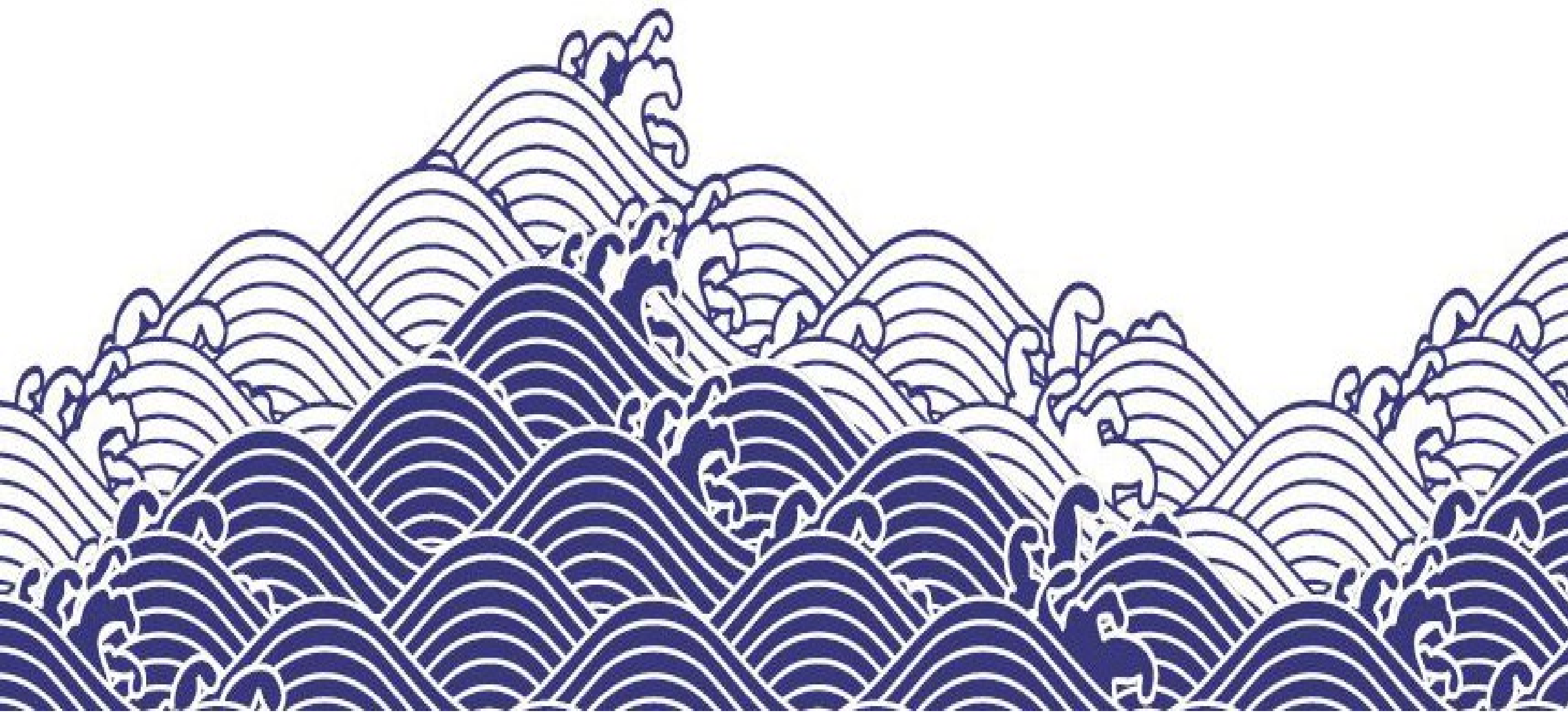
Bonaparte Basin 3D Marine Seismic Survey Environment Plan



Acknowledgement

INPEX is committed to recognising and respecting Aboriginal and Torres Strait Islander peoples whose cultures have existed in Australia for tens of thousands of years.

We wish to pay respects to their Elders – past and present – and acknowledge the important role Aboriginal and Torres Strait Islander peoples continue to play in the development of our business in Australia.

Environment plan summary

This environment plan summary has been prepared from material provided in this environment plan (EP). The summary consists of the following as required by Regulation 11(4) of the OPGGS (E) Regulations 2009:

EP summary and material requirement	**Relevant section of EP containing EP summary material**
The location of the activity	Section 3.1
A description of the receiving environment	Section 4
A description of the activity	Section 3
Details of the environmental impacts and risks	Sections 7 and 8
The control measures for the activity	Sections 7 and 8
The arrangements for ongoing monitoring of the titleholders environmental performance	Sections 9.11, 9.12 and 9.13
Response arrangements in the oil pollution emergency plan	Section 8.3 and INPEX *Browse Regional OPEP*
Consultation already undertaken and plans for ongoing consultation	Sections 5 and 9.8.3
Details of the titleholders nominated liaison person for the activity	Section 1.4

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Terms, abbreviations and acronyms

Term, abbreviation or acronym	Meaning
°C	degrees Celsius
%	percent
3D	three-dimensional
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AFMA	Australian Fisheries Management Authority (Cwlth)
AFZ	Australian fishing zone
AHD	Australian Height Datum
AHO	Australian Hydrographic Office
AIMS	Australian Institute of Marine Science
AIS	automatic identification system
ALARP	as low as reasonably practicable
AMOSC	Australian Marine Oil Spill Centre
AMP	Australian marine park
AMSA	Australian Maritime Safety Authority (Cwlth)
APPEA	Australian Petroleum Production and Exploration Association
AR-AFFF	alcohol resistant aqueous film-forming foam
BIA	biologically important area
BMS	business management system
BOD	basis of design
BOM	Bureau of Meteorology
Bonn Agreement	Bonn Agreement for Cooperation in Dealing with Pollution of the North Sea by Oil and other harmful substances
BPPH	benthic primary producer habitat
BROPEP	INPEX's Browse Regional Oil Pollution Emergency Plan
BROPEP BOD/FCA	Browse Regional Oil Pollution Emergency Plan - Basis of Design and Field Capability Assessment

Term, abbreviation or acronym	Meaning
BROPEP IMTCA	Browse Regional Oil Pollution Emergency Plan – Incident Management Team Capability Assessment
BTEX	Benzene, Toluene, Ethylene, Xylene
BWM	ballast water management
BWM Convention	International Convention for the Control and Management of Ships' Ballast Water and Sediments
CCS	carbon capture and storage
CFC	chlorofluorocarbon
CO	carbon monoxide
CO_2	carbon dioxide
COLREGs	International Regulations for Preventing Collisions at Sea 1972
cP	centipoise
CRWG	Community Relations Working Group
CTS	craft tracking system
CW	cooling water
Cwlth	Commonwealth
DAWE	Department of Agriculture Water and the Environment (Cwlth)
dB	decibel
DBCA	Department of Biodiversity, Conservation and Attractions (WA)
DCCEEW	Department of Climate Change, Energy, Environment and Water (Cwlth) formerly the Department of Agriculture Water and the Environment (Cwlth)
DIPL	Department of Infrastructure, Planning and Logistics (NT)
DITT	Department of Industry, Tourism and Trade (NT) (formerly DPIR)
DMIRS	Department of Mines, Industry Regulation and Safety (WA)
DNP	Director of National Parks (Cwlth)
DO	dissolved oxygen
DPIR	Department of Primary Industries and Resources (NT) (now DITT)
DPIRD	Department of Primary Industries and Regional Development (WA)

Term, abbreviation or acronym	Meaning
EAA	East Asian-Australasian
EEZ	exclusive economic zone
EIAPP	Engine International Air Pollution Prevention
EMBA	environment that may be affected
EMS	Environmental Management System
EP	environment plan
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)
EPBC Regulations	Environment Protection and Biodiversity Conservation Regulations 2000
EPO	environmental performance outcome
EPS	environmental performance standard
EMS	Environmental management system
ERA	environmental risk assessment
ESD	ecological sustainable development
FFFP	film forming fluoroprotein foam
FRDC	Fisheries Research and Development Corporation
FWAD	Fixed wing aerial dispersant
g/cm^3	grams per cubic centimetre
g/m^2	grams per square metre
GHG	greenhouse gas
GT	gross tonnage
HAZID	environmental hazard identification
HCFC	hydrochlorofluorocarbon
HFO	heavy fuel oil
HSE	health, safety and environment
IAPP	International Air Pollution Prevention
IBA	important bird area

Term, abbreviation or acronym	Meaning
IEE	International energy efficiency
IFO	intermediate fuel oil
IMO	International Maritime Organization
IMS	invasive marine species
IMT	incident management team
in^3	cubic inch
INPEX	INPEX Browse E & P Pty Ltd
IOGP	International Association of Oil and Gas Producers
IOPP	International Oil Pollution Prevention
IPA	Indigenous protected area
ISPP	International Sewage Pollution Prevention
ISPPC	International Sewage Pollution Prevention Certificate
ISO	International Standards Organisation
IUCN	International Union for Conservation of Nature
JBG	Joseph Bonaparte Gulf
JRCC	joint rescue coordination centre
KEF	key ecological feature
km	kilometre
km^2	square kilometre
km/h	kilometres per hour
L	litre
LC_{50}	Lethal concentration 50. Lethal concentration in which 50% of the population will be killed in a given period of time
m	metre
m^2	square metres
m^3	cubic metres
m/m	mass for mass
m/s	metres per second

Term, abbreviation or acronym	Meaning
MARPOL	International Convention for the Prevention of Pollution from Ships, 1973/1978
MDO	marine diesel oil
MFO	Marine Fauna Observer
mg/L	milligrams per litre
mg/m3	milligrams per cubic metre
MGO	marine gas oil
mm	millimetre
MMF	Mackerel Managed Fishery (WA)
MNES	Matters of National Environmental Significance
MoC	management of change
MP	marine park
MSS	marine seismic survey
NatPlan	National Plan for Maritime Environmental Emergencies
NAXA	North Australian Exercise Area
NDSMF	Northern Demersal Scalefish Managed Fishery (WA)
NGER	National Greenhouse and Energy Reporting
NGER Act	*National Greenhouse and Energy Reporting Act* (Cwlth)
nm	nautical miles
NMR	north marine region
NO_2	nitrogen dioxide
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NOPTA	National Offshore Petroleum Titles Administrator
NOTAM	Notice to Airmen
NO_X	nitrogen oxides
NPF	Northern Prawn Fishery
NPFI	Northern Prawn Fishery Industry

Term, abbreviation or acronym	Meaning
NRSMPA	National Representative System of Marine Protected Areas
NSW	New South Wales
NT	Northern Territory
NTG	Northern Territory government
NWCS	North-west cable system
NWMR	north-west marine region
NWS	north-west shelf
ODS	ozone-depleting substance
OEM	original equipment manufacturer
OIW	oil in water
OPEP	oil pollution emergency plan
OPGGS Act	*Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cwlth)
OPGGS (E) Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cwlth)
OWD	oil-in-water dispersions
OWS	oil-water separator
PAH(s)	polycyclic aromatic hydrocarbon(s)
PDCA	plan, do check, act
PEZ	potential exposure zone (the area exposed to hydrocarbons in the event of a worst-case credible oil spill, established using low exposure thresholds)
PK	peak pressure
PK-PK	peak-to-peak pressure
POTS Act	Protection of the Sea (Prevention of Pollution from Ships) Act 1983
ppb	parts per billion
ppm	parts per million
ppm(v)	parts per million by volume
psi	pounds per square inch
PTS	permanent threshold shift

Term, abbreviation or acronym	Meaning
QLD	Queensland
Ramsar Convention	The Convention on Wetlands of International Importance, especially as Waterfowl Habitat (the Ramsar Convention)
s	seconds
SEEMP	Ship Energy Efficiency Management Plan
SEL	sound exposure level
SIMA	spill impact mitigation assessment
SMPEP	a shipboard marine pollution emergency plan
SO_2	sulphur dioxide
SOLAS	International Convention for the Safety of Life at Sea
SOPEP	shipboard oil pollution emergency plan
SPI	source point interval
SPL	sound pressure level
SPRAT	species profile and threats
T	tonne
TH	titleholder
TPH	total petroleum hydrocarbons
TSS	total suspended solids
TTS	temporary threshold shift
UXO	unexploded ordinance
VMS	vessel monitoring system
VOCs	volatile organic compounds
WA	Western Australia
WA DoT	Department of Transport (WA)
WA EPA	Environment Protection Authority (WA)
WCSS	worst-case spill scenarios
WSF	water-soluble fraction
µPa	micropascal

1 INTRODUCTION

1.1 Scope

In December 2021, the Australian Government released five greenhouse gas (GHG) storage acreage release areas offshore of Western Australia (WA) and the Northern Territory (NT), for the purpose of GHG storage exploration and assessment. INPEX Browse E&P Pty Ltd (INPEX) on behalf of the Bonaparte Carbon Capture and Storage Assessment Joint Operating Agreement participants was successfully awarded a GHG assessment permit over one of these areas, G-7-AP (Figure 1-1), located offshore in the Bonaparte Basin off northern Australia.

INPEX is proposing to conduct a three-dimensional (3D) marine seismic survey (MSS) to further assess the storage complex to confirm suitability for injection and storage of carbon dioxide (CO_2).

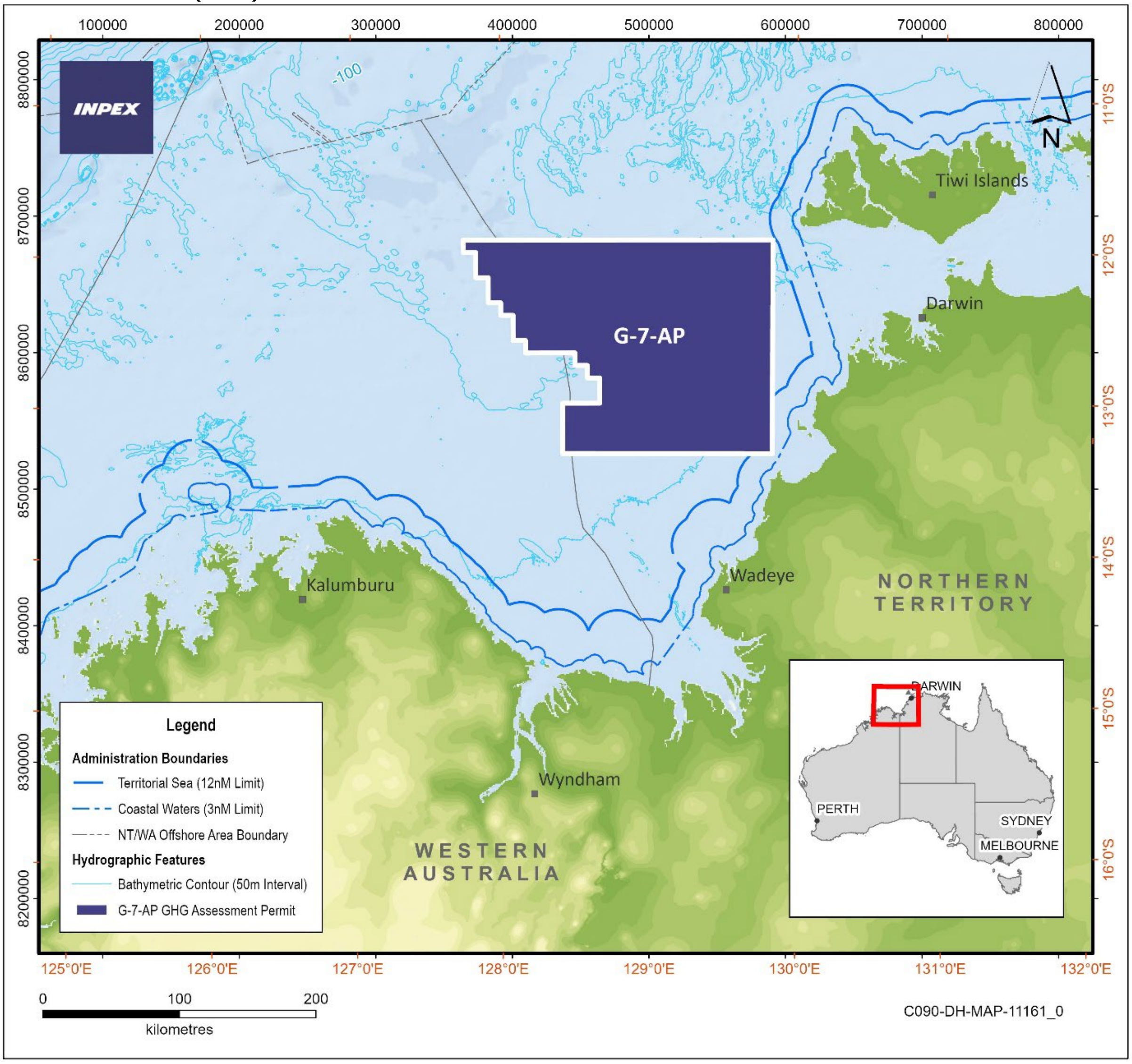


Figure 1-1: Location of G-7-AP greenhouse gas assessment permit

The proposed activities covered by this EP will consist of:

- 3D seismic data acquisition within a defined Acquisition Area.
- associated operation of the seismic source during line run-ins, run-outs, and seismic testing within a defined Active Source Area.
- associated vessel movements, line turns, and support activities within a defined Operational Area.
- The defined Acquisition Area, Active Source Area and Operational Area are further described in Section 3.1.
- The 3D MSS will be undertaken over approximately 65 days by a single seismic survey vessel and it is anticipated that the seismic survey vessel will also be accompanied by one or two support vessels, which will assist with on-the-water communication with other marine users, refuelling, re-supply and other support functions. One or two small work-boats, launched from the seismic survey vessel, may assist during deployment, testing and recovery of the seismic equipment. Personnel transfers to and from the seismic survey vessel may also be undertaken by helicopter.

The scope of this EP is defined as commencing at the point when the seismic survey vessel is within the defined Operational Area and the towed seismic equipment is deployed, until the seismic survey vessel has demobilised and departed the Operational Area following completion of the survey. The EP does not include any required movement of vessels or helicopters outside of the Operational Area (e.g. travel to and from port). These activities will be undertaken in accordance with relevant maritime and aviation legislation; most notably, the *Navigation Act 2012* (Cwlth).

The 3D MSS is provisionally expected to be conducted in Q2 2023. However, for contingency purposes subject to seismic survey vessel availability, operational efficiencies, and weather, this EP allows for the activity to occur anytime during calendar years 2023 and 2024.

1.2 Objectives

The objectives of this EP are to:

- demonstrate that the environmental impacts and risks associated with the GHG storage exploration activity have been reduced to 'as low as reasonably practicable' (ALARP) and are of an acceptable level
- establish appropriate environmental performance outcomes (EPOs), environmental performance standards (EPSs) and measurement criteria in relation to the operation of the survey vessels
- define an appropriate implementation strategy and monitoring, recording and reporting arrangements, whereby compliance with this EP, the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cwlth) (OPGGS (E) Regulations), and other relevant legislative requirements, can be demonstrated
- demonstrate that INPEX has carried out the consultations required by the OPGGS (E) Regulations
- demonstrate that the measures adopted by INPEX, arising from the consultation process, are appropriate
- demonstrate that the GHG storage exploration activity complies with the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) and the OPGGS (E) Regulations.

1.3 Overview of activity description

Table 1-1 provides an overview of the activities to be undertaken under this EP.

Table 1-1: Overview of the activity description

Item	Description
Basin	Bonaparte Basin, Petrel Sub-basin
INPEX GHG assessment permit	G-7-AP
Other titleholders' permit areas that survey lines may enter (subject to Access Authority)	NT/P88 NT/RL1 WA-6-R
Activity location	Wholly located within Commonwealth waters in the northern Joseph Bonaparte Gulf in the North Marine Region (NMR) of the Timor Sea. The Operational Area is located approximately 175 km west of Darwin (NT), 145 km south-west of Bathurst Island (Tiwi Islands, NT), 125 km north-west of Wadeye (NT), 280 km east-north-east of Wyndham (WA), and 255 km north-east from Kalumburu (WA).
Water depth	Approximately 65 m to 106 m below Australian Height Datum (AHD; mean sea level).
Activities	3D marine seismic survey
Vessels	1 x seismic survey vessel 1 to 2 x supply/support vessels 1 to 2 x work boats (small launch from survey vessel)
Activity timing	2023 – 2024
Duration	Up to 65 days

1.4 Titleholder details

INPEX Browse E&P Pty Ltd is a joint titleholder of GHG assessment permit G-7-AP but has been nominated as the single titleholder for the purposes of taking eligible voluntary actions under subsection 775B of the OPGGS Act, such as making submissions.

In accordance with Regulation 15(1) of the OPGGS (E) Regulations, details of the titleholder are described in Table 1-2. INPEX will be responsible for ensuring that activities covered in this EP are carried out in accordance with the OPGGS (E) Regulations, this EP and other applicable Australian legislation.

In accordance with Regulation 15(2) of the OPGGS (E) Regulations, details of the titleholder's nominated liaison person are provided in Table 1-3.

Table 1-2: Titleholder details

Name	INPEX Browse E&P Pty Ltd (INPEX)
Business address	Level 22, 100 St Georges Tce, Perth, WA 6000
Telephone number	+61 8 6213 6000
Fax number	+61 8 6213 6455
Email address	enquiries@inpex.com.au
ABN	61 165 711 017

Table 1-3: Titleholder nominated liaison person

Name	Jake Prout
Position	Environment Operations Team Lead
Business address	Level 22, 100 St Georges Tce, Perth, WA 6000
Telephone number	+61 8 6213 6000
Email address	jake.prout@inpex.com.au

1.4.1 Notification arrangements

In the event that the titleholder, nominated liaison person or contact details for the nominated liaison person change, INPEX will notify the regulator in accordance with Regulation 15(3) of the OPGGS (E) Regulations.

2 ENVIRONMENTAL MANAGEMENT FRAMEWORK

2.1 Corporate framework

INPEX's Business Management System (BMS) is a comprehensive, integrated system that includes standards and procedures necessary for the management of health, safety and environment (HSE) risks.

The INPEX Environmental Policy sets the direction and minimum expectations for environmental performance, and is implemented through the standards and procedures of the BMS. The BMS and Environment Policy are further described in Section 9 in accordance with Regulation 16(a) of the OPGGS (E) Regulations.

2.2 Legislative framework

In accordance with Regulation 13(4) of the OPGGS (E) Regulations, the legislative framework relevant to the activity is listed in Table 2-1. A summary of applicable industry standards and guidelines is also presented in Table 2-2. Ongoing management of legislative and other requirements is described further in in Section 9.8.1.

2.3 Seismic survey and underwater noise assessment guidelines

A summary of policies and guidelines applicable to the assessment and management of seismic surveys and underwater noise impacts in Australia is presented in Table 2-3.

Table 2-1: Summary of applicable legislation

Legislation	Description	Requirements	Demonstration of how requirements are met in EP
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act; Cwlth) and Environment Protection and Biodiversity Conservation Regulations 2000 (EPBC Regulations)	Provides for the protection and management of nationally and internationally important flora, fauna, ecological communities, and heritage places.	The OPGGS (E) Regulations were revised in February 2014 to include the requirement that matters protected under Part 3 of the EPBC Act are considered and any impacts are at acceptable levels. Part 8 of the EPBC Regulations outlines requirements for vessel when interacting with cetaceans. EPBC Act Policy Statement 2.1 provides a framework for minimising the risk of injury to whales by outlining requirements for vertical seismic profiling. The EPBC Act provides for protection of 'matters of national environmental significance' including not only listed species but also heritage properties and Ramsar wetlands. There are exemptions covering provisions of Part 3 and 13 of the EPBC Act, for the undertaking of activities when responding to maritime environmental emergencies, in accordance with the National Plan for Maritime Environmental Emergencies (NatPlan). Australian Marine Parks (AMPs) are proclaimed under this Act and associated management plans are enacted under this legislation.	Section 4.3 – Australian Marine Parks. Section 7.1 – Noise and vibration. Section 7.2 – Social and cultural heritage protection. Section 7.4.2 – Interaction with marine fauna. Section 8 – Emergency Conditions INPEX *Browse Regional Oil Pollution Emergency Plan (OPEP)* A demonstration of how this EP addresses the relevant conservation management documents related to EPBC-listed species has been presented in Appendix A.
OPGGS Act and OPGGS (E) Regulations (Cwlth)	The OPGGS Act provides the regulatory framework for petroleum exploration, production and greenhouse gas activities in Commonwealth waters.	The OPGGS (E) Regulations require that the activity is undertaken in an ecologically sustainable manner, and in accordance with an accepted EP.	Throughout this EP and implementation of the BMS.

Legislation	Description	Requirements	Demonstration of how requirements are met in EP
	The OPGGS (E) Regulations under the OPGGS Act require a titleholder to have an accepted environment plan in place for a GHG storage exploration activity.		
Navigation Act 2012 (Cwlth)	The primary legislation that regulates ship and seafarer safety, shipboard aspects of protection of the marine environment, and employment conditions for Australian seafarers.	The *Navigation Act 2012* includes specific requirements for safe navigation, including systems, equipment and practices consistent with the International Convention for the Safety of Life at Sea (SOLAS) and the International Regulations for Preventing Collisions at Sea (COLREGS), as implemented as maritime law in Australia through a series of Marine Orders, including Marine Orders – Part 21 – Safety of navigation and emergency procedures and Marine Orders – Part 30 – Prevention of collisions. The *Navigation Act 2012*, in conjunction with the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and through legislative Marine Orders, also requires vessels to have pollution prevention certificates (see below).	Section 7.2 – Social and cultural heritage protection. Section 8.2 - Vessel collision. Implementation of the BMS.
Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (POTS Act; Cwlth)	The POTS Act provides for the prevention of pollution from vessels, including pollution by oil, noxious liquid substances, packaged harmful substances, sewage, garbage, and air pollution. In conjunction with Chapter 4 of the *Navigation Act 2012*, the POTS Act gives effect to relevant requirements of the International	The requirements of the POTS Act and the *Navigation Act 2012* are implemented as maritime law in Australia through a series of Marine Orders and legislative instruments, made and administered by the Australian Maritime Safety Authority (AMSA). The requirements of each Marine Order made under the POTS Act and the *Navigation Act 2012* and their relevance to the activity are outlined separately below.	Section 5 and Section 8. Implementation of the BMS.

Legislation	**Description**	**Requirements**	**Demonstration of how requirements are met in EP**
	Convention for the Prevention of Pollution from Ships, 1973/1978 (MARPOL 73/78) in Australia.		
Marine Orders Part 91 – Marine pollution prevention — oil	Marine Orders Part 91 implements Part II of the POTS Act, Chapter 4 of the *Navigation Act 2012*, and Annex I of MARPOL 73/78 (oil pollution). The Marine Orders provide standards for the discharge of certain oily mixtures or oily residues and associated equipment and include duties to manage bunkering and transfers of oil between vessels; to maintain Oil Record Books and Shipboard Oil Pollution Emergency Plans (SOPEPs); and to report oil pollution.	The survey vessels ≥400 gross tonnes (GT) are required to maintain: • International Oil Pollution Prevention (IOPP) certificates to demonstrate that the vessel and onboard equipment comply with the requirements of Annex I of MARPOL 73/78 (as applicable to vessel size, type and class). • Oil Record Books to record activities, such as fuel/oil bunkering and discharges of oil, oily water, mixtures and residues. • SOPEPs outlining the procedures to be followed during an oil pollution incident. • Discharges must also comply with Annex I of MARPOL 73/78, and oil pollution incidents must also be reported to AMSA.	Section 7.5.3 – Routine discharges. Section 7.7 – Loss of containment. Section 8 - Emergency Conditions - Impact and Risk Evaluation. INPEX *Browse Regional OPEP.* Implementation of the BMS.
Marine Order 93 – Marine pollution prevention – noxious liquid substances	Marine Order 93 - Marine pollution prevention – noxious liquid substances (made under the *Navigation Act 2012* and the POTS Act and Annex II of MARPOL) specifies the requirements for the prevention of contaminating liquids and chemicals entering the marine environment. It also sets out guidelines for developing a	Requirements of Marine Order 93 include: • International pollution prevention certificates • reporting requirements • emergency plans, record books and tank cleaning. • INPEX and vessel contractor will comply with the Marine Order 93 as appropriate to vessel class, in relation to the discharge to sea of any noxious liquid substances.	Section 7.7.1 – Accidental release Implementation of the BMS.

