geographically referenced areas such as bays, islands, coastlines and/or protected area (WHA, Commonwealth or State/Territory marine reserve or park) containing one or more receptor type).
Receptor Sensitivities	This is a classification scheme to categorise receptor sensitivity to an oil spill. The Environmental Sensitivity Index (ESI) is a numerical classification of the relative sensitivity of a particular environment (particularly different shoreline types) to an oil spill. Refer to the Woodside Oil Pollution Emergency Arrangements (Australia) for more details.
Regulator	NOPSEMA is the Environment Regulator under the Environment Regulations.
Reliability	The probability that at any point in time a control measure will operate correctly for a further specified length of time.

Term	Description / Definition
Response technique	The key priorities and objectives to be achieved by the response plan. Measures taken in response to an event to reduce or prevent adverse consequences.
Survivability	Whether or not a control measure is able to survive a potentially damaging event is relevant for all control measures that are required to function after an incident has occurred.
Threshold	Hydrocarbon threshold concentrations applied to the risk assessment to evaluate hydrocarbon spills. These are defined as: surface hydrocarbon concentration – ≥10 g/m², dissolved – ≥50 ppb and entrained hydrocarbon concentrations – ≥100 ppb.
Zone of Application	The zone in which Woodside may elect to apply dispersant. The zone is determined based on a range of considerations, such as hydrocarbon characteristics, weathering and metocean conditions. The zone is a key consideration in the Net Environmental Benefit Analysis for dispersant use.

11.2 Abbreviations

Abbreviation	Meaning
ADIOS	Automated Data Inquiry for Oil Spills
AIIMS	Australasian Inter-Service Incident Management System
ALARP	As low as reasonably practicable
AMOSC	Australian Marine Oil Spill Centre
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
APASA	Asia Pacific ASA
AUV	Autonomous Underwater Vehicle
BAOAC	Bonn Agreement Oil Appearance Code
CC	Coastal Compartments
C&R/ CAR	Containment and Recovery
cSt	Centistokes
CICC	Corporate Incident Coordination Centre
COP	Common Operating Picture
CS	Credible scenario
DEPWS	Northern Territory Department of Environment, Parks and Water Security
DIPL	Northern Territory Department of Infrastructure, Planning and Logistics
DM	Duty Manager
DoEE	Commonwealth Department of the Environment and Energy
DTC	Northern Territory Department of Tourism and Culture
EMBA	Environment that May Be Affected
EMSA	European Maritime Safety Agency
Environment Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
EP	Environment Plan
EPA	Northern Territory Environment Protection Authority
ESI	Environmental Sensitivity Index
ESD	Emergency Shut Down
ESP	Environmental Services Panel
FSP	First Strike Plan
GIS	Geographic Information System
GPS	Global Positioning System
HSP	Hydrocarbon Spill Preparedness
IAP	Incident Action Plan
ICC	Incident Coordination Centre
IMT	Incident Management Team
IPIECA	International Petroleum Industry Environment Conservation Association
ITOPF	International Tanker Owners Pollution Federation
IUCN	International Union for Conservation of Nature

Abbreviation	Meaning
KBSF	King Bay Supply Facility
KICC	Karratha Incident Coordination Centre
KSAT	Kongsberg Satellite
ME	Monitor and Evaluate
MEE	Major Environmental Event
MoU	Memorandum of Understanding
NEBA	Net Environmental Benefit Analysis
NOAA	National Oceanic and Atmospheric Administration
NRT	National Response Team
NT	Northern Territory
NT OWRP	Northern Territory Oiled Wildlife Response Plan
OILMAP	Oil Spill Model and Response System
OPEA	Oil Pollution Emergency Arrangements
OPEP	Oil Pollution Emergency Plan
OPGGSA	Offshore Petroleum and Greenhouse Gas Storage Act
OSMP	Operational and Scientific Monitoring Program
OSRL	Oil Spill Response Limited
OSRO	Oil Spill Response Organisations
OSTM	Oil Spill Trajectory Modelling
OWR	Oiled Wildlife Response
OWRP	Oiled Wildlife Response Plan
OWROP	Regional Oiled Wildlife Response Operational Plan
PEARLS	People, Environment, Asset, Reputation, Livelihood and Services
PBA	Pre-emptive Baseline Areas
PPA	Priority Protection Area
PPB	Parts per billion
PPM	Parts per million
ROV	Remotely Operated Vehicle(s)
RPA	Response Protection Area
SCAT	Shoreline Contamination Assessment Techniques
SIMAP	Integrated Oil Spill Impact Model System
SMP	Scientific monitoring program
SOP	Standard Operating Procedure
TRP	Tactical Response Plan
TOA	Testing of Arrangements
WHA	World Heritage Area
Woodside / WEL	Woodside Energy Limited
WCC	Woodside Communication Centre
WCCS	Worst Case Credible Scenario

Abbreviation	Meaning
ZoA	Zone of Application

ANNEX A: NET ENVIRONMENTAL BENEFIT ANALYSIS DETAILED OUTCOMES

A NEBA has been conducted to assess the net environmental benefit of different response techniques to selected receptors in the event of an oil spill from the activity for release of Marine Diesel caused by a vessel collision during seismic survey operations. The complete list of potential receptor locations within the EMBA within the activity is included in Section 4 of the EP.

The locations utilised for the NEBA were limited to the RPAs identified from modelling (see Section 3 for outline of selection). These include receptors which have potential for the following:

- Surface contact (>50 g/m²)
- Shoreline accumulation (100 g/m²) – please note there is no shoreline accumulation for CS-01 or CS-02
- Entrained contact (>100 ppb and <14 days)

More detailed NEBA assessment outcomes are available via this Link

Table A-1: NEBA assessment technique recommendations for a spill of Marine Diesel – Credible Scenario-01

Receptor	Monitor and Evaluate	Source control via vessel SOPEP	Dispersant application: > 20 m water depth and > 10 km from shore/reefs	Mechanical dispersion	In situ burning	Containment and Recovery	Shoreline protection	Shoreline clean-up (manual)	Shoreline clean-up (mechanical)	Shoreline clean-up (chemical)	Oiled Wildlife Response
Commonwealth waters (>50 g/m²)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Oceanic Shoals AMP (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Goodrich Bank (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Marie Shoal (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
The Boxers Area (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Moss Shoal (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Parry Shoal (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Margaret Harries Bank (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Arafura MP (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Calder Shoal (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Cootamundra Shoal (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes

Overall assessment

Sensitive receptor (Sites identified in EP)	Monitor and Evaluate	Source control via vessel SOPEP	Dispersant application: > 20 m water depth and > 10 km from shore/reefs	Mechanical dispersion	In situ burning	Containment and Recovery	Shoreline protection	Shoreline clean-up (manual)	Shoreline clean-up (mechanical)	Shoreline clean-up (chemical)	Oiled Wildlife Response
Is this response Practicable?	Yes	Yes	No	No	No	No	No	No	No	No	Yes
NEBA identifies Response potentially of Net Environmental Benefit?	Yes	Yes	No	No	No	No	No	No	No	No	Yes

Table A-2: NEBA assessment technique recommendations for a spill of Marine Diesel – Credible Scenario-02

Receptor	Monitor and Evaluate	Source control via vessel SOPEP	Dispersant application: > 20 m water depth and > 10 km from shore/reefs	Mechanical dispersion	In situ burning	Containment and Recovery	Shoreline protection	Shoreline clean-up (manual)	Shoreline clean-up (mechanical)	Shoreline clean-up (chemical)	Oiled Wildlife Response
Commonwealth waters (>50 g/m²)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Oceanic Shoals MP (>50 g/m²)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Lynedoch Bank (>50 g/m²)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Margaret Harries Bank (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Tassie Shoal (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes

Blackwood Shoal (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Echo Shoals (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Flinders Shoal (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Franklin Shoal (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Loxton Shoal (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Martin Shoal (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Sunrise Bank (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Sunset Shoal (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
The Boxers Area (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes
Troubadour Shoals (>100 ppb)	Yes	Yes	No	No	No	No	No	No	No	No	Yes

Overall assessment

Sensitive receptor (Sites identified in EP)	Monitor and Evaluate	Source control via vessel SOPEP	Dispersant application: > 20 m water depth and > 10 km from shore/reefs	Mechanical dispersion	In situ burning	Containment and Recovery	Shoreline protection	Shoreline clean-up (manual)	Shoreline clean-up (mechanical)	Shoreline clean-up (chemical)	Oiled Wildlife Response
Is this response Practicable?	Yes	Yes	No	No	No	No	No	No	No	No	Yes
NEBA identifies Response potentially of Net Environmental Benefit?	Yes	Yes	No	No	No	No	No	No	No	No	Yes

NEBA Impact Ranking Classification Guidance

To reduce variability between assessments, the following ranking descriptions have been devised to guide the workshop process:

Table A-3: NEBA impact ranking classifications

			Degree of impact [6]	Potential duration of impact	Equivalent Woodside Corporate Risk Matrix Consequence Level
Positive	**3P**	**Major**	Likely to prevent: • behavioural impact to biological receptors • behavioural impact to socio-economic receptors e.g. changes to day-today business operations, public opinion/behaviours (e.g. avoidance of amenities such as beaches) or regulatory designations.	Decrease in duration of impact by > 5 years	N/A
	2P	**Moderate**	Likely to prevent: • significant impact to a single phase of reproductive cycle of biological receptors • detectable financial impact, either directly (e.g. loss of income) or indirectly (e.g. via public perception), for socio-economic receptors.	Decrease in duration of impact by 1–5 years	N/A
	1P	**Minor**	Likely to prevent impacts on: • significant proportion of population or breeding stages of biological receptors • socio-economic receptors such as: ○ significant impact to the sensitivity of protective designation; or ○ significant and long-term impact to business/industry.	Decrease in duration of impact by several seasons (< 1 year)	N/A
	0	**Non-mitigated spill impact**	**No detectable difference to unmitigated spill scenario.**		
Negative	**1N**	**Minor**	Likely to result in: • behavioural impact to biological receptors • behavioural impact to socio-economic receptors e.g. changes to day-to-day business operations, public opinion/behaviours (e.g. avoidance of amenities such as beaches), or regulatory designations.	Increase in duration of impact by several seasons (< 1 year)	Increase in risk by one sub-category, without changing category (e.g. Minor (E) to Minor (D))
	2N	**Moderate**	Likely to result in: • significant impact to a single phase of reproductive cycle for biological receptors; or • detectable financial impact, either directly (e.g. loss of income) or indirectly (e.g. via public perception), for socio-economic receptors. This level of negative impact is recoverable and unlikely to result in closure of business/industry in the region.	Increase in duration of impact by 1–5 years	Increase in risk by one category (e.g. Minor (D) to Moderate (C or B))
	3N	**Major**	Likely to result in impacts on: • significant proportion of population or breeding stages of biological receptors • socio-economic receptors resulting in either: ○ significant impact to the sensitivity of protective designation; or ○ significant and long-term impact to business/industry.	Increase in duration of impact by > 5 years or unrecoverable	Increase in risk by two categories (e.g. Minor (E) to Major (A))

[6] the maximum likely impact should be considered; for example, if a spill were to directly impact the behaviour that results in an impact to reproduction and/or the breeding population (such as fish failing to aggregate to spawn), then the score should be a 2 or 3 rather than a 1. Similarly, if a change in behaviour resulted in an increased risk of mortality of a population, then it should be scored as a 2 or 3.

ANNEX B: OPERATIONAL MONITORING ACTIVATION AND TERMINATION CRITERIA

Table B-1: Operational monitoring objectives, triggers and termination criteria

Operational Monitoring Operational Plan	Objectives	Activation triggers	Termination criteria
Operational Monitoring Operational Plan 1 (OM01) Predictive Modelling of Hydrocarbons to Assess Resources at Risk	OM01 focuses on the conditions that have prevailed since a spill commenced, as well as those that are forecasted in the short term (1–3 days ahead) and longer term. OM01 utilises computer-based forecasting methods to predict hydrocarbon spill movement and guide the management and execution of spill response operations to maximise the protection of environmental resources at risk. The objectives of OM01 are to: • Provide forecasting of the movement and weathering of spilled hydrocarbons • Identify resources that are potentially at risk of contamination • Provide simulations showing the outcome of alternative response options (booming patterns etc.) to inform on-going Net Environmental Benefit Analysis (NEBA) and continually assess the efficacy of available response options in order to reduce risks to ALARP	OM01 will be triggered immediately following a level 2/3 hydrocarbon spill.	The criteria for the termination of OM01 are: • The hydrocarbon discharge has ceased • Response activities have ceased • Hydrocarbon spill modelling (as verified by OM02 surveillance observations) predicts no additional natural resources will be impacted

Operational Monitoring Operational Plan	Objectives	Activation triggers	Termination criteria
Operational Monitoring Operational Plan 2 (OM02) Surveillance and reconnaissance to detect hydrocarbons and resources at risk	OM02 aims to provide regular, on-going hydrocarbon spill surveillance throughout a broad region, in the event of a spill. The objectives of OM02 are: • Verify spill modelling results and recalibrate spill trajectory models (OM01) • Understand the behaviour, weathering and fate of surface hydrocarbons • Identify environmental receptors and locations at risk or contaminated by hydrocarbons • Inform ongoing Net Environmental Benefit Analysis (NEBA) and continually assess the efficacy of available response options in order to reduce risks to ALARP • To aid in the subsequent assessment of the short- to long-term impacts and/or recovery of natural resources (assessed in SMPs) by ensuring that the visible cause and effect relationships between the hydrocarbon spill and its impacts to natural resources have been observed and recorded during the operational phase.	OM02 will be triggered immediately following a level 2/3 hydrocarbon spill.	The termination triggers for the OM02 are: • 72 hours has elapsed since the last confirmed observation of surface hydrocarbons • Latest hydrocarbon spill modelling results (OM01) do not predict surface exposures at visible levels
Operational Monitoring Operational Plan 3 (OM03) Monitoring of hydrocarbon presence, properties, behaviour and weathering in water	OM03 will measure surface, entrained and dissolved hydrocarbons in the water column to inform decision-making for spill response activities. The specific objectives of OM03 are as follows: • Detect and monitor for the presence, quantity, properties, behaviour and weathering of surface, entrained and dissolved hydrocarbons • Verify predictions made by OM01 and observations made by OM02 about the presence and extent of hydrocarbon contamination Data collected in OM03 will also be used for the purpose of longer-term water quality monitoring during SM01.	OM03 will be triggered immediately following a level 2/3 hydrocarbon spill.	The criteria for the termination of OM03 are as follows: • The hydrocarbon release has ceased • Response activities have ceased • Concentrations of hydrocarbons in the water are below available ANZECC/ ARMCANZ (2000) trigger values for 99% species protection.

Operational Monitoring Operational Plan	Objectives	Activation triggers	Termination criteria
Operational Monitoring Operational Plan 4 (OM04) Pre-emptive assessment of sensitive receptors at risk	OM04 aims to undertake a rapid assessment of the presence, extent and current status of shoreline sensitive receptors prior to contact from the hydrocarbon spill, by providing categorical or semi-quantitative information on the characteristics of resources at risk. The primary objective of OM04 is to confirm understanding of the status and characteristics of environmental resources predicted by OM01 and OM02 to be at risk, to further assist in making decisions on the selection of appropriate response actions and prioritisation of resources. Indirectly, qualitative/semi-quantitative pre-contact information collected by OM04 on the status of environmental resources may also aid in the verification of environmental baseline data and provide context for the assessment of environmental impacts, as determined through subsequent SMPs.	Triggers for commencing OM04 include: • Contact of a sensitive habitat or shoreline is predicted by OM01, OM02 and/or OM03 • The pre-emptive assessment methods can be implemented before contact from hydrocarbons (once a receptor has been contacted by hydrocarbons it will be assessed under OM05)	The criteria for the termination of OM04 at any given location are: • Locations predicted to be contacted by hydrocarbons have been contacted • The location has not been contacted by hydrocarbons and is no longer predicted to be contacted by hydrocarbons (resources should be reallocated as appropriate)

Operational Monitoring Operational Plan	Objectives	Activation triggers	Termination criteria
Operational monitoring operational plan 5 (OM05) Monitoring of contaminated resources	OM05 aims to implement surveys to assess the condition of fauna and habitats contacted by hydrocarbons at sensitive habitat and shoreline locations. The primary objectives of OM05 are: • Record evidence of oiled fauna (mortalities, sub-lethal impacts, number, extent, location) and habitats (mortalities, sub-lethal impacts, type, extent of cover, area, hydrocarbon character, thickness, mass and content) throughout the response and clean-up at locations contacted by hydrocarbons to inform and prioritise clean-up efforts and resources, while minimising the potential impacts of these activities. Indirectly, the information collected by OM05 may also support the assessment of environmental impacts, as determined through subsequent SMPs.	OM05 will be triggered when a sensitive habitat or shoreline is predicted to be contacted by hydrocarbons by OM01, OM02 and/or OM03.	The criteria for the termination of OM05 at any given location are: • No additional response or clean-up of fauna or habitats is predicted • Spill response and clean-up activities have ceased OM05 survey sites established at sensitive habitat and shoreline locations will continue to be monitored during SM02. The formal transition from OM05 to SM02 will begin on cessation of spill response and clean-up activities.

ANNEX C: OIL SPILL SCIENTIFIC MONITORING PROGRAM

Oil Spill Environmental Monitoring

The following provides some further detail on Woodside's oil spill scientific monitoring Program and includes the following:

- The organisation, roles and responsibilities of the Woodside oil spill scientific monitoring team and external resourcing.
- A summary table of the ten scientific monitoring programs as per the specific focus receptor, objectives, activation triggers and termination criteria.
- Details on the oil spill environmental monitoring activation and termination decision-making processes.
- Baseline knowledge and environmental studies knowledge access via geo-spatial metadata databases.
- An outline of the reporting requirements for oil spill scientific monitoring programs.

Oil Spill Scientific Monitoring – Delivery Team Roles and Responsibilities

Woodside Oil Spill Scientific Monitoring Delivery Team

The Woodside science team is responsible for the delivery of the oil spill scientific monitoring. The roles and responsibilities of the Woodside scientific monitoring delivery team are presented in Table C-1 and the organisational structure and Incident Control Centre (ICC) linkage provided in Figure C-1.

Woodside Oil Spill Scientific monitoring program - External Resourcing

In the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors, scientific monitoring personnel and scientific equipment to implement the appropriate SMPs will be provided by SMP Standby contractor who hold a standby contract for SMP via the Woodside Environmental Services Panel (ESP). In the event that additional resources are required other consultancy capacity within the Woodside ESP will be utilised (as needed and may extend to specialist contractors such as research agencies engaged in long-term marine monitoring programs). In consultation with the SMP Standby Contractor and/or specialist contractors, the selection, field sampling and approach of the SMPs will be determined by the nature and scale of the spill.

Table C-1: Woodside and Environmental Service Provider – Oil Spill Scientific Monitoring Program Delivery Team Key Roles and Responsibilities

Role	Location	Responsibility
Woodside Roles		
SMP Lead/Manager	Onshore (Perth)	• Approves activated the SMPs based on operational monitoring data provided by the Planning Function • Provides advice to the ICC in relation to scientific monitoring • Provides technical advice regarding the implementation of scientific monitoring • Approves detailed sampling plans prepared for SMPs • Directs liaison between statutory authorities, advisors and government agencies in relation to SMPs.
SMP Co-ordinator	Onshore (Perth)	• Activates the SMPs based on operational monitoring data provided by the Planning Function • Sits in the Planning function of the ICC. • Liaises with other ICC functions to deliver required logistics, resources and operational support from Woodside to support the Environmental Service Provider in delivering on the SMPs. Acts as the conduit for advice from the SMP Lead/Manager to the Environmental Service Provider • Manages the Environmental Service Provider's implementation of the SMPs • Liaises with the Environmental Service Provider on delivery of the SMPs • Arranges all contractual matters, on behalf of Woodside, associated with the Environmental Service Provider's delivery of the SMPs.

Role	Location	Responsibility
Environmental Service Provider Roles		
SMP standby contractor SMP Duty Manager/Project Manager	Onshore (Perth)	• Coordinates the delivery of the SMPs • Provides costings, schedule and progress updates for delivery of SMPs • Determines the structure of the Environmental Service Provider's team to necessitate delivery of the SMPs • Verifies that HSE Plans, detailed sampling plans and other relevant deliverables are developed and implemented for delivery of the SMPs • Directs field teams to deliver SMPs • Arranges all contractual matters, on behalf of Environmental Service Provider, associated with the delivery of the SMPs to Woodside • Manages sub-consultant delivery to Woodside • Provides required personnel and equipment to deliver the SMPs
SMP Field Teams	Offshore – Monitoring Locations	• Delivers the SMPs in the field consistent with the detailed sampling plans and HSE requirements, within time and budget. • Provides early communication of time, budget, HSE risks associated with delivery of the SMPs to the Environmental Service Provider – Project Manager • Provides start up, progress and termination updates to the Environmental Service Provider – Project Manager (will be led in-field by a party chief).

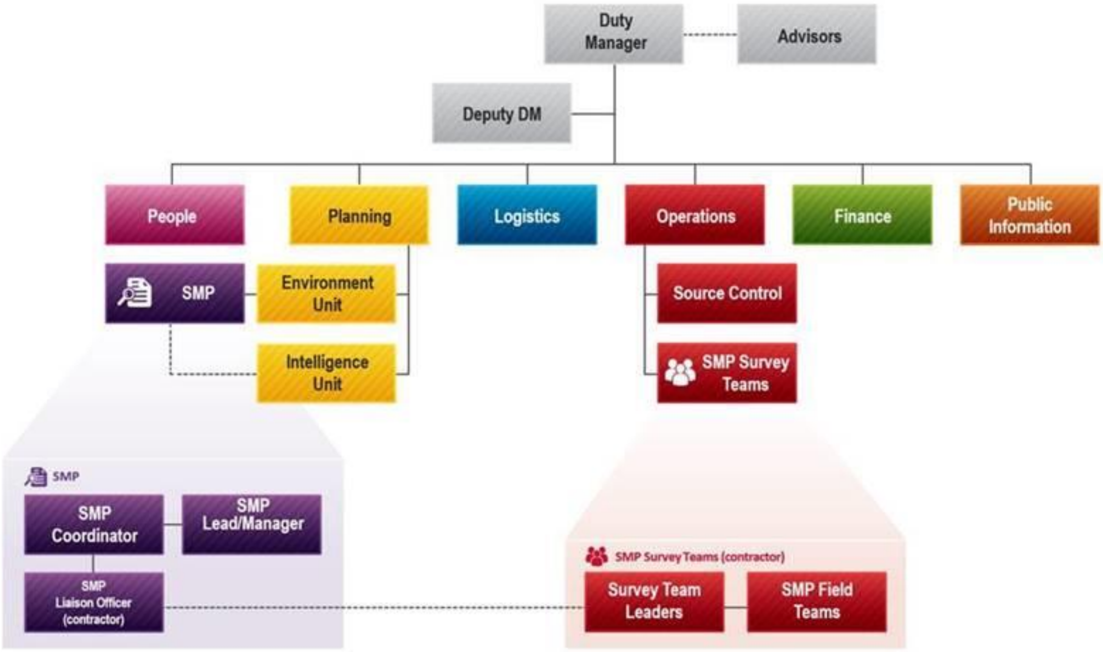


Figure C-1: Woodside Oil Spill Scientific Monitoring Program Delivery Team and Linkage to Incident Control Centre (ICC) organisational structure.

Table C-2: Oil Spill Environmental Monitoring: Scientific Monitoring Program - Objectives, Activation Triggers and Termination Criteria

Scientific monitoring Program (SMP)	Objectives	Activation Triggers	Termination Criteria
Scientific monitoring program 1 (SM01) **Assessment of Hydrocarbons in Marine Waters**	SM01 will detect and monitor the presence, extent, persistence and properties of hydrocarbons in marine waters following the spill and the response. The specific objectives of SM01 are as follows: • Assess and document the extent, severity and persistence of hydrocarbon contamination with reference to observations made during surveillance activities and / or in-water measurements made during operational monitoring; and • Provide information that may be used to interpret potential cause and effect drivers for environmental impacts recorded for sensitive receptors monitored under other SMPs.	SM01 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors	SM01 will be terminated when: • Operational monitoring data relating to observations and / or measurements of hydrocarbons on and in water have been compiled, analysed and reported; and • The report provides details of the extent, severity and persistence of hydrocarbons which can be used for analysis of impacts recorded for sensitive receptors monitored under other SMPs. SMP monitoring of sensitive receptor sites: • Concentrations of hydrocarbons in water samples are below NOPSEMA guidance note (2019[7]) concentrations of 1 g/m^2 for floating, 10 ppb for entrained and dissolved; and • Details of the extent, severity and persistence of hydrocarbons from concentrations recorded in water have been documented at sensitive receptor sites monitored under other SMPs.
Scientific monitoring program 2 (SM02) **Assessment of the Presence, Quantity and Character of Hydrocarbons in Marine Sediments**	SM02 will detect and monitor the presence, extent, persistence and properties of hydrocarbons in marine sediments following the spill and the response. The specific objectives of SM02 are as follows: • Determine the extent, severity and persistence of hydrocarbons in marine sediments across selected sites where hydrocarbons were observed or recorded during operational monitoring; and • Provide information that may be used to interpret potential cause and effect drivers for environmental impacts recorded for sensitive receptors monitored under other SMPs.	SM02 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented as follows: • Response activities have ceased; and • Operational monitoring results made during the response phase indicate that shoreline, intertidal or sub-tidal sediments have been exposed to surface, entrained or dissolved hydrocarbons (at or above 0.5 g/m² surface, 5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m² for shoreline accumulation).	SM02 will be terminated once pre-spill condition is reached and agreed upon as per the SMP termination criteria process and include consideration of: • Concentrations of hydrocarbons in sediment samples are below ANZECC/ ARMCANZ (2013[8]) sediment quality guideline values (SQGVs) for biological disturbance; and • Details of the extent, severity and persistence of hydrocarbons from concentrations recorded in sediments have been documented.
Scientific monitoring program 3 (SM03) **Assessment of Impacts and Recovery of Subtidal and Intertidal Benthos**	The objectives of SM03 are: • Characterize the status of intertidal and subtidal benthic habitats and quantify any impacts to functional groups, abundance and density that may be a result of the spill; and • Determine the impact of the hydrocarbon spill and subsequent recovery (including impacts associated with the implementation of response options). Categories of intertidal and subtidal habitats that may be monitored include: • Coral reefs • Seagrass • Macro-algae • Filter-feeders SM03 will be supported by sediment contamination records (SM02) and characteristics of the spill derived from OMPs.	SM03 will be activated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented as follows: • As part of a pre-emptive assessment of PBAs of receptor locations identified by time to hydrocarbon contact >10 days, to target receptors and sites where it is possible to acquire pre-hydrocarbon contact baseline; and • Operational monitoring identified shoreline potential contact of hydrocarbons (at or above 0.5 g/m² surface, 5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m² for shoreline accumulation) for subtidal and intertidal benthic habitat.	SM03 will be terminated once pre-spill condition is reached and agreed upon as per the SMP termination criteria process and include consideration of: • Overall impacts to benthic habitats from hydrocarbon exposure have been quantified. • Recovery of impacted benthic habitats has been evaluated. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 4 (SM04) **Assessment of Impacts and Recovery of Mangroves / Saltmarsh**	The objectives of SM04 are: • Characterize the status of mangroves (and associated salt marsh habitat) at shorelines exposed/contacted by spilled hydrocarbons; • Quantify any impacts to species (abundance and density) and mangrove/saltmarsh community structure; and • Determine and monitor the impact of the hydrocarbon spill and potential subsequent recovery (including impacts associated with the implementation of response options). SM03 will be supported by sediment sampling undertaken in SM02 and characteristics of the spill derived from OMPs.	SM04 will be activated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented as follows: • As part of a pre-emptive assessment of receptor locations identified by time to hydrocarbon contact >10 days; and	SM04 will be terminated once pre-spill condition is reached and agreed upon as per the SMP termination criteria process and include consideration of: • Impacts to mangrove and saltmarsh habitat from hydrocarbon exposure have been quantified. • Recovery of impacted mangrove/saltmarsh habitat has been evaluated.

[7] NOPSEMA (2019) Bulletin #1 – Oil spill modelling – April 2019, https://www.nopsema.gov.au/assets/Bulletins/A652993.8.9.pdf

[8] Simpson SL, Batley GB and Chariton AA (2013). Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines. CSIRO and Water Science Report 08/07. Land and Water, pp. 132.

Scientific monitoring Program (SMP)	Objectives	Activation Triggers	Termination Criteria
		• Operational monitoring identified shoreline potential contact of hydrocarbons (at or above 0.5 g/m² surface, 5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m² for shoreline accumulation) for mangrove/saltmarsh habitat.	• Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 5 (SM05) **Assessment of Impacts and Recovery of Seabird and Shorebird Populations**	The Objectives of SM05 are to: • Collate and quantify impacts to avian wildlife from results recorded during OM02 and OM05 (such as mortalities, oiling, rescue and release counts) and undertake a desk-based assessment to infer potential impacts at species population level; and • Undertake monitoring to quantify and assess impacts of hydrocarbon exposure to seabirds and shorebird populations at targeted breeding colonies / staging sites / important coastal wetlands where hydrocarbon contact was recorded.	SM05 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented as follows: • As part of a pre-emptive assessment of receptor locations identified by time to hydrocarbon contact >10 days; • Operational monitoring predicts shoreline impact of hydrocarbons (at or above 0.5 g/m² surface, 5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m² for shoreline accumulation) at important bird colonies / staging sites / important coastal wetland locations; or • Records of dead, oiled or injured bird species made during the hydrocarbon spill or response.	SM05 will be terminated once it is agreed that the receptor has returned to pre-spill condition. The SMP termination criteria process will be followed and include consideration of: • Impacts to seabird and shorebird populations from hydrocarbon exposure have been quantified. • Recovery of impacted seabird and shorebird populations has been evaluated. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 6 (SM06) **Assessment of Impacts and Recovery of Nesting Marine Turtle Populations**	The objectives of SM06 are to: • To quantify impacts of hydrocarbon exposure or contact on marine turtle nesting populations (including impacts associated with the implementation of response options); • Collate and quantify impacts to adult and hatchling marine turtles from results recorded during OM02 and OM05 (such as mortalities, oiling, rescue and release counts) and undertake a desk-based assessment to infer potential impacts at species population levels (including impacts associated with the implementation of response options); and • Undertake monitoring to quantify and assess impacts of hydrocarbon exposure to nesting marine turtle populations at known rookeries (including impacts associated with the implementation of response options).	SM06 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented if operational monitoring has: • As part of a pre-emptive assessment of receptor locations identified by time to hydrocarbon contact >10 days; • Predicted shoreline impact of hydrocarbons (at or above 0.5 g/m² surface, 5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m² for shoreline accumulation) at known marine turtle rookery locations; or • Records of dead, oiled or injured marine turtle species made during the hydrocarbon spill or response.	SM06 will be terminated once it is agreed that the receptor has returned to pre-spill condition. The SMP termination criteria process will be followed and include consideration of: • Impacts to nesting marine turtle populations from hydrocarbon exposure have been quantified. • Recovery of impacted nesting marine turtle populations has been evaluated. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 7 (SM07) **Assessment of Impacts to Pinniped Colonies including Haul-out Site Populations**	The objectives of SM07 are to: • Quantify impacts on pinniped colonies and haul-out sites as a result of hydrocarbon exposure/contact. • Collate and quantify impacts to pinniped populations from results recorded during OM02 and OM05 (such as mortalities, oiling, rescue and release counts) and undertake a desk-based assessment to infer potential impacts at species population levels.	SM07 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented if operational monitoring has: • As part of a pre-emptive assessment of receptor locations identified by time to hydrocarbon contact >10 days; • Identified shoreline impact of hydrocarbons ((at or above 0.5 g/m² surface, ≥5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m² for shoreline accumulation) at known pinniped colony or haul-out site(s) (i.e. most northern site is the Houtman Abrolhos Islands); or • Records of dead, oiled or injured pinniped species made during the hydrocarbon spill or response.	SM07 will be terminated once it is agreed that the receptor has returned to pre-spill condition. The SMP termination criteria process will be followed and include consideration of: • Impacts to pinniped populations from hydrocarbon exposure have been quantified. • Recovery of pinniped populations has been evaluated. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 8 (SM08) **Desk-Based Assessment of Impacts to Other Non-Avian Marine Megafauna**	The objective of SM08 is to provide a desk-based assessment which collates the results of OM02 and OM05 where observations relate to the mortality, stranding or oiling of mobile marine megafauna species not addressed in SM06 or SM07, including: • Cetaceans; • Dugongs; • Whale sharks and other shark and ray populations; • Sea snakes; and • Crocodiles.	SM08 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented if operational monitoring reports records of dead, oiled or injured non-avian marine megafauna during the spill/ response phase.	SM08 will be terminated when the results of the post-spill monitoring have quantified impacts to non-avian megafauna. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.

Scientific monitoring Program (SMP)	Objectives	Activation Triggers	Termination Criteria
	The desk-based assessment will include population analysis to infer potential impacts to marine megafauna species populations.		
Scientific monitoring program 9 (SM09) **Assessment of Impacts and Recovery of Marine Fish associated with SM03 habitats**	The objectives of SM09 are: • Characterise the status of resident fish populations associated with habitats monitored in SM03 exposed/contacted by spilled hydrocarbons; • Quantify any impacts to species (abundance, richness and density) and resident fish population structure (representative functional trophic groups); and • Determine and monitor the impact of the hydrocarbon spill and potential subsequent recovery (including impacts associated with the implementation of response options).	SM09 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented with SMO3.	SM09 will be undertaken and terminated concurrent with monitoring undertaken for SM03, as per the SMP termination criteria process • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 10 (SM10) **SM10 - Assessment of physiological impacts important fish and shellfish species (fish health and seafood quality/safety) and recovery**	SM10 aims to assess any physiological impacts to important commercial fish and shellfish species (assessment of fish health) and if applicable, seafood quality/safety. Monitoring will be designed to sample key commercial fish and shellfish species and analyse tissues to identify fish health indicators and biomarkers, for example: • Liver Detoxification Enzymes (EROD activity) • PAH Biliary Metabolites • Oxidative DNA Damage • Serum SDH • Other physiological parameters, such as condition factor (CF), liver somatic index (LSI), gonado-somatic index (GSI) and gonad histology, total weight, length, condition, parasites, egg development, testes development, abnormalities. Seafood tainting may be included (where appropriate) using applicable sensory tests to objectively assess targeted finfish and shellfish species for hydrocarbon contamination. Results will be used to make inferences on the health of commercial fisheries and the potential magnitude of impacts to fishing industries.	SM10 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented if operational monitoring (OM01, OM02 and OM05) indicates the following: • The hydrocarbon spill will or has intersected with active commercial fisheries or aquaculture activities; • Commercially targeted finfish and/or shellfish mortality has been observed/recorded; • Commercial fishing or aquaculture areas have been exposed to hydrocarbons (≥0.5 g/m² surface and ≥5 ppb for entrained/dissolved hydrocarbons); and • Taste, odour or appearance of seafood presenting a potential human health risk is observed.	SM10 will be terminated once it is agreed that the receptor has returned to pre-spill condition. The SMP termination criteria process will be followed and include consideration of: • Physiological impacts to important commercial fish and shellfish species from hydrocarbon exposure have been quantified. • Recovery of important commercial fish and shellfish species from hydrocarbon exposure has been evaluated. • Impacts to seafood quality/safety (if applicable) have been assessed and information provided to the relevant stakeholders and regulators for the management of any impacted fisheries. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.

Activation Triggers and Termination Criteria

Scientific monitoring program Activation

The Woodside oil spill scientific monitoring team will be stood up immediately on the occurrence of a hydrocarbon spill (actual or suspected) Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors via the first strike plan for the petroleum activity programme. The presence of any level of hydrocarbons in the marine environment triggers the activation of the oil spill scientific monitoring program (SMP). This is to ensure the full range of eventualities relating to the environmental, socio-economic and health consequences of the spill are considered in the planning and execution of the SMP. The activation process also takes into consideration the management objectives, species recovery plans, conservation advices and conservations plans for any World Heritage Area (WHA), CMRs, State Marine Parks, other protected area designations (e.g., State nature reserves) and Matters of National Environmental Significance (including listed species under part 3 of the EPBC Act) potentially exposed to hydrocarbons. Within the first 24-48 hours of a spill event, such information will be sourced and evaluated as part of the SMP planning process guided by Appendix D (identified receptors vulnerable to hydrocarbon contact), the information presented in the Existing Environment section of the EP as well as other information sources such as the Woodside Baseline Environmental Studies Database.

The starting point for decision-making on which SMPs are activated and spatial extent of monitoring activities will be based on the predictive modelling results (OM01) in the first 24-48 hours until more information is made available from other operational monitoring activities such as aerial surveillance and shoreline surveys. Pre-emptive Baseline Areas (WHA, CMRs and State Marine Parks encompassing key ecological and socio-economic values) are a key focus of the SMP activation decision-making process, particularly, in the early spill event/response phase. As the operational monitoring progresses and further situational awareness information becomes available, it will be possible to understand the nature and scale of the spill. The SMP activation and implementation decision-making will be revisited on a daily basis to account for the updates on spill information. One of the priority focus areas in the early phase of the incident will be to identify and execute pre-emptive SMP assessments at key receptor locations, as required. The SMP activation and implementation decision tree is presented in Figure C-2.

Scientific monitoring Program Termination

The basis of the termination process for the active SMPs (SMPs 1-10) will include quantification of impacts, evaluation of recovery for the receptor at risk and consultation with relevant authorities, persons and organisations. Termination of each SMP will not be considered until the results (as presented in annual SMP reports for the duration of each program) indicate that the target receptor has returned to pre-spill condition.

Once the SMP results indicate impacted receptor(s) have returned to pre-spill condition (as identified by Woodside) a termination decision-making process will be triggered and a number of steps will be undertaken as follows:

- Woodside will engage expert opinion on whether the receptor has returned to pre-spill condition (based on monitoring data). Subject Matter Expert (SMEs) will be engaged (via the Woodside SME scientific monitoring terms of reference to review program outcomes, provide expert advice and recommendations for the duration of each SMP.
- Where expert opinion agrees that the receptor has returned to pre-spill condition, findings will then be presented to the relevant authorities, persons and organisations (as defined by the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulation 11A). Stakeholder identification, planning and engagement will be managed by Woodside's Reputation Functional Support Team (FST) and follow the stakeholder management FST guidelines. These guidelines outline the FST roles and responsibilities, competencies, stakeholder communications and

planning processes. An assessment of the merits of any objection to termination will be documented in the SMP final report.

- Woodside will decide on termination of SMP based on expert opinion and merits of any stakeholder objections. The final report following termination will include: monitoring results, expert opinion and stakeholder consultation including merits of any objections.
- Termination of SMPs will also consider applicable management objectives, species recovery plans, conservation advices and conservations plans for any World Heritage Area (WHA), CMRs, State Marine Parks, other protected area designations (e.g., State nature reserves) and Matters of National Environmental Significance (including listed species under part 3 of the EPBC Act).

The SMP termination decision-making process will be applied to each active SMP and an iterative process of decision steps continued until each SMP has been terminated (refer to decision-tree diagram for SMP termination criteria, Figure C-3).

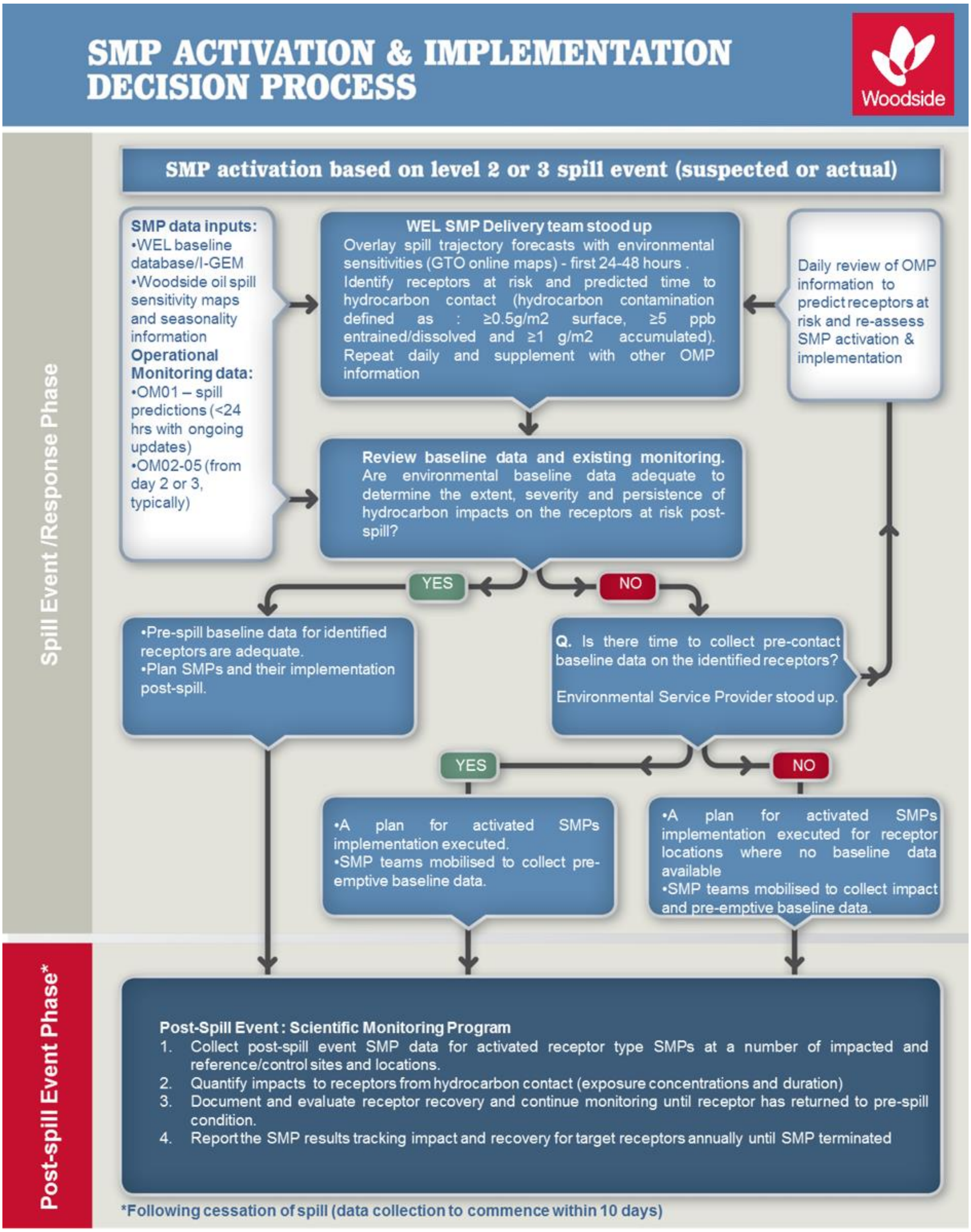


Figure C-2: Activation and Implementation Decision-tree for Oil Spill Environmental Monitoring

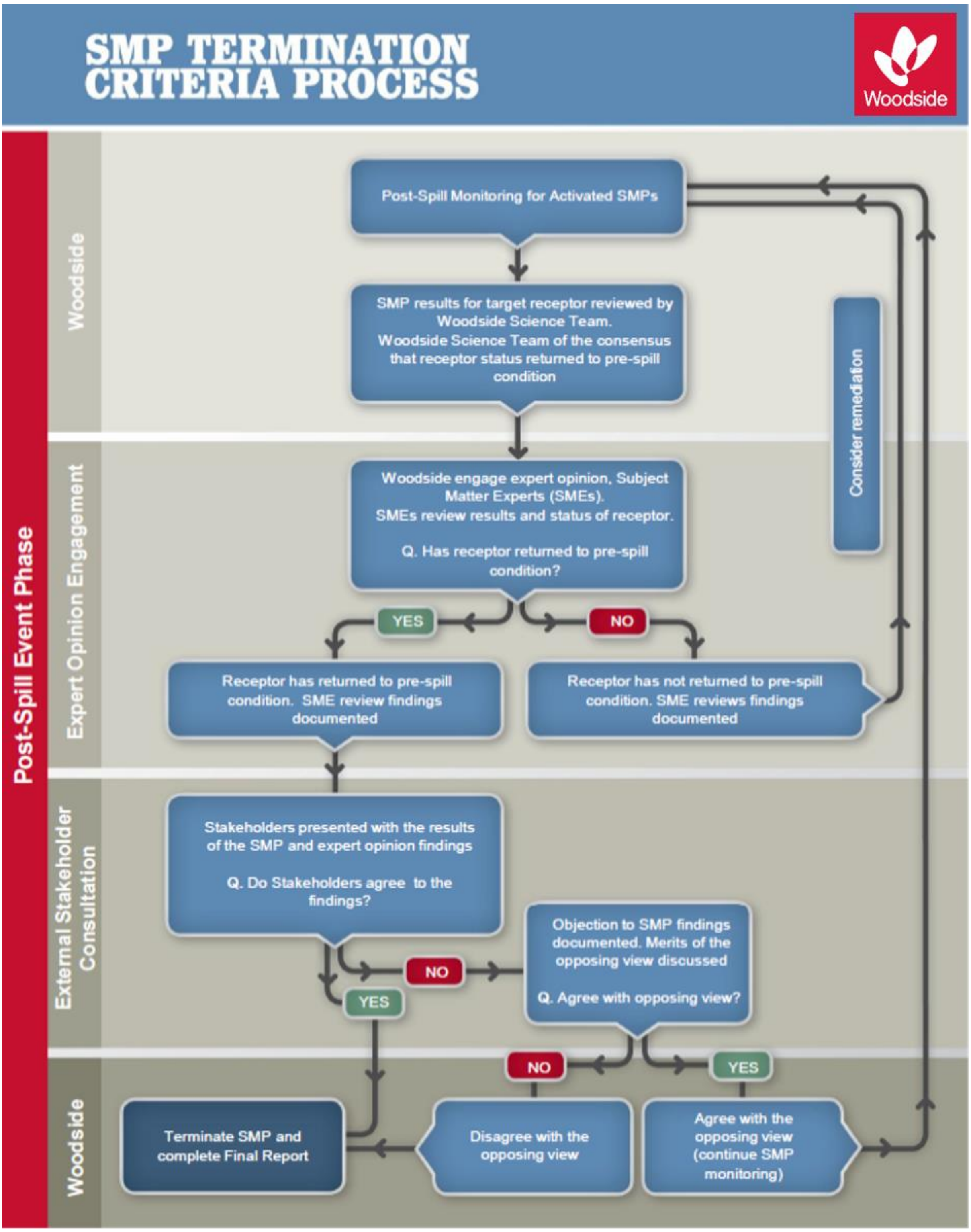


Figure C-3: Termination Criteria Decision-tree for Oil Spill Environmental Monitoring

Receptors at Risk and Baseline Knowledge

In order to assess the baseline studies availability and suitability for oil spill scientific monitoring, Woodside maintains knowledge of environmental baseline studies through the upkeep and use of its Environmental Knowledge Management System.

Woodside's Environmental Knowledge Management System is a centralised platform for scientific information on the existing environment, marine biodiversity, Woodside environmental studies, key environmental impact topics, key literature and web-based resources. The system comprises a number of data directories and an environmental baseline database, as well as folders within the 'Corporate Environment' server space. The environmental baseline database was set up to support Woodside's SMP preparedness and as a SMP resource in the event of an unplanned hydrocarbon spill. The environmental baseline database is subject to updates including annual reviews completed as part of SMP standby contract. This database is accessed pre-activity to identify Pre-emptive Baseline Areas (PBAs) where hydrocarbon contact is predicted to occur <10 days.

In addition to Woodside's Environmental Knowledge Management System, it is acknowledged that many relevant baseline datasets are held by other organisations (e.g. other oil and gas operators, government agencies, state and federal research institutions and non-governmental organisations). In order to understand the present status of environmental baseline studies a spatial environmental metadata database for Western Australia (Industry-Government Environmental Metadata, I-GEM) was established. I-GEM was a collaboration comprising oil and gas operators (including Woodside), government and research agencies and other organisations. I-GEM held data was integrated into the Department of Water and Environmental Regulation (WA) Index of Marine Surveys for Assessment (IMSA[9]) in 2020. The Index of Marine Surveys for Assessments (IMSA) is an online portal for information about marine-based environmental surveys in Western Australia. IMSA is a project of the Department of Water and Environmental Regulation (the department) for the systematic capture and sharing of marine data created as part of an environmental impact assessment (EIA).

In the event of an unplanned hydrocarbon release, Woodside intends to interrogate the information on baseline studies status as held by the various databases (e.g. Woodside Environmental Knowledge Management System, IMSA and other sources of existing baseline data) to identify Pre-emptive Baseline Areas (PBAs), i.e., receptors at risk where hydrocarbon contact is predicted to be >10 days, and baseline data can be collected before hydrocarbon contact.

Reporting

For the scientific monitoring program relevant regulators will be provided with:

- Annual reports summarising the SMPs deployed and active, data collection activities and available findings; and
- Final reports for each SMP summarising the quantitative assessment of environmental impacts and recovery of the receptor once returned to pre-spill condition and termination of the monitoring program.

The reporting requirements of the scientific monitoring program will be specific to the individual SMPs deployed and terms of responsibilities, report templates, schedule, QA/QC and peer-review will be agreed with the contractors engaged to conduct the SMPs. Compliance and auditing mechanisms will be incorporated into the reporting terms.

[9] https://biocollect.ala.org.au/imsa#max%3D20%26sort%3DdateCreatedSort

ANNEX D: MONITORING PROGRAM AND BASELINE STUDIES FOR THE PETROLEUM ACTIVITIES PROGRAM

Table D-1: Oil Spill Environmental Monitoring – scientific monitoring program scope for the Petroleum Activities Program based on Spill EMBA for CS-01 and CS-02 (release of Marine Diesel caused by a vessel collision)

Receptors to be Monitored	Applicable SMP	Oceanic Shoals AMP	Arafura AMP	Lynedoch Bank	Oceanic Shaoals	Mermaid Shoal	Trourbadour SHaols
Water Quality	SM01	X	X	X	X	X	X
Marine Sediment Quality	SM02	X	X	X	X	X	
Coral Reef	SM03	X		X			
Seagrass / Macro-Algae	SM03	X					
Deeper Water Filter Feeders	SM03	X			X	X	X
Mangroves and Saltmarsh	SM04						
Sea Birds and Migratory Shorebirds (significant colonies / staging sites / coastal wetlands)	SM05						
Marine Turtles (significant nesting beaches)	SM06						
Pinnipeds (significant colonies / haul-out sites)	SM07						
Cetaceans - Migratory Whales	SM08						
Oceanic and Coastal Cetaceans	SM08						
Dugongs	SM08						
Sea Snakes	SM08	X	x	X	X	x	x
Whale Sharks	SM08						
Other Shark and Ray Populations	SM08, SM09	X	X	X	X	x	X
Fish Assemblages	SM09	X	X	X	X	X	X
Fisheries - Commercial	SM10	X	X	X	X	X	X
Fisheries - Traditional	SM10						
Tourism (incl. recreational fishing)	SM10						

Table D-2: Baseline Studies for the SMPs applicable to identified Pre-emptive Baseline Areas for the Petroleum Activities Program

SMP	Proposed Scientific monitoring operational plan and Methodology	Lynedoch Bank	Oceanic Shoals-
Benthic Habitat (Coral Reef)	**SM03** Quantitative assessment using image capture using either diver held camera or towed video. Post analysis into broad groups based on taxonomy and morphology.	Benthic commununity surveys	Benthic commununity surveys
		1. Towed video	1. Towed video
		1. AIMS, 2014. 2. Jacobs, 2016. 3. Heyward et al. 2017a	1. Heyward *et al.* 2017a
Benthic Habitat (Seagrass and Macro-algae)	**SM03** Quantitative assessment using image capture using either diver held camera or towed video. Post analysis into broad groups based on taxonomy and morphology.	As above	As above
Benthic Habitat (Deeper Water Filter Feeders)	**SM03** Quantitative assessment using image capture using towed video. Post analysis into broad groups based on taxonomy and morphology.	As above	As above
Fish	**SM09** Baited Remote Underwater Video Stations (BRUVS), Visual Underwater Counts (VUC), Diver Operated Video (DOV).	1. Fish species richness and abundance.	1. Fish species richness and abundance.
		1. BRUVs	1.BRUVS
		1. Jacobs 2016. 2. Heyward *et al.* 2017b	1. Jacobs 2016. 2. Heyward et al. 2017b

References for above Table

(AIMS) Australian Institute of Marine Science, 2014. Towed Video deployments to address strategic knowledge gaps in the Oceanic Shoals bioregion 2014, Western Australia (AIMS). https://eatlas.org.au/data/uuid/bb5f2a32-9eee-404d-b2ee-0feef965eb91?_ga=2.179027748.1275322686.1610334665-1127418343.1573002697

(AIMS) Australian Institute of Marine Science, 2015. Oceanic Shoals Commonwealth Marine Reserve (CMR) 2012 pelagic baited camera surveys. Video content available from: https://www.youtube.com/watch?v=4ycARo_j80Q

Heyward, A., Colquhoun, J., Stower, M., Case, M., 2017a. BRUVS surveys collected for the Barossa Environmental Baseline Study 2015, Western Australia (ConocoPhillips).

Heyward, A., Radford, B., Cappo, M., Wakeford, M., Fisher, R., Colquhoun, J., Case, M., Stowar, M., Miller, K., 2017b. Barossa Environmental Baseline Study, Regional Shoals and Shelf Assessment 2015 Final Report. A report for ConocoPhillips Australia Exploration Pty Ltd by the Australian Institute of Marine Science, Perth 2017. 143pp.

Jacobs, 2016. Barossa Environmental Studies, Benthic Habitat Report. Report prepared for ConocoPhillips. WV04831-NMS-RP-0028, Rev 2. Available at: Barossa Area Development OPP Rev 5 Appendices.pdf (conocophillips.com).

ANNEX E: OPERATIONAL SECTOR MAPS

For this scenario there is no shoreline impact predicted at response threshold (100 g/m^2). If, however, Operational Monitoring predicted that a spill may impact the Northern Territory coastline, Woodside would utilise the Operational Sector maps included in the NT OWRP (AMOSC, 2019) as a basis for any required Tactical Response Plans. The NT OWRP Operational Sector maps are based upon Geoscience Australia's Coastal Compartments (CC) in order to offer a consistent framework for regional planning and coastal management, and to align with other NT and national marine planning documents and strategies (AMOSC, 2019).

Each Operational Sector's description includes details on the terrain, prevailing metocean conditions, key environmental sensitivities, accessibility and staging information.

NT OWRP Operational Sectors are shown below in Table E- 1.

Table E- 1: NT OWRP Operational Sectors

Sector number	Start/end locations
SECTOR 1	WA/NT Border to Pearce Point (CC 325)
SECTOR 2	Pearce Point to Cape Ford (CC 326)
SECTOR 3	Cape Ford to Paterson Point (CC 327)
SECTOR 4	Paterson Point to Charles Point (CC 328)
SECTOR 5	Charles Point to Gunn Point (CC 329)
SECTOR 6	Cape Fourcroy (Bathurst Island) to Gunn Point (CC 330)
SECTOR 7	Cape Fourcroy (Bathurst Island) to Cape Van Diemen (Melville Island) (CC 331)
SECTOR 8	Cape Van Diemen to Soldier Point (CC 332 and 333)
SECTOR 9	Soldier Point to Cape Gambier (CC 334)
SECTOR 10	Cape Hotham to Point Farewell (CC 335 and 226)
SECTOR 11	Point Farewell to Cape Don (CC 337 and 338)
SECTOR 12	Cape Don to Cape Croker (Croker Island) (CC 339)
SECTOR 13	Cape Croker (Croker Island) to Angularli Creek (CC 340)

APPENDIX E NOPSEMA REPORTING FORMS

NOPSEMA Recordable Environmental Incident Monthly Reporting Form:
https://www.nopsema.gov.au/assets/Forms/A198750.doc

Report of an accident, dangerous occurrence or environmental incident:
https://www.nopsema.gov.au/assets/Forms

APPENDIX F STAKEHOLDER CONSULTATION

Galactic Hybrid 2D MSS Environment Plan

Appendix F

Date: September 2021

Revision: 0

Phase 1 consultation
Consultation Information Sheet sent to all stakeholders

Woodside

STAKEHOLDER CONSULTATION

INFORMATION SHEET

March 2021

GALACTIC HYBRID MARINE SEISMIC ENVIRONMENT PLAN

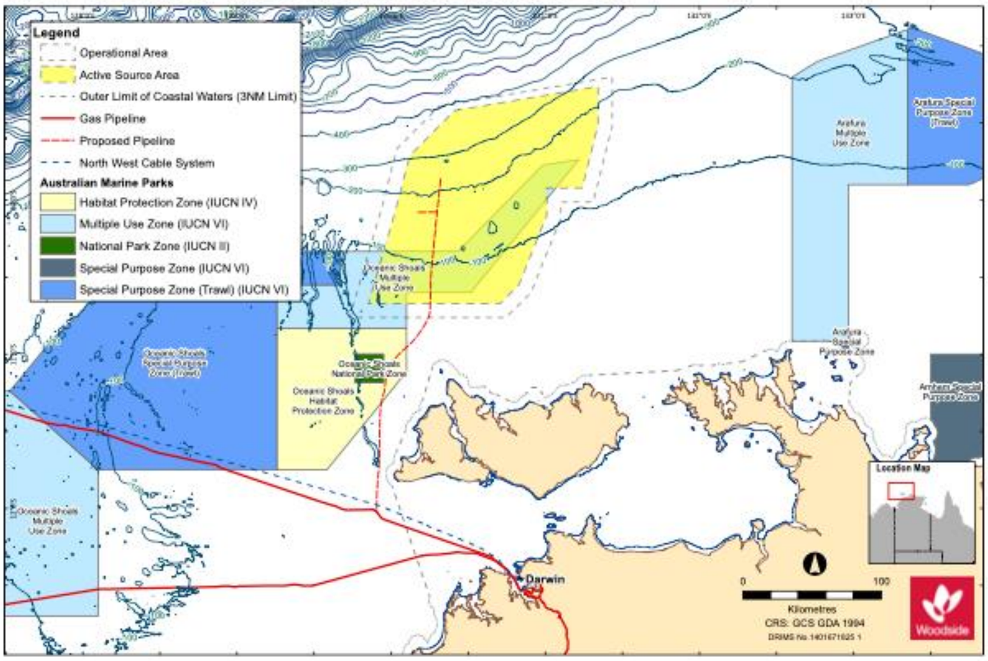
BONAPARTE BASIN, NORTHERN AUSTRALIA

Woodside is planning to conduct a marine seismic survey in exploration permit NT/P86 in Commonwealth waters offshore Northern Territory, starting at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

The survey is part of Woodside's work program commitments for the permit and will be the first 3D survey over the permit, or the first comprehensive 2D survey over the permit since the mid 2000s.

The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define new and existing leads and assess commerciality of potential hydrocarbon accumulations.

Woodside is the Operator and holds 100% equity in the NT/P86 permit.



About Marine Seismic Surveys

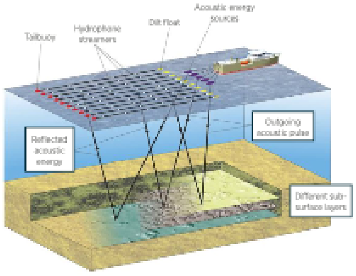
During planned activities, a seismic vessel traverses a series of pre-determined sail lines within the survey Active Source Area at a speed of approximately three to five knots (5.5 – 9.3 km/hr).

An additional buffer area, or Operational Area, around the Active Source Area is allowed for vessel manoeuvring and line turns — no source discharge will occur in this zone. Testing of the seismic source, 'soft starts', and operation of the seismic source during seismic line 'run in's' and 'run out's' will all be undertaken within the Active Source Area.

As the vessel travels along a sail line series, seismic air sources are used to generate acoustic pulses approximately every 2 to 18 seconds.

These acoustic pulses are directed vertically through the water column and into the seabed. The released energy is reflected at geological boundaries, with the reflected signals detected by sensitive microphones called 'hydrophones', embedded within a number of cables, or streamers, towed behind the seismic vessel.

The reflected sound is recorded and then processed to generate a seismic image, providing information about the structure and composition of geological formations below the seabed.



Proposed activity

Table 1. Activity summary

Activity	Details
Earliest Commencement date	From May 2022
Estimated duration	20 days – 45 days
Survey size	Max. 2000 line km of 2D seismic data or Max. 2000 km^2 of 3D seismic data
Operational Area	Max. 21,608 km^2
Water depth in Operational Area	12 m - 384 m
Vessels	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel
Distance from Active Source Area to nearest town	187 km north of the Port of Darwin
Distance from Active Source Area to nearest marine park	The Active Source Area overlaps part of the Multiple Use Zone of the Oceanic Shoals Australian Marine Park

The proposed Galactic Hybrid Marine Seismic Survey (MSS) will be conducted by a single, purpose-built seismic vessel.

Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the Environment Plan (EP) being submitted to the regulator for consideration and acceptance.

In a 2D survey both the sound source and the streamers travel along a single straight line. In a 3D survey, multiple streamers are used and are spread out over an area. 3D surveys provide significantly improved imaging of subsurface features compared to 2D surveys as more reflected signals are recorded with the multiple streamers.

For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.

Seismic nodes have been widely used since the mid-2000s using remotely operated vehicles operated from a support vessel for node placement and retrieval from the seabed. However, advances in autonomous technology mean that the nodes will be able to self-reposition. The autonomous devices will make minimal noise when moving between locations and will have negligible disturbance to the seabed when positioning.

An additional support vessel may be used to manage potential interactions with other marine users in the vicinity of the survey. Both vessels may be used for deployment and retrieval of the seismic nodes. Survey activities will take place 24 hrs per day.

Technical details for each option are outlined in **Table 2.**

Table 2 – Technical overview

Activity	2D survey	3D survey
Number of streamers	Up to two streamers	Six to 12 streamers
Streamer length	10 km	5 m – 8 km
Distance between streamers	125 m – 150 m	125 m – 150 m
Maximum width of streamer array	~400 m	~2 km
Safe navigation area (cautionary zone)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations
Streamer tow depth	>15 m	>15 m
Sound source size	<3500 cuin	<2500 cuin

Communications with mariners

A temporary three nautical mile radius safe navigation area will be maintained around the seismic vessel and towed array during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

The seismic vessel will be operating within the Operational Area determined for these activities. Marine notices will be issued prior to the start of work to alert vessels that maybe operating in waters nearby and that access to these areas may be limited.

Woodside will provide updates on vessel movements and their details during the activities at an appropriate frequency to meet relevant stakeholder needs.

The location of the Active Source Area and Operational Area are outlined in **Table 3.**

Table 3 – Survey location

Location Point	
Latitude	**Longitude**
Active Source Area	
9° 25' 13.081" S	130° 24' 36.472" E
9° 15' 47.904" S	131° 20' 31.807" E
9° 30' 34.538" S	131° 20' 32.029" E
9° 55' 20.145" S	131° 14' 21.024" E
9° 55' 20.251" S	131° 0' 32.517" E
10° 5' 56.869" S	131° 0' 32.697" E
10° 32' 56.451" S	130° 49' 45.311" E
10° 40' 20.263" S	130° 42' 21.618" E
10° 40' 18.893" S	129° 51' 8.807" E
9° 42' 47.616" S	130° 7' 9.613" E
Operational Area	
9° 23' 27.904" S	130° 18' 40.679" E
9° 12' 7.753" S	131° 25' 59.209" E
9° 31' 14.141" S	131° 25' 59.775" E
10° 0' 45.343" S	131° 18' 37.901" E
10° 0' 45.668" S	131° 6' 0.887" E
10° 6' 58.802" S	131° 6' 1.110" E
10° 35' 57.981" S	130° 54' 26.421" E
10° 45' 45.572" S	130° 44' 39.115" E
10° 45' 43.581" S	129° 43' 51.419" E
9° 40' 1.969" S	130° 2' 13.416" E

Implications for stakeholders

In support of the proposed activities, Woodside will consult relevant stakeholders whose interests, functions and activities may be affected by the proposed activities. We will also keep other stakeholders who have identified an interest informed about our planned activities.

Woodside has undertaken an assessment to identify potential risks to the marine environment and relevant stakeholders, considering timing, duration, location and potential impacts arising from the Galactic Hybrid MSS.

A number of mitigation and management measures will be implemented and are summarised below. Further details will be provided in the EP.

Potential Risk and/or Impact	Mitigation and/or Management Measure
Planned activities	
Interests of relevant stakeholders with respect to: • Defence activities • Petroleum activities • Commercial fishing activities • Shipping activities • Infrastructure activities	• Consultation with petroleum titleholders, commercial fishers and their representative organisations, and government departments and agencies to inform decision making for the proposed activity and development of the EP. • Advice to relevant stakeholders prior to the commencement of activities. • Ongoing consultation by way of updates on vessel movements during survey activities at a frequency to meet relevant stakeholder needs. • Specific fishing stakeholder factsheet.

Risk assessment

Potential Risk and/or Impact	Mitigation and/or Management Measure
Planned activities	
Marine discharges	• All routine marine discharges will be managed according to legislative and regulatory requirements and Woodside's Environmental Performance Standards.
Underwater noise	• Implementation of Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) Policy Statement 2.1. • Noise modelling to inform potential impacts and input to mitigation and management measures.
Vessel interaction	• Woodside will notify relevant fishery stakeholders and Government maritime safety agencies of specific start and end dates, specific vessel-on-location dates and any exclusion zones prior to commencement of the activity. • A three nautical mile radius safe navigation area will be in place around the seismic vessel and streamers during seismic operations. • The seismic vessel will display appropriate day shapes and lights to indicate the vessel is towing and is therefore restricted in its ability to manoeuvre. • The streamers will tow surface tail buoys fitted with radar reflectors. • A visual and radar watch will be maintained on the project vessel bridges at all times. • A support vessel and a potential chase vessel will be on standby to direct any shipping traffic or commercial fishing vessels away from the seismic vessel and its towed equipment.
Waste management	• Waste generated on the vessels will be managed in accordance with legislative requirements and a Waste Management Plan. • Wastes will be managed and disposed of in a safe and environmentally responsible manner that prevents accidental loss to the environment. • Wastes transported onshore will be sent to appropriate recycling or disposal facilities by a licensed waste contractor.
Unplanned activities	
Hydrocarbon release	• Appropriate spill response plans, equipment and materials will be in place and maintained. • Appropriate refuelling procedures and equipment will be used to prevent spills to the marine environment.
Introduction of invasive marine species	• All vessels will be assessed and managed as appropriate to prevent the introduction of invasive marine species. • Compliance with Australian biosecurity requirements and guidance. • Contracted vessels comply with Australian ballast water requirements.
Marine fauna interactions	• Measures will be taken to protect marine fauna and ecosystems from vessel activities and to prevent vessel collisions and groundings. • Maintaining dedicated marine fauna observers throughout the survey. • All marine fauna sightings are recorded and reported to the Department of Agriculture, Water and the Environment.

Providing Feedback

Our intent is to minimise environmental and social impacts associated with the proposed activities, and we are seeking any interest or comments you may have to inform our decision making. If you would like to comment on the proposed activities outlined in this information sheet, or would like additional information, please contact Woodside before **10 May 2021.**

Please note that your feedback and our response will be included in our Environment Plan for the proposed activity, which will be submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

[redacted]

Please note that stakeholder feedback will be communicated to NOPSEMA as required under legislation. Woodside will communicate any material changes to the proposed activity to affected stakeholders as they arise.

Woodside

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Commercial Fishing Information Sheet sent to all stakeholders with commercial fishing interests

Woodside

STAKEHOLDER CONSULTATION

INFORMATION SHEET

COMMERCIAL FISHING

March 2021

GALACTIC HYBRID MARINE SEISMIC ENVIRONMENT PLAN

BONAPARTE BASIN, NORTHERN AUSTRALIA

Woodside is planning to conduct a marine seismic survey in Commonwealth waters offshore Northern Territory in exploration permit NT/P86, starting at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

Options are currently being carried for 2D and 3D seismic acquisition, of which only one option will be selected. Woodside is also considering using autonomous ocean bottom seismic nodes in some parts of the Active Source Area. Woodside will advise relevant commercial fishers when the activity scope has been finalised.

The survey is a part of Woodside's work program commitments for the title and will be the first 3D survey over the permit, or the first comprehensive 2D survey over the permit since the mid 2000s.

Relevant fisheries

Woodside has identified one Commonwealth-managed and five Northern Territory-managed fisheries as being potentially affected by the proposed activity. These fisheries are shown in Figures 1 and 2 relative to the proposed Operational Area and Active Source Area.

The survey will occur at water depths of between 12 m and 384 m. A temporary three nautical mile radius safe navigation area will be maintained around the seismic vessel and towed array during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

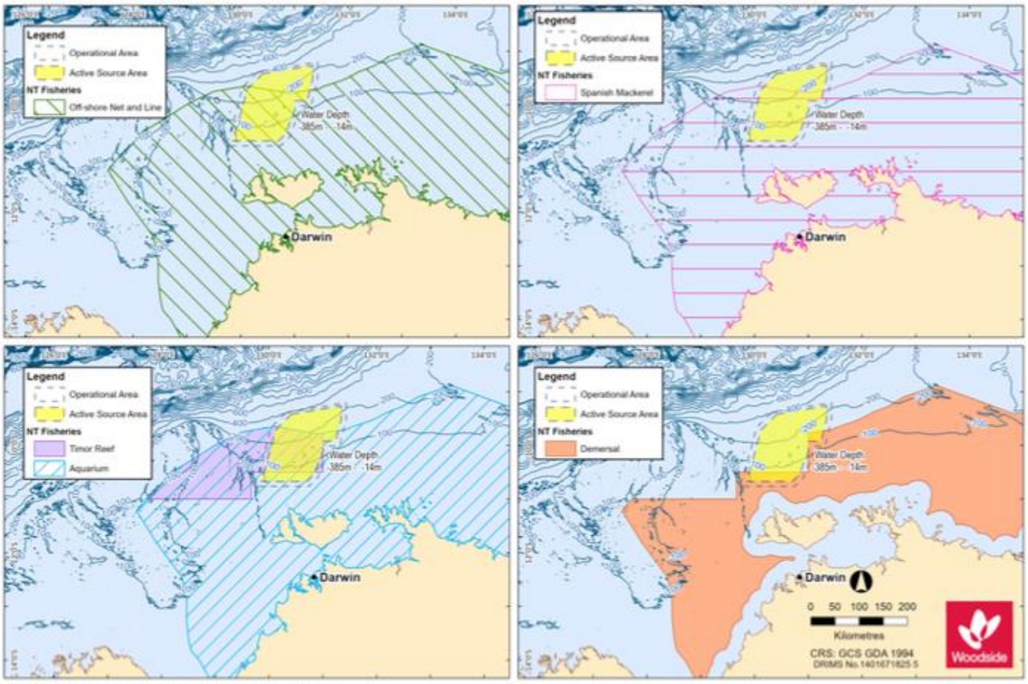


Figure 1. Relevant Northern Territory-managed fisheries

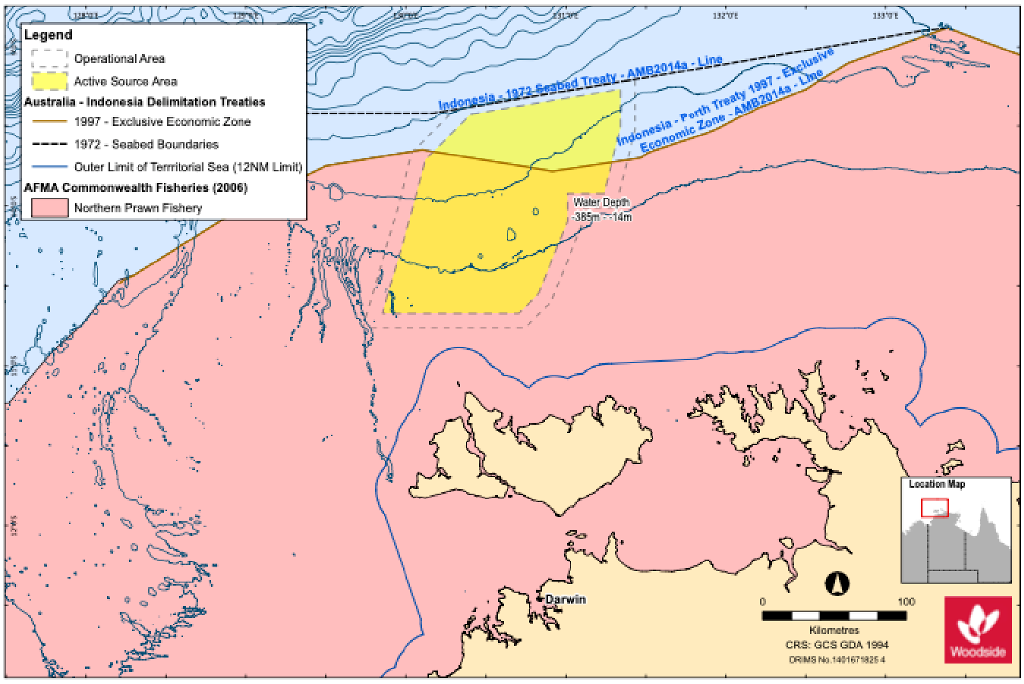


Figure 2. Relevant Commonwealth-managed fisheries

Proposed activity

An overview of survey activities and technical aspects of the proposed activity are outlined in **Table 1.**

Table 1. Activity and technical overview

Activity	Details	
Earliest commencement date	From May 2022 pending approvals, vessel availability and weather constraints	
Estimated duration	20 days - 45 days	
Survey size	Max. 2000 line km of 2D seismic data or Max. 2000 km^2 of 3D seismic data	
Operational Area	Max. 21,608 km^2	
Vessels	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel	
Water depth in Operational Area	12 m to 384 m	
Distance from Active Source Area to nearest town	187 km north of the Port of Darwin	
Distance from Active Source Area to nearest marine park	The Active Source Area overlaps part of the Multiple Use Zone of the Oceanic Shoals Australian Marine Park	
	2D Survey Option	**3D Survey Option**
Source size	<3500 cuin	<2500 cuin
Streamer tow depth	>15 m	>15 m
Number of streamers	Up to two streamers	Six to 12 streamers
Maximum width of streamer array	400 m	2 km
Distance from seismic vessel bow to tail buoy	~10.5 km	~5.5 km – 8.5 km
Distance between streamers	125 m – 150 m	125 m – 150 m
Safe navigation area (cautionary zone)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations
Average length of sail lines	80 km	Subject to planning confirmation
Time to traverse a sail line	Avg duration 10 – 11 hours	Subject to planning confirmation
Seismic vessel sail line speed	3 knots – 5 knots	3 knots – 5 knots

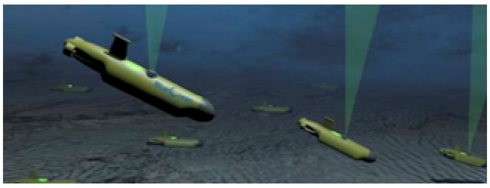
AUV Nodes

For part of the survey area, Woodside is considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.

Seismic nodes have been widely used since the mid-2000s using remotely operated vehicles controlled from a support vessel for node placement and retrieval from the seabed. However, advances in autonomous technology mean that the nodes will be able to self-reposition.

The autonomous devices will make minimal noise between locations and will have negligible disturbance to the seabed when positioning.

The devices will be fitted with a special recovery device so that they can be easily retrieved from the ocean surface in the unlikely event of a malfunction.



Operational aspects

Woodside recognises the rights of all marine users to go about their business and has taken steps to mitigate potential operational impacts on other marine users, including commercial fishing, shipping, and defence and petroleum activities.

Wherever possible, Woodside looks to minimise these impacts to 'As Low As Reasonably Practicable' (ALARP). Where this is not possible, Woodside will consider legitimate and reasonable claims from stakeholders for compensation.

Woodside has a set of compensation principles relevant to commercial fishing activities. In summary, Woodside will consider claims from commercial fishing licence holders where:

- There is genuine displacement from undertaking normal fishing activities that results in economic loss
- Fishing equipment has been lost or damaged by any activities under Woodside's control
- Loss of catch that can be demonstrated by licence holders

Woodside will not reimburse stakeholders for their time in attending activity planning meetings.

Noise modelling

Woodside has assessed impacts to fishes and fish eggs and larvae based on the application of internationally recognised sound exposure thresholds, and predictions of received sound levels at the seafloor and in the water column from the detailed underwater noise modelling. Woodside does not expect there to be any significant behavioural responses in key target species that will result in a decline in 'catchability' of these fishes.

Potential impacts on fishes and catch

Modelling of underwater noise emissions from the seismic source for the Galactic Hybrid Marine Seismic Survey has been undertaken to assess potential impacts on sensitive receptors, including fish species targeted by commercial fisheries.

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

Based on the timing and duration (up to 45 days) of seismic acquisition, and the control measures proposed (see **Table 2**), predicted noise levels are not considered likely to cause injury or permanent hearing impairment in fishes, or result in any impacts at a population level for any species of fish that may be present within or adjacent to the Active Source Area during the survey.

Potential impacts on fish spawning and recruitment

It is highly unlikely the proposed activity will cause significant impacts to fish spawning and recruitment in any key commercial fish species due to underwater noise.

Acquisition of the survey won't overlap the peak spawning season for key target species in the region, such as goldband snapper and red emperor (September to May). Impacts to fish eggs and larvae are not likely due to the short duration of the Galactic Hybrid Marine Seismic Survey and lack of overlap with the peak spawning season.

Risk assessment overview

We have undertaken a risk assessment specific to the interests of commercial fishers in **Table 2.**

Table 2. Summary of key commercial fishing risks and/or impacts and management measures.

Potential risk	Risk description	Mitigation and/or management measures
Planned Activities		
Vessel interaction	The presence of seismic vessel, towed array, support vessel and potential chase vessel may preclude other marine users from access to the area.	• Woodside will notify relevant fishery stakeholders and Government maritime safety agencies of specific start and end dates, specific vessel-on-location dates and any exclusion zones prior to commencement of the activity. • A three nautical mile safe navigation area, including a 500 m temporary exclusion zone, will be maintained around seismic vessel and towed array during seismic operations • A communications protocol will be in established between the project vessels and known vessels within the Operational Area, to actively manage concurrent activities. • A support vessel and potential chase vessel will be on standby to direct any shipping traffic or commercial fishing vessels away from the seismic vessel and its towed equipment.
Underwater noise emissions from vessels	Noise will be generated by the seismic vessel, support vessel and potential chase vessel. Due to the low acoustic source levels associated with vessel operations there is not likely to be any interaction or potential impact to fish hearing, behaviour, feeding, spawning or recruitment.	• Environment Protection and Biodiversity Conservation Act 1999, Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans will be implemented.
Underwater noise-emissions from seismic survey equipment a) Acoustic energy will be generated by the seismic source. b) Use of the smallest practicable seismic source	Noise will be generated by the seismic source. Based on the impact assessment conducted for the survey it is highly unlikely that there will be any significant impacts to fish hearing, behaviour, feeding, spawning or recruitment.	• Noise modelling to inform potential impacts • Use of the smallest possible seismic source • Buffer zones around shallow banks and shoals to minimise the likelihood of impacts to site-attached fish assemblages • Limited duration of the activity
Marine discharges	Discharges from the operation vessels include sewage, grey water, cooling water, desalination brine, deck drainage, ballast and bilge water These discharges may result in a localised short-term reduction in water quality however they will be rapidly diluted and dispersed in the water column.	• All routine marine discharges will be managed according to legislative and regulatory requirements and Woodside's Environmental Performance Standards.
Unplanned Risks		
Hydrocarbon release	Loss of hydrocarbons to the marine environment from a vessel collision resulting in a tank rupture.	• In the unlikely event of an oil spill or unplanned discharge into the environment, relevant agencies and organisations will be notified as appropriate to the nature and scale of the event, as soon as practicable following the occurrence. • Oil spill response strategies will be assessed based on potential impact to identified key receptor locations and sensitivities, which includes fish spawning and nursery areas.
Invasive Marine Species	Introduction or translocation and establishment of invasive marine species to the area via vessels ballast water or biofouling.	• All vessels will be assessed and managed as appropriate to prevent the introduction of invasive marine species. • Compliance with Australian biosecurity requirements and guidance.

Operations protocols

Woodside has developed a set of operations protocols to minimise interactions with other marine users, which are outlined in **Table 3.**

Table 3. Operations protocols.

Timing	Activity
During activity planning and Environment Plan development prior to public review and NOPSEMA assessment	• Engagement of relevant government agencies, peak industry organisations, infrastructure owners, petroleum operators and commercial fishing licence holders.
Upon finalisation of activity scope	• Notification to relevant commercial fishing licence holders.
If when the Environment Plan for the proposed activity has been accepted by NOPSEMA	• Notification to relevant commercial fishing licence holders.
No less than five weeks prior to survey start date	• Notification to Defence on planned activities and vessel movements.
No less than four weeks prior to survey start date	• Notification to the Australian Hydrographic Office for Notice to Mariners and AUSCOAST warnings to be generated. • Notification to relevant commercial fishing licence holders on planned activities and vessel movements. • Request to relevant licence holders for details of vessel names, key personnel and contact details for vessels likely to be in the vicinity of the survey.
24 hours to 48 hours prior to survey start date	• Notification to the Australian Maritime Safety Authority Joint Rescue Coordination Centre (AMSA JRCC) on planned activities and vessel movements. • Notification to relevant commercial fishing licence holders on planned activities and vessel movements.
During survey	• If requested, provision to relevant marine users a daily report on survey activities. At a minimum, the daily report will have: • Current position of the survey vessel • 72 hours (about 3 days) look ahead for survey activities and locations • Contact details for the seismic vessel and support vessels
Upon survey completion	• Notification to relevant commercial fishing licence holders.

Providing Feedback

Our intent is to minimise environmental and social impacts associated with the proposed activities, and we are seeking any interest or comments you may have to inform our decision making. If you would like to comment on the proposed activities outlined in this information sheet, or would like additional information, please contact Woodside before **10 May 2021.**

Please note that your feedback and our response will be included in our Environment Plan for the proposed activity, which will be submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

[redacted]

Please note that stakeholder feedback will be communicated to NOPSEMA as required under legislation. Woodside will communicate any material changes to the proposed activity to affected stakeholders as they arise.

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Commonwealth Government department or agency

Ref 1.1 – Email to Australian Border Force (ABF), Department of Industry, Science, Energy and Resources (DISER), NT Department of Industry, Tourism and Trade (NTDITT), Petroleum, Australian Petroleum Production and Exploration Association (APPEA) – 25-26 March 2021

Woodside is planning to conduct a marine seismic survey in Commonwealth waters offshore Northern Territory in exploration permit NT/P86, starting at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

An Environment Plan for this activity will be submitted in accordance with the the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risks and associated management measures. The Information Sheet is also available on our website.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit. Data obtained from the survey will be used to define new and existing leads and to assess the commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Duration:	20 days - 45 days
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Approximate Water Depth (m)	12 m - 384 m
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:

The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

Feedback:

If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.

Ref 1.2 – Email to Australian Communications and Media Authority (ACMA) – 25 March 2021

Woodside is planning to conduct a marine seismic survey in Commonwealth waters offshore Northern Territory in exploration permit NT/P86, starting at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

An Environment Plan for this activity will be submitted in accordance with the the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risk and associated management measures. The Information Sheet is also available on our website.

Implications for ACMA interests

We are seeking your feedback given the proximity of our proposed Activity to the North West Cable System (NWCS) (see map attached) operated by Vocus Communications.

Your feedback on the above matters will greatly assist our planning for the survey and the Environment Plan for the proposed Activity.

For reference, Woodside will also be consulting Vocus as part of the Environment Plan consultation process given Vocus' announcement in 2019 that it intends to build, own and operate the Bonaparte Basing Cable Loop, a spur communications line from the NWCS.

We would also be happy to meet online should you wish to discuss the proposed activity in more detail.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define new and existing leads and assess commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity.

	For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Duration:	20 days - 45 days
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Approximate Water Depth (m)	12 m - 384 m
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:
The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

Feedback:
If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.

Ref 1.3 – Email to Australian Fisheries Management Authority (AFMA) – 25 March 2021

Woodside is planning to submit an Environment Plan for a marine seismic survey in Commonwealth waters offshore Northern Territory around 187 km north of Darwin in exploration permit NT/P86.

The activity is planned to commence at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

A three nautical mile radius safe navigation area (cautionary area) will be in place around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

We have identified potential impacts to active commercial fishers and the environment, which are summarised below. We have endeavoured to reduce these risks to an as low as reasonably practicable level.

An information sheet (also on our website) and an information sheet specific to commercial fishing interests is attached.

Fisheries have been identified as being relevant based on fishing licence overlap with the activity area, assessment of government fishing effort data from recent years, fishing methods and water depth.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define new and existing leads and assess commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Approximate Water Depth (m):	12 m - 384 m
Schedule:	Commencement from May 2022
Duration:	20 days - 45 days
Relevant fisheries	Northern Territory Aquarium Fishery Demersal Fishery Offshore Net and Line Fishery Spanish Mackerel Fishery Timor Reef Fishery Commonwealth Northern Prawn Fishery
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:
The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

Commercial fishing implications:
Information is included in the attached commercial fishing information sheet specific to commercial fishing interests, including maps of identified relevant fisheries, an activity and technical overview, an assessment of potential impacts on fishes, catch, fish spawning and recruitment, a summary of

risks and management measures, and operations protocols to minimise interactions with other marine users.

Feedback:

If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.

Ref 1.4 – Email to Australian Hydrographic Office (AHO) and Australian Maritime Safety Authority (AMSA) (marine safety) – 25 March 2021

Woodside is planning to conduct a marine seismic survey in Commonwealth waters offshore Northern Territory in exploration permit NT/P86, starting at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

An Environment Plan for this activity will be submitted in accordance with the the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risks and associated management measures. The Information Sheet is also available on our website.   A map showing vessel density is also attached for reference.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit. Data obtained from the survey will be used to define new and existing leads and to assess the commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Duration:	20 days - 45 days

Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Approximate Water Depth (m)	12 m - 384 m
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:

The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

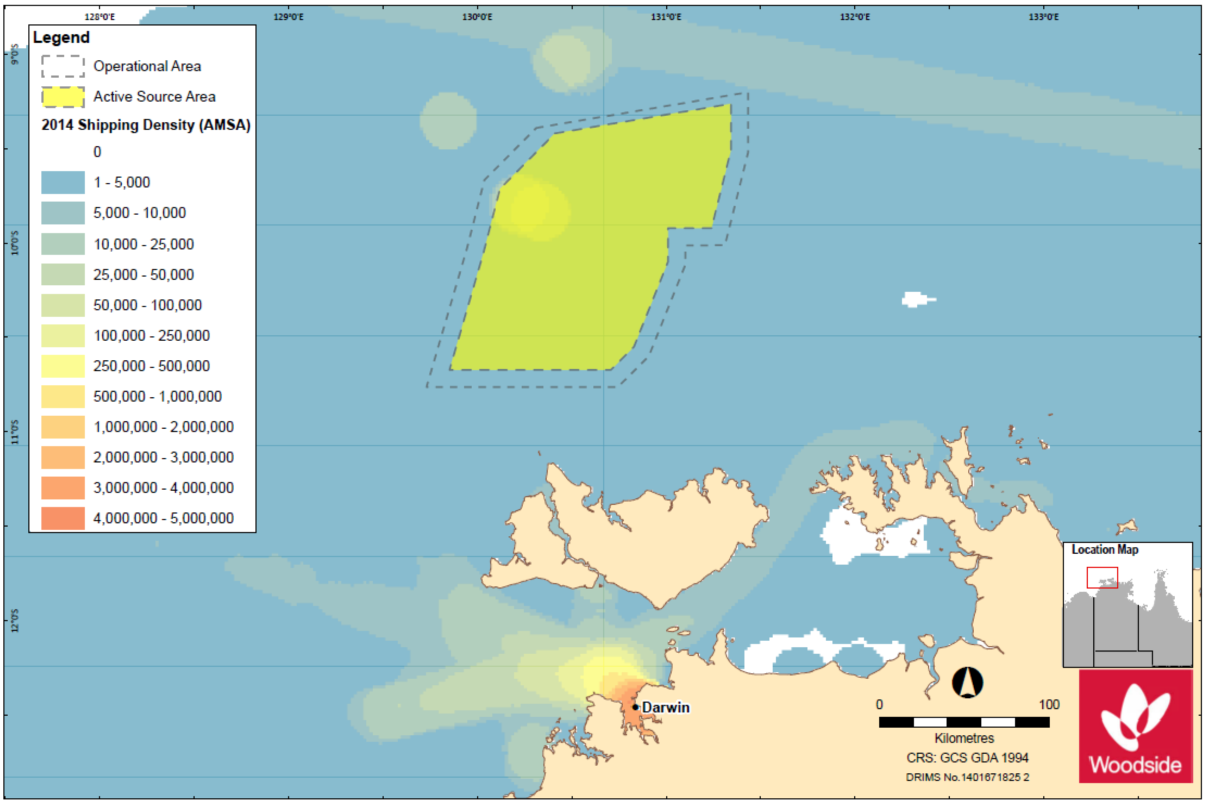
Feedback:

If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.



Ref 1.5 – Email to AMSA (marine pollution) – 25 March 2021

Woodside is planning to conduct a marine seismic survey in Commonwealth waters offshore Northern Territory in exploration permit NT/P86, starting at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

An Environment Plan for this activity will be submitted in accordance with the the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risks and associated management measures. The Information Sheet is also available on our website.

We are currently developing our First Strike Response Plan for the planned activity and will provide a final copy of this Plan to you if relevant to the proposed activity.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit. Data obtained from the survey will be used to define new and existing leads and to assess the commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Duration:	20 days - 45 days
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Approximate Water Depth (m)	12 m - 384 m
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:

The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

Feedback:

If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.

Ref 1.6 Email to Department of Agriculture, Water and the Environment (DAWE) (fisheries and biosecurity) – 25 March 2021

Woodside is planning to conduct a marine seismic survey in Commonwealth waters offshore Northern Territory in exploration permit NT/P86, starting at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

An Environment Plan for this activity will be submitted in accordance with the the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risk and associated management measures. The Information Sheet is also available on our website.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define new and existing leads and assess commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Duration:	20 days - 45 days
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Approximate Water Depth (m)	12 m - 384 m
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are

requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:

The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

Implications for DAWE's interests

We have identified and assessed potential risks and impacts to active Commonwealth commercial fishers, biosecurity matters and the marine environment that overlap the proposed Operational Area in the development of the proposed Environment Plan for this activity.

Woodside has endeavoured to reduce these risks to an as low as reasonably practicable (ALARP) level.

Commercial fishing implications:

One Commonwealth-managed fishery has been identified as being relevant to the proposed Activity, this being the Northern Prawn Fishery.

Woodside will consult licence holders in this fishery, including the provision of a fact sheet specific to commercial fishing interests. This fact sheet (attached) includes an activity and technical overview, an assessment of potential impacts on fishes, catch, fish spawning and recruitment, a summary of risks and management measures, and operations protocols to minimise interactions with other marine users.

Fisheries were assessed for relevance on the basis of fishing licence overlap with the Operational Area, as well as consideration of government fishing effort data from recent years, fishing methods, and water depth.

Biosecurity implications:

With respect to the biosecurity matters, please note the following information below.

Environment description:	
Operational Area is approximately 187 km north of the Port of Darwin in water depths between 12 and 384 m. The majority of the seabed within the Operational Area can be characterised by a largely uniform slope of moderate gradient covering the mid-outer continental shelf and slope. The south-west portion of the Operational Area partially overlaps with the Van Diemen Rise, which as a whole represents an area of relatively complex bathymetry, containing several geomorphic features including carbonate banks, terraces, ridges and valleys. Two banks are located within the Operational Area, Lynedoch and Goodrich Bank. Four additional banks and shoal systems have been identified in the wider EMBA. A portion of the Operational Area overlaps the Oceanic Shoals Australian Marine Park.	
Potential IMS risk	***IMS mitigation management***
Introduction and establishment of IMS.	Vessels are required to comply with the Australian Biosecurity Act 2015, specifically the Australian Ballast Water Management Requirements (as defined under the Biosecurity Act 2015) (aligned with the International Convention for the Control and

Management of Ships' Ballast Water and Sediments) to prevent introducing IMS.
Vessels will be assessed and managed to prevent the introduction of invasive marine species in accordance with Woodside's Invasive Marine Species Management Plan.
Woodside's Invasive Marine Species Management Plan includes a risk assessment process that is applied to vessels undertaking Activities. Based on the outcomes of each IMS risk assessment, Management measures commensurate with the risk (such as the treatment of internal systems, IMS inspections or cleaning) will be implemented to minimise the likelihood of IMS being introduced.

Feedback:
If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.

Ref 1.7 – Email to Department of Defence – 25 March 2021

Woodside is planning to conduct a marine seismic survey in Commonwealth waters offshore Northern Territory in exploration permit NT/P86, starting at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

An Environment Plan for this activity will be submitted in accordance with the the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risk and associated management measures. The Information Sheet is also available on our website. A map of practice and training defence areas is also attached.

Implications for Defence activities
With respect to the proposed Activity we are keen to understand from the Department the timing of next year's Exercise Kakadu, to ensure our activities are completed by this time.

We also seek feedback from the Department on the potential location of UXOs, which we are aware maybe in the vicinity of the survey Operational Area.

Your feedback on the above matters will greatly assist our planning for the survey and the Environment Plan for the proposed Activity.

We would also be happy to meet online should you wish to discuss the proposed activity in more detail.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define new and existing leads and assess commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Duration:	20 days - 45 days
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Approximate Water Depth (m)	12 m - 384 m
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:

The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

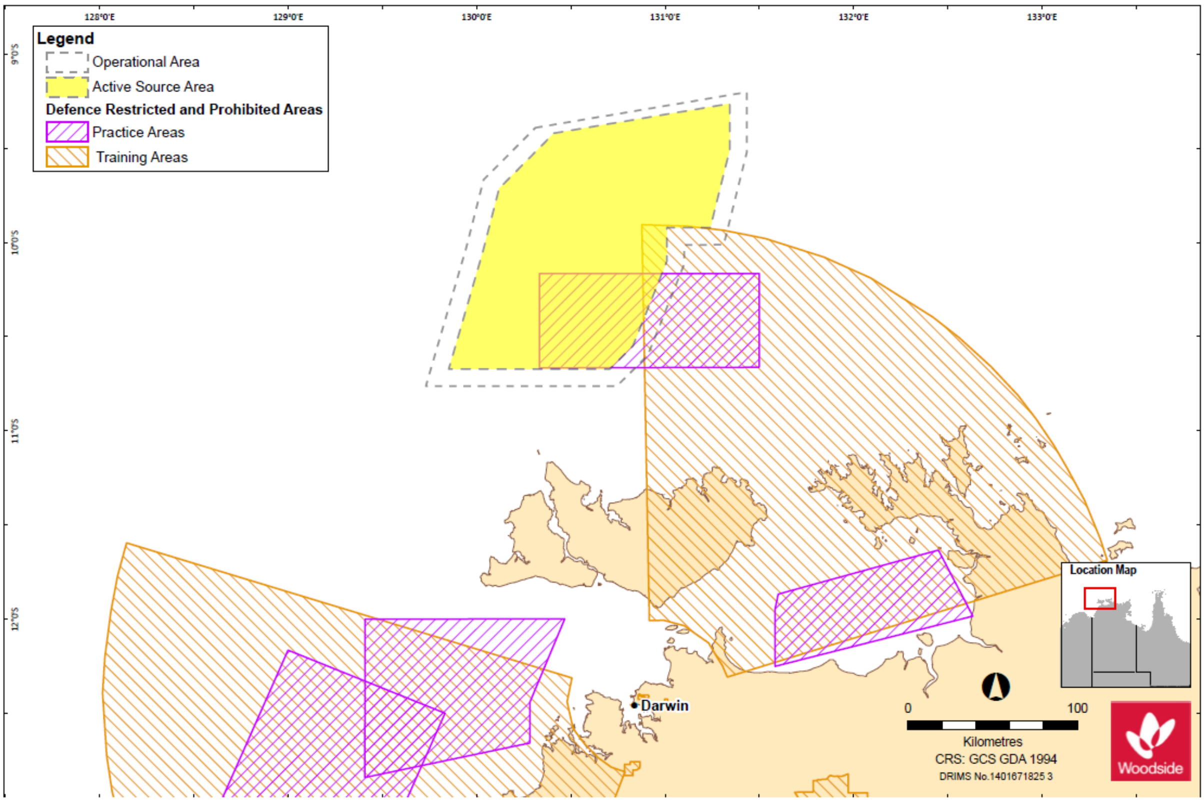
Feedback:

If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.



Ref 1.8 – Email to Department of Foreign Affairs and Trade (DFAT) – 25 March 2021

Woodside is planning to conduct a marine seismic survey in Commonwealth waters offshore Northern Territory in exploration permit NT/P86, starting at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

An Environment Plan for this activity will be submitted in accordance with the the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risk and associated management measures. The Information Sheet is also available on our website.

Implications for DFAT

With respect to the proposed Activity we are keen to understand from the Department implications for oil spill planning and response in international waters.

We also seek feedback from the Department on management of Indonesian fishing vessels should these vessels be present in Commonwealth waters and in the vicinity of the survey Operational Area. We would also be happy to meet online should you wish to discuss the proposed activity in more detail.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define new and existing leads and assess commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Duration:	20 days - 45 days
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Approximate Water Depth (m)	12 m - 384 m
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:
The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

Feedback:
We look forward to hearing from you soon as it will greatly assist our planning and the Environment Plan for the proposed Activity.

Ref 1.9 – Email to Director of National Parks – 25 March 2021

Woodside is planning to conduct a marine seismic survey in Commonwealth waters offshore Northern Territory in exploration permit NT/P86, starting at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

An Environment Plan for this activity will be submitted in accordance with the the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risk and associated management measures. The Information Sheet is also available on our website.

We would also be happy to meet online should you wish to discuss the proposed activity in more detail.

Implications for Parks Australia interests

We note Australian Government Guidance on consultation activities with respect to the proposed activities and confirm that:

- The Active Source Area overlaps part of the Multiple Use Zone of the Oceanic Shoals Australian Marine Park (AMP).
- We have assessed potential impacts and risks to AMPs in the development of the proposed Environment Plan for this activity and believe that there are no credible impacts associated with planned activities that have potential to impact marine park values.
- In the unlikely event of a hydrocarbon release there is risk of hydrocarbons contacting the Oceanic Shoals and Arafura AMPs. The worst-case credible spill scenario assessed for this activity is a marine diesel oil spill resulting from the highly unlikely event of a vessel collision.
- A Commonwealth Government approved oil spill response plan will be in place for the duration of the activities, which includes notification to relevant agencies and organisations as to the nature and scale of the event, as soon as practicable following an occurrence. The Director of National Parks will be advised if an environmental incident occurs that may impact on the values of a marine park.

A Consultation Information Sheet about the planned activity is attached, which provides background on the activity, including a summary of potential key risk and associated management measures. The Information Sheet is also available on our website.

In line with Australian Government guidance on consultation with government agencies, can you please advise within 10 business days if you have any feedback on the proposed activity, noting that your feedback and our response will be included in an Environment Plan for consideration by the National Offshore Petroleum Safety and Environmental Management Authority, as is required under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth).

Comments can be made by email, letter or by phone.

NT Government department or agency

Ref 1.10 – Email to NTDITT, Fisheries – 1 April 2021

Woodside is planning to submit an Environment Plan for a marine seismic survey in Commonwealth waters offshore Northern Territory around 187 km north of Darwin in exploration permit NT/P86.

The activity is planned to commence at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

A three nautical mile radius safe navigation area (cautionary area) will be in place around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

We have identified potential impacts to active commercial fishers and the environment, which are summarised below. We have endeavoured to reduce these risks to an as low as reasonably practicable level.

An information sheet (also on our website) and an information sheet specific to commercial fishing interests is attached.

Fisheries have been identified as being relevant based on fishing licence overlap with the activity area, assessment of government fishing effort data from recent years, fishing methods and water depth.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define new and existing leads and assess commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Approximate Water Depth (m):	12 m - 384 m
Schedule:	Commencement from May 2022
Duration:	20 days - 45 days
Relevant fisheries	Northern Territory Aquarium Fishery Demersal Fishery Offshore Net and Line Fishery Spanish Mackerel Fishery Timor Reef Fishery Commonwealth Northern Prawn Fishery
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:

The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

Commercial fishing implications:

Information is included in the attached commercial fishing information sheet specific to commercial fishing interests, including maps of identified relevant fisheries, an activity and technical overview, an assessment of potential impacts on fishes, catch, fish spawning and recruitment, a summary of risks and management measures, and operations protocols to minimise interactions with other marine users.

Feedback:
If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.

Ref 1.11 – Email to NT Department of the Environment, Parks and Water Security (NT DEPWS) – 17 March 2021

Thank you for your time this morning – much appreciated.

As noted during the meeting, I have quite a few oil spill questions which I felt were a little too detailed for the discussions this morning. These mostly relate to notification requirements and correct points of contact, and ensuring that Woodside's understanding of spill arrangements and requirements within the Territory is accurate.

Would it therefore be possible to schedule some one-to-one time via phone or video call to go through them? If so, please could you let me know your availability to the end of this week and, if that doesn't work, any availability next week as well? I am fairly flexible. I have copied Nick Young (Woodside's Hydrocarbon Spill Advisor) for information and who I believe you have had some contact with via the APPEA Oil Spill Working Group. Thank you in anticipation.

Commonwealth managed fisheries

Ref 1.12 – Email to licence holders in relevant Commonwealth managed fisheries – Northern Prawn Fishery

Woodside is planning to submit an Environment Plan for a marine seismic survey in Commonwealth waters offshore Northern Territory around 187 km north of Darwin in exploration permit NT/P86.

The activity is planned to commence at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

A three nautical mile radius safe navigation area (cautionary area) will be in place around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

We have identified potential impacts to active commercial fishers and the environment and have endeavoured to reduce these risks to an as low as reasonably practicable level. Fisheries have been identified as being relevant based on fishing licence overlap with the activity area, assessment of government fishing effort data from recent years, fishing methods and water depth.

A Consultation Information Sheet and an information sheet specific to commercial fishing interests is attached. Both information sheets are available on our website. We would also be happy to meet online or in Darwin should you wish to discuss the proposed activity in person.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define new and existing leads and assess commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Approximate Water Depth (m):	12 m - 384 m
Schedule:	Commencement from May 2022
Duration:	20 days - 45 days
Relevant fisheries	Northern Territory - Aquarium Fishery - Demersal Fishery - Offshore Net and Line Fishery - Spanish Mackerel Fishery - Timor Reef Fishery Commonwealth - Northern Prawn Fishery
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:

The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

Commercial fishing implications:

Information is included in the attached commercial fishing information sheet specific to commercial fishing interests, including maps of identified relevant fisheries, an activity and technical overview, an assessment of potential impacts on fishes, catch, fish spawning and recruitment, a summary of risks and management measures, and operations protocols to minimise interactions with other marine users.

Feedback:
If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.

NT managed fisheries

Ref 1.13 – Letter to licence holders in relevant NT managed fisheries – Aquarium Fishery, Demersal Fishery, Offshore Net and Line Fishery, Spanish Mackerel Fishery and Timor Reef Fishery – 25 March 2021

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[redacted]

25 March 2021

Dear Fishery Licence Holder

CONSULTATION INFORMATION – GALACTIC HYBRID MARINE SEISMIC SURVEY

Woodside is planning to submit an Environment Plan for a marine seismic survey in Commonwealth waters offshore Northern Territory around 187 km north of Darwin in exploration permit NT/P86.

The activity is planned to commence at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

A three nautical mile radius safe navigation area (cautionary area) will be in place around the seismic vessel and streamers during seismic operations. Marine users will be requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

We have identified potential impacts to active commercial fishers and the environment and have endeavoured to reduce these risks to an as low as reasonably practicable level. Potential impacts and associated management measures are outlined in the enclosed information sheet and commercial fishing-specific information sheet. These information sheets are also on our website at www.woodside.com.au/sustainability/consultation-activities.

For the proposed Activity Woodside has identified fisheries as being relevant based on fishing licence overlap with the Operational Area, assessment of government fishing effort data from recent years, fishing methods and water depth. These fisheries are outlined in the summary table below.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define new and existing leads and assess commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Approximate Water Depth (m):	12 m - 384 m

Schedule:	Commencement from May 2022
Duration:	20 days - 45 days
Relevant fisheries	Northern Territory - Aquarium Fishery - Demersal Fishery - Offshore Net and Line Fishery - Spanish Mackerel Fishery - Timor Reef Fishery Commonwealth - Northern Prawn Fishery
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:
The location of the Active Source Area and Operational Area are outlined in the enclosed information sheets.

Commercial fishing implications:
Information in the attached commercial fishing information sheet includes an activity and technical overview; an assessment of potential impacts on fishes, catch, fish spawning and recruitment; a summary of risks and management measures; and operations protocols to minimise interactions with other marine users.

Feedback:
If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 429 500 799.

Woodside would also be happy to meet stakeholders in person (Darwin and Perth) or online should you wish to discuss the proposed activity in more detail.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.

Regards

[redacted]
Corporate Affairs Adviser | Corporate Affairs

As a service provider to Woodside Energy Ltd

Page 2 of 2

Industry

Ref 1.14 – Email to Inpex and Santos – 26 March 2021

Woodside is planning to conduct a marine seismic survey in Commonwealth waters offshore Northern Territory in exploration permit NT/P86, starting at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

An Environment Plan for this activity will be submitted in accordance with the the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risks and associated management measures. The Information Sheet is also available on our website. A map showing the proposed activity relevant to adjacent petroleum titles is also attached.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit. Data obtained from the survey will be used to define new and existing leads and to assess the commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Duration:	20 days - 45 days
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Approximate Water Depth (m)	12 m - 384 m
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

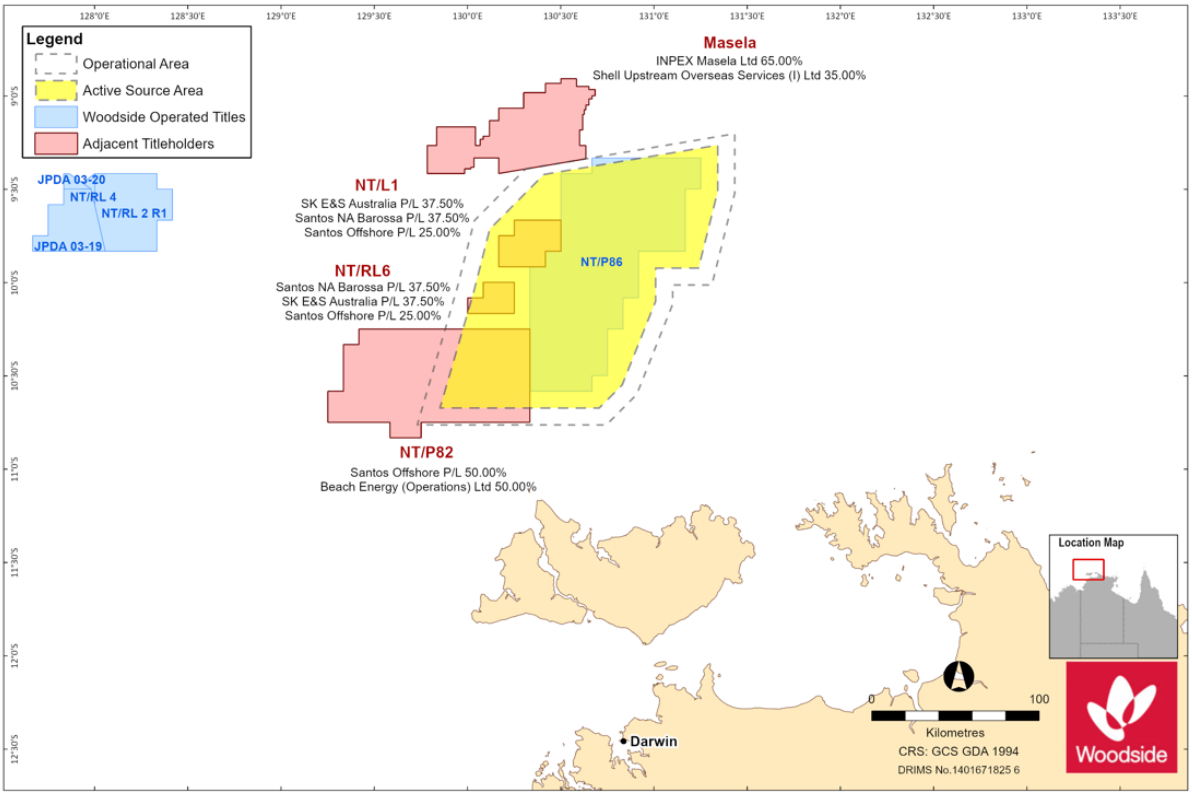
Survey location:
The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

Feedback:
If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.



Ref 1.15 – Email to Vocus Communications – 25 March 2021

Further to our call a week or so back, I wish to provide further detail on Woodside's planned Galactic Hybrid Marine Seismic Survey.

By way of background, Woodside is planning to conduct a marine seismic survey in Commonwealth waters offshore Northern Territory in exploration permit NT/P86, starting at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

An Environment Plan for this activity will be submitted in accordance with the the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risk and associated management measures. The Information Sheet is also available on our website.

Implications for Vocus activities

With respect to the proposed Activity we are keen to understand from Vocus Communications the nature and timing of planned activities for the proposed Bonaparte Basin Cable Loop. A map showing the proximity of the proposed Activity to the North West Cable System is attached for reference.

I would also be grateful if could share any spatial data for the proposed fibreoptic cable to ensure we understand Vocus' future activities in the region.

Your feedback on the above matters will greatly assist our planning for the survey and the Environment Plan for the proposed Activity.

We would also be happy to meet online should you wish to discuss the proposed activity in more detail.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define new and existing leads and assess commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Duration:	20 days - 45 days
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Approximate Water Depth (m)	12 m - 384 m
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:

The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

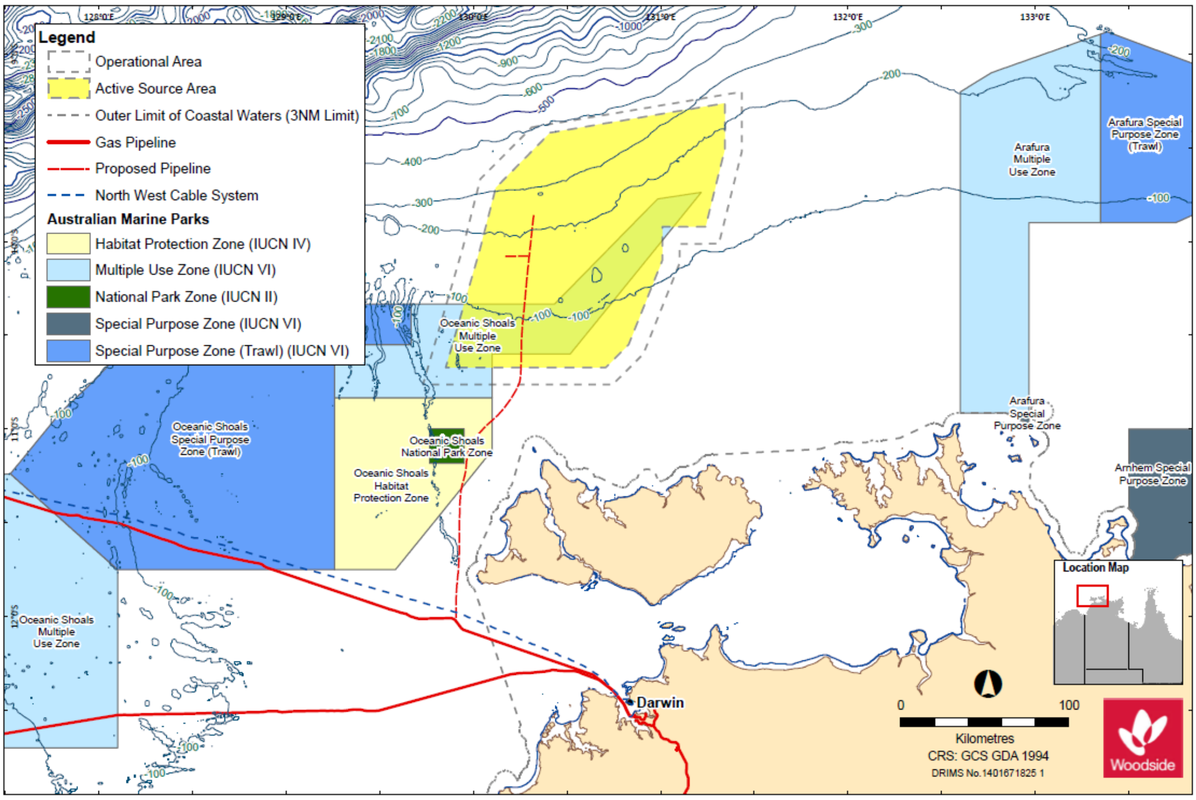
Feedback:

If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.



Industry representative organisations

Ref 1.16 – Email to Amateur Fishermen's Association of the Northern Territory (AFANT), Commonwealth Fisheries Association (CFA), Northern Prawn Fishery Industry Pty Ltd (NPF Industry), Northern Territory Game Fishing Association of Australia (NTGFA), Pearl Producers Association (PPA), Seafood Industry Australia (SIA),
– 25 March 2021

Woodside is planning to submit an Environment Plan for a marine seismic survey in Commonwealth waters offshore Northern Territory around 187 km north of Darwin in exploration permit NT/P86. The activity is planned to commence at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

A three nautical mile radius safe navigation area (cautionary area) will be in place around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

We have identified potential impacts to active commercial fishers and the environment and have endeavoured to reduce these risks to an as low as reasonably practicable level.

A Consultation Information Sheet and an information sheet specific to commercial fishing interests is attached. Both information sheets are available on our website.

Fisheries have been identified as being relevant based on fishing licence overlap with the activity area, assessment of government fishing effort data from recent years, fishing methods and water depth.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define new and existing leads and assess commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Approximate Water Depth (m):	12 m - 384 m
Schedule:	Commencement from May 2022
Duration:	20 days - 45 days
Relevant fisheries	Northern Territory - Aquarium Fishery - Demersal Fishery - Offshore Net and Line Fishery - Spanish Mackerel Fishery - Timor Reef Fishery Commonwealth - Northern Prawn Fishery
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:

The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

Commercial fishing implications:

Information is included in the attached commercial fishing information sheet specific to commercial fishing interests, including maps of identified relevant fisheries, an activity and technical overview, an assessment of potential impacts on fishes, catch, fish spawning and recruitment, a summary of risks and management measures, and operations protocols to minimise interactions with other marine users.

Feedback:

If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.

Ref 1.17 – Email to NT Seafood Council – 24 March 2021

My name is [name supplied] and I am providing engagement and communications support to Woodside Energy for a planned seismic survey in Commonwealth waters offshore Northern Territory in 2022.

I left a voicemail for you yesterday as I am keen to have a conversation with you about Woodside's approach to engagement with commercial fishers to ensure that we are going about this in an efficient way, and have the right level of information in our communications material for fishers to understand the scope of activities and our proposed management measures.

We would appreciate your guidance on these matters and I look forward to hearing from you.

Ref 1.18 – Email to NT Seafood Council (NTSC) – 25 March 2021

Have been trying to reach you for a couple days to discuss engagement activities in the NT for Woodside's planned Galactic Hybrid Marine Seismic Survey. Would still like to catch up if you have time further to the information provided below.

By way of background, Woodside is planning to submit an Environment Plan for a marine seismic survey in Commonwealth waters offshore Northern Territory around 187 km north of Darwin in exploration permit NT/P86.

The activity is planned to commence at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

A three nautical mile radius safe navigation area (cautionary area) will be in place around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

We have identified potential impacts to active commercial fishers and the environment and have endeavoured to reduce these risks to an as low as reasonably practicable level. Fisheries have been identified as being relevant based on fishing licence overlap with the activity area, assessment of government fishing effort data from recent years, fishing methods and water depth.

A Consultation Information Sheet and an information sheet specific to commercial fishing interests is attached. Both information sheets are available on our website. We would also be happy to meet online or in Darwin should you wish to discuss the proposed activity in person.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define new and existing leads and assess commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Approximate Water Depth (m):	12 m - 384 m
Schedule:	Commencement from May 2022
Duration:	20 days - 45 days
Relevant fisheries	Northern Territory - Aquarium Fishery - Demersal Fishery - Offshore Net and Line Fishery - Spanish Mackerel Fishery - Timor Reef Fishery Commonwealth - Northern Prawn Fishery
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:

The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

Commercial fishing implications:

Information is included in the attached commercial fishing information sheet specific to commercial fishing interests, including maps of identified relevant fisheries, an activity and technical overview, an assessment of potential impacts on fishes, catch, fish spawning and recruitment, a summary of risks and management measures, and operations protocols to minimise interactions with other marine users.

Feedback:

If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.

Traditional Owners

Ref 1.19 – Email to Tiwi Land Council (TLC) – 26 March 2021

Thanks for getting back to me. I gave you a buzz yesterday and left a voice message.

The reason I was reaching out is because Woodside is planning to conduct a marine seismic survey in Commonwealth waters offshore Northern Territory in exploration permit NT/P86.

The seismic survey is starting at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints. The survey operational area is about 187 km north of Darwin and about 45 km north of Melville Island.

Part of the reason for my call, was to understand from the Tiwi Land Council how it would best like to be engaged (fact sheet, presentation, meeting, etc). We also seek guidance from the TLC on whether other land councils should be engaged (eg Northern Land Council).

An Environment Plan for this activity will be submitted in accordance with the the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risks and associated management measures. The Information Sheet is also available on our website. We would also be happy to meet online or in Darwin should you wish to discuss the proposed activity in person.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit. Data obtained from the survey will be used to define new and existing leads and to assess the commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.

Location:	187 km north of the Port of Darwin.
Duration:	20 days - 45 days
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Approximate Water Depth (m)	12 m - 384 m
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:
The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

Implications for Traditional Owners:
At this time our understanding is that there are no locations of cultural heritage in the survey area, nor would any locations of cultural heritage be impacted in the event of an unplanned event [such as a marine diesel spill].

Feedback:
If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.

Other stakeholders

Ref 1.20 – Email to the Australian Institute of Marine Science (AIMS) – 25 March 2021

Woodside is planning to conduct a marine seismic survey in Commonwealth waters offshore Northern Territory in exploration permit NT/P86, starting at the earliest from May 2022 for a period of 20 to 45 days, pending approvals, vessel availability and weather constraints.

An Environment Plan for this activity will be submitted in accordance with the the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risk and associated management measures. The Information Sheet is also available on our website.

Implications for AIMS activities

With respect to the proposed Activity, we are keen to understand from AIMS the nature and timing of any planned activities with respect to the Integrated Marine Observing System (IMOS) mooring located on Lynedoch Bank or other field research activities in the region around the time of the proposed Activity.

Your feedback on the above matters will greatly assist our planning for the survey and the Environment Plan for the proposed Activity.

We would also be happy to meet online should you wish to discuss the proposed activity in more detail.

Activity:

Summary:	The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define new and existing leads and assess commerciality of potential hydrocarbon accumulations. The survey is part of Woodside's work program commitments for the permit.
Survey type:	Woodside is considering a two-dimensional (2D) or three-dimensional (3D) seismic acquisition over the area, of which only one survey type will be selected prior to the submission of the Environment Plan for this activity. For part of the Active Source Area, Woodside is also considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy.
Location:	187 km north of the Port of Darwin.
Duration:	20 days - 45 days
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel.
Approximate Water Depth (m)	12 m - 384 m
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels.

Survey location:

The location of the Active Source Area and Operational Area are outlined in the attached Consultation Information Sheet.

Feedback:

If you have any issues or concerns with these activities, or any other issues relevant to this location then please respond to Woodside at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in our Environment Plans which will be submitted to submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Please provide your views by **10 May 2021**.

Ref 1.21 – Email to research organisations – CSIRO, Geoscience Australia, Charles Darwin University and Marine Biodiversity Hub (UTAS)

Dear CSIRO

Woodside is planning to conduct a 2D marine seismic survey in Commonwealth waters offshore Northern Territory (~187 km north of Darwin) in exploration permit NT/P86, starting at the earliest from May 2022 for a period of 35-60 days, pending approvals, vessel availability and weather constraints.

An Environment Plan for this activity will be submitted in accordance with the the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Woodside is seeking any feedback from you based on Guidance note DMAC 12 issued by the UK Diving Medical Advisory Committee (DMAC) "Safe Diving Distance from Seismic Surveying Operations" (DMAC, 2019). The guidance aims to manage potential impact on divers from seismic acquisition:

- Where diving and seismic activity are scheduled to occur within a distance of 45 km, it would be good practice for all parties to be made aware of the planned activity where practicable. This should include clients/operators, diving and seismic contractors.
- Where diving and seismic activity will occur within a distance of 30 km a joint risk assessment should be conducted, between the clients/operators involved and the seismic and diving contractors in advance of any simultaneous operations.

Based on the above research, commercial or recreational dive operators are encouraged to inform Woodside of any proposed dive operations during the proposed seismic activity that may be within 30 km of the proposed location.

A Consultation Information Sheet including map is attached, which provides background on the proposed activity, including a summary of potential key risks and associated management measures. The Information Sheet is also available on our website. Please note that the information sheet refers to 3D and 2D survey options. A decision was made recently that the survey will be 2D only.

Your feedback

We would welcome your feedback by close of business on **30 July 2021** and can be contacted at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in the Environment Plan that will be submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Ref 1.22 – Email to dive operators – Darwin Sub Aqua Club, Dive Air, Learn to Dive Darwin and Sea Darwin

Dear stakeholder

Woodside is planning to conduct a 2D marine seismic survey in Commonwealth waters offshore Northern Territory (~187 km north of Darwin) in exploration permit NT/P86, starting at the earliest from May 2022 for a period of 35-60 days, pending approvals, vessel availability and weather constraints.

An Environment Plan for this activity will be submitted in accordance with the the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Woodside is seeking any feedback from you based on Guidance note DMAC 12 issued by the UK Diving Medical Advisory Committee (DMAC) "Safe Diving Distance from Seismic Surveying Operations" (DMAC, 2019). The guidance aims to manage potential impact on divers from seismic acquisition:

- Where diving and seismic activity are scheduled to occur within a distance of 45 km, it would be good practice for all parties to be made aware of the planned activity where practicable. This should include clients/operators, diving and seismic contractors.
- Where diving and seismic activity will occur within a distance of 30 km a joint risk assessment should be conducted, between the clients/operators involved and the seismic and diving contractors in advance of any simultaneous operations.

Based on the above commercial or recreational dive operators are encouraged to inform Woodside of any proposed dive operations during the proposed seismic activity that may be within 30 km of the proposed location.

A Consultation Information Sheet including map is attached, which provides background on the proposed activity, including a summary of potential key risks and associated management measures. The Information Sheet is also available on our website. Please note that the information sheet refers to 3D and 2D survey options. A decision was made recently that the survey will be 2D only.

Your feedback

We would welcome your feedback by close of business on **30 July 2021** and can be contacted at Feedback@woodside.com.au or +61 439 500 799.

Your feedback and our response will be included in the Environment Plan that will be submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Phase 2 consultation

Ref 1.23 – Email to stakeholders with commercial fishing interests – AFMA, DAWE, NT DITT Fisheries, licence holders in the Northern Prawn Fishery, AFANT, CFA, DFLC (via NTSC), NPF Industry, NTGFA, NTSC, PPA, SIA and TRLC (via NTSC) (30 June 2021)

Dear stakeholder

Further to previous consultation advice, Woodside has further defined the survey type, coverage and duration of the proposed Galactic Hybrid Marine Seismic Survey (MSS) in Commonwealth waters offshore Northern Territory. Key clarifications comprise:

- Elimination of 3D survey acquisition option.
- Confirmation of 2D survey option, with a minimum and maximum kilometre line length, which will be finalised closer to start date of the survey.
- A minor adjustment to the Operational and Acquisition Areas as previously advised to accommodate the revised planned survey lines.

There has been no change to the planned source size and survey timing, with commencement from around May 2022.

An updated activity scope is outlined in the table below and we are seeking any additional feedback you may have.

Activity overview

Survey type:	A two-dimensional (2D) seismic acquisition, as well as autonomous ocean bottom seismic nodes (AUV nodes) for part of the survey area to record the reflected energy
Survey coverage:	Minimum: ~2250km line km Maximum:~4475 line km
Duration:	~2250 line km – approximately 30-35 days[1] ~4475 line km – approximately 55-60 days[1]
Schedule:	From around May 2022
Source size:	<3500 cuin
Number of streamers:	Single streamer, with a minimum length of 12 km
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels

[1] Duration is cumulative and does not include additional time required due to unforeseen circumstances, e.g. adverse weather.

Commercial fishing information
Woodside acknowledges feedback provided by stakeholders with an interest in commercial fishing, including government departments, individual commercial fishing licence holders and their representative organisations.

In response, Woodside will make available upon request, and prior to submission to NOPSEMA, the section of the Environment Plan that outlines noise impact assessment, as well the independent noise modelling report that underpinned our assessment. Please let us know if you would like copies of this information. We would also be pleased to meet to discuss this information.

Woodside also attaches the following maps for your reference:

- A map showing the planned minimum and maximum survey acquisition lines. These lines remain subject to change and can be provided to stakeholders if requested once planning for the activity is finalised. The Operational Area and Acquisition Area will not change.
- Maps showing historical 2D and 3D surveys in relation to exploration permit NT/P86.

Your feedback
We would welcome further feedback by close of business on **30 July 2021** on the planned activity and can be contacted at Feedback@woodside.com.au or +61 439 500 799.

As previously advised your feedback and our response will be included in the Environment Plan that will be submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Ref 1.24 – Letter to licence holders in relevant NT managed fisheries – Aquarium Fishery, Demersal Fishery, Offshore Net and Line Fishery, Spanish Mackerel Fishery and Timor Reef Fishery (30 June 2021)

Woodside Energy Ltd.
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Mia Yellagonga
11 Mount Street
Perth WA 6000
Australia
T +61 8 9348 4000
F +61 8 9214 2777
www.woodside.com.au

Please direct all responses/queries to:
[redacted]

2 July 2021

Dear Fishery Licence Holder

ADDITIONAL CONSULTATION INFORMATION – GALACTIC HYBRID MARINE SEISMIC SURVEY

Further to previous consultation advice, Woodside has further defined the survey type, coverage and duration of the proposed Galactic Hybrid Marine Seismic Survey (MSS) in Commonwealth waters offshore Northern Territory. Key clarifications comprise:

- Elimination of 3D survey acquisition option.
- Confirmation of 2D survey option, with a minimum and maximum kilometre line length, which will be finalised closer to start date of the survey.
- A minor adjustment to the Operational and Acquisition Areas as previously advised to accommodate the revised planned survey lines.

There has been no change to the planned source size and survey timing, with commencement from around May 2022.

An updated activity scope is outlined in the table below and we are seeking any additional feedback you may have.

Activity overview

Survey type:	A two-dimensional (2D) seismic acquisition, as well as autonomous ocean bottom seismic nodes (AUV nodes) for part of the survey area to record the reflected energy
Survey coverage:	Minimum: ~2250km line km Maximum:~4475 line km
Duration:	~2250 line km – approximately 30-35 days[1] ~4475 line km – approximately 55-60 days[1]
Schedule:	From around May 2022
Source size:	<3500 cuin
Number of streamers:	Single streamer, with a minimum length of 12 km
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels

[1] *Duration is cumulative and does not include additional time required due to unforeseen circumstances, e.g. adverse weather.*

Commercial fishing information
Woodside acknowledges feedback provided by stakeholders with an interest in commercial fishing, including government departments, individual commercial fishing licence holders and their representative organisations.

In response, Woodside will make available upon request, and prior to submission to NOPSEMA, the section of the Environment Plan that outlines noise impact assessment, as well the independent noise modelling report that underpinned our assessment. Please let us know if you would like copies of this information. We would also be pleased to meet to discuss this information.

Woodside also encloses the following maps for your reference:

- A map showing the planned minimum and maximum survey acquisition lines. These lines remain subject to change and can be provided to stakeholders if requested once planning for the activity is finalised. The Operational Area and Acquisition Area will not change.
- Maps showing historical 2D and 3D surveys in relation to exploration permit NT/P86.

Your feedback
We would welcome further feedback by close of business on **30 July 2021** on the planned activity and can be contacted at Feedback@woodside.com.au or +61 439 500 799.

As previously advised your feedback and our response will be included in the Environment Plan that will be submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Regards

[redacted]
Corporate Affairs Adviser | Corporate Affairs

As a service provider to Woodside Energy Ltd

Ref 1.25 – Email to all other relevant stakeholders with non-commercial fishing interests (30 June 2021)

Dear Stakeholder

Further to previous consultation advice, Woodside has further defined the survey type, coverage and duration of the proposed Galactic Hybrid Marine Seismic Survey (MSS) in Commonwealth waters offshore Northern Territory. Key clarifications comprise:

- Elimination of 3D survey acquisition option.
- Confirmation of 2D survey option, with a minimum and maximum kilometre line length, which will be finalised closer to start date of the survey.
- A minor adjustment to the Operational and Acquisition Areas as previously advised to accommodate the revised planned survey lines.

There has been no change to the planned source size and survey timing, with commencement from around May 2022.

An updated activity scope is outlined in the table below and we are seeking any additional feedback you may have.

Activity overview

Survey type:	A two-dimensional (2D) seismic acquisition, as well as autonomous ocean bottom seismic nodes (AUV nodes) for part of the survey area to record the reflected energy
Survey coverage:	Minimum: ~2250km line km Maximum:~4475 line km
Duration:	~2250 line km – approximately 30-35 days[1] ~4475 line km – approximately 55-60 days[1]
Schedule:	From around May 2022
Source size:	<3500 cuin
Number of streamers:	Single streamer, with a minimum length of 12 km
Vessels:	Single, purpose-built seismic vessel, one support vessel and a potential chase vessel
Safe navigation zone (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations. Marine users are requested to avoid this area during the survey to ensure the safety of the seismic vessel and third-party vessels

[1] Duration is cumulative and does not include additional time required due to unforeseen circumstances, e.g. adverse weather.

In support of this consultation, Woodside attaches a map showing the planned minimum and maximum survey acquisition lines. These lines remain subject to change and can be provided to stakeholders if requested once planning for the activity is finalised. The Operational Area and Acquisition Area will not change.

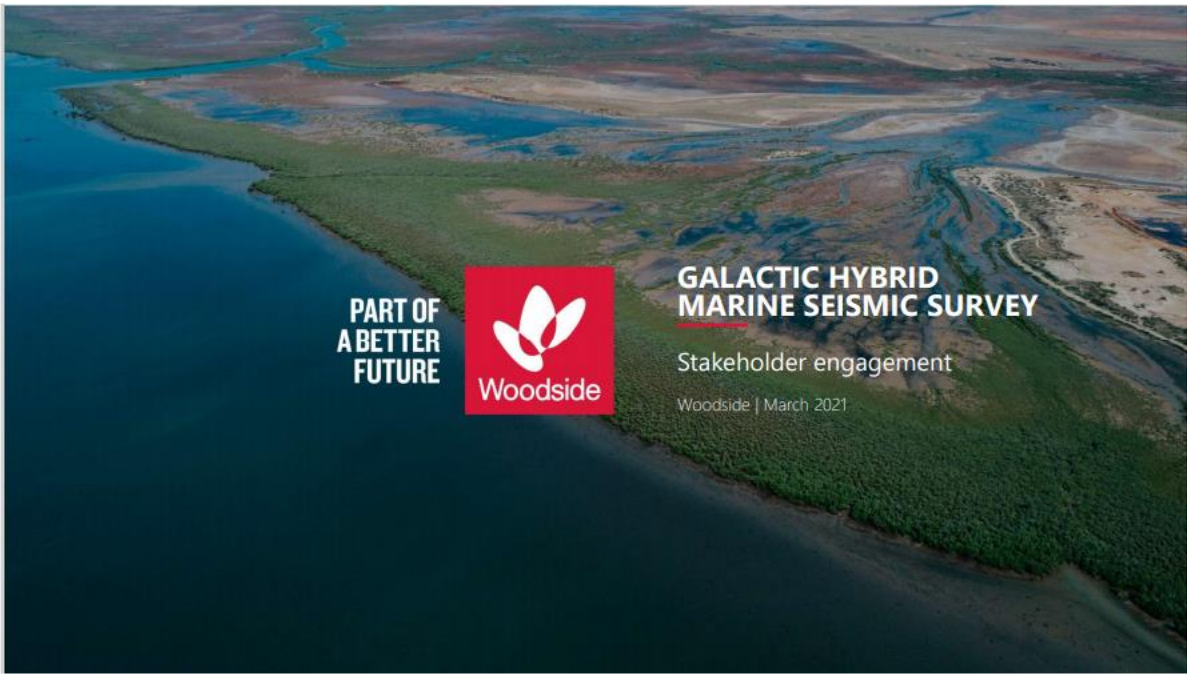
Your feedback

We would welcome further feedback by close of business on **30 July 2021** on the planned activity and can be contacted at Feedback@woodside.com.au or +61 439 500 799.