Legislation	Description	Requirements	Demonstration of how requirements are met in EP
	Shipboard Marine Pollution Emergency Plan (SMPEP).	• Marine vessels >150 GT will carry SMPEPs approved under MARPOL Annex II, Regulation 17 if the vessel is carrying noxious liquid substances in bulk (noting that the vessels SOPEP and SMPEP may be combined into a single document).	
Marine Orders Part 94 – Marine pollution prevention — packaged harmful substances	Marine Orders Part 94, – Marine pollution prevention — packaged harmful substances, and the *POTS Act* relating to packaged harmful substances as defined by Annex III of MARPOL 73/78.	Requirements of Marine Order 94 include: • management of harmful substances in packaged form • considerations prior to washing substances overboard • notifying and reporting incidents. INPEX and vessel contractor will comply with the *Navigation Act 2012* – Marine Orders – Part 94: Marine Pollution Prevention– Packaged Harmful Substances (as appropriate to vessel class), through reporting the loss or discharge to sea of any harmful materials.	Section 7.6– Waste management. Implementation of the BMS.
Marine Orders Part 95 – Marine pollution prevention — garbage	Marine Orders Part 95 – Marine pollution prevention — garbage implements Part IIIC of the POTS Act, Chapter 4 of the *Navigation Act 2012*, and Annex V of MARPOL 73/78 (garbage). The Marine Orders provide for the discharge of certain types of garbage at sea, waste storage, waste incineration, and the comminution and discharge of food waste. They also set out	Survey vessels ≥100 GT, or vessels certified to carry 15 persons or more, are required to maintain a Garbage Management Plan. Survey vessels ≥400 GT are required to maintain a Garbage Record Book. The requirements will apply to the vessels (as appropriate to their size, type and class) at all times.	Section 7.6 – Waste Management. Implementation of the BMS.

Legislation	Description	Requirements	Demonstration of how requirements are met in EP
	requirements for garbage management and recording.		
Marine Orders Part 96 – Marine pollution prevention — sewage	Marine Orders Part 96 – Marine pollution prevention — sewage implements Part IIIB of the POTS Act, Chapter 4 of the *Navigation Act 2012*, and Annex IV of MARPOL 73/78 (sewage). The Marine Orders include requirements for the treatment, storage and discharge of sewage and associated sewage systems, and for an International Sewage Pollution Prevention (ISPP) certificate to be maintained on board.	Survey vessels ≥400 GT are required to maintain International Sewage Pollution Prevention (ISPP) certificates to demonstrate that vessels and their onboard sewage systems comply with the requirements of Annex IV of MARPOL 73/78. Discharges of sewage must also comply with Annex I of MARPOL 73/78, and oil pollution incidents must also be reported to AMSA.	Section 7.5.3 – Routine discharges. Implementation of the BMS.
Marine Orders Part 97 – Marine pollution prevention — air pollution	Marine Orders Part 97 – Marine pollution prevention — air pollution implements Part IIID of the POTS Act, Chapter 4 of the *Navigation Act 2012*, and Annex VI of MARPOL 73/78 (air pollution). The Marine Orders set requirements for marine diesel engines and associated emissions, waste incineration on board vessels, engine fuel quality, and equipment and systems containing ozone-depleting substances (ODS).	Survey vessels ≥400 GT are required to have International Air Pollution Prevention (IAPP) certificates and Engine International Air Pollution Prevention (EIAPP) certificates to demonstrate that the vessel and onboard marine diesel engines comply with the requirements of Annex VI of MARPOL 73/78. Low-sulphur fuel oil / marine diesel with 0.5% m/m sulphur content. Vessels ≥400 GT are required to have an Internal Maritime Organization (IMO)-approved waste incinerator, as confirmed by the IAPP certificate. The Marine Orders require vessels ≥400 GT with rechargeable systems containing ODS to maintain an ODS Record Book.	Section 7.5.2 – Atmospheric emissions. Implementation of the BMS.

Legislation	Description	Requirements	Demonstration of how requirements are met in EP
		Vessels ≥400 GT to have an International Energy Efficiency (IEE) certificate (as applicable to the vessel and engine size, type and class). Vessels ≥400 GT to have a Ship Energy Efficiency Management Plan (SEEMP) (as applicable to the vessel and engine size, type and class).	
Biosecurity Act 2015 (Cwlth) and Biosecurity Regulations 2016	The *Biosecurity Act 2015* and subordinate legislation are the primary legislative means for managing risk of pests and diseases entering Australian territory and seas and causing harm to animals, plant and human health, the environment and/or the economy.	Of specific relevance to this EP, the *Biosecurity Act 2015* requires that ballast is managed within Australian seas. The *Biosecurity Act 2015* defines Australian seas as: • for domestic and international vessels whose Flag State Administration is party to the Ballast Water Management (BWM) Convention – the waters (including the internal waters of Australia) that are within the outer limits of the exclusive economic zone (EEZ) of Australia (all waters within 200 nm) or • for all other international vessels – the Australian territorial seas (all waters within 12 nm). The Biosecurity Amendment (Biofouling Management) Regulations 2021 entered into force on 15 June 2022. Operators of all international vessels will be required to provide information on how biofouling has been managed prior to arrival in Australian territorial seas. Requirements may include a biofouling management plan; or cleaning within 30 days prior to arrival; or implementation of alternative biofouling management methods.	Section 7.4.1 - Invasive marine species. Implementation of the BMS.

Legislation	Description	Requirements	Demonstration of how requirements are met in EP
Biodiversity Conservation Act 2016 (WA) Biodiversity Conservation Regulations 2018 (WA) *Animal Welfare Act 1999* (NT) *Animal Welfare Act 2002* (WA)	Ensures the protection of biodiversity and humane treatment of native fauna. Ensures appropriate treatment and management of wildlife in the event of a potential hydrocarbon spill and response activities.	Consult with WA and NT bodies to obtain relevant permit(s) before a wildlife hazing and post-contact wildlife response.	Section 8 – Emergency conditions. INPEX *Browse Regional OPEP.*
Fisheries Act 1988 (NT) Fisheries Regulations 1992 (NT)	The *Fisheries Act 1988* (NT) is administered by the NT Department of Industry, Tourism and Trade (DITT) and provides for the long-term sustainable management of aquatic resources including the protection of the environment and economy from the introduction and spread of aquatic pests.	INPEX will manage its operations in accordance with the *Fisheries Act 1988* and the associated Fisheries Regulations (1992) with respect to managing potential invasive marine species (IMS) risks.	Section 7.4.1 - Invasive marine species. Implementation of the BMS.
Underwater Cultural Heritage Act 2018	This Act replaced the *Historic Shipwreck Act 1976* and provides protection for shipwrecks, sunken aircraft and other types of underwater heritage including human remains that have been in Australian waters for at least 75 years.	The *Underwater Cultural Heritage Act 2018* prohibits certain activities within protected zones (prohibited conduct) including but not limited to: • Entry of persons or vessels • Allowing a vessel to become stationary • Underwater activities • Anchoring or mooring vessels • Release or deposit of objects or materials.	N/A

Legislation	Description	Requirements	Demonstration of how requirements are met in EP
		Any access to protected zones would only occur during oil spill response activities and this is exempt as per Section 29(3)C 'dealing with an emergency involving a serious threat to the environment'.	
National Greenhouse and Energy Reporting Act 2007 (Cwlth; NGER Act)	The Act provides a single, national framework for the reporting and distribution of information related to greenhouse gas (GHG) emissions, GHG projects, energy production and energy consumption.	The Clean Energy Regulator administers the NGER Act, its legislative instruments, and related policies and processes. Reporting requirements under the NGER Act are made via the Emissions and Energy Reporting System (EERS) on an annual basis. EERS allows all NGER reporters to submit emissions and energy reports under sections 19, 22G and 22X of the NGER Act. Vessel contractors are responsible for NGER reporting* for the activity described within this EP as they have operational control under the NGER Act. *subject to exceeding the reporting threshold of 25 kt or more of GHG (scope 1 and 2 emissions).	Section 7.5.2 Atmospheric emissions.

Table 2-2: Summary of applicable industry standards and guidelines

Guideline	Description
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018)	These Guidelines provide a framework for water resource management and state specific water quality guidelines for environmental values, and the context within which they should be applied.
International Convention for the Prevention of Pollution from Ships, 1973/1978 (MARPOL 73/78)	This Convention is designed to reduce pollution of the seas, including dumping, oil and exhaust pollution. MARPOL 73/78 currently includes six technical annexes. Special areas with strict controls on operational discharges are included in most annexes.
International Convention on the Control of Harmful Anti-fouling Systems	This Convention prohibits the use of harmful organotins in antifouling paints used on ships and establishes a mechanism to prevent the potential future use of other harmful substances in antifouling systems.
International Convention for the Safety of Life at Sea (SOLAS) 1974	In the event of an offshore emergency event that endangers the life of personnel, the International Convention for the Safety of Life at Sea (SOLAS) 1974 may take precedence over environmental management.
Bonn Agreement for Cooperation in Dealing with Pollution of the North Sea by Oil and other harmful substances (Bonn Agreement)	The Bonn Agreement is the mechanism by which the North Sea states, and the European Union (the Contracting Parties), work together to help each other in combating pollution in the North Sea area from maritime disasters and chronic pollution from ships and offshore installations; and to carry out surveillance as an aid to detecting and combating pollution at sea. The Bonn Agreement Oil Appearance Code may be used during spill response activities.
The Australian Petroleum Production and Exploration Association (APPEA) *Code of Environmental Practice* (APPEA 2008)	Recognising the need to avoid or minimise and manage impacts to the environment, this code of environmental practice includes four basic recommendations to APPEA members undertaking activities: Assess the risks to, and impacts on, the environment as an integral part of the planning process. Reduce the impact of operations on the environment, public health and safety to as low as reasonably practicable (ALARP) and to an acceptable level by using the best available technology and management practices. Consult with stakeholders regarding industry activities. Develop and maintain a corporate culture of environmental awareness and commitment that supports the necessary management practices and technology, and their continuous improvement.
Australian Ballast Water Management Requirements, Version 8 (DAWE 2020)	Australian Ballast Water Management Requirements outline the mandatory ballast water management requirements to reduce the risk of introducing harmful aquatic organisms into Australia's marine environment through ballast water from international vessels. These requirements are enforceable under the *Biosecurity Act 2015*.

Guideline	Description
National Biofouling Management Guidelines for the Petroleum Production and Exploration Industry (MPSC 2018)	A voluntary biofouling management guidance document developed under the National System for the Prevention and management of Marine Pest Incursions. Its purpose is to provide tools to operators to minimise the amount of biofouling accumulating on their vessels, infrastructure and submersible equipment and thereby to minimise the risk of spreading marine pests.
International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) (IMO 2009)	All vessels are required to manage their ballast water and sediments in accordance with the BWM Convention and *Biosecurity Act 2015*. The convention came into force on 8 September 2017 and Australia's ballast water policy and legislation align with the convention.
Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species (IMO 2012)	The guidelines provide a globally consistent approach to the management of biofouling. They aim to reduce the risk of translocation of marine pests from biofouling present on immersed areas of vessels. It was adopted by IMO marine environment committee in the form of Resolution MEPC.207 (62) in 2011.
National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (DEE 2020)	The Guidelines provide best-practice industry standard for managing potential impacts of light pollution on marine fauna.
United Nations Framework Convention on Climate Change (1992)	The objective of the Convention is to stabilise GHG concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system. Australia ratified the Convention in December 1992 and it came into force on 21 December 1993.
Paris Agreement on Climate Change (2015)	The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 °C. The Paris Agreement provides the international framework and context around Australia's nationally determined contributions (NDC).
National disaster risk reduction framework	In 2019, the Australian Government agreed to a National Disaster Risk Reduction Framework outlining foundational actions to be taken across all sectors to address existing disaster risk and minimise the creation of new risk. The Framework recognises global climate change as an underlying driver of disaster risk.

Table 2-3: Summary of policies and guidelines applicable to the assessment and management of underwater noise impacts and marine seismic surveys

Policy / Guideline	Description
EPBC Act Policy Statement 2.1 (DEWHA 2008a)	The Policy Statement encourages industry to minimise the likelihood of seismic activities causing injury and/or hearing

Policy / Guideline	Description
	impairment to whales in Australian waters. The Policy Statement outlines sound exposure criteria for determining appropriate precaution zones and outlines recommended management procedures. Part A of the policy statement outlines standard management procedures, which include: pre-start-up visual observations soft-start procedures start-up delay procedures operations and shut-down procedures night-time and low visibility procedures. Part B of the policy statement outlines additional optional management procedures for consideration for seismic surveys in areas where there is a moderate to high likelihood of encountering whales.
NOPSEMA (2020a) Information Paper IPI765: Acoustic Impact Evaluation and Management	The information paper provides advice to titleholders to assist with preparing EPs for marine seismic survey activities, and in particular the components of an EP that relate to detailing, evaluating and managing impacts from acoustic emissions.
WA DPIRD Fisheries Research Report No. 288: Risk Assessment of the potential impacts of seismic air gun surveys on marine finfish and invertebrates in Western Australia (Webster et al. 2018)	The Fisheries Division of the WA DPIRD undertook an ecological risk assessment (ERA) of the potential effects of seismic surveys on marine finfish and invertebrates. The ERA assessed different categories of seismic source volume and the potential exposure of different types of finfish and invertebrates in different water depths. The ERA was undertaken at the level of *individual* adult finfish and invertebrate organisms closest to the seismic source and it was assumed that an individual organism remains stationary (i.e. does not flee) and is positioned directly in the path of the vessel, thus experiencing numerous pulses with varying degrees of intensity as the vessel approaches, passes overhead and moves further away. Therefore, the WA DPIRD ERA represents a highly conservative worst-case scenario that is not representative of real-life exposures in all cases, as it does not account for any avoidance response by mobile organisms. The WA DPIRD ERA identified that overall the greater the intensity of sound and shallower the water depth the greater the assigned risk. The organisms classified as most at risk from seismic impacts were immobile invertebrates (e.g. molluscs) while pelagic fish were rated as the least at risk. The 3D MSS environmental impact and risk assessment in Section 7.1 of this EP has applied additional activity-specific and situation-specific context to assess potential risks to individuals and populations.

3 ACTIVITY DESCRIPTION

3.1 Location and Operational Area

G-7-AP (herein referred to as the GHG assessment permit) is located in the Bonaparte Basin, to the north of the Joseph Bonaparte Gulf in Commonwealth waters offshore of the NT (Figure 1-1). It is situated 14 km north-west of the NT coastline at its closest point.

The 3D MSS will be undertaken within a small section of the broader GHG assessment permit (Figure 3-1). There are three areas defined for the activity, based on the types of activities that will be undertaken. These are:

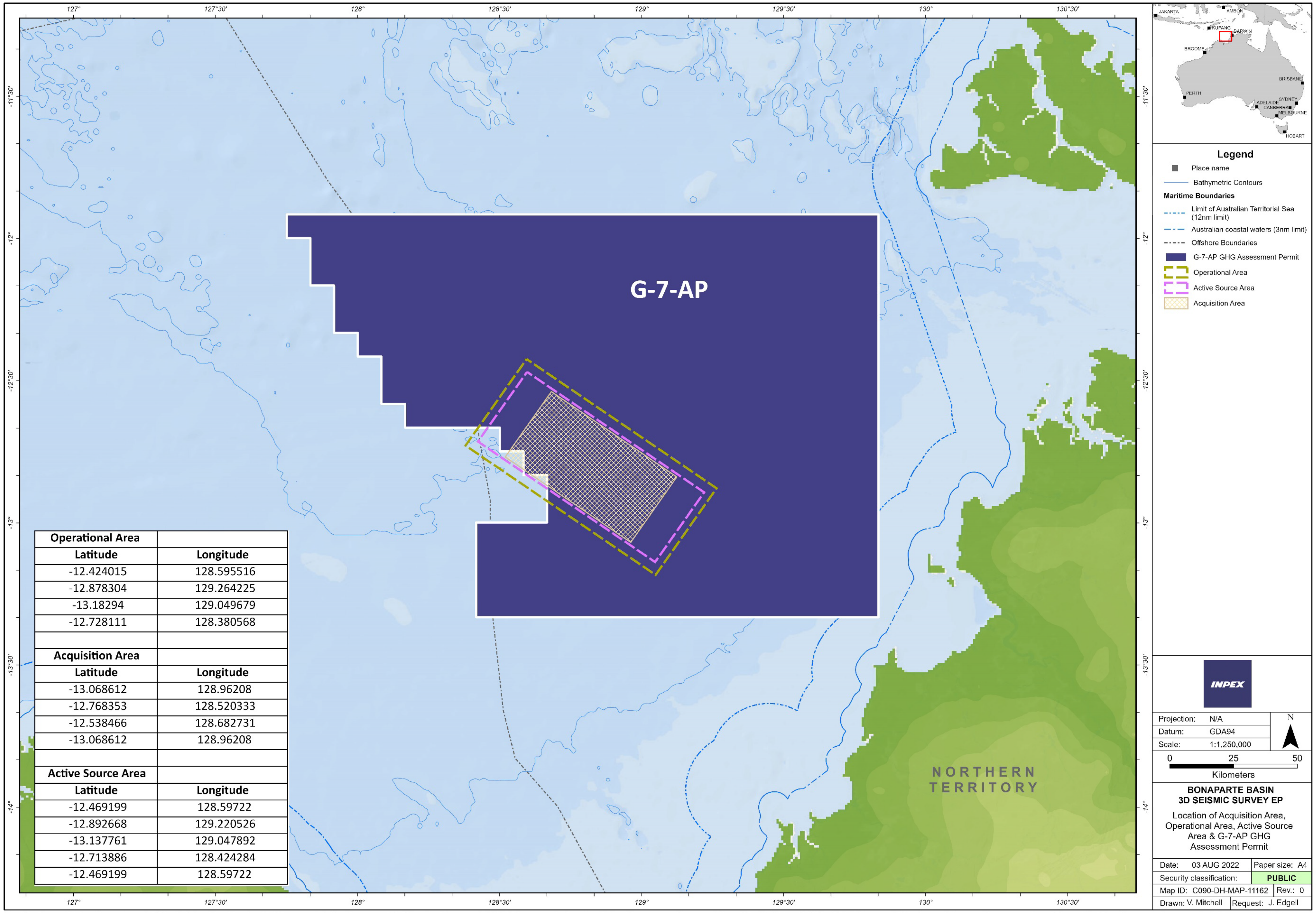
- Acquisition Area
- Active Source Area
- Operational Area.

The purpose and key characteristics of the three areas are presented in Table 3-1. The defined activity and the scope of this EP commences at the point when the seismic survey vessel is within the defined Operational Area and the towed seismic equipment is deployed, until the seismic survey vessel has demobilised and departed the Operational Area following completion of the survey.

The EP does not include any required movement of vessels or helicopters outside of the Operational Area (e.g. travel to and from port). These activities will be undertaken in accordance with relevant maritime and aviation legislation; most notably, the *Navigation Act 2012* (Cwlth). Note, the planned activity does not require the seismic vessel to transit through the Oceanic Shoals Marine Park.

Table 3-1: Purpose and characteristics of proposed 3D MSS areas

Characteristic	Acquisition Area	Active Source Area	Operational Area
Purpose	Where operation of the seismic source at full capacity will occur for the purpose of seismic data acquisition.	Where operation of the seismic source may occur beyond the Acquisition Area, at or below full capacity (e.g. during "soft-starts", line run-ins and run-outs).	Where associated vessel movements, line turns, and support activities will occur beyond the extents of the Active Source Area and Acquisition Area.
Area (km^2)	1,811	2,723	3,632
Water depth range (m AHD)	70 – 104	67 – 105	65 – 106



Operational Area	
Latitude	Longitude
-12.424015	128.595516
-12.878304	129.264225
-13.18294	129.049679
-12.728111	128.380568
Acquisition Area	
Latitude	Longitude
-13.068612	128.96208
-12.768353	128.520333
-12.538466	128.682731
-13.068612	128.96208
Active Source Area	
Latitude	Longitude
-12.469199	128.59722
-12.892668	129.220526
-13.137761	129.047892
-12.713886	128.424284
-12.469199	128.59722

The information contained on this map is confidential and for information only, and must not be communicated to other persons without the prior written consent of INPEX. Any unauthorised use of such information may expose the user and the provider of that information to legal risk. While every effort has been made to ensure the accuracy and completeness of the information presented, no guarantee is given nor responsibility taken by INPEX for any errors or omissions. INPEX accepts no liability for any use of the said information or reliance placed on it.

Figure 3-1: Map showing the proposed Bonaparte Basin 3D MSS Acquisition Area and Operational Area

3.2 Schedule

The 3D MSS will comprise approximately 40 days of seismic data acquisition. To allow for equipment deployment and recovery, potential adverse weather and operational downtime, the survey may occur over a longer period, and so the survey vessel may be present in the Operational Area for up to a total of 65 days. Activities will be undertaken on a continual 24 hours per day basis.

It is expected that the earliest that the 3D MSS may commence is in April-May 2023; however, an exact start date is subject to vessel availability, operational efficiencies, other site survey and drilling activities that INPEX plan to undertake within the permit area, potential Department of Defence exercises that may occur, and weather. For contingency purposes, this EP allows for the activities to occur within the calendar years 2023-2024.

3.3 Seismic survey activities

Key details of the 3D MSS are summarised in Table 3-2 and described below.

Table 3-2: Key seismic survey details

Feature / Parameter	Description
3D Seismic Data Acquisition	
Total survey duration	Up to 65 days
Seismic source volume	Approximately 2,500 – 3,300 cubic inches (in^3)
Source discharge pressure	Approximately 2,000 pounds per square inch (psi)
Source point interval (SPI)	12.5 m (triple) or 18.75 m (dual)
Source tow depth	6 – 8 m
Streamer length	Approximately 7 – 10 km (ends may extend up to 11 km behind vessel)
Streamer spread width	Approximately 825 – 1,500 m
Streamer tow depth	15 – 25 m
Vessel acquisition speed	Approximately 4.5 knots (8.33 km/hr)
Seismic Survey Vessel	
Number of seismic vessels	One
Fuel type	Marine diesel oil (MDO) / Marine gas oil (MGO)
Largest fuel tank volume	1,062 m^3
Support Activities	
Number of support / supply vessels	One to two vessels will assist with on-the-water communications with other marine users, refuelling, re-supply and other support functions.

Feature / Parameter	Description
	One to two small work boats (typically 5-10 m in length) launched from the seismic vessel will be used to assist with equipment deployment, maintenance and recovery.
Refuelling and resupply	In port or at sea (approximately every 35 days).
Crew changes	In port or at sea via helicopter or supply vessel (approximately every 35 days).

The 3D MSS will be undertaken by a seismic survey vessel towing the seismic source and a series of streamers behind it. The seismic source will emit regular pulses of sound which reflect off the seabed and underlying geological rock formations. The reflected sound is recorded by hydrophones or similar devices installed on the streamers.

The seismic source is expected to be a conventional triple or a dual source. A triple source will comprise three separate source arrays, with individual arrays discharged alternately approximately every 12.5 m (approximately every 5.4 seconds). A dual source will comprise two separate source arrays, with individual arrays discharged alternately approximately every 18.75 m (approximately every 8 seconds). The seismic source will be towed behind the seismic survey vessel at a depth of approximately 6 – 8 m below sea level.

The streamers will be towed at a depth of between 15 m and 25 m below sea level and will not make contact with the seabed at any time. At the front of each streamer is a dilt float and at the end is a tail buoy. The streamers may be between approximately 7 km and 10 km in length and, therefore, may extend up to approximately 11 km behind the seismic survey vessel. Depending on the final number of streamers and the separation distance selected for the survey, the total width of the streamer spread may range between approximately 825 m and 1,500 m.

The seismic survey vessel and towed equipment will traverse a series of pre-determined, parallel sail lines within the Acquisition Area and Active Source Area, spaced approximately 375 – 675 m apart depending upon the final seismic source and streamer configuration selected for the survey. The seismic survey vessel will traverse the lines at a speed of approximately 4.5 knots (8.3 kilometres per hour (km/hr)). The seismic survey vessel will typically complete the lines in a "racetrack" (loop) formation, whereby a line is completed, then the vessel turns to survey a parallel line offset several kilometres away, before turning again to survey a line adjacent to the first line (offset by approximately 375 – 675 m). The racetrack pattern is repeated as the seismic survey vessel gradually moves across the Acquisition Area.

The 3D MSS sail lines will be acquired in a north-west to south-east orientation. An indicative sail line configuration is presented in Figure 3-2 as an example.

3.3.1 Seismic source volume

The 3D MSS will be acquired using a seismic source with an approximate total volume of between 2,500 in^3 and 3,300 in^3 with an operating pressure of approximately 2,000 psi.

The range of feasible seismic source volumes was identified following a feasibility study and using information provided by prospective seismic contractors. The source specifications have considered the range of water depths within the Acquisition Area and depth of the targets within the subsurface geology to ensure adequate seismic imaging.

Use of a triple source configuration may be able to acquire the seismic data with a lower total source volume than a dual source and a triple source of approximately 3,000 in^3 or less may be suitable. A dual source may require a source volume slighty greater than 3,000 in^3 to achieve the required seismic imaging.

INPEX has not yet selected a seismic contractor to undertake the seismic survey. Therefore, to account for different seismic source configurations available from prospective 3D seismic contractors and maximum potential underwater sound outputs, INPEX has evaluated a seismic source with a volume at the upper end of the volume range specified in this EP to provide representative, but potentially conservative, sound levels in the assessment of environmental impacts and risks (Section 7.1.2).

3.3.2 Seismic source activation

On the approach to the start of each sail line in the Acquisition Area, the seismic survey vessel completes a "run-in" for several kilometres to allow for all streamers to be straightened and for the vessel to accurately position itself for the start of the line. "Soft starts", where the seismic source is gradually increased from low power to the full required power level, will also be undertaken during each approach.

After the survey vessel completes a sail line, it will undertake a 'run-out', which involves operating the seismic source for approximately half a streamer length (4 – 5 km) beyond the end of each sail line to complete the required data acquisition for the line. The seismic source is then shut down and the vessel turns to make a line change before commencing the run-in for the next line.

All operation of the seismic source during run-ins/soft-starts and run-outs will be completed within the Active Source Area.

In addition, the seismic source or individual source elements may be operated at or below full capacity anywhere within the Acquisition Area or Active Source Area for the purpose of source testing (e.g. bubble tests) and maintenance. Tests typically take just minutes or a few hours to complete. The seismic source will not be operated anywhere in the Operational Area that is outside of the Active Source Area.

3.4 Supporting vessels and aircraft

The seismic survey vessel will be accompanied by one to two support vessels, which will assist with on-the-water communication with other marine users, refuelling, re-supply and other support functions. One or two small work-boats (typically 5-10 m in length which are deployed from the seismic survey vessel) may also assist the seismic survey vessel within the Operational Area during deployment and recovery of the seismic source and streamers.

Refuelling and re-supply will occur approximately every 35 days (5 weeks), either at sea or in port. Crew changes may also occur approximately every 5 weeks, which will involve either the vessels returning to port or personnel transfers via helicopter or supply vessels.

Vessels are expected to operate from the Port of Darwin.

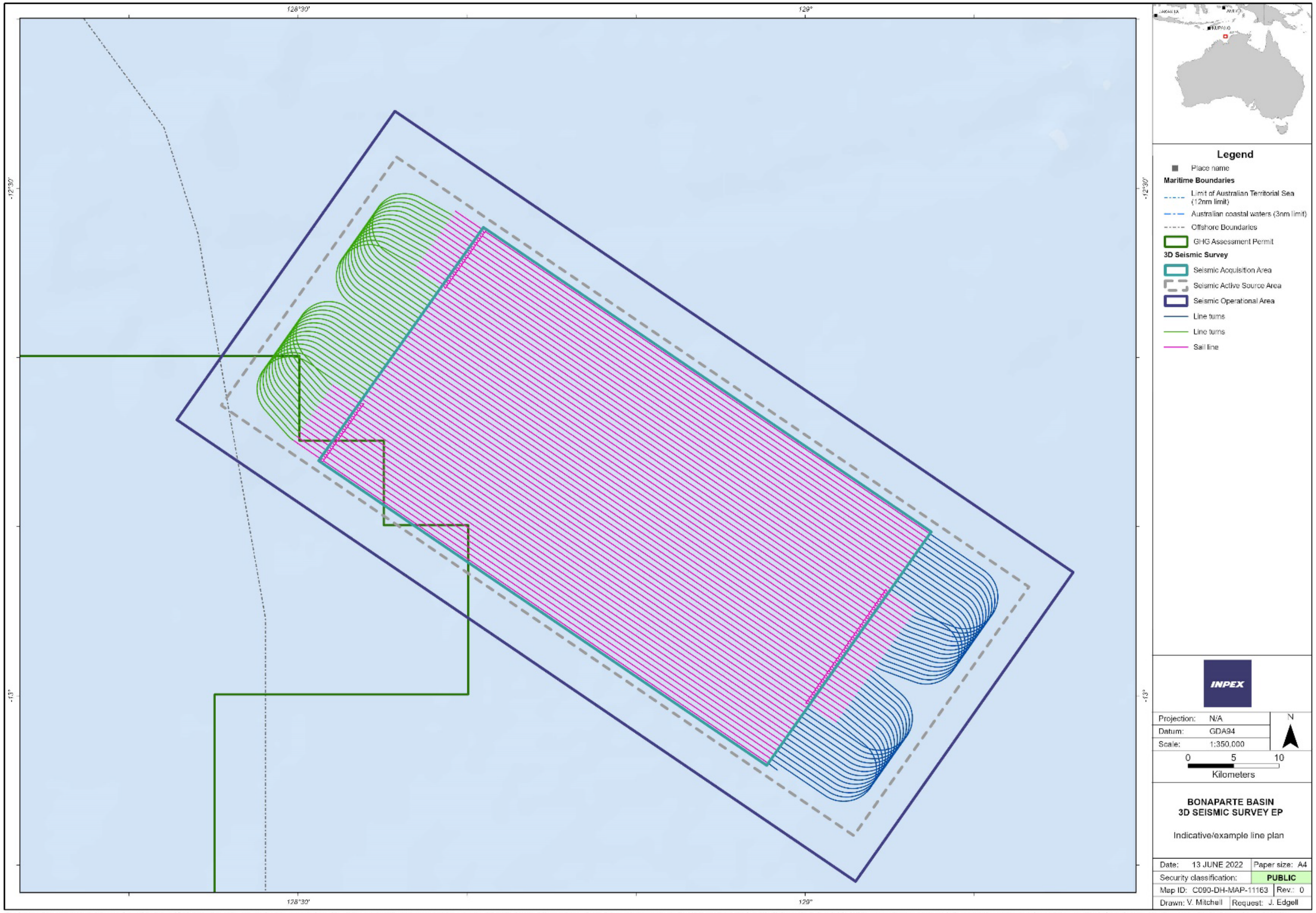


Figure 3-2: Example sail line plan

3.5 GHG emissions

Forecast direct GHG emissions generated during the proposed activity are presented in Table 3-3 Noting that these direct emissions relate to vessel contractors who have operational control and are therefore required to report under the NGER Act (refer to Table 2-1). There are no INPEX scope 1 or 2 emissions associated with the exploration activities covered by this EP. The direct emissions are considered scope 3 emissions for INPEX Australia.

Table 3-3 Expected direct GHG emissions associated with the 3D Marine Seismic survey

Activity	Fuel usage/GHG emissions (t-C0_2-e)
3D marine seismic survey vessel	2600m^3/7064 t-CO_2-e
Support vessel	650m^3/1766 t-CO_2-e
Helicopter	8 m^3/21 t-CO_2-e
Total	**3,258m^3 /~ 8851 t-CO_2-e**

Assumptions: 3D marine seismic survey vessel assumes 40m^3 of fuel use per day for 65 days. Support vessel assumes 10m^3 of fuel use per day for 65 days. Helicopter assumes two visits within 65 days.

3.6 Summary of emissions, discharges and wastes

A summary of the emissions, discharges, and wastes resulting from the activities covered in this EP are identified in Table 3-4. Relevant monitoring and measurement conducted on the emissions and discharges detailed below are described within the respective subsections of Section 7.

Table 3-4: Emissions (E), discharges (D) and wastes (W) generated during the 3D MSS

Activity/system	E, D, W	Description	
Seismic source	E	Seismic source operation	Sound emissions (pulses) from the seismic source during the survey. Seismic source volume: ~2,500 - 3,300 in^3. Source point interval: Triple source: 12.5 m (approximately every 5.4 seconds); or dual source: 18.75 m (approximately every 8 seconds). Sound levels and exposures are described in Section 7.1.2. Records of seismic source activation (on/off) will be retained by the survey contractor.
Power generation	E	Vessels	Combustion emissions from vessels and diesel-powered generators onboard emitted to the atmosphere. Records of diesel consumed will be retained by vessels oil record book.

Activity/system	**E, D, W**	**Description**	
Cooling water	D	Vessels	Treated seawater used as heat-exchange medium for machinery and engines is returned to sea.
Vessel deck drainage	D	Vessels	Vessel deck drainage water will be discharged to sea.
Bilge system	D	Vessels	Treated contaminated bilge water with <15 ppm (v) oil in water (OIW) is discharged to sea. Records of discharges will be recorded in vessels oil record book.
Sewage, grey water and macerated food waste effluent	D	Vessels	Effluent produced by vessel sewage systems is discharged to sea. Records of waste disposal, including discharge of sewage, will be recorded in the vessel's garbage record book.
Ballast system	D	Vessels	N/A. No ballast exchange will occur within the Operational Area during the survey, except in an emergency.
Waste incineration	E	Vessels	Combustion gas emissions from on board incineration of permitted wastes.
	W		Ash from incinerators will be stored as waste for disposal on the mainland. Records of waste disposal, including incinerator ash (if applicable), will be recorded in the vessel's garbage record book.
Miscellaneous	E	Vessels	Light emissions from deck and navigation lights on vessels.
	W		Solid and liquid wastes from general maintenance operations, equipment replacement, etc., and domestic wastes are transported to the mainland for disposal. Records of waste disposal, will be recorded in the vessel's garbage record book.

4 EXISTING ENVIRONMENT

4.1 Regional setting

The Operational Area is situated in the Bonaparte Basin, approximately 175 km west of Darwin in the NT (Figure 3-1). In the event of a worst-case unplanned oil spill, the area potentially exposed to hydrocarbons, hereafter referred to as the potential exposure zone (PEZ), covers a considerably larger area than the Operational Area where planned activities will occur.

The spatial extent of the PEZ was determined from stochastic spill modelling using the low hydrocarbon exposure thresholds described in NOPSEMA Bulletin #1 (NOPSEMA 2019). This considered the worst-case credible hydrocarbon spill scenarios identified for the activity (refer Section 7.7, Table 7-31) for surface hydrocarbons, shoreline accumulations of oil, and entrained oil and dissolved aromatic hydrocarbons in the water column. The PEZ has been used to identify relevant values and sensitivities that may be affected and has been used as the basis for the EPBC Act Protected Matters database search (Appendix A). In the absence of confirmed operational areas/well locations, an EPBC Act Protected Matters database search was undertaken for the Operational Area and is also presented in Appendix A[1].

The low thresholds that have been used to inform the extent of the PEZ are useful for oil spill response planning and scientific monitoring (water quality) purposes but may not be ecologically significant (NOPSEMA 2019). Therefore, in addition to the PEZ, an environment that may be affected (EMBA) has also been established from stochastic spill modelling using hydrocarbon exposure thresholds identified as having the potential to cause impacts to receptors such as fauna and habitats (refer Section 8, Table 8-2).

The resulting PEZ and EMBA from the oil spill modelling are the sum of overlaid stochastic modelling runs for the worst-case spill scenario, during all seasons (wet, transitional and dry) and under different hydrodynamic conditions (e.g. currents, winds, tides, etc.). As such, the actual area that may be affected from any single spill event would be considerably smaller than represented by the PEZ or EMBA. The PEZ and EMBA are both geographically represented in the figures throughout this section of the EP and in Figure 8-1.

4.1.1 Australian waters

Australia’s offshore waters have been divided into six marine regions in order to facilitate their management by the Australian Government under the EPBC Act. The Operational Area is located entirely within the North Marine Region. The PEZ intersects with the NMR and the Northwest Marine Region (NWMR). The relevant key features of the NMR and NWMR in the context of the Operational Area and PEZ are further described in subsequent sections of this EP.

North-west Marine Region

The NWMR comprises Commonwealth waters, from the WA–NT border in the north, to Kalbarri in the south. The NWMR encompasses a number of regionally important marine communities and habitats which support a high biodiversity of marine life and feeding and breeding aggregations (DSEWPaC 2012a).

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[1] The EPBC Act Protected Matters Search Tool (https://pmst.awe.gov.au) uses a 32 km grid square for data across marine regions. Where boundaries of an Operational Area, EMBA or PEZ overlap a 32 km^2 grid square, all protected matters that fall within that grid square are captured within the PMST report output, regardless of whether the Operational Area, EMBA or PEZ actually overlap the protected matter or not. This results in protected matters being included in the PMST that may actually be >30 km away from a location.

North Marine Region

The NMR comprises Commonwealth waters from the WA–NT border to West Cape York Peninsula. This region is highly influenced by tidal flows and less by ocean currents. The marine environment of the NMR is known for its high diversity of tropical species but relatively low endemism, in contrast to other bioregions (DSEWPaC 2012b).

4.2 Key ecological features

The Australian Government has identified parts of the marine ecosystem that are of importance for a marine region's biodiversity or ecosystem function and integrity, referred to as key ecological features (KEFs). The Operational Area does not overlap any KEFs (Appendix A). Three KEFs are located within the PEZ (Figure 4-1) as follows:

- Pinnacles of the Bonaparte Basin
- Carbonate bank and terrace system of the Sahul Shelf
- Carbonate bank and terrace system of the Van Diemen Rise.

4.2.1 Pinnacles of the Bonaparte Basin KEF

The Pinnacles of the Bonaparte Basin KEF is present within the NMR and NWMR. The Pinnacles of the Bonaparte Basin KEF consists of an area containing limestone pinnacles, up to 50 m high (above the surrounding seabed) and is located in the western Joseph Bonaparte Gulf on the mid-to-outer edge of the shelf (DSEWPaC 2012b). They represent 61% of the limestone pinnacles in the NWMR and 8% of limestone pinnacles in the Australian EEZ (Baker et al. 2008). There are no pinnacles present within the Operational Area with the nearest pinnacle located approximately 8 km north-west at the closest point.

The Pinnacles of the Bonaparte Basin are thought to be the eroded remnants of underlying strata. It is likely that the vertical walls generate local upwelling of nutrient-rich water, leading to phytoplankton productivity that attracts aggregations of planktivorous and predatory fish, seabirds and foraging turtles (DSEWPaC 2012b).

As the pinnacles provide areas of hard substrate in an otherwise relatively featureless, soft sediment environment they are presumed to support a high number of species. Associated communities are thought to include sessile benthic invertebrates including hard and soft corals and sponges, and aggregations of demersal fish species such as snapper, emperor and grouper (Brewer et al. 2007). The pinnacles are thought to be a feeding area for flatback, loggerhead and olive ridley turtles, while green turtles may traverse the area. Humpback whales and green sawfish are also likely to occur in the Pinnacles of the Bonaparte Basin KEF (Donovan et al. 2008). However, due to their ecology, sawfish (generally estuarine rather than open-ocean species) are not expected to be present within open-ocean environments.

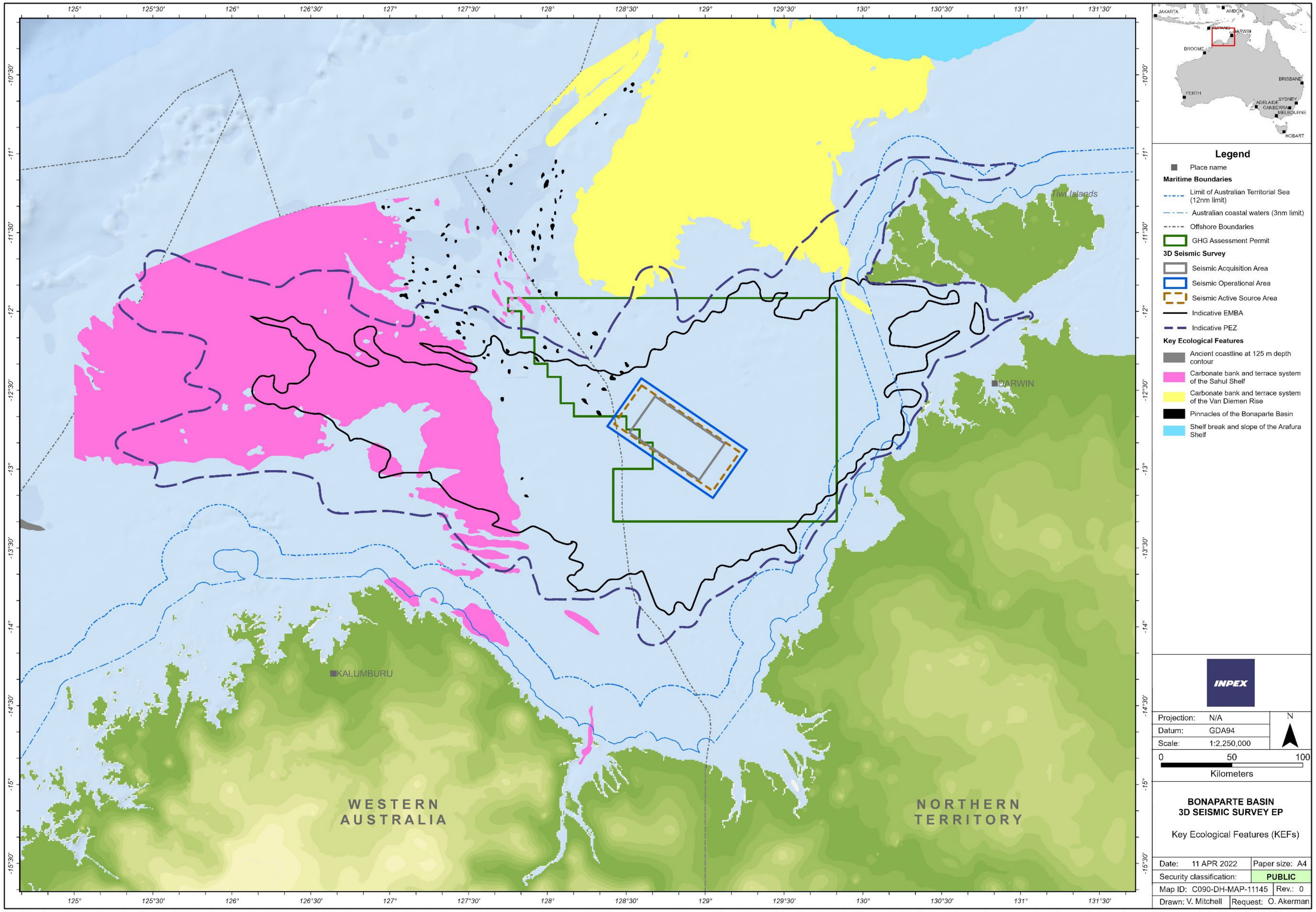

Figure 4-1: Key ecological features in north-west Australia

4.2.2 Carbonate Bank and Terrace System of the Sahul Shelf KEF

The carbonate bank and terrace system of the Sahul Shelf KEF is located in the western Joseph Bonaparte Gulf, approximately 70 km west of the Operational Area, at its closest point. The carbonate bank and terrace system of the Sahul Shelf KEF is recognised for its biodiversity values (a unique seafloor feature with ecological properties of regional significance), which apply to both its benthic and pelagic habitats. The banks consist of a hard substrate with flat tops. Each bank occupies an area generally less than 10 km^2 and is separated from the next bank by narrow sinuous channels up to 150 m deep (DSEWPaC 2012a).

Although little is known about the bank and terrace system of the Sahul Shelf, it is considered to be regionally important due to its continuous and large expanse, as well as the ecological role it is likely to play in the biodiversity and productivity of the Sahul Shelf (DSEWPaC 2012a). The banks 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). They are foraging areas for loggerhead, olive ridley and flatback turtles. Humpback whales and green and freshwater sawfish are also likely to occur in the carbonate bank and terrace system of the Sahul Shelf KEF (Donovan et al. 2008). However, due to their ecology, sawfish (generally estuarine rather than open-ocean species), are not expected to be present within open-ocean environments.

4.2.3 Carbonate Bank and Terrace System of the Van Diemen Rise KEF

The carbonate bank and terrace system of the Van Diemen Rise KEF is located approximately 55 km north of the Operational Area at its closest point.

The carbonate bank and terrace system of the Van Diemen Rise KEF supports a complex system of shallow carbonate banks and shoals over a limestone terrace, strongly dissected by tidal channels and paleo-river channels (including the >150 m deep Malita Shelf Valley). Shallow, clear waters provide for a deep euphotic zone, the depth to which sufficient light for photosynthesis penetrates into the ocean. Therefore, enhanced benthic primary production and localised upwellings generated by interactions between the complex topography and tidal currents encourage phytoplankton productivity and aggregations of fish. The banks, shoals and channels offer a heterogeneous environment of shallow to deep reef, canyon, soft sediment and pelagic habitats to a diverse range of tropical species of predominantly Western Australian affinities (DSEWPaC 2012b).

4.3 Australian marine parks

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

Established AMPs under the EPBC Act, and any zones within them, must be assigned to an International Union for Conservation of Nature (IUCN) Protected Area Category (Environment Australia 2002). The IUCN categories that are present within the AMPs intersected by the PEZ, as shown in Table 4-1, include:

IUCN Category Ia – Strict nature reserve – Protected area managed mainly for science.

IUCN Category II – National Park – Protected area managed mainly for ecosystem conservation and recreation.

IUCN Category IV – Habitat/species management area – Protected area managed mainly for conservation through management intervention.

IUCN Category VI – Managed resources protected areas – Protected area managed mainly for the sustainable use of natural ecosystems. Area containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs.

The Director of National Parks (DNP) may make, amend and revoke prohibitions, restrictions and determinations under regulations 12.23, 12.23A, 12.26, 12.56 and 12.58 of the EPBC Regulations where it is considered necessary to:

protect and conserve biodiversity and other natural, cultural and heritage values; or

to ensure human safety or visitor amenity; or

where it is otherwise necessary to give effect to the management plan.

The Commonwealth DNP has issued a general approval under Section 359B of the EPBC Act allowing a range of activities to occur within these AMPs. The activities approved including 'mining operations' which, as defined under the EPBC Act, also includes all GHG activities, including associated emergency response activities. No other approvals relating to this activity are required from the DNP.

Actions to respond to oil pollution incidents (including environmental monitoring and remediation) in AMPs, can be undertaken without an authorisation issued by the DNP, provided that the actions are undertaken in accordance with an EP that has been accepted by NOPSEMA. However, the DNP is to be notified of the pollution event or proposed spill response actions within AMPs prior to the activity being undertaken where practicable. The Operational Area does not overlap any AMPs (Figure 4-2; Appendix A). The AMPs that overlap the PEZ and their IUCN categories are shown in Figure 4-2 and outlined in Table 4-1, with a further description provided in subsequent sections.

Table 4-1: AMP and IUCN categories

AMP*	**Sanctuary Zone (IUCN Ia)**	**(Marine) National Park Zone (IUCN II)**	**Habitat Protection Zone (IUCN IV)**	**Recreational Zone (IUCN IV)**	**Multiple Use Zone (IUCN VI)**	**Special Purpose Zone (IUCN VI)**	**Special Purpose Zone (Trawl) (IUCN VI)**
Oceanic Shoals			X		X		X
Joseph Bonaparte Gulf					X	X	

* While the Kimberley MP is included in the EPBC Act Protected Matters database search of the PEZ (Appendix A), it is located approximately 12 km from the boundary of the PEZ at its closest point (Figure 4-2) and therefore does not overlap.

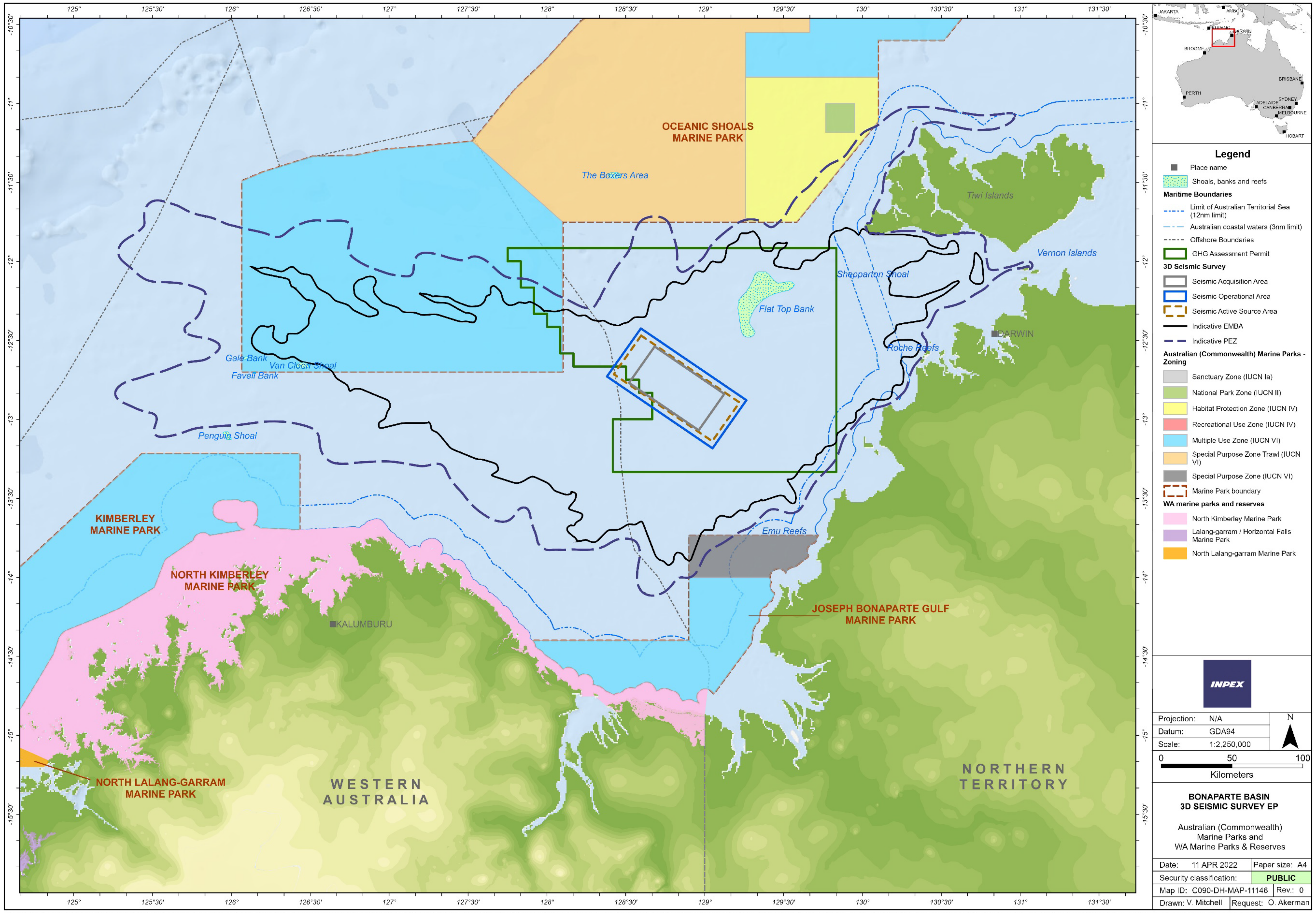

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Figure 4-2: Australian and State/Territory marine parks, reserves, banks and shoals

4.3.1 Oceanic Shoals MP

The Operational Area is located 32 km east of the Oceanic Shoals MP at its closest point. The Oceanic Shoals MP occupies an area of approximately 72,000 km^2 with water depths from less than 15 m to 500 m (Parks Australia 2022a). he Oceanic Shoals MP is the largest marine park in the NMR and includes important sea country for the Tiwi people (TLC 2021) (refer to Section 4.9.5).

The Oceanic Shoals MP is an important resting area for turtles (internesting) for the threatened flatback turtle and olive ridley turtle. It is also an important foraging area for the threatened loggerhead turtle and olive ridley turtle (DNP 2018a).

4.3.2 Joseph Bonaparte Gulf MP

The Joseph Bonaparte Gulf MP is located in the NMR, approximately 60 km south of the Operational Area at its closest point. It occupies an area of approximately 8,600 km^2 with water depths ranging from less than 15 to 75 m (Parks Australia 2022b; Galaiduk et al, 2018). Areas of the coastline within the Joseph Bonaparte Gulf MP are home to many Aboriginal groups each with their own cultural values. The Miriuwung, Gajerrong, Doolboong, Wardenybeng and Gija and Balangarra people have responsibilities for sea country in the marine park (Parks Australia 2022b; refer to Section 4.9.5).

The Joseph Bonaparte Gulf MP experiences some of the highest tides in northern Australia (up to 7 m) which, together with a wide intertidal zone near the Joseph Bonaparte Gulf MP, create a physically dynamic and turbid environment characterised by a high level of primary productivity (Galaiduk et al, 2018). Key conservation values of the reserve include (Parks Australia 2022b; DNP 2018a):

- important foraging area for threatened and migratory marine turtles (green and olive ridley), and the Australian snubfin dolphin
- examples of the shallow water ecosystems and communities of the North West Shelf Transition Province, the second largest of all the provincial bioregions on the shelf, which includes the extensive banks that make up the Sahul Shelf, broad shelf terraces and the shallow basin in the Joseph Bonaparte Gulf (including the Cambridge-Bonaparte, Anson Beagle and Bonaparte Gulf mesoscale bioregions).

The carbonate bank and terrace system of the Sahul Shelf KEF (enhanced productivity, high biodiversity, and unique seafloor feature) is partly located within the Joseph Bonaparte Gulf MP.

4.4 State and Territory reserves and marine parks

No State or Territory marine parks/reserves including indigenous protected areas (IPAs) are located within the Operational Area or the PEZ (Appendix A). The PEZ extends to the Tiwi Islands but does not include any IPAs and there is no shoreline contact.

4.5 Wetlands of conservational significance

There are no Ramsar sites within the Operational Area or the PEZ (Appendix A). One nationally important wetland the Finniss Floodplain and Fog Bay System, is located adjacent the south eastern boundary of the PEZ on the NT coastline.

4.5.1 Finniss Floodplain and Fog Bay System

The Finniss Floodplain and Fog Bay System is an example of a beach-fringed curved bay with continuous intertidal mudflats (DAWE 2022a). It is located approximately 1.5 km from the outer boundary of the PEZ at its closest point.

The site is a major breeding area for the magpie goose (*Anseranas semipalmata*) and during the dry season acts as a refuge area for water birds. It is also a migration stop-over area for shorebirds and a major breeding area for saltwater crocodile (DAWE 2022a). This site is also recognised as an important bird area (IBA), with the intertidal mudflats of Fog Bay reported to support many species of shorebird and waterbird colonies (BirdLife International 2022a).

4.6 Physical environment

4.6.1 Climate

Air temperature

Air temperatures recorded at Channel Point, the closest Bureau of Meteorology (BOM) climatological station to the Operational Area, shows a mean temperature range of 17.2 degrees Celsius (°C) to 32.3 °C (BOM 2022).

Winds

The Joseph Bonaparte Gulf is characterised by a tropical climate with a dry (winter) season from May to August, a wet (summer) season from October to March and transitional months of April and September. During the dry (winter) season, east to southeast winds blow constantly, and an anticlockwise sea circulation exists (Lees 1992), while during the wet (summer) season wind and sea circulation are reversed, and tropical cyclones are common.

During the wet (summer) season the weather in northern Australia is largely determined by the position of the monsoon trough, which can be in either an active or an inactive phase. The active phase is usually associated with broad areas of cloud and rain, with sustained moderate to fresh north-westerly winds on the north side of the trough. Widespread heavy rainfall can result if the trough is close to, or over, land. An inactive phase occurs when the monsoon trough is temporarily weakened or retreats north of Australia. It is characterised by light winds, isolated showers, and thunderstorm activity, sometimes with gusty squall lines.

Tropical cyclones can develop off the coast in the northern wet (summer) season, usually forming within an active monsoon trough. Heavy rain and strong winds, sometimes of destructive strength, can be experienced along the coast within several hundred km of the centre of the cyclone. The Bonaparte Basin is prone to tropical cyclones, mostly during the wet (summer) season from December to March. Under extreme cyclone conditions, winds can reach 300 km/h.

Ambient wind-driven currents are generally directed from west to east during the wet (summer) season (December to March) and east to west during the trade wind season (April to November), while an offshore westward current persists throughout the year.

Rainfall

Rainfall data collected at Channel Point shows the mean monthly rainfall to range from 0.1 mm (dry/winter season) to 459.8 mm (wet/summer season) with the highest rainfalls occurring between December to March (BOM 2022). Heaviest rainfall is typically associated with tropical cyclones

Air quality

There is currently no air quality data recorded within the vicinity of the Operational Area. However, given the distance from land, air quality is expected to be relatively high. Potential sources of air pollution associated with anthropogenic influences are expected to be emissions generated by shipping, and oil and gas activities, and therefore considered to be localised in relation to the regional setting.

4.6.2 Oceanography

Currents

Broad-scale oceanography in the north-west Australian offshore area is complex, with major surface currents influencing the region, including the Indonesian Throughflow, the Leeuwin Current, the South Equatorial Current, and the Eastern Gyral Current (Figure 4-3). The Indonesian Throughflow current is generally strongest during the south-east monsoon from May to September (Qiu et al. 1999). The Indonesian Throughflow is a key link in the global exchange of water and heat between ocean basins. It brings warm, low-nutrient, low-salinity water from the western Pacific Ocean, through the Indonesian archipelago, to the Indian Ocean. It is the primary driver of the oceanographic and ecological processes in the region (DSEWPaC 2012a).