As previously advised your feedback and our response will be included in the Environment Plan that will be submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth).

Please let us know if your feedback for this activity is sensitive and we will make this known to NOPSEMA upon submission of the Environment Plan in order for this information to remain confidential to NOPSEMA.

Ref 1.26 – Presentation to NTDITT (Petroleum and Fisheries) – 17 March 2021



GALACTIC HYBRID MARINE SEISMIC SURVEY

Introduction

Woodside is planning to conduct a marine seismic survey in exploration permit NT/P86 in Commonwealth waters offshore Northern Territory

The survey will start at the earliest from May 2022 pending approvals, vessel availability and weather constraints.

The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define and assess new and existing hydrocarbon leads.

The survey is a part of Woodside's work program commitments for the title and will be the first 3D survey over the permit, or the first comprehensive 2D survey over the permit since the mid 2000s.

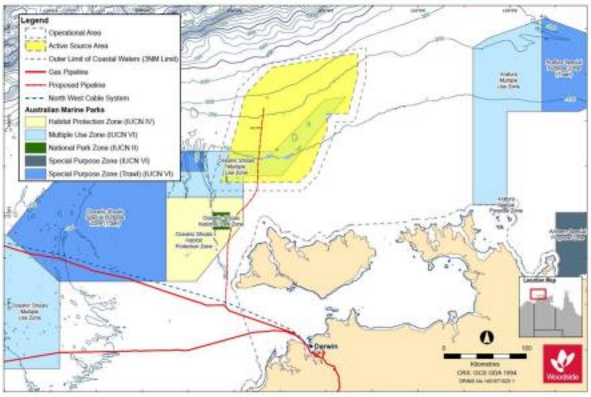
Woodside will develop an Environment Plan for the activity under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006*. Acceptance of this Plan by NOPSEMA is required before any activities can take place.

A full assessment of key environment and socio-cultural sensitives that overlap survey Operational Area will be undertaken as part of the Environmental Plan.

2 |

GALACTIC HYBRID MSS ENVIRONMENT PLAN

Project Overview



Location:
- NT/P86
- ~187 km north of Darwin

Timing:
- From May 2022 pending approvals, vessel availability and weather constraints

Estimated duration:
- 20 days - 45 days

Vessels
- Single, purpose-built seismic vessel, one support vessel and a potential chase vessel

Scope:
- 2D or 3D survey
  - 2D option: up to 2000 km
  - 3D option: up to 2000 km²

- For part of the survey area, Woodside is considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy

Scope to be confirmed before submission of EP

PART OF A BETTER FUTURE Woodside

GALACTIC HYBRID MARINE SEISMIC SURVEY

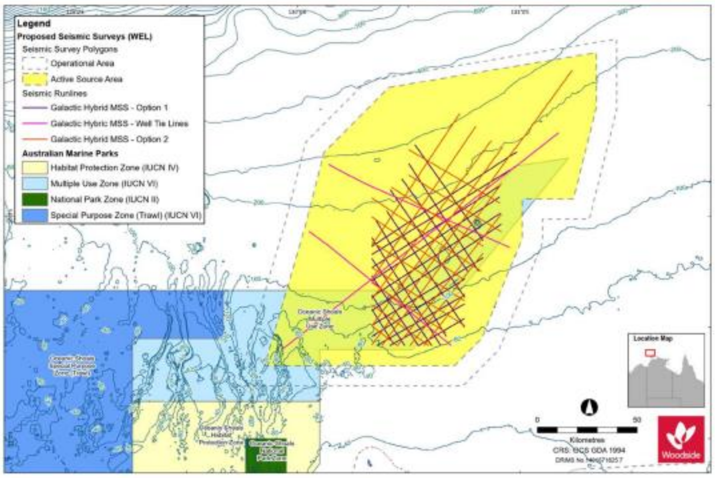
Project Overview - continued

Activity	Details	
	2D Survey Option	**3D Survey Option**
Source size	<3500 cubic inches	<2500 cubic inches
Streamer tow depth	>15 m	>15 m
Number of streamers	Up to two streamers	Six to 12 streamers
Maximum width of streamer array	~400 m	~2 km
Distance from seismic vessel bow to tail buoy	~10.5 km	~5.5 km – 8.5 km
Distance between streamers	125 m – 150 m	125 m – 150 m
Safe navigation area (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations
Average length of sail lines	80 km	Subject to planning confirmation
Time to traverse a sail line	Avg duration 10 – 11 hours	Subject to planning confirmation
Seismic vessel sail line speed	3 knots – 5 knots	3 knots – 5 knots

PART OF A BETTER FUTURE Woodside

GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview - continued



Indicative survey lines:

- Two options being considered for 2D seismic, of which only one 2D option will be selected + well tie lines
- Planning also under way for scope of 3D seismic
- Only one of the 2D or 3D survey options will be selected
- Relevant stakeholders will be advised once planning is finalised

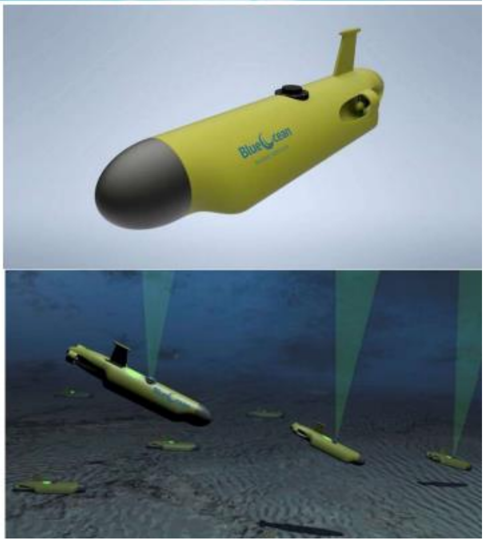
PART OF A BETTER FUTURE Woodside

GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview - continued

Potential Opportunity to use AUV Seismic Nodes:

- Node seismic surveys and technology are common practice in industry
- The autonomous nature of the Blue Ocean Seismic Services nodes is seen as an evolution of the technology with the following benefits:
  - Reduces the time required for deployment and retrieval
  - Minimises potential displacement of other marine users
  - Removes the need for ROV seafloor placement and the associated marine operations
  - Improves seismic data quality, operational efficiency and the potential to reduce both the frequency and duration for future seismic surveys
- Likely configuration will be a sparse grid on the seabed, with each AUV node expected to have five movements before retrieval is required



GALACTIC HYBRID MARINE SEISMIC SURVEY

Stakeholder Consultation

Timing:

- Activity information will be provided to stakeholders from March 2021
- Engagement period of 45 days, with ongoing consultation to follow
- Environment Plan will have a 30-day NOPSEMA public comment period

Consultation Activities:

- **Consultation plan** builds on previously accepted EPs for Woodside and other titleholders in the region
- **Activity factsheet** sent to all stakeholders – activity overview, details on seismic, identification of risks and management/mitigation measures
- **Bespoke factsheet** for commercial fishers and fishing representative organisations – operational aspects, compensation principles, noise modelling and key commercial fishing risks and/or impacts and management measures
- **Bespoke maps** for relevant stakeholders - Defence, commercial shipping, other industry activities

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GALACTIC HYBRID MARINE SEISMIC SURVEY

Stakeholder Consultation and Communications Protocols

Timing	Activity
During activity planning and Environment Plan development prior to public review and NOPSEMA assessment	• Engagement of relevant government agencies, peak industry organisations, representative organisations, Aboriginal corporations, commercial fishing licence holders, infrastructure owners and petroleum Operators.
Upon finalisation of activity scope	• Notification to relevant commercial fishing licence holders.
When the Environment Plan for the proposed activity has been accepted by NOPSEMA	• Notification to relevant commercial fishing licence holders.
No less than five weeks prior to survey start date	• Notification to Defence on planned activities and vessel movements.
No less than four weeks prior to survey start date	• Notification to the Australian Hydrographic Office for Notice to Mariners and AUSCOAST warnings to be generated. • Notification to relevant commercial fishing licence holders on planned activities and vessel movements. • Request to relevant licence holders for details of vessel names, key personnel and contact details for vessels likely to be in the vicinity of the survey.
24 hours to 48 hours prior to survey start date	• Notification to the Australian Maritime Safety Authority Joint Rescue Coordination Centre (AMSA JRCC) on planned activities and vessel movements. • Notification to relevant commercial fishing licence holders on planned activities and vessel movements.

During survey	• If requested, provision to relevant marine users of a daily look ahead report on survey activities. At a minimum, the report will have:
	  • Current position of the survey vessel
	  • 72 hours (about 3 days) look ahead for survey activities and locations
	  • Contact details for the seismic vessel and support vessels

Upon survey completion	• Notification to relevant stakeholders.

PART OF A BETTER FUTURE Woodside

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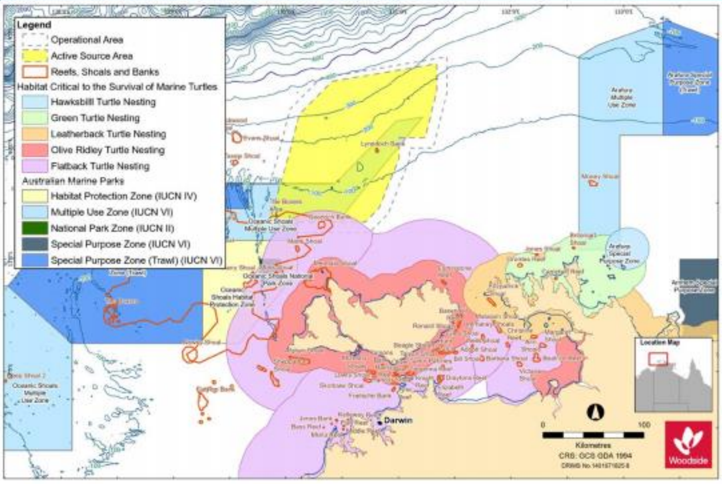
GALACTIC HYBRID MARINE SEISMIC SURVEY

Key Environment Sensitivities



Key environmental sensitivities:

- Active Source Area overlaps the Multiple Use Zone of the Oceanic Shoals Australian Marine Park
- Shallow water areas (Lynedoch Bank and Goodrich Bank) – site-attached fish assemblages
- Habitat Critical inter-nesting areas for flatback and olive ridley turtles
- Potential turtle foraging on shallow water banks and shoals

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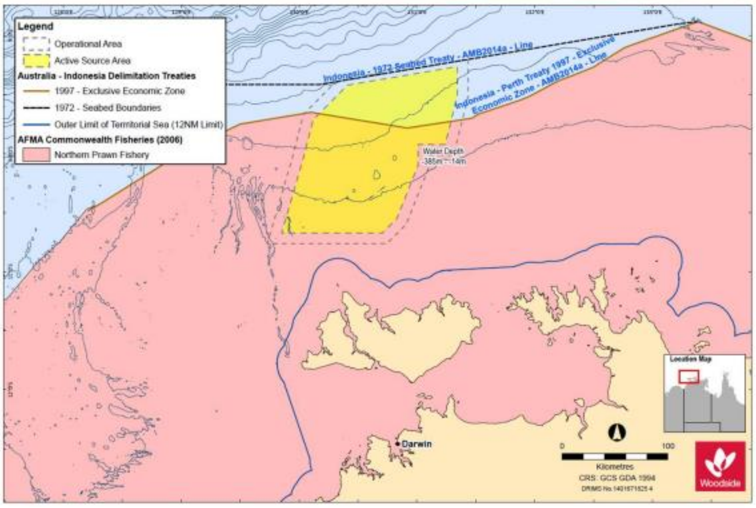
GALACTIC HYBRID MARINE SEISMIC SURVEY

Socio-Cultural Sensitivities – relevant commercial fisheries (Commonwealth)



PART OF A BETTER FUTURE Woodside

GALACTIC HYBRID MARINE SEISMIC SURVEY

Socio-Cultural Sensitivities – commercial fishing

Overview

- Impacts to fishes and fish eggs and larvae assessed based on the application of internationally recognised sound exposure thresholds, and predictions of received sound levels at the seafloor and in the water column from detailed underwater noise modelling
- Acquisition of the survey won't overlap the peak spawning season for key target species in the region, such as goldband snapper and red emperor (September to May)
- Consultation activities and communications protocols to actively manage potential concurrent activities

Assessment

- No significant behavioural responses are expected in key target species that will result in a decline in 'catchability' of these fishes
- Impacts to fish eggs and larvae are not likely due to the short duration of the Galactic Hybrid Marine Seismic Survey and lack of overlap with the peak spawning season

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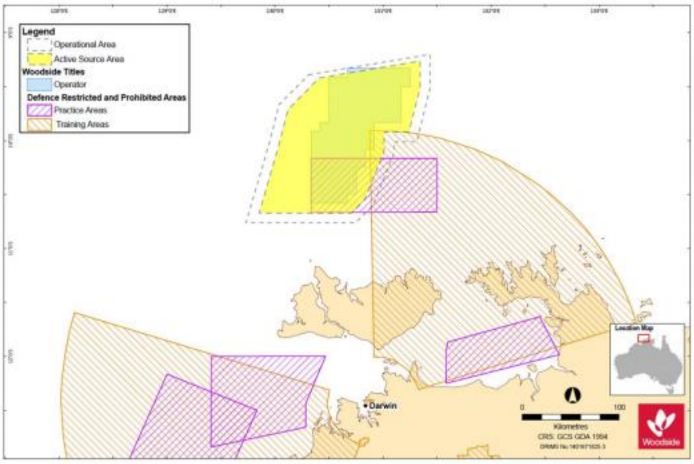
GALACTIC HYBRID MARINE SEISMIC SURVEY

Socio-Cultural Sensitivities – Defence activities



Potential impacts:

- Operational Area overlaps Defence practice and training areas
- Consultation with Defence to inform activity planning with respect to potential UXOs
- Activity scheduled to be completed prior to start of biennial Exercise Kakadu

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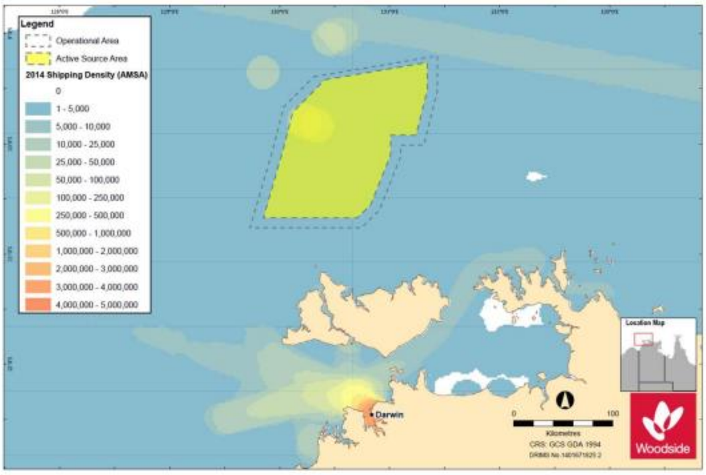
PART OF A BETTER FUTURE Woodside

GALACTIC HYBRID MARINE SEISMIC SURVEY

Socio-Cultural Sensitivities – commercial shipping



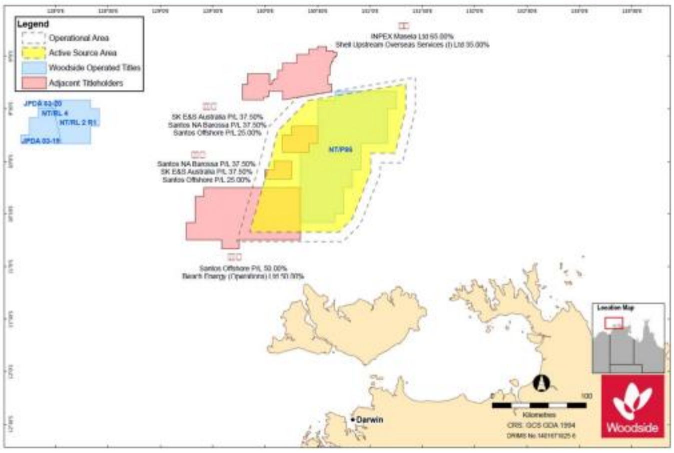
Potential impacts:

- Unlikely commercial shipping will be impacted by planned Activity
- Operational aspects to be managed via consultation activities and communications protocols

PART OF A BETTER FUTURE Woodside

GALACTIC HYBRID MARINE SEISMIC SURVEY

Socio-Cultural Sensitivities – industry activities

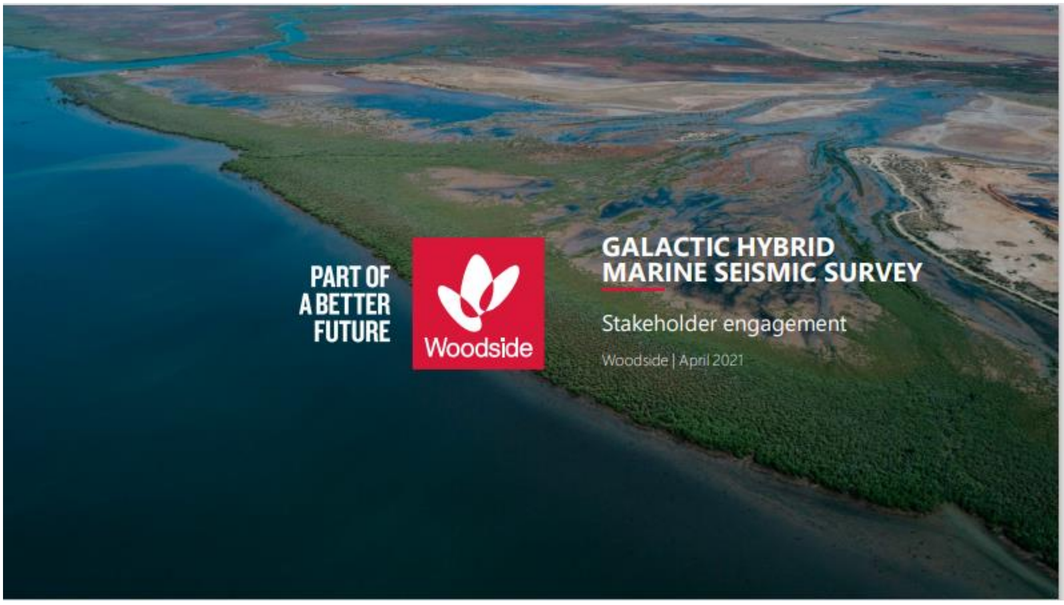


Potential impacts:

- Other Petroleum Operators
  - Santos
  - Inpex
- Other industry
  - Vocus Communications – proposed Bonaparte Basin Cable Loop
- Consultation activities and communications protocols to actively manage potential concurrent activities

PART OF A BETTER FUTURE Woodside

Ref 1.27 – Presentation to NT Seafood Council (16 April 2021) and Austral Fisheries (22 April 2021)



GALACTIC HYBRID MARINE SEISMIC SURVEY

Introduction

Woodside is planning to conduct a marine seismic survey in exploration permit NT/P86 in Commonwealth waters offshore Northern Territory

The survey will start at the earliest from May 2022 pending approvals, vessel availability and weather constraints.

The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define and assess new and existing hydrocarbon leads.

The survey is a part of Woodside's work program commitments for the title and will be the first 3D survey over the permit, or the first comprehensive 2D survey over the permit since the mid 2000s.

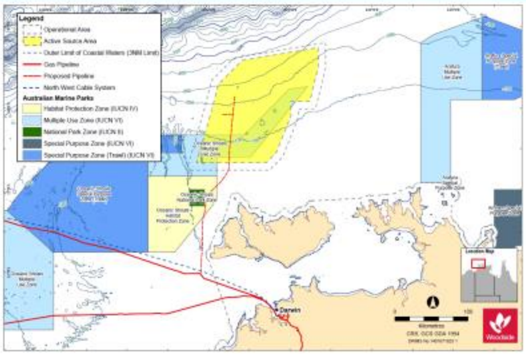
Woodside will develop an Environment Plan for the activity under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006*. Acceptance of this Plan by NOPSEMA is required before any activities can take place.

A full assessment of key environment and socio-cultural sensitives that overlap survey Operational Area will be undertaken as part of the Environmental Plan.

2

GALACTIC HYBRID MSS ENVIRONMENT PLAN

Project Overview



Location:
- NT/P86
- ~187 km north of Darwin

Timing:
- From May 2022 pending approvals, vessel availability and weather constraints

Estimated duration:
- 20 days - 45 days

Vessels
- Single, purpose-built seismic vessel, one support vessel and a potential chase vessel

Scope:
- 2D or 3D survey
  - 2D option: up to 2000 km
  - 3D option: up to 2000 km^2
- For part of the survey area, Woodside is considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy

PART OF A BETTER FUTURE

Scope to be confirmed before submission of EP

3

GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview - continued

Activity	Details	
	2D Survey Option	3D Survey Option
Source size	<3500 cubic inches	<2500 cubic inches
Streamer tow depth	>15 m	>15 m
Number of streamers	Up to two streamers	Six to 12 streamers
Maximum width of streamer array	~400 m	~2 km
Distance from seismic vessel bow to tail buoy	~10.5 km	~5.5 km – 8.5 km
Distance between streamers	125 m – 150 m	125 m – 150 m
Safe navigation area (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations
Average length of sail lines	80 km	Subject to planning confirmation
Time to traverse a sail line	Avg duration 10 – 11 hours	Subject to planning confirmation
Seismic vessel sail line speed	3 knots – 5 knots	3 knots – 5 knots

PART OF A BETTER FUTURE Woodside

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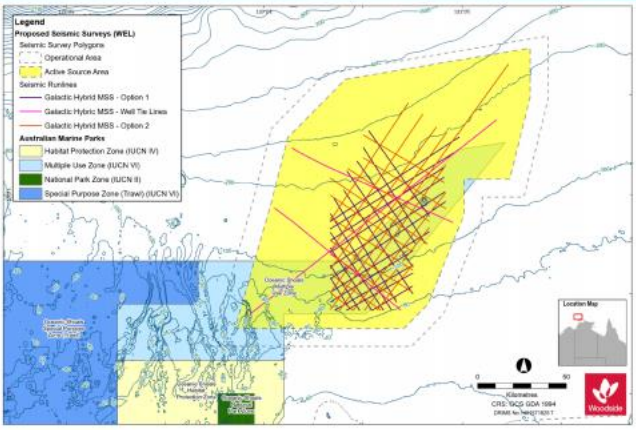
GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview - continued



Indicative survey lines:

- Two options being considered for 2D seismic, of which only one 2D option will be selected + well tie lines
- Planning also under way for scope of 3D seismic
- Only one of the 2D or 3D survey options will be selected
- Relevant stakeholders will be advised once planning is finalised

PART OF A BETTER FUTURE Woodside

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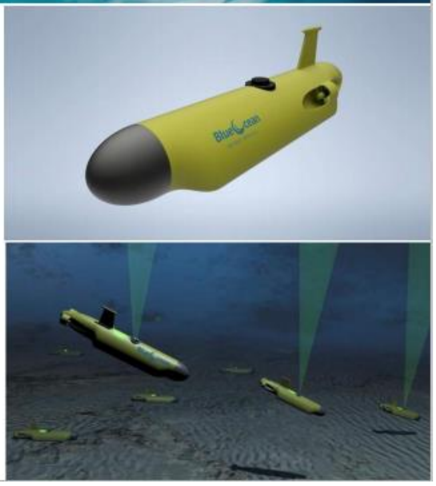
GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview - continued

Potential Opportunity to use AUV Seismic Nodes:

- Node seismic surveys and technology are common practice in industry
- The autonomous nature of the Blue Ocean Seismic Services nodes is seen as an evolution of the technology with the following benefits:
  - Reduces the time required for deployment and retrieval
  - Minimises potential displacement of other marine users
  - Removes the need for ROV seafloor placement and the associated marine operations
  - Improves seismic data quality, operational efficiency and the potential to reduce both the frequency and duration for future seismic surveys
- Likely configuration will be a sparse grid on the seabed, with each AUV node expected to have five movements before retrieval is required



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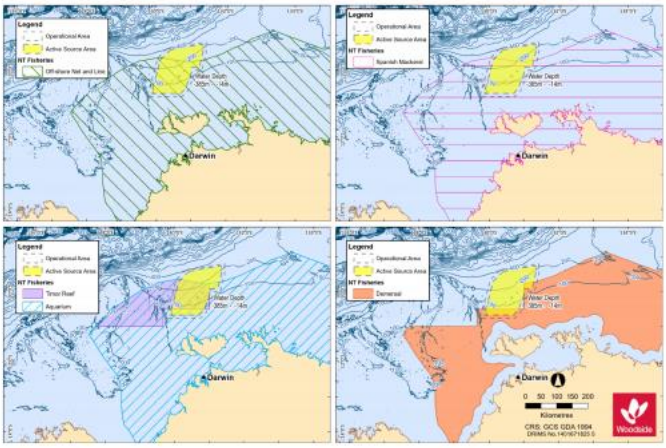
GALACTIC HYBRID MARINE SEISMIC SURVEY

Socio-Cultural Sensitivities – relevant commercial fisheries (Northern Territory)



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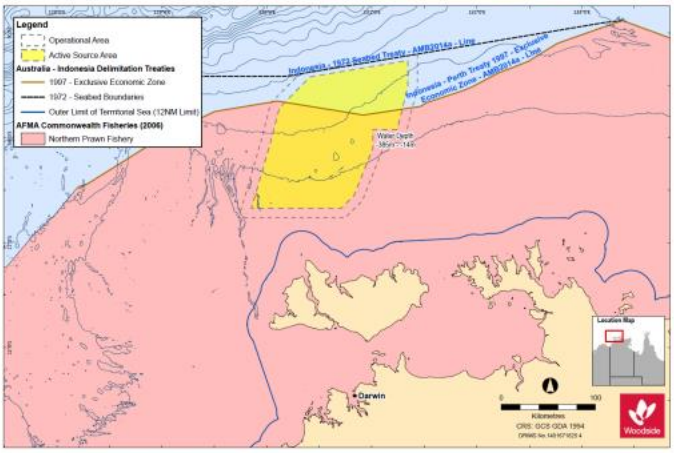
GALACTIC HYBRID MARINE SEISMIC SURVEY

Socio-Cultural Sensitivities – relevant commercial fisheries (Commonwealth)



PART OF A BETTER FUTURE Woodside

8

GALACTIC HYBRID MARINE SEISMIC SURVEY

Stakeholder Consultation

Timing:

- Activity information will be provided to stakeholders from March 2021
- Engagement period of 45 days, with ongoing consultation to follow
- Environment Plan will have a 30-day NOPSEMA public comment period

Consultation Activities:

- **Consultation plan** builds on previously accepted EPs for Woodside and other titleholders in the region
- **Activity factsheet** sent to all stakeholders – activity overview, details on seismic, identification of risks and management/mitigation measures
- **Bespoke factsheet** for commercial fishers and fishing representative organisations – operational aspects, compensation principles, noise modelling and key commercial fishing risks and/or impacts and management measures
- **Bespoke maps** for relevant stakeholders - Defence, commercial shipping, other industry activities

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GALACTIC HYBRID MARINE SEISMIC SURVEY

Stakeholder Consultation and Communications Protocols

Timing	Activity
During activity planning and Environment Plan development prior to public review and NOPSEMA assessment	• Engagement of relevant government agencies, peak industry organisations, representative organisations, Aboriginal corporations, commercial fishing licence holders, infrastructure owners and petroleum Operators.
Upon finalisation of activity scope	• Notification to relevant commercial fishing licence holders.
When the Environment Plan for the proposed activity has been accepted by NOPSEMA	• Notification to relevant commercial fishing licence holders.
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24 hours to 48 hours prior to survey start date	• Notification to the Australian Maritime Safety Authority Joint Rescue Coordination Centre (AMSA JRCC) on planned activities and vessel movements. • Notification to relevant commercial fishing licence holders on planned activities and vessel movements.

During survey	• If requested, provision to relevant marine users of a daily look ahead report on survey activities. At a minimum, the report will have:
	  • Current position of the survey vessel
	  • 72 hours (about 3 days) look ahead for survey activities and locations
	  • Contact details for the seismic vessel and support vessels

Upon survey completion	• Notification to relevant stakeholders.

PART OF A BETTER FUTURE Woodside

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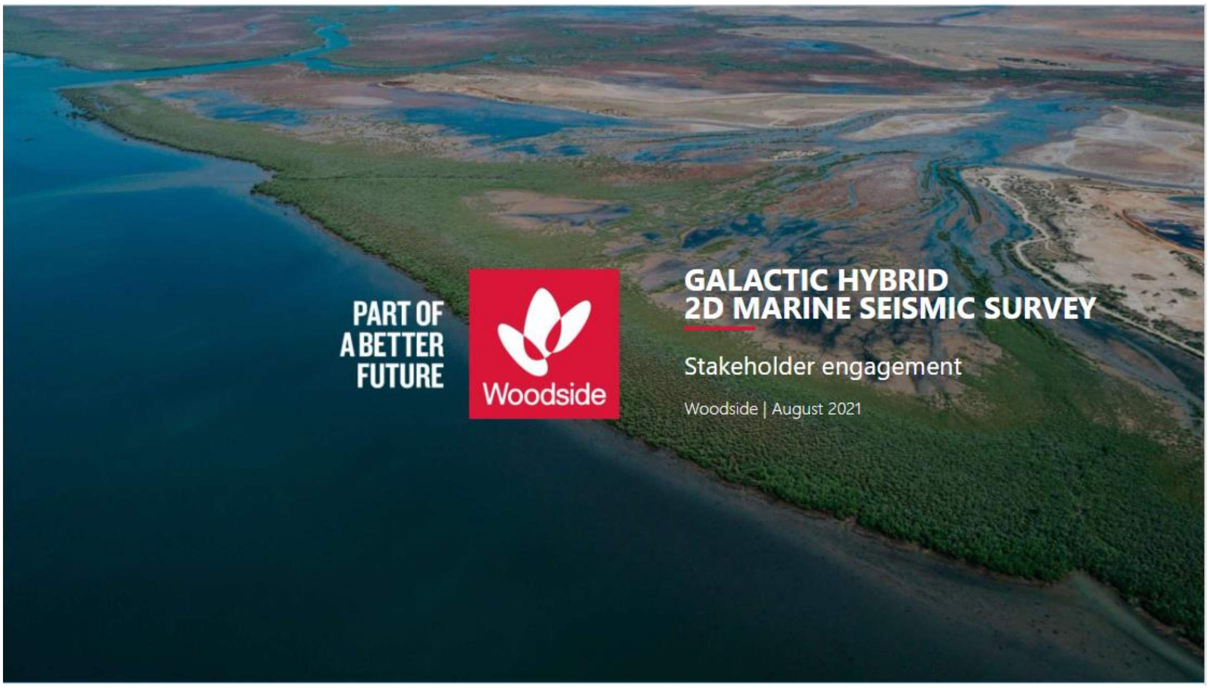
Ref 1.28 – Presentation to Northern Prawn Fishery Industry – 4 August 2021



GALACTIC HYBRID MARINE SEISMIC SURVEY

Introduction

Woodside is planning to conduct a marine seismic survey in exploration permit NT/P86 in Commonwealth waters offshore Northern Territory

The survey will start at the earliest from May 2022 pending approvals, vessel availability and weather constraints.

The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define and assess new and existing hydrocarbon leads.

The survey is a part of Woodside's work program commitments for the title and will be the first comprehensive 2D survey over the permit since the mid 2000s.

Woodside will develop an Environment Plan for the activity under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006*. Acceptance of this Plan by NOPSEMA is required before any activities can take place.

A full assessment of key environment and socio-cultural sensitives that overlap survey Operational Area will be undertaken as part of the Environmental Plan.

GALACTIC HYBRID MSS ENVIRONMENT PLAN

Project Overview

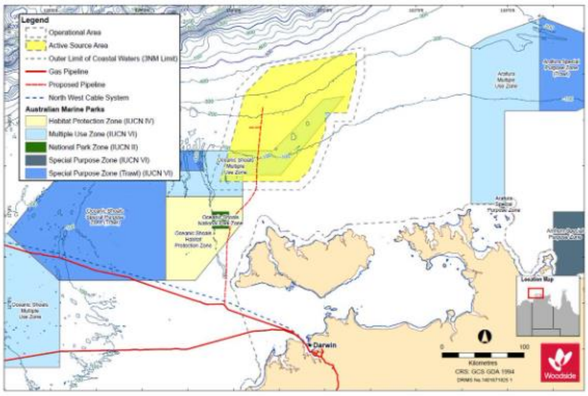
Location:
- NT/P86
- ~187 km north of Darwin

Timing:
- From May 2022 pending approvals, vessel availability and weather constraints

Scope:
- 2D survey
  - Minimum: ~2250 line km
  - Maximum: ~4475 line km
- For part of the survey area, Woodside is considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy

Estimated duration:
- ~2250 line km – approximately 30-35 days
- ~4475 line km – approximately 55-60 days

Vessels
- Single, purpose-built seismic vessel, one support vessel and a potential chase vessel



NOTE: Duration is cumulative and does not include additional time required due to unforeseen circumstances, e.g. adverse weather.

PART OF A BETTER FUTURE Woodside

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GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview - continued

Activity	Details
Source size	<3500 cubic inches
Streamer tow depth	>15 m
Number of streamers	Single streamer
Minimum length of streamer	12 km
Safe navigation area (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamer during seismic operations
Average length of sail lines	~ 60 km
Time to traverse a sail line	Avg duration 7 – 8 hours
Seismic vessel sail line speed	~ 4 knots

PART OF A BETTER FUTURE Woodside

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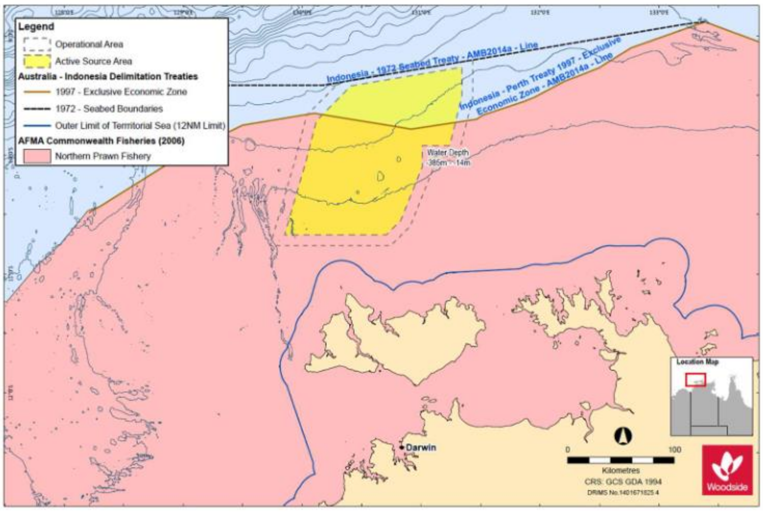
GALACTIC HYBRID MARINE SEISMIC SURVEY

Socio-Cultural Sensitivities – relevant commercial fisheries (Commonwealth)



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PART OF A BETTER FUTURE Woodside

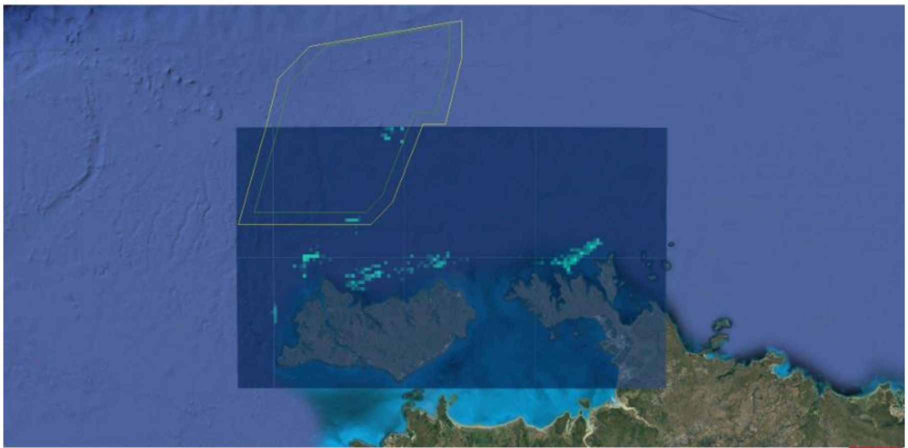
GALACTIC HYBRID MARINE SEISMIC SURVEY

NPF – banana prawn season 2021

1 April to 15 June 2021

Vessels:

- Amanda Verne K
- Xanadu I
- Adelaide Pearl
- Australian Pearl
- Dampier Pearl



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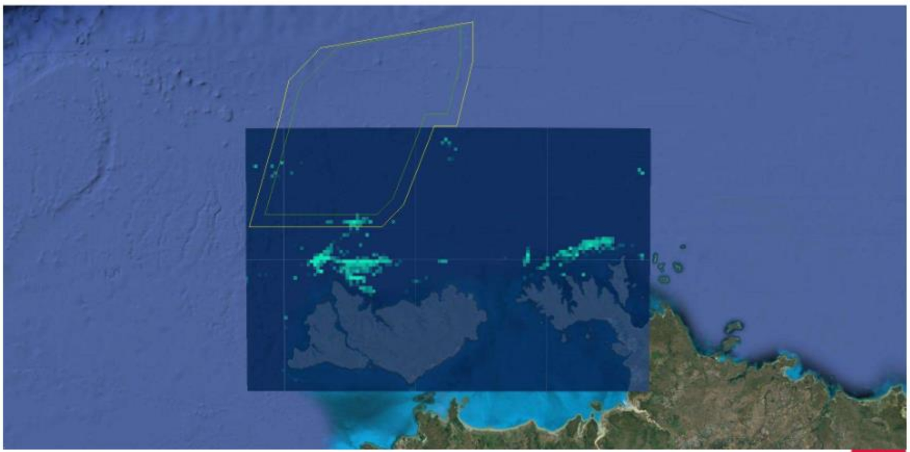
GALACTIC HYBRID MARINE SEISMIC SURVEY

NPF – tiger prawn season 2020

1 Aug to 1 Dec 2020

Vessels:

- Amanda Verne K
- Xanadu I
- Territory Spirit
- Karumba Pearl



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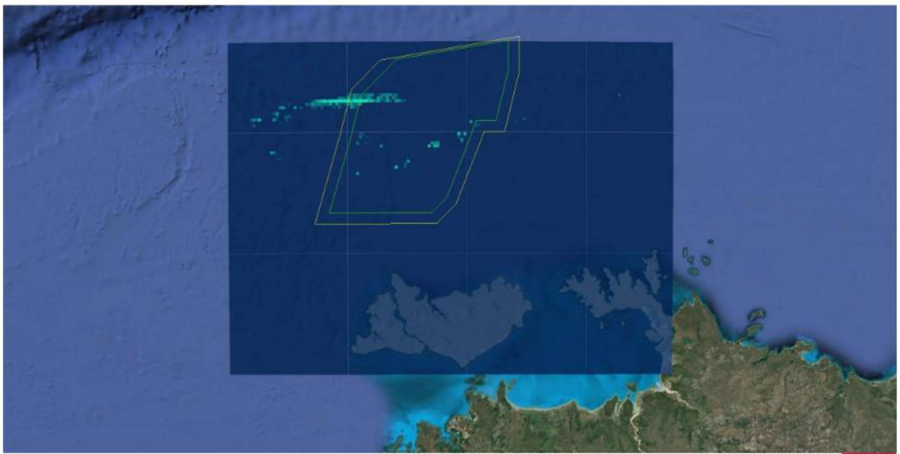
GALACTIC HYBRID MARINE SEISMIC SURVEY

NPF – scampi Dec-Jan

1 Dec 2020 to 31 Jan 2021

Vessels:

- Territory Spirit

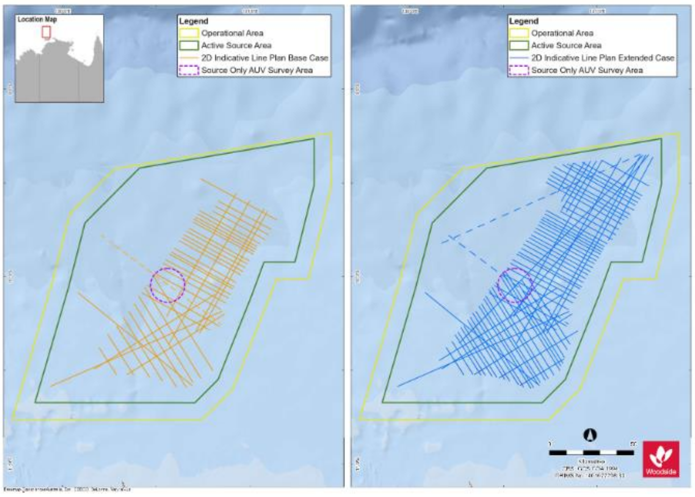


PART OF A BETTER FUTURE Woodside

8

GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview - continued



Indicative survey lines:

- Two options being considered for 2D seismic, of which only one 2D option will be selected + well tie lines
- No overlap between Active Source Area / 2D line plans and NPF fishing effort 2020-2021

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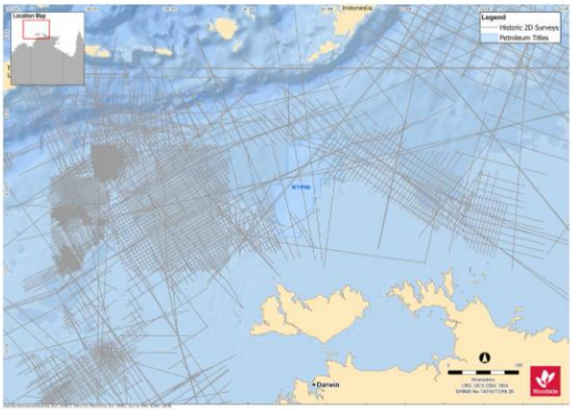
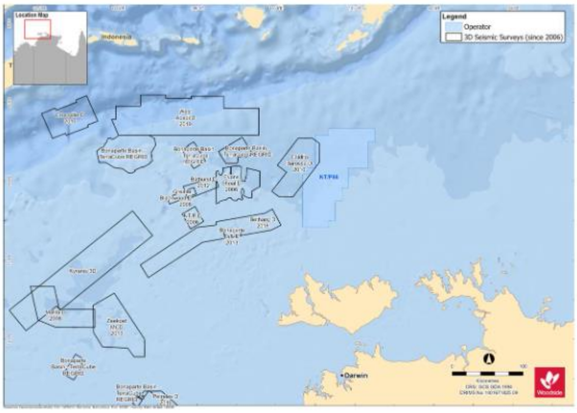
GALACTIC HYBRID MARINE SEISMIC SURVEY

Historic Regional 2D and 3D surveys





PART OF A BETTER FUTURE Woodside

GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview - continued

Potential Opportunity to use AUV Seismic Nodes:

- Node seismic surveys and technology are common practice in industry
- The autonomous nature of the Blue Ocean Seismic Services nodes is seen as an evolution of the technology with the following benefits:
  - Reduces the time required for deployment and retrieval
  - Minimises potential displacement of other marine users
  - Removes the need for ROV seafloor placement and the associated marine operations
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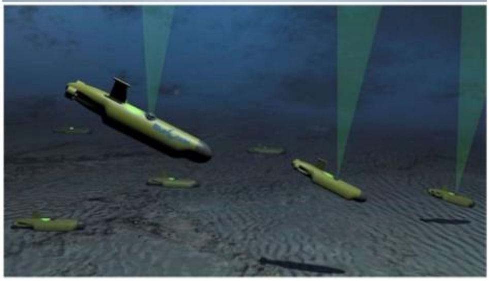

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GALACTIC HYBRID MARINE SEISMIC SURVEY

Stakeholder Consultation

Timing:

- Initial activity information provided to stakeholders in March 2021, engagement period of 45 days
- Additional information provided to stakeholders in June/July 2021, engagement period of 30 days
- Environment Plan will have a 30-day NOPSEMA public comment period

Consultation Activities:

- **Consultation plan** builds on previously accepted EPs for Woodside and other titleholders in the region
- **Activity factsheet** sent to all stakeholders – activity overview, details on seismic, identification of risks and management/mitigation measures
- **Bespoke factsheet** for commercial fishers and fishing representative organisations
- **Bespoke maps** for relevant stakeholders - Defence, commercial shipping, other industry activities
- **EP draft and noise modelling report** made available to commercial fishers and fishing representative organisations

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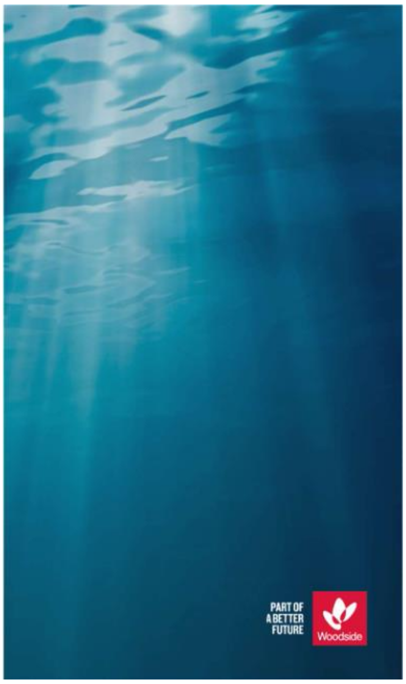

GALACTIC HYBRID MARINE SEISMIC SURVEY

Stakeholder Consultation and Communications Protocols

Timing	Activity
During activity planning and Environment Plan development prior to public review and NOPSEMA assessment	• Engagement of relevant government agencies, peak industry organisations, representative organisations, Aboriginal corporations, commercial fishing licence holders, infrastructure owners and petroleum Operators.
Upon finalisation of activity scope	• Notification to all relevant stakeholders.
When the Environment Plan for the proposed activity has been accepted by NOPSEMA	• Notification to relevant commercial fishing licence holders.
No less than five weeks prior to survey start date	• Notification to Defence on planned activities and vessel movements.
No less than four weeks prior to survey start date	• Notification to the Australian Hydrographic Office for Notice to Mariners and AUSCOAST warnings to be generated. • Notification to relevant commercial fishing licence holders on planned activities and vessel movements. • Request to relevant licence holders for details of vessel names, key personnel and contact details for vessels likely to be in the vicinity of the survey.
24 hours to 48 hours prior to survey start date	• Notification to the Australian Maritime Safety Authority Joint Rescue Coordination Centre (AMSA JRCC) on planned activities and vessel movements. • Notification to relevant commercial fishing licence holders on planned activities and vessel movements.

During survey	• If requested, provision to relevant marine users of a daily look ahead report on survey activities. At a minimum, the report will have:
	  • Current position of the survey vessel
	  • 72 hours (about 3 days) look ahead for survey activities and locations
	  • Contact details for the seismic vessel and support vessels

Upon survey completion	• Notification to relevant stakeholders.

PART OF A BETTER FUTURE Woodside

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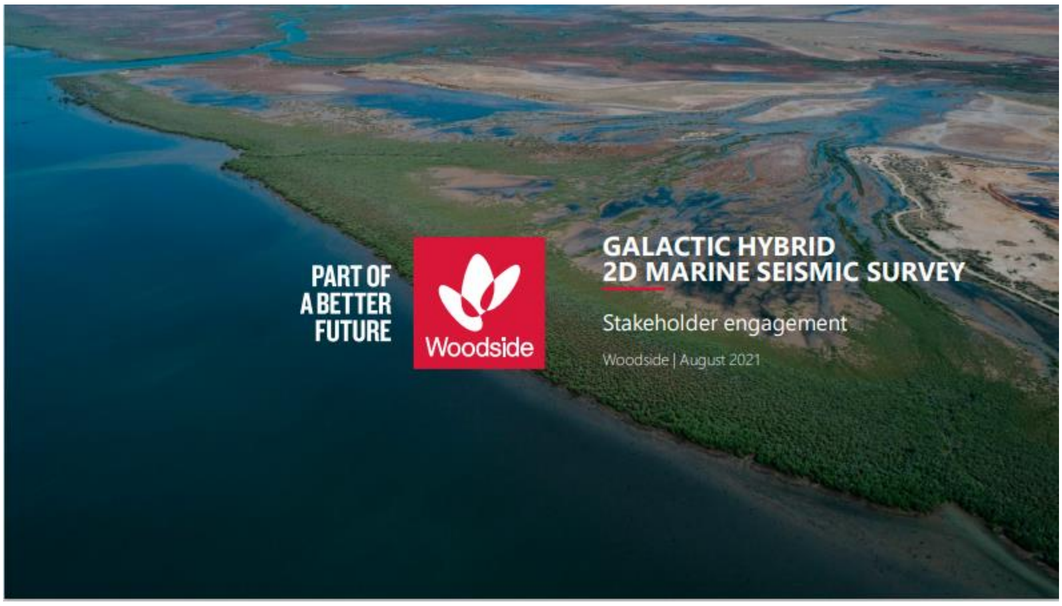
Ref 1.29 – Presentation to Australian Institute of Marine Science – 5 August 2021



GALACTIC HYBRID MARINE SEISMIC SURVEY

Introduction

Woodside is planning to conduct a marine seismic survey in exploration permit NT/P86 in Commonwealth waters offshore Northern Territory

The survey will start at the earliest from May 2022 pending approvals, vessel availability and weather constraints.

The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define and assess new and existing hydrocarbon leads.

The survey is a part of Woodside's work program commitments for the title and will be the first comprehensive 2D survey over the permit since the mid 2000s.

Woodside will develop an Environment Plan for the activity under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006*. Acceptance of this Plan by NOPSEMA is required before any activities can take place.

A full assessment of key environment and socio-cultural sensitives that overlap survey Operational Area will be undertaken as part of the Environmental Plan.

GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview

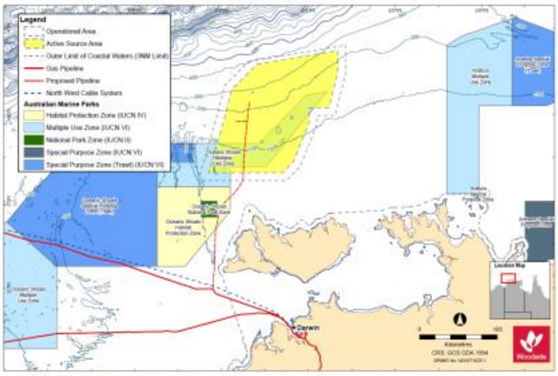
Location:
- NT/P86
- ~187 km north of Darwin

Timing:
- From May 2022 pending approvals, vessel availability and weather constraints

Scope:
- 2D survey
  - Minimum: ~2250 line km
  - Maximum: ~4475 line km
- For part of the survey area, Woodside is considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy

Estimated duration:
- ~2250 line km – approximately 30-35 days
- ~4475 line km – approximately 55-60 days

Vessels
- Single, purpose-built seismic vessel, one support vessel and a potential chase vessel



NOTE: Duration is cumulative and does not include additional time required due to unforeseen circumstances, e.g. adverse weather.

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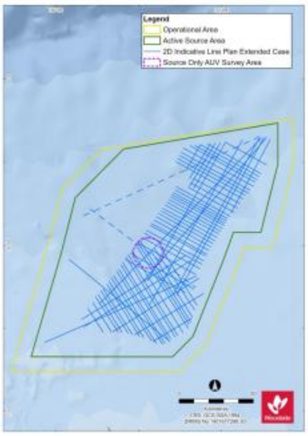
GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview - continued



Indicative survey lines:

- Two options being considered for 2D seismic, of which only one 2D option will be selected + well tie lines

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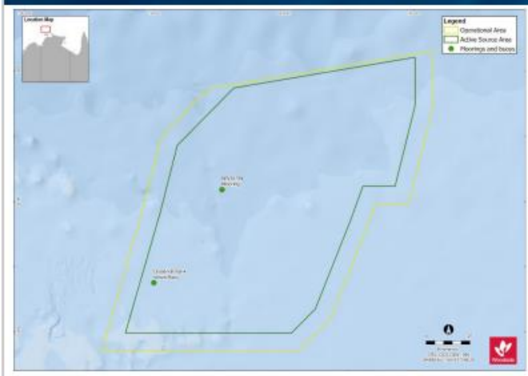
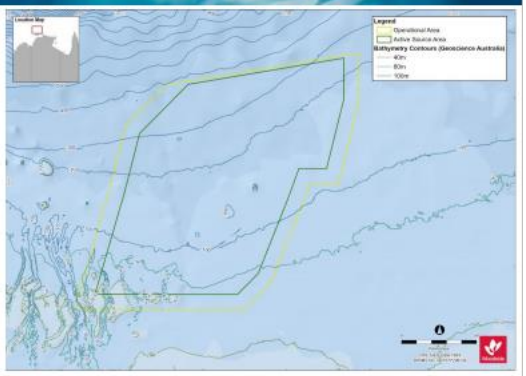
GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview - continued





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GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview - continued

Activity	Details
Source size	<3500 cubic inches
Streamer tow depth	>15 m
Number of streamers	Single streamer
Minimum length of streamer	12 km
Safe navigation area (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamer during seismic operations
Average length of sail lines	~ 60 km
Time to traverse a sail line	Avg duration 7 – 8 hours
Seismic vessel sail line speed	~ 4 knots

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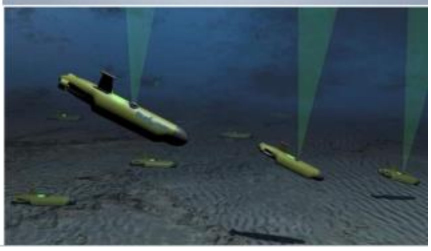
GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview - continued

Potential Opportunity to use AUV Seismic Nodes:

- Node seismic surveys and technology are common practice in industry
- The autonomous nature of the Blue Ocean Seismic Services nodes is seen as an evolution of the technology with the following benefits:
  - Reduces the time required for deployment and retrieval
  - Minimises potential displacement of other marine users
  - Removes the need for ROV seafloor placement and the associated marine operations
  - Improves seismic data quality, operational efficiency and the potential to reduce both the frequency and duration for future seismic surveys
- Likely configuration will be a sparse grid on the seabed, with each AUV node expected to have five movements before retrieval is required



GALACTIC HYBRID MARINE SEISMIC SURVEY

Stakeholder Consultation

Timing:

- Initial activity information provided to stakeholders in March 2021, engagement period of 45 days
- Additional information provided to stakeholders in June/July 2021, engagement period of 30 days
- Environment Plan will have a 30-day NOPSEMA public comment period

Consultation Activities:

- **Consultation plan** builds on previously accepted EPs for Woodside and other titleholders in the region
- **Activity factsheet** sent to all stakeholders – activity overview, details on seismic, identification of risks and management/mitigation measures
- **Bespoke factsheet** for commercial fishers and fishing representative organisations
- **Bespoke maps** for relevant stakeholders - Defence, commercial shipping, other industry activities
- **EP draft and noise modelling report** made available to commercial fishers and fishing representative organisations

GALACTIC HYBRID MARINE SEISMIC SURVEY

Stakeholder Consultation and Communications Protocols

Timing	Activity
During activity planning and Environment Plan development prior to public review and NOPSEMA assessment	• Engagement of relevant government agencies, peak industry organisations, representative organisations, Aboriginal corporations, commercial fishing licence holders, infrastructure owners and petroleum Operators.
Upon finalisation of activity scope	• Notification to all relevant stakeholders.
When the Environment Plan for the proposed activity has been accepted by NOPSEMA	• Notification to relevant commercial fishing licence holders.
No less than five weeks prior to survey start date	• Notification to Defence on planned activities and vessel movements.
No less than four weeks prior to survey start date	• Notification to the Australian Hydrographic Office for Notice to Mariners and AUSCOAST warnings to be generated. • Notification to relevant commercial fishing licence holders on planned activities and vessel movements. • Request to relevant licence holders for details of vessel names, key personnel and contact details for vessels likely to be in the vicinity of the survey.
24 hours to 48 hours prior to survey start date	• Notification to the Australian Maritime Safety Authority Joint Rescue Coordination Centre (AMSA JRCC) on planned activities and vessel movements. • Notification to relevant commercial fishing licence holders on planned activities and vessel movements.

During survey	• If requested, provision to relevant marine users of a daily look ahead report on survey activities. At a minimum, the report will have:
	  • Current position of the survey vessel
	  • 72 hours (about 3 days) look ahead for survey activities and locations
	  • Contact details for the seismic vessel and support vessels

Upon survey completion	• Notification to relevant stakeholders.

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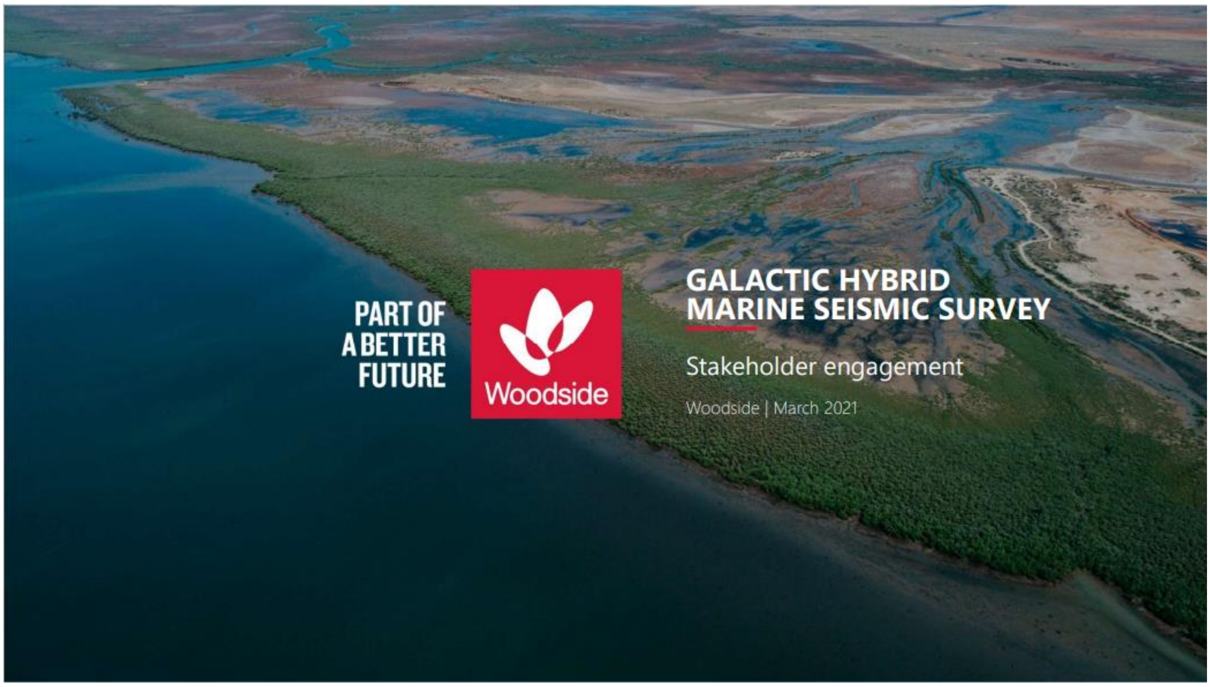
Ref 1.30 – Presentation to Tiw Land Council – 14 May 2021



GALACTIC HYBRID MARINE SEISMIC SURVEY

Introduction

Woodside is planning to conduct a marine seismic survey in exploration permit NT/P86 in Commonwealth waters offshore Northern Territory

The survey will start at the earliest from May 2022 pending approvals, vessel availability and weather constraints.

The purpose of the survey is to improve data quality and subsurface imaging within the permit, allowing Woodside to define and assess new and existing hydrocarbon leads.

The survey is a part of Woodside's work program commitments for the title and will be the first 3D survey over the permit, or the first comprehensive 2D survey over the permit since the mid 2000s.

Woodside will develop an Environment Plan for the activity under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006*. Acceptance of this Plan by NOPSEMA is required before any activities can take place.

A full assessment of key environment and socio-cultural sensitives that overlap survey Operational Area will be undertaken as part of the Environmental Plan.

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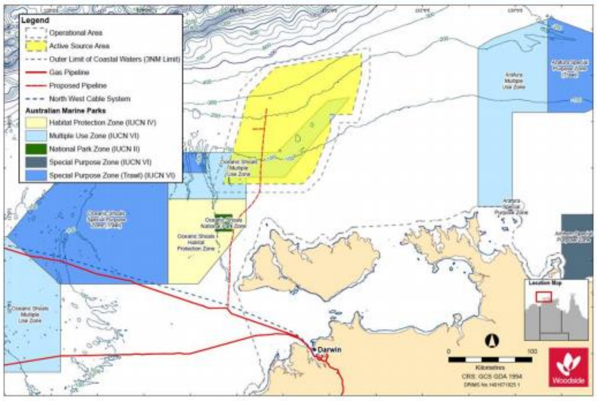
GALACTIC HYBRID MSS ENVIRONMENT PLAN

Project Overview



Location:
- NT/P86
- ~187 km north of Darwin

Timing:
- From May 2022 pending approvals, vessel availability and weather constraints

Estimated duration:
- 20 days - 45 days

Vessels
- Single, purpose-built seismic vessel, one support vessel and a potential chase vessel

Scope:
- 2D or 3D survey
  - 2D option: up to 2000 km
  - 3D option: up to 2000 km^2

- For part of the survey area, Woodside is considering using autonomous ocean bottom seismic nodes (AUV nodes) to record the reflected energy

Scope to be confirmed before submission of EP

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GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview - continued

Activity	Details	
	2D Survey Option	3D Survey Option
Source size	<3500 cubic inches	<2500 cubic inches
Streamer tow depth	>15 m	>15 m
Number of streamers	Up to two streamers	Six to 12 streamers
Maximum width of streamer array	~400 m	~2 km
Distance from seismic vessel bow to tail buoy	~10.5 km	~5.5 km – 8.5 km
Distance between streamers	125 m – 150 m	125 m – 150 m
Safe navigation area (cautionary area)	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations	Three nautical mile radius safe navigation area around the seismic vessel and streamers during seismic operations
Average length of sail lines	80 km	Subject to planning confirmation
Time to traverse a sail line	Avg duration 10 – 11 hours	Subject to planning confirmation
Seismic vessel sail line speed	3 knots – 5 knots	3 knots – 5 knots

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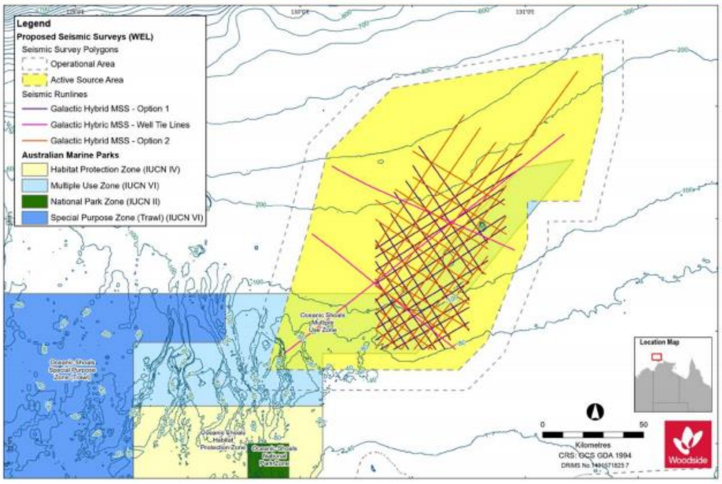
GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview - continued



Indicative survey lines:

- Two options being considered for 2D seismic, of which only one 2D option will be selected + well tie lines
- Planning also under way for scope of 3D seismic
- Only one of the 2D or 3D survey options will be selected
- Relevant stakeholders will be advised once planning is finalised

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GALACTIC HYBRID MARINE SEISMIC SURVEY

Project Overview - continued

Potential Opportunity to use AUV Seismic Nodes:

- Node seismic surveys and technology are common practice in industry
- The autonomous nature of the Blue Ocean Seismic Services nodes is seen as an evolution of the technology with the following benefits:
  - Reduces the time required for deployment and retrieval
  - Minimises potential displacement of other marine users
  - Removes the need for ROV seafloor placement and the associated marine operations
  - Improves seismic data quality, operational efficiency and the potential to reduce both the frequency and duration for future seismic surveys
- Likely configuration will be a sparse grid on the seabed, with each AUV node expected to have five movements before retrieval is required

GALACTIC HYBRID MARINE SEISMIC SURVEY

Stakeholder Consultation

Timing:

- Activity information will be provided to stakeholders from March 2021
- Engagement period of 45 days, with ongoing consultation to follow
- Environment Plan will have a 30-day NOPSEMA public comment period

Consultation Activities:

- **Consultation plan** builds on previously accepted EPs for Woodside and other titleholders in the region
- **Activity factsheet** sent to all stakeholders – activity overview, details on seismic, identification of risks and management/mitigation measures
- **Bespoke factsheet** for commercial fishers and fishing representative organisations – operational aspects, compensation principles, noise modelling and key commercial fishing risks and/or impacts and management measures
- **Bespoke maps** for relevant stakeholders - Defence, commercial shipping, other industry activities

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GALACTIC HYBRID MARINE SEISMIC SURVEY

Stakeholder Consultation and Communications Protocols

Timing	Activity
During activity planning and Environment Plan development prior to public review and NOPSEMA assessment	• Engagement of relevant government agencies, peak industry organisations, representative organisations, Aboriginal corporations, commercial fishing licence holders, infrastructure owners and petroleum Operators.
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Upon survey completion	• Notification to relevant stakeholders.