Cyclone events generate the strongest currents in the Gulf, with current speeds in some areas expected to reach 1.4 m/s; whereas ambient, noncyclonic wind-driven current speeds are generally less than 0.1 m/s (Przeslawski et al. 2011).

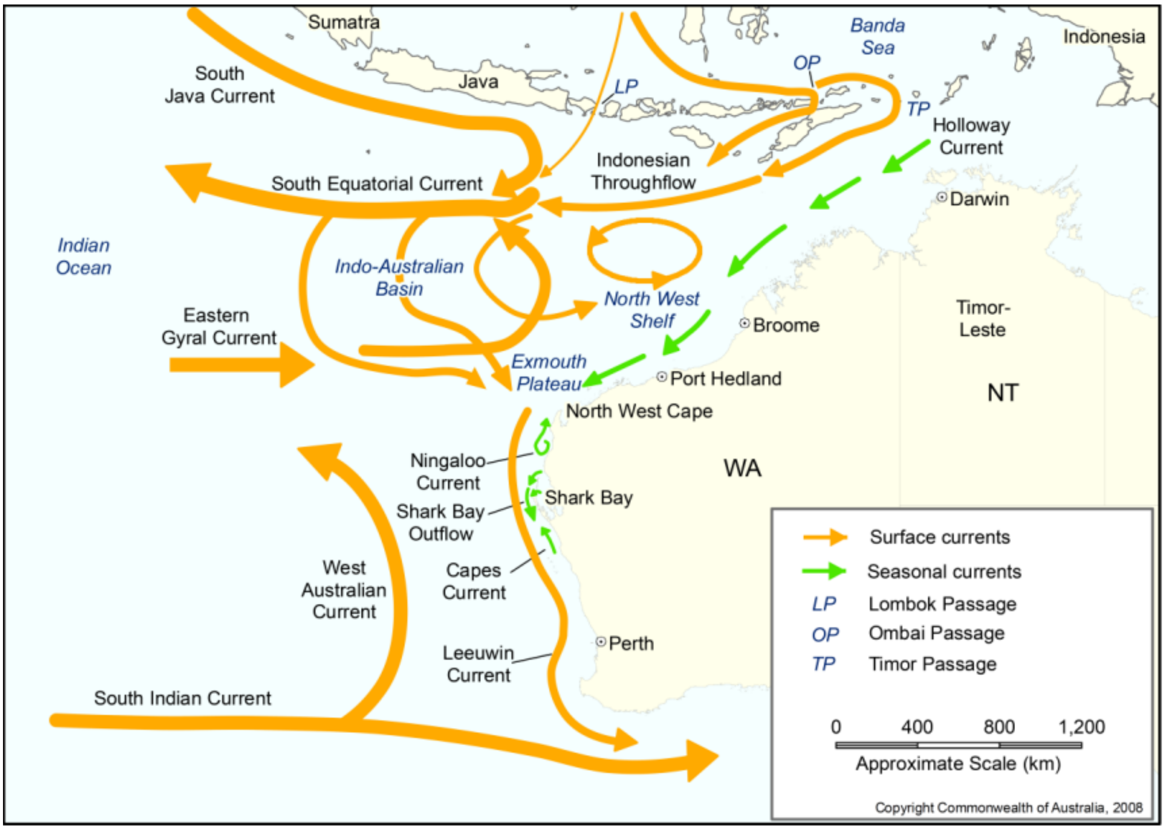

Figure 4-3: Surface currents for Western Australian waters

Tides

The Joseph Bonaparte Gulf experiences a mixed semidiurnal tide with a very large range in tidal elevations and correspondingly strong tidal currents, recording some of the highest tides in northern Australia (up to 7 m) (Przeslawski et al. 2011; Galaiduk et al. 2018).

Waves

Summertime tropical cyclones generate waves propagating radially out from the storm centre. Depending upon the storm size, intensity, relative location and forward speed, tropical cyclones may generate swell with periods of 6–10 seconds (s) from any direction and with wave heights of 0.5–9.0 m.

4.6.3 Bathymetry and seabed habitats

The geomorphology of Joseph Bonaparte Gulf is characterised by a large basin, inner shelf, banks and shoals, terraces and pinnacles (Carroll et al. 2012; Galaiduk et al. 2018). The seabed is generally flat to gently sloping and is smooth, although pinnacles exist (refer to Section 4.2.1) with the nearest pinnacle located 8 km north-west from the Operational Area at its closest point. Water depths within the Operational Area ranges from 65 m to 106 m below AHD.

A collaborative study between Geoscience Australia and the Australian Institute of Marine Science (AIMS) was undertaken to assess the Petrel sub-basin of the Bonaparte Basin as a potential CO2 storage site (Nicholas et al. 2015). The study involved collection of baseline geological data and ecological information on the seabed environments and habitats. The assessment of seabed environments and habitats focussed on two areas, one of which (Area 1) partially overlaps the Operational Area and therefore provides relevant information on the seabed habitats to be expected.

The seabed in Area 1 (in water depths of 78 m to 102 m) is characterised by shallow palaeochannels, plains, low-lying ridges and fields of shallow pockmarks (Nicholas et al. 2015). Plains were reported to comprise approximately 88% of the seafloor of the area, and were dissected by branching and discontinuous channels, which covered approximately 11% of the area (Nicholas et al. 2015). Channels ranged in size from tens of centimetres deep and tens of metres wide, to six metres deep and up to one kilometre wide. Low-lying ridges were identified on the plains and reported to be approximately 0.5 m high and 150 m to 200 m wide (Nicholas et al. 2015). Shallow depressions were numerous on the plains and in palaeochannels of the area, many of which were identified as pockmarks. On the plains these were generally less than 1 m deep.

Seabed sediment samples collected from the area during the study were dominantly poorly to very poorly sorted, gravelly to muddy sand. A total of 953 individual infauna representing more than 100 species were collected from 21 grabs at ten sampling stations within the area. Crustaceans dominated assemblages with 66% of individuals, followed by polychaetes with 25% of individuals. The remaining taxa included nematodes, echinoderms, and molluscs as well as epifaunal organisms such as cnidarians, sponges, and bryozoans. Infaunal assemblages were not statistically different across the geomorphic features (Nicholas et al. 2015).

Seabed habitats were reported to include barren sediments, bioturbated sediments, and mixed patches with octocorals and sponges. Benthic assemblages generally corresponded with geomorphic features where low-lying ridges supported mixed patches of octocorals and sponges, reflecting stable substrate for their colonisation and growth (Nicholas et al. 2015). In contrast, plains and palaeochannels supported lower densities of epifauna and a higher occurrence of bioturbation from mobile surface sediments. Depressions on the seabed (pockmarks) had no distinctive epifauna associated with these features.

Environmental Resources Management Australia Pty Ltd undertook marine baseline studies in 2010 and 2011 within the Joseph Bonaparte Gulf for the GDF SUEZ Bonaparte LNG Project in the Petrel and Tern gas fields (ERM 2011). These included surveys over petroleum titles WA-6-R, WA-27-R and NT/RL1. NT/RL1 and WA-6-R (Petrel field), which are located immediately west of the Operational Area in water depths of approximately 85 m to 100 m (refer Table 4-6 and Figure 4-15). ERM (2011) describes the seabed as mainly comprised of sand, coarse shell fragment and silt with sparse (~2%) coverage of heterotrophic filter feeders such as octocorals (soft corals and sea pens) and sponges, and hydrozoa (11-30% coverage at all sites). Infauna comprised mainly polychaete worms, gastropods, shrimps and crabs.

4.6.4 Water quality

Offshore surface waters are typically oligotrophic. This has been confirmed by studies recording low nitrate concentrations and low phytoplankton abundance (Hallegraeff 1995). In general, the region experiences an influx of comparatively nutrient-rich waters at depth in summer (wet season) and a variety of processes, such as tidal currents, internal waves and cyclone mixing, are known to carry these nutrients into the bottom waters of the shelf (Hallegraeff 1995).

With a large load of terrestrial sediment input to the Joseph Bonaparte Gulf, the strong semi-diurnal tidal currents present induce strong water column mixing and sediment resuspension, which results in higher turbidity (e.g. suspended sediment concentrations in excess of 100 mg/L) and enhanced nutrient levels (Galaiduk et al. 2018).

The surface waters in the Joseph Bonaparte Gulf MP, located approximately 60 km south of the Operational Area, are characterised by very high primary productivity. The long-term annual mean surface chlorophyll-a concentrations range from 0.6 - 27 mg/m^3 with levels in the dry season (winter) often higher than other the wet season (summer). However, these values are likely over-estimates due to the dissolved and suspended materials brought in by rivers and the contamination of the remote sensing satellite imagery resulting in bottom reflectance in shallow water areas (Galaiduk et al. 2018).

Sea temperatures and salinity in the region are heavily influenced by the Indonesian Throughflow, which transports warm, low salinity water from the western Pacific Ocean through to the Indian Ocean (DSEWPaC 2012a).

Marine baseline studies undertaken by ERM 2010 and 2011 measured water quality during the wet season and dry season in the Joseph Bonaparte Gulf in the Petrel and Tern gas fields (ERM 2011), located south-west of the Operational Area. Water quality was found to be relatively pristine with results typical of nutrient poor offshore northern Australian waters. Dissolved oxygen (DO) concentrations ranged from a minimum of 3.6 mg/L (49.8%) near the seabed to 7.8 mg/L (117.2%) at the sea surface. DO was consistently found to decrease with depth (ERM 2011). This is often linked to higher photosynthetic activity at the seawater surface and wave/wind generated mixing. These values are typical of unpolluted seawater (ERM 2011).

ERM (2011) found total suspended solids (TSS) levels were low across the area during the time of sampling, as would be expected for offshore waters in the region. Concentrations of nutrients (nitrogen and phosphorous) were also found to be low, as is expected for oligotrophic offshore waters (ERM 2011).

Seawater temperature is well mixed through the water column in the Joseph Bonaparte Gulf and tidal currents restrict formation of a thermocline. ERM (2011) reported that temperature remained consistent throughout the 100 m sampled water column, with a mean temperature of 29.5 °C recorded during the 2010 wet (summer) season and a mean of 27.9 °C recorded during the 2011 dry (winter) season. The seawater pH was found to range from a minimum of 7.67 to a maximum of 8.37, with basic to slightly alkaline properties (ERM 2011).

Benzene, Toluene, Ethylene, Xylene (BTEX), Polycyclic Aromatic Hydrocarbons (PAH) and Total Petroleum Hydrocarbons (TPH) were all below levels of detection in water samples (ERM 2011). Concentrations of the metals were all below their respective trigger values as defined by the Australia and New Zealand Environment and Conservation Council (ANZECC/ARMCANZ) guidelines (ERM 2011).

4.6.5 Sediment quality

Sampling of seabed sediments by Lees (1992) across an area of the Joseph Bonaparte Gulf MP (located approximately 60 km south of the Operational Area) recorded a complex pattern of mixed silt, sand and gravel of terrestrial and biogenic extending from the rivers. Further offshore, seabed sediments become silty sand and clayey sand across mostly flat to rippled seabed (Galaiduk et al, 2018).

The marine baseline studies undertaken within the Joseph Bonaparte Gulf by ERM (2011) found low concentrations of metals in sediments from the area with mean concentrations of all metals found to be below the trigger values defined by ANZECC/ARMCANZ (2000) guidelines (ERM 2011). TPH, BTEX, PAH and tributyltin were not detected in the area (ERM 2011).

4.7 Biological environment

4.7.1 Planktonic communities

Plankton communities comprise phytoplankton and zooplankton, including fish eggs and larvae. Phytoplankton and zooplankton are a source of primary and secondary productivity, and key food sources for other organisms in the oceans (Brewer et al. 2007). Eggs and larvae may be dispersed throughout the water column and throughout the region, playing an important role in species recruitment.

Plankton abundance and distribution is patchy, dynamic and strongly linked to localised and seasonal productivity (Evans et al. 2016). The mixing of warm surface waters with deeper, more nutrient-rich waters (i.e. areas of upwelling) generates phytoplankton production and zooplankton blooms. In the offshore waters of north-western Australia, productivity typically follows a ‘boom and bust’ cycle. Productivity booms are thought to be triggered by seasonal changes to physical drivers or episodic events, which result in rapid increases in primary production over short periods, followed by extended periods of lower productivity.

The Indonesian Throughflow has an important effect on biological productivity in the northern areas of Australia. Generally, its deep, warm and low nutrient waters suppress upwelling of deeper, comparatively nutrient-rich waters, thereby forcing the highest rates of primary productivity to occur at depths associated with the thermocline (generally 70 – 100 m depth). When the Indonesian Throughflow is weaker, the thermocline lifts, and brings deeper, more nutrient-rich waters into the photic zone, which results in conditions favourable to increased productivity. Consequently, plankton populations have a high degree of temporal and spatial variability. In tropical regions, higher plankton concentrations generally occur during June to August (Brewer et al. 2007).

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

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

Larval fishes during both seasons were dominated by the Serranidae (cods) and Lutjanidae (snappers), both of which are species of interest targeted by commercial fisheries in the region. Larval fish density also varied seasonally with the 2011 dry season (May 2011) recording the highest densities of larval fishes in the zooplankton (ERM 2011). This seasonal effect is consistent with the notion of an extended spawning season (and possibly planktonic larval duration) of the reef species dominating the larval fish assemblage in the study area at this time (ERM 2011).

4.7.2 Benthic communities

Banks and shoals

A number of banks, shoals and reefs exist within the Bonaparte Basin (Figure 4-2). There are no banks, shoals, reefs or pinnacles within the Operational Area. The closest pinnacle feature, part of the Pinnacles of the Bonaparte Basin KEF, is located approximately 8 km north-west of the Operational Area. The closest bank feature is Flat Top Bank located approximately 40 km north-east of the Operational Area at its closest point.

Other, representative banks and shoals within the PEZ, with approximate distances from the Operational Area include:

- Shepparton Shoal (135 km north-east)
- the Boxers Area (140 km north)
- Baldwin Bank (220 km west)
- Van Cloon Shoal (200 km west)
- Favell Bank (230 km west)
- Gale Bank (240 km west)
- Penguin Shoal (265 km south-west).

The shoals and banks within the PEZ are characterised by abrupt bathymetry, rising steeply from the surrounding shelf to horizontal plateau areas typically 20–30 m deep (AIMS 2012). Substrate types tend to differ from patches of coarse sand, to extensive fields of rubble and rocks, limited areas of consolidated reef and occasional isolated rock or live coral outcrops.

The submerged shoals within the PEZ can support diverse tropical ecosystems, including phototrophic benthos typical of tropical coral reefs. The shoals support a diverse biota, including algae, reef-building corals, hard corals and filter-feeders. The shoals and banks of the area may act as 'stepping stones' for enhanced biological connectivity between the reef systems of the region. Shoal and bank habitats are thought to provide additional regional habitat for marine fauna, including sharks and sea snakes (AIMS 2012).

The community structure of the banks and shoals is likely to be influenced by a number of processes, including disturbance resulting from storms and cyclones, and localised recruitment due to the limited larval dispersal of some invertebrate species (AIMS 2012). It is unknown how interconnected the individual banks and shoals are in regard to larval recruitment. The majority lie in the path of a south-westerly flowing current originating in the Indonesian Throughflow. However, seasonal reversals of current flow suggest larval recruitment can be supplied from outside this process.

Coral reefs

There are no coral reefs located in the Operational Area. Coral reefs within the NMR/NWMR regions can be categorised into three general groups: fringing reefs, large platform reefs, and intertidal reefs. Corals are significant benthic primary producers that play a key ecosystem role in many reef environments and have an iconic status in the environments where they occur.

No platform reefs are present within the PEZ. Fringing and intertidal coral reefs within or adjacent to the PEZ boundary are listed below where "*" denotes overlap with the EMBA, noting that many coastal islands in the PEZ also support fringing coral reefs:

- Roche Reefs* (120 km east)
    - Vernon Islands (210 km east-north-east)
    - Tiwi Islands* (145 km north-east)
    - Emu Reefs (85 km south-east).

Observations throughout the world indicate that coral spawning on most reefs extends over a few months during the spawning period, typically between late spring and autumn (Stoddart & Gilmour 2005, cited in INPEX 2010). Spawning of corals in the NT Aquarium has been observed around the full moon period in October and November (TWP 2006, cited in INPEX 2010). Research into coral larval dispersal (Gilmour et al. 2009, 2010, 2011; Underwood et al. 2009, 2017; Cook et al. 2017; Waples et al. 2019) has indicated that dispersal and recruitment is predominately local and limited to within a few kilometres to a few tens of kilometres from natal reef patches.

Seagrass

There is no seagrass within the Operational Area due to water depth (65 m to 106 m) and lack of suitable habitat.

Seagrasses do occur within the PEZ at the Tiwi Islands and Vernon Islands. Seagrass at the Tiwi Islands are predominantly located on the northern coastlines of Bathurst and Melville islands (Roelofs et al. 2005). The furthest northern extent of the EMBA overlaps a portion of the southern coastline of Bathurst Islands and does not overlap Melville Island. A survey of intertidal seagrasses carried out by the WA Museum did not record any seagrasses in the Joseph Bonaparte Gulf (Walker et al. 1996).

Coastal shallow-water seagrass habitats are generally rare in the region, accounting for only 11.5 km or 0.2% of the total coastline surveyed by Duke et al. (2010). The regionally dominant genera in Australia are *Halophila* and *Halodule*.

Demersal fish communities

ERM (2011) deployed baited remote underwater video systems in the Joseph Bonaparte Gulf to characterise the demersal fish communities. The survey recorded a total of 22 genera, representing 17 families associated with soft sediment habitats in water depths of approximately 85 m to 100 m. The most common families by density were Terapontidae (grunters) Nemipteridae (threadfin breams), and Lutjanidae (snappers). Lutjanid species, targeted by commercial and recreational fishers in tropical Australia, included goldband snapper (*Pristipomoides multidens*) and saddletail snapper (*Lutjanus malabaricus*).

4.7.3 Shoreline habitats

There are no islands within the Operational Area. Adjacent to the eastern boundary of the PEZ are the Tiwi Islands and the Vernon Islands.

Tiwi Islands

The Tiwi Island group consists of two large, inhabited islands (Melville and Bathurst), and nine smaller uninhabited islands (Buchanan, Harris, Seagull, Karslake, Irritutu, Clift, Turiturina, Matingalia and Nodlaw). Melville Island is Australia's second largest island (after Tasmania), while Bathurst Island is fifth largest. Bathurst Island is approximately 2,600km^2 and Melville Island is approximately 5,785 km^2. The main islands are separated by Apsley Strait, which connects Saint Asaph Bay in the north and Shoal Bay in the south. The islands have been identified as an IBA as they support populations of many migratory shorebirds (BirdLife International 2022b) and they provide nesting habitat for marine turtles (DEE 2017a). The southern coast of Melville Island is predominantly characterised by sand–mud tidal flats with some mangroves and coral communities. The south-east of Melville Island has extensive tidal mudflats which provide an extensive habitat for shorebirds (INPEX 2010). The south coast of Bathurst Island has less extensive intertidal habitats than Melville Island. The islands' shorelines also feature numerous mangrove-lined bays and inlets. Melville and Bathurst islands are approximately 190 km and 145 km, respectively, from the Operational Area.

Seagrasses have been recorded along the northern coastlines of both Bathurst and Melville islands (Roelofs et al. 2005).

Vernon Islands

The Vernon Islands are located in the Clarence Straight, north of Darwin, 210 km from the Operational Area at its closest point. Three major islands make up the Vernon Islands group, plus a large reef and numerous lesser reefs and sand islands (TLC 2013). The islands are low lying, with a maximum height of 4 m above mean sea level. The islands are generally fringed with mangroves and surrounded by mud flats and rocks/reefs exposed at low tides.

Sediments around the Vernon Islands are gravel-dominated, due to the very strong tidal currents, experienced every day in the Clarence Straight.

Significant coral reefs are established within the intertidal and subtidal zone of the Vernon Islands, dominated by *Acropora* and *Montipora* spp. Extensive coralline algal terraces have also developed at the Vernon Islands reef complex. Extensive mangrove forests are present along the Vernon Islands coastline (Smit et al. 2000; KBR 2003) as well as seagrass and algal beds (TLC 2013).

The waters surrounding the Vernon Islands support populations of dugong and turtles, and studies have shown that dugong spend a considerable amount of time on intertidal rocky reefs at the Vernon Islands (Whiting, 2002).

Sandy beaches

Sandy beaches are the dominant shoreline habitat on the offshore islands such as the Tiwi Islands within or adjacent to the PEZ and provide significant habitat for turtles and seabird nesting above the high tide line (Section 4.7.4).

Generally, sands are highly mobile and therefore do no support a high level of biodiversity. Fauna within sandy beach habitats usually consists of polychaete worms, crustaceans and bivalves. These faunas provide a valuable food source for resident and migratory sea and shorebirds (DECMPRA 2005). Natural processes tend to supply fresh sediments and larval stock (food source) with each tidal influx.

Mangroves

Mangrove communities make up a common shoreline habitat along the northern WA and NT coastlines. There are extensive mangrove communities at the Tiwi and Vernon islands within the PEZ. Mangroves play an important role in connecting the terrestrial and marine environments and reducing coastal erosion. They also play an important ecosystem role in nutrient cycling and carbon fixing (NOAA 2010).

During 2009, shoreline ecological aerial and ground surveys were conducted from Darwin in the NT to Broome in WA in response to the Montara oil spill (Duke et al. 2010). Approximately 5,100 km of shoreline was surveyed, analysed and mapped to quantitatively characterise coastal ecological features. Mangroves were found to grow along 63% of the surveyed shoreline and salt marshes occurred over 24% of the shoreline.

4.7.4 Marine fauna

Species of conservation significance

Species of conservation significance within the PEZ were identified through a search of the EPBC Act Protected Matters database.

The search identified a total of 26 "listed threatened" species and 57 "listed migratory" species that potentially use or pass through the PEZ. In addition, 105 "listed marine" species were identified, of which 25 are "whales and other cetaceans" that may occur at, or immediately adjacent to, the area. The full search results are contained in Appendix A.

Table 4-2 presents the marine species that are "listed threatened" species or "listed migratory species". Note that true terrestrial species have not been listed in Table 4-2.

Table 4-2: Listed threatened and/or migratory species under the EPBC Act potentially occurring within the PEZ

Species	Common name	Conservation status	Migratory
Marine mammals			
Balaenoptera borealis	Sei whale	Vulnerable	Migratory
Balaenoptera edeni	Bryde's whale	N/A	Migratory
Balaenoptera musculus	Blue whale	Endangered	Migratory
Balaenoptera physalus	Fin whale	Vulnerable	Migratory
Megaptera novaeangliae	Humpback whale	N/A	Migratory

Species	**Common name**	**Conservation status**	**Migratory**
Orcinus orca	Killer whale	N/A	Migratory
Physeter macrocephalus	Sperm whale	N/A	Migratory
Dugong dugon	Dugong	N/A	Migratory
Orcaella heinsohni	Australian snubfin dolphin	N/A	Migratory
Sousa sahulensis/chinensis	Indo-Pacific humpback dolphin	N/A	Migratory
Tursiops aduncus	Spotted bottlenose dolphin	N/A	Migratory
Marine reptiles			
Caretta caretta	Loggerhead turtle	Endangered	Migratory
Chelonia mydas	Green turtle	Vulnerable	Migratory
Dermochelys coriacea	Leatherback turtle	Endangered	Migratory
Eretmochelys imbricata	Hawksbill turtle	Vulnerable	Migratory
Lepidochelys olivacea	Olive ridley turtle	Endangered	Migratory
Natator depressus	Flatback turtle	Vulnerable	Migratory
Crocodylus porosus	Saltwater crocodile	N/A	Migratory
Aipysurus foliosquama	Leaf-scaled sea snake	Critically Endangered	N/A
Sharks, fish and rays			
Rhincodon typus	Whale shark	Vulnerable	Migratory
Carcharodon carcharias	Great white shark	Vulnerable	Migratory
Glyphis garricki	Northern river shark	Endangered	N/A
Glyphis glyphis	Speartooth Shark	Critically Endangered	N/A
Pristis clavata	Dwarf sawfish	Vulnerable	Migratory
Pristis pristis	Northern sawfish, Freshwater sawfish, Largetooth sawfish	Vulnerable	Migratory
Pristis zijsron	Green sawfish	Vulnerable	Migratory
Anoxypristis cuspidata	Narrow sawfish	N/A	Migratory
Carcharhinus longimanus	Oceanic whitetip shark	N/A	Migratory

Species	Common name	Conservation status	Migratory
Sphyrna lewini	Scalloped hammerhead	Conservation dependent	N/A
Isurus oxyrinchus	Shortfin mako	N/A	Migratory
Isurus paucus	Longfin mako	N/A	Migratory
Manta alfredi	Reef manta ray	N/A	Migratory
Manta birostris	Giant manta ray	N/A	Migratory
Marine avifauna			
Anous tenuirostris melanops	Australian lesser noddy	Vulnerable	N/A
Calidris canutus	Red knot	Endangered	Migratory
Calidris ferruginea	Curlew sandpiper	Critically Endangered	Migratory
Calidris tenuirostris	Great knot	Critically Endangered	Migratory
Charadrius leschenaultii	Greater sand plover	Vulnerable	Migratory
Charadrius mongolus	Lesser sand plover	Endangered	Migratory
Limosa Lapponica baueri	Bar-tailed godwit	Vulnerable	Migratory
Numenius madagascariensis	Eastern curlew	Critically Endangered	N/A
Rostratula australis	Australian painted snipe	Endangered	N/A
Anous stolidus	Common noddy	N/A	Migratory
Apus pacificus	Forktailed swift	N/A	Migratory
Calonectris leucomelas	Streaked shearwater	N/A	Migratory
Fregata ariel	Lesser frigatebird	N/A	Migratory
Fregata minor	Great frigatebird	N/A	Migratory
Sternula albifrons	Little tern	N/A	Migratory
Thalasseus bengalensis	Lesser crested tern	N/A	Migratory
Acrocephalus orientalis	Oriental reed-warbler	N/A	Migratory
Actitis hypoleucos	Common sandpiper	N/A	Migratory
Arenaria interpres	Ruddy turnstone	N/A	Migratory
Calidris acuminata	Sharp-tailed sandpiper	N/A	Migratory

Species	Common name	Conservation status	Migratory
Calidris alba	Sanderling	N/A	Migratory
Calidris melanotos	Pectoral sandpiper	N/A	Migratory
Charadrius veredus	Oriental plover	N/A	Migratory
Glareola maldivarum	Oriental pratincole	N/A	Migratory
Limnodromus semipalmatus	Asian dowitcher	N/A	Migratory
Limosa limosa	Black-tailed godwit	N/A	Migratory
Numenius phaeopus	Whimbrel	N/A	Migratory
Pandion haliaetus	Osprey	N/A	Migratory
Pluvialis squatarola	Grey plover	N/A	Migratory
Thalasseus bergii	Greater crested tern	N/A	Migratory
Tringa nebularia	Common greenshank	N/A	Migratory

Conservation management plans

In addition to species being identified as threatened or migratory and Matters of National Environmental Significance (MNES), depending on the threat classification, the Department of Climate Change, Energy, the Environment and Water (DCCEEW) has established management policies, guidelines, plans and other materials for threatened fauna, threatened flora (other than conservation-dependent species) and threatened ecological communities listed under the EPBC Act.

In particular, the objectives of DCCEEW recovery plans and conservation advice, seek to support the long-term recovery of various species outlining research and management measures that must be undertaken to stop the decline of, and support the recovery of a species, including the management of threatening processes.

Species identified during the EPBC Act Protected Matters database search that have a conservation advice or a recovery plan in place, as well as any particular relevant actions to assist their recovery and conservation, including threat abatement plans, are summarised in Appendix A.

Biological important areas

The DCCEEW has, through the marine bioregional planning program, identified, described and mapped biologically important areas (BIAs) for protected species under the EPBC Act. BIAs spatially and temporally define areas where protected species display biologically important behaviours (including breeding, foraging, resting or migration), based on the best available scientific information. These areas are those parts of a marine region that are particularly important for the conservation of protected species.

Table 4-3 provides an overview of the EPBC Act-listed species, identified by the EPBC Act Protected Matters database search, that are associated with a BIA either within the PEZ or adjacent to the PEZ boundary. The only BIAs that overlap the Operational Area relate to two turtle foraging BIAs. They both overlap the southern portion of the Operational Area and relate to green and olive ridley turtles in the Joseph Bonaparte Gulf. The locations of relevant BIAs for EPBC Act-listed species are shown in Figure 4-4 to Figure 4-7.

Table 4-3: BIAs intersecting the PEZ

Species	Foraging	Internesting	Breeding
Whale shark	X		
Avifauna: Lesser frigatebird Lesser crested tern Crested tern			 X X X
Flatback turtle	X	X	
Olive ridley turtle	X	X	
Green turtle	X	X	
Loggerhead turtle	X		

Marine mammals

Marine mammals that could potentially use or pass through the PEZ are identified in Table 4-2 and the locations to the closest marine mammal BIAs are presented in Figure 4-4. There are no identified BIAs for marine mammals within the Operational Area, EMBA or PEZ.