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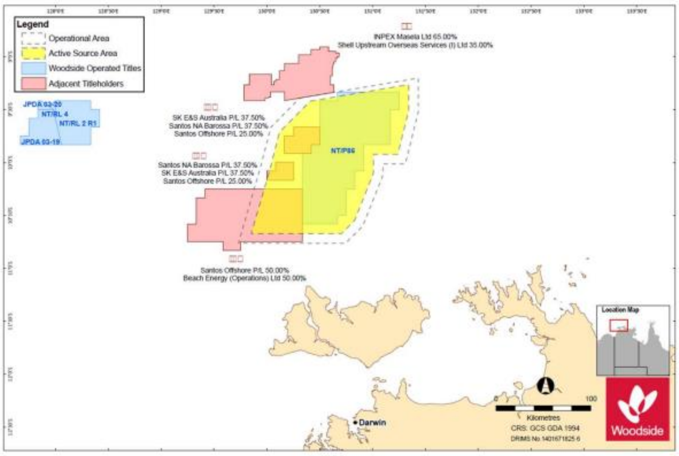
GALACTIC HYBRID MARINE SEISMIC SURVEY

Socio-Cultural Sensitivities – industry activities



Potential impacts:

- Other Petroleum Operators
  - Santos
  - Inpex
- Other industry
  - Vocus Communications – proposed Bonaparte Basin Cable Loop
- Consultation activities and communications protocols to actively manage potential concurrent activities

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Ref 1.31 – Poster sent to the Tiwi Land Council – 14 May 2021

Woodside

GALACTIC HYBRID MARINE SEISMIC SURVEY

MAY 2021

WHERE?

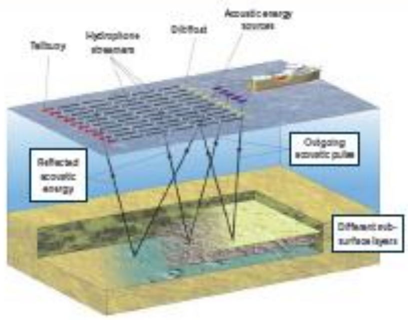
About 45km north of the Tiwi Islands.

WHY?

So Woodside can see if there might be oil and gas. Woodside is just looking at this early stage.

WHEN?

It's planned from May 2022. It should take about 20 to 45 days.



HOW?

It's called a Marine Seismic Survey.

This means a boat goes to the survey area and travels slowly in a straight line while sending a signal to the bottom of the sea.

The signal is reflected by rocks of different hardness. The reflected signal is then recorded by special microphones towed by the boat.

The recorded information helps Woodside create a picture of the land under the sea bed.

WHAT ARE THE IMPACTS?

Woodside did an assessment of what might happen in the survey area and don't believe there will be much impact on animals and fish in the sea.

Woodside thought about when the survey will start, how long it will take and the area where it will be done. Woodside also thought about existing marine life and other marine users that might be in the area, and how they might be impacted by the boat and the signal.

Woodside is developing a plan to manage potential impacts to acceptable levels. This plan will be submitted to the Australian Government for approval. No activities can start until this plan has been approved.

PROVIDING FEEDBACK

We would like to hear from you to help our planning for the survey. If you have any issues or concerns please contact us at **Feedback@woodside.com.au** or **+61 439 500 799**. Your feedback and our response will be included in the Environment Plan that will be submitted to the Government.

MORE INFORMATION

More information about the Galactic Hybrid Marine Seismic Survey can also be found on our web site at **https://www.woodside.com.au/sustainability/consultation-activities**

Woodside

APPENDIX G WOODSIDE CO-EXISTENCE APPROACH

Galactic Hybrid 2D MSS Environment Plan

Appendix G

Date: September 2021

Revision: 0

Appendix G: Woodside Co-existence Approach

Woodside acknowledges the importance of co-existence between commercial fishers and marine seismic surveys (MSS) operations to enable both parties to conduct their activities. Woodside conducts meaningful consultation with fishers to develop an understanding of and seek feedback on planned MSSs. The mitigation hierarchy is applied to avoid and minimise the potential for interaction. Woodside acknowledges that commercial fishers should not suffer an economic loss as a direct result of a Woodside MSS.

Woodside will consider evidenced based claims from commercial fishing licence holders during a MSS where:

- there is genuine displacement from undertaking normal fishing activities that results in economic loss
- fishing equipment has been lost or damaged
- there is a loss of catch that can be demonstrated

Displacement

Where the commercial fishing licence holder intends to relocate and potentially make a claim as a result of the MSS, the licence holder is required to notify Woodside prior to relocating and state the reason that the MSS has caused them to relocate. A commercial fishing licence holder wishing to make a claim for compensation will be required to provide Woodside with:

- evidence of costs of bait, fuel, wages and any other costs that are additional to the costs that would have been incurred

- the previous 5 years of fishing effort, catch, and/or Vessel Management System (VMS) data to demonstrate that the licence holder's vessels have recently and consistently fished within the MSS operational area during the same time of year

- evidence of fishing in the operational area during the same time of year as the MSS timing for at least 3 years within the last 5 years.

Lost or damaged equipment

Woodside will assess all evidence-based claims by commercial fishing licence holders for lost or damaged equipment within the operational area that occurred as a direct result of a Woodside MSS. Woodside should be notified and provided with evidence as soon as possible but within 14 days of the loss or damage by the commercial fishing licence holder.

Loss of Catch

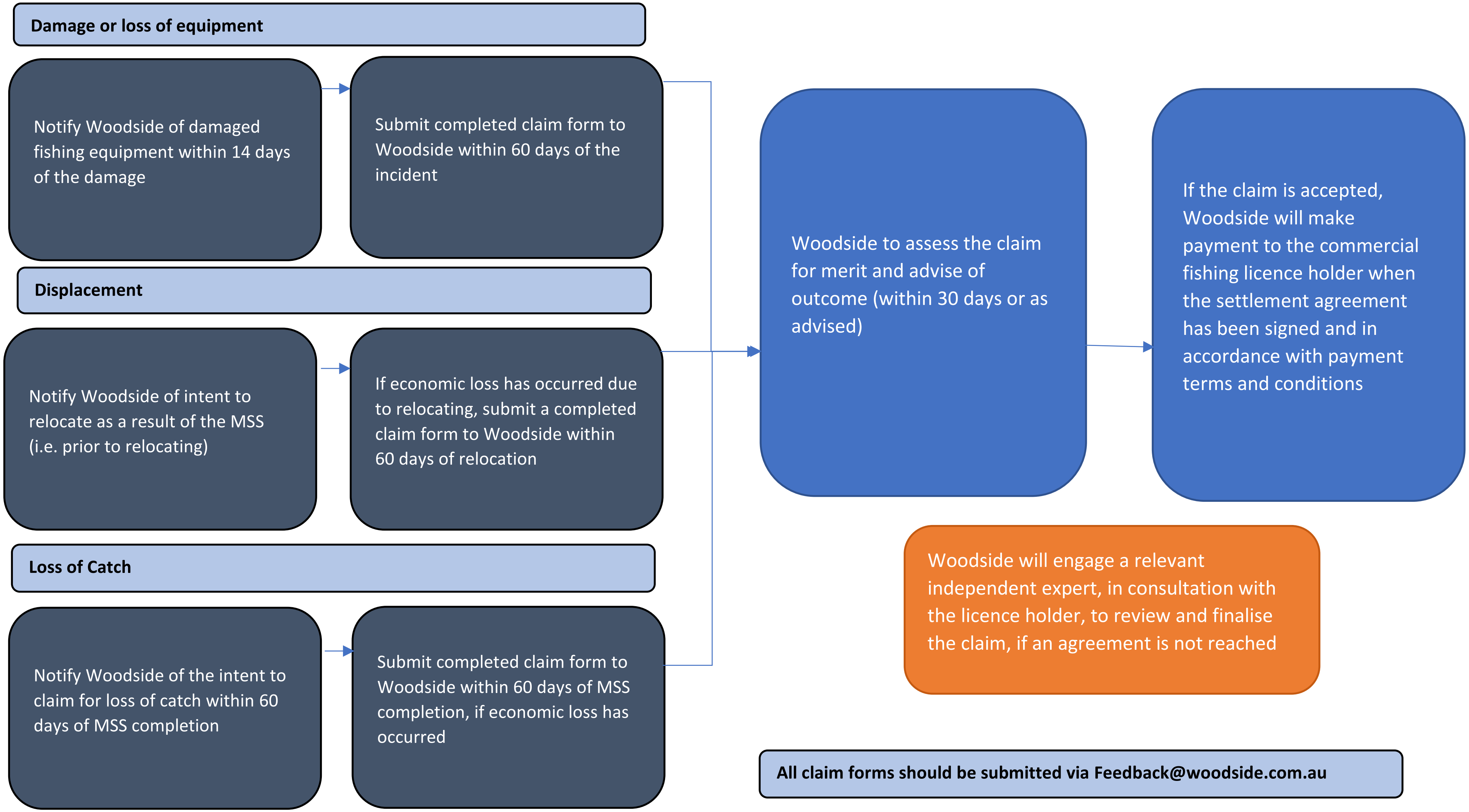
Where a commercial fishing licence holder has suffered an economic loss from a reduction in catch during the MSS that occurred as a direct result of that MSS, all evidence-based claims will be considered by Woodside.

General Claim Requirements

The Woodside claim form with supporting evidence, should be submitted within 60 days of Woodside completing the MSS. All information provided will be treated in accordance with the Woodside Privacy Statement.

The claim process should be completed in a timely manner. Figure 1 outlines the key steps and timing commitments. In addition, Woodside will acknowledge receipt of the claim and confirm the Woodside contact person for the claim. Woodside may seek a meeting with the commercial fishing licence holder to clarify any information or request further details. If there is disagreement with the required evidence, loss of catch determination or payment amount, Woodside will, in consultation with the commercial fishing licence holder, engage an independent relevant expert to review and finalise the claim. The independent relevant expert will be agreed between Woodside and the commercial fishing licence holder.

Figure 1: Woodside Claim Summary



APPENDIX H

Galactic Hybrid Marine Seismic Survey Oil Pollution First Strike Plan

Security & Emergency Management
Hydrocarbon Spill Preparedness

September 2021
Revision 0

TABLE OF CONTENTS

GALACTIC HYBRID MARINE SEISMIC SURVEY OIL POLLUTION FIRST STRIKE PLAN

SPILL FROM VESSEL ENTERING NORTHERN TERRITORY (NT) COASTAL WATERS

(Note: SOPEP should be implemented in conjunction with this document)

LEVEL 1

CONTROL AGENCY:	VESSEL OWNER
INCIDENT CONTROLLER:	VESSEL MASTER (with response assistance from Woodside)

LEVEL 2 & 3

HAZARD MANAGEMENT AGENCY:	NT DEPARTMENT OF ENVIRONMENT, PARKS AND WATER SECURITY
INCIDENT CONTROLLER:	TERRITORY MARINE POLLUTION COORDINATOR

SPILL FROM VESSEL ENTERING COMMONWEALTH WATERS

(Note: SOPEP should be implemented in conjunction with this document)

LEVEL 1

CONTROL AGENCY:	VESSEL OWNER
INCIDENT CONTROLLER:	VESSEL MASTER (with response assistance from Woodside)

LEVEL 2 & 3

CONTROL AGENCY:	AMSA
INCIDENT CONTROLLER:	AMSA (with response assistance from Woodside)

Guidance to Oil Spill Incident Levels

The most significant characteristic of the below guidance should be considered when determining level or escalation potential.

Characteristic	Level 1 Indicators	Level 2 Indicators	Level 3 Indicators
General Description	Generally able to be resolved within 24-48 hours.	Generally, a response is required beyond 48 hours.	Response may extend beyond weeks.
Woodside Emergency Management (EM)/Crisis Management Team (CMT) Activation	Onsite Incident Controller (IC) activated. Use of ICC support may be required.	Handover of Control from Onsite IC Corporate Incident Coordination Centre (CICC) Duty Manager (DM) in Peth.	Includes Perth based CMT activation.
Number of Agencies	First-response agency and Incident Management Team (IMT).	Multi-agency response.	Agencies from across government and industry.
Environment	Isolated impacts or with natural recovery expected within weeks.	Significant impacts and recovery may take months.	Significant area and recovery may take months. Remediation required.
Economy	Business level disruption (i.e. Woodside).	Business failure or 'Channel' impacts.	Disruption to a sector.
Public Affairs	Local and regional media coverage (WA).	National media coverage.	International media coverage.

For guidance on credible spill scenarios and hydrocarbon characteristics refer to Appendix A.

For Spills Entering Northern Territory Coastal Waters and Shorelines

Administrative Orders for the *NT Marine Pollution Act 1999* sits with the NT Department of Environment, Parks and Water Security (DEPWS) which provides services on behalf of the NT Environment Protection Authority (NT EPA). DEPWS is also the Hazard Management Authority for the NT.

In the event of an incident entering NT Coastal Waters, the Territory Marine Pollution Controller (TMPC) will appoint an NT Incident Controller (NT IC) who, together, will determine the incident classification level. The NT IC will then call upon competent personnel to form an Incident Management Team (IMT) commensurate to the incident level. Woodside understands that this may necessitate them, as titleholder, in forming the IMT and providing all operational taskings and Incident Action Plans (IAPs). Approval from the NT IC must be provided prior to their implementation. The NT IC, with advice from the NT Environment, Scientific and Technical Advisors will work with the Woodside IMT to agree protection priorities and determine the most appropriate response in NT Coastal Waters.

For spills resulting in shoreline contact, the NT IC will mobilise NT Governmental Functional Groups and response resources. Woodside will provide support to the NT IMT both from the Perth CICC and their forward operating base (FOB). At the request of the TMPC, Woodside will be required to provide all necessary resources, including personnel and equipment, to assist the NT IMT in performing its duties. Woodside personnel may be required to work within the NT IMT, undertake response activities e.g. shoreline protection, clean-up or oiled wildlife response. Numbers of personnel required from Woodside will be determined by the nature and scale of the spill.

To facilitate coordination between the NT Statutory and Control Agencies and Woodside's IMT, the NT IMT and Woodside FOB will be established to ensure alignment of objectives and provide a mechanism for prioritising conflicting resource requests between the Woodside IMT in Perth and the NT IMT in Darwin.

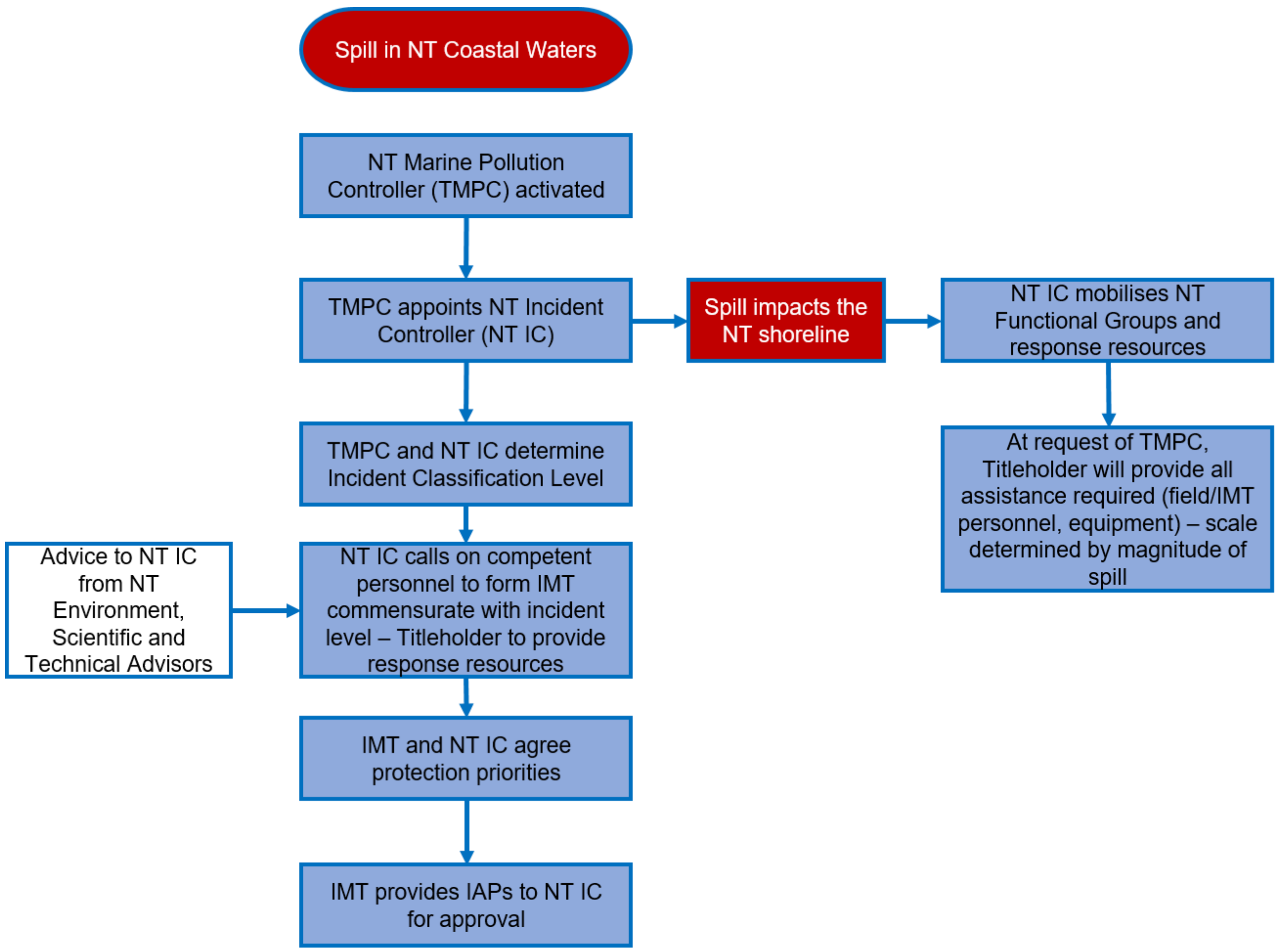


Figure 1-1: Incident response activation process in Northern Territory Coastal Waters (based on information received from DEPWS in April 2021)

The coordination structure for a concurrent hydrocarbon spill in both Commonwealth and NT Coastal Waters/ shorelines is shown in Appendix E.

Woodside's Incident Management Structure (IMS) for hydrocarbon spills can be seen at Appendix F**.**

Response Process Overview

Use the below to determine which parts of this plan are relevant to the incident.

For guidance on credible scenarios and hydrocarbon characteristics, refer to:
APPENDIX A – Credible spill scenarios and hydrocarbon information**.**

Vessel Incident

Level 1

Implement Section 1, 2 and 4

Notify the WCC on [redacted]

Make relevant notifications in Table 1-1 of this Oil Pollution First Strike Plan.

Coordinate pre-identified tactics in Table 2-1 of this Oil Pollution First Strike Plan.

If the spill escalates such that the site cannot manage the incident inform the WCC on [redacted] and escalate to a level 2/3 incident.

Handover control to AMSA.

Level 2/3

Implement Section 1

Notify the WCC on [redacted] to stand up the CICC.

CICC DM to coordinate relevant notifications in Table 1-1 of this Oil Pollution First Strike Plan.

If requested by AMSA implement sections 3 and 4 (continue below)

Undertake quick revalidation of the recommended strategies on Table 3-1 taking into consideration seasonal sensitivities and current situational awareness.

Undertake validated strategies.

Create an IAP for all ongoing operational periods
The content of the IAP should reflect the selected response strategies based on current situational awareness.

For the full detailed pre-operational NEBA click here or see Appendix A of the OSPRMA

Figure 1-2: Response process overview for Woodside vessel incidents

1. NOTIFICATIONS (ALL LEVELS)

The Incident Controller or delegate must ensure the below notifications (**Table 1-1**) are completed within the designated timeframes.

For other environmental notifications required, refer to the Galactic Hybrid Marine Seismic Survey Environment Plan.

Table 1-1: Immediate Notifications

Notification timing	Responsibility	Authority /Company	Name	Contact Number	Instruction	Form/ Template	Mark Complete (✓)
Notifications to be made for ALL LEVELS of spill – for spills from a vessel the following notifications must be undertaken by a WEL representative).							
Immediately	Vessel master/ Woodside Representative (WSR)	Woodside Communication Centre (WCC)	GTO Duty Manager	[redacted] [redacted] [redacted] [redacted]	Verbally notify WCC of event and estimated volume and hydrocarbon type.	Verbal	
Without delay as per protection of the Sea Act, part II, section 11(1)	Vessel Master	Australian Maritime Safety Authority (AMSA)	Response Coordination Centre (RCC)	[redacted] [redacted] [redacted]	Verbally notify AMSA RCC of the hydrocarbon spill. Follow up with a written Marine Pollution Report (NT EPA/ AMSA POLREP) as soon as practicable following verbal notification.	App B Form 3	
Within 2 hours	GTO Duty Manager	National Offshore Petroleum Safety Environmental Management	Incident notification office	[redacted]	Verbally notify NOPSEMA for spills >80L. Record notification using Initial Verbal Notification Form or equivalent and send to NOPSEMA as soon as possible.	App B Form 1	
Within 3 days	WSR, CICC DM or Delegate				Provide a written NOPSEMA Incident Report Form as soon as practicable (no later than 3 days after notification)	App B Form 2	

Notification timing	Responsibility	Authority /Company	Name	Contact Number	Instruction	Form/ Template	Mark Complete (✓)
		Authority (NOPSEMA[1])			NOPSEMA: submissions@nopsema.gov.au		
As soon as practicable	CICC DM or Delegate	Woodside	Environment Duty Manager	As per roster	Verbally notify Duty Environment of event and seek advice on relevant performance standards from EP	Verbal	
As soon as practicable	CICC DM or Delegate	Department of Agriculture, Water and the Environment (Director of National Parks)	Marine Park Compliance Duty Officer	[redacted]	The Marine Park Compliance Duty Officer is notified in the event of oil pollution within a marine park, or where an oil spill response action must be taken. The notification should include: • titleholder details • time and location of the incident • proposed response arrangements and locations as per the OPEP • contact details for the response coordinator.	Verbal	
As soon as possible if spill affects NT Coastal Waters (within 24 hours of becoming aware of the incident) and/or if there is potential for oiled wildlife in	CICC DM or Delegate	Department of Environment, Parks and Water Security (DEPWS) on behalf of NT Environment Protection Authority (NT EPA)/	Marine Pollution Coordinator	[redacted]	Verbally notify the NT EPA/ DEPWS and AMSA as soon as possible after the incident occurs. Follow up with an online report via the website of written report and send to: [redacted] • [redacted]	online report or App B Form 3	

[1] Notification to NOPSEMA must be from a Woodside Representative.

Notification timing	Responsibility	Authority /Company	Name	Contact Number	Instruction	Form/ Template	Mark Complete (✓)
Commonwealth waters							
Additional Level 2/3 notifications							
As soon as practicable	CICC DM or Delegate	AMOSC	AMOSC Duty Manager	[redacted]	Notify AMOSC that a spill has occurred and follow-up with an email from the **IC/CICC DM and CMT Leader** to formally activate AMOSC. Determine what resources are required consistent with the AMOSPlan and detail in a Service Contract that will be sent to Woodside from AMOSC upon activation.	App B Form 4	
As soon as practicable	CICC DM or Delegate	Oil Spill Response Limited (OSRL)	OSRL Duty Manager	[redacted]	Contact OSRL Duty Manager and request assistance from technical advisor in Perth. Send the notification form to OSRL as soon as practicable. For mobilisation of resources, send the Mobilisation Form to OSRL as soon as practicable.	Notification: App B Form 5a Mobilisation: App B Form 5b	
As soon as practicable	CICC DM or Delegate	Marine Spill Response Corporation (MSRC)	MSRC Response Manager	[redacted]	Activate the contract with MSRC (in full) for the provision of up to 30 personnel depending on what skills are required. Please note that provision of these personnel from MSRC are on a best endeavours basis and are not guaranteed.	Verbal	
FOR OIL ENTERING INTERNATIONAL WATERS, CICC TO CONTACT AUSTRALIAN DEPARTMENT OF FOREIGN AFFAIRS AND TRADE (DFAT): [redacted]							

2. LEVEL 1 RESPONSE

2.1 Mobilisation of response techniques

For the relevant hydrocarbon type, undertake quick revalidation of the recommended techniques and pre-identified tactics indicated with a ‘Yes’ in **Table 2-1.** Undertake all validated pre-identified tactics immediately. These tactics should be carried out using the associated plan identified under **Table 2-1** Operational Plan column.

All response techniques and pre-identified tactics have been identified from the pre-operational Net Environmental Benefits Analysis (NEBA) presented in the Galactic Hybrid Marine Seismic Survey Environment Plan Appendix D (Woodside’s Oil Spill Preparedness and Response Mitigation Assessment for the Galactic Hybrid Marine Seismic Survey) (Link).

Table 2-1: Level 1 Response Summary

Response Techniques	Hydrocarbon Type Marine Diesel Oil	Pre- Identified Tactics	Responsible	ALARP Commitment Summary	Complete ✓	Link to Operational Plans for notification numbers and actions
Monitor and evaluate – tracking buoy (OM02)	Yes	Coordinate deployment of satellite tracking buoy immediately from seismic vessel. If a vessel is on location, consider the need to deploy the oil spill tracking buoy. If no vessel is on location, consider the need to mobilise oil spill tracking buoys from the King Bay Supply Base (KBSB) Stockpile. If a surface sheen is visible from the facility, deploy the satellite tracking buoy within two hours.	Chief Officer/ Marine Crew	**DAY 1:** Tracking buoy deployed within two hours		Surveillance and Reconnaissance to Detect Hydrocarbons and Resources at Risk – OM02 of The Operational Monitoring Operational Plan (Link). Deploy tracking buoy in accordance with Appendix D - Tracking Buoy Deployment Instructions
Please consider instructing the CICC DM to activate or implement any of the following Pre-Identified tactics. The following tactics will assist in answering the '7 Questions of Spill Assessment' identified in Appendix C to increase situational awareness.						
Monitor and evaluate – predictive modelling (OM01)	Yes	Undertake initial modelling using the Rapid assessment oil spill tool and weathering fate analysis using ADIOS (or refer to the hydrocarbon information in Appendix A).	Intelligence or Environment	**Day 1:** Initial modelling to be available within six hours using the Rapid Assessment Tool		Predictive Modelling of Hydrocarbons to Assess Resources at Risk - OM01 of The Operational Monitoring Operational Plan (Link). *Planning to download immediately and follow steps*
	Yes	Send Oil Spill Trajectory Modelling (OSTM) form (Appendix B Form 6) to RPS Response team (email [redacted]	Intelligence			
Monitor and evaluate – aerial surveillance (OM02)	Yes	Instruct Aviation Duty Manager to commence aerial observations in daylight hours. Aerial surveillance observer to complete log in Appendix B Form 7.	Logistics - Aviation	**Day 1:** Two trained aerial observers One aircraft available Report made available to the IMT within two hours of landing after each sortie		Surveillance and Reconnaissance to Detect Hydrocarbons and Resources at Risk - OM02 of The Operational Monitoring Operational Plan (Link). *Planning to download immediately and follow steps*

Response Techniques	Hydrocarbon Type Marine Diesel Oil	Pre- Identified Tactics	Responsible	ALARP Commitment Summary	Complete ✓	Link to Operational Plans for notification numbers and actions
Monitor and evaluate – satellite tracking (OM02)	Yes	The Intelligence duty manager should be instructed to stand up KSAT to provide satellite imagery of the spill. [redacted]	Intelligence	**Day 1:** Service provider will confirm initial acquisition within two hours Data received to be uploaded into Woodside Common Operation Picture daily		
Monitor and evaluate – monitoring hydrocarbon s in water (OM03)	Yes	Consider the need to mobilise resources to undertake water quality monitoring (OM03).	Planning or Environment	**Day 3:** Water quality assessment access and capability Daily fluorometry reports to be provided to IMT.		Detecting and Monitoring for the Presence and Properties of Hydrocarbons in the Marine Environment – OM03 of The Operational Monitoring Operational Plan (Link).
Monitor and evaluate – pre-emptive assessment of receptors at risk (OM04)	Potentially	Consider the need to mobilise resources to undertake pre-emptive assessment of sensitive receptors at risk (OM04).	Planning or Environment	10 days prior to any impact predicted by OM01/02/03, and in agreement with NT authorities (for Level 2/3 incidents), deployment of 2 specialists from resource pool in establishing the status of sensitive receptors.		Pre-emptive Assessment of Receptors at Risk (OM04 of the Operational Monitoring Operational Plan)
Monitor and evaluate – shoreline assessment (OM05)	Potentially	Consider the need to mobilise resources to undertake shoreline assessment surveys (OM05).	Planning or Environment	10 days prior to any impact predicted by OM01/02/03, and in agreement with NT authorities (for Level 2/3 incidents), deployment of 1		Monitoring of Contaminated Resources (OM05 of the Operational Monitoring Operational Plan)

Response Techniques	Hydrocarbon Type Marine Diesel Oil	Pre- Identified Tactics	Responsible	ALARP Commitment Summary	Complete ✓	Link to Operational Plans for notification numbers and actions
				specialist(s) in SCAT from resource pool for each of the Response Protection Areas (RPAs) with predicted impacts		

3. LEVEL 2/3 RESPONSE

3.1 Mobilisation of response techniques

For the relevant hydrocarbon type, undertake quick revalidation of the recommended techniques and pre-identified tactics indicated with a 'Yes' in **Table 3-1**. Undertake all validated pre-identified tactics immediately. These tactics should be carried out using the associated plan identified under **Table 3-1** Operational Plan column.

All response techniques and pre-identified tactics have been identified from the pre-operational Net Environmental Benefits Analysis (NEBA) presented in the Galactic Hybrid Marine Seismic Survey Environment Plan Appendix D (Woodside's Oil Spill Preparedness and Response Mitigation Assessment for the Galactic Hybrid Marine Seismic Survey) (Link).

Table 3-1: Level 2/3 Response Summary

Response Techniques	Hydrocarbon Type Marine Diesel Oil	Pre- Identified Tactics	Responsible	ALARP Commitment Summary	Complete ✓	Link to Operational Plans for notification numbers and actions
Monitor and evaluate – tracking buoy (OM02)	Yes	Coordinate deployment of satellite tracking buoy immediately from seismic vessel. If a vessel is on location, consider the need to deploy the oil spill tracking buoy. If no vessel is on location, consider the need to mobilise oil spill tracking buoys from the King Bay Supply Base (KBSB) Stockpile. If a surface sheen is visible from the facility, deploy the satellite tracking buoy within two hours.	Chief Officer/ Marine Crew	**DAY 1:** Tracking buoy deployed within two hours		Surveillance and Reconnaissance to Detect Hydrocarbons and Resources at Risk - OM02 of The Operational Monitoring Operational Plan (Link). Deploy tracking buoy in accordance with Appendix D - Tracking Buoy Deployment Instructions
Please consider instructing the CICC DM to activate or implement any of the following Pre-Identified tactics. The following tactics will assist in answering the '7 Questions of Spill Assessment' identified in Appendix C to increase situational awareness.						
Monitor and evaluate – predictive modelling (OM01)	Yes	Undertake initial modelling using the Rapid assessment oil spill tool and weathering fate analysis using ADIOS (or refer to the hydrocarbon information in Appendix A).	Intelligence or Environment	**Day 1:** Initial modelling to be available within six hours using the Rapid Assessment Tool		Predictive Modelling of Hydrocarbons to Assess Resources at Risk - OM01 of The Operational Monitoring Operational Plan (Link). *Planning to download immediately and follow steps*
	Yes	Send Oil Spill Trajectory Modelling (OSTM) form (Appendix B Form 6) to RPSResponse team (email [redacted]	Intelligence			
Monitor and evaluate – aerial surveillance (OM02)	Yes	Instruct Aviation Duty Manager to commence aerial observations in daylight hours. Aerial surveillance observer to complete log in Appendix B Form 7.	Logistics - Aviation	**Day 1:** Two trained aerial observers One aircraft available Report made available to the IMT within two hours of landing after each sortie		Surveillance and Reconnaissance to Detect Hydrocarbons and Resources at Risk - OM02 of The Operational Monitoring Operational Plan (Link). *Planning to download immediately and follow steps*

Response Techniques	Hydrocarbon Type Marine Diesel Oil	Pre- Identified Tactics	Responsible	ALARP Commitment Summary	Complete ✓	Link to Operational Plans for notification numbers and actions
Monitor and evaluate – satellite tracking (OM02)	**Yes**	The Intelligence duty manager should be instructed to stand up KSAT to provide satellite imagery of the spill. [redacted]	Intelligence	**Day 1:** Service provider will confirm initial acquisition within two hours Data received to be uploaded into Woodside Common Operation Picture daily		
Monitor and evaluate – monitoring hydrocarbons in water (OM03)	**Yes**	Consider the need to mobilise resources to undertake water quality monitoring (OM03).	Planning or Environment	**Day 3:** Water quality assessment access and capability Daily fluorometry reports to be provided to IMT.		Detecting and Monitoring for the Presence and Properties of Hydrocarbons in the Marine Environment - OM03 of The Operational Monitoring Operational Plan (Link).
Monitor and evaluate – pre-emptive assessment of receptors at risk (OM04)	**Potentially**	Consider the need to mobilise resources to undertake pre-emptive assessment of sensitive receptors at risk (OM04).	Planning or Environment	10 days prior to any impact predicted by OM01/02/03, and in agreement with NT authorities (for Level 2/3 incidents), deployment of 2 specialists from resource pool in establishing the status of sensitive receptors.		Pre-emptive Assessment of Receptors at Risk (OM04 of the Operational Monitoring Operational Plan)
Monitor and evaluate – shoreline assessment (OM05)	**Potentially**	Consider the need to mobilise resources to undertake shoreline assessment surveys (OM05).	Planning or Environment	10 days prior to any impact predicted by OM01/02/03, and in agreement with NT authorities (for Level 2/3 incidents), deployment of 1		Monitoring of Contaminated Resources (OM05 of the Operational Monitoring Operational Plan)

Response Techniques	Hydrocarbon Type Marine Diesel Oil	Pre- Identified Tactics	Responsible	ALARP Commitment Summary	Complete ✓	Link to Operational Plans for notification numbers and actions
				specialist(s) in SCAT from resource pool for each of the Response Protection Areas (RPAs) with predicted impacts		
Surface Dispersant Application	No	This technique is not recommended for a spill of Marine Diesel.	N/A			
Containment and Recovery	No	This technique is not recommended for a spill of Marine Diesel.	N/A			
In-situ Burning	No	This technique is not recommended for a spill of Marine Diesel.	N/A			
Mechanical dispersion	No	This technique is not recommended. Although feasible, highly volatile hydrocarbons are likely to weather, spread and evaporate quickly and lead to unsafe conditions in the vicinity of fresh hydrocarbon. Additionally, vessels used for mechanical dispersion would be contaminated by the hydrocarbon and could cause secondary contamination of unimpacted areas.	N/A			
Shoreline Protection and Deflection	No	Modelling undertaken for this activity does not predict any shoreline impact at feasible response thresholds.	N/A			
Shoreline Clean up	No	Modelling undertaken for this activity does not predict any shoreline impact at feasible response thresholds.	N/A			
Oiled Wildlife Response	Yes	If oiled wildlife is a potential impact, request AMOSC to mobilise containerised oiled wildlife first strike kits and relevant personnel. Refer to relevant Tactical Response Plan for potential wildlife at risk.	Logistics and Planning	**Day 5:** Contracted capability to treat up to an additional		Oiled Wildlife Response Operational Plan (Link).

Response Techniques	**Hydrocarbon Type** **Marine Diesel Oil**	**Pre- Identified Tactics**	**Responsible**	**ALARP Commitment Summary**	**Complete ✓**	**Link to Operational Plans for notification numbers and actions**
		Mobilise AMOSC Oiled Wildlife Containers. Consider whether additional equipment is required from local suppliers.		250 individual fauna within a five-day period. Facilities for oiled wildlife rehabilitation are operational 24/7.		
Scientific Monitoring (Type II)	**Yes**	Notify Woodside science team of spill event.	Environment			Oil Spill Scientific Monitoring Programme – Operational Plan (Link)

4. PRIORITY RECEPTORS

Based on hydrocarbon spill risk modelling results, the sensitive receptors outlined in Table 4-2 have the potential to be contacted by hydrocarbon at impact threshold levels within 48 hours of a spill. There is no shoreline impact associated with either Credible Scenario-01 (CS-01) or Credible Scenario-02 (CS-02).

Please note that impact thresholds (10 g/m^2 surface hydrocarbon concentration, 100 g/m^2 shoreline accumulation, and 500 ppb entrained hydrocarbon concentration) used to determine the 'environment that may be affected' (EMBA) identified in the Environment Plan are lower than the response thresholds (Table 4-1).

Table 4-1: Response Thresholds

Surface Hydrocarbon (g/m^2)	Description
>10	Predicted minimum threshold for commencing operational monitoring[2]
50	Predicted minimum floating oil threshold for containment and recovery and surface dispersant application[3]
100	Predicted optimum floating oil threshold for containment and recovery and surface dispersant application
100	Predicted minimum shoreline accumulation threshold for shoreline assessment operations
250	Predicted minimum threshold for commencing shoreline clean-up operations

Table 4-2: Receptors contacted within 48 hours

Credible scenario (CS)	Receptor	Distance and direction from spill site	Threshold triggered and recommended strategy	Tactical response plans (also available within Data Directory)
CS-01	Commonwealth Waters	W – 0-37 km from spill site	Threshold: floating hydrocarbon at >50 g/m^2 Strategies: Monitor the slick to assess if any shoreline RPAs become at risk of impact. *N.B. No shoreline impact is predicted at response thresholds. Additionally, although this RPA has some surface concentrations at the >50 g/m^2 threshold, dispersant and containment and recovery are not feasible for a spill of marine diesel as detailed in Table 3-1*.	N/A – offshore receptor

[2] Operational monitoring will be undertaken from the outset of a spill whether or not this threshold has been reached. Monitoring is needed throughout the response to assess the nature of the spill, track its location and inform the need for any additional monitoring and/or response techniques. It also informs when the spill has entered Territory Waters and/or control of the incident passes to Territory jurisdictional authorities or AMSA.

[3] At 50g/m^2 containment and recovery and surface dispersant application operations are not expected to be particularly effective. This threshold represents a conservative approach to planning response capability and displaying the spread of surface oil.

CS-02	Commonwealth Waters	W – 0-44 km from spill site	Threshold: floating hydrocarbon at >50 g/m^2 Strategies: Monitor the slick to assess if any shoreline RPAs become at risk of impact. *N.B. No shoreline impact is predicted at response thresholds. Additionally, although these RPAs have some surface concentrations at the >50 g/m^2 threshold, dispersant and containment and recovery are not feasible for a spill of marine diesel as detailed in Table 3-1.*	N/A – offshore receptors
	Oceanic Shoals AMP			
	Lynedoch Bank			

Oil spill trajectory modelling specific to the spill event will be required to determine the regional sensitive receptors to be contacted beyond 48 hours of a spill.

Preliminary hydrocarbon spill modelling results indicate that no additional RPAs will be impacted at response thresholds after 48 hours.

Figure 4-4-1 illustrates the location of regional sensitive receptors in relation to the Galactic Hybrid Marine Seismic Survey operational area and identifies priority protection areas.

Consideration should be given to other stakeholders (including mariners) in the vicinity of the spill location. **Table 4-3** indicates the assets within the vicinity of the Galactic Hybrid Marine Seismic Survey operational area. Please note that this asset is located outside of the modelled environment that may be affected (EMBA) for both credible scenarios.

Table 4-3: Assets in the vicinity of the Galactic Hybrid Marine Seismic Survey operational area.

Asset	Distance and Direction from Galactic Hybrid Marine Seismic Survey Operational Area – Site 1 (CS-01)	Operator
Blacktip well-head platform	SW – 425 km from Site 1 (outside of EMBA)	Eni
Asset	**Distance and Direction from Galactic Hybrid Marine Seismic Survey Operational Area – Site 2 (CS-02)**	**Operator**
Blacktip well-head platform	SW – 498 km from Site 2 (outside of EMBA	Eni

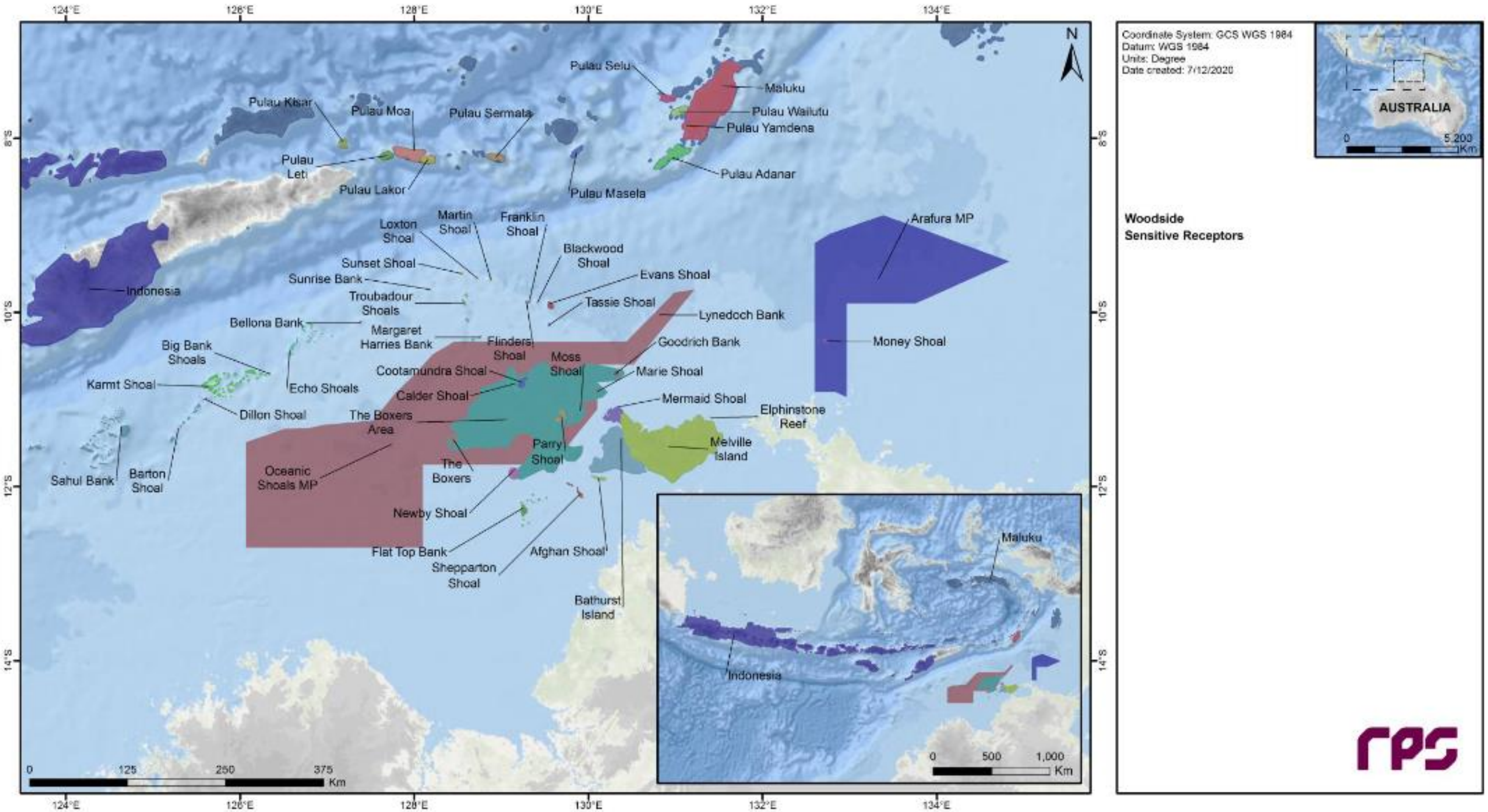


Figure 4-4-1 Regional Sensitive Receptors – Galactic Hybrid Marine Seismic Survey operational area

5. DISPERSANT APPLICATION

Dispersant is not considered an appropriate response strategy for this activity as described in Appendix D of the Galactic Hybrid Marine Seismic Survey Environment Plan (Link).

APPENDIX A – CREDIBLE SPILL SCENARIOS AND HYDROCARBON INFORMATION

For more detailed hydrocarbon information see the Hydrocarbon Data Directory (Link)

Credible Spill Scenarios

Scenario	Product	Maximum Volumes	Suggested ADIOS2 Analogue*
CS-01: Hydrocarbon release at surface caused by vessel collision at Site 1 (*Lat: 10° 45' 57.58'' S, Long: 130° 44' 33.63'' E)*	Marine Diesel	Activity vessel – 650 m³	Diesel Fuel Oil (Southern USA 1) API of 37.2
CS-02: Hydrocarbon release at surface caused by vessel collision at Site 2 (*Lat: 10° 2' 7.83'' S, Long: 130° 49' 28.79'' E)*	Marine Diesel	Activity vessel – 650 m³	Diesel Fuel Oil (Southern USA 1) API of 37.2

Credible scenarios

Two vessel collision scenarios (CS-01 and CS-02) were modelled and are considered to determine the worst-case credible scenario (WCCS) for response planning purposes given that they are instantaneous, surface releases of Marine Diesel. The location of CS-01 was selected as the closest point to the Tiwi Islands within the operational area, and the location of CS-02 was selected as the closest point to Lynedoch Bank. Modelling of both scenarios predicts that the WCCS will not result in shoreline accumulation at response thresholds.

Marine Diesel (Group 1-2 Oil)

Marine diesel is a mixture of volatile and persistent hydrocarbons, with approximately 40-50% by mass predicted to evaporate over the first day or two, depending upon the prevailing conditions, with further evaporation slowing over time (**Figure A-0-1**). The heavier components of diesel have a strong tendency to entrain into the upper water column due to wind-waves, but can re-float to the surface if wind waves abate.

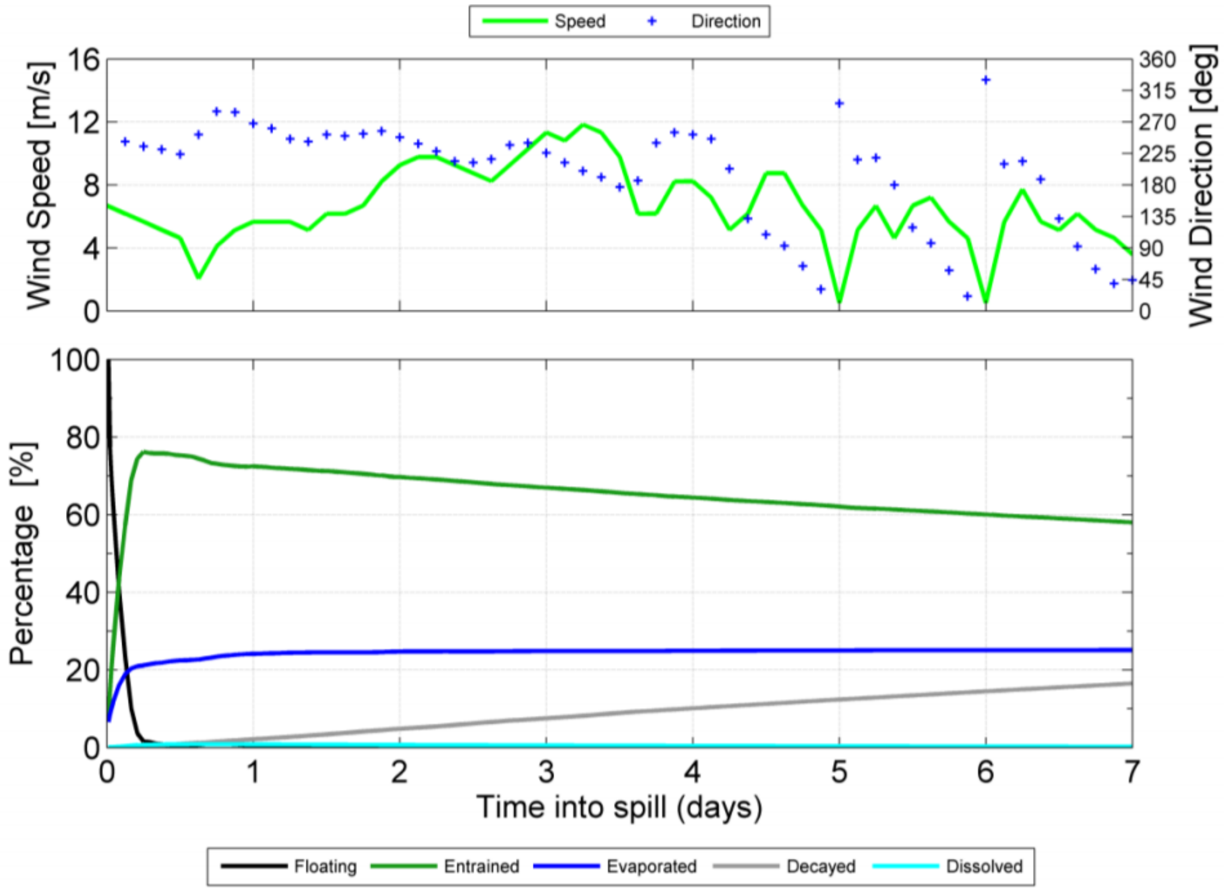


Figure A-0-1 Proportional mass balance plot representing the weathering of marine diesel spilled onto the water surface as a one-off release (50 m^3) and subject to variable wind at 27 °C water temperature and 25 °C air temperature

Source: Data available from the RPS Response oil database (Diesel Fuel Oil (Southern USA 1997)). NOTE: This information is provided as guidance only. Spill event OSTM should be sought.

APPENDIX B – FORMS

Form No.	Form Name	Link
1	Record of Verbal Notification to Regulator Template	Link
2	NOPSEMA Notification Template	Link
3	Marine Pollution Report (POLREP – NT EPA/ AMSA)	Link
4	AMOSC Service Contract Note	Link
5a	OSRL Initial Notification Form	Link
5b	OSRL Mobilisation Activation Form	Link
6	RPS Response Oil Spill Trajectory Modelling Request	Link
7	Aerial Surveillance Observer Log	Link

FORM 1

Record of initial verbal notification to NOPSEMA

(NOPSEMA ph: [redacted])

Date of call	
Time of call	
Call made by	
Call made to	

Information to be provided to NOPSEMA:

Date and Time of incident/time caller became aware of incident	
Details of incident	**1. Location** ______ **2. Title**______ **3. Hydrocarbon source** □ **Platform**______ □ **Pipeline**______ □ **FPSO**______ □ **Exploration drilling**______ □ **Well**______ □ **Other (please specify)**______ **4. Hydrocarbon type**______ **5. Estimated volume of hydrocarbon** ______ **6. Has the discharge ceased?**______ **7. Fire, explosion or collision?** ______ **8. Environment Plan(s)** ______ **9. Other Details**______

Actions taken to avoid or mitigate environmental impacts	
Corrective actions taken or proposed to stop, control or remedy the incident	

After the initial call is made to NOPSEMA, please send this record as soon as practicable to:

NOPSEMA [redacted]

FORM 2

[insert NOPSEMA Notification Template when printing]
Link

FORM 3

[insert Marine Pollution Report (POLREP – NT EPA/ DEPWS and AMSA) when printing]

Link

FORM 4

[insert AMOSC Service Contract note when printing]

Link

FORM 5a

[insert OSRL Initial Notification Form when printing]
Link

FORM 5b

[insert OSRL Mobilisation Activation Form when printing]
Link

FORM 6

[insert RPS Response Oil Spill Trajectory Modelling Request form when printing]

Link

FORM 7

[insert Aerial Surveillance Observer Log when printing]

Link

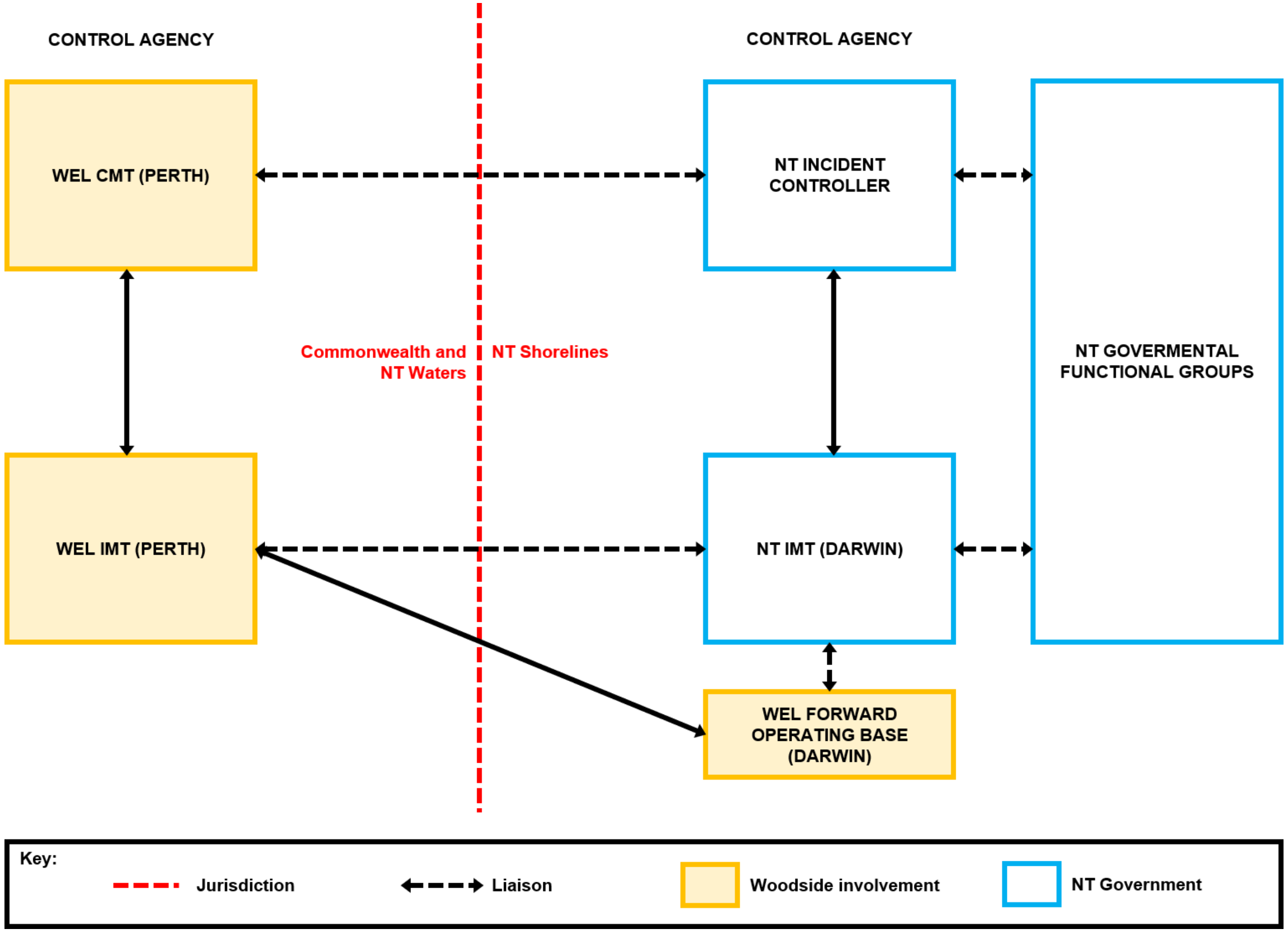
APPENDIX C – 7 QUESTIONS OF SPILL ASSESSMENT

WHAT IS IT? **Oil Type/name** **Oil properties** **Specific gravity / viscosity / pour point / asphaltenes / wax content / boiling point**	
WHERE IS IT? Lat/Long Distance and bearing	
HOW BIG IS IT? Area Volume	
WHERE IT IS GOING? Weather conditions Currents and tides	
WHAT IS IN THE WAY? Resources at risk	
WHEN WILL IT GET THERE? Weather conditions Currents and tides	
WHAT'S HAPPENING TO IT? Weathering processes	

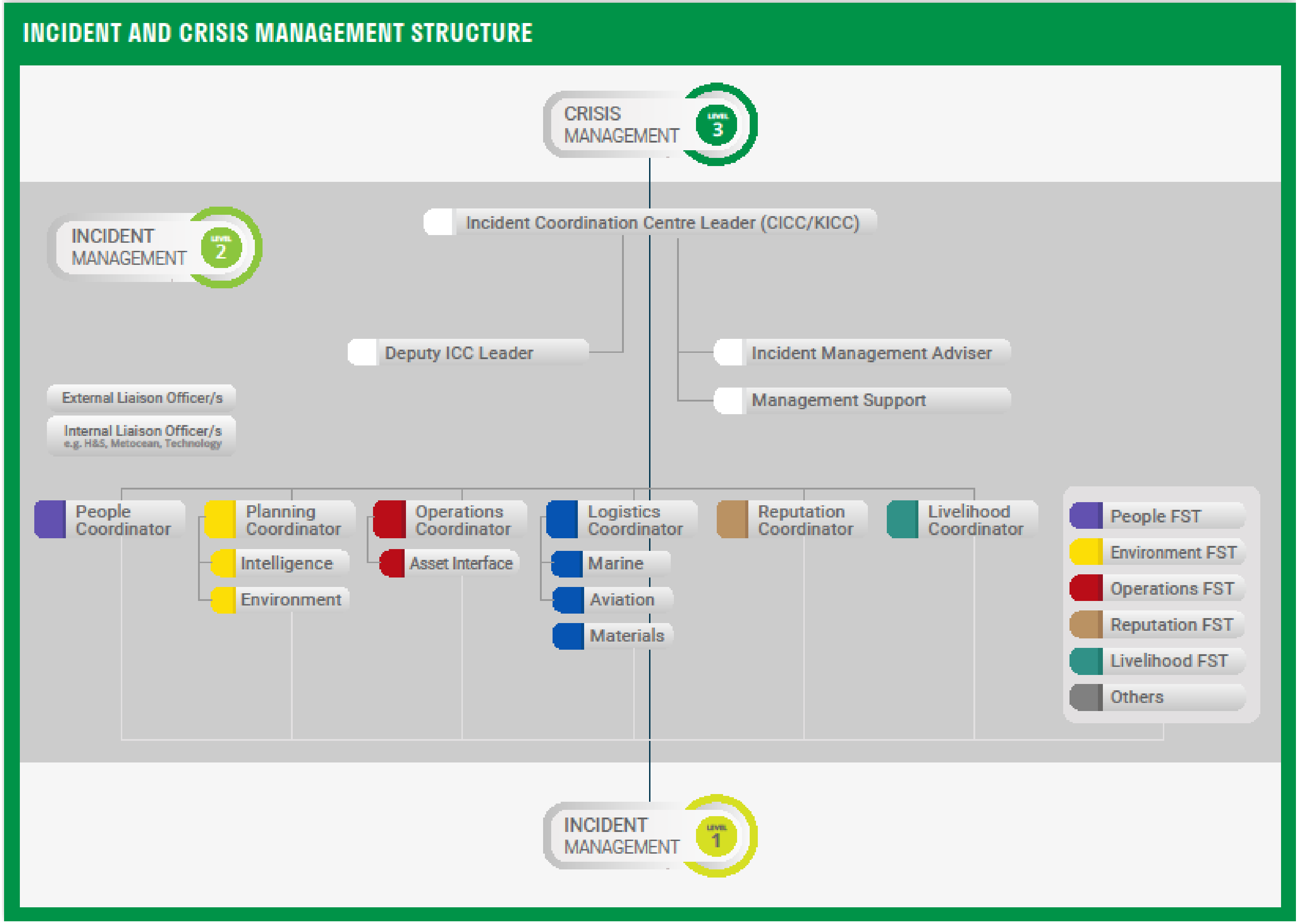
APPENDIX D – TRACKING BUOY DEPLOYMENT INSTRUCTIONS

(Insert Link when printing)

APPENDIX E – COORDINATION OF RESPONSE ENTERING NORTHERN TERRITORY COASTAL WATERS



APPENDIX F – WOODSIDE INCIDENT MANAGEMENT STRUCTURE FOR HYDROCARBON SPILLS



APPENDIX J JASCO ACOUSTIC MODELLING REPORT

Woodside Galactic Hybrid 2D/3D Marine Seismic Survey

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

Submitted to:

Jeremy Colman
Woodside Energy Ltd.
Contract: 4510648522

Authors:

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13 November 2020

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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 (JASCO) performed a numerical estimation study of underwater sound levels associated with the planned Galactic Hybrid 2D/3D Marine Seismic Survey (MSS) to assist in understanding the potential acoustic impact on receptors including marine mammals, fish, sea turtles, and invertebrates. Modelling considered the following seismic source arrays, towed at 6 m depth behind a single vessel, and survey line configurations:

- A 2D survey line plan using a single 3150 in^3 seismic source (25 m pulse spacing),
- A 3D survey line plan using a triple 2495 in^3 seismic source (125 m source separation, 12.5 m pulse spacing),
- A 3D survey line plan using a penta 1510 in^3 seismic source (50 m source separation, 7.5 m pulse spacing), and
- A 3D survey line plan using a hexa 1510 in^3 seismic source (50 m source separation, 6.25 m pulse spacing).

A specialised airgun array source model was used to predict the acoustic signature of the seismic sources, and complementary underwater acoustic propagation models were used in conjunction with the modelled array signatures to estimate sound levels over a large area around the source. Single-impulse sound fields were predicted at eight sites within the survey area. The water depths at the modelled sites ranged between 52.9 and 304 m. Accumulated sound exposure fields were predicted for representative survey lines for the four survey line and seismic source combinations for likely operations within the survey area 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; $L_{pk\text{-}pk}$), particle acceleration (peak magnitude), 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. The impact criteria for impairment of marine mammals, fish and sea turtles use dual metrics (PK and SEL_{24h}), and the longest distance associated with either metric is required to be applied, and thus is presented in this summary.

The sound footprints are highly directional, and while the maximum distances to criteria are presented in the summary, this distance may not be relevant to receptors or areas of interest in a specific direction. For example, the stated ranges contain no context of the shape or size of the ensonified area which may be affected by source directivity and local bathymetric features.

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. Where the corresponding SEL_{24h} radii for are larger than those for peak pressure criteria, they often represent an unlikely worst-case scenario. More realistically, marine mammals, fish and sea turtles would not stay in the same location for 24 hours, but rather a shorter period, depending upon their behaviour and the proximity and movements of the source. Therefore, a reported radius for SEL_{24h} criteria does not mean that marine fauna travelling within this radius of the source will be impaired, but rather that an animal could be exposed to the sound level associated with impairment (either PTS or TTS) if it remained in that location for 24 hours.

Marine mammals

Table 1. Maximum (R_{max}) horizontal distances (in km) from modelled sites or scenario lines to thresholds for marine mammals and the metric associated with the stated distance.

Relevant hearing group	Effect Threshold	2D Survey/Well-tie		3D Survey					
		Single 3150 in^3 source		Triple 2495 in^3 source		Penta 1510 in^3 source		Hexa 1510 in^3 source	
		Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)
Low-frequency cetaceans[1]	PTS	SEL_{24h}	0.40	SEL_{24h}	2.08	SEL_{24h}	2.60	SEL_{24h}	3.11
	TTS	SEL_{24h}	17.2	SEL_{24h}	25.5	SEL_{24h}	24.7	SEL_{24h}	26.6
Mid-frequency cetaceans[1]	PTS	SEL_{24h}	<0.02	SEL_{24h}	0.14	SEL_{24h}	0.12	SEL_{24h}	0.14
	TTS	SEL_{24h}	<0.02	SEL_{24h}	0.14	SEL_{24h}	0.12	SEL_{24h}	0.14
High-frequency cetaceans[1]	PTS	PK	0.29	PK	0.38	PK	0.39	PK	0.39
	TTS	PK	0.66	PK	0.73	PK	0.80	PK	0.80
Sirenians[1]	PTS	–	–	–	–	–	–	–	–
	TTS	PK	0.03	SEL_{24h}	0.14	SEL_{24h}	0.12	SEL_{24h}	0.14
All Marine mammals, behavioural response[2]		SPL	9.00	SPL	7.99	SPL	7.09	SPL	7.09

A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).
[1] Noise exposure criteria: NMFS (2018)
[2] Noise exposure criteria: NOAA (2019)

Sea turtles

Table 2. Maximum (R_{max}) horizontal distances (in km) from modelled sites or scenarios to thresholds for sea turtles and the metric associated with the stated distance.

Hearing group	Effect Threshold	2D Survey/Well-tie		3D Survey					
		Single 3150 in^3 source		Triple 2495 in^3 source		Penta 1510 in^3 source		Hexa 1510 in^3 source	
		Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)
Turtles	Behavioural response[1]	SPL	4.04	SPL	4.55	SPL	3.76	SPL	3.76
	Behavioural disturbance[2]	SPL	1.84	SPL	1.41	SPL	1.30	SPL	1.30
	PTS[3]	SEL_{24h}	<0.02	SEL_{24h}	0.14	SEL_{24h}	0.13	SEL_{24h}	0.16
	TTS[3]	SEL_{24h}	0.16	SEL_{24h}	0.74	SEL_{24h}	1.42	SEL_{24h}	1.69

[1] Noise exposure criteria: NSF (2011)
[2] Noise exposure criteria: McCauley et al. (2000a)
[3] Noise exposure criteria: Finneran et al. (2017)

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 as well as impairment in the following groups:
    - Fish without a swim bladder (also appropriate for sharks in the absence of other information)
    - Fish with a swim bladder that do not use it for hearing
    - Fish that use their swim bladders for hearing

- Fish eggs and fish larvae

Table 3. Summary of maximum fish, fish eggs, and larvae distances to various criteria for single impulse and SEL_{24h} modelled scenarios for the entire water column and receivers at the seafloor only.

Relevant hearing group	Effect Threshold	Entire water column							
		2D Survey/Well-tie		3D Survey					
		Single 3150 in³ source		Triple 2495 in³ source		Penta 1510 in³ source		Hexa 1510 in³ source	
		Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)
Fish: No swim bladder	Injury	PK	0.07	SEL_{24h}	0.14	SEL_{24h}	0.12	SEL_{24h}	0.14
	TTS	SEL_{24h}	0.90	SEL_{24h}	3.75	SEL_{24h}	4.28	SEL_{24h}	4.29
Fish: Swim bladder not involved in hearing and Swim bladder involved in hearing	Injury	PK	0.18	SEL_{24h}	0.16	PK	0.13	SEL_{24h}	0.16
	TTS	SEL_{24h}	0.90	SEL_{24h}	3.75	SEL_{24h}	4.28	SEL_{24h}	4.29
Fish eggs, and larvae	Injury	PK	0.18	PK	0.14	PK	0.13	SEL_{24h}	0.14

Relevant hearing group	Effect Threshold	Seafloor*							
		2D Survey/Well-tie		3D Survey					
		Single 3150 in³ source		Triple 2495 in³ source		Penta 1510 in³ source		Hexa 1510 in³ source	
		Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)
Fish: No swim bladder	Injury	PK	0.10	PK	0.09	PK	0.10	PK	0.10
	TTS	SEL_{24h}	0.85	SEL_{24h}	3.36	SEL_{24h}	4.23	SEL_{24h}	4.28
Fish: Swim bladder not involved in hearing and Swim bladder involved in hearing	Injury	PK	0.21	PK	0.22	PK	0.21	PK	0.21
	TTS	SEL_{24h}	0.85	SEL_{24h}	3.36	SEL_{24h}	4.23	SEL_{24h}	4.28
Fish eggs, and larvae	Injury	PK	0.21	PK	0.22	PK	0.21	PK	0.21

* Seafloor PK values were estimated for receivers at a range of water depths rather than the specific single impulse modelled sites, hence reported ranges may differ to those reported over the entire water column.

Invertebrates, Sponges, Coral, and Plankton

To assist with assessing the potential effects on these receptors, the following were determined:

- Bivalves: The distance where a particle acceleration of 37.57 ms^{-2} at the seafloor could occur was determined for comparing to results presented in Day et al. (2016a). The maximum distance to this particle acceleration level was 15 m.
- Crustaceans: The sound level of 202 dB re 1 µPa PK-PK from Payne et al. (2008) was considered for seafloor sound levels; the maximum ranges across all considered water depths were 0.523, 0.631, and 0.690 km for the 3150, 2495, and 1510 in^3 arrays respectively.

- Sponges and coral: the PK sound level at the seafloor directly underneath the seismic source was estimated at all modelled sites and compared to the sound level of 226 dB re 1 µPa PK for sponges and corals (Heyward et al. 2018); it was not reached at any of the modelled water depths for any of the modelled seismic sources.
- Plankton: The maximum distance to potential injury in plankton, applying the threshold from Popper et al. (2014), is 0.18, 0.14 and 0.13 km for the 3150, 2495, and 1510 in^3 arrays respectively within the water column.

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1. Introduction

JASCO Applied Sciences (JASCO) performed a numerical estimation study of underwater sound levels associated with the planned Galactic Hybrid 2D/3D Marine Seismic Survey (MSS) to assist in understanding the potential acoustic impact on receptors including marine mammals, fish, sea turtles, benthic invertebrates plankton, sponges and corals.

JASCO's specialised Airgun Array Source Model (AASM) was used to predict acoustic signatures and spectra for three airgun arrays with volumes between 1510 and 3150 in^3. AASM accounts for individual airgun volumes, airgun bubble interactions, and array geometry to yield accurate source predictions.

Complementary underwater acoustic propagation models were used in conjunction with the selected array signature to estimate sound levels considering environmental effects. Single-impulse sound fields were predicted at eight defined locations within the potential survey areas, and an accumulated sound exposure field was predicted for four representative scenarios for survey operations over 24 h (Section 2). A conservative sound speed profile that would be most supportive of sound propagation conditions for the potential survey period was defined and applied throughout.

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; $L_{pk\text{-}pk}$), particle acceleration (peak magnitude), and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria.

Section 3 explains the metrics used to represent underwater acoustic fields and the impact criteria considered. Section 4 details the methodology for predicting the source levels and modelling the sound propagation, including the specifications of the seismic source and all environmental parameters the propagation models require. Section 5 presents the results, which are then discussed and summarised in Section 6.

2. Modelling Scenarios

The modelling scenarios were determined based on four proposed survey line plans and seismic source combinations:

- A 2D survey line plan using a single 3150 in^3 seismic source,
- A 3D survey line plan using a triple 2495 in^3 seismic source,
- A 3D survey line plan using a penta 1510 in^3 seismic source, and
- A 3D survey line plan using a hexa 1510 in^3 seismic source.

Eight standalone single impulse sites and four scenarios for survey operations over 24 hours to assess accumulated SEL were therefore modelled. The modelled sites are listed in Table 4, and more details on the accumulated SEL scenarios are presented in Table 5. The modelled sites and acquisition lines are shown in Figure 1 along with the survey boundaries and other areas of interest.

The accumulated SEL lines were selected to cover a range of water depths along lines that would be acquired consecutively within 24 hours for each survey line plan. No acquisition order or turn distance information was provided for the 2D survey line plan, hence it was assumed that adjacent parallel lines were acquired consecutively and that turn distances were similar to the 3D survey line plan. The single impulse sites were then selected to encompass the shallowest point along the well-tie lines, and to provide as broad spatial coverage and range of water depths as possible along or adjacent to the selected lines. The selected locations are considered representative of the range of water depths that will be covered during the Galactic Hybrid 2D/3D surveys and the potential sound propagation characteristics that may arise during survey acquisition. The modelling assumed that a survey vessel sailed along survey lines at a maximum of 5 knots, and that the seismic source was in operation during lines and run-outs but not turns or run-ins.

The 2D scenario with a single 3150 in^3 source consisted of two full lines (Table 5) for a total of 6792 seismic impulses. The 3D scenarios with a triple 2495 in^3 source, penta 1510 in^3 source, and hexa 1510 in^3 source each consisted of three full lines (Table 5), for a total of 12 916, 21 320, and 25 580 seismic impulses respectively.

Additionally, for each accumulated SEL scenario, groups of static receivers were considered for a modelled time history of sound exposure accumulation and for discussing the influence of accumulated sound levels on fish. Static receivers were spaced along transects perpendicular to the survey lines at:

- 50 m increments between distances of 50 to 1000 m,
- 100 m increments between 1000 m to 5 km,
- 500 m increments between 5 and 10 km, and
- 1000 m increments between 10 and 30 km.

The static receiver locations for the 2D and 3D survey line plans are shown in Figures 2 and 3 respectively.

Table 4. Location details for the single impulse modelled sites and associated SEL_{24h} scenarios.

Relevant Scenario	Site	Latitude	Longitude	MGA Zone 52, GDA1994		Water depth (m)
				X (m)	Y (m)	
Well-Tie	1A	10° 35' 24.6584" S	129° 56' 27.9684" E	602953.4	8829178	52.9
2D	2A	10° 22' 22.8817" S	130° 20' 07.5529" E	649376.6	8867653	119.1
	2B	10° 07' 13.5257" S	130° 20' 31.6689" E	663163.8	8905147	207.3
	2C	9° 32' 22.1290" S	130° 43' 43.3380" E	689746.4	8945029	304.2
3D	3A	10° 09' 43.5130" S	130° 38' 57.8439" E	680700.2	8876208	89.7
	3B	10° 14' 10.0023" S	130° 26' 50.1539" E	661758.4	8871284	117.4
	3C	9° 53' 19.0697" S	130° 47' 22.4202" E	692381.0	8902343	174.0
	3D*	9° 59' 41.9320" S	130° 47' 06.8702" E	695687.4	8894613	125.7

*Used for MONM-BELLHOP Modelling only, see Section 4.3

Table 5. Accumulated SEL scenario details. Note that line lengths include run-outs and only two lines were considered for the 2D survey design.

Scenario	Source	Line 1		Line 2		Line 3		Source separation (m)	Source Width (m)	In-line pulse spacing (m)
		Length (km)	Bearing (°)	Length (km)	Bearing (°)	Length (km)	Bearing (°)			
2D	Single (3150 in^3)	78.3	33.8	91.5	213.8	–	–	N/A	N/A	25
3D	Triple (2495 in^3)	53.8	224.6	53.7	44.6	53.9	224.6	125	250	12.5
	Penta (1510 in^3)	53.3	224.6	53.2	44.6	53.3	224.6	50	200	7.5
	Hexa (1510 in^3)	53.3	224.6	53.2	44.6	53.3	224.6	50	250	6.25

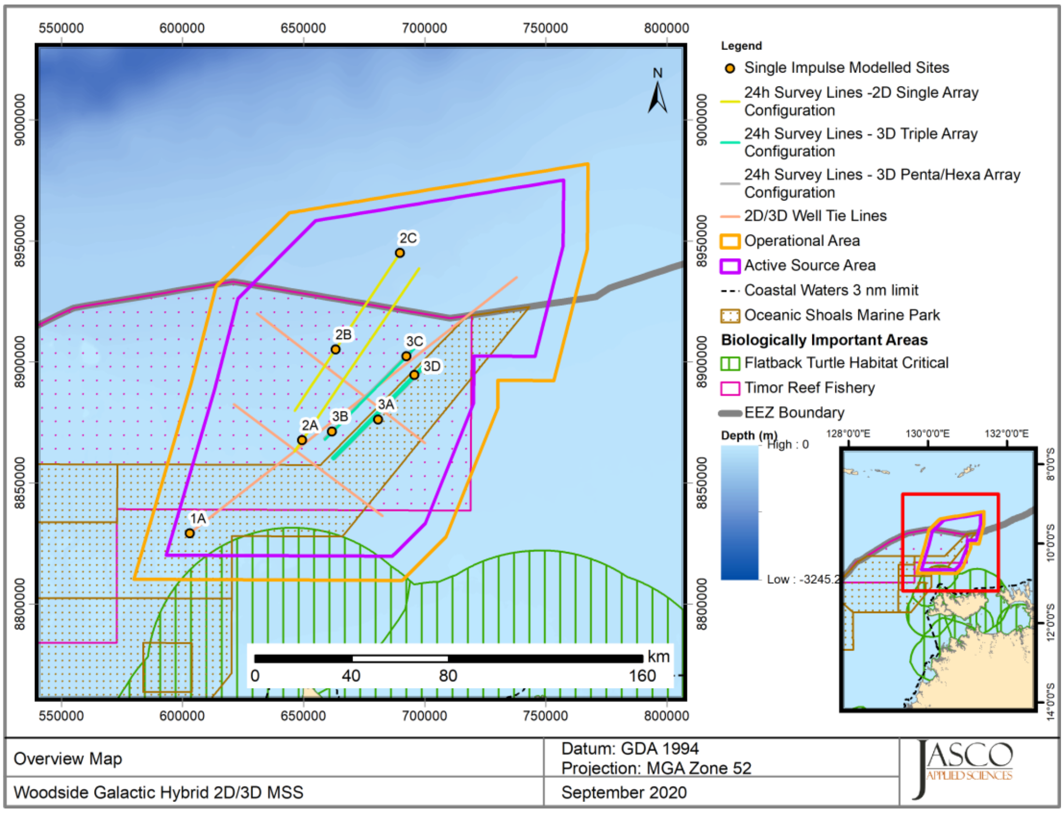

Figure 1. Overview of the modelled sites, acquisition lines, and features for the Galactic Hybrid 2D/3D MSS.

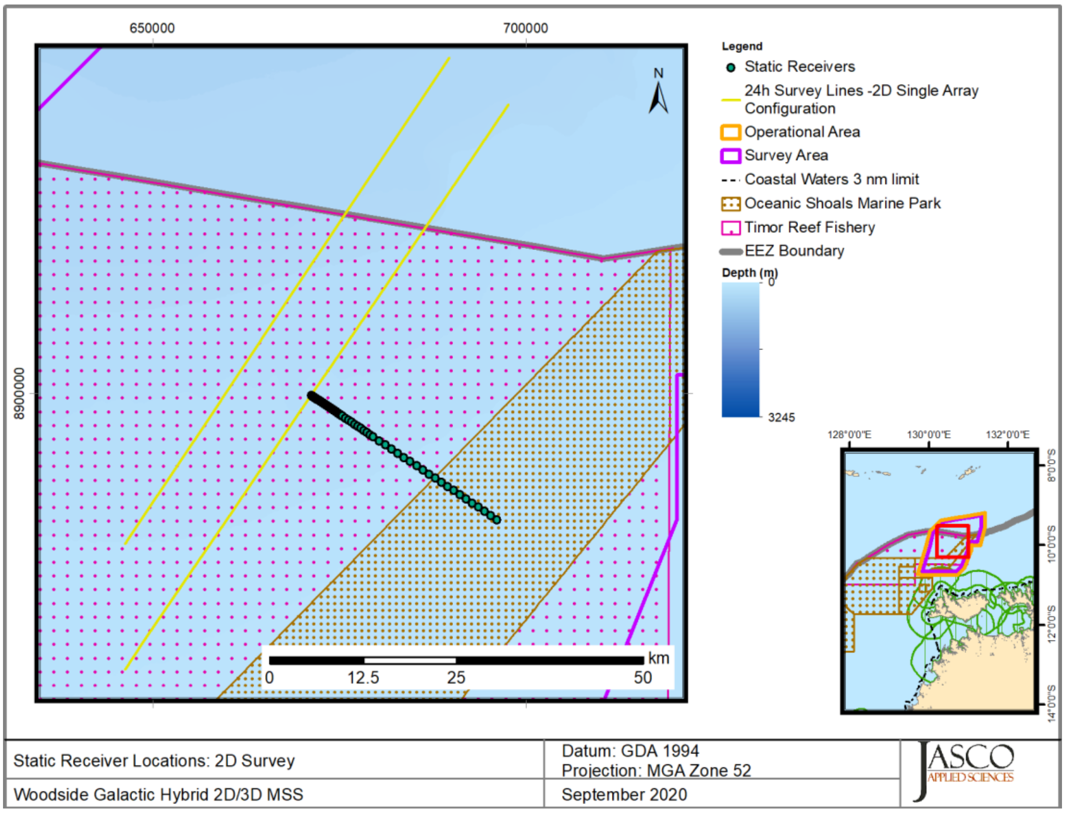

Figure 2. 2D survey line plan: selected acquisition lines and static receiver locations.

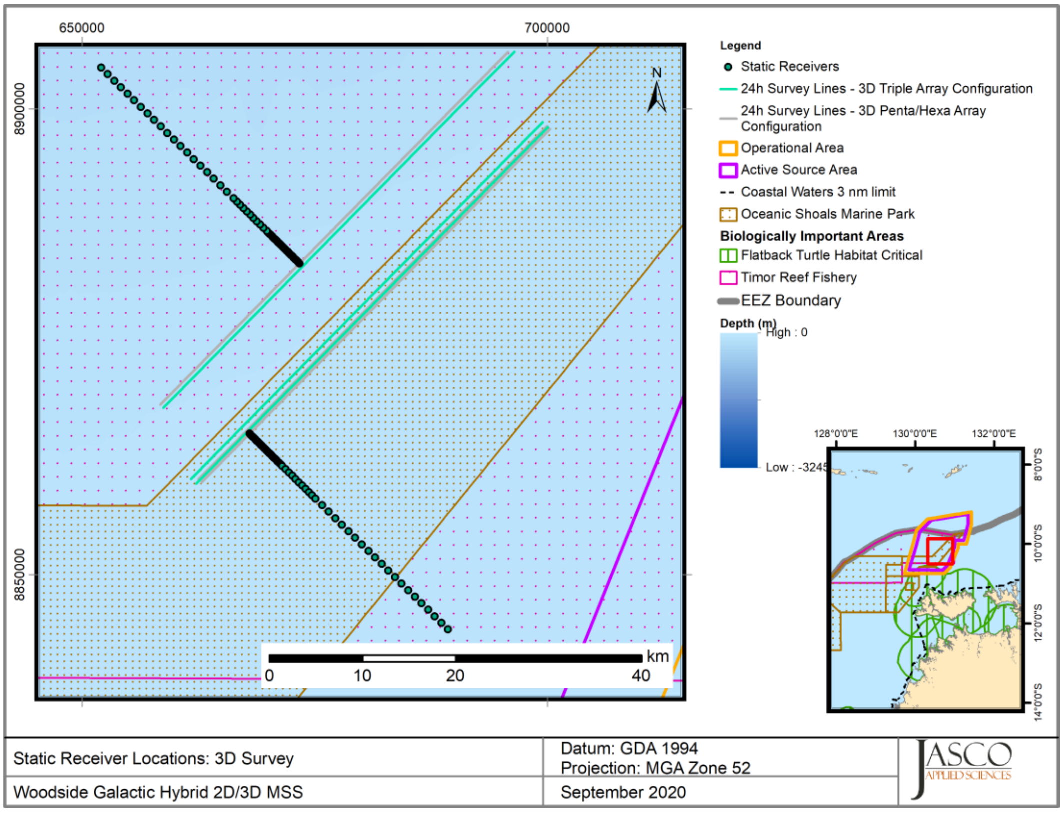

Figure 3. 3D survey line plans: selected acquisition lines and static receiver locations.

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, impair or disturb marine fauna is an active research topic. Since 2007, several expert groups have developed SEL-based assessment approaches for evaluating auditory injury and impairment, with key works including Southall et al. (2007), Finneran and Jenkins (2012), Popper et al. (2014), United States National Marine Fisheries Service (NMFS 2018) and Southall et al. (2019). The number of studies that have investigated the level of behavioural disturbance to marine fauna by anthropogenic sound has also increased substantially.

The following thresholds, guidelines and sound levels for this study were chosen because they represent the best available science, and sound levels presented in literature for fauna with no defined thresholds:

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) and temporary threshold shift (TTS) in marine mammals.
2. Marine mammal behavioural threshold based on the current NOAA (2019) criterion for marine mammals of 160 dB re 1 µPa (SPL; L_p) for impulsive sound sources.
3. Sound exposure guidelines for fish, fish eggs and larvae (including plankton) (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 PTS and TTS in turtles.
5. Sea 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; L_p) (McCauley et al. 2000b, 2000a).
6. Peak-peak pressure levels (PK-PK; $L_{pk\text{-}pk}$) at the seafloor to help assess effects of noise on crustaceans through comparing to results in Day et al. (2016a), Day et al. (2019), Day et al. (2016b), Day et al. (2017) and Payne et al. (2008).
7. For comparison to published literature, a no effect sound level for sponges and corals of 226 dB re 1 µPa (PK; L_{pk}) is reported for comparing to Heyward et al. (2018).

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 (SEL; L_E) is reported.

The following sections (Sections 3.1–3.4, along with Appendix A.4 and A.6), expand on the thresholds, guidelines and sound levels for marine mammals, fish, fish eggs, fish larvae, sea turtles, benthic invertebrates.

3.1. Marine Mammals

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 help assess the potential for the possible injury and hearing sensitivity changes in marine mammals, this report applies the criteria recommended by NMFS (2018), considering both PTS and

TTS. These criteria, along with the applied behavioural criteria (NOAA 2019), are summarised in Table 6, with descriptions included in Appendix A.4.1 (auditory impairment) and Appendix A.4.2 (behavioural response), with frequency weighting explained in Appendix A.5.

Table 6. Unweighted SPL, SEL_{24h}, and PK thresholds for acoustic effects on marine mammals.

Hearing group	NOAA (2019)	NMFS (2018)			
	Behaviour	PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	**PK** (L_{pk}; dB re 1 µPa)
Low-frequency cetaceans	160	183	219	168	213
Mid-frequency cetaceans		185	230	170	224
High-frequency cetaceans		155	202	140	196
Sirenians (Dugong)		190	226	175	220

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS and TTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.
L_p–denotes sound pressure level period and has a reference value of 1 µPa.
L_{pk}, flat–peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa.
L_E - denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa²s.
Subscripts indicate the designated marine mammal auditory weighting.

3.2. Fish, 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. However, as these depend upon activity-based subjective ranges, these effects are not addressed in this report and are included in Table 7 for completeness only. 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 7 lists relevant effects thresholds from Popper et al. (2014).

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 applying a standard period, where this is either defined as a justified fixed period or the duration of the activity; however, Popper et al. (2014) also included 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). Additional information is provided in Appended A.6.

Following this, the analysis in this report has considered time periods of 1–4 and 24 h for the accumulation of SEL, to examine the time over which the maximum exposure occurs at difference ranges, and the point from which recovery might start to occur. This is to help contextualise the potential effects on both site-attached and pelagic fish species.

Table 7. 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 (relevant to plankton)	>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).

3.3. Sea 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. Popper et al. (2014) suggested thresholds for onset of mortal injury (including PTS) and mortality for sea turtles and, in absence of taxon-specific information, adopted the levels for fish that do not hear well (suggesting that this likely would be conservative for sea turtles).

Finneran et al. (2017) presented revised thresholds for sea turtle injury and hearing impairment (TTS and PTS). Their rationale is that sea turtles have best sensitivity at low frequencies and are known to have poor auditory sensitivity (Bartol and Ketten 2006, Dow Piniak et al. 2012). Accordingly, TTS and PTS thresholds for turtles are likely more similar to those of fishes than to marine mammals (Popper et al. 2014).

McCauley et al. (2000b) observed the behavioural response of caged sea turtles—green (*Chelonia mydas*) and loggerhead (*Caretta caretta*)—to an approaching seismic airgun. For received levels above 166 dB re 1 µPa (SPL), the sea 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 Environmental Impact Statement (PEIS) (NSF 2011). In addition, the 175 dB re 1 µPa level from McCauley et al. (2000b) is recommended as a criterion for behavioural disturbance. The Recovery Plan for Marine Turtles in Australia (Department of the Environment and Energy et al. 2017) acknowledges the 166 dB re 1 µPa SPL reported by McCauley et al. (2000b) as the level that may result in a behavioural response to marine turtles. These thresholds are shown in Table 8.

Table 8. Acoustic effects of impulsive noise on sea turtles: Unweighted SPL, weighted SEL_{24h}, and PK thresholds

Effect type	Criterion	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)
Behavioural response	NSF (2011)	166	NA	
Behavioural disturbance	McCauley et al. (2000a) and (2000b)	175		
PTS onset thresholds* (received level)	Finneran et al. (2017)	NA	204	232
TTS onset thresholds* (received level)			189	226

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS and TTS 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.
$L_{pk,flat}$ denotes 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 h period and has a reference value of 1 µPa²s.

3.4. Invertebrates

3.4.1. Benthic Invertebrates (Crustaceans and Bivalves)

Research is ongoing into the relationship between sound and its effects on crustaceans, including the relevant metrics for both effect and impact. Available literature suggests particle motion, rather than sound pressure, is a more important factor for crustacean and bivalve hearing. Water depth and seismic source size are related to the particle motion levels at the seafloor, with larger arrays and shallower water being related to higher particle motion levels, more likely relevant to effects on crustaceans and bivalves.

At the seafloor interface, crustaceans and bivalves are subject to particle motion stimuli from several acoustic or acoustically-induced waves. These include the particle motion associated with an impinging sound pressure wave in the water column (the incident, reflected, and transmitted portions), substrate acoustic waves, and interface waves of the Scholte type. However, it is unclear which aspect(s) of these waves is/are most relevant to the animals, either when they normally sense the environment or their physiological responses to loud sounds so there is not enough information to establish similar criteria and thresholds as done for marine mammals and fish. Including recent research, such as Day et al. (2016b), 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 related to different levels of potential impairment, the PK-PK sound levels determined for crustaceans in Day et al. (2016b), 209–212 dB re 1 µPa and 213 dB re 1 µPa from Day et al. (2019), are also included.

For bivalves, PK-PK sound levels of 212 and 213 are presented to allow comparison to the maximum sound levels measured in Day et al. (2016a) and Day et al. (2017) for scallops and pearl shell oyster. For bivalves, literature does not present a sound level associated with no impact, and as particle motion is the more relevant metric, particle acceleration from the seismic source has been presented for comparing the results in Table 7 of Day et al. (2016b); therefore the maximum particle acceleration assessed for bivalves was 37.57 ms^{-2}.

3.4.2. Plankton

To assess impacts to plankton, there are only a few studies to base threshold criteria on. Popper et al. (2014) cites many of the references and studies on potential impacts of noise emissions on fish eggs and larvae prior to 2014. Results presented in Day et al. (2016b) for embryonic lobsters and Fields et al. (2019) for copepods align with those presented in Popper et al. (2014), which is that mortality and sub-lethal injury are limited to within tens of metres of seismic sources. Additionally, the Popper et al. (2014) criteria (Table 7), are extrapolated from simulated pile driving signals which have a more rapid rise time and greater potential for trauma than pulses from a seismic source.

Other research, such as McCauley et al. (2017), has indicated the potential for effects at longer range, however Fields et al. (2019) noted that it was difficult to reconcile the high mortality reported by McCauley et al. (2017) with the low mortalities reported in the greater previous body of earlier research and their experiment. They recommended further research into whether it is the sound pulse itself (i.e. the energy, peak pressures, or particle acceleration), the (turbulent) fluid flow occurring more slowly (i.e. not related to the sound pulse), or other effects such as the bubble cloud that which might cause higher mortality near the seismic source.

4. Methods

4.1. Parameters Overview

Sound propagation was modelled up to 100 km from each single impulse modelled site (listed in Table 4). The specifications of the seismic source and the environmental parameters used in the propagation models are described in detail in Appendices C.4 and C.5. A single sound speed profile for May was considered in this modelling study; this was identified as the period that would provide the farthest propagation over the potential operational window (May to September; see Appendix C.4.2).

The acoustic properties of the seabed in the survey acquisition area vary depending on the area on the continental shelf, however detailed information for the region was scarce. Therefore, a single geoacoustic profile was developed for the region and used for all modelled sites (see Appendix C.4.3). Based on the available information, the seabed profile was assumed to be a thick layer of fine carbonate sand.

4.2. Acoustic Source Model

The pressure signature of the individual airguns and the composite decidecade-band point-source equivalent directional levels (i.e., source levels) of the seismic sources 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.

All seismic sources considered were modelled over AASM's full frequency range, up to 25 kHz. Appendix B.1 details this model.

4.3. 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, 10 Hz to 1000 Hz).
- Wavenumber integration model (VSTACK, 5 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 B.2 details each model. MONM-BELLHOP was used to calculate SEL in a 360° area around each source location. The model calculated propagation losses up to distances of 100 km from the source in each cardinal direction, with a horizontal separation of 10 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 1 m to a maximum of 3000 m, with step sizes that increased with depth. To supplement the MONM results, high-frequency results for propagation loss were modelled using Bellhop for frequencies from 1 to 25 kHz. The MONM and Bellhop results were combined to produce results for the full frequency-range of interest.

FWRAM was used to model synthetic seismic pulses and to generate a generalised range-dependent SEL to SPL conversion function for the considered modelled sites (Appendix C.2). FWRAM was run to 80 km at all single impulse modelling sites excluding Site 3D (see Table 4), along four radials (fore and aft endfire, and port and starboard broadside) for computational efficiency. Sites 3A-3C were modelled for both the 2495 in^3 array (to represent the triple array) and the 1510 in^3 array (to represent the penta/hexa arrays). Along each radial, the computation was done with a regular depth step of 1 m over the entire water column, and a horizontal range step of 10 m. 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 levels.

VSTACK was used to calculate close range PK, PK-PK, and particle acceleration magnitude along transects at the seafloor from the loudest direction of the seismic source. Levels were calculated at water depths corresponding to the shallowest depth on the well-tie lines (Site 1A, 52.9 m) and then in 10 m depth increments from 60 m to 110 m. Particle motion levels were calculated for Site 1A only. The maximum modelled range for VSTACK was 1000 m and a variable receiver range increment that increased away from the source was used, which increased from 10 to 25 m. Received PK and PK-PK levels and particle acceleration were computed for a receiver 50 cm above the seafloor for the assessment of receptors at or just above the seabed.

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, turtle and fish SEL criteria used in this report (Sections 3.1 to 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. Appendix C.3 provides additional details on the methods used to calculate the accumulated sound energy for the considered scenarios.

5. Results

5.1. Acoustic Source Levels and Directivity

AASM (Section 4.2) was used to predict the horizontal and vertical overpressure signatures, and corresponding power spectrum levels for the seismic sources, with detailed results provided in Appendix C.5 along with horizontal directivity plots.

Tables 9 to 11 present 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.

Figures C-17 to C-19 show the broadside, endfire, and vertical overpressure signatures and corresponding power spectrum levels for each source. In all cases the signatures consist 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 lower frequencies, typically those below approximately 600 Hz. Frequency-dependent peaks and nulls in the spectra result from interference among airguns in the array and correspond with the volumes and relative locations of the airguns.

Table 9. Far-field source level specifications for the 3150 in^3 seismic source, for a 6 m tow depth. Source levels are for a point-like acoustic source with equivalent far-field acoustic output in the specified direction. Sound level metrics are per-pulse and unweighted.

Direction	Peak source pressure level ($L_{S,pk}$) (dB re 1 µPa m)	Per-pulse source SEL ($L_{S,E}$) (dB 1 µPa^{2}m^{2}s)		
		5–2000 Hz	2000–25000 Hz	5–25000 Hz
Broadside	247.6	224.5	185.0	224.5
Endfire	249.4	225.8	189.5	225.8
Vertical	256.4	229.6	195.7	229.6
Vertical (surface affected source level)	256.4	232.6	198.7	232.6

Table 10. Far-field source level specifications for the 2495 in^3 seismic source, for a 6 m tow depth. Source levels are for a point-like acoustic source with equivalent far-field acoustic output in the specified direction. Sound level metrics are per-pulse and unweighted.

Direction	Peak source pressure level ($L_{S,pk}$) (dB re 1 µPa m)	Per-pulse source SEL ($L_{S,E}$) (dB 1 µPa^{2}m^{2}s)		
		5–2000 Hz	2000–25000 Hz	5–25000 Hz
Broadside	249.1	224.4	183.9	224.4
Endfire	245.2	222.3	187.2	222.3
Vertical	255.1	227.8	194.5	227.8
Vertical (surface affected source level)	255.1	230.4	197.5	230.4

Table 11. Far-field source level specifications for the 1510 in^3 seismic source, for a 6 m tow depth. Source levels are for a point-like acoustic source with equivalent far-field acoustic output in the specified direction. Sound level metrics are per-pulse and unweighted.

Direction	Peak source pressure level ($L_{S,pk}$) (dB re 1 µPa m)	Per-pulse source SEL ($L_{S,E}$) (dB 1 µPa^{2}m^{2}s)		
		5–2000 Hz	2000–25000 Hz	5–25000 Hz
Broadside	249.1	222.2	182.5	222.2
Endfire	241.2	218.4	182.4	218.4
Vertical	249.5	222.4	189.4	222.4
Vertical (surface affected source level)	249.5	224.9	192.4	224.9

5.2. Per-Pulse sound fields

This section presents the per-pulse sound fields in terms of maximum-over-depth SPL, SEL, PK, and seafloor PK, PK-PK and particle acceleration. The different metrics are presented for the following reasons:

- SPL sound fields were used to determine the distances to marine mammal and turtle behavioural thresholds (see Sections 3.1 and 3.3).
- Per-pulse SEL sound fields are used as inputs into the 24 h SEL scenarios and context for the range to 160 dB re 1 µPa^2·s, relevant for the EPBC Act Policy Statement 2.1 (DEWHA 2008).
- PK metrics within the water column are relevant to thresholds and guidelines for marine mammals, sea turtles, fish, fish eggs and larvae (as well as plankton) (Sections 3.1–3.2).
- PK metrics at the seafloor are relevant to guidelines for fish, fish eggs and larvae (Section 3.2) and the sound level for no effect on corals and sponges
- PK-PK metrics at the seafloor are relevant to sound levels used in the assessment of impacts to benthic invertebrates (Section 3.4.1).
- Particle acceleration metrics are relevant for the assessment of impacts to bivalves (Section 3.4.1).

The maximum and 95% distances (calculated as detailed in Appendix C.1) for per-pulse SEL and SPL metrics are presented in Tables 12–15. These distances can be visualised for selected sites on the contour maps presented in Figures 4 to 7 with maps for remaining sites presented in Appendix D. The SPL sound fields are also presented as vertical slices for selected sites along the endfire and broadside directions out to 20 km, with the airgun array in the centre (Figures 8 to 11).

Maximum distances to PK thresholds were calculated for all modelling sites, with the exception of Site 3D, using all relevant seismic sources. Results are presented over the entire water column (maximum-over-depth; Tables 16 to 18) and at the seafloor (Table 19). The maximum-over-depth PK sound fields were used to determine distances to marine mammal, turtle, fish, fish egg and larvae injury thresholds. The seafloor PK sound fields were used to determine distances to sponges and corals, fish, fish eggs and larvae injury thresholds.

The PK-PK at the seafloor were also modelled for sites from the shallowest site on the well tie line (Site 1A, 52.9 m) and then from 60 to 110 m in 10 m depth increments (Table 20). These sound fields were used to calculate maximum distances to thresholds for benthic invertebrates (Section 3.4.1).

5.2.1. Tabulated results

5.2.1.1. Entire water column

Table 12. *2D Survey and Well-Tie:* Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the seismic source to modelled maximum-over-depth SPL isopleths from the modelled single impulse sites, with water depth and tow azimuth indicated.

SPL (L_p; dB re 1 µPa)	3150 in³ array							
	Well-tie line		2D Survey					
	Site 1A Depth: 52.9 m Heading: 51.7°		Site 2A Depth: 119 m Heading: 213.8°		Site 2B Depth: 207 m Heading: 33.8°		Site 2C Depth: 304 m Heading: 33.8°	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03
190	0.21	0.18	0.16	0.13	0.13	0.12	0.13	0.11
180	0.87	0.70	0.58	0.48	0.68	0.58	0.66	0.50
175#	1.84	1.38	1.42	1.09	1.20	0.85	1.08	0.93
170	2.77	2.14	2.59	2.05	2.40	1.90	2.13	1.74
166†	4.04	3.13	3.83	3.19	3.55	2.93	3.51	2.85
160‡	9.00	5.98	7.43	5.60	6.29	5.17	6.61	5.30
150	29.4	19.8	15.7	12.4	16.1	12.3	17.1	12.4
140	54.8	41.5	35.8	26.3	39.7	29.1	38.1	28.4

Threshold for turtle behavioural disturbance from impulsive noise (McCauley et al. 2000b).
† Threshold for turtle behavioural response to impulsive noise (NSF 2011).
‡ Marine mammal behavioural threshold for impulsive sound sources (NOAA 2019).

Table 13. *3D Survey*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the seismic source to modelled maximum-over-depth SPL isopleths from the modelled single impulse sites, with water depth and tow azimuth indicated.

SPL (L_p; dB re 1 µPa)	2495 in³ array							
	Site 3A Depth: 89.7 m Heading: 224.6°		Site 3B Depth: 117 m Heading: 44.6°		Site 3C Depth: 174 m Heading: 44.6°		Site 3D Depth: 126 m Heading: 224.6°	
	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
190	0.16	0.14	0.13	0.12	0.13	0.11	0.14	0.12
180	0.72	0.57	0.60	0.49	0.65	0.57	0.59	0.51
175#	1.41	1.19	1.32	1.15	1.16	0.94	1.33	1.08
170	2.90	2.26	2.59	2.14	2.39	2.00	2.59	2.08
166†	4.55	3.39	3.95	3.23	3.59	2.98	3.99	3.00
160‡	7.64	6.11	7.39	5.61	6.78	5.27	7.99	5.46
150	19.5	16.0	17.2	13.5	17.8	13.4	20.1	16.5
140	43.3	35.7	37.8	28.7	40.8	32.3	44.3	36.0
SPL (L_p; dB re 1 µPa)	1510 in³ array							
	Site 3A Depth: 89.7 m Heading: 224.6°		Site 3B Depth: 117 m Heading: 44.6°		Site 3C Depth: 174 m Heading: 44.6°		Site 3D Depth: 126 m Heading: 224.6°	
	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
190	0.17	0.16	0.13	0.11	0.11	0.10	0.13	0.11
180	0.59	0.51	0.51	0.46	0.60	0.54	0.57	0.50
175#	1.26	1.17	1.30	1.03	1.16	0.89	1.20	1.01
170	2.65	2.21	2.42	1.97	2.35	1.85	2.41	1.91
166†	3.76	3.13	3.34	3.00	3.15	2.83	3.20	2.80
160‡	7.09	5.53	5.85	5.01	5.60	4.73	6.39	5.15
150	17.0	13.7	13.9	11.4	14.5	11.6	17.4	14.5
140	40.0	32.1	33.0	25.8	34.2	28.7	39.7	32.9

Threshold for turtle behavioural disturbance from impulsive noise (McCauley et al. 2000b).
† Threshold for turtle behavioural response to impulsive noise (NSF 2011).
‡ Marine mammal behavioural threshold for impulsive sound sources (NOAA 2019).

Table 14. *2D Survey and Well-Tie*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the seismic source to modelled maximum-over-depth per-pulse SEL isopleths from the modelled single impulse sites, with water depth and tow azimuth indicated.

Per-pulse SEL (L_E; dB re 1 µPa²·s)	**3150 in³ array**							
	Well-tie line		**2D Survey**					
	Site 1A Depth: 52.9 m Heading: 51.7°		**Site 2A** Depth: 119 m Heading: 213.8°		**Site 2B** Depth: 207 m Heading: 33.8°		**Site 2C** Depth: 304 m Heading: 33.8°	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	0.06	0.05	0.05	0.05	0.03	0.03	0.05	0.04
180	0.23	0.20	0.22	0.17	0.16	0.14	0.14	0.13
170	0.91	0.78	0.71	0.55	0.73	0.64	0.80	0.68
160#	3.34	2.31	2.80	2.31	2.70	2.20	2.56	2.10
150	9.27	6.88	8.33	6.61	8.33	6.73	8.62	7.03
140	31.4	21.3	20.4	14.0	22.3	16.9	24.0	18.2
130	60.2	44.0	39.0	29.9	47.5	36.8	54.2	39.6
120	>100	/	70.6	53.4	82.2	66.0	>100	/

Low power zone assessment criteria (DEWHA (2008).
A slash indicates that $R_{95\%}$ radius to threshold is not reported when the R_{max} is greater than the maximum modelling extent.

Table 15. *3D Survey*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the seismic source to modelled maximum-over-depth per-pulse SEL isopleths from the modelled single impulse sites, with water depth and tow azimuth indicated.

Per-pulse SEL (L_E; dB re 1 µPa²·s)	**2495 in³ array**							
	Site 3A Depth: 89.7 m Heading: 224.6°		**Site 3B** Depth: 117 m Heading: 44.6°		**Site 3C** Depth: 174 m Heading: 44.6°		**Site 3D** Depth: 126 m Heading: 224.6°	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
180	0.24	0.21	0.16	0.13	0.14	0.13	0.16	0.14
170	0.94	0.69	0.68	0.55	0.69	0.60	0.69	0.54
160#	2.99	2.50	3.10	2.40	2.82	2.29	2.86	2.34
150	9.39	7.10	8.38	6.81	8.73	6.60	9.07	7.08
140	23.9	18.4	20.1	15.3	22.5	17.1	24.4	19.1
130	47.0	38.7	42.1	32.1	47.6	37.5	49.1	39.8
120	78.3	63.9	69.7	54.6	80.7	65.6	82.4	66.6
Per-pulse SEL (L_E; dB re 1 µPa²·s)	**1510 in³ array**							
	Site 3A Depth: 89.7 m Heading: 224.6°		**Site 3B** Depth: 117 m Heading: 44.6°		**Site 3C** Depth: 174 m Heading: 44.6°		**Site 3D** Depth: 126 m Heading: 224.6°	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
180	0.24	0.21	0.17	0.16	0.14	0.13	0.16	0.16
170	0.76	0.68	0.64	0.53	0.65	0.59	0.64	0.55
160#	2.93	2.41	2.60	2.34	2.46	2.18	2.50	2.28
150	7.85	6.32	7.38	6.07	7.34	6.10	8.66	6.28
140	19.1	15.8	16.7	13.2	18.5	15.2	20.3	16.9
130	43.6	35.5	36.0	28.8	41.3	34.2	44.3	36.9
120	71.9	61.4	63.6	52.0	74.0	62.7	77.0	63.7

Low power zone assessment criteria (DEWHA (2008).
A slash indicates that $R_{95\%}$ radius to threshold is not reported when the R_{max} is greater than the maximum modelling extent.

Table 16. *2D Survey and Well-Tie: 3150 in^3 array*: Maximum (R_{max}) horizontal distances (km) from the seismic array to modelled maximum-over-depth peak pressure level (PK) thresholds based on the NOAA Technical Guidance (NMFS 2018) for marine mammals, Popper et al. (2014) for fish, and Finneran et al. (2017) for turtles, with water depth and tow azimuth indicated.

Hearing group	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (km)			
		Well-tie line	2D Survey		
		Site 1A Depth: 52.9 m Heading: 51.7°	Site 2A Depth: 119 m Heading: 213.8°	Site 2B Depth: 207 m Heading: 33.8°	Site 2C Depth: 304 m Heading: 33.8°
Low-frequency cetaceans (PTS)	219	0.03	0.03	0.03	0.03
Low-frequency cetaceans (TTS)	213	0.06	0.06	0.06	0.06
Mid-frequency cetaceans (PTS)	230	–	–	–	–
Mid-frequency cetaceans (TTS)	224	–	–	–	–
High-frequency cetaceans (PTS)	202	0.29	0.18	0.20	0.22
High-frequency cetaceans (TTS)	196	0.66	0.56	0.53	0.38
Sirenians (PTS)	226	–	–	–	–
Sirenians (TTS)	220	0.03	0.03	0.03	0.03
Turtles (PTS)	232	–	–	–	–
Turtles (TTS)	226	–	–	–	–
Fish: No swim bladder (also applied to sharks)	213	0.06	0.06	0.06	0.06
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	0.18	0.11	0.12	0.12

A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

Table 17. *3D Survey: 2495 in³ array*: Maximum (R_{max}) horizontal distances (km) from the seismic array to modelled maximum-over-depth peak pressure level (PK) thresholds based on the NOAA Technical Guidance (NMFS 2018) for marine mammals, Popper et al. (2014) for fish, and Finneran et al. (2017) for turtles, with water depth and tow azimuth indicated.

Hearing group	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (km)		
		Site 3A Depth: 89.7 m Heading: 224.6°	Site 3B Depth: 117 m Heading: 44.6°	Site 3C Depth: 174 m Heading: 44.6°
Low-frequency cetaceans (PTS)	219	0.03	0.03	0.03
Low-frequency cetaceans (TTS)	213	0.07	0.07	0.07
Mid-frequency cetaceans (PTS)	230	–	–	–
Mid-frequency cetaceans (TTS)	224	–	–	–
High-frequency cetaceans (PTS)	202	0.38	0.32	0.24
High-frequency cetaceans (TTS)	196	0.63	0.66	0.73
Sirenians (PTS)	226	–	–	–
Sirenians (TTS)	220	0.03	0.03	0.03
Turtles (PTS)	232	–	–	–
Turtles (TTS)	226	–	–	–
Fish: No swim bladder (also applied to sharks)	213	0.07	0.07	0.07
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	0.14	0.13	0.13

A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

Table 18. *3D Survey: 1510 in³ array*: Maximum (R_{max}) horizontal distances (km) from the seismic array to modelled maximum-over-depth peak pressure level (PK) thresholds based on the NOAA Technical Guidance (NMFS 2018) for marine mammals, Popper et al. (2014) for fish, and Finneran et al. (2017) for turtles, with water depth and tow azimuth indicated.

Hearing group	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (km)		
		Site 3A Depth: 89.7 m Heading: 224.6°	Site 3B Depth: 117 m Heading: 44.6°	Site 3C Depth: 174 m Heading: 44.6°
Low-frequency cetaceans (PTS)	219	0.03	0.03	0.03
Low-frequency cetaceans (TTS)	213	0.07	0.06	0.07
Mid-frequency cetaceans (PTS)	230	–	–	–
Mid-frequency cetaceans (TTS)	224	–	–	–
High-frequency cetaceans (PTS)	202	0.39	0.24	0.24
High-frequency cetaceans (TTS)	196	0.80	0.68	0.73
Sirenians (PTS)	226	–	–	–
Sirenians (TTS)	220	0.03	0.03	0.03
Turtles (PTS)	232	–	–	–
Turtles (TTS)	226	–	–	–
Fish: No swim bladder (also applied to sharks)	213	0.07	0.06	0.07
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	0.13	0.13	0.13

A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

5.2.1.2. Seafloor

Table 19. Maximum (R_{max}) horizontal distances (in m) from the three seismic source arrays to modelled seafloor peak pressure level thresholds (PK) from sites with seven different water depths.

Hearing group/animal type	PK threshold (L_{pk}; dB re 1 µPa)	3150 in³ array						
		Site water depth (m)						
		52.9	60	70	80	90	100	110
Sponges and corals†	226	*	*	*	*	*	*	*
Fish: No swim bladder (also applied to sharks)	213	100.3	93.2	84.5	76.2	69.2	65.4	59.2
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	176.5	183.3	198.9	205.7	207.2	209.5	197.3
Hearing group/animal type	**PK threshold** (L_{pk}; dB re 1 µPa)	**2495 in³ array**						
		Site water depth (m)						
		52.9	60	70	80	90	100	110
Sponges and corals†	226	*	*	*	*	*	*	*
Fish: No swim bladder (also applied to sharks)	213	94.5	81.0	80.3	71.8	64.0	57.7	55.3
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	193.9	204.8	213.1	218.6	213.7	192.7	171.9
Hearing group/animal type	**PK threshold** (L_{pk}; dB re 1 µPa)	**1510 in³ array**						
		Site water depth (m)						
		52.9	60	70	80	90	100	110
Sponges and corals†	226	*	*	*	*	*	*	*
Fish: No swim bladder (also applied to sharks)	213	96.0	77.8	66.4	52.0	28.2	*	*
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	190.2	196.9	211.2	214.6	211.7	206.2	175.1

† Heyward et al. (2018)
An asterisk indicates that the sound level was not reached.

Table 20. Maximum (R_{max}) horizontal distances (in m) from the three seismic source arrays to modelled seafloor peak-peak pressure levels (PK-PK) from sites with seven different water depths, based on PK-PK thresholds for benthic invertebrates (Section 3.4.1).

PK-PK (L_{pk-pk}; dB re 1 µPa)	**3150 in³ array**						
	Site water depth (m)						
	52.9	60	70	80	90	100	110
213[a,b,c]	161.3	162.1	143.8	144.6	139.9	132.4	131.7
212[b,c]	179.2	183.5	183.4	163.2	163.1	150.6	150.5
210[a,b]	204.6	216.9	226.4	233.5	233.7	220.9	209.0
209[a,b]	216.1	231.8	239.7	255.6	259.6	263.1	251.8
202[d]	497.0	523.7	522.6	401.2	422.6	443.1	461.7
PK-PK (L_{pk-pk}; dB re 1 µPa)	**2495 in³ array**						
	Site water depth (m)						
	52.9	60	70	80	90	100	110
213[a,b,c]	190.9	197.0	205.4	205.4	198.4	177.7	164.0
212[b,c]	202.3	213.9	223.2	228.4	232.6	227.1	205.7
210[a,b]	225.9	242.9	259.7	268.9	282.5	291.9	294.8
209[a,b]	240.0	256.5	276.6	287.0	303.7	312.7	322.3
202[d]	581.6	571.2	594.8	620.7	631.1	480.7	503.9
PK-PK (L_{pk-pk}; dB re 1 µPa)	**1510 in³ array**						
	Site water depth (m)						
	52.9	60	70	80	90	100	110
213[a,b,c]	189.6	195.0	201.9	202.4	196.1	167.2	146.0
212[b,c]	201.2	209.3	224.2	229.3	227.6	223.8	198.1
210[a,b]	226.0	239.1	252.9	270.7	278.4	287.1	293.0
209[a,b]	239.6	252.0	271.5	285.3	304.1	314.0	321.9
202[d]	687.7	682.4	614.6	656.9	690.3	481.3	504.3

[a] Day et al. (2019)_ENREF_37, lobster
[b] Day et al. (2016a), lobster and scallops
[c] Day et al. (2017), scallops.
[d] Payne et al. (2008), lobster

5.2.2. Sound field maps and graphs

5.2.2.1. Sound Level Contour Maps

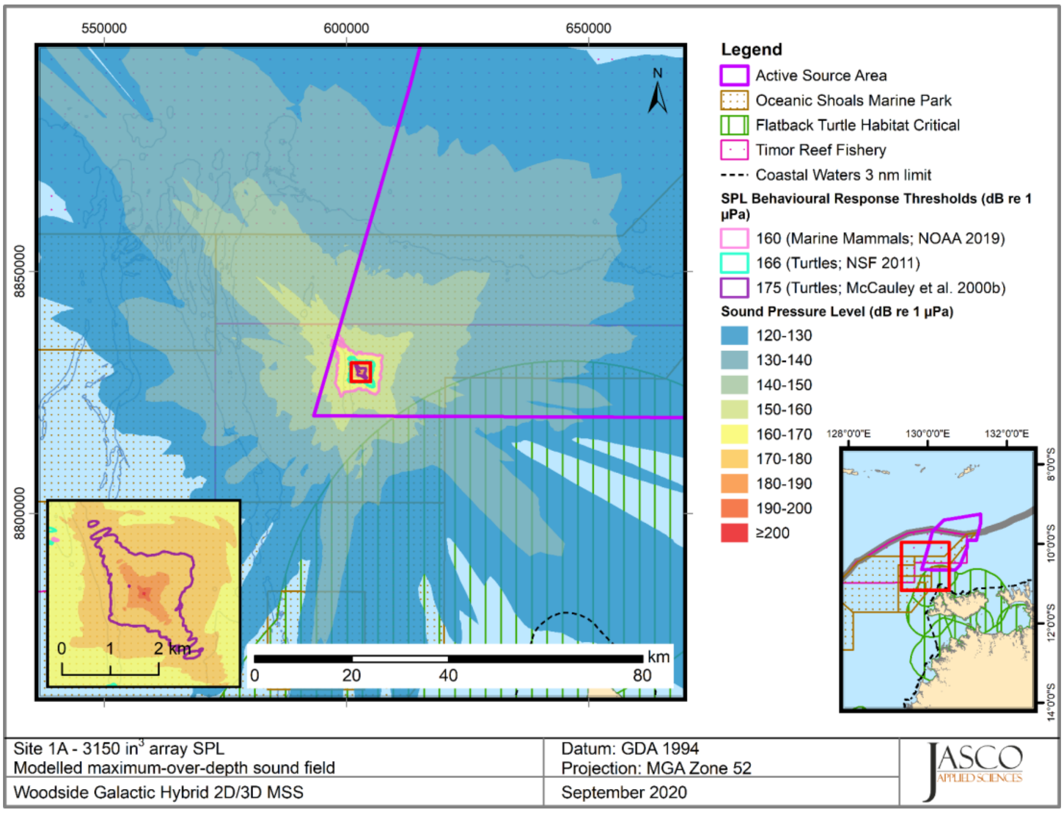

Figure 4. *Site 1A, 3150 in^3 array, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths of behavioural response thresholds for marine mammals and turtles.

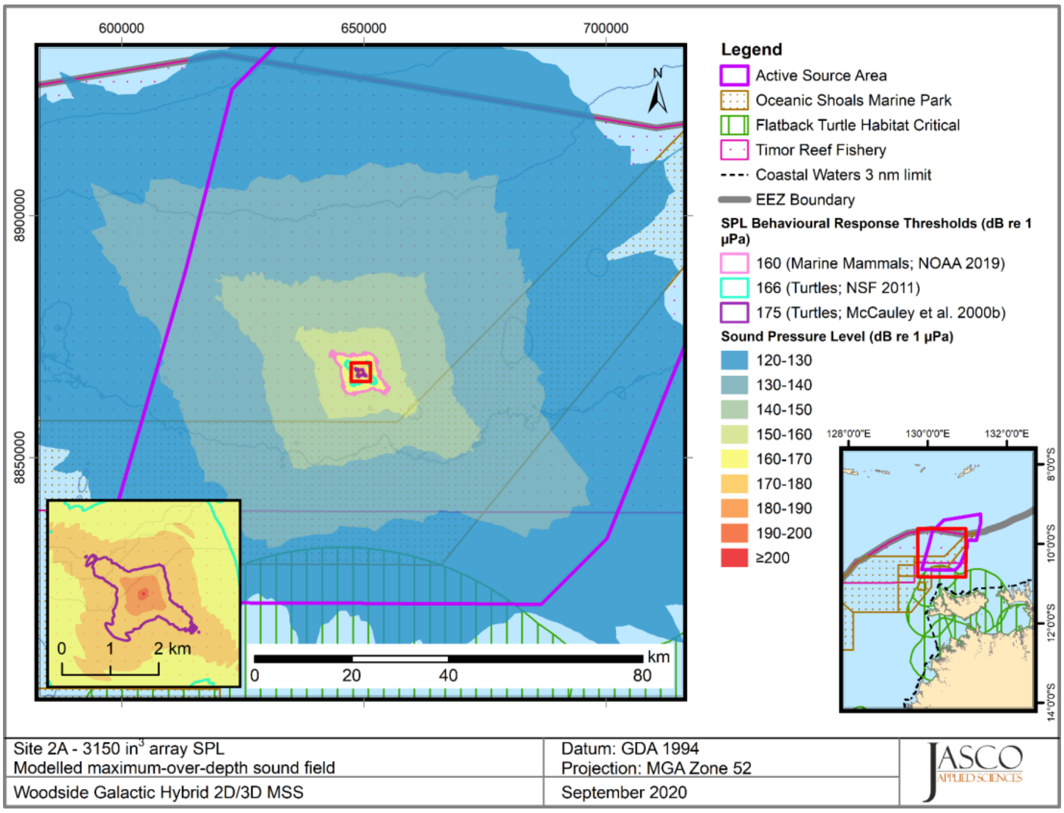

Figure 5 *Site 2A, 3150 in³ array, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths of behavioural response thresholds for marine mammals and turtles.

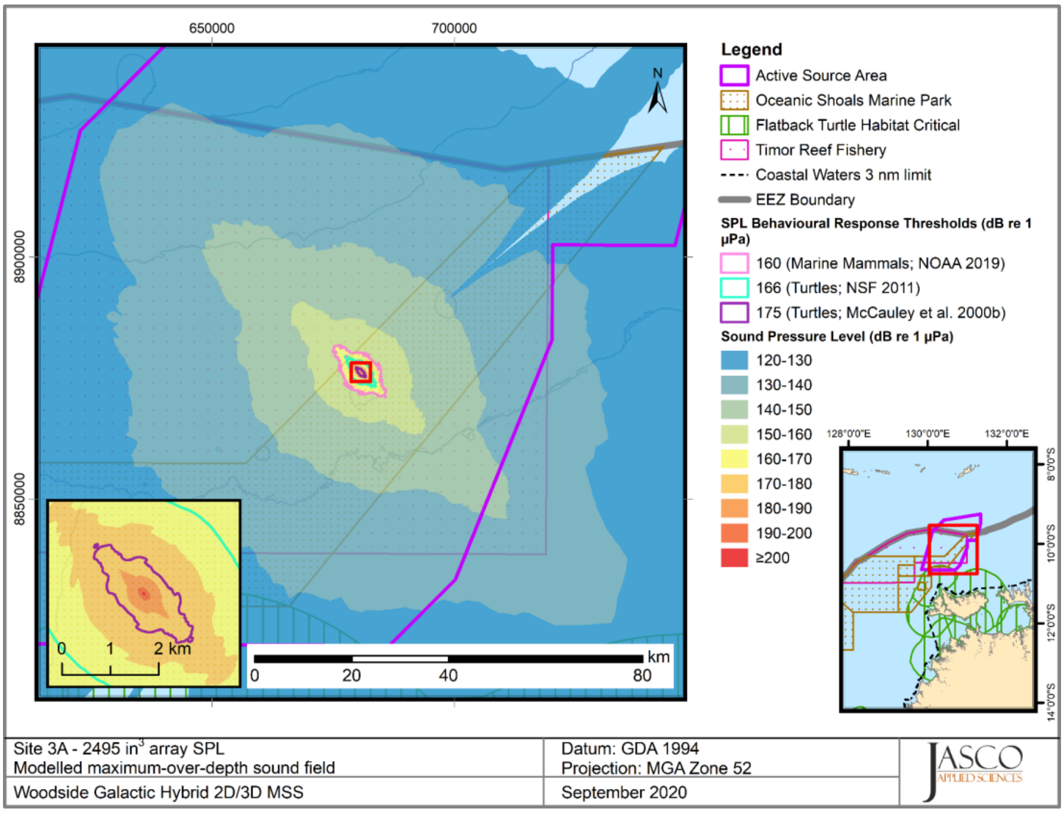

Figure 6. *Site 3A, 2495 in³ array, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths of behavioural response thresholds for marine mammals and turtles.

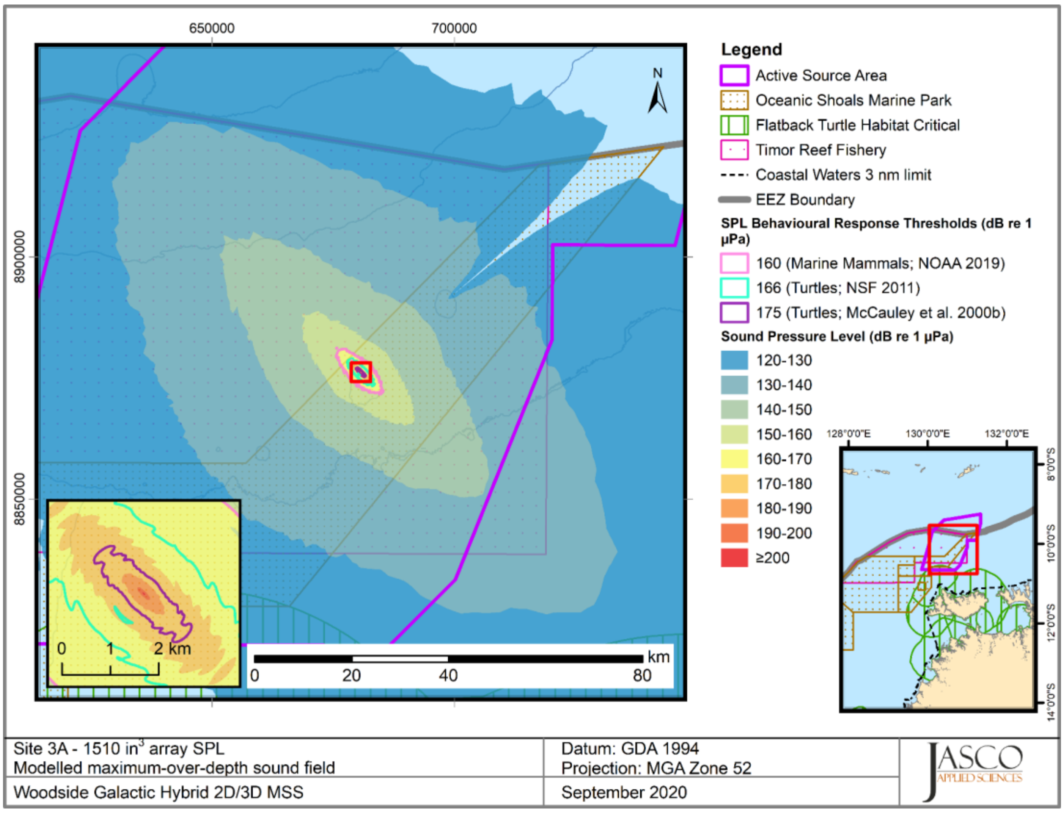

Figure 7. *Site 3A, 1510 in^3 array, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths of behavioural response thresholds for marine mammals and turtles.

5.2.2.2. Vertical Slices of Modelled Sound Fields

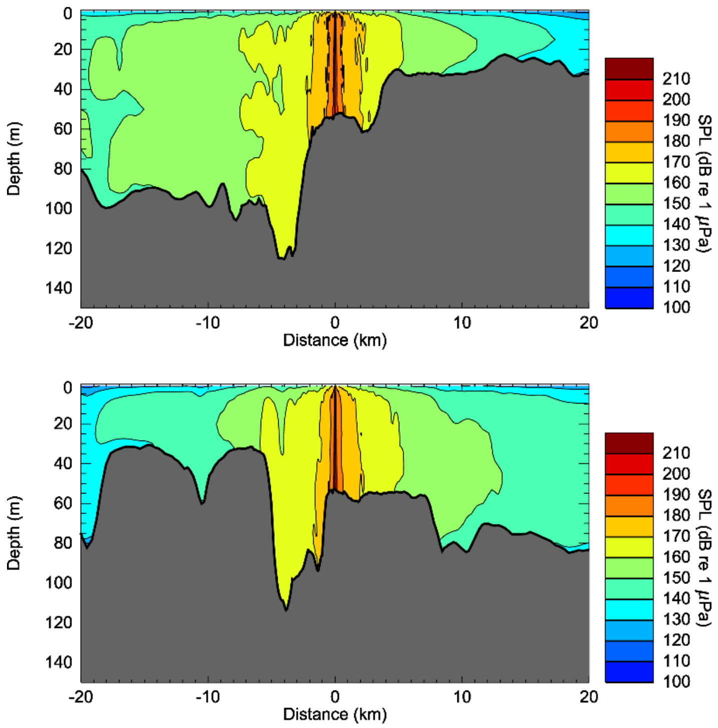

Figure 8. *Site 1A, 3150 in^3 array (tow azimuth 51.7°), SPL*: Sound level contours in vertical slice of the sound field, perpendicular to (broadside, top) and along the tow direction (endfire, bottom). The positive distance direction in each slice is the tow azimuth for the endfire slice, and 90° clockwise from the tow azimuth for broadside.

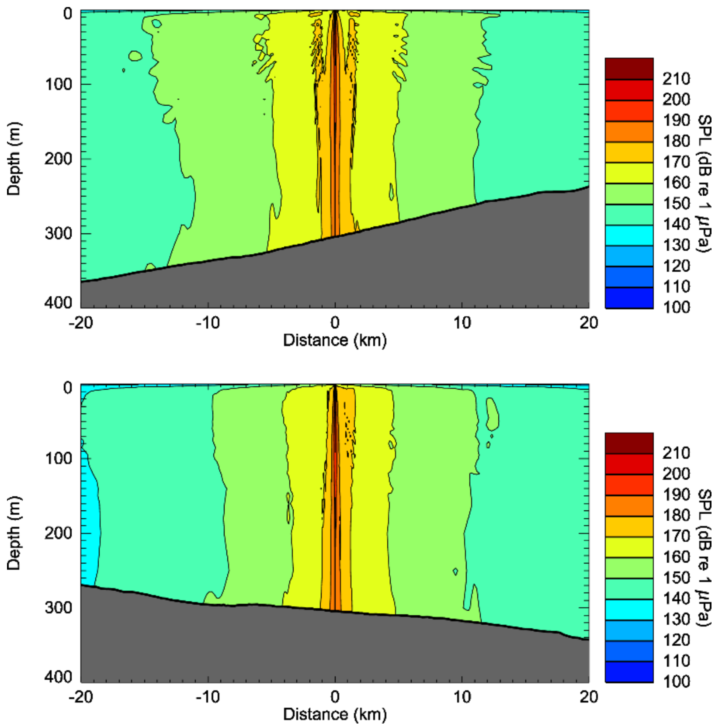

Figure 9. *Site 2C, 3150 in*^{3} *array (tow azimuth 33.8°), SPL*: Sound level contours in vertical slice of the sound field, perpendicular to (broadside, top) and along the tow direction (endfire, bottom). The positive distance direction in each slice is the tow azimuth for the endfire slice, and 90° clockwise from the tow azimuth for broadside.

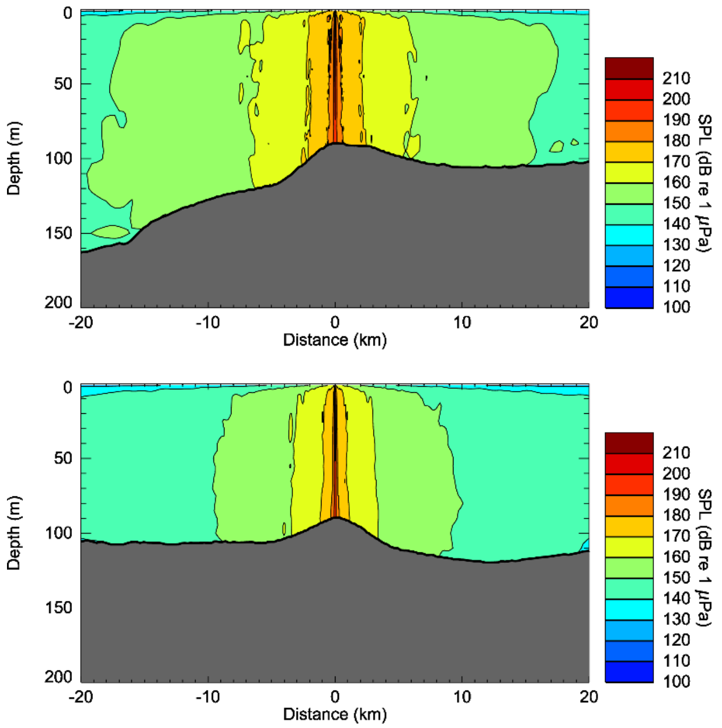

Figure 10. *Site 3A, 2495 in*^{3} *array (tow azimuth 224.6°), SPL*: Sound level contours in vertical slice of the sound field, perpendicular to (broadside, top) and along the tow direction (endfire, bottom). The positive distance direction in each slice is the tow azimuth for the endfire slice, and 90° clockwise from the tow azimuth for broadside.

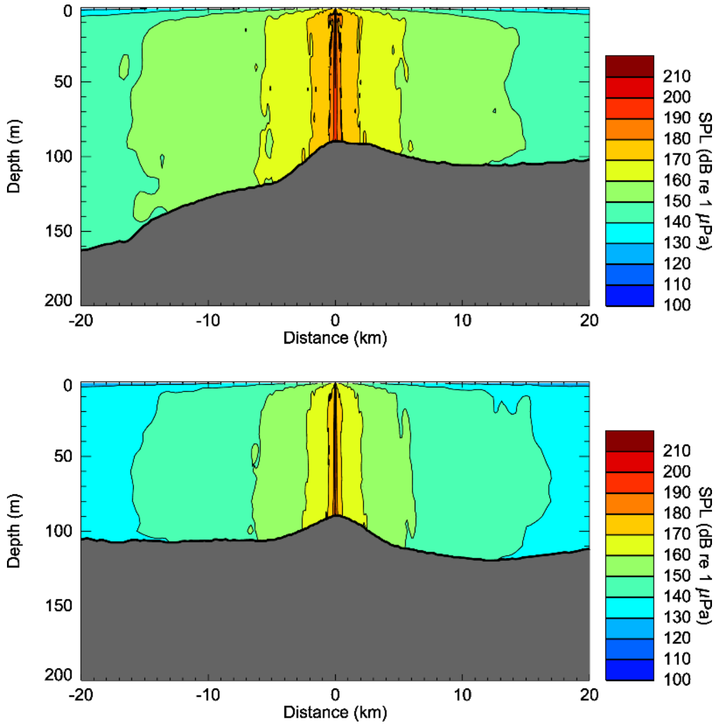

Figure 11. *Site 3A, 1510 in^3 array (tow azimuth 224.6°), SPL*: Sound level contours in vertical slice of the sound field, perpendicular to (broadside, top) and along the tow direction (endfire, bottom). The positive distance direction in each slice is the tow azimuth for the endfire slice, and 90° clockwise from the tow azimuth for broadside.