Whale species such as humpback, sei, Bryde’s and fin whales may occur in the Operational Area occasionally, although the Operational Area does not provide any unique or significant habitat for these species. At their closest points, the migration, calving and resting BIAs for humpback whale are located over 400 km south-west from the Operational Area and so only occasional individuals are expected to travel the additional distance towards the Joseph Bonaparte Gulf and waters offshore from the NT. Blue whales, specifically the sub-species pygmy blue whale, are also unlikely to occur in the Operational Area; the Operational Area and PEZ are outside of the known distribution and core range for the species, and the pygmy blue whale migration BIA is located 300 km north-west of the Operational Area at its closest point.

Although not listed as a listed threatened or migratory species under the EPBC Act, the Omura’s whale (*Balaenoptera omurai*) may also occur in the Operational Area. Limited information is available on Omura’s whales but current data includes detections across north-western Australia between Exmouth and Darwin including in the Joseph Bonaparte Gulf and the Timor Sea (McCauley 2009, 2014, cited in Cerchio et al. 2019; McPherson et al. 2016a, 2017), as well as off north-east Queensland (Cerchio et al. 2019).

The coastal waters of the Joseph Bonaparte Gulf and Darwin Harbour are BIAs for coastal dolphin species, including Indo-Pacific humpback dolphin, Australian snubfin dolphin and spotted bottlenose dolphin. The BIAs are not located within the PEZ; however, these species represent important populations in region. Given their coastal distribution, the dolphin species are unlikely to occur in the deep offshore waters of the Operational Area but may occasionally occur in the waters of the PEZ. These species are described further below.

Indo-Pacific humpback dolphin

The Indo-Pacific humpback dolphin (*Sousa sahulensis/chinensis*) [2] occurs along the northern coastline of Australia from the Queensland-New South Wales border to western Shark Bay on the WA coastline (DAWE 2022b). Humpback dolphins live in warm waters, generally warmer than 15 ^{o}C, and at an average depth of 20 m, rarely traveling to waters deeper than 25 m (Napier 2011). As they live in close proximity to the shore, they are at risk of getting tangled in fishing nets and destruction of habitats is most likely the greatest threat to this species. They feed mainly on fishes associated with coastal-estuarine waters (DAWE 2022b). Humpback dolphins breed once yearly, and births typically occur in the spring and summer (Napier 2011).

In the NT, the species is mainly found in water less than 20 km from the nearest river mouth, and in water depths of less than 15 m to 20 m; however, a few animals have been observed in waters up to 30 m to 50 m deep, but these remained in close proximity (within 5 km) to the coast (DAWE 2022b). Therefore, they would not be expected to be present in the Operational Area located approximately 145 km west of the breeding BIA with water depths ranging from 65 m to 106 m.

The species does not appear to undergo large-scale seasonal migrations, although seasonal shifts in abundance have been observed (DAWE 2022b). A recent study of snubfin and humpback dolphins in the Kimberley region of WA (Waples et al. 2019) confirmed these species are present at low densities and occur as relatively small populations across the Kimberley.

Australian snubfin dolphin

The Australian snubfin dolphin (*Orcaella heinsohni*) occurs in waters off the northern half of Australia from Broome on the west coast to the Brisbane River on the east coast. The Australian snubfin dolphin occurs almost exclusively in protected shallow waters close to the coast and close to river and creek mouths (estuarine), preferring shallow waters, less than 20 m deep, although there are records of Australian snubfin dolphins in waters out to 23 km offshore (DAWE 2022c). Therefore, they would not be expected to be present in the Operational Area located approximately 90 km offshore and in water depths ranging from 65 m to 106 m.

Breeding, calving, resting and foraging BIAs are located in coastal waters of the Joseph Bonaparte Gulf (outside of the PEZ), including near Cape Londonderry, King George River, Ord River, Cambridge Gulf, and Darwin Harbour.

Spotted bottlenose dolphin

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[2] Previously recognised as the Indo-Pacific humpback dolphin (*S. chinensis*), which it is still listed as under the EPBC Act, the species was recognised as a separate species, Australian humpback dolphin (*S. sahulensis*), in 2014 (Jefferson & Rosenbaum 2014). However, the EP continues to refer to Indo-Pacific humpback dolphin, consistent with the current EPBC Act listing and PMST search results.

Spotted bottlenose dolphins (*Tursiops aduncus*) occur in tropical and subtropical coastal and shallow offshore waters of the Indian Ocean, Indo-Pacific region and the western Pacific Ocean (DAWE 2022d). The species is typically found close to shore, within approximately 1 km from the nearest land or oceanic islands, or in water depths of less than 30 m. BIAs identified for foraging and breeding between April and November, include Darwin Harbour and are located outside of the PEZ.

Given the species preference for shallow water and close proximity to shore, the presence of the species within the Operational Area, located approximately 90 km offshore and in water depths ranging from 65 m to 106 m, is likely to be limited.

Omura's whales

The Omura's whale is not listed as threatened or migratory under the EPBC Act, and therefore was not identified in Appendix A. Omura's whale is a relatively recently described species, found to be distinct from similar species, Bryde's whales, sei whale and the larger fin whale (Wada et al. 2003; Cerchio et al. 2019). The Omura's whale is widely distributed in primarily tropical and warm-temperate locations, between 35°S and 35°N (Cerchio et al. 2019).

In Australia, acoustic detections, photographic accounts and a single stranding record has documented Omura's whales from Exmouth to the Great Barrier Reef (Cerchio et al. 2019). Acoustic recordings documented in Australia between 2010 and 2013 (McCauley 2009, 2014) were previously attributed to Bryde's whales before the description of Omura's whale song by Cerchio et al. (2015). The attribution of the detections as potential Omura's whales by Erbe et al. (2017) was based on a review of spectrograms. The data from McCauley (2009, 2014) indicates the potential year-round presence of Omura's whales near Scott Reef, north-west of Broome, and in the Joseph Bonaparte Gulf.

Additionally, McPherson et al. (2017) examined recordings from the Pilbara, west Kimberley, Browse Basin and Timor Sea for the period 2010 to 2015. The Joseph Bonaparte Gulf was not included in the study. Water depths at the recording stations ranged from 130 m to 500 m. In the Timor Sea, to the north of the Joseph Bonaparte Gulf, Omura's whales were detected year-round, but more commonly between April and September, with a peak in the winter months of June and July. Based on the recordings, the whales seem to enter and leave the Timor Sea from the south-west, leaving the area by the start of November (McPherson et al. 2016, 2017). Fewer calls were detected in the Timor Sea between October and March (McPherson et al. 2017). Conversely, there were fewer detections in the Pilbara, west Kimberley and Browse Basin between May and December (McPherson et al. 2017). The results indicate presence across north-west Australian continental shelf, with potential seasonal movements across the region; however, McPherson et al. (2017) state that more data and analysis are needed to understand coastal/oceanic basin movements and population structure.

It is believed that some Omura's whale populations may be non-migratory, and therefore, foraging, breeding, calving and resting are likely to occur in waters where the population is distributed (Cerchio et al. 2019). However, habitat use and movements across north-western Australia are still unknown.

Given the year-round detection of potential Omura's whale vocalisations in the Joseph Bonaparte Gulf and across north-western Australia, the Omura's whale may be encountered within the Operational Area and PEZ.

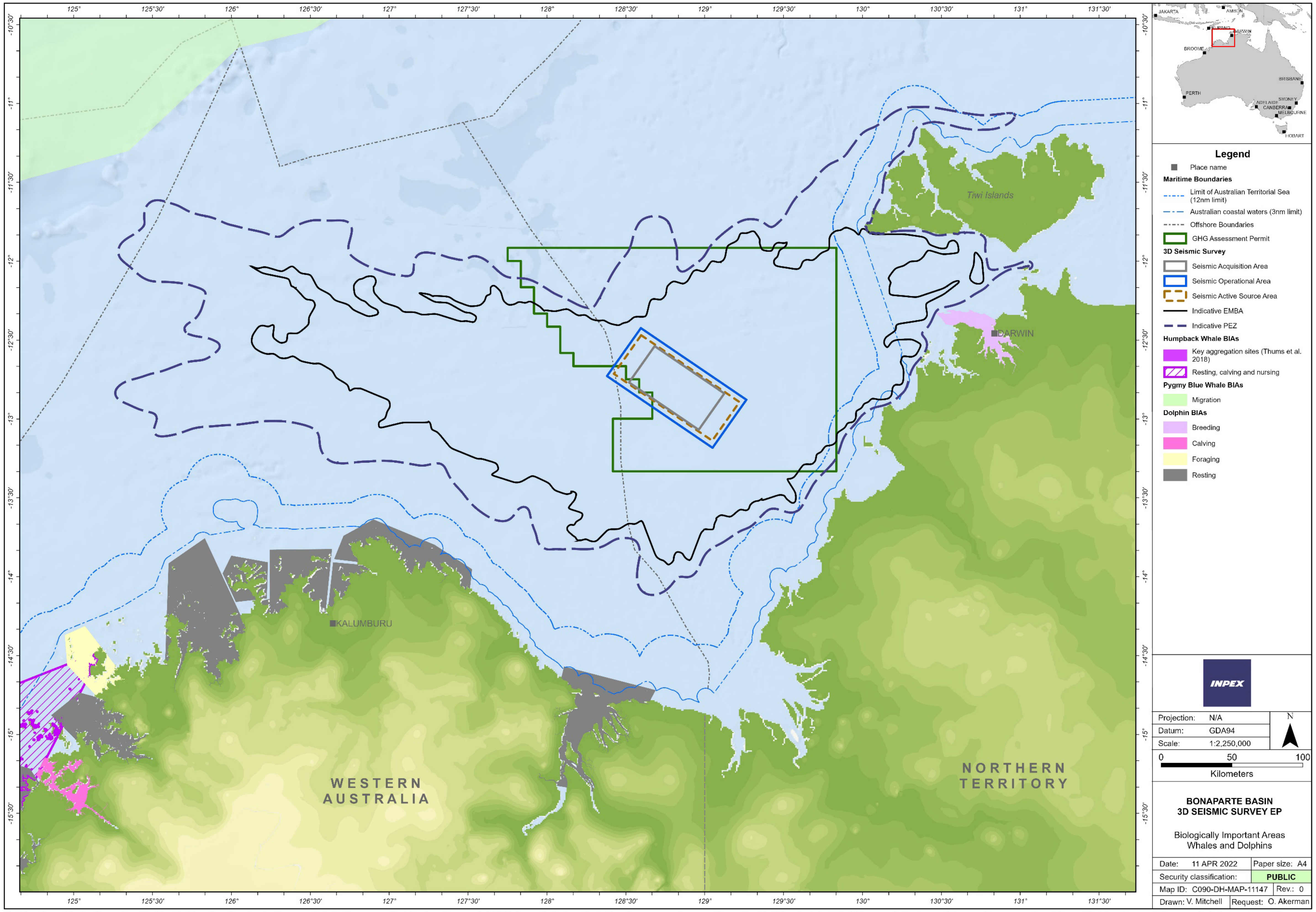

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Figure 4-4: Biologically important areas associated with whales and dolphins

Marine reptiles

Turtles

The EPBC Act Protected Matters database search identified six species of marine turtle which may occur within the PEZ: the green turtle (*Chelonia mydas*), loggerhead turtle (*Caretta caretta*), leatherback turtle (*Dermochelys coriacea*), flatback turtle (*Natator depressus*), hawksbill turtle (*Eretmochelys imbricate*) and olive ridley turtle (*Lepidochelys olivacea*). A range of BIAs and habitats critical to survival for turtles overlap the PEZ (Figure 4-5).

Satellite tracking data reviewed in recent studies (Ferreira et al. 2020; Thums et al. 2021) concluded that, although the spatial extent of marine turtle internesting areas (habitat critical to survival) was adequately covered by the defined internesting buffers and therefore afforded an appropriate level of protection, it was not the same for foraging areas. The spatial extents of foraging BIAs are considered to potentially underestimate the distribution of foraging turtles.

A marine turtle foraging BIA relating to green and olive ridley turtles overlaps the Operational Area. Although overlapping, it is unlikely that the Operational Area is the predominant foraging area for these particular species. Water depths in the Operational Area range from 65 m to 106 m and the seabed in the Operational Area comprises predominantly bare substrates, whereas the most recent study in this area indicates that green turtles predominantly forage over more complex substrates and habitats in coastal areas, and olive ridley turtle foraging is not common in the offshore waters of the Operational Area (Thums et al. 2021).

In addition, Northern Prawn Fishery (NPF) bycatch records (Poiner & Harris 1996) indicate that all species of turtle found off northern Australia are most common in water depths less than 40 m. Dietary samples of olive ridley turtles from the eastern Joseph Bonaparte Gulf also indicate foraging depths of less than 14 m (Conway 1994 reported in Whiting et al. 2007). Most foraging by green and olive ridley turtles is therefore expected to be associated shallower waters.

A foraging BIA is also defined for flatback turtles and loggerhead turtles, located approximately 10 km west of the Operational Area at the closest point. However, flatback turtles are reported to forage in areas of the Joseph Bonaparte Gulf with bare substrate, including those found in the Operational Area (Thums at al. 2021).

The closest turtle nesting beaches and internesting habitat is located at the Tiwi Islands approximately 145 km from the Operational Area including internesting habitat critical to the survival of flatback and olive ridley turtles. Therefore, marine turtle species are likely to be present in the waters of the PEZ and EMBA year-round as it encompasses several locations that support turtle foraging, nesting and internesting behaviours. Those turtle species with BIAs or habitats critical to survival that overlap the PEZ are further described below.

Flatback turtles

There are five genetically distinct populations of flatback turtles currently described around Australia. These are known as the: eastern Queensland, Arafura Sea, Cape Domett, south west Kimberley and Pilbara stocks (DEE 2017a). Additional genetic analysis is underway to provide better resolution of geographic boundaries for flatback turtles. Flatback turtles forage across the Australian continental shelf and into the continental waters off Indonesia (DEE 2017a). Breeding occurs along the NT coastline, Joseph Bonaparte Gulf and Kimberley coastline at all times of the year, with a reported peak between June to September (DEE 2017a).

At the Tiwi Islands (approximately 145 km from the Operational Area and adjacent to the PEZ boundary), nesting beaches are surrounded by an 80 km internesting BIA and a 60 km habitat critical internesting buffer for flatback turtles. Nesting and internesting activities occur within these areas on a year-round basis (DEE 2017a), with peak nesting occurring between June – September. Another notable flatback turtle nesting beach is Cape Domett (approximately 190 km south-west of the Operational Area). The Cape Domett nesting population appears to be one of the largest known nesting populations of this species, with an estimated yearly population in the order of several thousand turtles (Whiting et al. 2008). Nesting beaches are surrounded by an 80 km internesting BIA and a 60 km habitat critical internesting buffer for flatback turtles. Nesting and internesting activities occur within these areas on a year-round basis (DEE 2017a), with peak nesting occurring between July – September.

NPF bycatch data indicates that flatback turtles are more commonly part of bycatch in water depths of 10 m to 40 m than in deeper waters (Poiner & Harris 1996). However, more recently, core foraging activity for flatback turtles in northern Australia has been found to overlap deeper waters and bare substrates with much lower contributions of hard corals, seagrass, mixed benthic communities, macroalgae and turfing algae habitat (Thums et al. 2021). Therefore, bare substrate appears to be important foraging habitat for flatback turtles (Thums et al. 2021).

Although a BIA for foraging flatback turtles is defined to the north-west of the Operational Area, Thums et al. (2021) identifies areas utilised for foraging activity by flatback turtles that include the deep-water, bare substrate areas as found both within the Operational Area and to the north-west.

Flatback turtles display highly complex and connected networks across the NMR and NWMR (Thums et al. 2021). Movements between the NMR and NWMR show the Oceanic Shoals MP to the north of the Operational Area, and Kimberley MP to the west of the Operational Area are important nodes in the connectivity network, connecting movements between flatback stocks across the two marine regions (Thums et al. 2021).

Olive ridley turtles

There are two olive ridley turtle stocks in Australia, one in the NT (NT stock) and one on western Cape York near Weipa (Cape York Peninsula stock) (DEE 2017a). Low density nesting has also been described on the Kimberley coast, but genetic relatedness is currently unknown. Breeding of olive ridley turtles in the NT has been reported all year around, with peaks between April to August while the Kimberley stock nesting is reportedly year-round, with a peak around May to July (DEE 2017a). The majority of nesting occurs from the Arnhem Land coast (including Bathurst Island with a 20 km internesting buffer) to the north-western coast of Cape York Peninsula (DAWE 2022e).

Limited tagging data indicates that olive ridley turtles remain on the Australian continental shelf into waters off Indonesia (DEE 2017a). After nesting, olive ridley turtles are known to migrate up to 1,050 km to various foraging areas (DAWE 2022e) including the pinnacles of the Bonaparte Basin and the carbonate bank and terrace system of the Sahul Shelf KEFs (DEWHA 2008b).

Core foraging activity by olive ridley turtles was found to overlap predominantly bare substrate with much lower contributions of hard corals, seagrass, mixed benthic communities, macroalgae and turfing algae habitat (Thums et al. 2021). Therefore, bare substrate appears to be important foraging habitat for olive ridley turtles (Thums et al. 2021). Olive ridley turtles are reported to eat predominantly gastropod molluscs, which are expected in sandy habitats (Conway 1994 reported in Whiting et al. 2007). However, olive ridley turtles could also be targeting prey on patchy hard substrate among sand habitat or foraging in the water column on species such as jellyfish (Guinea et al. 1995).

Although a BIA for foraging olive ridley turtles overlaps the Operational Area, Thums et al. (2021) did not identify the Operational Area as being a location utilised by the species for foraging. Instead, Thums et al. (2021) identified areas in the western Joseph Bonaparte Gulf and the Oceanic Shoals MP in the Timor Sea as being utilised for foraging.

Olive ridley turtles display highly fragmented and separate movements across the NMR and NWMR with limited connectivity, likely due to having fewer genetic stocks compared to other species (Thums et al. 2021). Olive ridley turtle movements include some foraging in the western Joseph Bonaparte Gulf, but are typically north of the Operational Area, moving between East Timor, the Oceanic Shoals MP, and near the Tiwi Islands to the east (Thums et al. 2021).

Green turtles

Green turtles nesting in Australia are distributed across nine genetically distinct stocks with other green turtles known to feed in Australian waters that are part of stocks that breed in other countries (e.g. Indonesia, Papua New Guinea and New Caledonia) (DEE 2017a). Green turtles are predominantly found in Australian waters off the NT, Queensland and WA coastlines. A 20 km internesting buffer associated with green turtles has been identified for Melville Island (Tiwi islands) between November and March.

The pinnacles of the Bonaparte Basin KEF is located to the north-west of the Operational Area (Section 4.2.1). The KEF is thought to provide important habitat for green turtles traversing between foraging and nesting grounds. The species primarily forages in shallow benthic habitats (<10 m) such as tropical tidal and subtidal coral and rocky reef habitat or inshore seagrass beds, feeding on seagrass beds or algae mats (DAWE 2022d).

Green turtle core foraging activity was found to overlap hard coral, macro algae, seagrass, filter feeder habitats, turfing algae and bare substrate habitats, typically in coastal areas, as their main diet is seagrass and algae (Thums et al. 2021).

Although a BIA for foraging green turtles overlaps the offshore waters of Joseph Bonaparte Gulf, including the Operational Area, Thums et al. (2021) did not identify the Operational Area as being a location utilised by the species for foraging. Instead, foraging activity was found to be localised in relatively small areas, sparsely distributed along the coastline, including around Cobourg Peninsula and the Tiwi Islands to the north-east of the Operational Area (Thums et al. 2021).

Green turtles display highly complex and connected networks across the NMR and NWMR (Thums et al. 2021) indicating significant use of coastal waters and both AMPs and State MPs. Green turtles were found to move between the North Kimberley MP and Kimberley MP to the west of the Operational Area, into the Joseph Bonaparte Gulf MP and offshore to the Oceanic Shoals MP. Based on the findings of Thums et al. (2021), the Operational Area is unlikely to provide significant foraging habitat for green turtles, but green turtles may be transient within the Operational Area as they move between areas.

Loggerhead turtles

In Australia, there are two unique breeding populations of loggerhead turtles. The eastern Australian population nests on the southern Great Barrier Reef and adjacent mainland Queensland coastal areas. Major nesting areas for the WA population include Muiron Islands, Ningaloo Coast and islands near Shark Bay (DEE 2017a). Satellite tagging of nesting female loggerhead turtles from the Ningaloo/Pilbara coast have shown dispersal north-west as far as Indonesia and southern Borneo, north-east as far as the Tiwi Islands and south as far as the Great Australian Bight (Waayers et al. 2015; Whiting et al. 2008). Loggerhead turtle breeding in WA reportedly occurs between November to May (DEE 2017a). Loggerhead turtles are known to forage around the pinnacles of the Bonaparte Basin and the carbonate bank and terrace system of the Sahul Shelf KEFs with a foraging BIA located approximately 120 km west of the Operational Area.

Sea snakes

The EPBC Act Protected Matters Database search identified 21 sea snakes which may occur both within the Operational Area and the PEZ. There are no reported BIAs for sea snakes. Most of the knowledge of sea snakes in Australian waters comes from trawler bycatch (Milton et al. 2009; Ward 1996). These studies indicate that sea snakes in northern regions of Australia tend to breed in shallow embayments and estuaries which are only represented in the PEZ. Therefore, these species may be seen in the open waters of the Operational Area, but their presence is unlikely to be common. There is only a single specific occurrence of a sea snake reported in the Joseph Bonaparte Gulf MP (*Hyrdophis hardwickii*) (Galaiduk et al. 2018), which is located 60 km south of the Operational Area; however there have been occurrences reported adjacent to the MP. This further supports the assumption that sea snakes, although not common, may be present in low numbers.

Crocodiles

The salt-water crocodile has a tropical distribution that extends across the northern coastline of Australia, where it can be found in coastal waters, estuaries, freshwater lakes, inland swamps and marshes, as well as far out to sea (Webb et al. 1987). There are no reported BIAs for crocodiles. Due to the species preference for estuaries and swamps and coastal waters it is unlikely to occur in the open waters of Operational Area and is more likely to be observed in the PEZ where these preferred habitats occur.

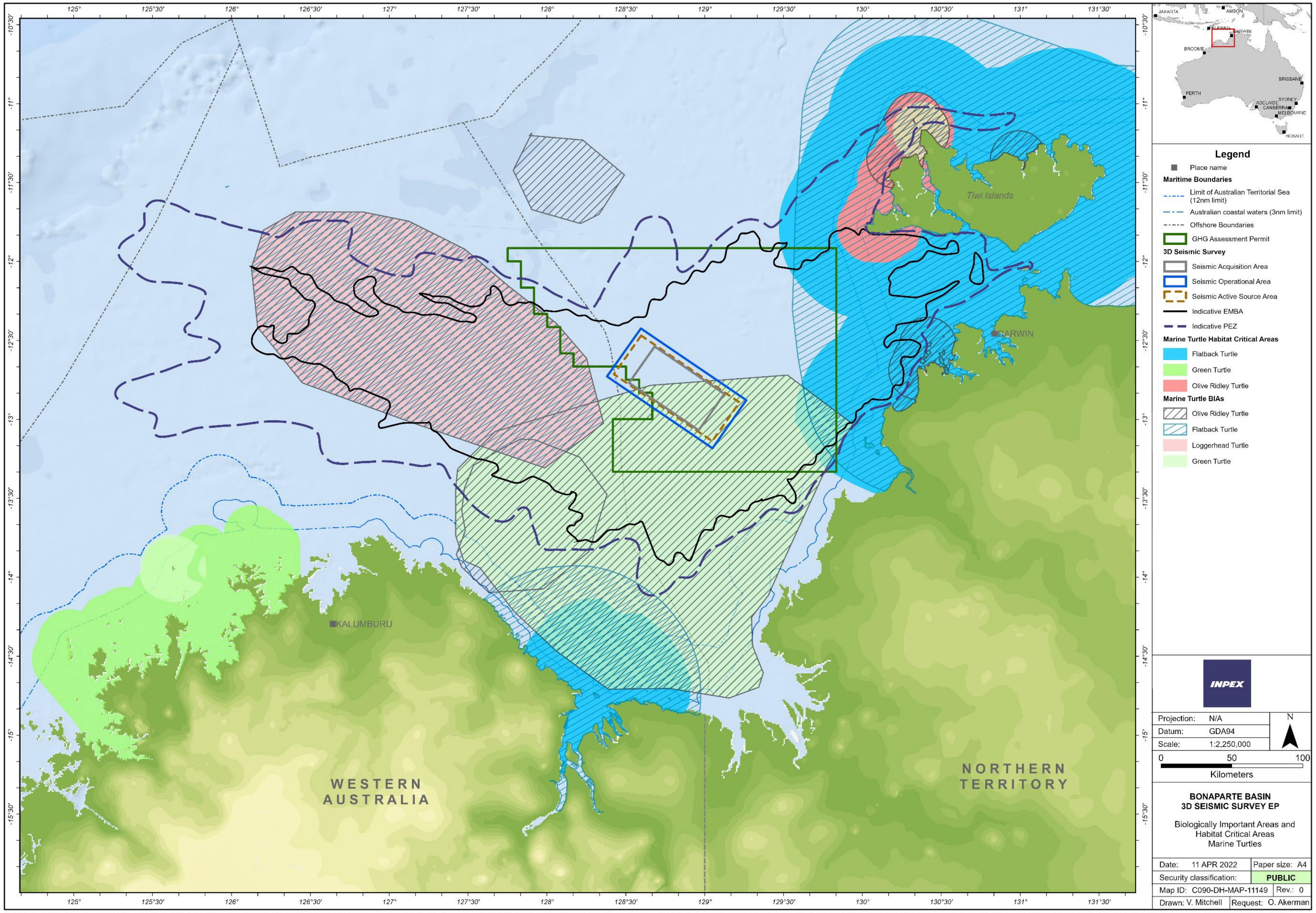

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Figure 4-5: Biologically Important Areas and Habitat Critical areas associated with marine turtles

Fishes and sharks

While there are no BIAs for fishes and sharks within the Operational Area, the furthest western extent of the PEZ overlaps a foraging BIA for whale sharks as shown in Figure 4-6. Although not specifically identified as BIAs, the KEFs within the PEZ, as described in Section 4.2, are also known to provide important habitat for diverse fish assemblages.

Whale shark

The whale shark is a solitary planktivorous species that spends the greater part of its foraging time at water depths above 100 m, often near the surface (Brunnschweiler & Sims 2011; Wilson et al. 2006). However, whale sharks are also known to engage in mesopelagic and even bathypelagic diving when in bathymetrically unconstrained habitats (Brunnschweiler et al. 2009; Wilson et al. 2006).

Whale sharks appear to prefer different locations at different times of year, and despite a reasonable understanding of the various whale shark aggregation locations and timings, little is known about the large-scale transoceanic movements in response to seasonal abundance of planktonic prey species (Eckert & Stewart 2001). The relatively limited number and dispersed origin of dietary studies of whale sharks mean it is difficult to determine general patterns in the trophic ecology of these animals in coastal ecosystems and the degree to which they act as links between oceanic and reef environments (Marcus et al. 2019). Patterns suggest that their foraging behaviour and role in oceanic and coastal ecosystems is likely to vary both in space and time (Marcus et al. 2019).

Whale sharks can travel over vast distances between aggregation sites. One whale shark tagged in the Seychelles was relocated after 42 days having travelled 3,000 km to south of Sri Lanka and then located again four months later, a further 5,000 km away in the waters of Thailand (Hsu et al. 2007). It is possible that whale sharks may transit through the PEZ in both Australian and Indonesian waters.

Whale sharks are widely distributed in tropical Australian waters. Within WA, whale sharks aggregate seasonally (March–June) to feed in coastal waters off Ningaloo Reef (Wilson et al. 2006). Ningaloo is the nearest aggregation area to the Operational Area and is located over 1,800 km to the south west. Whale sharks from Ningaloo Reef fitted with satellite trackers were observed to travel either north-east towards Timor Leste, or north-west towards the Indonesia islands of Sumatra and Java, with some individuals passing through the broad vicinity of Scott Reef (McKinnon et al. 2002, Wilson et al. 2006, Meekan & Radford 2010; Sleeman et al. 2010). Aerial (Jenner & Jenner 2009a; RPS Environment and Planning Pty Ltd 2010, 2011) and vessel (Jenner et al. 2008; Jenner & Jenner 2009b) surveys conducted in 2008 and 2009, involving over 1,000 hours of observer effort, recorded one whale shark in 2008 and two whale sharks in 2010 in the Browse Basin (Jenner et al. 2008 and RPS Environment and Planning Pty Ltd 2011 respectively).

The whale shark foraging BIA slightly overlaps the western boundary of the PEZ, approximately 290 km west of the Operational Area. Based on the low levels of whale shark abundance observed in the studies listed above from the Browse Basin, the likelihood of whale shark presence within this BIA is considered very low, with no specific seasonal pattern of migration.

Sawfish

Four species of sawfish (largetooth/freshwater/northern, narrow, dwarf and green sawfish) were identified in the EPBC Act Protected Matters database search (Table 4-2). While sawfish are identified as being found within the Operational Area and the PEZ, due to their ecology (generally estuarine rather than open-ocean species), it is expected that they will only be present on the periphery of the PEZ (Figure 4-6). Sawfish are not expected to occur within the open ocean location of the Operational Area.

As described in Section 4.2, environments found in the PEZ provide protection for shallow shelf habitats that are important foraging, nursing and pupping areas for freshwater, green and dwarf sawfish. The range of sawfish species overlaps with popular recreational fishing locations in some parts of the NMR (DSEWPaC 2012b) and adjacent areas. Observations of dead discarded sawfish species from recreational fishing highlights that mortality occurs as a direct result of capture and discarding (DSEWPaC 2012b).

Pipefish and seahorses

The EPBC Act Protected Matters database search identified 34 species of the family Syngnathidae which potentially may be present both within the Operational Area and the PEZ. Syngnathidae is a group of bony fishes that includes seahorses, pipefishes, pipehorses and sea dragons. Seahorses and pipefishes are a diverse group and occupy a wide range of habitats. However, the species identified in the EPBC Act Protected Matters database search (Appendix A) generally display a preference for shallow water habitats such as seagrass and macroalgal beds, coral reefs, mangroves and sponge gardens that can be found in the shallower areas of the PEZ (Foster & Vincent 2004; Lourie et al. 1999; Scales 2010). Therefore, pipefish and seahorses are only expected to occur in the PEZ in areas where suitable habitats are present.

Sharks and rays

Eight shark species (including whale shark described above) and two ray species were identified as having the potential to occur within the PEZ (Table 4-2; Appendix A).

It is considered possible that larger pelagic sharks such as the great white, oceanic whitetip, whale and mako sharks may transit through the Operational Area/PEZ. However, sharks with known coastal habitats, such as the Northern River Shark (*Glyphis garricki*) are not expected to occur within the open ocean location of the Operational Area, and therefore are only likely to be present in coastal habitats on the periphery of the PEZ. Similarly, the critically endangered, speartooth shark (*G. glyphis*) inhabits tidal rivers and estuaries in the NT and Queensland and is therefore only likely to be present in the PEZ (DAWE 2022e).

Listed manta rays have been observed within the PEZ, but for the same reasons as the large pelagic sharks, are unlikely to be common or resident within the Operational Area.

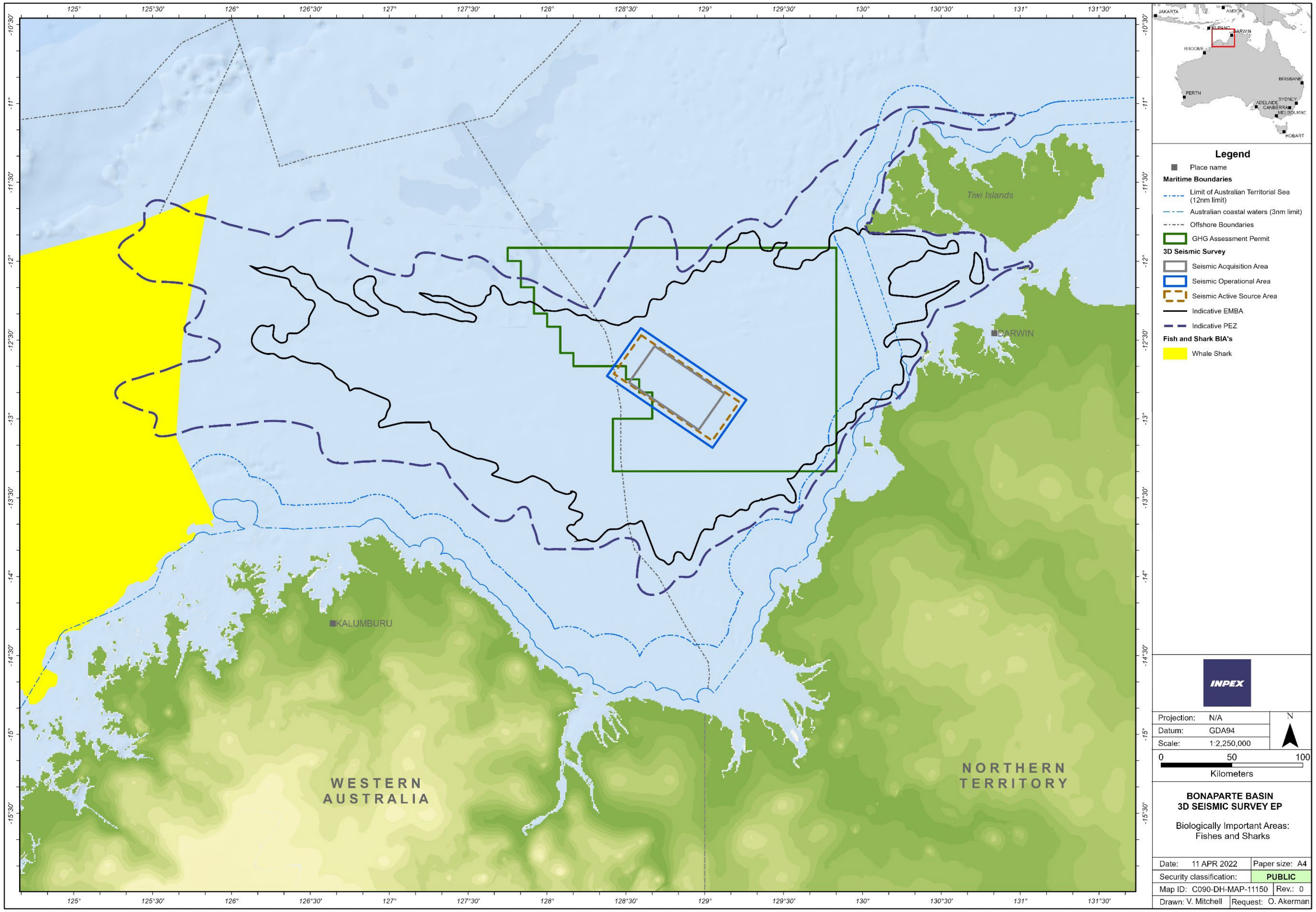

Figure 4-6: Biologically important areas associated with fishes and sharks

Marine avifauna

The Operational Area is located within what is known as the East Asian-Australasian (EAA) Flyway an internationally recognised migratory bird pathway that covers the whole of Australia and its surrounding waters. 'Flyway' is the term used to describe a geographic region that supports a group of populations of migratory waterbirds throughout their annual cycle. There are 54 species of migratory shorebirds that are known to specifically follow migration paths within the EAA Flyway (Bamford et al. 2008). Migratory shorebird species are mostly present in Australia during the non-breeding period, from as early as August to as late as April/May each year. After arrival in Australia at the end of long migrations, they disperse throughout the country to a wide variety of habitats including coastal wetlands, mudflats, reefs and sandy beaches (DEE 2017b).

There are no BIAs for marine avifauna within the Operational Area or the EMBA. However, the PEZ overlaps three BIAs for different marine avifauna species (Figure 4-7). The BIAs relate to crested tern (*Thalasseus bergii*) breeding in high numbers at the Tiwi Islands, centred on the northern coast of Melville Island (which overlaps a portion of the PEZ in the north east, approximately 190 km from the Operational Area at its closest point). Lesser crested tern (*Thalasseus bengalensis*) and lesser frigatebird (*Fregata ariel*) breeding BIAs with associated foraging areas are also present overlapping the far south west of the PEZ with the outer boundaries of the BIAs approximately 135 km and 190 km away from the Operational Area at the closest points. No Ramsar sites overlap the PEZ; however, a nationally important wetland (Finniss Floodplain and Fog Bay Systems) is present within the PEZ (refer to Section 4.5). This site provides important habitat for marine avifauna including migratory species which could be expected to be encountered in low numbers as they are likely to transit through the Operational Area and the PEZ.

In addition to seabirds, the search of the EPBC Act Protected Matters database identified 22 species of migratory wetland bird species potentially present within the PEZ. These species may migrate through the PEZ to wetland habitats on the mainland and/or larger coastal islands (DEE 2017b). It is considered unlikely that Operational Area would provide any significant resources to support these species given the lack of suitable habitat.

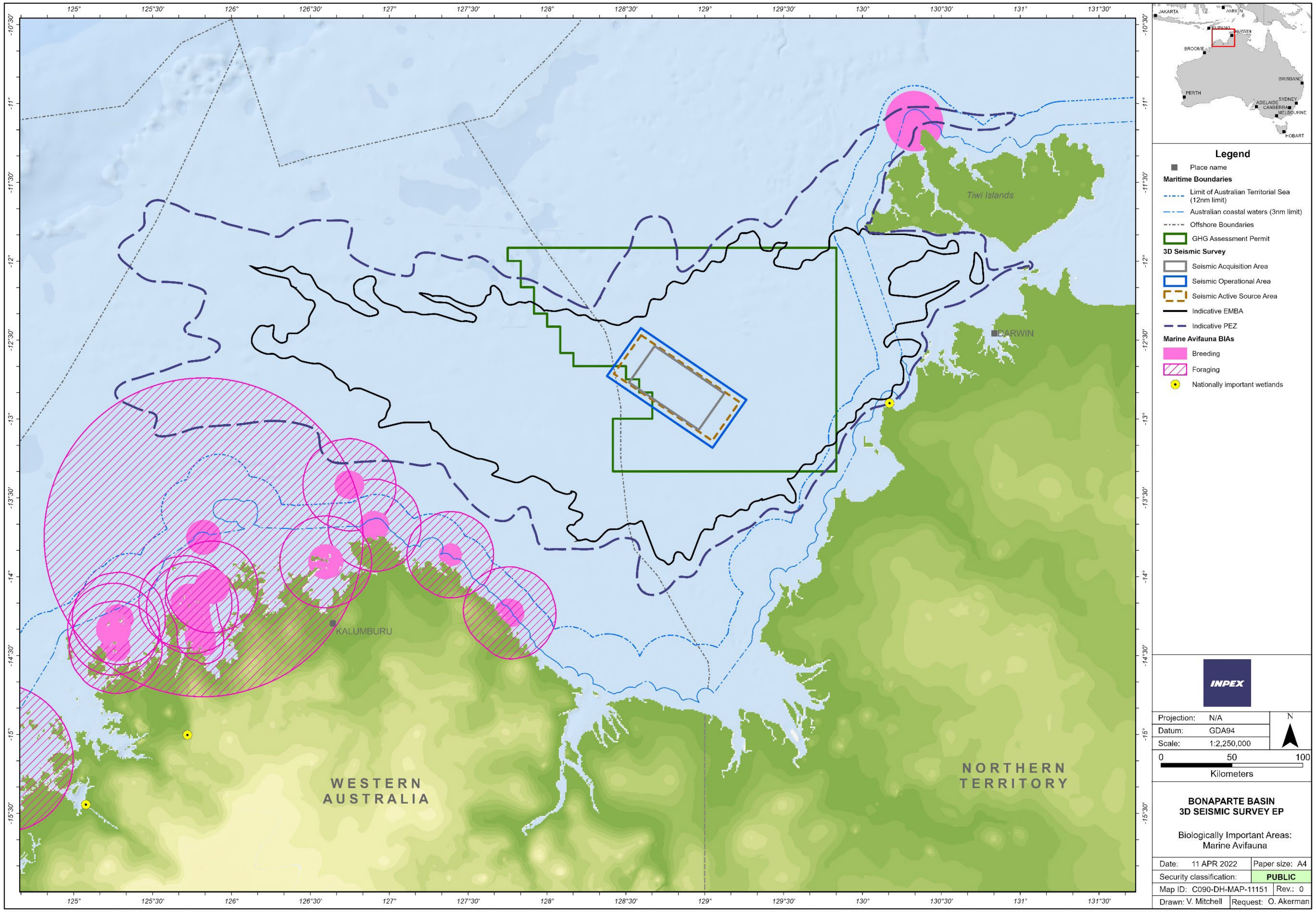

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Figure 4-7: Biologically important areas associated with marine avifauna

4.8 Marine pests

Marine pests, or Invasive Marine Species (IMS), are defined as non-native marine plants or animals that harm Australia's marine environment, social amenity or industries that use the marine environment; or have the potential to do so if they were to be introduced, established (that is, forming self-sustaining populations) or spread in Australia's marine environment (DAWR 2018). There are 60 known non-native marine species that have become established in WA waters. Most are temperate species, with only six that are exclusively tropical. The greatest number of introduced species is found in the south-west corner of WA (DoF 2016).

Not all marine species introduced into a new area become pests as not all of them will survive or may not manage to reproduce and establish a viable population. Many IMS that establish self-sustaining populations cause no detectable harm. However, others have the potential to cause significant long-term economic, ecological and health consequences for the marine environment (DoF 2016).

Marine pests pose a major threat to the environment, economy and social amenity by disrupting ecological processes both directly (through predation or competition with native plants and animals) or indirectly (through habitat alteration). Once established, marine pests can rarely be eradicated, and their impacts are often long lasting (DAWR 2018).

Shallow water, coastal marine environments are most susceptible to the establishment of invasive populations, with most IMS associated with artificial substrates in disturbed shallow water environments such as ports and harbours (e.g. Glasby et al. 2007; Dafforn et al. 2009a, 2009b). The supply base supporting the activity is Darwin Port, described in Section 4.9.7, including a summary of the IMS status.

Within WA and NT waters the marine pest, *Didemnum perlucidum* (white colonial sea squirt) is widely established in many ports, marinas and other locations (Smale & Childs 2012; Dias et al. 2016; DPIRD 2021). *D. perlucidum* has been recorded in natural and artificial marine environments in WA from Busselton to Broome and the NT in Darwin and surrounding coastal waters (Muñoz & McDonald 2014.) This ascidian can survive temperatures between 15 and 30 °C and has been recorded at depths of up to 8 m, however, it is commonly found in the upper 1–3 m of the water column (Muñoz & McDonald 2014).

4.9 Socioeconomic and cultural environment

4.9.1 World heritage areas

World heritage areas are locations that represent the best examples of the world's cultural and natural heritage. The EPBC Act Protected Matters database search (Appendix A) identified no world heritage areas occurring within the Operational Area or the PEZ.

4.9.2 Commonwealth heritage areas

The Commonwealth Heritage List contains places with Indigenous, historic and natural value and are protected under provisions of the EPBC Act. No Commonwealth heritage places including indigenous protected areas occur within the Operational Area or PEZ.

4.9.3 National heritage places

The National Heritage List contains places of natural, historic and Indigenous significance to the nation. No National Heritage Places were identified as overlapping the Operational Area or the PEZ.

4.9.4 Underwater heritage

Underwater cultural heritage sites are recognised as a part of the marine environment ecosystem. Under the *Underwater Cultural Heritage Act 2018,* there are two sites within the PEZ that have protection zones declared around them, the SS Florence D (DAWE 2022f) and the submarine, I-124 (DAWE 2022g), located in a north-easterly direction approximately 205 km and 125 km away respectively from the Operational Area. The protection zones extend to an 800 m radius surrounding the wrecks and are in place to limit disturbance of the cultural heritage and also the surrounding environment.

4.9.5 Cultural values

Aboriginal and Torres Strait Islander people have been sustainably using and managing their sea country for tens of thousands of years, in some cases since before rising sea levels created these marine environments (DNP 2018b). Sea country refers to the areas of the sea that Aboriginal and Torres Strait people are particularly affiliated with through their traditional lore and customs. Sea country is valued for Indigenous cultural identity, health and wellbeing (DNP 2018b).

The PEZ broadly spans the coastline from Kalumburu (WA) to the Coburg Peninsula and Tiwi Islands (NT). This coastline is the home of many Aboriginal groups, each with their own culture, customs, language and laws (AIATSIS 1996). Each group has its own, recognised connections to land and sea country, through customary fishing, cultural practises, foraging, harvesting and hunting. These connections are formalised in some areas through the establishment of Indigenous Protected Areas (IPAs, i.e. TLC 2018), and Aboriginal ranger groups for the management of country.

Aboriginal land in the NT is defined by the Aboriginal Land Rights Act (NT) 1976, which affords Traditional owners sovereign rights to country. In WA, recognition of Aboriginal rights is afforded by the Native Title Act 1993 and Land Administration Act 1997, which give rights to access, live upon, forage, harvest and hunt upon and carry out traditional cultural practises on country. For the PEZ, three land councils represent the communities, the Kimberly Land Council for WA, and the Northern and Tiwi Land Councils in NT. There are also a number of Prescribed Bodies Corporate that represent Aboriginal people both the NT and WA.

The NT coastline also contains evidence of Macassan people, who sailed from Indonesia in the early 1700s until the early 1900s and interacted with Aboriginal people. Evidence of these visits include the remains of stone fireplaces and smoke houses, tamarind trees planted by Macassan people, fragments of earthenware and porcelain. Although not marine based, Aboriginal and Macassan archaeological places are important to Aboriginal people as part of their continuing culture and identity.

INPEX maintains a reconciliation action plan (RAP [3]) which outlines the company's engagement with the Aboriginal and Torres Strait Islander communities that it works within. In implementing this EP and the RAP, INPEX acknowledges the national and international rights and cultural interests of Aboriginal and Torres Strait Islander peoples and the deep understanding and experience that they can contribute.

[3] Available online at reconciliation-action-plan-a4-brochure-2019_fa_hr_web.pdf (inpex.com.au)

4.9.6 Fishing

Commercial fisheries – Australian waters

The Australian Fisheries Management Authority (AFMA) manages Australian Commonwealth fisheries within the Australian fishing Zone (AFZ). AFMA carry out objectives that are listed in the *Fisheries Administration Act 1991* and the *Fisheries Management Act 1991*. NT fisheries are managed by the NT DITT. Wild harvest fisheries are managed under the NT *Fisheries Act 1988* and Fisheries Regulations 1992. WA fisheries are managed by the WA Department of Primary Industries and Regional Development (DPIRD) under the *Fish Resources Management Act 1994* and Fisheries Resources Management Regulations 1995.

The licence and management areas of four Commonwealth-managed commercial fisheries, two joint authority commercial fisheries, 13 NT-managed commercial fisheries, six WA-managed commercial fisheries, and occur within the PEZ. These fisheries are:

- Commonwealth Northern Prawn Fishery (NPF)
- Commonwealth Western Skipjack Tuna Fishery
- Commonwealth Southern Bluefin Tuna Fishery
- Commonwealth Western Tuna and Billfish Fishery
- WA Joint Authority Northern Shark Fishery
- NT Joint Authority Northern Finfish Fishery (comprises the NT Demersal Fishery, NT Offshore Net and Line Fishery and the NT Timor Reef Fishery)
- NT Demersal Fishery
- NT Offshore Net and Line Fishery
- NT Spanish Mackerel Fishery
- NT Aquarium Fishery
- NT Jigging Fishery
- NT Pearl Oyster Managed Fishery
- NT Coastal Line Fishery
- NT Coastal Net Fishery
- NT Barramundi Fishery
- NT Trepang Fishery
- NT Development Fishery (Small Pelagic)
- NT Mud Crab Fishery
- NT Bait Net Fishery
- WA Northern Demersal Scalefish Managed Fishery (NDSMF)
- WA Mackerel Managed Fishery (MMF; Area 1)
- WA Pearl Oyster Managed Fishery (Zone 4)
- WA Marine Aquarium Fish Managed Fishery
- WA Specimen Shell Managed Fishery
- WA Sea Cucumber Managed Fishery.

Not all of the above fisheries are active within the Operational Area or PEZ. INPEX has analysed commercial fishing catch and effort data from the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), NT DITT and WA DPIRD to further understand the fisheries that are active in waters overlapping and adjacent to the Operational Area.

Commonwealth fisheries data, available from ABARES for the period 2010—2020, confirmed that the only Commonwealth-managed fishery that actively fishes in the Joseph Bonaparte Gulf is the NPF. According to the AFMA website, the Western Skipjack Tuna Fishery is not currently active, and no Australian boats have fished for skipjack tuna since 2009; as confirmed by the ABARES fishing effort data. The Western Tuna and Billfish Fishery has consistently fished off the west coast of WA and off South Australia, while the Southern Bluefin Tuna Fishery operates off South Australia and New South Wales.

The Operational Area and Active Source Area extend approximately 6 km and less than 1 km into WA offshore waters respectively. However, no WA-managed fisheries have operated in or near the Operational Area in recent years. The fishing effort data provided by WA DPIRD for the 10-year period, 2011 – 2020, confirms that the two WA fisheries active in the general area are the NDSMF and the MMF.

The nearest NDSMF fishing effort includes blocks located approximately 7 km to the south-west of the Operational Area (11 km from the Active Source Area), where less than three vessels have fished during the entire 10-year period, and a block approximately 7.5 km north-west from the Operational Area (11.5 km from the Active Source Area), which appears to be associated with pinnacle features and where just 1 day of fishing effort per year in the years 2015, 2016 and 2017 has occurred during the entire 10-year period. Fishing effort by this fishery is primarily focussed on the outer continental shelf and an area of shoals located over 300 km west of the Operational Area.

The nearest MMF fishing effort is a block approximately 75 km south-west from the seismic Operational Area, where less than 3 vessels have fished during the entire 10-year period. The fishing effort data also confirmed that fishing effort in any of the other WA fisheries during the 10-year period has taken place over 180 km from the Operational Area.

NT fishing effort data for the period 2016—2020 provided by NT DITT demonstrates that the main fishery that operates in the Operational Area is the NT Demersal Fishery. The NT Offshore Net and Line Fishery, NT Spanish Mackerel Fishery, and NT Aquarium Fishery have also reported relatively low-level fishing effort in the eastern half of the Operational Area. The NT DITT fishing effort data indicated that other NT fisheries operate 40 km or more from the Operational Area.

The NPF and NT-managed fisheries that have previously been active in the Operational Area are described in Table 4-4.

Table 4-4: Commonwealth and NT-managed commercial fisheries operating near the Operational Area

Fishery	Licence area description	Gear types and usage	Target species	Summary of fishing activities	Fishing effort in the Operational Area
Commonwealth-managed fisheries					
Northern Prawn Fishery	The NPF extends from the Joseph Bonaparte Gulf across the top end to the Gulf of Carpentaria (AFMA 2022a).	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.	White banana prawn Redleg banana prawn Tiger prawns By-product species include endeavour prawns, deep-water scampi, bugs and saucer scallops.	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 (1 August – 1 December) tiger prawns are predominantly caught. Either season has the potential to end early if catch rates fall below pre-set trigger levels. Closures in between these seasons protect / allow recovery of the stocks (Patterson et al. 2021). The Joseph Bonaparte Gulf fishery comprises less than 5% of the area of the NPF; however, it contributes most of the NPF's redleg banana prawn catch (Patterson et al. 2021). Since 2021, a closure area has applied to the whole of the Joseph Bonaparte Gulf south of latitude 13°S. The closure area excludes fishing in the Joseph Bonaparte Gulf during the first 1 April to 15 June fishing season for better management of the redleg banana prawn stock of the Joseph Bonaparte Gulf (AFMA 2022a).	Based on 2010 to 2020 fishing data, fishing intensity within the Joseph Bonaparte Gulf in any given year is usually low (<0.1 days/km^2) although in some years it has been or medium (0.1-0.25 days/km^2) or high (0.25-0.55 days/km^2). Most fishing effort in the Joseph Bonaparte Gulf has historically occurred >50 km south-west of the Operational Area (Figure 4-8). Due to the presence of the new closure area, these key fishing grounds will now only be accessible during the tiger prawn fishing season. The Operational Area is located to the north of the closure area but overlaps waters where <5 vessels have historically fished during any year (Figure 4-8). Fishing effort data provided by the Northern Prawn Fishery Industry during stakeholder consultation for the EP is consistent with the ABARES data and confirms limited or no fishing effort within the Operational Area each season.
NT-managed fisheries					

Fishery	Licence area description	Gear types and usage	Target species	Summary of fishing activities	Fishing effort in the Operational Area
NT Demersal Fishery	Demersal fishing is allowed from 15 nm from the low water mark to the outer boundary of the AFZ, excluding the area of the Timor Reef Fishery (NTG 2022a).	Vertical lines, drop lines, finfish long-lines, baited fish traps and semi-demersal trawl nets in two multi-gear areas. The Operational Area is located in a multi-gear area where trawling is permitted	Saddletail snapper Crimson snapper Goldband snapper Red emperor	There are currently 18 active licences (NTG 2022a) and in 2017, the reported catch was 3,389 tonnes, including, red snapper (70.8 %) and goldband snapper (10.1 %) (NT DPIR 2019). The majority of fishing activity that takes place in the multi-gear area overlapping the Operational Area is trawling, with very limited trap and line activity. Fishing occurs year-round (NT DPIR 2019).	A review of historic fishing effort data (2016 – 2020) provided by NT DITT indicates that the Operational Area overlaps an area of consistent trawl effort with approximately 345 – 1,400 hours of effort per year within the Operational Area (Figure 4-9). Further review of Global Fishing Watch automatic identification system (AIS) and vessel monitoring system (VMS) data, indicates that trawl vessels consistently operate in the Operational Area as well as waters located to the north of the Operational Area. Stakeholder consultation with a Demersal Fishery licence holder has confirmed that a single licence holder typically accesses this area. One of their three vessels consistently trawls within the Operational Area and further north, throughout the year.
NT Offshore Net and Line Fishery	The Offshore Net and Line extends from the low water mark to the outer boundary of the AFZ to the extent the waters are relevant to the NT (NTG 2022b).	Demersal long lines, pelagic long lines, longlines and pelagic nets.	Grey mackerel Black-tip shark	The fleet operates with an average of 10 vessels per year, and the fishery harvested 632 tonnes in 2018-19, including grey mackerel (510 tonnes) and combined finfish (58 tonnes) (NTG 2020).	A review of historic fishing effort data (2016 – 2020) provided by NT DITT indicates that fishing by the Offshore Net and Line Fishery has previously occurred in the eastern part of the Operational Area (Figure 4-10). However, fishing has been infrequent, with a total of 15 hours of effort in 2016, 3 hours of effort in 2017, 5 hours of effort in 2019 and 35 hours of effort in 2020. No effort occurred within the Operational Area in 2018.
NT Spanish Mackerel Fishery	The Spanish Mackerel Fishery management area	Commercial fishers operate using a	Spanish mackerel	The Spanish Mackerel Fishery is a limited entry fishery and is limited to 15 licences (NTG 2021a). Total catch in	A review of historic fishing effort data (2016 – 2020) provided by NT DITT indicates that fishing by the Spanish Mackerel Fishery has

Fishery	Licence area description	Gear types and usage	Target species	Summary of fishing activities	Fishing effort in the Operational Area
	covers waters between the WA/NT and QLD/NT border from the high-water mark to the outer boundary of the AFZ (NTG 2021a)	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.		2019-20 was approximately 375 tonnes (NT DITT 2021a). The fishing season is all year. 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.	previously been limited to waters on the south-eastern edge of the Operational Area and closer towards the coast (Figure 4-11). Fishing in the Operational Area has been infrequent, with a total of 39 hours of effort in 2016, 10 hours of effort in 2017, and 28 hours of effort in 2019. No effort occurred within the Operational Area in 2018 or 2020.
NT Aquarium Fishery	The Aquarium Fishery management area encompasses freshwater, estuarine and marine waters between the WA/NT and Queensland (QLD)/NT border to the outer boundary of the AFZ.	Diving. Collection via hand-held equipment, including nets (barrier, cast, scoop, drag and skimmer) and hand pumps. Freshwater pots are also permitted.	Rainbowfish Catfish Scats 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. The fishing season is all year. There are 11 licences in the Aquarium Fishery and in 2018-19 there were 7 licences actively collecting marine species (NT DPIR 2019). Harvesting usually takes place in depths less than 10 m, and occasionally in depths up to 30 m (NT DPIR 2019). 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 (NTG 2022a).	A review of historic fishing effort data (2016 – 2020) provided by NT DITT indicates that a single 10 nm block on the north-east edge of the Operational Area has reported a single hour fishing effort in 2020 (Figure 4-12). This block is located in water depths in excess of 80 m and is not associated with any obvious bathymetric features so it is unclear if this is accurate or an error in the data. Fishing effort has also been reported in blocks approximately 17 km and 20 km to the south and the north-east of the Operational Area respectively. All other fishing effort has taken place in blocks over 50 km from the Operational Area.