5.2.3. Particle Motion

Figure 12 shows modelled maximum particle acceleration as a function of horizontal range in four perpendicular directions from the centre of the 3150 in^3 seismic source at the shallowest modelling site (well-tie line, Site 1A, 52.9 m water depth). The modelling considered a resolution of 10 m, and the maximum distance to a particle acceleration of the closest value to 37.57 ms^{-2} (Section 3.4, Day et al. (2016a)) at the seafloor occurs at approximately 15 m (Figure 12).

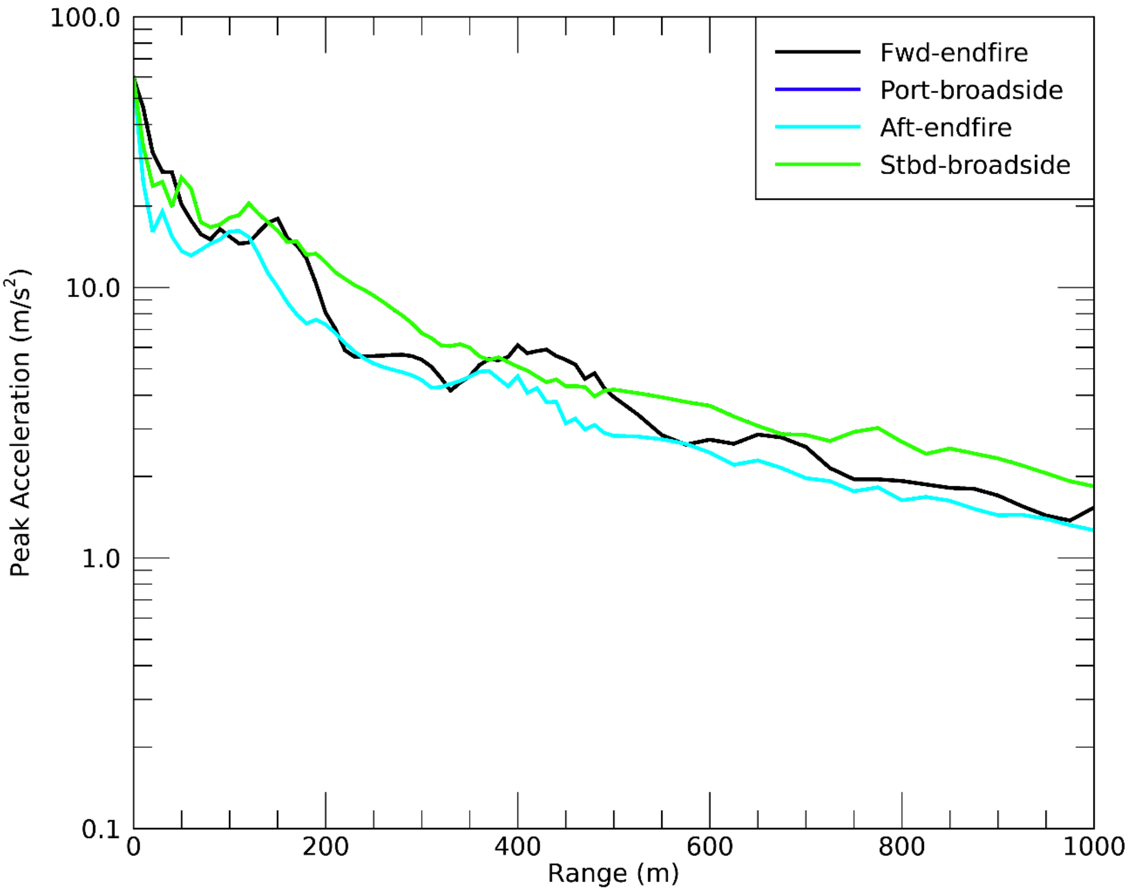

Figure 12. Site 1A (52.9 m water depth): Maximum particle acceleration at the seafloor as a function of horizontal range from the centre of a single 3150 in^3 seismic source along four directions.

5.3. Multiple Pulses Sound Fields

This section presents the sound fields in terms of SEL accumulated over 24 h of survey, for the four modelled SEL_{24h} scenarios. Frequency-weighted SEL_{24h} sound fields were used to estimate the maximum and 95% distances (R_{max} and $R_{95\%}$; calculated as detailed in Appendix C.1) to marine mammals and turtle PTS and TTS thresholds (listed in Table 21), and to estimate maximum distance and the area to injury and temporary threshold shift (TTS) thresholds for fish over the entire water column and at the seafloor (Table 22)

The SEL_{24h} sound fields are presented as contour maps in Figures 13 to 20. These figures present the unweighted SEL_{24h} in 10 dB steps, as well as the isopleths corresponding to criteria thresholds for which R_{max} is greater than the modelling resolution (20 m) taking into account source offset from the tow line.

5.3.1. Tabulated Results

5.3.1.1. Entire Water Column

Table 21. *Marine mammal and sea turtle criteria*: Maximum (R_{max}) horizontal distances (in km) from the survey lines to permanent threshold shift (PTS) and temporary threshold shift (TTS) thresholds considering 24 h of survey activity in the water column.

Hearing group	Weighted SEL thresholds ($L_{E,24h}$; dB re 1 µPa²·s)	2D Survey 3150 in³ Single array		3D Survey 2495 in³ Triple array		3D Survey 1510 in³ Penta array		3D Survey 1510 in³ Hexa array	
		R_{max} (km)	Area (km²)	R_{max} (km)	Area (km²)	R_{max} (km)	Area (km²)	R_{max} (km)	Area (km²)
PTS									
Low-frequency cetaceans	183	0.40	81.6	2.08	320	2.60	355	3.11	460
Mid-frequency cetaceans	185	<0.02	/	0.14	/	0.12	/	0.14	/
High-frequency cetaceans	155	<0.02	/	0.14	/	0.12	/	0.14	/
Sirenians	190	–	–	–	–	–	–	–	–
Sea Turtles	204	<0.02	/	0.14	/	0.13	2.16	0.16	2.56
TTS									
Low-frequency cetaceans	168	17.2	3137	25.5	3095	24.7	3013	26.6	3284
Mid-frequency cetaceans	170	<0.02	/	0.14	/	0.12	/	0.14	/
High-frequency cetaceans	140	0.10	27.7	0.45	110	0.45	89.4	0.64	112
Sirenians	175	<0.02	/	0.14	/	0.12	/	0.14	/
Sea Turtles	189	0.16	39.6	0.74	151	1.42	208	1.69	264

A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).
A slash indicates that the area is not reported when the R_{max} is smaller than the modelling resolution (20 m) accounting for source offset from the line.

Table 22. *Fish criteria*: Maximum horizontal distances (R_{max}, in km) from the survey lines and area (km²) to injury and temporary threshold shift (TTS) thresholds considering 24 h of survey activity.

Marine fauna group	Threshold for SEL24h ($L_{E,24h}$; dB re 1 µPa²·s)	2D Survey 3150 in³ Single array		3D Survey 2495 in³ Triple array		3D Survey 1510 in³ Penta array		3D Survey 1510 in³ Hexa array	
		R_{max} (km)	Area (km²)	R_{max} (km)	Area (km²)	R_{max} (km)	Area (km²)	R_{max} (km)	Area (km²)
Mortality and potential mortal injury									
Maximum-over-depth									
I	219	<0.02	/	0.14	/	0.12	/	0.14	/
II, fish eggs and fish larvae	210	<0.02	/	0.14	/	0.12	/	0.14	/
III	207	<0.02	/	0.14	/	0.12	/	0.15	2.21
Seafloor									
I	219	*	*	*	*	*	*	*	*
II, fish eggs and fish larvae	210	*	*	*	*	*	*	*	*
III	207	*	*	*	*	*	*	*	*
Fish recoverable injury									
Maximum-over-depth									
I	216	<0.02	/	0.14	/	0.12	/	0.14	/
II, III	203	0.03	1.92	0.16	3.88	0.13	4.37	0.16	4.99
Seafloor									
I	216	*	*	*	*	*	*	*	*
II, III	203	*	*	*	*	*	*	*	*
Fish TTS									
Maximum-over-depth									
I, II, III	186	0.90	262.3	3.75	687.1	4.28	775.3	4.29	831.9
Seafloor									
I, II, III	186	0.85	243.7	3.36	553.7	4.23	657.2	4.28	772.8

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.
An asterisk indicates that the sound level was not reached.

5.3.2. Sound Level Contour Maps

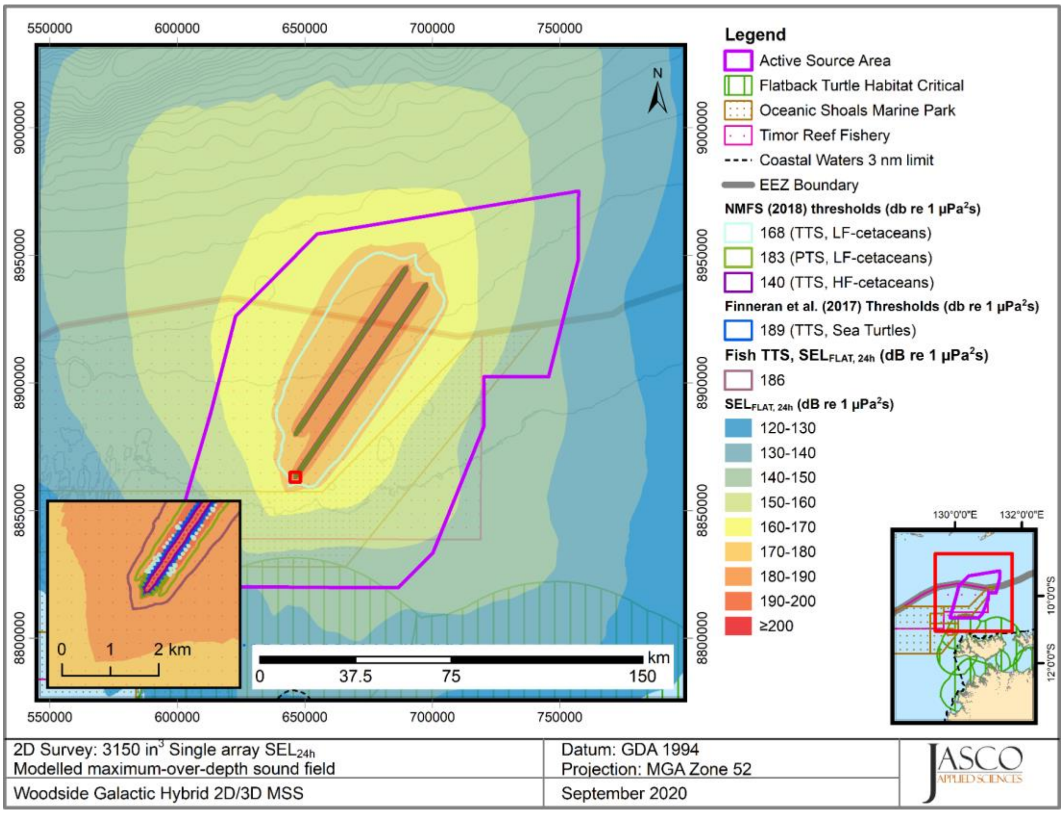

Figure 13. *2D Survey, single 3150 in³ array*: Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with weighted isopleths for cetaceans, turtles and unweighted isopleths for fish. Thresholds omitted were not reached or not large enough to display graphically.

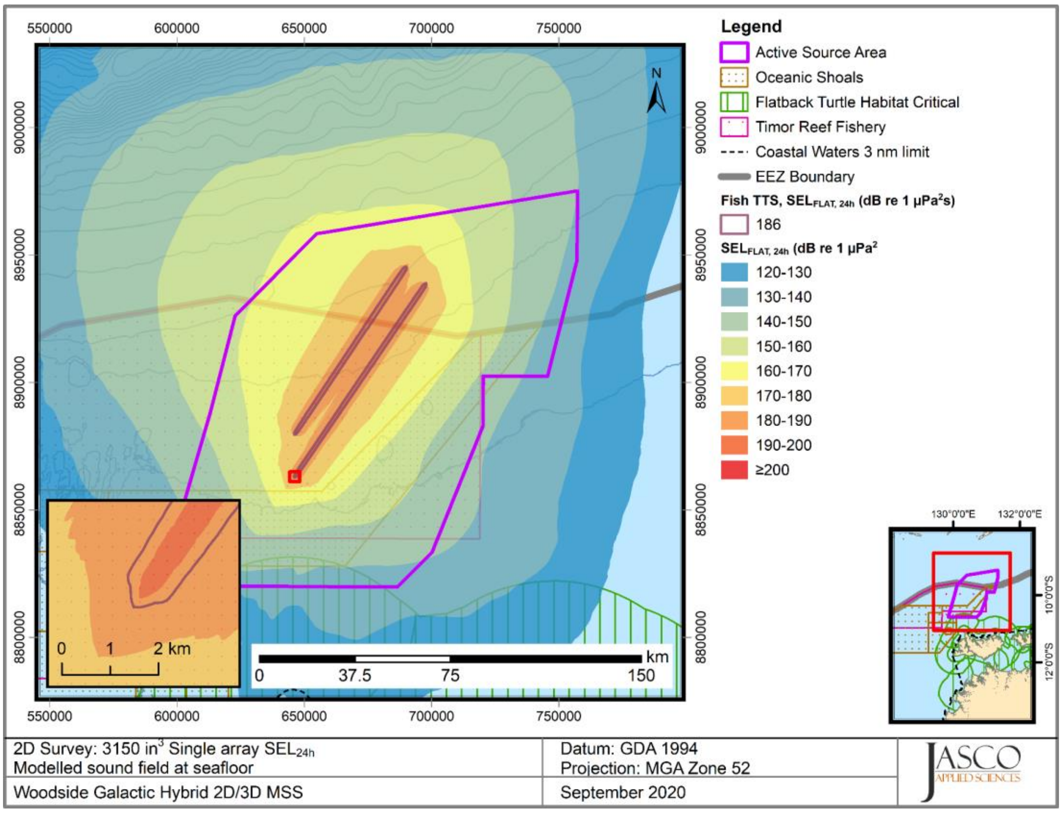

Figure 14. *2D Survey, single 3150 in³ array*: Sound level contour map showing unweighted SEL_{24h} results at the seafloor, along with isopleths for fish TTS in relation to the Timor Reef Fishery and the Oceanic Shoals Marine Park.

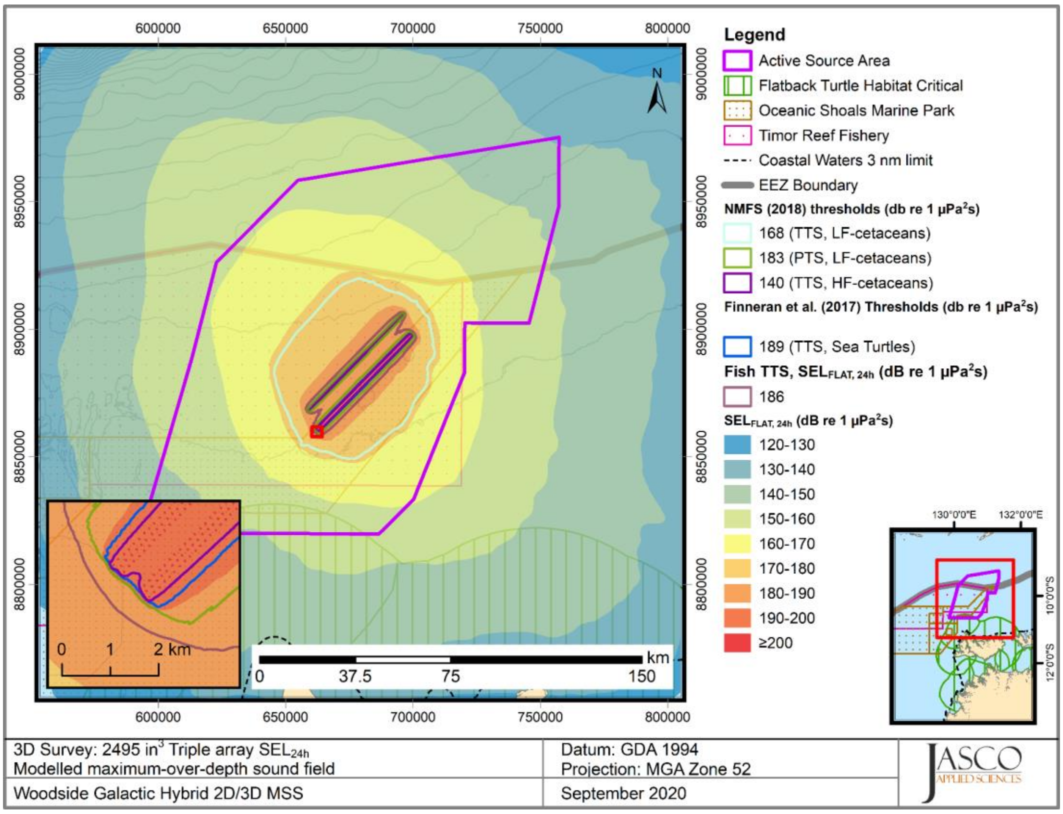

Figure 15. *3D Survey, triple 2495 in³ array*: Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with weighted isopleths for cetaceans, turtles and unweighted isopleths for fish. Thresholds omitted were not reached or not large enough to display graphically.

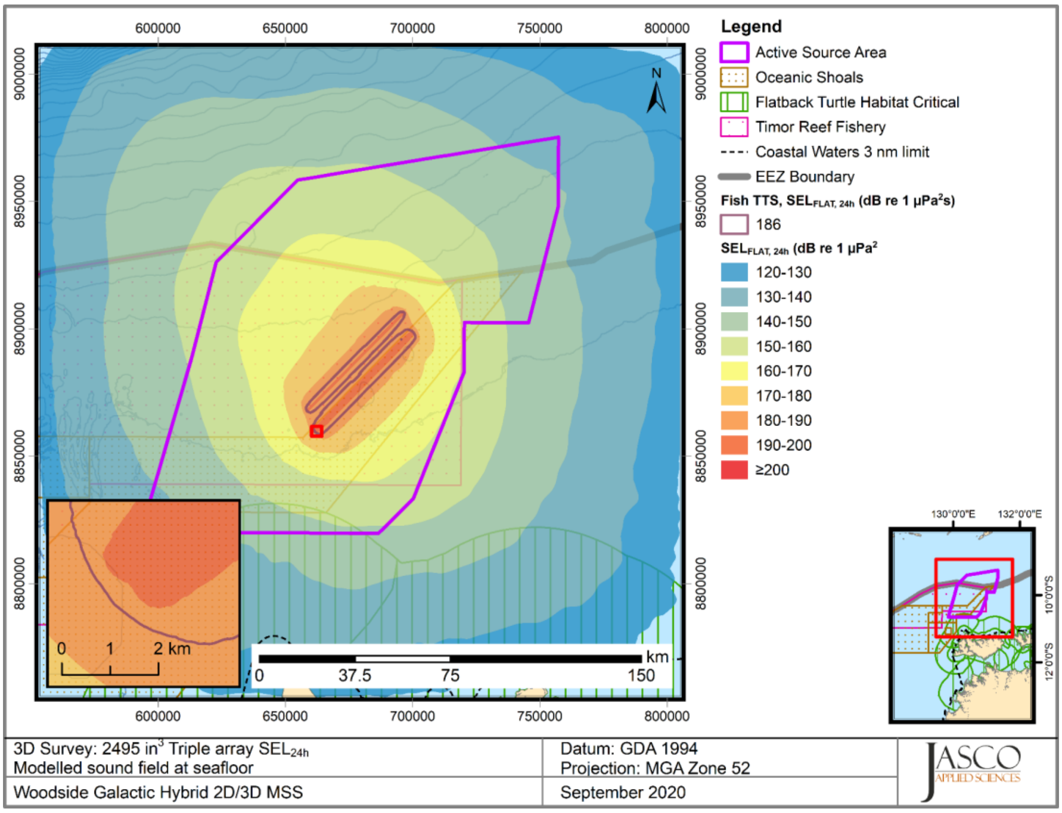

Figure 16. *3D Survey, triple 2495 in^3 array*: Sound level contour map showing unweighted SEL_{24h} results at the seafloor, along with isopleths for fish TTS in relation to the Timor Reef Fishery and the Oceanic Shoals Marine Park.

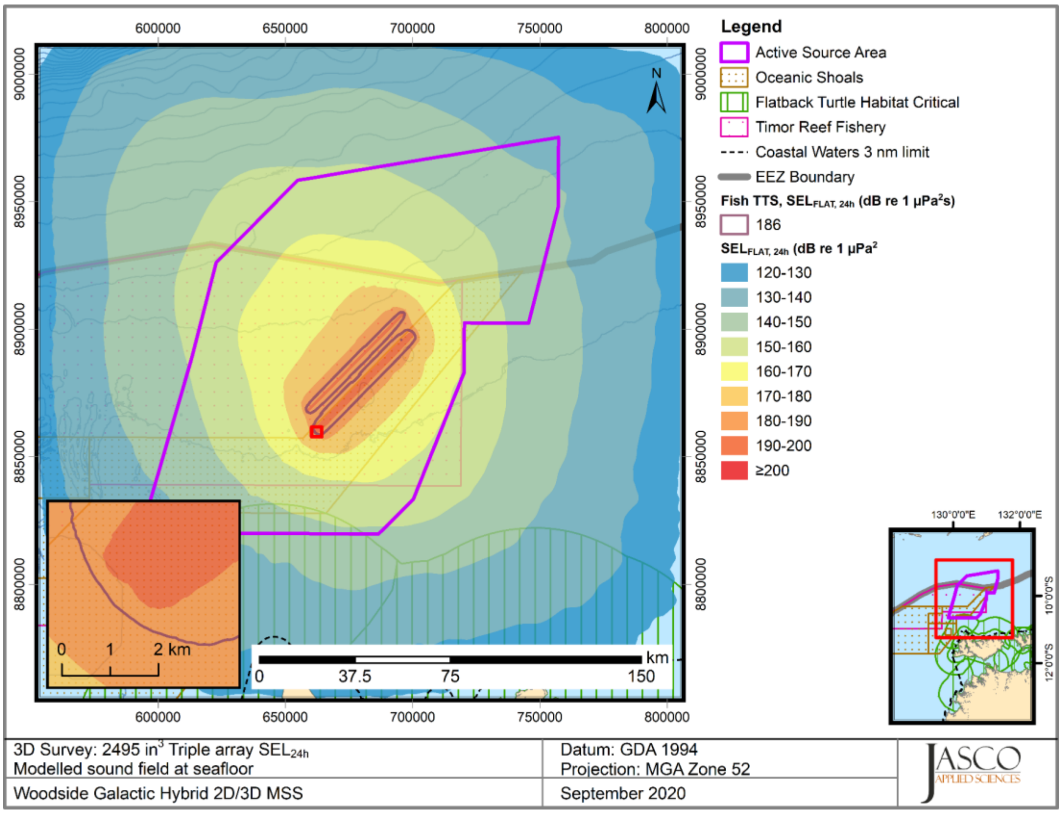

Figure 17. *3D Survey, penta 1510 in^3 array*: Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with weighted isopleths for cetaceans, turtles and unweighted isopleths for fish. Thresholds omitted were not reached or not large enough to display graphically.

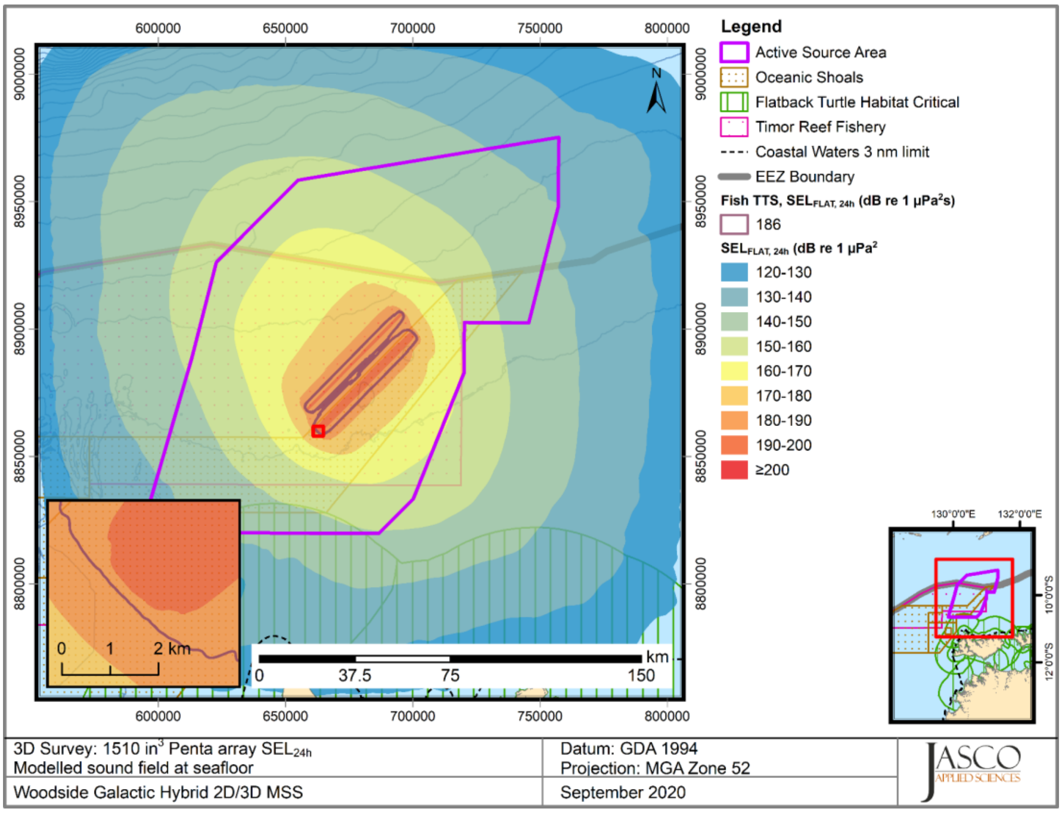

Figure 18. *3D Survey, penta 1510 in³ array*: Sound level contour map showing unweighted SEL_{24h} results at the seafloor, along with isopleths for fish TTS in relation to the Timor Reef Fishery and the Oceanic Shoals Marine Park.

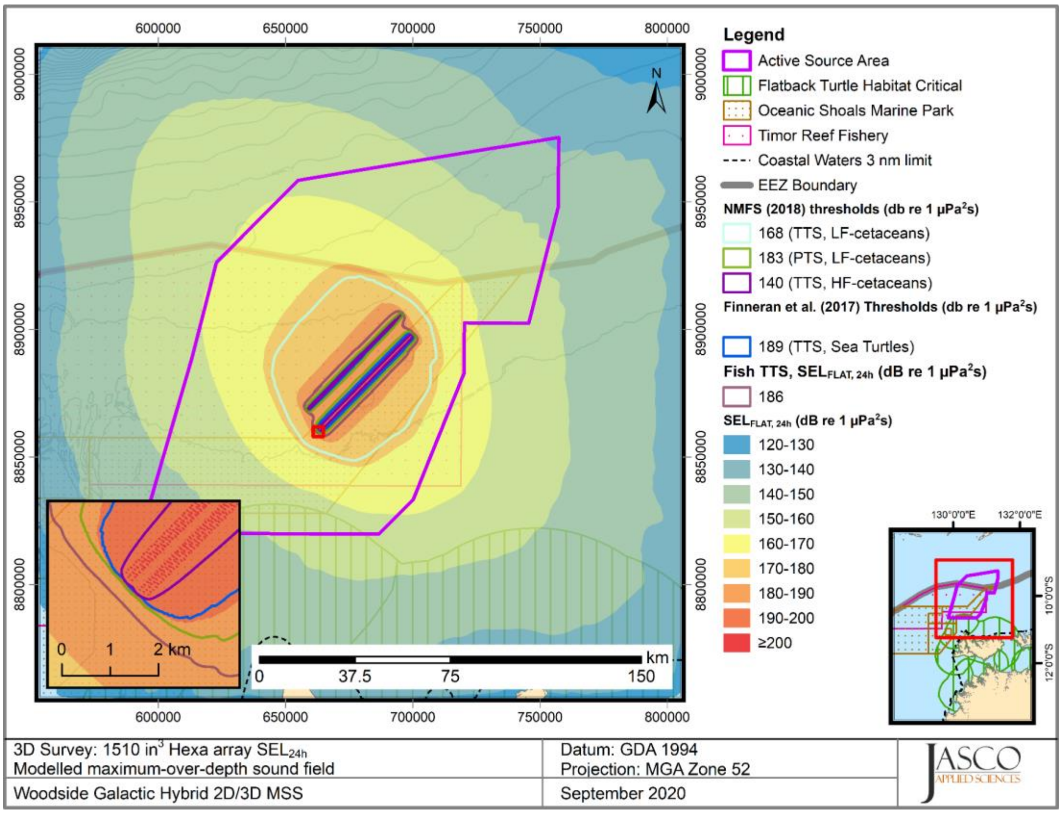

Figure 19. *3D Survey, hexa 1510 in³ array*: Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with weighted isopleths for cetaceans, turtles and unweighted isopleths for fish. Thresholds omitted were not reached or not large enough to display graphically.

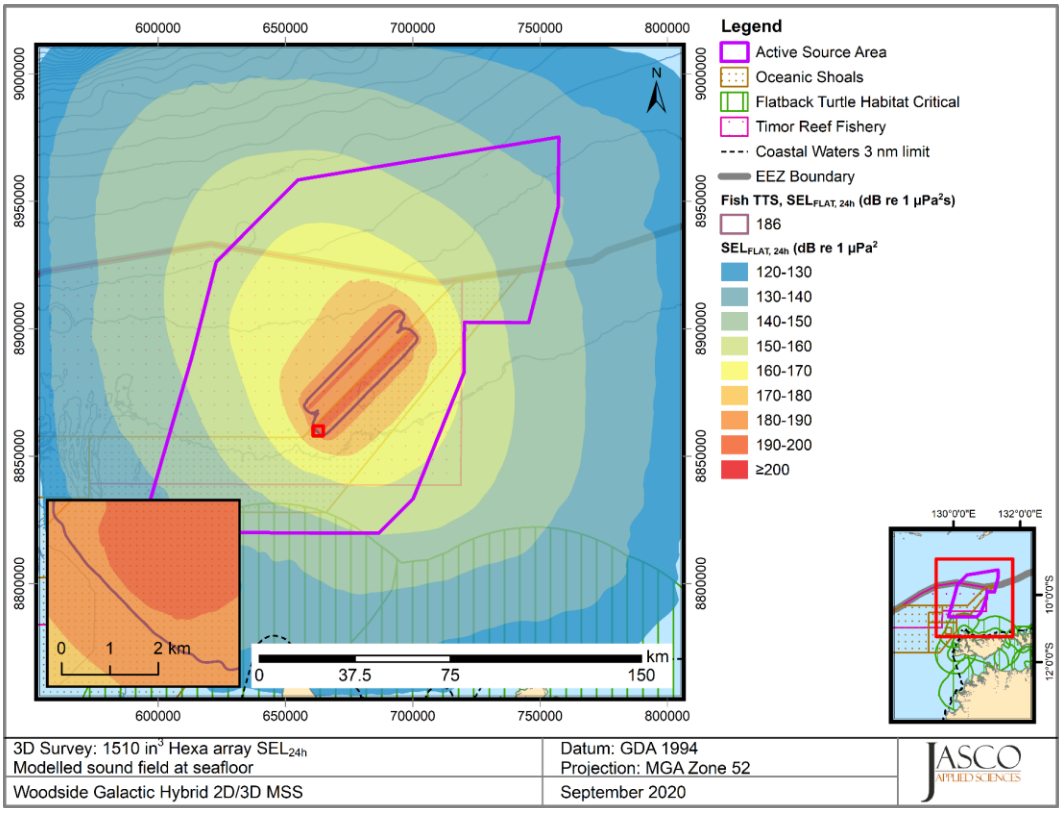

Figure 20. *3D Survey, hexa 1510 in^3 array*: Sound level contour map showing unweighted SEL_{24h} results at the seafloor, along with isopleths for fish TTS in relation to the Timor Reef Fishery and the Oceanic Shoals Marine Park.

5.3.3. Accumulated levels at static receivers

To provide further assessment of the influence of accumulated sound levels on fish, unweighted sound exposure levels were modelled at static receivers at perpendicular offsets from the closest survey line in the 2D and 3D survey line plans; see Figures 2 and 3 for receiver location relative to survey lines. The static receivers in the 3D scenario were sub-categorised into the group of receivers heading inshore (due southeast) from the survey lines and those heading offshore (due northwest) from the survey lines. Accumulated and per-pulse SEL were extracted at a subset of considered receiver distances for plotting purposes.

The results are presented in Figures 21 to 27. Fourteen receiver offset distances out of the ninety considered (0.1, 0.25, 0.5, 1.0, 2.0, 3.0, 5.0, 10.0, 15.0, 20.0, 25.0, and 30.0 km) were plotted as a function of time on a common graph. The notable gaps in per-pulse levels are associated the vessel turning, and run-ins, during which the source was not in operation for modelling purposes.

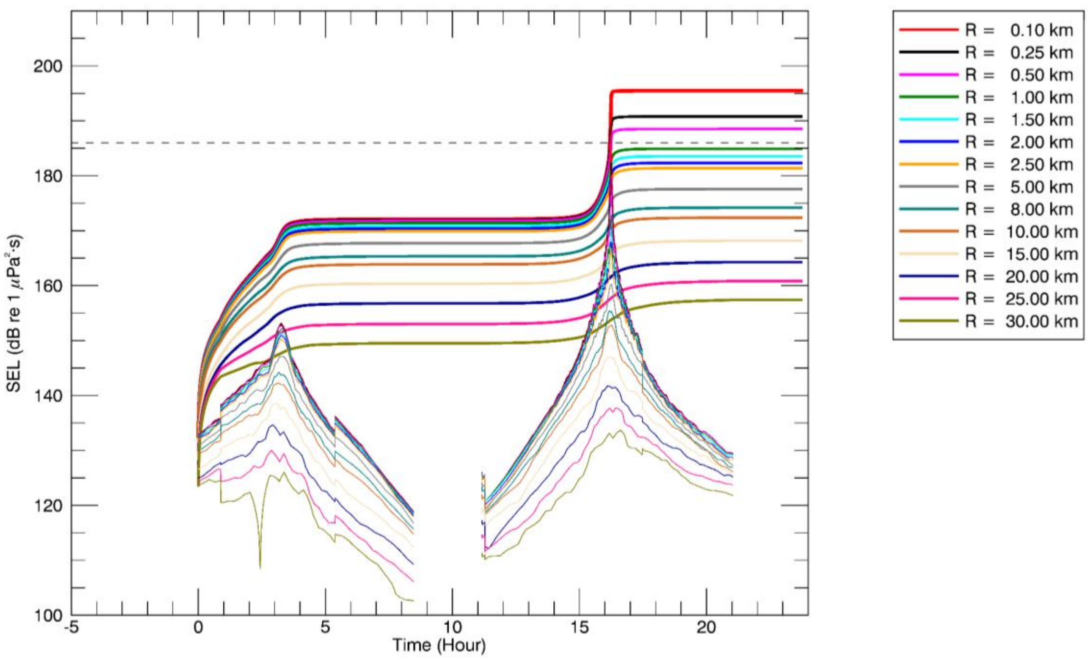

Figure 21. 2D survey, single 3150 in^3 array, static receivers: Maximum-over-depth per-pulse unweighted SEL (thin lines) and accumulated unweighted SEL (thick lines) for fourteen receivers (denoted by R) located at increasing distance from the survey lines. Gaps in the per-pulse curves correspond to vessel turns. The horizontal black dashed line corresponds to the fish TTS threshold of 186 dB re 1 μPa^2·s.

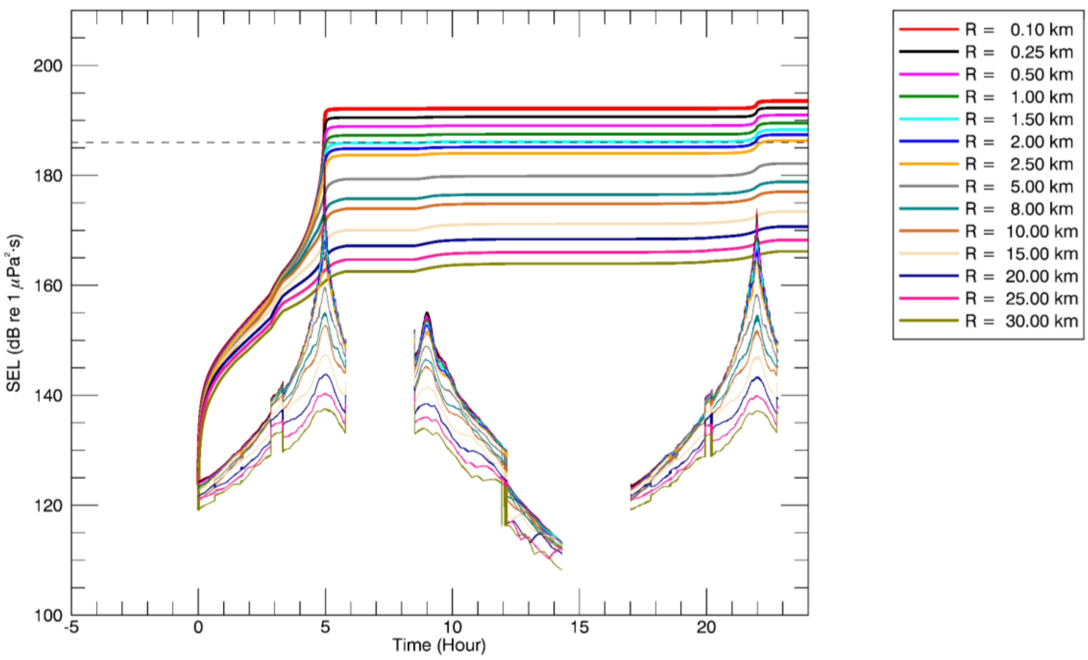

Figure 22. 3D survey, triple 2495 in^3 array, inshore static receivers: Maximum-over-depth per-pulse unweighted SEL (thin lines) and accumulated unweighted SEL (thick lines) for fourteen receivers (denoted by R) located at increasing distance from the survey lines. Gaps in the per-pulse curves correspond to vessel turns. The horizontal black dashed line corresponds to the fish TTS threshold of 186 dB re 1 μPa^2·s.

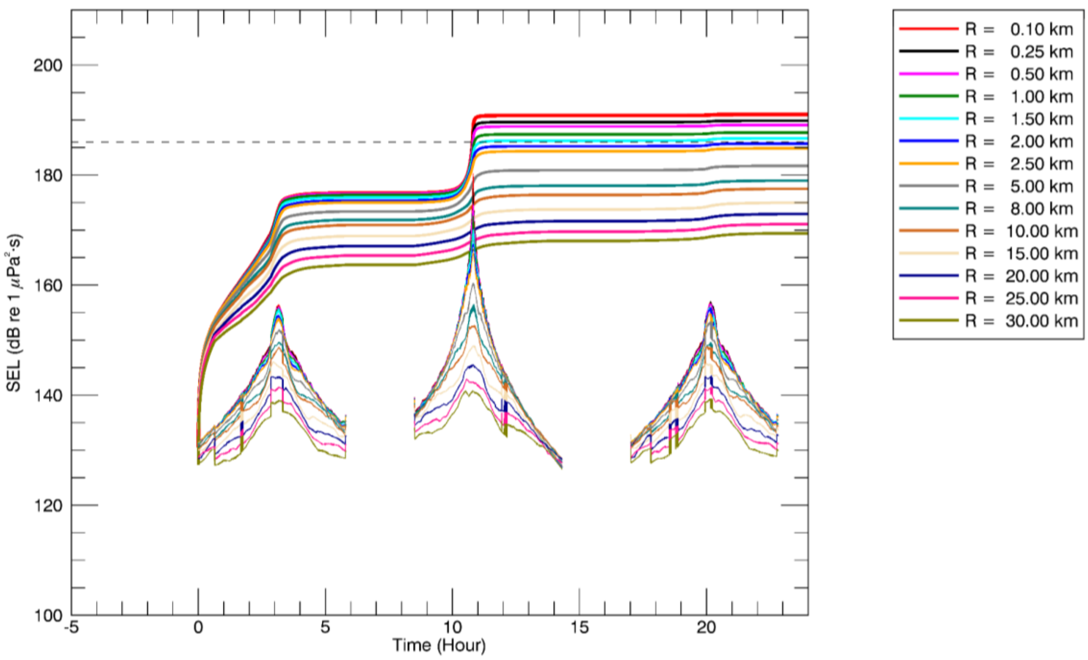

Figure 23. 3D survey, triple 2495 in^3 array, offshore static receivers: Maximum-over-depth per-pulse unweighted SEL (thin lines) and accumulated unweighted SEL (thick lines) for fourteen receivers (denoted by R) located at increasing distance from the survey lines. Gaps in the per-pulse curves correspond to vessel turns. The horizontal black dashed line corresponds to the fish TTS threshold of 186 dB re 1 μPa^2·s.

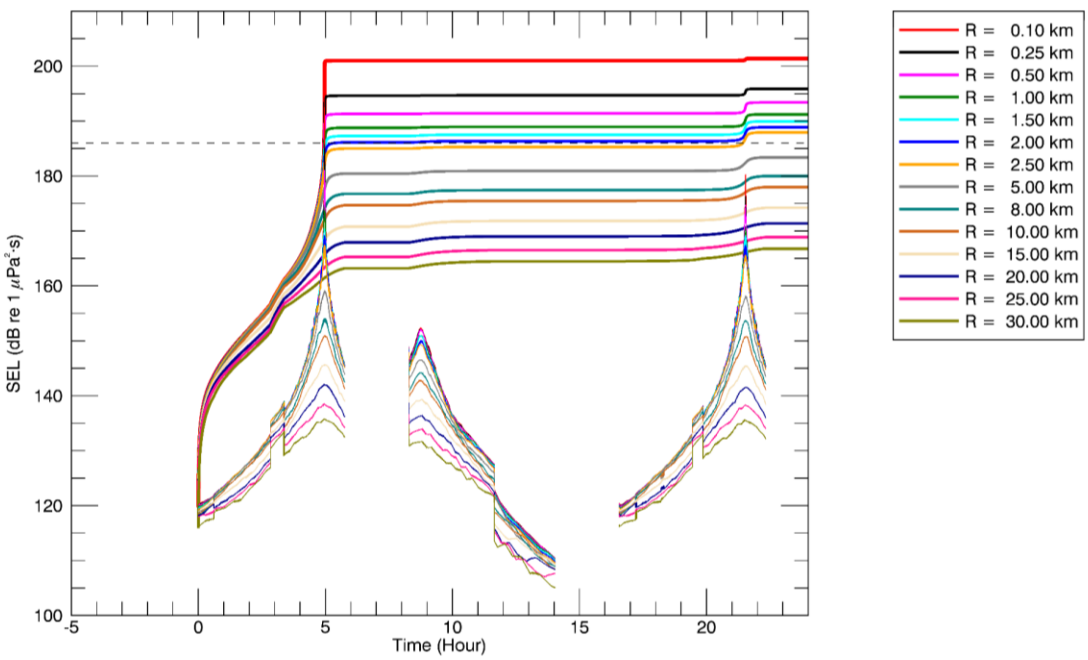

Figure 24. 3D survey, penta 1510 in^3 array, inshore static receivers: Maximum-over-depth per-pulse unweighted SEL (thin lines) and accumulated unweighted SEL (thick lines) for fourteen receivers (denoted by R) located at increasing distance from the survey lines. Gaps in the per-pulse curves correspond to vessel turns. The horizontal black dashed line corresponds to the fish TTS threshold of 186 dB re 1 μPa^2·s.

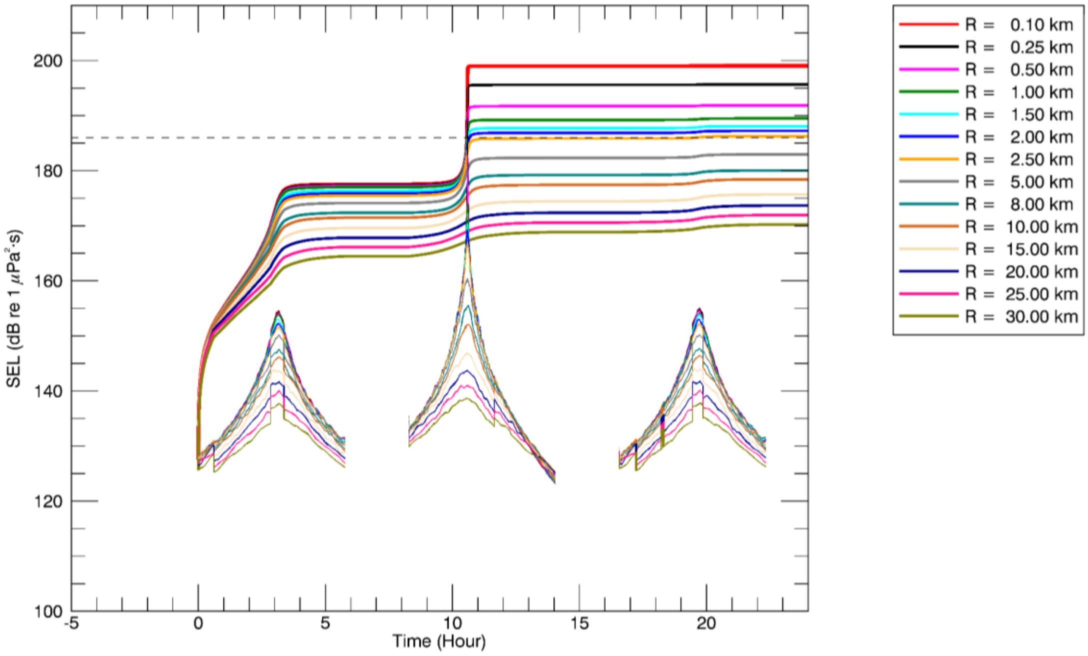

Figure 25. 3D survey, penta 1510 in^3 array, offshore static receivers: Maximum-over-depth per-pulse unweighted SEL (thin lines) and accumulated unweighted SEL (thick lines) for fourteen receivers (denoted by R) located at increasing distance from the survey lines. Gaps in the per-pulse curves correspond to vessel turns. The horizontal black dashed line corresponds to the fish TTS threshold of 186 dB re 1 μPa^2·s.

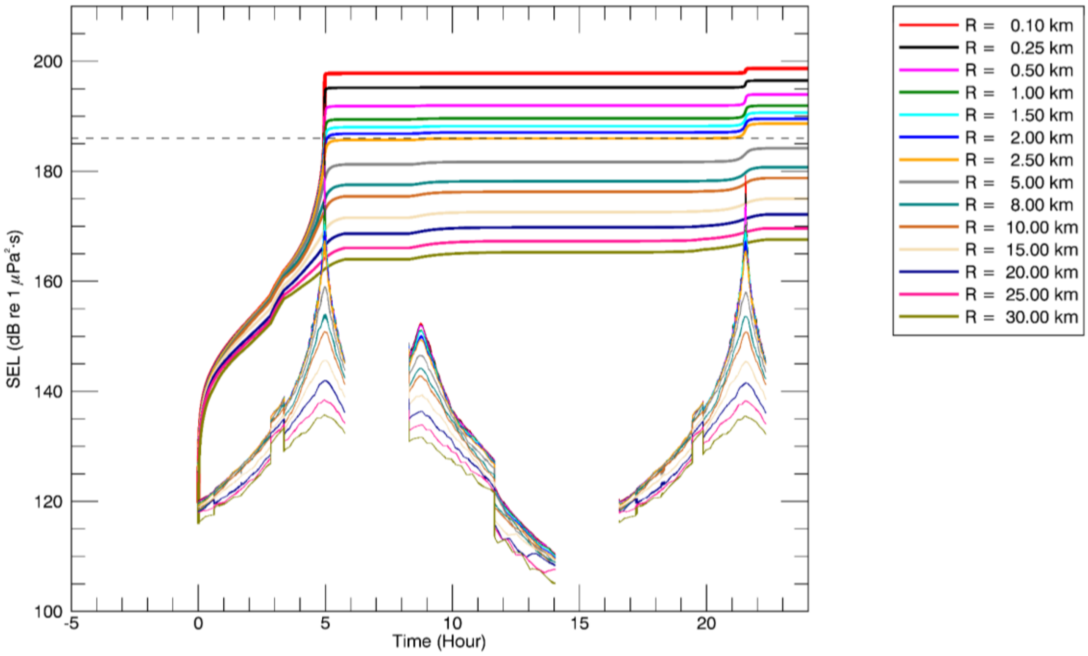

Figure 26. 3D survey, hexa 1510 in^3 array, inshore static receivers: Maximum-over-depth per-pulse unweighted SEL (thin lines) and accumulated unweighted SEL (thick lines) for fourteen receivers (denoted by R) located at increasing distance from the survey lines. Gaps in the per-pulse curves correspond to vessel turns. The horizontal black dashed line corresponds to the fish TTS threshold of 186 dB re 1 μPa^2·s.

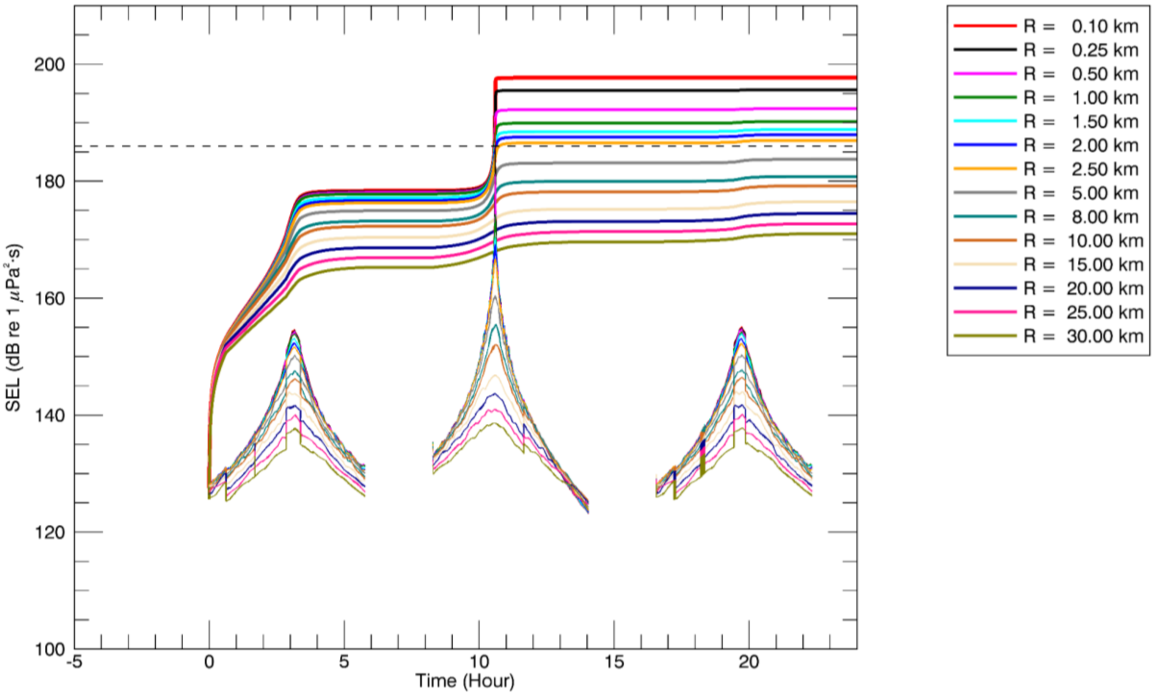

Figure 27. 3D survey, hexa 1510 in^3 array, offshore static receivers: Maximum-over-depth per-pulse unweighted SEL (thin lines) and accumulated unweighted SEL (thick lines) for fourteen receivers (denoted by R) located at increasing distance from the survey lines. Gaps in the per-pulse curves correspond to vessel turns. The horizontal black dashed line corresponds to the fish TTS threshold of 186 dB re 1 μPa^2·s.

The accumulated SEL results are also presented for several different time windows centred around periods corresponding to the closest point of approach (CPA). Table 23 shows the estimated isopleth ranges based on the static receiver locations to the fish TTS threshold of 186 dB re 1 μPa^2·s for water column and seafloor receptors for the considered SEL_{24h} scenarios. The ranges presented below were estimated by interpolating the receiver range where received levels drop below the threshold. Since all receiver locations were defined as perpendicular to survey lines, they represent an estimate of the perpendicular distance from the survey line to the relevant threshold; however, they are particular to that specific point along the line. The range for the full 24 h accumulated SEL, estimated by the same method, is also provided for comparison.

Figures 28 to 34 show the per-pulse SEL and SEL accumulated in the considered time windows around the CPA maxima as an example of the method described above.

Table 23. Distances to maximum-over-depth and seafloor static receiver SEL_{24h} based fish TTS criteria for the time windows for the considered receiver locations.

Marine fauna group	SEL_{24h} threshold ($L_{E,24h}$; dB re 1 µPa²·s)	Static Receiver	Distance (km)			
			1 h	2 h	3 h	4 h
2D survey, single 3150 in³ array						
Fish TTS I, II, III	186	Maximum-over-depth	0.74	0.76	0.77	0.77
		Seafloor	0.72	0.74	0.75	0.75
3D survey, triple 2495 in³ array						
Fish TTS I, II, III	186	Maximum-over-depth	1.37	1.44	1.45	1.46
		Seafloor	1.31	1.37	1.38	1.38
3D survey, penta 1510 in³ array						
Fish TTS I, II, III	186	Maximum-over-depth	2.07	2.11	2.12	2.12
		Seafloor	2.04	2.06	2.07	2.07
3D survey, hexa 1510 in³ array						
Fish TTS I, II, III	186	Maximum-over-depth	2.30	2.52	2.54	2.55
		Seafloor	2.16	2.19	2.20	2.20

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.

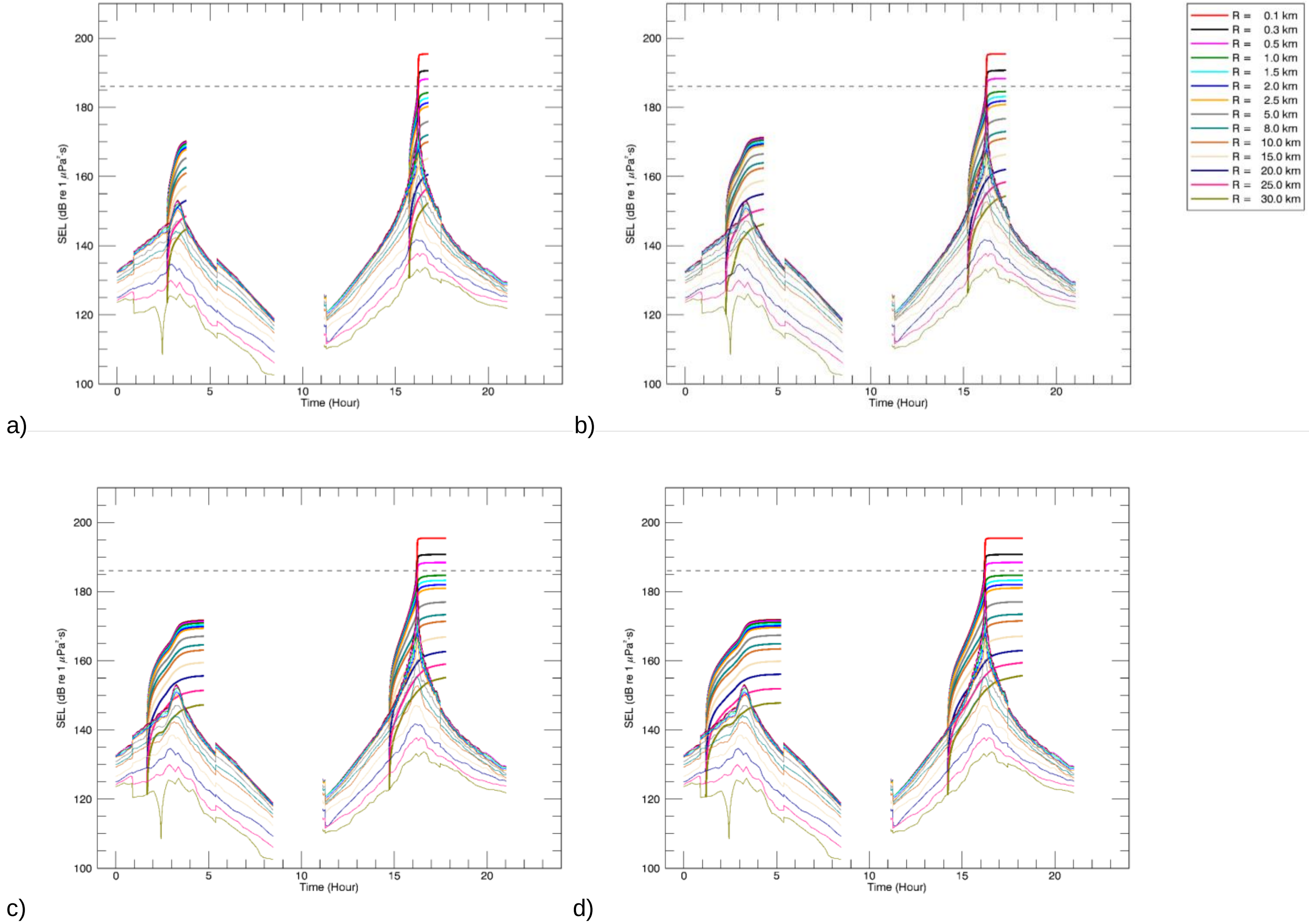

Figure 28. 2D survey, single 3150 in^3 array, static receivers: Maximum-over-depth per-pulse unweighted SEL (thin lines) and accumulated unweighted SEL (thick lines) within specified time windows around the closest point of approach for fourteen receivers (denoted by R) located at increasing distance from the survey lines. The plots show accumulation over a) 1, b) 2, c) 3, and d) 4 h windows around the closest point of approach, respectively. Gaps in the per-pulse curves correspond to vessel turns. The horizontal black dashed line corresponds to the fish TTS threshold of 186 dB re 1 µPa^2·s.

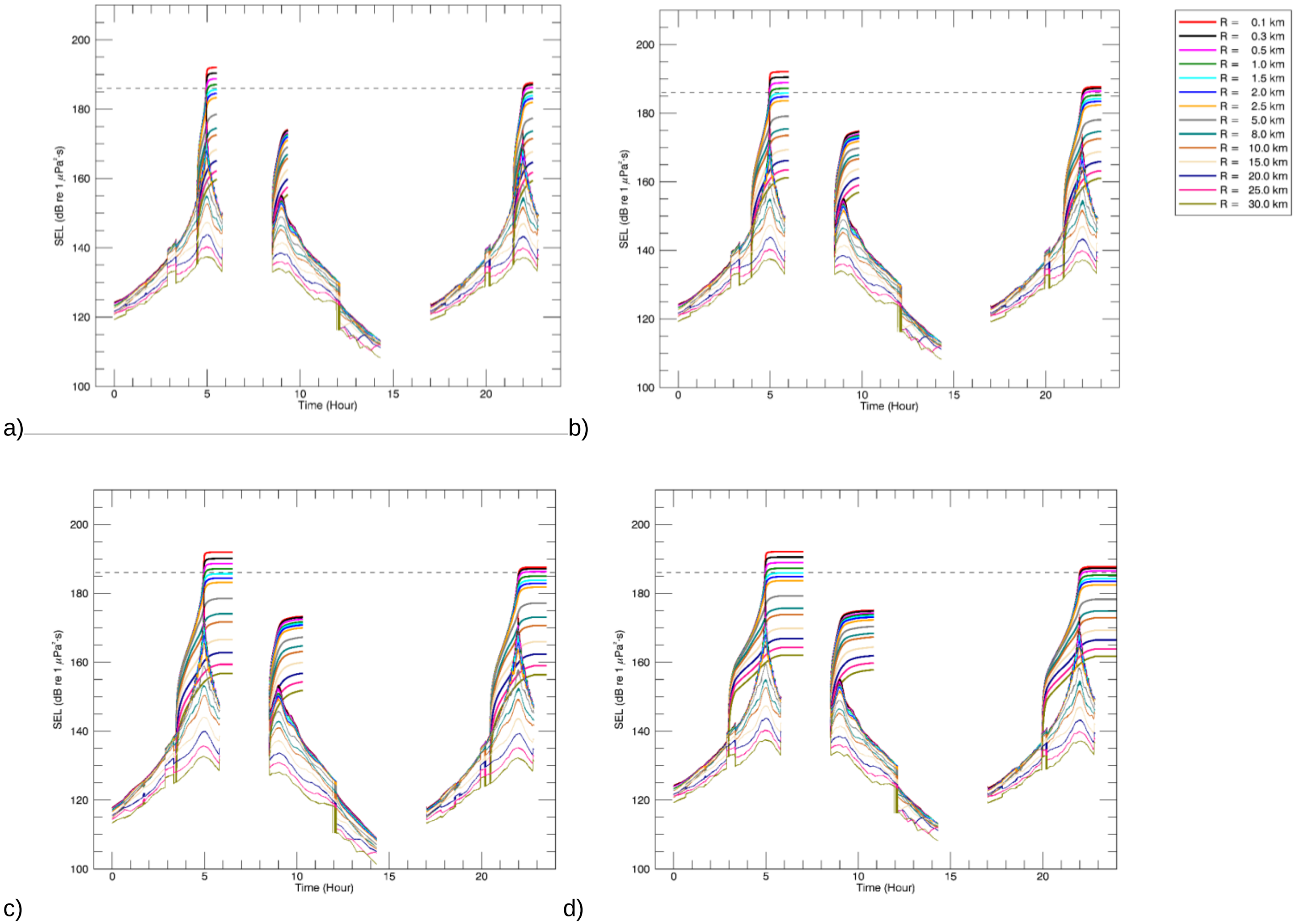

Figure 29. 3D survey, triple 2495 in^3 array, inshore static receivers: Maximum-over-depth per-pulse unweighted SEL (thin lines) and accumulated unweighted SEL (thick lines) within specified time windows around the closest point of approach for fourteen receivers (denoted by R) located at increasing distance from the survey lines. The plots show accumulation over a) 1, b) 2, c) 3, and d) 4 h windows around the closest point of approach, respectively. Gaps in the per-pulse curves correspond to vessel turns. The horizontal black dashed line corresponds to the fish TTS threshold of 186 dB re 1 µPa^2·s.

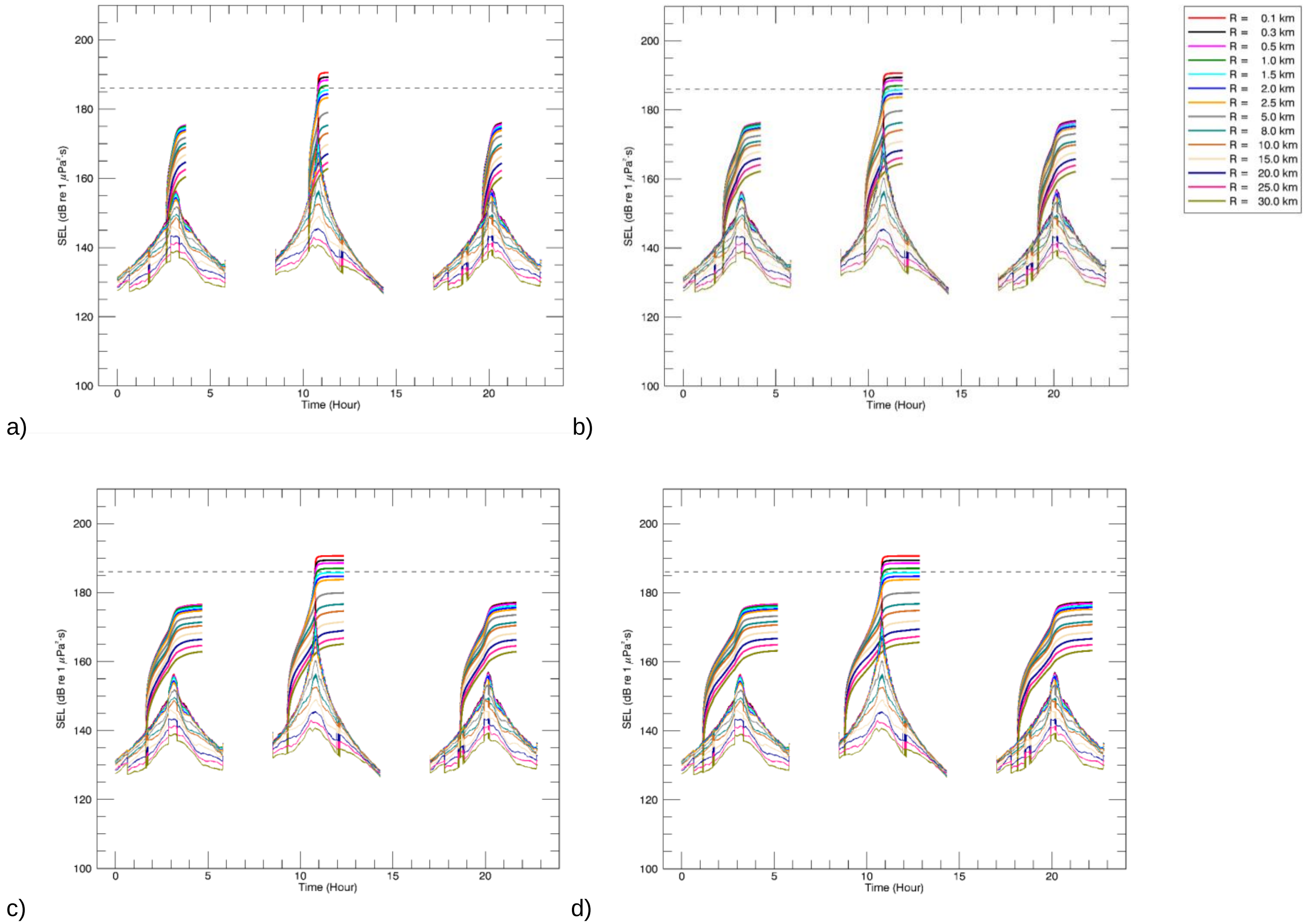

Figure 30. 3D survey, triple 2495 in^3 array, offshore static receivers: Maximum-over-depth per-pulse unweighted SEL (thin lines) and accumulated unweighted SEL (thick lines) within specified time windows around the closest point of approach for fourteen receivers (denoted by R) located at increasing distance from the survey lines. The plots show accumulation over a) 1, b) 2, c) 3, and d) 4 h windows around the closest point of approach, respectively. Gaps in the per-pulse curves correspond to vessel turns. The horizontal black dashed line corresponds to the fish TTS threshold of 186 dB re 1 μPa^2·s.