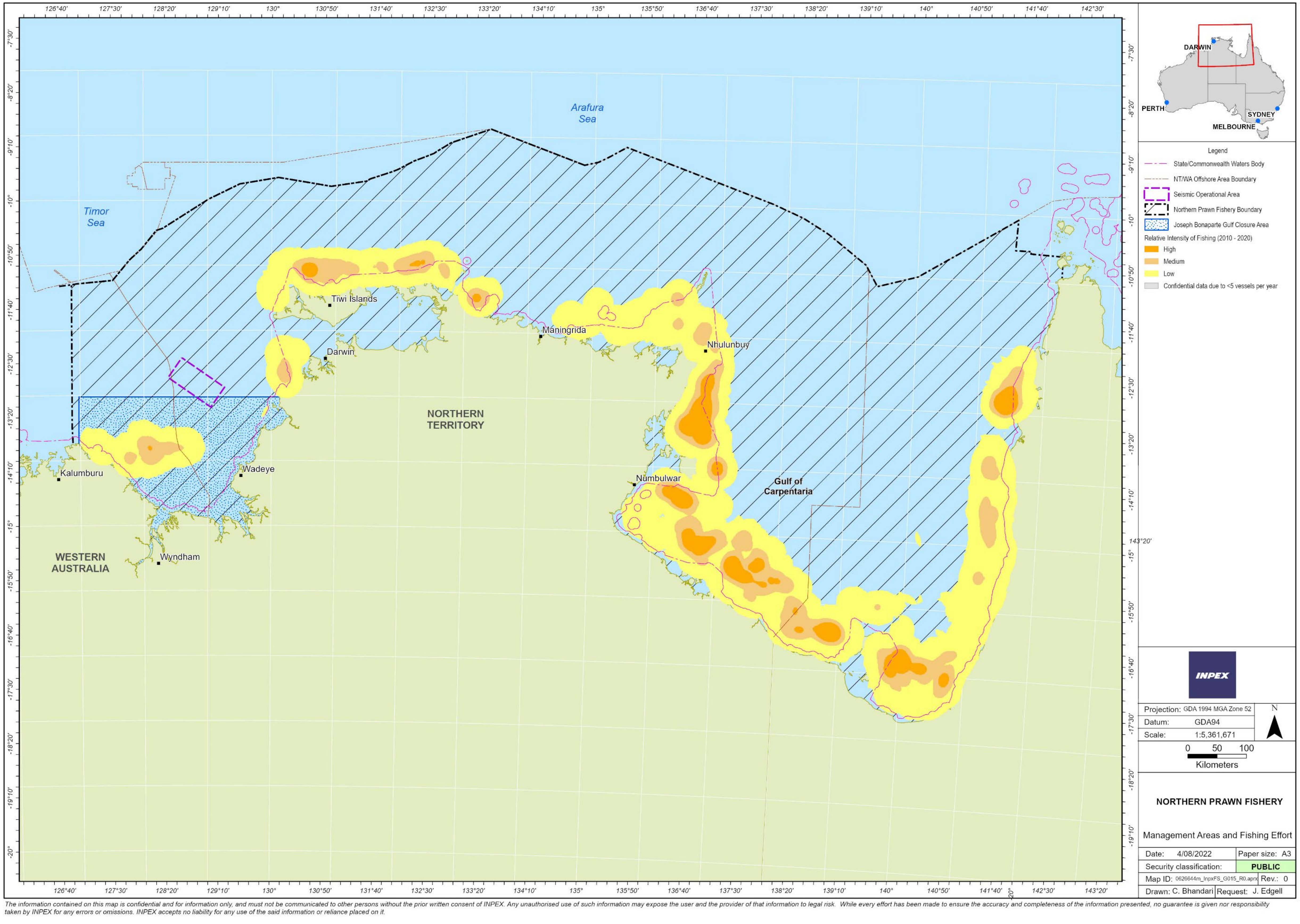

Figure 4-8: Northern Prawn Fishery (Commonwealth) fishing effort (2010 – 2020)

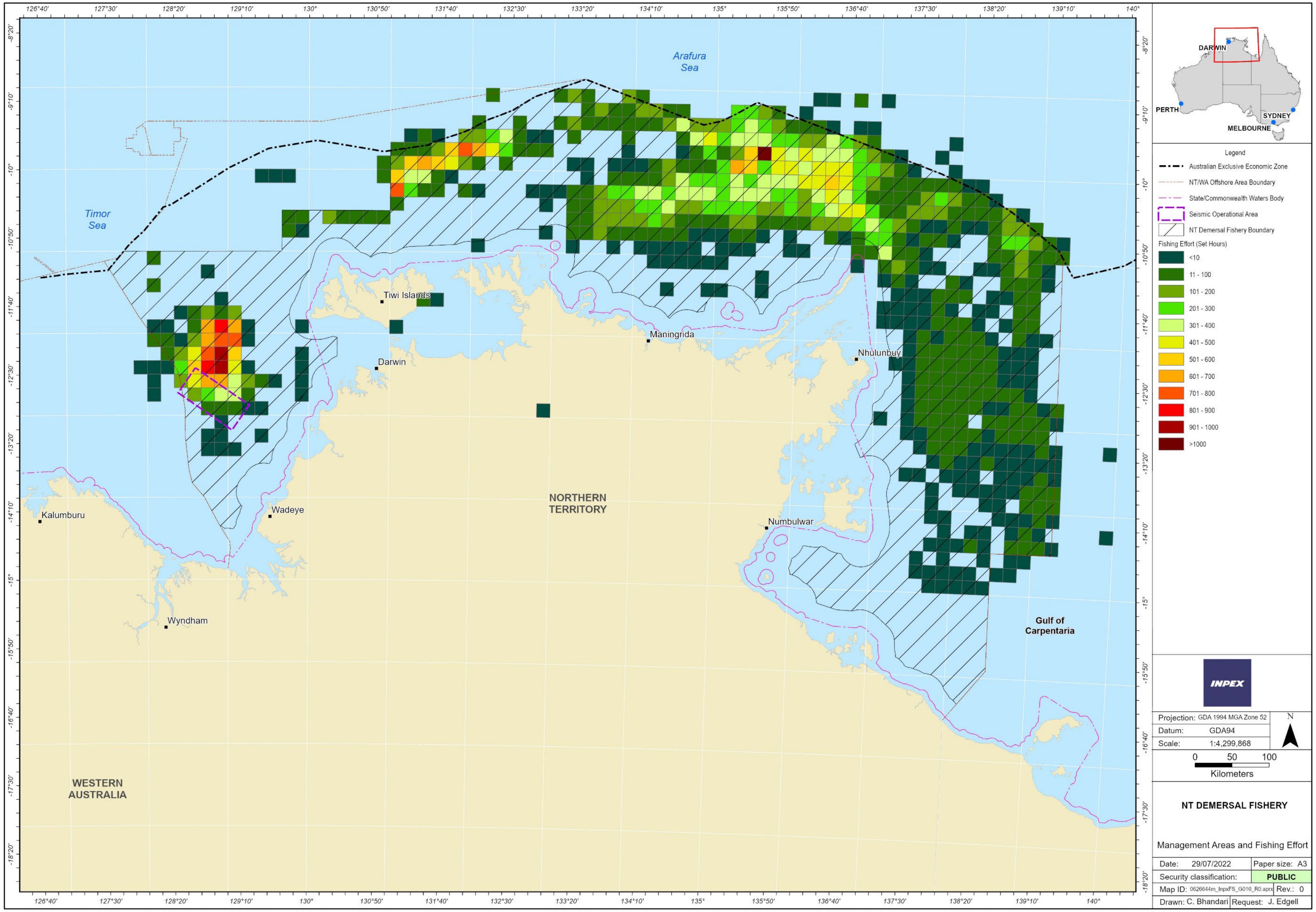

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Figure 4-9: NT Demersal Fishery fishing effort (2016 – 2020)

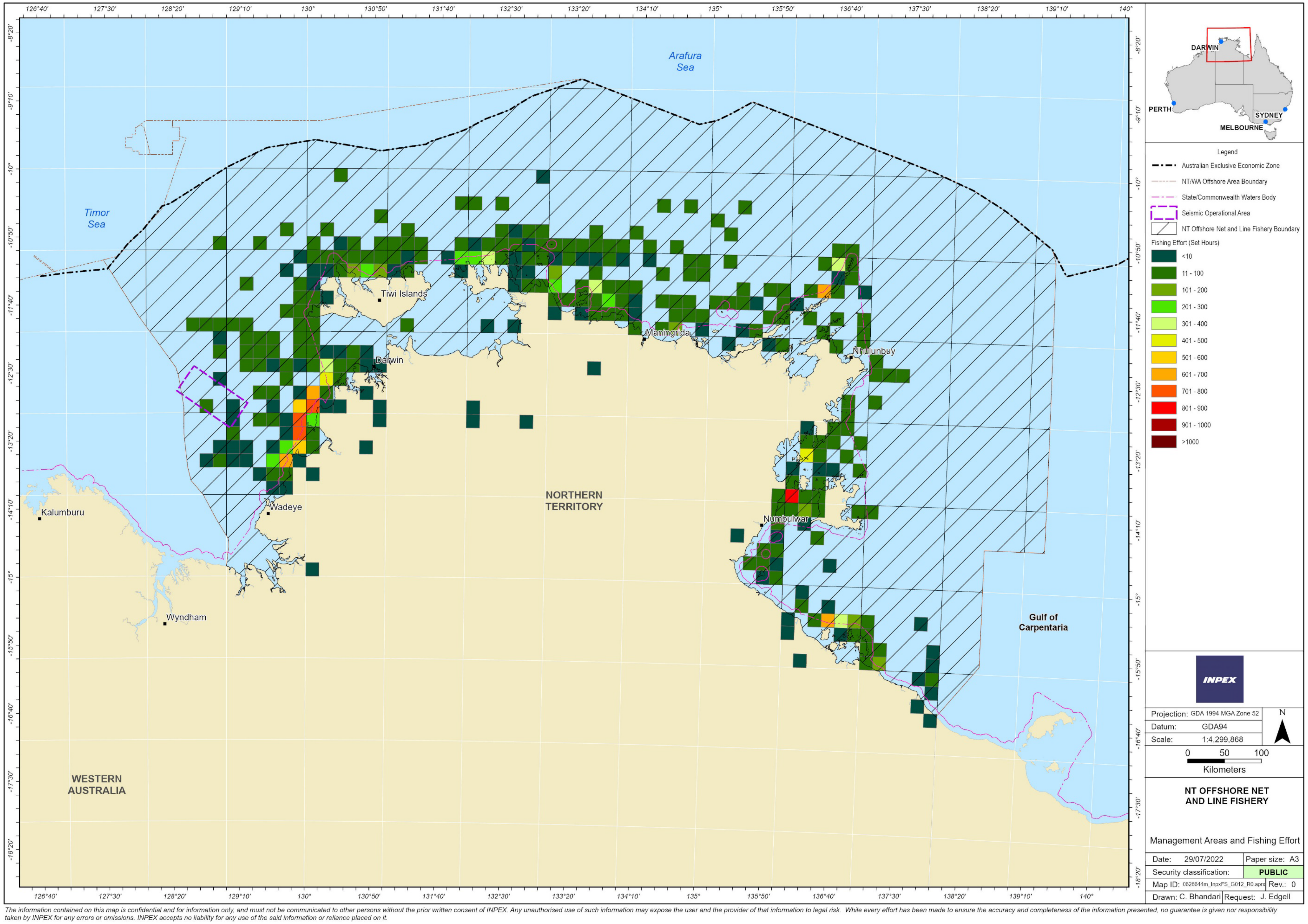

Figure 4-10: NT Offshore Net and Line Fishery fishing effort (2016 – 2020)

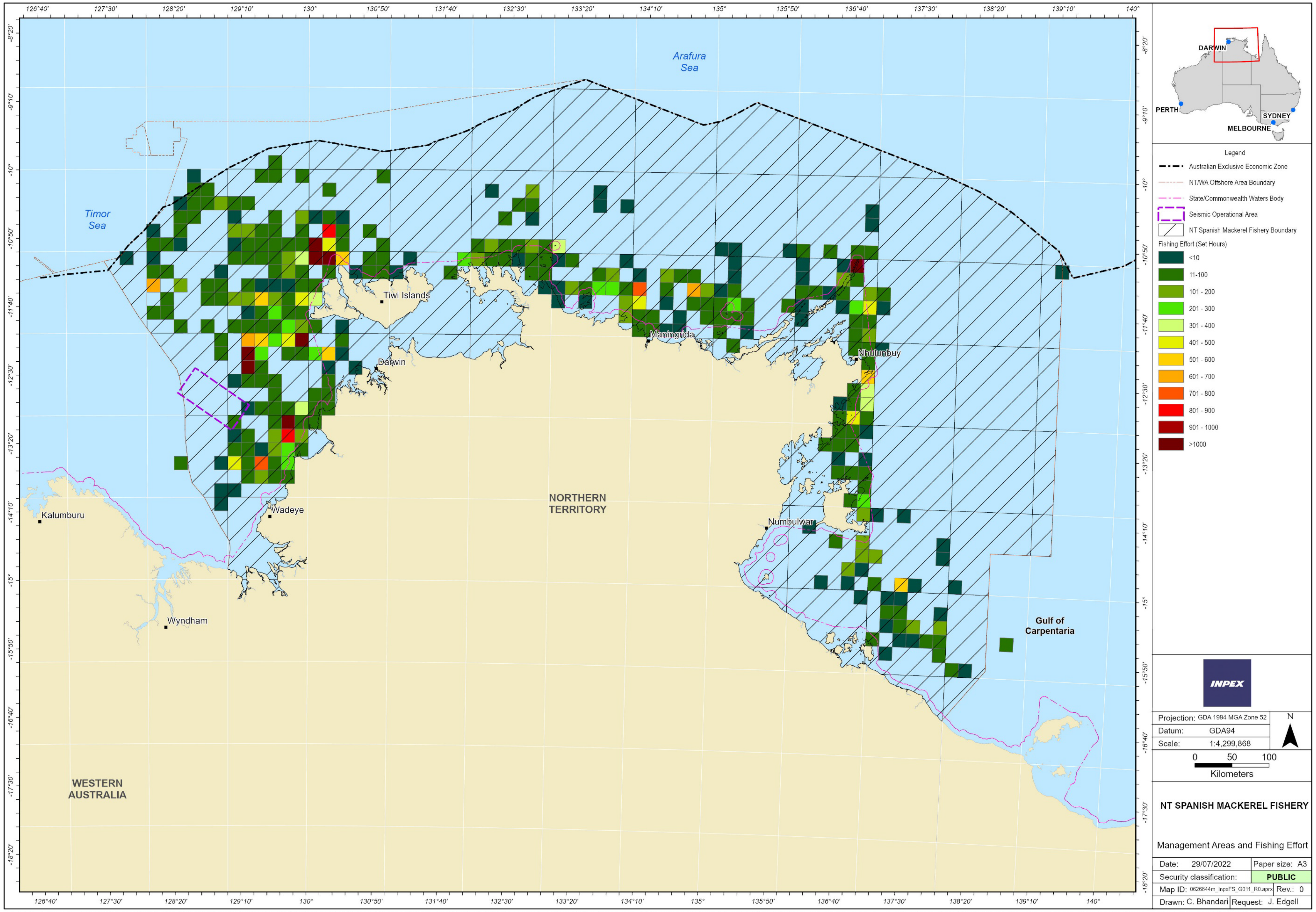

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Figure 4-11: NT Spanish Mackerel Fishery fishing effort (2016 – 2020)

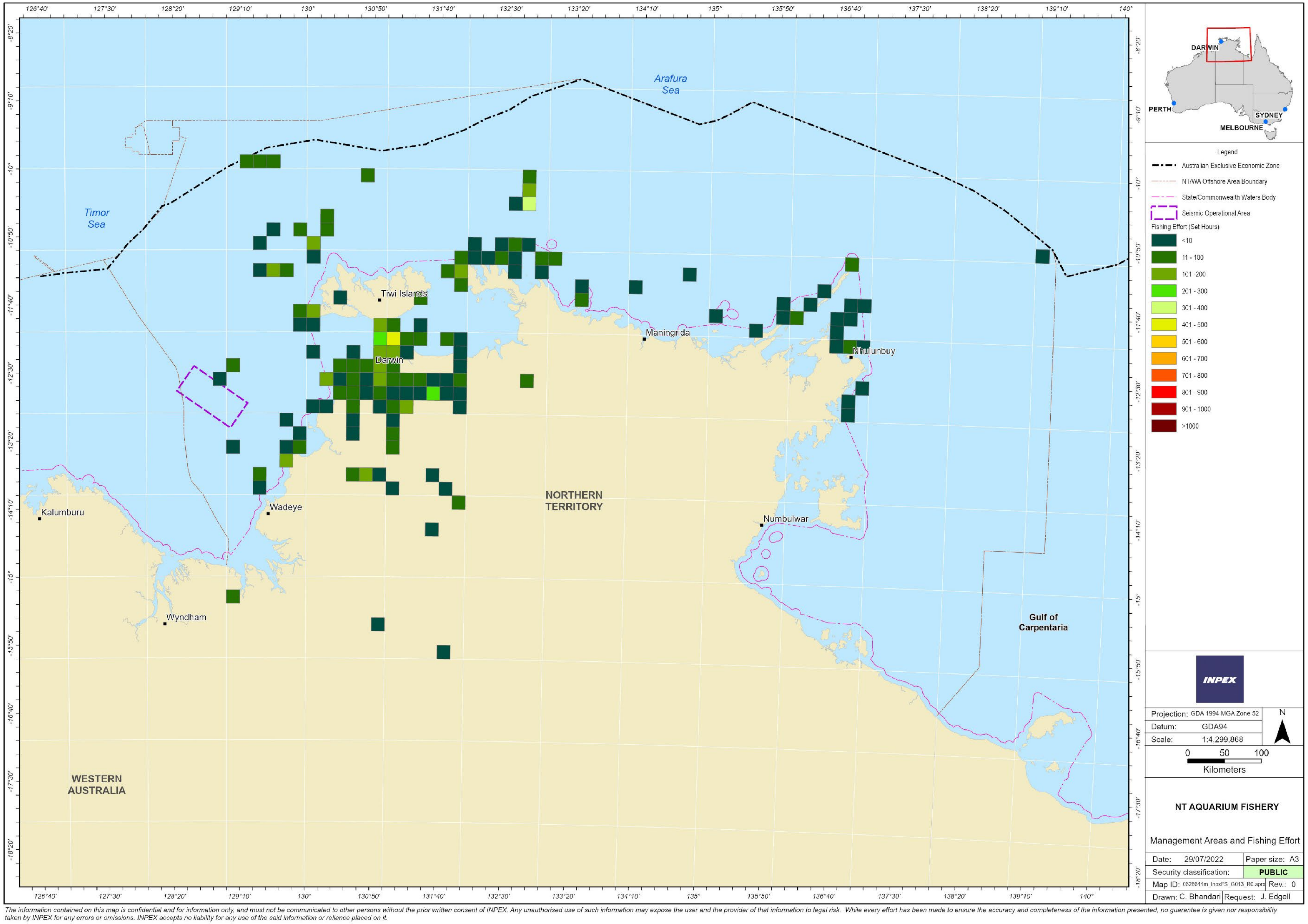

Figure 4-12: NT Aquarium Fishery fishing effort (2016 – 2020)

Recreational fishing

A wide range of recreational activities occur within the NWMR and NMR. Recreational fishing activities peak in winter and are concentrated in coastal waters along the Kimberley and NT coastlines, generally around the population centres of Broome, Wyndham and Darwin. Some of the recreationally important species of the coastal areas include barramundi, mangrove jack, jewfish and bream.

Annual expenditure by recreational fishers and the guided fishing industry in the NT was estimated at $52 million in 2019 (NT DITT 2022). Estuarine waters attract just over half (51%) of the total recreational fishing effort in the NT, followed by coastal waters (31%), rivers (10%), offshore marine waters (5%) and lakes/dams (3%) (NT DITT 2022). A review of historic fishing effort data (2016 – 2020) provided by NT DITT indicates that fishing tour operators occasionally access waters within the eastern half of the Operational Area, although waters closer to the coast and nearer Darwin are more frequently fished.

Recreational fishing occurs throughout the year, with peak fishing effort occurring from approximately October to December and April to June (NT DITT 2022).

Traditional fishing

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 and WA in order to protect and manage the marine environment, its resources and cultural values. Customary subsistence fishing is recognised in the NT and managed under Aboriginal coastal licences under the NT *Fisheries Act 1988* and Fisheries Regulations 1992 for fishing in coastal waters within 3 nm of the coastline (NT DITT 2021b). The offshore waters of the Operational Area are not understood to be of specific value or interest for traditional fishing practices.

Aboriginal communities on the Tiwi Islands, such as Wurrumiyanga on Bathhurst Island have been actively involved in managing their own sea turtle stocks in consultation with the NT government, forming an Indigenous marine ranger program. Anecdotal evidence indicates that green turtles are harvested in the water, while eggs of any turtle species are taken periodically. Dugongs are also sometimes taken (DEWR 2006). While the outer boundary of the PEZ reaches the Tiwi Islands it does not overlap any indigenous protected areas.

Hunting, subsistence fishing and shell collecting are recognised as occurring in the North Kimberley Marine Park and wider Kimberley region (DNP 2018b; Smyth 2007). The land and sea country of the Balanggarra people extends from Napier-Broome Bay to Cambridge Gulf and Wyndham in the Joseph Bonaparte Gulf, inshore from the Operational Area and PEZ. In the past, the Balanggarra people speared fish along the rocky shoreline and in shallow waters. Saltwater fish, turtles, dugong, mud crabs and cockles continue to be important food sources for the Balanggarra people today (DPaW 2016). The Miriuwung Gajerrong land and sea country extends from the Cambridge Gulf to the NT. In the past, the Miriuwung Gajerrong people would hunt, fish and gather bush tucker in tidal areas such as mangroves. Fishing and hunting are still practiced today (DPaW 2016).

Pearling and aquaculture

The Kimberley region is of significance to the WA pearling industry, which is the world's top producer of silver-white South Sea Pearls, which come from the silver-lipped pearl oyster, *Pinctada maxima* (Hart et al. 2016). However, WA pearling activities do not occur within the PEZ. All WA pearl farms and holding sites occur in coastal waters outside of the PEZ.

In the NT, historic fishing effort data (2016 – 2020) provided by NT DITT indicate that a limited amount of pearl oyster fishing (diving and hand collection) was undertaken by a single licence holder in the years 2018 and 2019. The areas fished include some limited fishing effort in 2019 at Flat Top Bank, between approximately 45 km and 95 km north-east of the Operational Area. The reported fishing effort was less than 20 minutes in each 10 nm block for the whole of 2019 and there was no fishing in any other year. The NT DITT data also indicate that fishing effort occurred at shoals located to the west of the Tiwi Islands, at the most northern extent of the PEZ. Fishing effort was typically less than 1 hour per 10 nm block per year in this area. Limited effort (up to 4 hours per 10 nm block per year) was also reported in waters offshore from Cobourg Pensinsula and Arnhem Land, located outside of the PEZ. Overall, pearl oyster fishing effort is infrequent and appears to be exploratory. Pearl farm leases in NT waters are limited to the coastal waters around Bynoe Harbour and Beagle Gulf near Darwin, as well as Cobourg Peninsula and Nhulunbuy further to the east (NTG 2021b, and confirmed by NT DITT during stakeholder consultation).

Other aquaculture activities in the Kimberley region of WA and in the NT are also understood to be limited to land-based projects (e.g. the Darwin Aquaculture Centre and Project Sea Dragon prawn hatchery development near Darwin), barramundi farming and other activities in shallow coastal waters (NTG 2021b), which are outside of the PEZ.

Fish and invertebrate species of commercial and recreational significance

The Operational Area overlaps with the known distribution and habitat of several commercially and recreationally significant fish and invertebrate species. Details of the key species targeted by the fisheries that are active within the Operational Area are provided in Table 4-5.

As described for each individual key indicator fish species in the Australian Fisheries Research and Development Corporation Status of Australian Fish Stocks Reports, 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 DPIR 2019). The level of mixing from egg and larval dispersal is influenced by the spatio-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 the key indicator fish species in NT, which spawn throughout their ranges and on multiple occasions during protracted spawning periods (Gaughan et al. 2018).

During stakeholder consultation, NT DITT advised that the warmer months of the year (approximately September through to the end of March) coincide with many tropical fish species spawning in the region.

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: Key fish and invertebrate species of commercial and recreational significance

Species	Distribution and habitat	Reproduction and recruitment	Food / Prey	Stock Status	References
Demersal fish species					
Goldband snapper	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, WA across the north to Moruya, New South Wales (NSW). 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. Goldband snapper are found at depths between 50 m and 200 m. However, the species is more concentrated in depths from 80 m – 150 m. Stock status is assessed at the management unit level. Relevant to the Operational Area is the biological stock belonging	There is limited movement and mixing of adult goldband snapper between different regions in Australia. Goldband snapper are highly fecund, serial, broadcast spawners and they can produce several million eggs per season. They spawn throughout their range. Larval settlement and juvenile development is likely to occur in similar water depths to adults, although juveniles are associated with different habitat. Fish reach maturity after ~4.6 years.	Goldband snapper feed on the bottom and in the water column, consuming fish, crustaceans, gastropods, squid and scallops.	Sustainable Joseph Bonaparte Gulf stock is undefined; however, goldband snapper in the Joseph Bonaparte Gulf is classified as a sustainable stock on the basis that the current level of fishing mortality is unlikely to cause the stock to become recruitment impaired.	Lloyd et al. (2000) Lloyd (2006) Newman & Dunk (2003) Newman et al. (2000) Newman et al. (2008) Newman et al. (2021) NTG (2018) NT DPIR (2019) Ovenden et al. (2002) Trinnie et al. (2021)

Species	Distribution and habitat	Reproduction and recruitment	Food / Prey	Stock Status	References
	to the Joseph Bonaparte Gulf.				
Saddletail snapper	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 QLD over a wide depth range, from coastal to offshore areas. 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. Stock status is assessed at the management unit level. Relevant to the Operational Area is the biological stock belonging to the Joseph Bonaparte Gulf.	Saddle-tail snapper reach reproductive maturity at about 9-years and have a lifespan of about 30-years. Published data available on the reproductive characteristics of tropical lutjanides indicate that most species are highly fecund, serial spawners with a protracted spawning season. Northern Australian populations of saddle-tail snapper show a single-modal cycle in their reproductive activity. The species has been recorded producing up to 997,000 oocytes per batch. Spawning occurs year-round in northern Australia, but peaks September – March.	Teleosts, crustaceans, tunicates, sea jellies.	Sustainable	Fry et al. (2009) NT DPIR (2019) Salini et al. (2006) Saunders et al. (2021a) Takahashi et al. (2020)
Crimson snapper	Widespread Indo-Pacific species found throughout tropical Australian waters, from Shark Bay in WA to central NSW over a wide	A relatively slow-growing and long-lived species, longevity is 42 years. Published data available on the reproductive characteristics of	Fish, crustaceans, cephalopods, and benthic invertebrates.	Undefined	Bray (2022) Fry et al. (2009) NT DPIR (2019)

Species	Distribution and habitat	Reproduction and recruitment	Food / Prey	Stock Status	References
	depth range, from coastal to offshore areas. This species is expected to be found between 5 m and 100 m. Stock status is assessed at the management unit level. Relevant to the Operational Area is the biological stock belonging to the Joseph Bonaparte Gulf.	tropical lutjanids indicate that most species are highly fecund, serial spawners with a protracted spawning season. Northern Australian populations of crimson snapper show a single-modal cycle in their reproductive activity. The species has been recorded producing up to 676,100 oocytes per batch. Spawning occurs year-round in northern Australia, but peaks September – March.			Salini et al. (2006) Saunders et al. (2021b)
Red emperor	Red emperor occur from the central west coast of WA to southern Queensland. Red emperor are widely distributed across the continental shelf and associated with reefs, lagoons, epibenthic communities, limestone sand flats and gravel patches. Red emperor are usually found in waters between 10 and 180 m. Stock status is assessed at the management unit level. Relevant to the Operational Area is the	Red emperor are highly fecund, serial, broadcast spawners. Females release numerous batches of eggs over an extended spawning period. They spawn throughout their range. Juvenile fish are more common in nearshore waters and move offshore and recruit to the stock as they mature. Fish are estimated to reach maturity after approximately 4—6 years. The species may spawn for 8-10 months of the year. As advised by NT Fisheries, the main spawning period is likely to occur between September and March.	Fish, crustaceans, cephalopods, and benthic invertebrates.	Undefined	Newman et al. (2021). Newman et al. (2008)