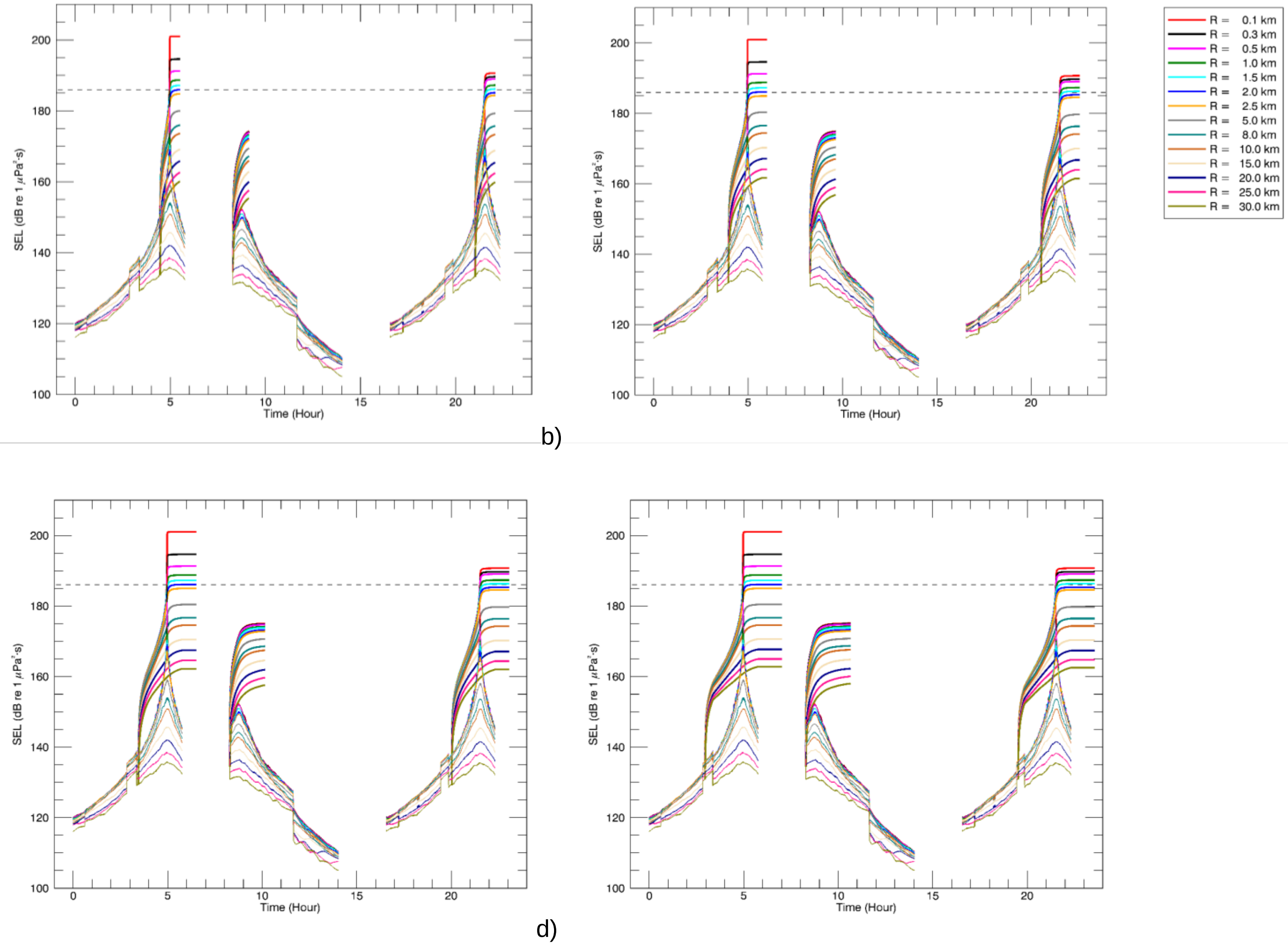

Figure 31. 3D survey, penta 1510 in^3 array, inshore static receivers: Maximum-over-depth per-pulse unweighted SEL (thin lines) and accumulated unweighted SEL (thick lines) within specified time windows around the closest point of approach for fourteen receivers (denoted by R) located at increasing distance from the survey lines. The plots show accumulation over a) 1, b) 2, c) 3, and d) 4 h windows around the closest point of approach, respectively. Gaps in the per-pulse curves correspond to vessel turns. The horizontal black dashed line corresponds to the fish TTS threshold of 186 dB re 1 μPa^2·s.

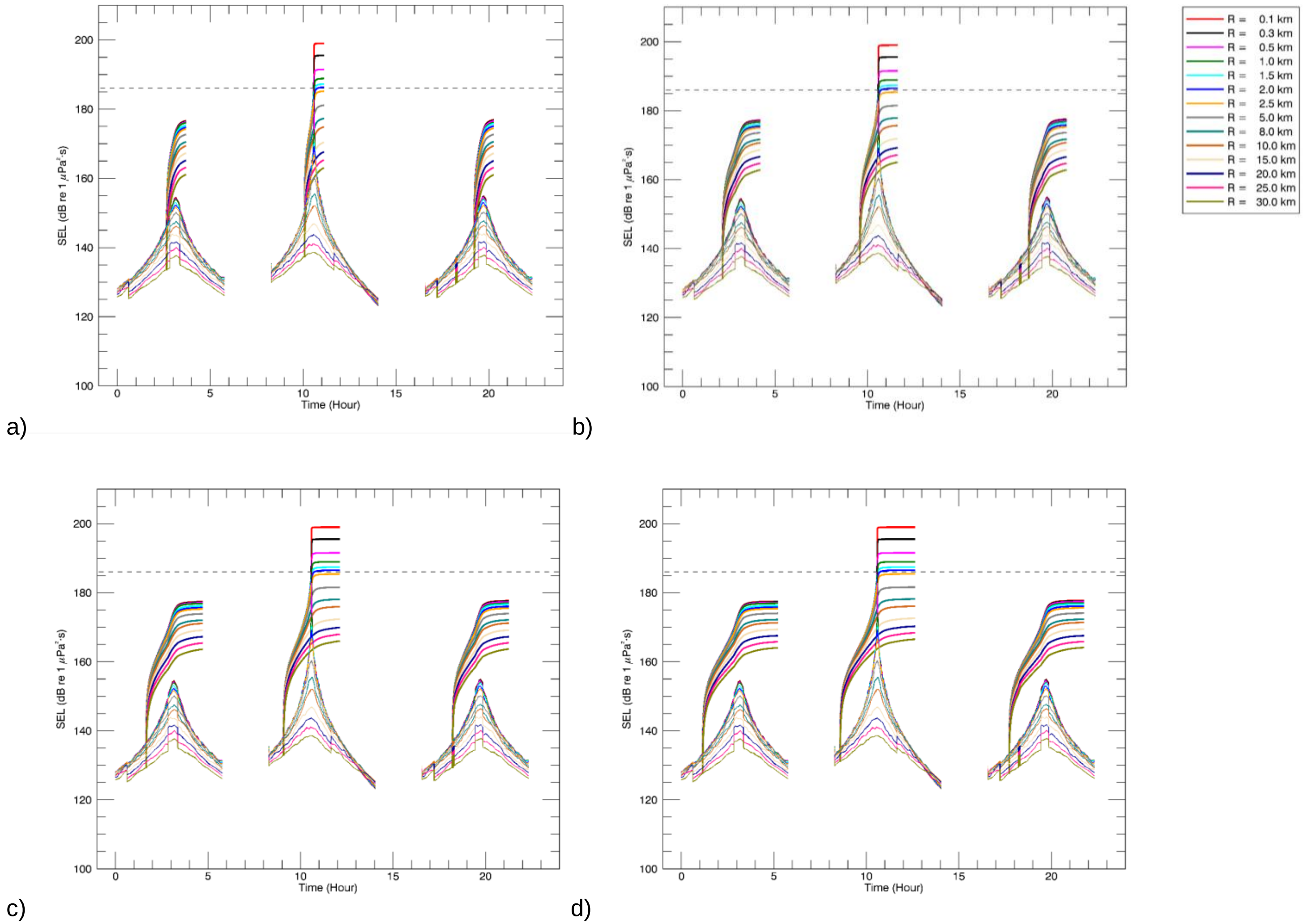

Figure 32. 3D survey, penta 1510 in^3 array, offshore static receivers: Maximum-over-depth per-pulse unweighted SEL (thin lines) and accumulated unweighted SEL (thick lines) within specified time windows around the closest point of approach for fourteen receivers (denoted by R) located at increasing distance from the survey lines. The plots show accumulation over a) 1, b) 2, c) 3, and d) 4 h windows around the closest point of approach, respectively. Gaps in the per-pulse curves correspond to vessel turns. The horizontal black dashed line corresponds to the fish TTS threshold of 186 dB re 1 μPa^2·s.

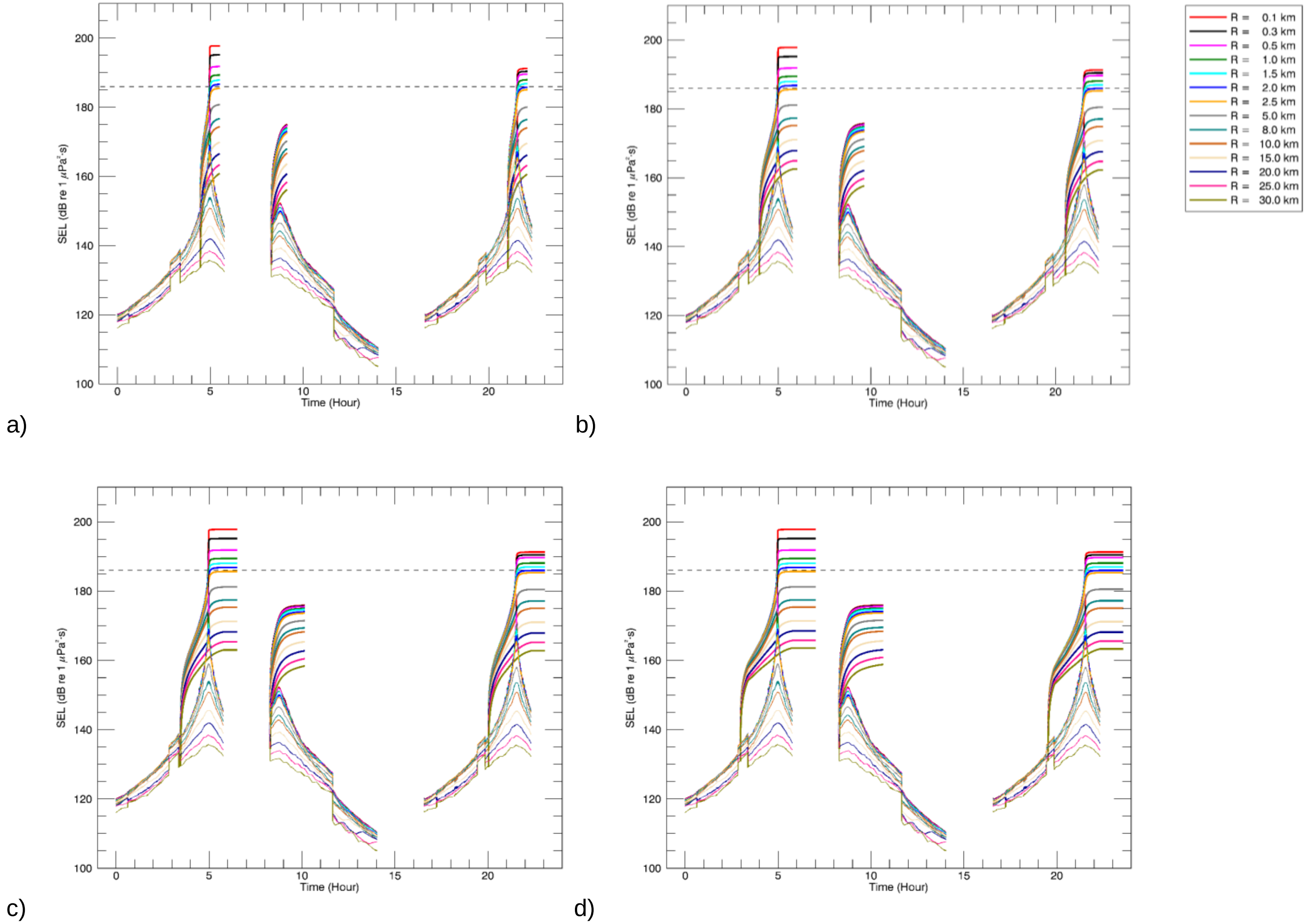

Figure 33. 3D survey, hexa 1510 in^3 array, inshore static receivers: Maximum-over-depth per-pulse unweighted SEL (thin lines) and accumulated unweighted SEL (thick lines) within specified time windows around the closest point of approach for fourteen receivers (denoted by R) located at increasing distance from the survey lines. The plots show accumulation over a) 1, b) 2, c) 3, and d) 4 h windows around the closest point of approach, respectively. Gaps in the per-pulse curves correspond to vessel turns. The horizontal black dashed line corresponds to the fish TTS threshold of 186 dB re 1 µPa^2·s.

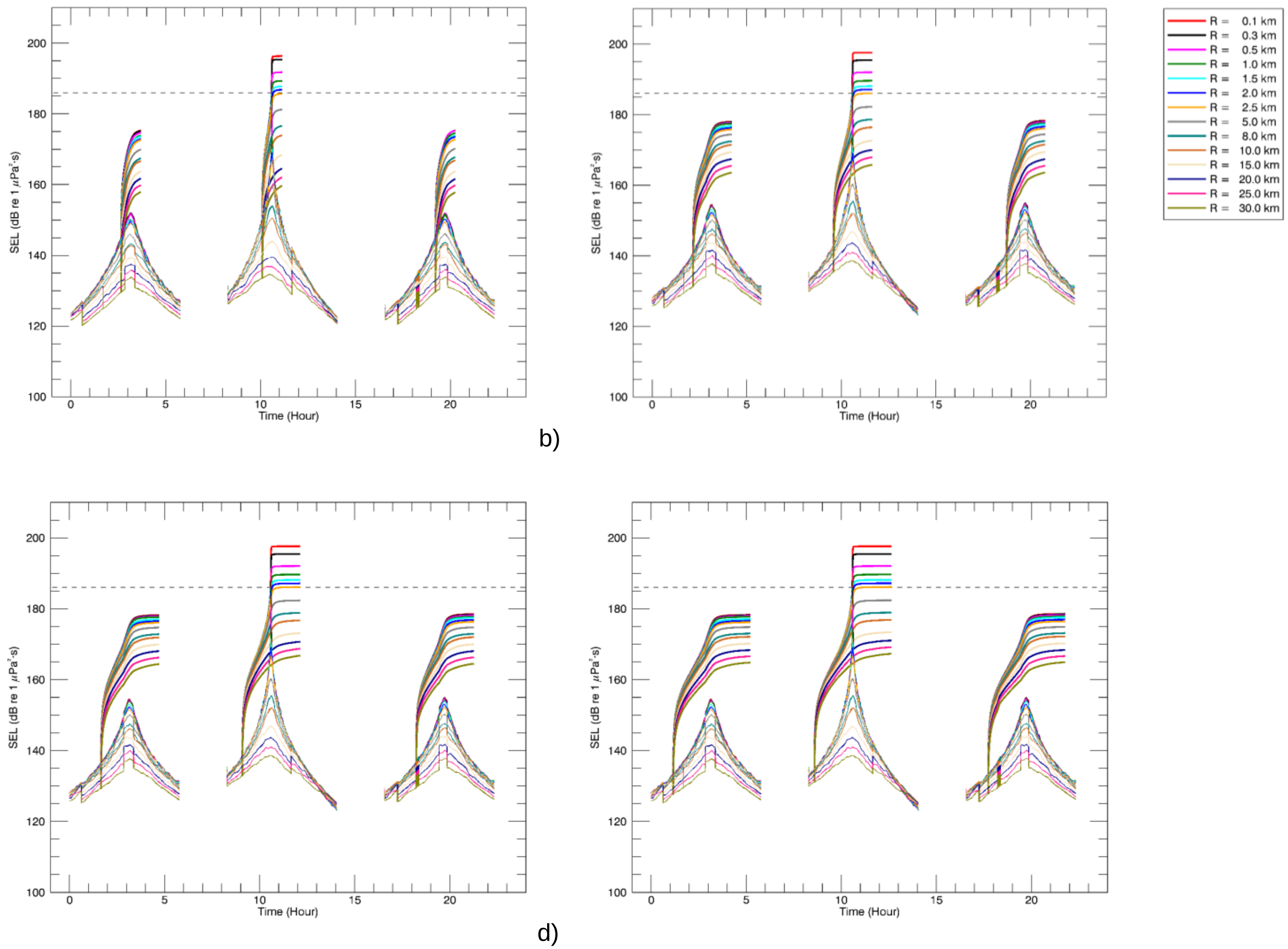

Figure 34. 3D survey, hexa 1510 in^3 array, offshore static receivers: Maximum-over-depth per-pulse unweighted SEL (thin lines) and accumulated unweighted SEL (thick lines) within specified time windows around the closest point of approach for fourteen receivers (denoted by R) located at increasing distance from the survey lines. The plots show accumulation over a) 1, b) 2, c) 3, and d) 4 h windows around the closest point of approach, respectively. Gaps in the per-pulse curves correspond to vessel turns. The horizontal black dashed line corresponds to the fish TTS threshold of 186 dB re 1 µPa^2·s.

6. Discussion and Conclusion

This modelling study predicted underwater sound levels associated with the planned Galactic Hybrid 2D/3D MSS. The underwater sound field was modelled for a single 3150 in^3 seismic source for the 2D survey line plan, and a triple 2495 in^3 seismic source, a penta 1510 in^3 seismic source, and a hexa 1510 in^3 seismic source for the 3D survey line plan (Appendix C.5).

An analysis of seasonal sound speed profiles for the initial potential survey time period (May to September), the results of which are presented in Appendix C.4.2, determined that the profile from May was expected to be marginally most favourable to longer-range sound propagation, and thus precautionary estimates of distances to received sound level thresholds within the water column, due to the a slight upward refracting profile in the upper 50 m. Modelling also accounted for site-specific bathymetric variations (Appendix C.4.1) and local geoacoustic properties (Appendix C.4.3).

Most acoustic energy from a seismic source is output at lower frequencies, in the tens to hundreds of hertz. The 3150 in^3 array displayed both pronounced broadside and endfire directivity at frequencies from 63-200 Hz (Figure C-20), while both the 2495 in^3 and 1510 in^3 array displayed more prominent broadside directivity at frequencies between 63-316 Hz.

The 3150 in^3 array produced a predicted broadband (5-25000 Hz) per-pulse SEL source level of 224.5 and 225.8 dB 1 μPa^{2}m^{2}s in the broadside and endfire directions respectively, and a peak source level of 247.6 and 249.4 dB 1 μPa in the same directions. The 2495 in^3 array produced a predicted broadband per-pulse SEL source level of 224.4 and 222.3 dB 1 μPa^{2}m^{2}s in the broadside and endfire directions respectively, and a peak source level of 249.1 and 245.2 dB 1 μPa in the same directions. The 1510 in^3 array produced a predicted broadband per-pulse SEL source level of 222.2 and 218.4 dB 1 μPa^{2}m^{2}s in the broadside and endfire directions respectively, and a peak source level of 249.1 and 241.2 dB 1 μPa in the same directions.

6.1. Per-Pulse Sound Levels

The per-pulse modelling sites encompassed water depths from 52.9 to 304 m across the modelled area with a single representative water column profile. At all single impulse sites the distances to identified isopleths were greater in the broadside direction than in the endfire direction, a difference apparent in all footprint maps in Section 5.2.2.1. The array directionality and frequency content coupled with the bathymetry had a considerable effect on propagation at longer distances, with generally slightly larger lobes of sound energy extending into the deeper waters. In particular a shallow obstruction within the 3D survey area (Lynedoch Bank) casts a noticeable acoustic shadow in the sound field where the noise does not transmit as easily over the shallow obstacle.

The sound speed profile (Figure C-13) was primarily downward refracting with a shallow surface duct in approximately the top 50 m. This depth of surface duct is unlikely to trap frequencies below approximately 550 Hz (Jensen et al. 2011), i.e. only frequencies contributing less to the overall broadband noise level (see Figures C-17 to C-19) are likely to propagate in this surface duct. However, when trapped, high frequencies can propagate with little loss and can produce higher levels near the sea-surface than if no duct was present.

The distances to SPL thresholds for behavioural response in marine mammals, and behavioural response and disturbance in turtles typically decrease as water depth increases (Tables 12 and 13), however various factors, such as array orientation and wider area bathymetry, have an effect on this. This is likely due to the sand geoacoustic profile, which acts as a strong reflector at steep grazing angles (close to the source). The sound field at the shallowest site (Site 1A) is not predicted to ensonify the flatback turtle habitat critical (internesting buffer) around the Tiwi Islands above the behavioural response or disturbance thresholds for sea turtles; this site is also the closest to the habitat critical boundary (Figure 4).

The distances to PK and PK-PK based criteria for fish, benthic crustaceans, and bivalves at the seafloor (Sections 3.2 and 3.4) are presented in Tables 19 and 20. The distances to these criteria for fish with no swim bladder decreased with increasing depth, but for other criteria this relationship was not always consistent. Any correlation between water depth and threshold distance is related to patterns of surface and seabed reflections that affect how sound propagates in shallow water. It is believed however that the range of modelled depths is representative of the depths in the survey area, and therefore a plausible range of results for seafloor receptors.

6.2. Particle Motion

Section 5.2.3 discuss the relevance of particle motion (acceleration) to benthic invertebrates for Site 1A, 52.9 m water depth. Particle acceleration decays rapidly away from the source location before shallow water propagation effects such as constructive interference from sea-surface and seabed reflections affect the predicted levels. Beyond approximately 125 m, the particle acceleration in both broadside and the aft endfire directions decays almost linearly, while the fore endfire signal broadly decays but with more variation in level. Particle motion traces generated during the modelling showed that vertical particle motion was larger than horizontal particle motion for receivers directly underneath or at short ranges from the array, but at longer ranges the horizontal particle motion dominated.

Day et al. (2016a) and Day et al. (2016b) included a regression of particle acceleration versus range for the single 150 in^3 airgun used in their study (minimum range of 6 m) and showed that acceleration at 10 and 100 m range was typically 26 and 5 ms^{-2}, respectively. Day et al. (2016a) and Day et al. (2016b) also referenced an unpublished maximum particle acceleration measurement of 6.2 ms^{-2} from a 3130 in^3 airgun array at 477 m range in 36 m of water. At the modelled site, predicted peak acceleration at 10 m was predicted to be between 24.7 and 46.3 ms^{-2} depending on the azimuth around the source and values at 100 m range were between 15.4 and 18.1 ms^{-2}. At ~477 m, the predicted acceleration was between 3.0-4.8 ms^{-2} in the modelled perpendicular directions. These results align with the measurements reported in Day et al. (2016a) and Day et al. (2016b), thus represents what is likely to occur.

JASCO has several measurements of particle acceleration vs distance from seismic airgun arrays made with a variety of sensor types, ranging from extremely close range in shallow water to deeper water and longer ranges. In 110 m of water over a sandy seabed we found seabed accelerations of 20 ms^{-2} at a radial closest point of approach (CPA) distance of 15 m. In much shallower waters, accelerations in excess of 40 ms^{-2} were measured at CPA distances of 50 m, and higher levels again were received at close range in shallow water. The results also show that the specific conditions at each location affect the fine scale results of both modelling and measurements.

The maximum distance to a particle acceleration of the closest value to 37.57 ms^{-2}, determined for comparing literature, (Section 3.4.1; Day et al. (2016a), Day et al. (2016b)) is 15 m.

6.3. Multiple Pulse Sound Fields

The accumulated SEL over 24 hours of seismic source operation was modelled considering four representative scenarios with realistic acquisition patterns for the different potential surveys and seismic sources considered for the Galactic Hybrid 2D/3D MSS. The modelling predicted the accumulation of sound energy, considering the change in location and the azimuth of the relevant source at each pulse point, which was 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 SEL_{24h} criteria are influenced by the locations of the single impulse modelling sites used to predict the accumulated sound field. However, the effect of the obstruction within the 3D survey line plan (Lynedoch Bank) does not feature in the SEL_{24h} sound field maps for any of the three seismic sources considered for these lines since the movement of the source along the lines has the effect of “blurring” this feature in the accumulated field.

Generally, as with the per-pulse sound fields, the largest ranges to isopleths are encountered where the broadside direction of the array aligns with the deeper water (see Figures 13 to 20). For the 3D survey, the ranges and ensonified areas for higher level thresholds are larger around the southeast lines where two adjacent lines are acquired within the 24-hour period and both lines contribute to the localised sound field.

Ranges to marine mammal and sea turtle impact criteria are largest for the 3D survey using the 1510 in^3 hexa array and shortest for the 2D survey using the single 3150 in^3 array, with ranges for the 3D survey using the triple 2495 in^3 triple array and 1510 in^3 penta array falling between the two. Despite the 3150 in^3 array having the highest per-pulse source levels and the 1510 in^3 array the lowest, the difference in predicted ranges can be attributed to the large difference in the number of seismic impulses considered. For example, the 3D line pattern using the triple 2495 in^3 array and hexa 1510 in^3 array considered almost double and quadruple the number of seismic impulses respectively of the 2D line pattern using the 3150 in^3 array, and the accumulated SEL is logarithmically proportional to the number of seismic pulses within the 24-hour time window (see Equation A-5). For thresholds with larger ranges (e.g. low-frequency cetacean TTS) the difference between scenarios is less pronounced where the directionality and spectral characteristics of the considered sources have more of an effect on the predicted ranges.

6.3.1. Time histories and accumulated levels at static receivers

Sound exposure levels were also modelled at static receivers located at various perpendicular offset distances from the closest survey line for each of the four survey line and seismic source combinations (Figures 21 to 27). This provides a sense for the accumulation of acoustic energy as the seismic source acquires multiple lines over a 24 h period. The resulting time histories of accumulated SEL show that the single nearest pass of the seismic source(s) to a receiver will account for the majority of exposure over the 24 h period regardless of whether it occurs earlier or later, and additional passes after that one nearest exposure event will not add appreciably to the total level. This is evident in the graphs for the inshore receivers for the 3D survey line plan (Figures 22, 24 and 26). This set of receivers is closest to the end of the first and third lines, and while the overall accumulated SEL rises fairly rapidly approaching the CPA along the first line, it does not significantly increase during the CPA along the third line.

The time history of the accumulated and per-pulse SEL depends on the spatial offset between source and receiver points; as well as, the shape and extent of the isopleths for each of the single impulse sites, which depend on the local environmental properties. The per-pulse time histories are sensitive to the single impulse site isopleths, which can lead to local ‘jumps’ in the shape of the curves when the local environmental properties differ between adjacent impulses. This is due to the approach of using a discrete number of modelled sites to represent the individual impulse sites within each scenario. However, for the accumulated SEL time histories, as well as the 24 h SEL assessments, larger scale sound propagation features dominated the accumulated and cumulative field as indicated by the smooth accumulated SEL time history curves.

An examination of the accumulation of sound exposure in 1–4 h windows centred around the CPAs for all scenarios and receiver sets (Table 23 and Figures 28 to 34) illustrate the effect of receiver location relative to the acquisition lines. In all cases, there was no significant difference between the TTS range between the 1–4 h windows around the CPA. Given the considerations in Popper (2018) for types of fish that are assumed to not move away from a surveying vessel and therefore experience TTS, accumulation of energy over longer periods than a few hours is likely inappropriate. For the receiver locations selected, only one high-level exposure event will likely occur per 24 h for the 2D survey line plan or two events for the 3D survey line plan, approximately 17 hours apart. For the scenarios considered, the ranges to TTS with only a 1–4 h window is more biologically appropriate, and these distances would therefore relate only to one acquisition line. For these fish, recovery could begin a few hours after exposure (not considering the time between pulses). In the considered scenarios, if these fish remained stationary, they are not predicted to experience another high-level exposure until the next most proximal pass of the source.

6.4. Summary

This section presents summary of the distances to the noise effect criteria applied in this study (Section 3) as relevant to the impact assessment. The impact criteria for impairment of marine mammals, fish and sea turtles use dual metrics (PK and SEL_{24h}), and the longest distance associated with either metric is required to be applied, and thus is presented in this summary.

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. Where the corresponding SEL_{24h} radii for are larger than those for peak pressure criteria, they often represent an unlikely worst-case scenario. More realistically, marine mammals, fish and sea turtles would not stay in the same location for 24 hours, but rather a shorter period, depending upon their behaviour and the proximity and movements of the source. Therefore, a reported radius for SEL_{24h} criteria does not mean that marine fauna travelling within this radius of the source will be impaired, but rather that an animal could be exposed to the sound level associated with impairment (either PTS or TTS) if it remained in that location for 24 hours.

Marine mammals

- Table 24 summarises the distances to criteria for marine mammals.

Table 24. Maximum (R_{max}) horizontal distances (in km) from modelled sites or scenario lines to behavioural response thresholds, and PTS and TTS thresholds for marine mammals and the metric associated with the stated distance (PK values from Tables 16 to 18, SEL_{24h} values from Table 21, and SPL values from Tables 12 and 13).

Relevant hearing group	Effect Threshold	2D Survey/Well-tie		3D Survey					
		Single 3150 in³ source		Triple 2495 in³ source		Penta 1510 in³ source		Hexa 1510 in³ source	
		Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)
Low-frequency cetaceans[1]	PTS	SEL_{24h}	0.40	SEL_{24h}	2.08	SEL_{24h}	2.60	SEL_{24h}	3.11
	TTS	SEL_{24h}	17.2	SEL_{24h}	25.5	SEL_{24h}	24.7	SEL_{24h}	26.6
Mid-frequency cetaceans[1]	PTS	SEL_{24h}	<0.02	SEL_{24h}	0.14	SEL_{24h}	0.12	SEL_{24h}	0.14
	TTS	SEL_{24h}	<0.02	SEL_{24h}	0.14	SEL_{24h}	0.12	SEL_{24h}	0.14
High-frequency cetaceans[1]	PTS	PK	0.29	PK	0.38	PK	0.39	PK	0.39
	TTS	PK	0.66	PK	0.73	PK	0.80	PK	0.80
Sirenians[1]	PTS	–	–	–	–	–	–	–	–
	TTS	PK	0.03	SEL_{24h}	0.14	SEL_{24h}	0.12	SEL_{24h}	0.14
All Marine mammals, behavioural response[2]		SPL	9.00	SPL	7.99	SPL	7.09	SPL	7.09

A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).
[1] Noise exposure criteria: NMFS (2018)
[2] Noise exposure criteria: NOAA (2019)

Sea turtles

- Table 25 summarises the distances to criteria for sea turtles.

Table 25. Maximum (R_{max}) horizontal distances (in km) from modelled sites or scenarios to behavioural response thresholds and PTS and TTS thresholds for sea turtles and the metric associated with the stated distance (PK values from Tables 16 to 18, SEL_{24h} values from Table 21, and SPL values from Tables 12 and 13).

Hearing group	Effect Threshold	2D Survey/Well-tie		3D Survey					
		Single 3150 in³ source		Triple 2495 in³ source		Penta 1510 in³ source		Hexa 1510 in³ source	
		Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)
Turtles	Behavioural response[1]	SPL	4.04	SPL	4.55	SPL	3.76	SPL	3.76
	Behavioural disturbance[2]	SPL	1.84	SPL	1.41	SPL	1.30	SPL	1.30
	PTS[3]	SEL_{24h}	<0.02	SEL_{24h}	0.14	SEL_{24h}	0.13	SEL_{24h}	0.16
	TTS[3]	SEL_{24h}	0.16	SEL_{24h}	0.74	SEL_{24h}	1.42	SEL_{24h}	1.69

[1] Noise exposure criteria: NSF (2011)
[2] Noise exposure criteria: McCauley et al. (2000a)
[3] Noise exposure criteria: Finneran et al. (2017)

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 as well as 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 26 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 26. Summary of maximum fish, fish eggs, and larvae injury and TTS onset distances for single impulse and SEL_{24h} modelled scenarios for the entire water column and receivers at the seafloor only. Water column PK from Tables 16 to 18, and SEL_{24h} values from Table 22, seafloor PK and SEL_{24h} values from Tables 19 and Table 22 respectively.

Relevant hearing group	Effect Threshold	Entire water column							
		2D Survey/Well-tie		3D Survey					
		Single 3150 in^3 source		Triple 2495 in^3 source		Penta 1510 in^3 source		Hexa 1510 in^3 source	
		Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)
Fish: No swim bladder	Injury	PK	0.07	SEL_{24h}	0.14	SEL_{24h}	0.12	SEL_{24h}	0.14
	TTS	SEL_{24h}	0.90	SEL_{24h}	3.75	SEL_{24h}	4.28	SEL_{24h}	4.29
Fish: Swim bladder not involved in hearing and Swim bladder involved in hearing	Injury	PK	0.18	SEL_{24h}	0.16	PK	0.13	SEL_{24h}	0.16
	TTS	SEL_{24h}	0.90	SEL_{24h}	3.75	SEL_{24h}	4.28	SEL_{24h}	4.29
Fish eggs, and larvae	Injury	PK	0.18	PK	0.14	PK	0.13	SEL_{24h}	0.14
Relevant hearing group	Effect Threshold	Seafloor*							
		2D Survey/Well-tie		3D Survey					
		Single 3150 in^3 source		Triple 2495 in^3 source		Penta 1510 in^3 source		Hexa 1510 in^3 source	
		Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)	Metric	R_{max} (km)
Fish: No swim bladder	Injury	PK	0.10	PK	0.09	PK	0.10	PK	0.10
	TTS	SEL_{24h}	0.85	SEL_{24h}	3.36	SEL_{24h}	4.23	SEL_{24h}	4.28
Fish: Swim bladder not involved in hearing and Swim bladder involved in hearing	Injury	PK	0.21	PK	0.22	PK	0.21	PK	0.21
	TTS	SEL_{24h}	0.85	SEL_{24h}	3.36	SEL_{24h}	4.23	SEL_{24h}	4.28
Fish eggs, and larvae	Injury	PK	0.21	PK	0.22	PK	0.21	PK	0.21

* Seafloor PK values were estimated for receivers at a range of water depths rather than the specific single impulse modelled sites in Table 4, hence reported ranges may differ to those reported over the entire water column.

Invertebrates, Sponges, Coral, and Plankton

To assist with assessing the potential effects on these receptors, the following were determined:

- Bivalves: The distance where a particle acceleration of 37.57 ms^{-2} at the seafloor could occur was determined for comparing to results presented in Day et al. (2016a). The maximum distance to this particle acceleration level was 15 m (Section 5.2.3).
- Crustaceans: The sound level of 202 dB re 1 µPa PK-PK from Payne et al. (2008) was considered for seafloor sound levels; the maximum ranges across all considered water depths were 0.523, 0.631, and 0.690 km for the 3150, 2495, and 1510 in^3 arrays respectively (Table 20).

- Sponges and coral: the PK sound level at the seafloor directly underneath the seismic source was estimated at all modelled sites and compared to the sound level of 226 dB re 1 µPa PK for sponges and corals (Heyward et al. 2018); it was not reached at any of the modelled water depths for any of the modelled seismic sources (Table 19).
- Plankton: The maximum distance to potential injury in plankton, applying the threshold from Popper et al. (2014), is 0.18, 0.14 and 0.13 km for the 3150, 2495, and 1510 in^3 arrays respectively within the water column (Tables 16 to 18).

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.

A-weighting
Frequency-selective weighting for human hearing in air that is derived from the inverse of the idealized 40-phon equal loudness hearing function across frequencies.

absorption
The reduction of acoustic pressure amplitude due to acoustic particle motion energy converting to heat in the propagation medium.

attenuation
The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium.

Auditory frequency weighting (auditory weighting function, frequency-weighting function)
The process of band-pass filtering sounds to reduce the importance of inaudible or less-audible frequencies for individual species or groups of species of aquatic mammals (ISO 2017). One example is M-weighting introduced by Southall et al. (2007) to describe "Generalized frequency weightings for various functional hearing groups of marine mammals, allowing for their functional bandwidths and appropriate in characterizing auditory effects of strong sounds".

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.

bandwidth
The range of frequencies over which a sound occurs. Broadband refers to a source that produces sound over a broad range of frequencies (e.g., seismic airguns, vessels) whereas narrowband sources produce sounds over a narrow frequency range (e.g., sonar) (ANSI/ASA S1.13-2005 R2010).

bar
Unit of pressure equal to 100 kPa, which is approximately equal to the atmospheric pressure on Earth at sea level. 1 bar is equal to 10^5 Pa or 10^{11} µPa.

boxcar averaging
A signal smoothing technique that returns the averages of consecutive segments of a specified width.

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.

cetacean
Any animal in the order Cetacea. These are aquatic, mostly marine mammals and include whales, dolphins, and porpoises.

CPA
Closest Point of Approach between source and receiver.

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.

continuous sound
A sound whose sound pressure level remains above ambient sound during the observation period (ANSI/ASA S1.13-2005 R2010). A sound that gradually varies in intensity with time, for example, sound from a marine vessel.

decade
Logarithmic frequency interval whose upper bound is ten times larger than its lower bound (ISO 2006).

decidecade
One tenth of a decade (ISO 2017). Note: An alternative name for decidecade (symbol ddec) is “one-tenth decade”. A decidecade is approximately equal to one third of an octave (1 ddec ≈ 0.3322 oct) and for this reason is sometimes referred to as a “one-third octave”.

decidecade band
Frequency band whose bandwidth is one decidecade. Note: The bandwidth of a decidecade band increases with increasing centre frequency.

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.

fast-average sound pressure level
The time-averaged sound pressure levels calculated over the duration of a pulse (e.g., 90%-energy time window), using the leaky time integrator from Plomp and Bouman (1959) and a time constant of 125 ms. Typically used only for pulsed sounds.

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.

hearing threshold
The sound pressure level for any frequency of the hearing group that is barely audible for a given individual in the absence of significant background noise during a specific percentage of experimental trials.

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: $\mu Pa^2/Hz$.

median
The 50th percentile of a statistical distribution.

mid-frequency (MF) cetacean
The functional cetacean hearing group that represents those odontocetes (toothed whales) specialized for mid-frequency hearing.

mysticete
Mysticeti, a suborder of cetaceans, use their baleen plates, rather than teeth, to filter food from water. They are not known to echolocate, but they use sound for communication. Members of this group include rorquals (Balaenopteridae), right whales (Balaenidae), and grey whales (*Eschrichtius robustus*).

non-impulsive sound
Sound that is broadband, narrowband or tonal, brief or prolonged, continuous or intermittent, and typically does not have a high peak pressure with rapid rise time (typically only small fluctuations in decibel level) that impulsive signals have (ANSI/ASA S3.20-1995 R2008). For example, marine vessels, aircraft, machinery, construction, and vibratory pile driving (NIOSH 1998, NOAA 2015).

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.

odontocete
The presence of teeth, rather than baleen, characterizes these whales. Members of the Odontoceti are a suborder of cetaceans, a group comprised of whales, dolphins, and porpoises. The skulls of toothed whales are mostly asymmetric, an adaptation for their echolocation. This group includes sperm whales, killer whales, belugas, narwhals, dolphins, and porpoises.

otariid
A common term used to describe members of the Otariidae, eared seals, commonly called sea lions and fur seals. Otariids are adapted to a semi-aquatic life; they use their large fore flippers for propulsion. Their ears distinguish them from phocids. Otariids are one of the three main groups in the superfamily Pinnipedia; the other two groups are phocids and walrus.

otariid pinnipeds in water (OPW)
The functional pinniped hearing group that represents eared seals under water.

parabolic equation method
A computationally efficient solution to the acoustic wave equation that is used to model transmission loss. The parabolic equation approximation omits effects of back-scattered sound, simplifying the computation of transmission loss. The effect of back-scattered sound is negligible for most ocean-acoustic propagation problems.

particle acceleration
The rate of change of particle velocity. Unit: metre per second squared (m/s^2). Symbol: *a*.

particle velocity
The physical speed of a particle in a material moving back and forth in the direction of the pressure wave. Unit: metre per second (m/s). Symbol: *v*.

peak pressure level (PK)
The maximum instantaneous sound pressure level, in a stated frequency band, within a stated period. Also called zero-to-peak pressure level. Unit: decibel (dB).

peak-to-peak pressure level (PK-PK)
The difference between the maximum and minimum instantaneous pressure levels. Unit: decibel (dB).

percentile level, exceedance
The sound level exceeded *n*% of the time during a measurement.

permanent threshold shift (PTS)
A permanent loss of hearing sensitivity caused by excessive noise exposure. PTS is considered auditory injury.

phocid
A common term used to describe all members of the family Phocidae. These true/earless seals are more adapted to in-water life than are otariids, which have more terrestrial adaptations. Phocids use their hind flippers to propel themselves. Phocids are one of the three main groups in the superfamily Pinnipedia; the other two groups are otariids and walrus.

phocid pinnipeds in water (PPW)
The functional pinniped hearing group that represents true/earless seals under water.

pinniped
A common term used to describe all three groups that form the superfamily Pinnipedia: phocids (true seals or earless seals), otariids (eared seals or fur seals and sea lions), and walrus.

point source
A source that radiates sound as if from a single point (ANSI S1.1-1994 R2004).

power spectrum density
Generic term, formally defined as power in W/Hz, but sometimes loosely used to refer to the spectral density of other parameters such as square pressure or time-integrated square pressure.

pressure, acoustic
The deviation from the ambient hydrostatic pressure caused by a sound wave. Also called overpressure. Unit: pascal (Pa). Symbol: *p*.

pressure, hydrostatic
The pressure at any given depth in a static liquid that is the result of the weight of the liquid acting on a unit area at that depth, plus any pressure acting on the surface of the liquid. Unit: pascal (Pa).

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 pressure level (SPL)
The decibel ratio of the time-mean-square sound pressure, in a stated frequency band, to the square of the reference sound pressure (ANSI S1.1-1994 R2004).

For sound in water, the reference sound pressure is one micropascal (p_0 = 1 µPa) and the unit for SPL is dB re 1 μPa^2:

$$L_p = 10 \log_{10}(p^2/p_0^2) = 20 \log_{10}(p/p_0)$$

Unless otherwise stated, SPL refers to the root-mean-square (rms) pressure level. See also 90% sound pressure level and fast-average sound pressure level. Non-rectangular time window functions may be applied during calculation of the rms value, in which case the SPL unit should identify the window type.

sound speed profile
The speed of sound in the water column as a function of depth below the water surface.

source level (SL)
The sound level measured in the far-field and scaled back to a standard reference distance of 1 metre from the acoustic centre of the source. Unit: dB re 1 µPa·m (pressure level) or dB re 1 $\mu Pa^2 \cdot s \cdot m$ (exposure level).

spectrum
An acoustic signal represented in terms of its power, energy, mean-square sound pressure, or sound exposure distribution with frequency.

temporary threshold shift (TTS)
Temporary loss of hearing sensitivity caused by excessive noise exposure.

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 pulsed sound 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 sound and its effects on marine life. Here we provide specific definitions of relevant metrics used in the accompanying report. Where possible, we follow the American National Standard Institute and International Organization for Standardization definitions and symbols for sound metrics (e.g., ISO 2017, ANSI R2013), but these standards are not always consistent.

The zero-to-peak sound pressure, or peak sound pressure (PK or $L_{p,pk}$; dB re 1 µPa), is the decibel level of the maximum instantaneous acoustic pressure in a stated frequency band attained by an acoustic pressure signal, $p(t)$:

$$L_{p,\mathrm{pk}} = 10\log_{10}\left(\frac{\max|p^2(t)|}{p_0^2}\right) = 20\log_{10}\left(\frac{\max|p(t)|}{p_0}\right) \quad \text{(A-1)}$$

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 an acoustic event, it is generally a poor indicator of perceived loudness.

The peak-to-peak sound pressure (PK-PK or $L_{p,pk\text{-}pk}$; dB re 1 µPa) is the difference between the maximum and minimum instantaneous sound pressure, possibly filtered in a stated frequency band, attained by an impulsive sound, $p(t)$:

$$L_{p,\mathrm{pk\text{-}pk}} = 10\log_{10}\left(\frac{[\max(p(t)) - \min(p(t))]^2}{p_0^2}\right) \quad \text{(A-2)}$$

The sound pressure level (SPL or L_p; dB re 1 µPa) is the root-mean-square (rms) pressure level in a stated frequency band over a specified time window (T; s). It is important to note that SPL always refers to an rms pressure level and therefore not instantaneous pressure:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T g(t)\,p^2(t)\,dt \Big/ p_0^2\right) \quad \text{(A-3)}$$

where $g(t)$ is an optional time weighting function. In many cases, the start time of the integration is marched forward in small time steps to produce a time-varying SPL function. For short acoustic events, such as sonar pulses and marine mammal vocalizations, it is important to choose an appropriate time window that matches the duration of the signal. For in-air studies, when evaluating the perceived loudness of sounds with rapid amplitude variations in time, the time weighting function $g(t)$ is often set to a decaying exponential function that emphasizes more recent pressure signals. This function mimics the leaky integration nature of mammalian hearing. For example, human-based fast time-weighted SPL ($L_{p,fast}$) applies an exponential function with time constant 125 ms. A related simpler approach used in underwater acoustics sets $g(t)$ to a boxcar (unity amplitude) function of width 125 ms; the results can be referred to as $L_{p,boxcar\ 125ms}$. Another approach, historically used to evaluate SPL of impulsive signals underwater, defines $g(t)$ as a boxcar function with edges set to the times corresponding to 5% and 95% of the cumulative square pressure function encompassing the duration of an impulsive acoustic event. This calculation is applied individually to each impulse signal, and the results have been referred to as 90% SPL ($L_{p,90\%}$). In this report, SPL refers to $L_{p,boxcar\ 125ms}$.

The sound exposure level (SEL or L_E; dB re 1 µPa²·s) is the time-integral of the squared acoustic pressure over a duration (T):

$$L_E = 10\log_{10}\left(\int_T p^2(t)\,dt \Big/ T_0 p_0^2\right) \quad \text{(A-4)}$$

where T_0 is a reference time interval of 1 s. SEL continues to increase with time when non-zero pressure signals are present. It is a dose-type measurement, so the integration time applied must be carefully considered for its relevance to impact to the exposed recipients.

SEL can be calculated over a fixed duration, such as the time of a single event or a period with multiple acoustic events. When applied to pulsed sounds, SEL can be calculated by summing the SEL of the N individual pulses. 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:

$$L_{E,N} = 10\log_{10}\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}} \quad \text{(A-5)}$$

Because the SPL and SEL are both computed from the integral of square pressure, these metrics are related numerically by the following expression, which depends only on the duration of the time window T:

$$L_p = L_E - 10\log_{10}(T) \quad \text{(A-6)}$$

When applied, the frequency weighting of an acoustic event should be specified, as in the case of weighted SEL (e.g., *LE,LF,24h*; see Appendix A.4).

A.2. Particle Acceleration and Velocity Metrics

Since sound is a mechanical wave, it can also be measured in terms of the vibratory motion of fluid particles. Particle motion can be measured in terms of three different (but related) quantities: displacement, velocity, or acceleration. Acoustic particle velocity is the time derivative of particle displacement, and likewise acceleration is the time derivative of velocity. For the present study, acoustic particle motion has been reported in terms of acceleration and velocity.

The particle velocity (v) is the physical speed of a particle in a material moving back and forth in the direction of the pressure wave. It can be derived from the pressure gradient and Euler's linearised momentum equation where ρ_0 is the density of the medium:

$$v = -\int \nabla p(t)dt/\rho_0 \quad \text{(A-7)}$$

The particle acceleration (a) is the rate of change of the velocity with respect to time, and it can be obtained from equation A-7 as:

$$a = \frac{dv}{dt} = -\frac{\nabla p(t)}{\rho_0} \quad \text{(A-8)}$$

Unlike sound pressure, particle motion is a vector quantity, meaning that it has both magnitude and direction: at any given point in space, acoustic particle motion has three different time-varying components (x, y, and z). Given the particle velocity in the x, y, and z, directions, v_x, v_y, and v_z, the particle velocity magnitude $|v|$ is computed per the Pythagorean equation:

$$|v| = \sqrt{v_x + v_y + v_z} \quad \text{(A-9)}$$

The magnitude of particle acceleration is calculated similarly from the particle acceleration in the *x*, *y*, and *z* directions.

A.3. Decidecade Band Analysis

The distribution of a sound's power with frequency is described by the sound's spectrum. The sound spectrum can be split into a series of adjacent frequency bands. Splitting a spectrum into 1 Hz wide bands, called passbands, yields the power spectral density of the sound. This splitting of the spectrum into passbands of a constant width of 1 Hz, however, does not represent how animals perceive sound.

Because animals perceive exponential increases in frequency rather than linear increases, analysing a sound spectrum with passbands that increase exponentially in size better approximates real-world scenarios. In underwater acoustics, a spectrum is commonly split into decidecade bands, which are one tenth of a decade wide. They are approximately one third of an octave (base 2) wide and are therefore often referred to as 1/3-octave-bands. Each octave represents a doubling in sound frequency. The centre frequency of the ith band, $f_c(i)$, is defined as:

$$f_c(i) = 10^{\frac{i}{10}} \text{ kHz} \quad \text{(A-10)}$$

and the low (f_{lo}) and high (f_{hi}) frequency limits of the ith decade band are defined as:

$$f_{lo,i} = 10^{\frac{-1}{20}} f_c(i) \quad \text{and} \quad f_{hi,i} = 10^{\frac{1}{20}} f_c(i) \quad \text{(A-11)}$$

The decidecade bands become wider with increasing frequency, and on a logarithmic scale the bands appear equally spaced (Figure A-1). The acoustic modelling spans from band 7 (f_c (7) = 5 Hz) to band 44 ($f_c(44)$ = 25 kHz).

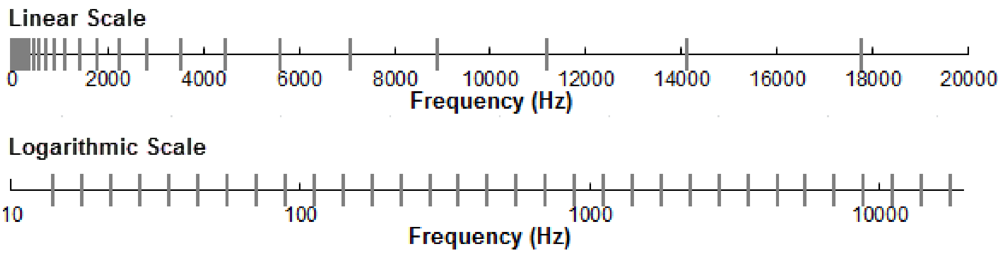

Figure A-1. Decidecade frequency bands (vertical lines) shown on a linear frequency scale and a logarithmic scale.

The sound pressure level in the ith band ($L_{p,i}$) is computed from the spectrum $S(f)$ between $f_{lo,i}$ and $f_{hi,i}$:

$$L_{p,i} = 10 \log_{10} \int_{f_{lo,i}}^{f_{hi,i}} S(f)\, df \quad \text{(A-12)}$$

Summing the sound pressure level of all the bands yields the broadband sound pressure level:

$$\text{Broadband SPL} = 10 \log_{10} \sum_i 10^{\frac{L_{p,i}}{10}} \quad \text{(A-13)}$$

Figure A-2 shows an example of how the decidecade band sound pressure levels compare to the sound pressure spectral density levels of an ambient noise signal. Because the decidecade bands are wider with increasing frequency, the decidecade band SPL is higher than the spectral levels at higher frequencies. Acoustic modelling of decidecade bands requires less computation time than 1 Hz bands and still resolves the frequency-dependence of the sound source and the propagation environment.

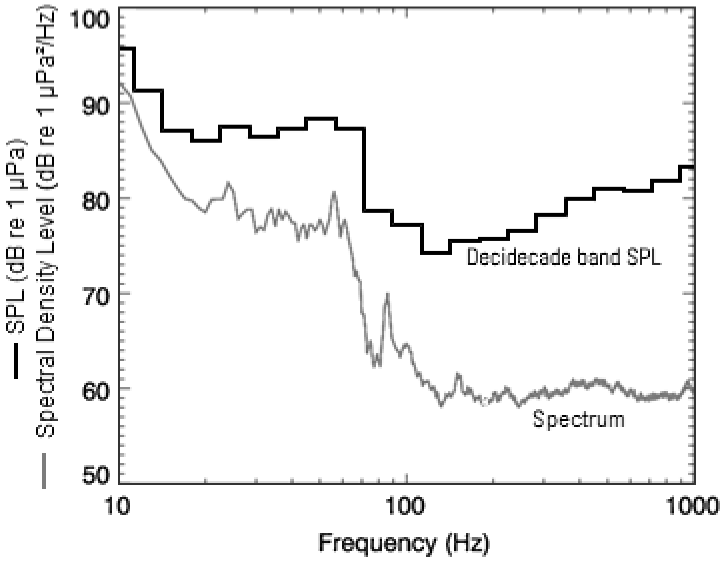

Figure A-2. Sound pressure spectral density levels and the corresponding decidecade band sound pressure levels of example ambient noise shown on a logarithmic frequency scale.

A.4. 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.4.1. Auditory Impairment

There are two categories of auditory threshold shifts (also termed Noise Induced Threshold Shift, NITS): Permanent Threshold Shift (PTS), a physical injury to an animal's hearing system; and Temporary Threshold Shift (TTS), a temporary reduction in an animal's hearing sensitivity as the result of physiological and mechanical processes in the inner ear. While PTS undoubtedly constitutes an injury, TTS (as a temporary effect) was not considered in the same way. However, recent research clearly indicates that already moderate levels (<12 dB) of TTS produced an accelerated hearing loss (PTS) resulting from progressive neural degeneration with age (Kujawa and Liberman 2006, 2009, Maison et al. 2013, Kujawa and Liberman 2015).

The criteria for assessing possible effects of impulsive sounds (such as pile driving or seismic impulses) noise on marine mammals, NMFS (2018), was applied in this study.

A.4.2. Behavioural response

Numerous studies on marine mammal behavioural responses to sound exposure have not resulted in consensus in the scientific community regarding the appropriate metric for assessing behavioural reactions. However, it is recognised that the context in which the sound is received affects the nature and extent of responses to a stimulus (Southall et al. 2007, Ellison and Frankel 2012, Southall et al. 2016).

For impulsive noise, NMFS currently uses step function thresholds of 160 dB re 1 µPa SPL (unweighted) to assess and regulate noise-induced behavioural impacts for marine mammals (NOAA

2019). The threshold for impulsive sound is derived from the High-Energy Seismic Survey (HESS) panel (HESS 1999) report that, in turn, is based on the responses of migrating mysticete whales to airgun sounds (Malme et al. 1984). The HESS team recognised that behavioural responses to sound may occur at lower levels, but significant responses were only likely to occur above a SPL of 140 dB re 1 µPa. Southall et al. (2007) found varying responses for most marine mammals between a SPL of 140 and 180 dB re 1 µPa, consistent with the HESS (1999) report, but lack of convergence in the data prevented them from suggesting explicit step functions.

A.5. 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.5.1. 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:

$$G(f) = K + 10\log_{10}\left[\left(\frac{(f/f_{lo})^{2a}}{\left[1+(f/f_{lo})^2\right]^a \left[1+(f/f_{hi})^2\right]^b}\right)\right] \quad \text{(A-14)}$$

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-3 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 (manatees and dugongs)	1.8	2	4,300	25,000	2.62

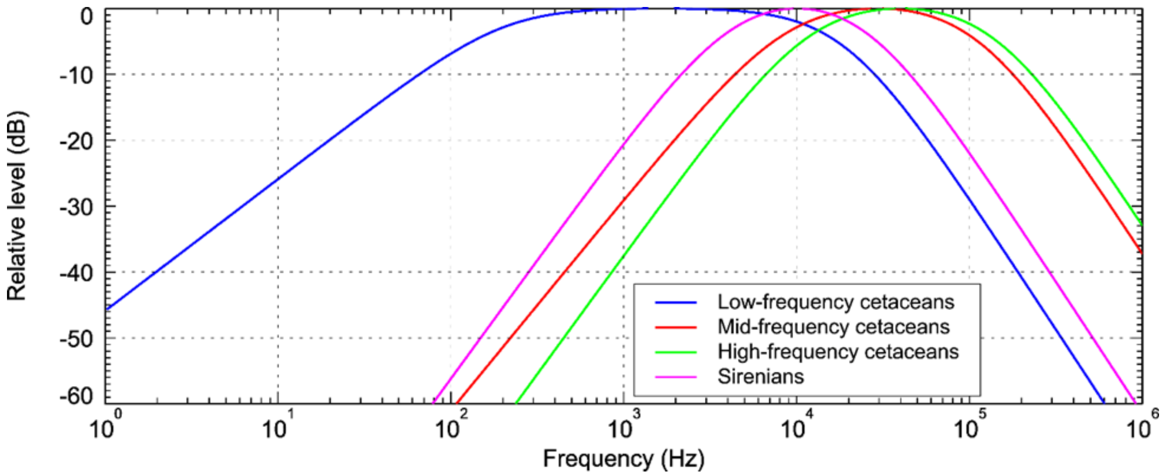

Figure A-3. Auditory weighting functions for functional marine mammal hearing groups used in this project as recommended by NMFS (2018).

A.6. Fish, Fish Eggs, and Fish Larvae Impact Criteria

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 µPa^2·s (SEL), remained alive for 7 days after exposure and that the probability of mortal injury did not differ between exposed and control fish.

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 because the source is moving, 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 (CPA) 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 the source (i.e., speed, duty cycle; NMFS 2016, 2018).

As discussed in Popper (2018), many fish species move around, some over large distances. The author suggests that it is reasonable to think that if the sound of a seismic source becomes too loud, the fish will move away from the source because they are able to determine the direction of a sound source. If the fish moves away, the amount of energy to which it is exposed is likely to be one or a few seismic pulses, and these would not likely be loud enough to result in any effect because the fish would move away at a much lower level signal than could cause harm. Data on TTS for fish are very limited, with the only study that examined recovery from seismic impulses being Popper et al. (2005). Popper (2018) states that if this study had been conducted on wild, free-swimming fish instead of caged ones, there would have been no effect whatsoever because they were likely to have moved away from the source as it approached them, as would happen with normally free-moving demersal and pelagic fish species associated with a 3-D seismic survey in northern Australian waters, extrapolating from the Bethany 3-D assessed in Popper (2018).

Therefore, the time over which energy should be accumulated in each individual fish in the survey area should be limited to the time over which fish receives the maximum exposure, and 24 h is likely too long a period for calculating the accumulation of energy in determining potential harm (e.g., damage or TTS) (Popper 2018). Even if fish 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 h (or less) is very likely. If TTS does occur, the duration of exposure to the most intense sounds that could result in TTS will be over just a few hours. Thus, energy accumulating over longer periods than a few hours is probably inappropriate (Popper 2018).

Appendix B. Models

B.1. Acoustic 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 decidecade frequency 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. Sound Propagation Models

B.2.1. 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 5 Hz to 2 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 > 2 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.

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 B-1).

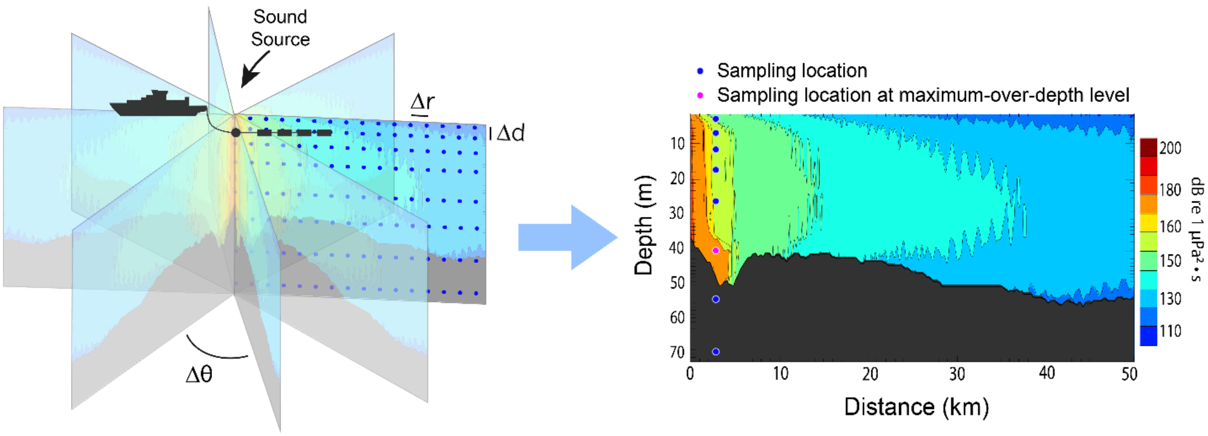

Figure B-1. The N×2-D and maximum-over-depth modelling approach used by MONM.

MONM treats frequency dependence by computing acoustic transmission loss at the centre frequencies of decidecade bands. Sufficiently many frequency bands, starting at 5 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 decidecade-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 decidecade-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.

B.2.2. 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.

B.2.3. 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.

B.2.3.1. Particle Motion

VSTACK was also used to compute estimates of particle acceleration for one modelled site (Site 1A) for the 3150 in^3 airgun array. Particle motion waveforms were modelled and pulse metrics were computed from the time-domain traces. VSTACK uses the wavenumber integration approach to solve the exact acoustic wave equation for arbitrarily layered range-independent acoustic environments.

The VSTACK model setup for the particle velocity scenarios was identical to that for the peak pressure scenarios in terms of source treatment, frequency range and environmental model. The particle acceleration and velocity waveforms were computed to a maximum distance of 1000 m in the broadside and endfire directions from the centre of the airgun array for a receiver 50 cm above the seafloor.

As discussed above in Appendix A.2, particle velocity (v) is the physical speed of a particle in a material. It can be derived from the pressure gradient and Euler's linearised momentum equation where ρ_0 is the density of the medium (Appendix A.2). Since the wavenumber integration kernel is a product of analytic expressions in terms of range and depth, VSTACK computes particle velocity by computing the spatial gradient of the pressure field analytically in the frequency domain. Fourier synthesis is applied to compute time series synthetic pressure and/or velocity waveforms at depth and range receivers by convolving the source waveforms with the impulse response of the waveguide. Particle velocity metrics at each receiver location were calculated from the modelled particle motion along three perpendicular axes (horizontal and along the source-receiver path, horizontal and perpendicular to the source-receiver path, and vertical).

The particle velocity results were converted to acceleration by time differentiation. The peak particle acceleration and velocity were calculated from the maximum of the predicted acceleration and velocity magnitude, defined as “peak magnitude” and are presented as plots of peak value versus range (Appendix A.2).

B.3. 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 C. 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.

C.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 C-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 C-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 C-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.

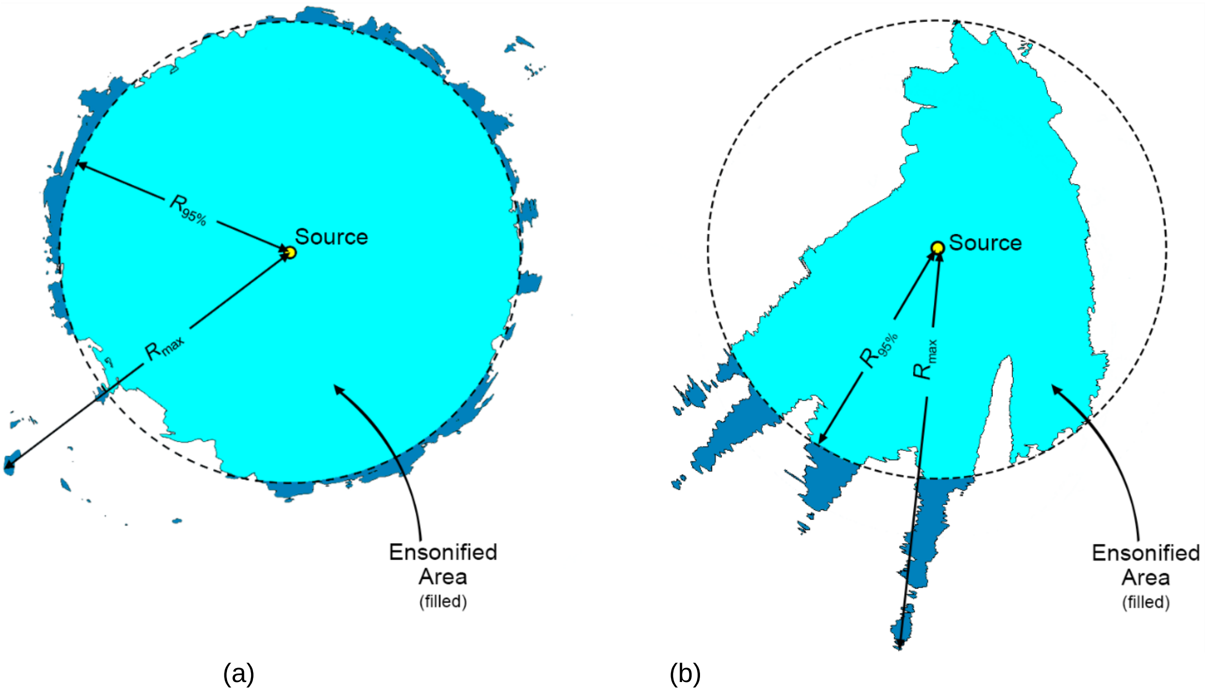

Figure C-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified areas bounded by $R_{95\%}$; darker blue indicates the areas outside this boundary which determine R_{max}.

C.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 B.2.2) was used to model synthetic seismic pulses over the frequency range 10-1000 Hz. This was performed along all broadside and endfire radials at seven 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 maximise the SPL over the pulse duration was applied. The resulting SEL -to-SPL offsets were averaged in 0.02 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 applied to predicted per-pulse SEL results from MONM to model SPL values at each site. Figures C-2 to C-11 show the conversion offsets for all modelled sites and source arrays; the spatial variation is caused by changes in the received airgun pulse as it propagates from the source.

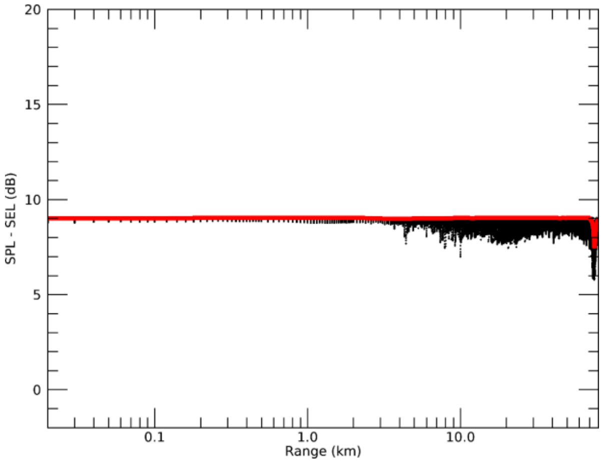

Figure C-2. *Site 1A, 3150 in³ array*: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

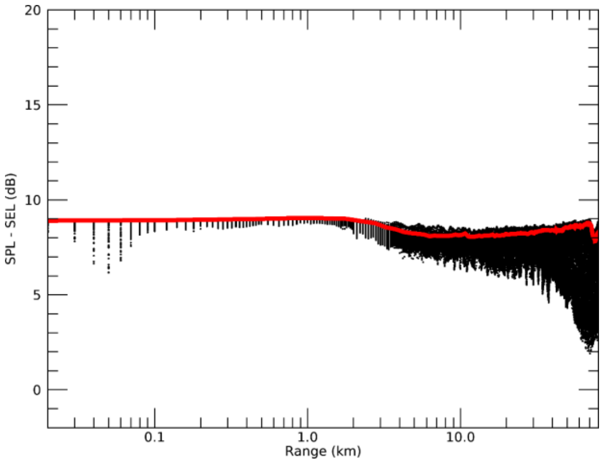

Figure C-3. *Site 2A, 3150 in³ array*: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

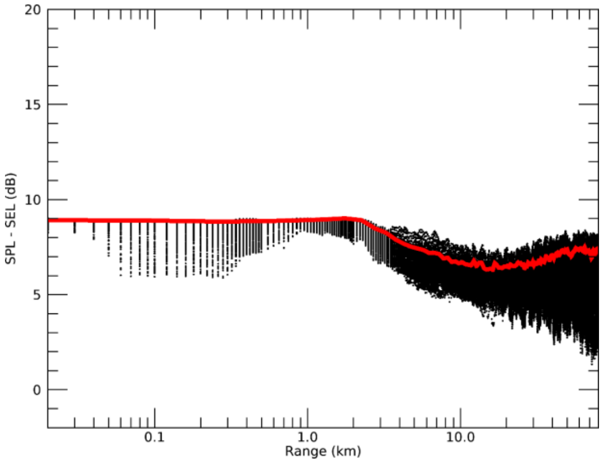

Figure C-4. *Site 2B, 3150 in³ array*: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

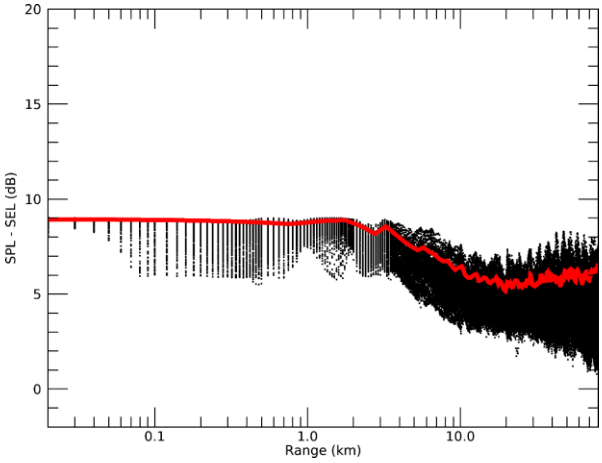

Figure C-5. *Site 2C, 3150 in³ array*: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

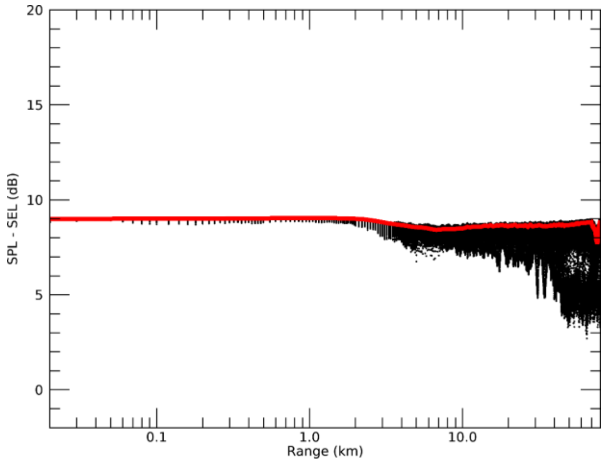

Figure C-6. *Site 3A, 2495 in³ array*: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

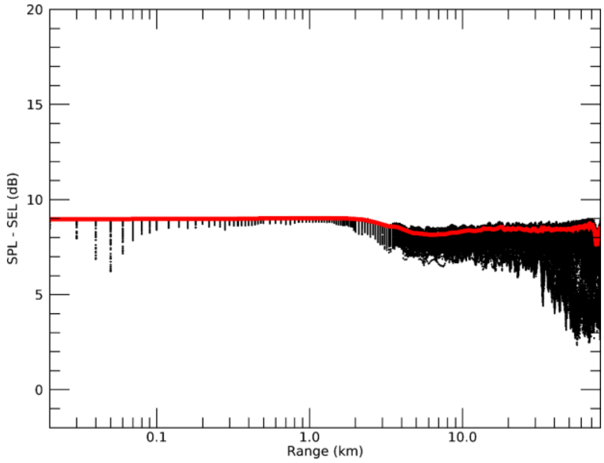

Figure C-7. *Site 3B, 2495 in³ array*: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

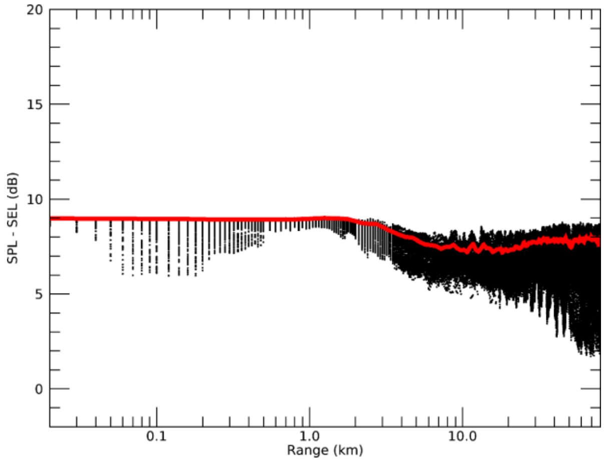

Figure C-8. *Site 3C, 2495 in³ array*: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

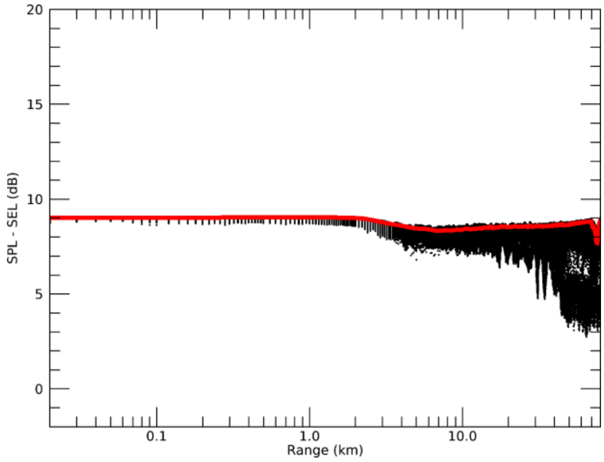

Figure C-9. *Site 3A, 1510 in^3 array*: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

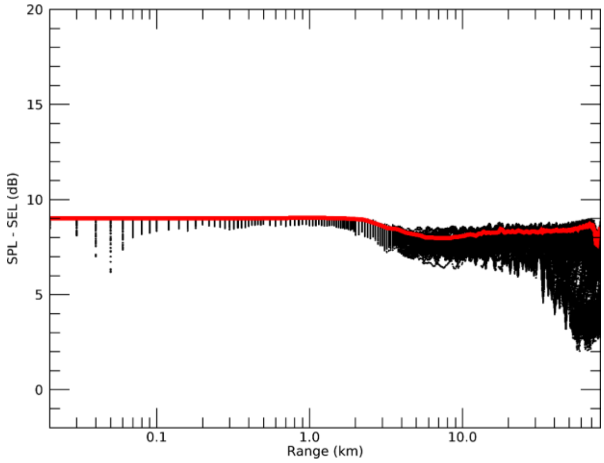

Figure C-10. *Site 3B, 1510 in^3 array*: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

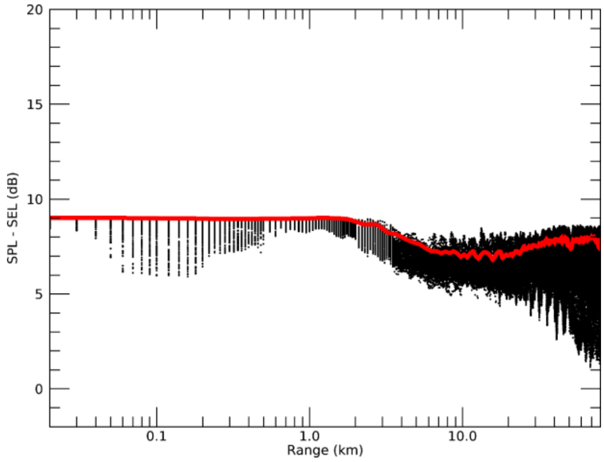

Figure C-11. *Site 3C, 1510 in^3 array*: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

C.3. Accumulated SEL Calculation

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 approximately 200 × 200 km in range, which encompasses the full area of the cumulative grid (the entire survey area).

C.4. Environmental Parameters

C.4.1. Bathymetry

Bathymetry data for the modelled area were provided by Woodside in the form of an extract from the high-resolution depth model for Northern Australia (Beaman and Spinoccia 2018) in MGA Zone 52 projection. The high-resolution depth model for Northern Australia is a compilation of all available source bathymetry data within Northern Australia into a 30 m-resolution (approximately 1 arc-second) Digital Elevation Model (DEM) encompassing the waters of the Timor Sea and Indian Ocean spanning parts of Western Australia and the Northern Territory. A subsection of the provided data covering the entire modelling area was extracted at its original resolution and used as the input to the models, shown in Figure C-12.

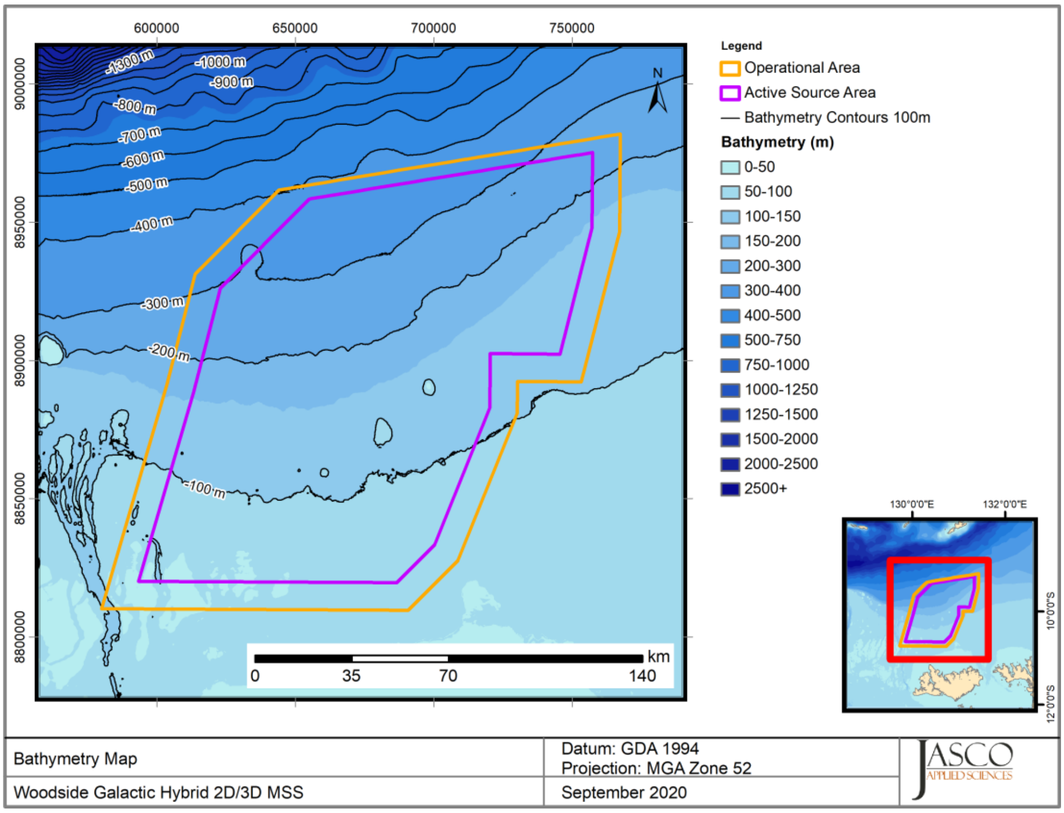

Figure C-12. Map of the modelling area presenting the variation in water depth.

C.4.2. Sound speed profile

The sound speed profile 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 sound speed profiles for May to September (operational time) were derived from the GDEM profiles within a 100 km box radius encompassing all modelling sites. While the sound speed profiles for all operational months were reasonably similar, the sound speed profile in May is expected to be most favourable to longer-range sound propagation due to the slight upward refracting profile in the upper 50 m. As such, May was selected for sound propagation modelling to ensure precautionary estimates of distances to received sound level thresholds. Sound speed profiles in the selected region had only a maximum depth of 600 m, hence a further profile was extracted for May from a site in the deeper NW region of the modelling area and the gradient of this profile was used to extrapolate the sound speed profile to a maximum depth of 1800 m, below which the profile was linearly extrapolated to a maximum depth of 3285 m. Figure C-13 shows the resulting profile used as input to the sound propagation modelling.

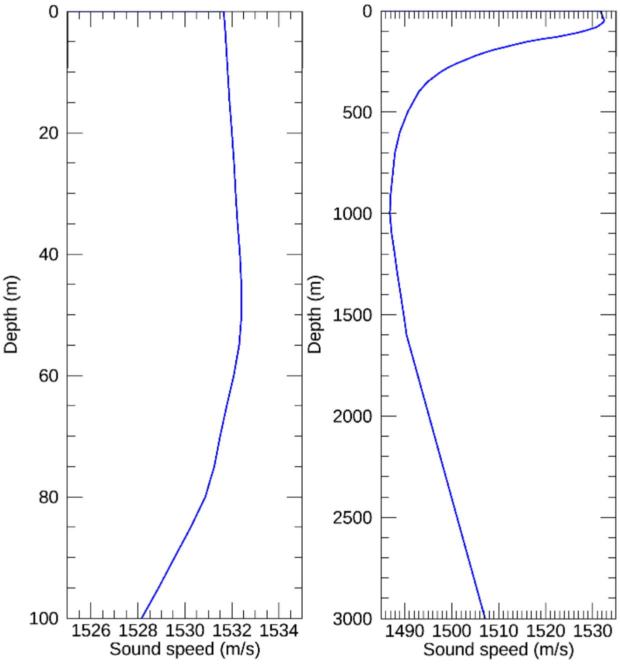

Figure C-13. Composite mean monthly sound speed profile for May. The plot on the left shows the top 100 m of water; the plot on the right shows the profiles over the entire water column. All profiles were calculated from temperature and salinity profiles from GDEM V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

C.4.3. Geoacoustics

The modelling region is located within the Nominated Northern Marine Region (Baker et al. 2008) whose coverage is predominantly gravelly muddy carbonate sand, with a smaller region of sandy mud. Further information was obtained from the Australian Government's Marine Sediments (MARS) database (Heap 2009). Data were queried within the vicinity of the operational area and local samples were characterised by high sand percentages (70-100%). Based on this, and with no further information on grain size or sub-surface stratification available, geoacoustic properties for the sediments were then estimated from the average parameters for very fine sand based on measurements presented by Hamilton (1980).

Table C-1. Geoacoustic profile for the modelled region. Each parameter varies linearly within the stated range.

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)
0-50	Very Fine Sand	1.86-1.95	1708-1793	1.11-0.89	270*	3.65
50-100		1.95-2.02	1793-1876	0.89-0.88	316	
100-150		2.02-2.08	1876-1957	0.88-0.87	367	
150-200		2.08-2.13	1957-2036	0.87-0.87	423	
200-250		2.13-2.17	2036-2113	0.87-0.87	484	
250-300		2.17-2.21	2113-2188	0.87-0.88	544	
300-350		2.21-2.24	2188-2262	0.88-0.88	600	
350-400		2.24-2.26	2262-2334	0.88-0.89	657	
400-450		2.26-2.29	2334-2403	0.89-0.89	712	
450-500		2.29-2.31	2403-2471	0.89-0.90	766	

*Only the shear wave speed at the surface is used for MONM-BELLHOP and FWRAM

C.5. Seismic Sources

The layout of the 3150 in³, 2495 in³, and 1510 in³ seismic sources used for modelling in this study are presented in Figures C-14 to C-16 respectively, and details of the corresponding airgun parameters are provided in Tables C-2 to C-4 respectively. Figures C-17 to C-19 show the broadside (perpendicular to the tow direction), endfire (parallel to the tow direction) and vertical overpressure signature including the corresponding power spectrum levels for each array, while decidecade-band source levels in the horizontal-plane are shown as a function of band centre frequency and azimuth in Figures C-20 to C-22.

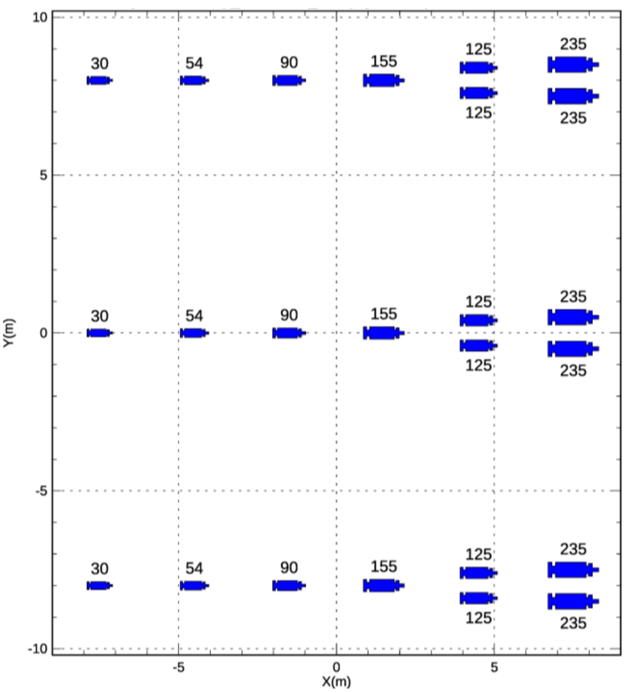

Figure C-14. Layout of the modelled 3150 in³ array. Tow depth is 6 m and the array is towed to the right i.e. in the positive x direction. The labels indicate the firing volume (in cubic inches) for each airgun. Also see Table C-2.

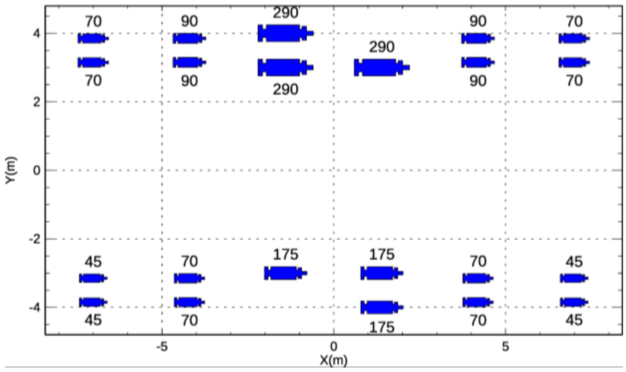

Figure C-15. Layout of the modelled 2495 in^3 array. Tow depth is 6 m and the array is towed to the right i.e. in the positive x direction. The labels indicate the firing volume (in cubic inches) for each airgun. Also see Table C-3.

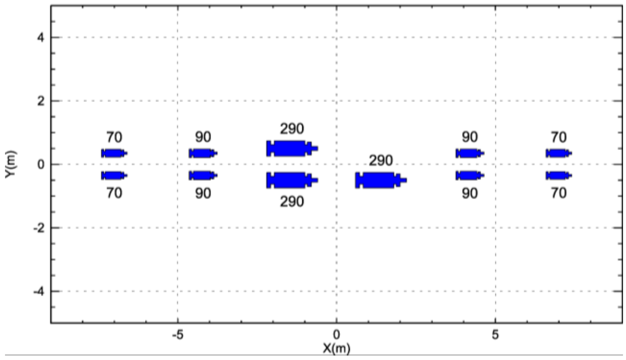

Figure C-16. Layout of the modelled 1510 in^3 array. Tow depth is 6 m and the array is towed to the right i.e. in the positive x direction. The labels indicate the firing volume (in cubic inches) for each airgun. Also see Table C-4.

Table C-2. Layout of the modelled 3150 in^3 array. Tow depth is 6 m and the array is towed in the positive x direction. Firing pressure for all guns is 2000 psi. Also see Figure C-14.

String	Gun	x (m)	y (m)	z (m)	Vol (in^3)	String	Gun	x (m)	y (m)	z (m)	Vol (in^3)	String	Gun	x (m)	y (m)	z (m)	Vol (in^3)
1	1	7.5	8.5	6	235	2	1	7.5	0.5	6	235	3	1	7.5	-7.5	6	235
	2	7.5	7.5	6	235		2	7.5	-0.5	6	235		2	7.5	-8.5	6	235
	3	4.5	8.4	6	125		3	4.5	0.4	6	125		3	4.5	-7.6	6	125
	4	4.5	7.6	6	125		4	4.5	-0.4	6	125		4	4.5	-8.4	6	125
	5	1.5	8	6	155		5	1.5	0	6	155		5	1.5	-8	6	155
	6	-1.5	8	6	90		6	-1.5	0	6	90		6	-1.5	-8	6	90
	7	-4.5	8	6	54		7	-4.5	0	6	54		7	-4.5	-8	6	54
	8	-7.5	8	6	30		8	-7.5	0	6	30		8	-7.5	-8	6	30

Table C-3. Layout of the modelled 2495 in^3 array. Tow depth is 6 m and the array is towed in the positive x direction. Firing pressure for all guns is 2000 psi and a dash in the volume column indicates a spare gun. Also see Figure C-15.

String	Gun	*x* (m)	*y* (m)	*z* (m)	Vol (in^3)	String	Gun	*x* (m)	*y* (m)	*z* (m)	Vol (in^3)
1	1	7	-3.85	6	45	2	1	7	3.15	6	70
	2	7	-3.15	6	45		2	7	3.85	6	70
	3	4.2	-3.85	6	70		3	4.2	3.15	6	90
	4	4.2	-3.15	6	70		4	4.2	3.85	6	90
	5	1.4	-4	6	175		5	1.4	3	6	290
	6	1.4	-3	6	175		6	1.4	4	6	–
	7	-1.4	-4	6	–		7	-1.4	3	6	290
	8	-1.4	-3	6	175		8	-1.4	4	6	290
	9	-4.2	-3.85	6	70		9	-4.2	3.15	6	90
	10	-4.2	-3.15	6	70		10	-4.2	3.85	6	90
	11	-7	-3.85	6	45		11	-7	3.15	6	70
	12	-7	-3.15	6	45		12	-7	3.85	6	70

Table C-4. Layout of the modelled 1510 in^3 array. Tow depth is 6 m and the array is towed in the positive x direction. Firing pressure for all guns is 2000 psi and a dash in the volume column indicates a spare gun. Also see Figure C-16.

String	Gun	*x* (m)	*y* (m)	*z* (m)	Vol (in^3)
1	1	7	3.15	6	70
	2	7	3.85	6	70
	3	4.2	3.15	6	90
	4	4.2	3.85	6	90
	5	1.4	3	6	290
	6	1.4	4	6	–
	7	-1.4	3	6	290
	8	-1.4	4	6	290
	9	-4.2	3.15	6	90
	10	-4.2	3.85	6	90
	11	-7	3.15	6	70
	12	-7	3.85	6	70

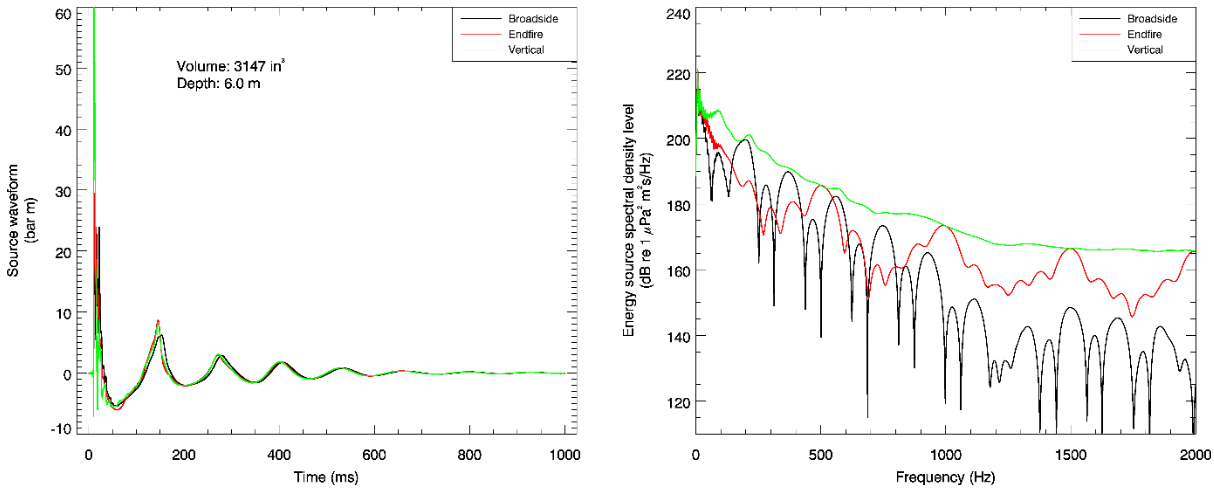

Figure C-17. Predicted source level details for the 3150 in^3 array at 6 m towed depth.Left: the overpressure signature and right: the power spectrum for in-plane horizontal (broadside), perpendicular (endfire), and vertical directions (no surface ghost).

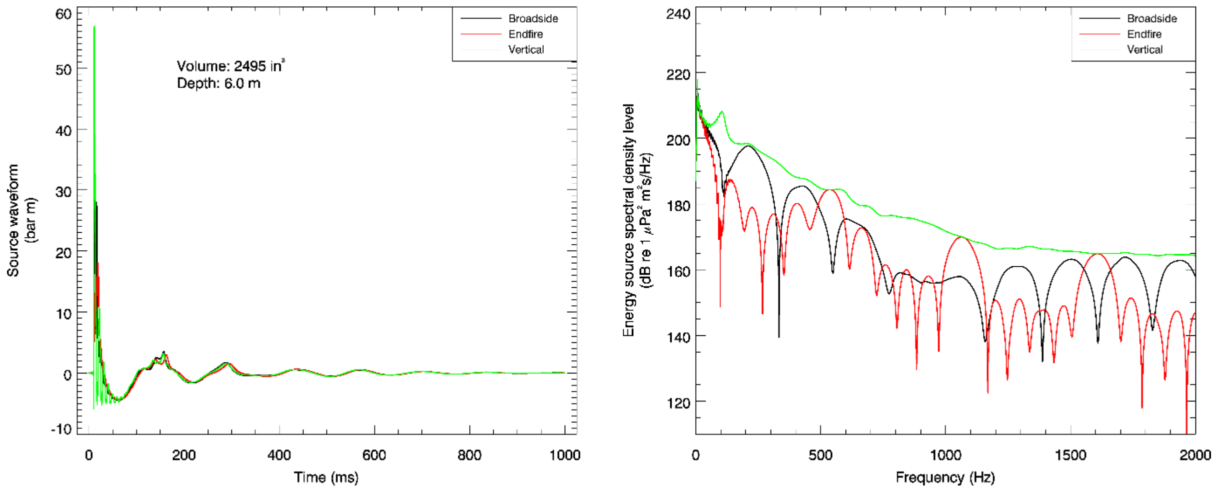

Figure C-18. Predicted source level details for the 2495 in^3 array at 6 m towed depth.Left: the overpressure signature and right: the power spectrum for in-plane horizontal (broadside), perpendicular (endfire), and vertical directions (no surface ghost).

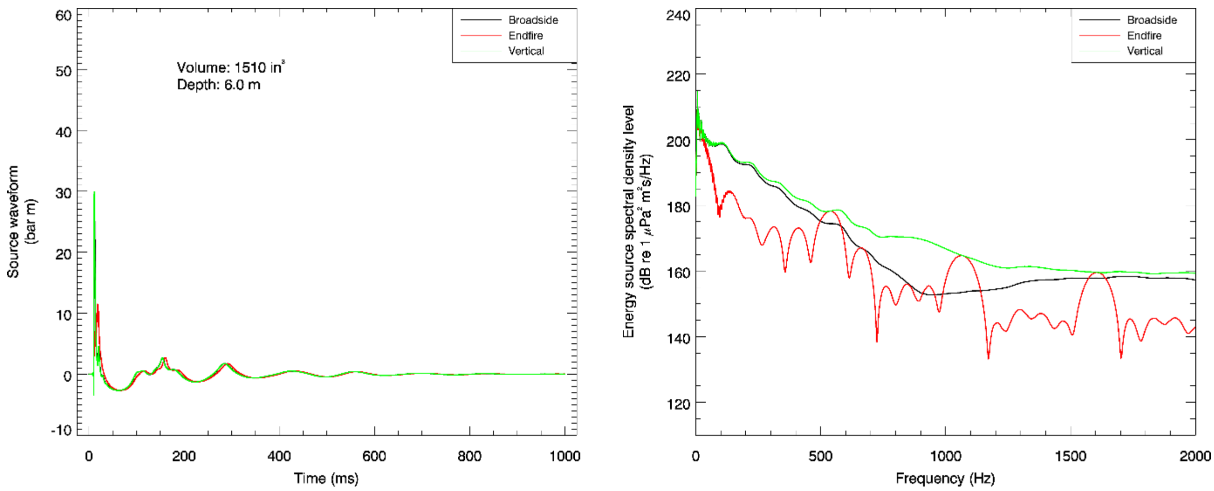

Figure C-19. Predicted source level details for the 1510 in3 array at 6 m towed depth. Left: the overpressure signature and right: the power spectrum for in-plane horizontal (broadside), perpendicular (endfire), and vertical directions (no surface ghost).

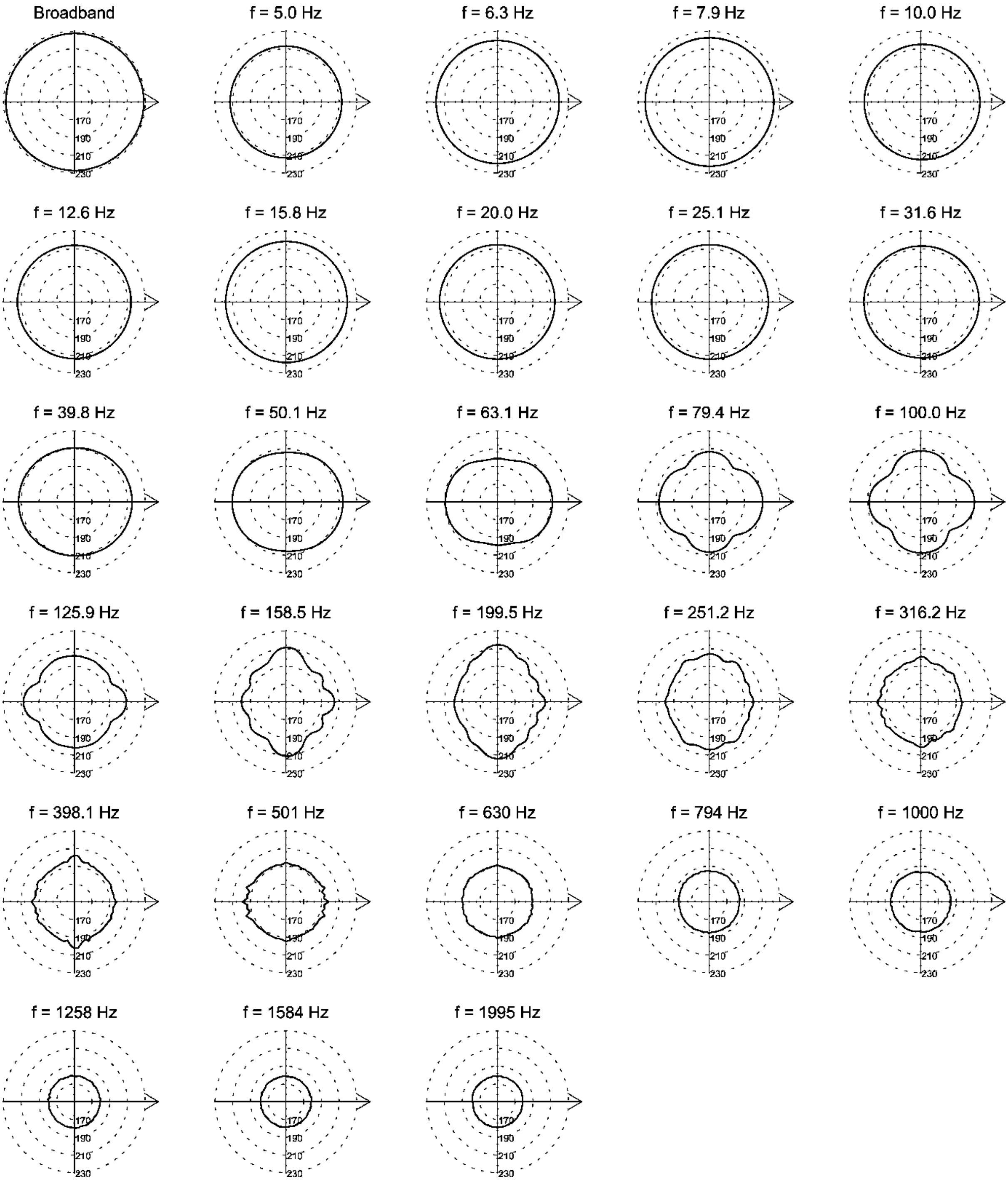

Figure C-20. Directionality of the predicted horizontal source levels for the 3150 in^3 seismic source, 5 Hz to 2 kHz. Source levels (in dB re 1 µPa^2·s m^2) are shown as a function of azimuth for the centre frequencies of the decidecade bands modelled; frequencies are shown above the plots. The tow direction is to the right. Tow depth is 6 m (see Figure C-17).

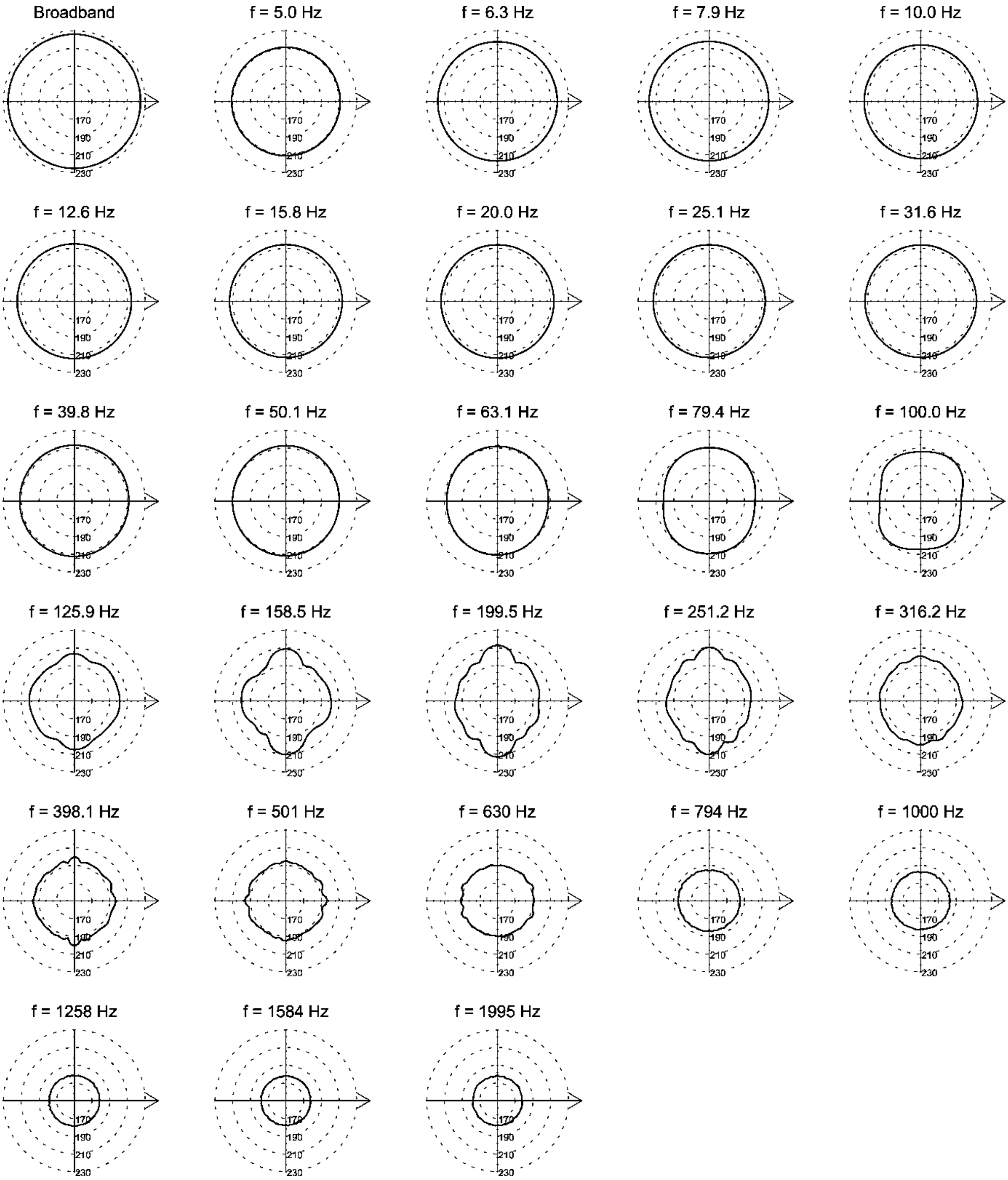

Figure C-21. Directionality of the predicted horizontal source levels for the 2495 in^3 seismic source, 5 Hz to 2 kHz. Source levels (in dB re 1 µPa^2·s m^2) are shown as a function of azimuth for the centre frequencies of the decidecade bands modelled; frequencies are shown above the plots. The tow direction is to the right. Tow depth is 6 m (see Figure C-18).

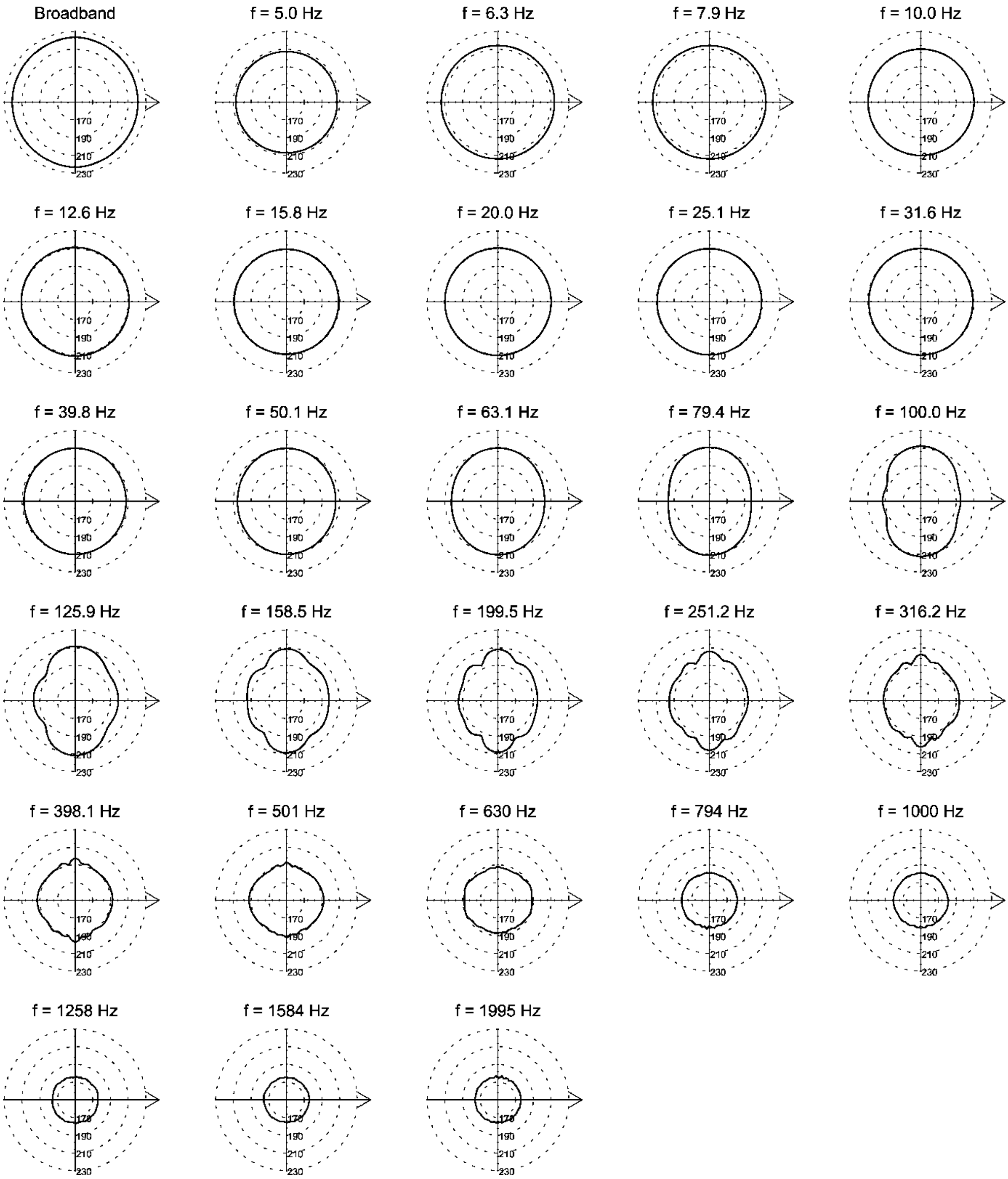

Figure C-22. Directionality of the predicted horizontal source levels for the 1510 in^3 seismic source, 5 Hz to 2 kHz. Source levels (in dB re 1 $\mu Pa^2 \cdot s\ m^2$) are shown as a function of azimuth for the centre frequencies of the decidecade bands modelled; frequencies are shown above the plots. The tow direction is to the right. Tow depth is 6 m (see Figure C-19).

Appendix D. Additional Sound Field Maps

Figures D-1 to D-8 present the SPL contour maps showing marine mammal and turtle behavioural response thresholds for sites not presented in Section 5.2.2.1.

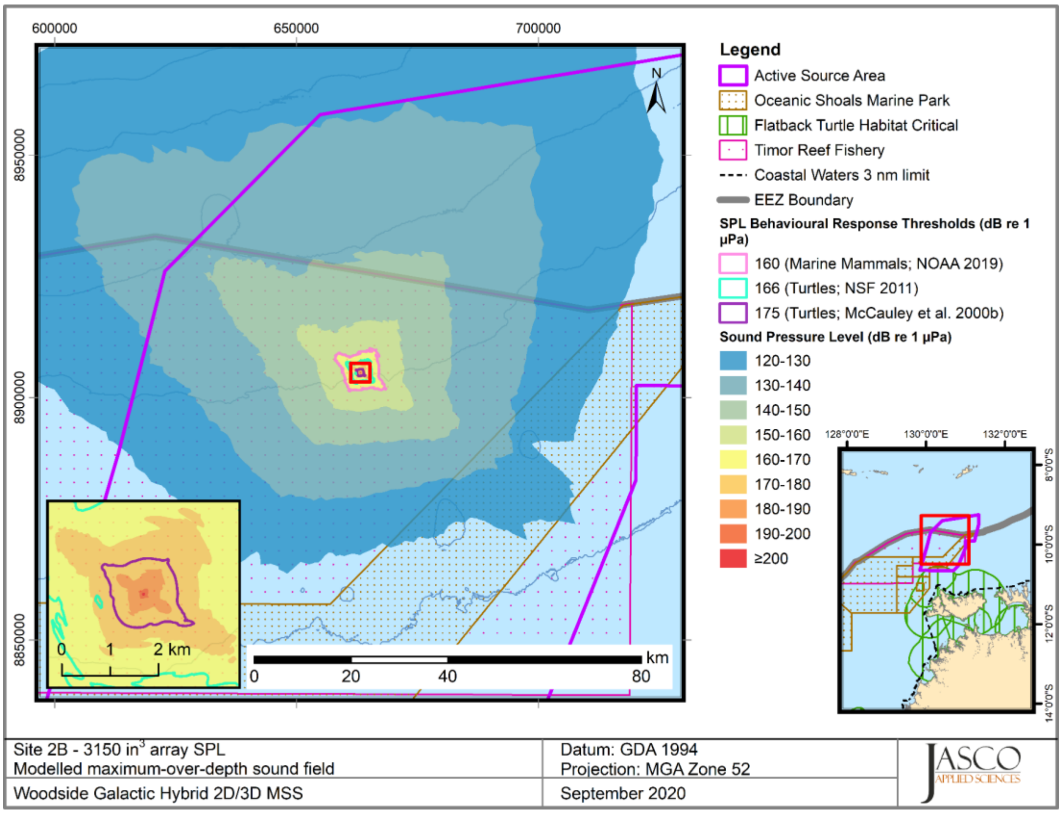

Figure D-1. *Site 2B, 3150 in^3 array, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths of behavioural response thresholds for marine mammals and turtles.

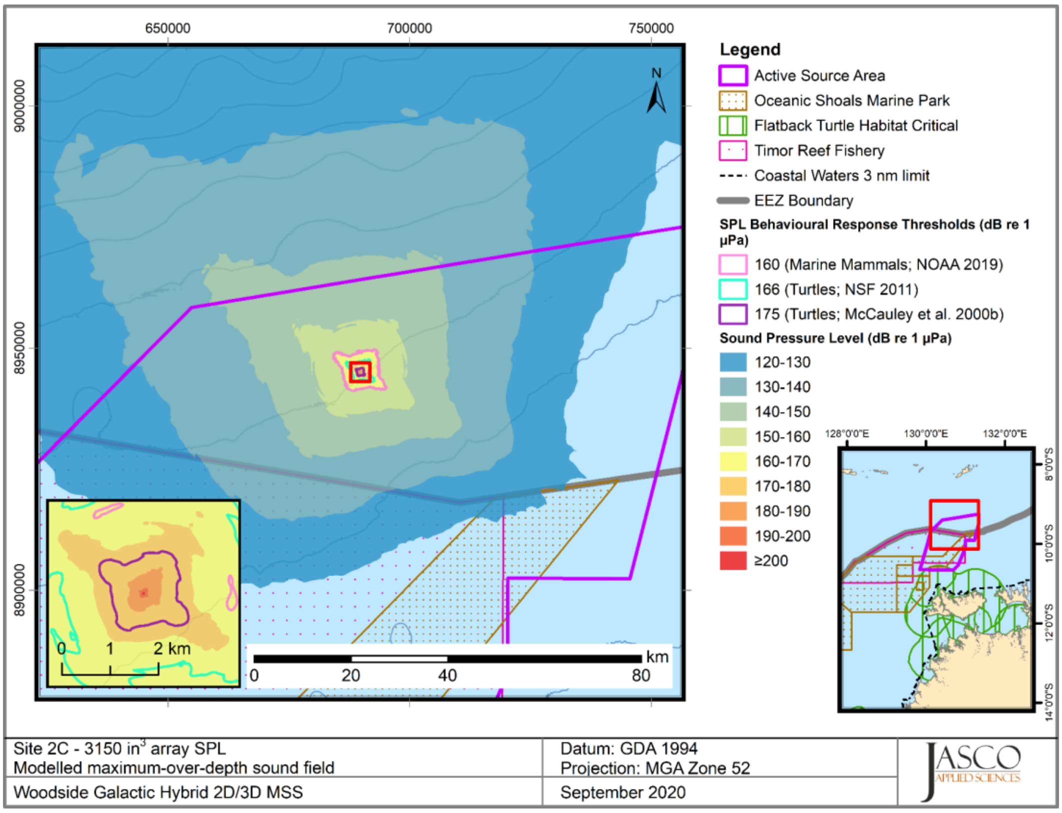

Figure D-2. *Site 2C, 3150 in^3 array, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths of behavioural response thresholds for marine mammals and turtles.

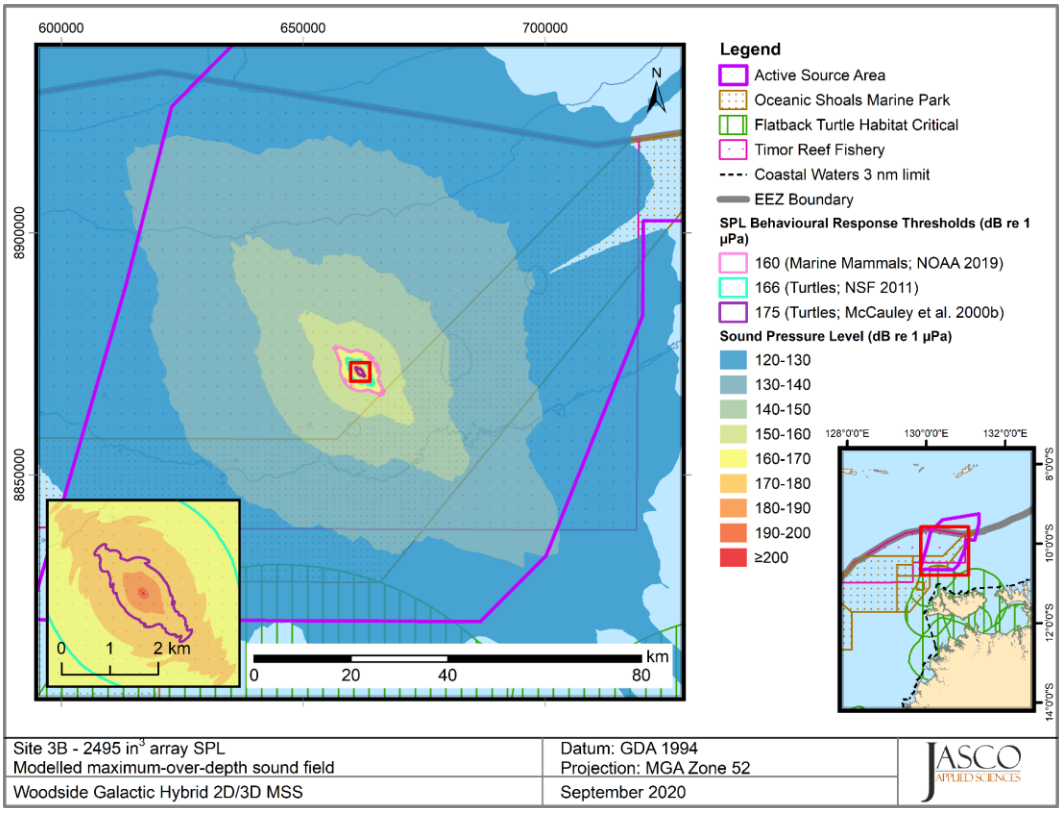

Figure D-3. *Site 3B, 2495 in^3 array, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths of behavioural response thresholds for marine mammals and turtles.

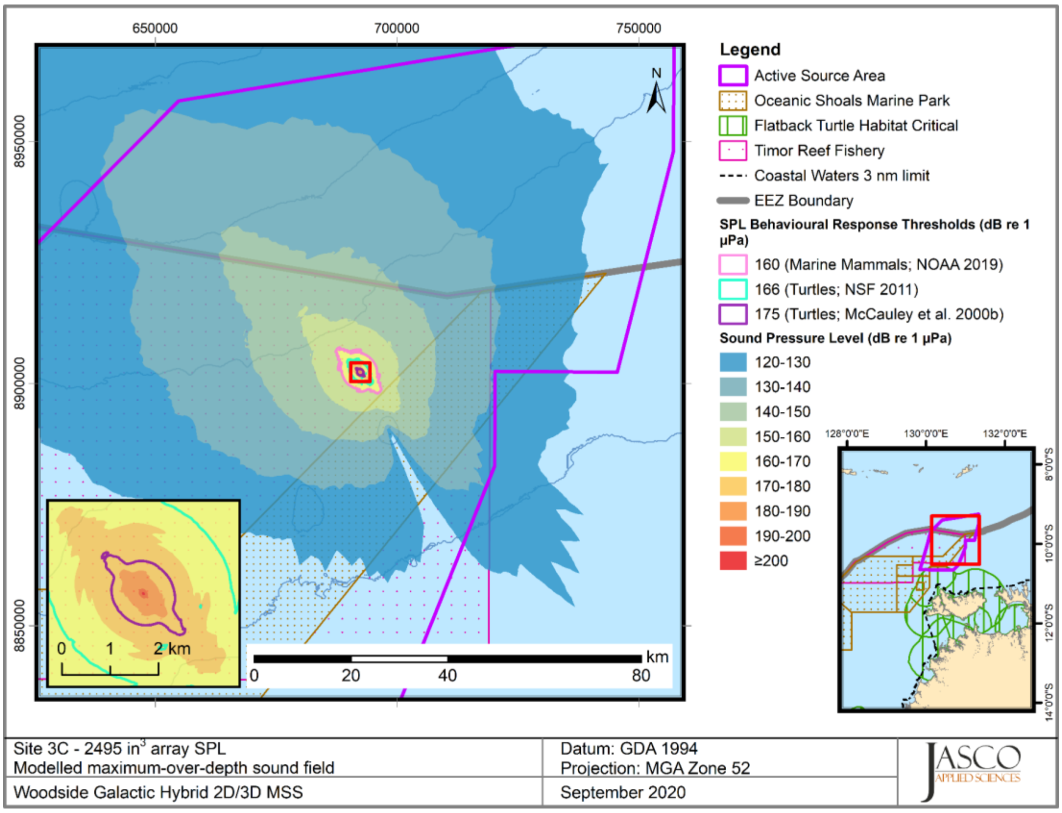

Figure D-4. *Site 3C, 2495 in^3 array, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths of behavioural response thresholds for marine mammals and turtles.

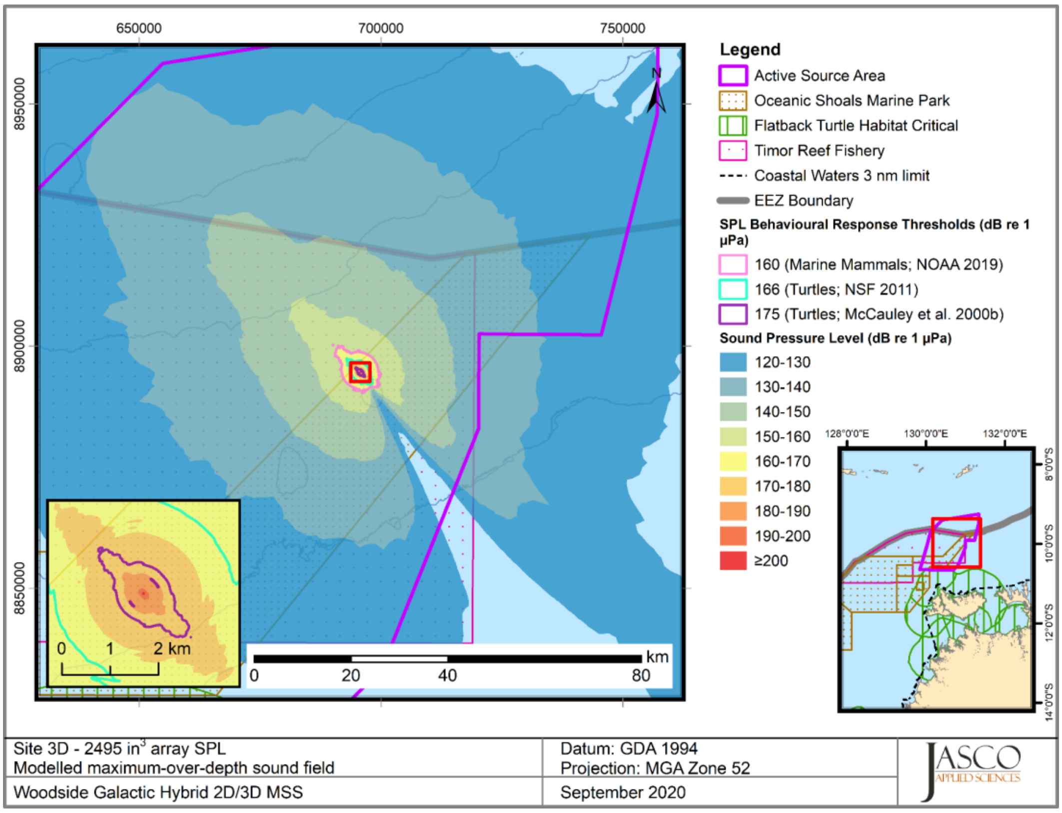

Figure D-5. *Site 3D, 2495 in^3 array, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths of behavioural response thresholds for marine mammals and turtles.

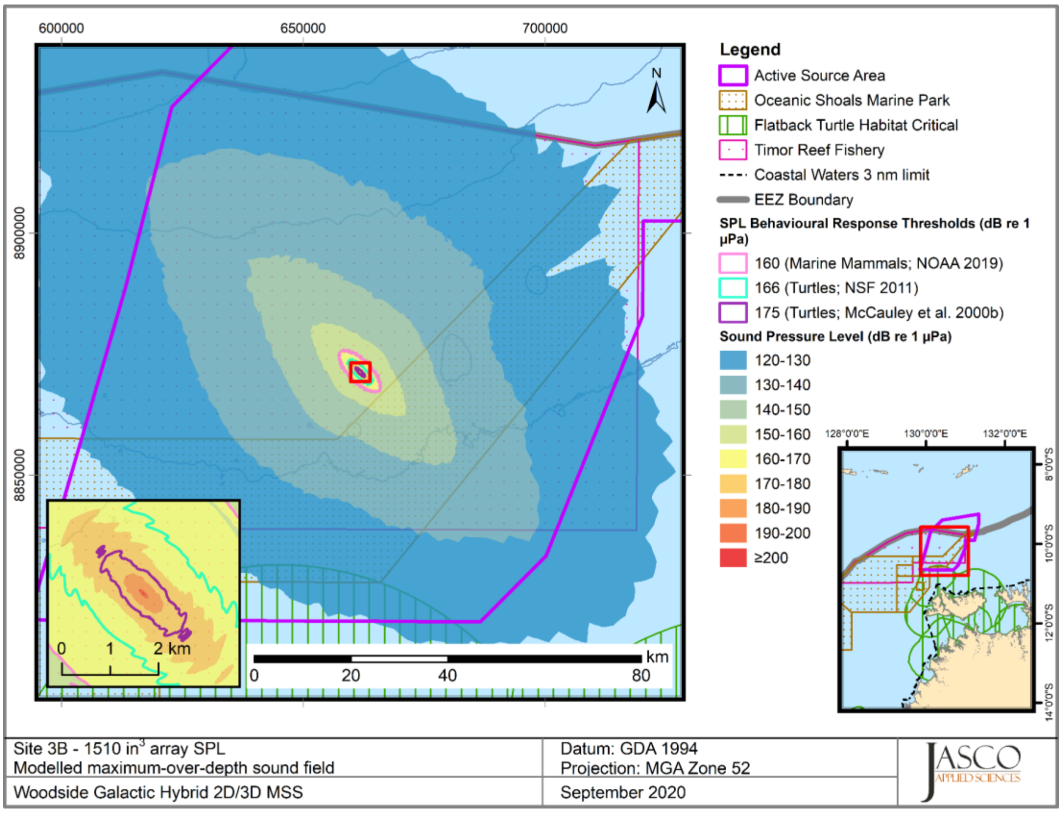

Figure D-6. *Site 3B, 1510 in^3 array, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths of behavioural response thresholds for marine mammals and turtles.

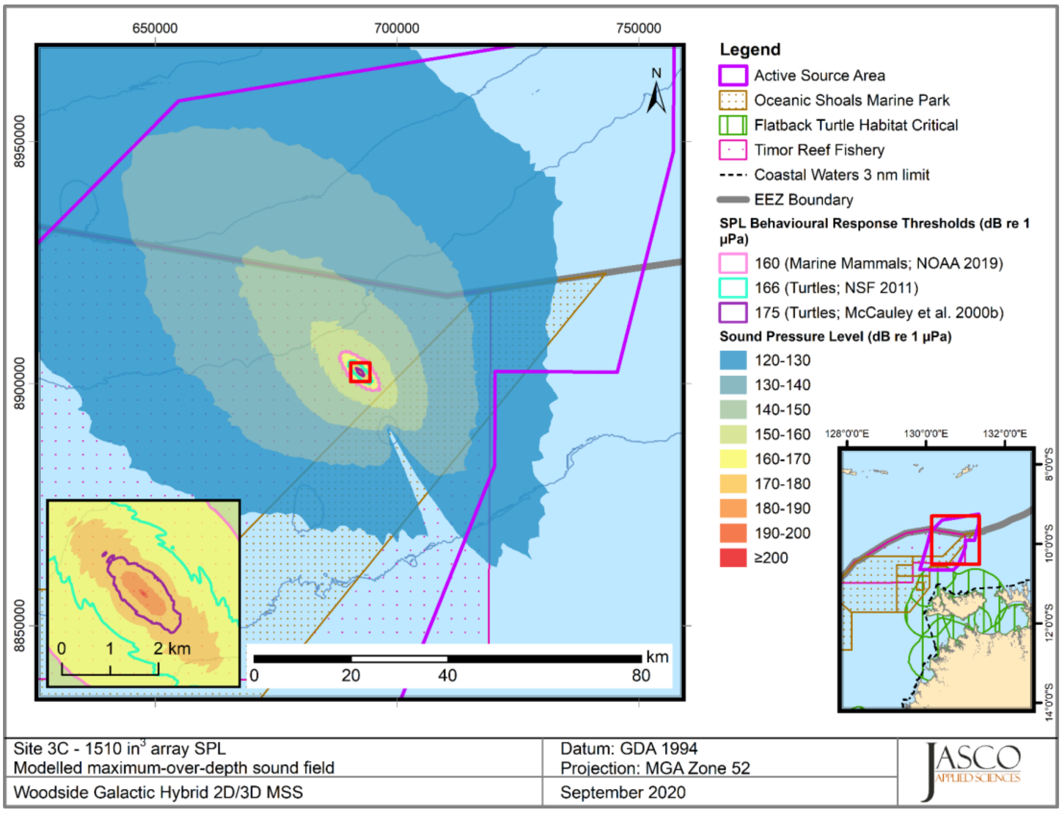

Figure D-7. *Site 3C, 1510 in^3 array, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths of behavioural response thresholds for marine mammals and turtles.

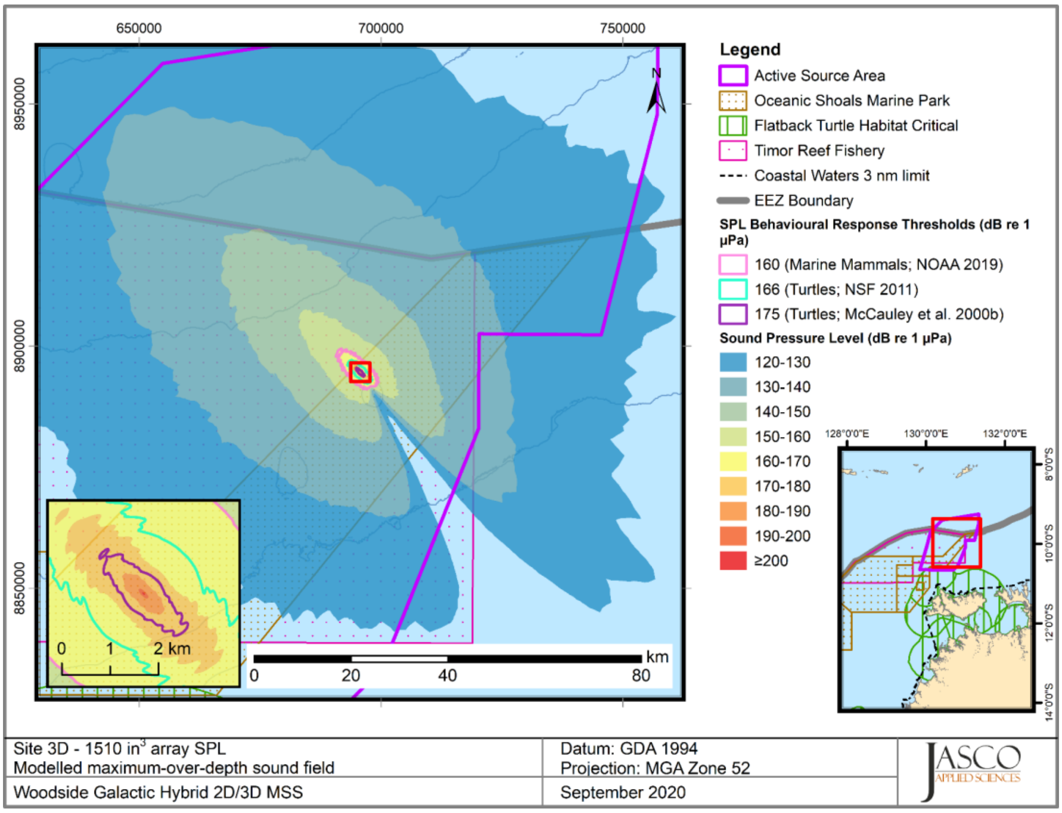

Figure D-8. *Site 3D, 1510 in³ array, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths of behavioural response thresholds for marine mammals and turtles.