Species	Distribution and habitat	Reproduction and recruitment	Food / Prey	Stock Status	References
	biological stock belonging to the Joseph Bonaparte Gulf.				
Pelagic fish species					
Spanish mackerel	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. Adult movements in Australian waters occur over ranges of 100 – 300 km. 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. They occur in water depths from 1 m to at least 50 m. Stock status is assessed at the management unit level. Relevant to the Operational Area is the	Spanish mackerel spawning in occurs in coastal waters where they form spawning schools around inshore reefs in the north coast bioregion. They are serial spawners and alongshore dispersal of eggs maintains genetic homogeneity. 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. 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. Fish are estimated to reach maturity after approximately 2 years. As advised by NT Fisheries, the main spawning period is likely to occur between September and March.	Pelagic baitfish such as sardines, anchovies and pilchards, as well as squids and prawns.	Sustainable	Begg et al. (2006) Lewis & Watt (2021) Mackie et al. (2010) McPherson (1993) NT DITT (2021a) Roelofs et al. (2021a)

Species	Distribution and habitat	Reproduction and recruitment	Food / Prey	Stock Status	References
	stock belonging to the NT management unit.				
Grey mackerel	Grey mackerel have a restricted distribution and are confined to the waters of southern Papua New Guinea and around northern Australia from the Houtman Abrolhos Islands on the west coast to northern NSW on the east coast (NTG 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. Stock status is assessed at the management unit level. Relevant to the Operational Area is the stock belonging to the north-west NT.	Spawning may extend from approximately August to February, with a peak between August and December. Fish are estimated to reach maturity after approximately 1-2 years. Females produce approximately 250,000 eggs per spawning event and will spawn multiple times over the spawning season. Larval and juvenile life history stages of grey mackerel are found inshore, often in estuarine environments.	Pelagic baitfishes such as anchovies and sardines.	Sustainable	Bray & Schultz (2022a) Cameron & Begg (2002) Helmke et al. (2018) Mackie et al. (2010) NT DITT (2021a) Roelofs et al. (2021b) Welch et al. (2014)
Shark species					

Species	Distribution and habitat	Reproduction and recruitment	Food / Prey	Stock Status	References
Australian blacktip shark	The Australian blacktip shark is endemic to the tropical continental shelf waters of northern Australia. Adults occur across the continental shelf up to 150 m water depth, while newborn and juvenile sharks are found in shallow nearshore habitats. Blacktip sharks are highly mobile animals, enabling them to readily move between preferred habitats. Stock status is assessed at the management unit level. Relevant to the Operational Area is the stock belonging to North Western Australia.	Adult females move inshore during the summer months when ready to give birth, and the young are also usually found in warm, shallow nearshore nursery areas. Individuals breed each year. Mating occurs in February – March, giving birth to 1-6 pups in December – January after a ten-month gestation period.	Pelagic and benthic fishes, cephalopods and crustaceans	Sustainable	Compagno and Niem (1998) Harry et al. (2011) Harry et al. (2012) Harry et al. (2013) Knip et al. (2010) Last & Stevens (2009) Stevens & Wiley (1986) Usher et al. (2021a) Welch et al. (2014)
Common blacktip shark	Common blacktip sharks are found in tropical and sub-tropical continental shelf waters up to 150 m water depth, in bays, estuaries, over coral reefs and off river mouths. Adults prefer deeper shelf waters while newborn and juvenile sharks are found	Adult females move inshore during the summer months when ready to give birth, and the young are also usually found in warm, shallow nearshore nursery areas. Adults breed every two years with a ten to 12-month gestation period.	Pelagic and benthic fishes, cephalopods and crustaceans	Sustainable	Davenport & Stevens (1988) Harry et al. (2011) Harry et al. (2012) Harry et al. (2013) Knip et al. (2010)

Species	Distribution and habitat	Reproduction and recruitment	Food / Prey	Stock Status	References
	in shallow, nearshore habitats. Blacktip sharks are highly mobile animals, enabling them to readily move between preferred habitats. Stock status is assessed at the management unit level. Relevant to the Operational Area is the stock belonging to North and West Coast.	Females move into coastal waters to give birth to 4-10 pups between October and March, peaking in November.			Last & Stevens (2009) Macbeth et al. (2009) Ovenden et al. (2010) Rigby et al. (2021) Usher et al., (2021b) Welch et al. (2014)
Invertebrate species					
Banana prawn (white and redleg banana prawn)	Inhabit coastal waters over muddy and sandy seabed. Banana prawns are widely distributed within tropical and subtropical waters. White banana prawns are typically found in water depths of 16-25 m. Redleg banana prawns are found in deeper waters of 35-90 m; however, they are schooling species and can occasionally form dense aggregations near the surface.	Spawn throughout the year with two spawning peaks: the late dry season (September - November) and the late wet season (March – May). Banana prawns are serial spawners. Each female lays several egg batches each year. Females produce 100,000-450,000 eggs per year. The eggs sink to the bottom and hatch into larvae within 24 hours. There is a 2-4 week planktonic larval phase to reach suitable coastal nursery habitats. After 1-3 months on the nursery grounds, the young prawns migrate offshore. Migration of the main cohort occurs	Small bivalve molluscs, crustaceans, polychaete worms, and foraminifera	Sustainable	AFMA (2022b) Butler et al. (2021a) Loneragan et al. (2002) Patterson et al. (2021)

Species	Distribution and habitat	Reproduction and recruitment	Food / Prey	Stock Status	References
	Stock status is assessed at the management unit level. Relevant to the Operational Area is the stock belonging to the Northern Prawn Fishery.	November-March. A possible second cohort migrates April-June. Bannana prawns reach sexual maturity at ~6 months, and have a of lifespan 1-2 years. Recruitment in the NPF is highly variable due to seasonal environmental conditions, particularly rainfall. Annual recruitment (as evidenced by catches) has been maintained and continued a pattern of high natural variability from year-to-year.			
Tiger prawn (brown and grooved tiger prawn)	Tiger prawns are endemic to Australian coastal waters, occurring in Northern Australia from Shark Bay to NSW. Tiger prawns are found in depths up to 200 m. Adults are typically found over coarse sediments. Adult grooved prawns are found in fine mud sediments. Juveniles are found in shallower waters. Stock status is assessed at the management unit level. Relevant to the Operational Area is the stock belonging to the Northern Prawn Fishery.	Spawning occurs throughout the year, in both inshore and offshore areas for brown tiger prawns and in offshore areas for grooved tiger prawns. Brown tiger prawns have a spawning peak between July and October. Grooved tiger prawns have a spawning peak in in August-September, with a secondary peak in February. Females produce about 186,000 eggs (brown tiger prawns) and 365,000 eggs (grooved tiger prawns) per year. Eggs hatch within 24 hours of fertilisation. Reach sexual maturity at ~6 months, lifespan 2 years.	Small bivalve molluscs, crustaceans, polychaete worms, and foraminifera	Sustainable	AFMA (2022b) Butler et al. (2021b) Patterson et al. (2021)

Species	Distribution and habitat	Reproduction and recruitment	Food / Prey	Stock Status	References
Endeavour prawn *(blue and red endeavor prawn)*	Endeavour prawns inhabit tropical coastal waters. *M. endeavouri* are found over sandy or mud-sand substrates to depths of about 60 m. *M. ensis* prefer muddy substrates and have been found to depths of 95 m. Juveniles *M. endeavouri* require seagrass beds in shallow estuaries, while juvenile *M. ensis* are more widely distributed across seagrass beds, mangrove banks, mud flats and open channels. Stock status is assessed at the management unit level. Relevant to the Operational Area is the stock belonging to the Northern Prawn Fishery.	Endeavour prawns reach reproductive maturity at ~ 0.5 years of age. Spawning occurs throughout the year. *M. endeavouri* spawning peaks in March and September. *M.* ensis spawning peaks in September - December.	Small crustaceans, molluscs, polychaete worms and foraminifera	Sustainable (*M. endeavouri*) Uncertain (*M. ensis*)	AFMA (2022b) Patterson et al. (2021) Roelofs et al (2021c)

4.9.7 Shipping and ports

The proximity of Darwin Port to south-east Asia makes the surrounding area a key shipping region. Vessel tracking data from AMSA's Craft Tracking System (CTS) for all months of 2021 is presented in Figure 4-13. The CTS collects vessel traffic data from a variety of sources, including terrestrial and satellite shipborne AIS data sources.

Figure 4-13 shows high traffic shipping volumes in close proximity to Darwin Port and along key shipping routes to and from south-east Asia. Vessel traffic within the Operational Area includes vessels passing between Darwin and the northern Kimberley coastline. Review of the AMSA vessel tracking data for 2021 shows that between 42 and 59 vessels pass through the Operational Area each calendar month, equivalent to 1 – 2 vessels per day. Vessel types include cargo, tanker, fishing, passenger, recreational and military vessels.

Darwin Port

Darwin Port, located in Darwin Harbour in the NT, is a major service centre for the mining and energy sectors. Darwin Port operations consist of marine traffic of non-commercial vessels (e.g. recreational anglers) and trading vessels, including commercial ships carrying cargo and passengers, platform supply vessels and anchor-handling supply vessels, tankers and bulk-cargo vessels.

A number of targeted marine pest monitoring programs have been executed in Darwin Port since 2010 (Cardno 2015, Golder Associates 2010), and through the course of these programs the following IMS have been detected; however, none of these are listed as noxious species by the NT Government (NTG): *Magallana gigas* (presence of one shell valve) and *Caulerpa racemosa var. lamourouxii* (Golder Associates 2010) *Amphibalanus amphitrite* (barnacle), *Bugula neritina* (bryozoan) and the ascidians *Botryllus schlosseri, Botrylloides leachi* and *D. perlucidum* (Cardno 2015). While *M. gigas* was detected during a survey, as this was based on the presence of one shell valve, Golder Associates (2010) determined it was likely to be a discarded shell from oysters imported and purchased for human consumption and therefore its presence did not confirm this species had established in Darwin Port. *C. racemosa var. lamourouxii* is common in tropical and warm temperate seas and has previously been recorded in warmer waters in Australia including Darwin Harbour (Golder Associates 2010).

A marine pest monitoring program managed by NT Aquatic Biosecurity officers is currently ongoing. Artificial settlement units are located throughout Darwin Port, including on the INPEX Ichthys liquified natural gas and liquified petroleum gas jetties. These settlement units are photographed monthly and collected, replaced and analysed every four months.

In addition to monitoring program outcomes, in 1999 an outbreak of black stripped mussels was recorded in three Darwin Port marinas. Following, a national response to the outbreak this species was successfully eradicated from invaded locations (Ferguson 2000).

In summary, numerous IMS monitoring studies have been undertaken at Darwin Port with IMS identified. Therefore, Darwin Port is considered to be an operationally active environment rather than a pristine environment.

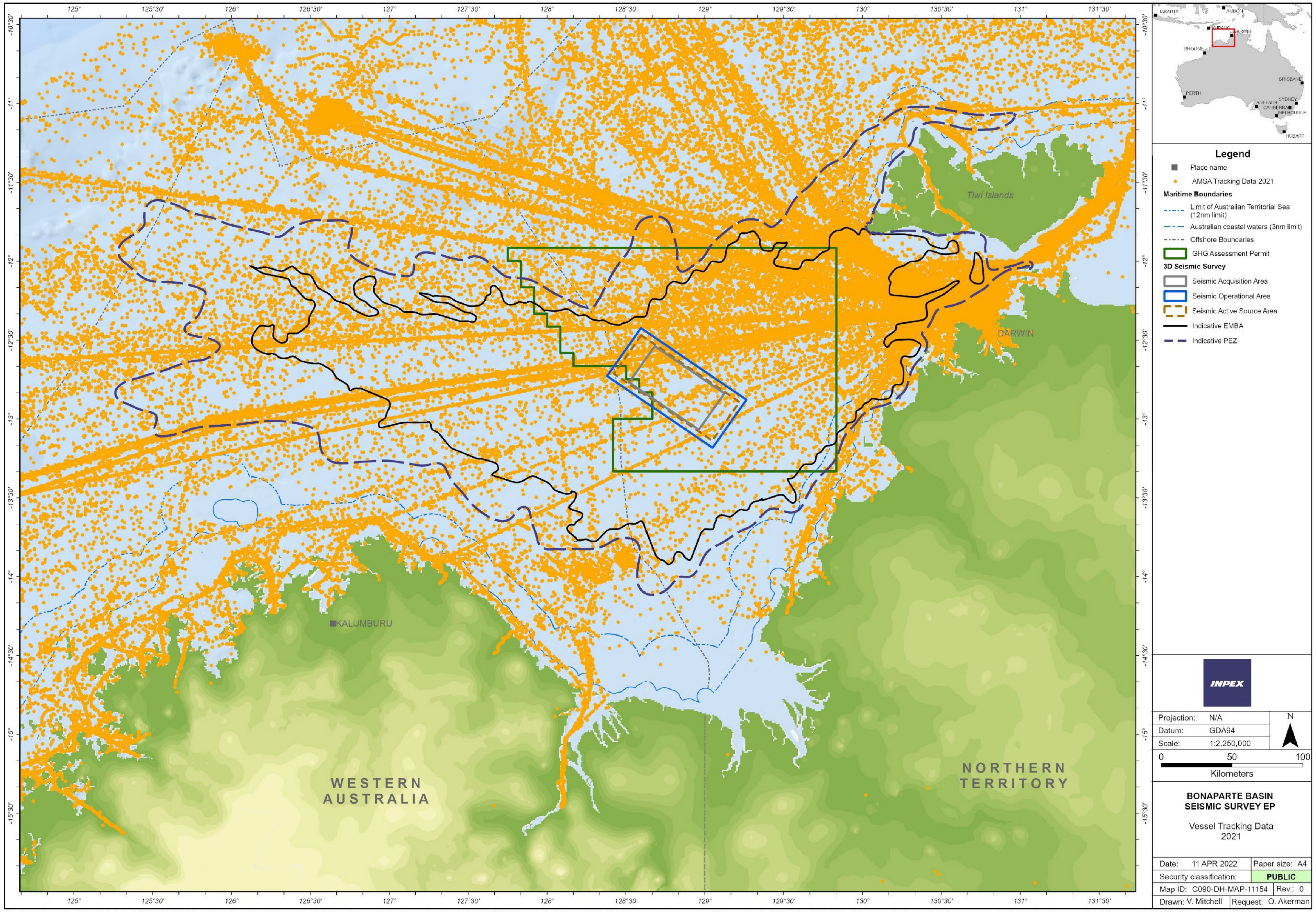

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Figure 4-13: Vessel tracking data in the Bonaparte Basin (2021)

4.9.8 Defence

Australian Border Force and Australian Defence Force vessels undertake civil and maritime surveillance within the region with the primary purpose of monitoring the passage of illegal entry vessels and illegal fishing activity within these areas.

The Operational Area overlaps with practice and training areas that comprise the North Australian Exercise Area (NAXA), a maritime military zone administered by the Australian Defence Force, as well as restricted airspace (Figure 4-14). The NAXA is used by the Royal Australian Air Force and the Royal Australian Navy for military operations including live weapons and missile firings.

From consultation with the Department of Defence, Operation Talisman-Sabre is a major international activity undertaken within the NAXA and is scheduled to occur in mid-2023, but exact timing is not confirmed. The NAXA is also the primary location of the KAKADU training exercise that operates biennially. The exercise involves numerous naval ships from various countries participating in the waters off Darwin and Northern Australia. Exercise KAKADU is understood to be planned for September 2022 and then again in 2024. Exercise Singaroo is conducted immediately following KAKADU in the same areas. During these exercises, access to NAXA may be restricted to all vessels and aircraft.

In addition to major training exercises, patrol boats regularly conduct training in the NAXA area that includes live firings; however, these are not usually programmed until six to eight weeks prior.

Unexploded ordinance (UXO) may be present on and in the sea floor of the Operational Area. According to the Defence UXO Database, the Operational Area is located within a former air-to-air weapons range (shared boundary with the Defence training area shown in Figure 4-14) and may be affected by UXOs (Department of Defence 2022). A search of the Department of Defence's UXO map confirmed ten areas of potential UXO exist within the PEZ, categorised[4] as follows (Department of Defence 2022):

1111 – Darwin Area. This area was a former air-to-air weapons range. (UXO Category: Other)

1110 Darwin Area. This area was a former air-to-air weapons range. (UXO Category: Other)

1091 – Timor Sea. This area was used for Naval Gunnery during the 1980's (UXO Category: Other)

[4] Defence classify areas of UXO risk according to the following categories:

- Substantial potential – Sites have a confirmed history of military activities that often results in numerous residual hazardous munitions, components or constituents. There will be a history of numerous UXO finds or heavy residual evidence such as fragmentation.
- Slight potential – Sites have a confirmed history of military activities that often results in numerous residual hazardous munitions, components or constituents; but where confirmed UXO affected areas cannot be defined. Alternatively, sites categorised as Slight may have a confirmed history of military activities of a type that sometimes results in occasional residual UXO. UXO or explosive ordnance fragments / components may have occasionally been recovered from the site.
- Remote potential – Sites have records which confirm that the area was used for military purposes, however the activity is of a nature that makes it unlikely that UXO would exist. UXO or explosive ordnance fragments / components have not been recovered from the site.
- Other – Defence records confirm that the area was used for military training but do not confirm that the site was used for live firing. UXO or explosive ordnance fragments / components have not been recovered from the site. These sites have been included for general information purposes only.
- Sea Dumping Area – These areas have been used for historical sea-dumping of waste material which may include explosive ordnance.

1098 – Melville Is / SS Don Isidro. The SS Don Isidro was used for practice bombing mast head attack during WW2. (UXO Category: Other).

1100 Quail Island – This area was declared as an RAAF Bombing Range. (UXO Category: Other)

1096 – Lanyer Swamp Air Weapons Range. This area was a RAAF Bombing and Gunnery Area. Sections of it have undergone UXO remediation. (UXO Category: Substantial Potential)

DEP036 – Potential Depth Charge UXO - Timor Sea. This site was an area where Depth Charges were used in WW2 and where some depth charges failed to function. Detail is contained in Notice To Mariners NTM/12/Aus 318. (UXO Category: Sea Dumping of Depth Charges).
DEP037 – Potential Depth Charge UXO - Timor Sea. This site was an area where Depth Charges were used in WW2 and where some depth charges failed to function. Detail is contained in Notice To Mariners NTM/12/Aus 315. (UXO Category: Sea Dumping of Depth Charges).

The EPBC Act Protected Matters database search identified the Quail Island Bombing Range as Commonwealth land overlapping with the PEZ (Appendix A).

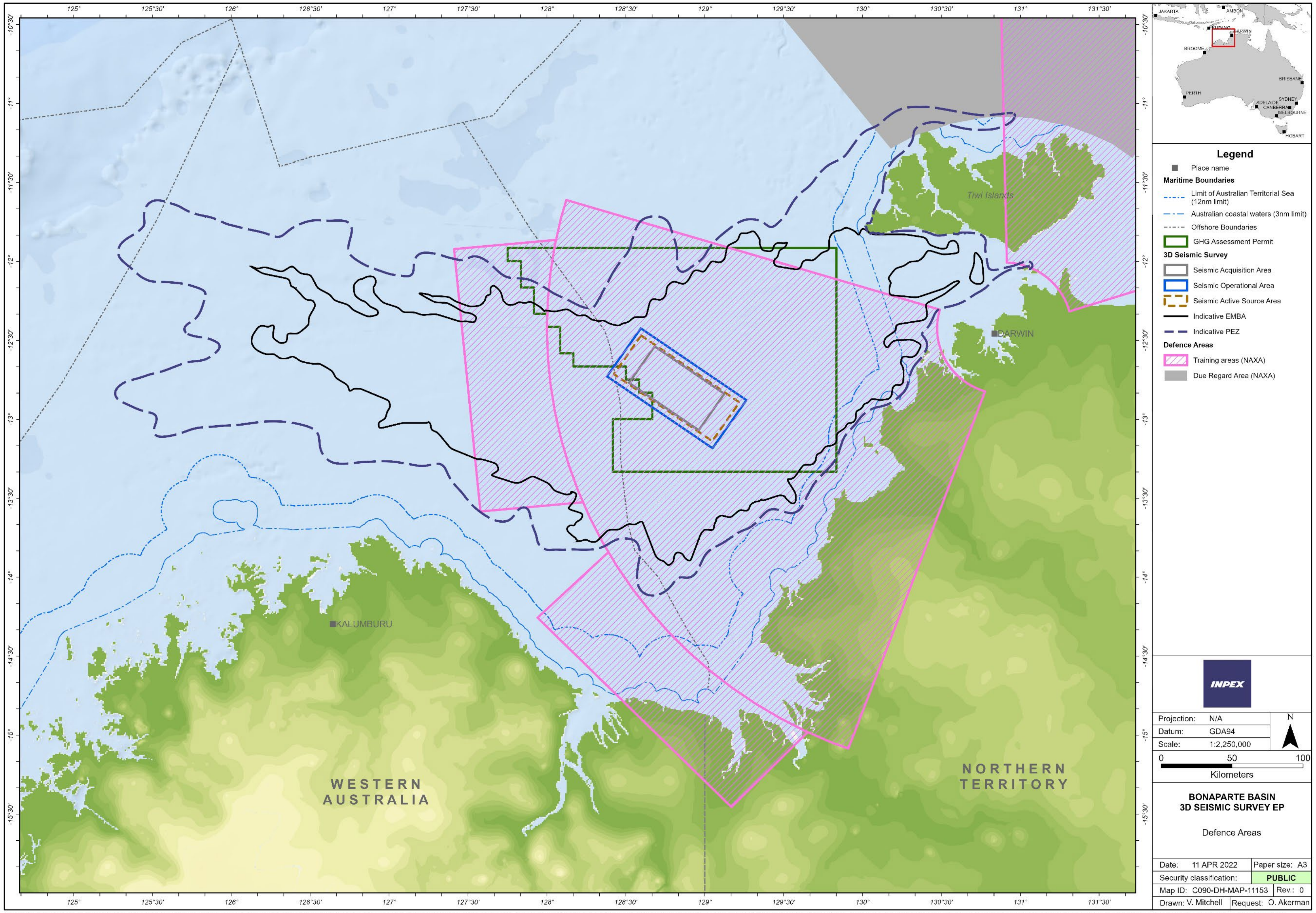

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Figure 4-14: Defence exercise and training areas

4.9.9 Oil and gas industry

The Bonaparte Basin is an established hydrocarbon province with a number of commercial operations (Figure 4-15). There are no operating petroleum assets in proximity to the project area with the closest production facility located approximately 100 km south (ENI Blacktip). Petroleum permits which overlap the GHG assessment permit and/or Operational Area are listed in Table 4-6.

Table 4-6: Overlapping or adjacent oil and gas permits

Permit	Permit type	Titleholder contact	Distance from the GHG assessment permit
NT/P88	Exploration permit	Neptune Energy Bonaparte Pty Limited	Overlaps GHG assessment permit and Operational Area
WA-6-R	Retention lease	Neptune Energy Bonaparte Pty Limited	Overlaps GHG assessment permit and Operational Area
NT/RL1	Retention lease	Neptune Energy Bonaparte Pty Limited	Overlaps GHG assessment permit and Operational Area
WA-548-P	Exploration permit	Neptune Energy Bonaparte Pty Limited	Overlaps GHG assessment permit but not the Operational Area

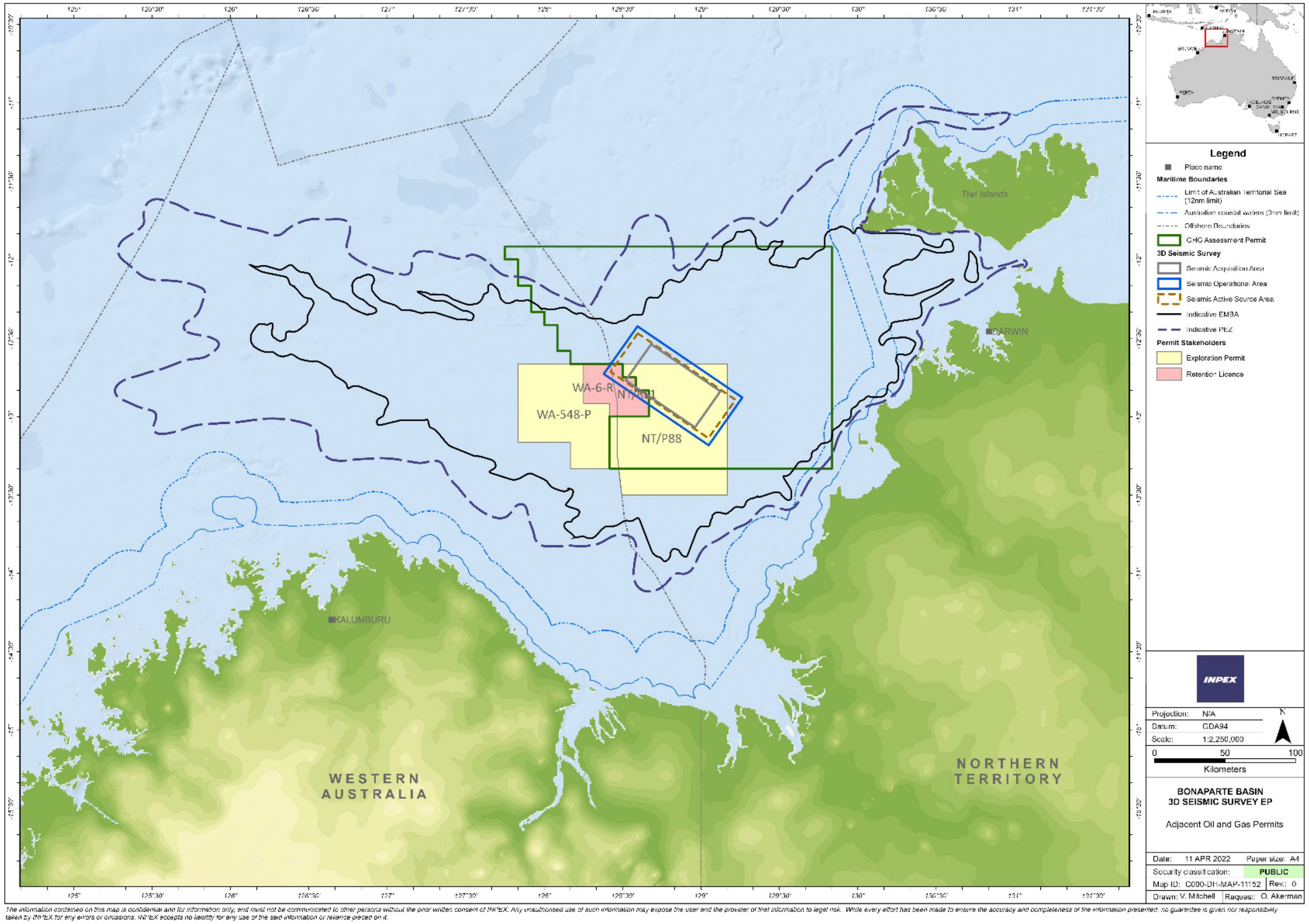


Figure 4-15: Oil and gas permits overlapping or adjacent to the GHG assessment permit

4.9.10 Telecommunications

No submarine cables intersect the Operational Area. There are three submarine telecommunication cables within the PEZ each approximately 150 km north-east of the Operational Area at the closest point including:

The North-west Cable System (NWCS)

Asia Connect Cable 1

Hawaiki Nui.

The 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 including Darwin and the Tiwi Islands (Vocus Group 2022). The NWCS system is managed by Vocus Communications and was built as a cooperation between the telecommunications industry and oil and gas industries.

4.9.11 Tourism

Most recreational and tourism activities in the region occur predominantly in State/Territory waters adjacent to population centres, such as Darwin. Tourism in the region typically peaks during the dry season (May to October), which includes activities such as recreational fishing, diving, snorkelling, wildlife watching and boating (DEWHA 2008b).

Tourism NT identifies the Daly River area, located south of Darwin and over 100 km south-east from the Operational Area, as a popular location for camping and fishing with bush camps and riverside fishing lodges in the area. The Tiwi Islands are also identified as a tourism location for Aboriginal arts culture and fishing.

A number of luxury cruise operators access Kimberley coastal waters to the south-west of the Operational Area and PEZ, including Kimberley Quest, Silversea and True North, which operate from late February/March to October/early November to avoid the wet season. Some Kimberley cruises extend to the coastal waters of the Joseph Bonaparte Gulf, sailing from Wyndham and visiting coastal locations such as Cambridge Gulf, Berkeley River, Reveley Island, King George River and Cape Bernier, all of which are approximately 180 km or more from the Operational Area. Activities are either land-based, or take place in rivers, estuaries or within a few kilometres from the coast. Cruise itinerates do not include offshore waters, although operators may occasionally transit through the Operational Area between Darwin and the Kimberley coastline (Kimberley Quest 2021; Silversea 2021; True North 2021).

Onshore tourism operations in the Kimberley include Berkeley River Lodge, Faraway Bay Lodge, Honeymoon Bay and Kimberley Coastal Camp. All camps close during October and reopen during March, following the wet season. Charter fishing, sightseeing tours and other excursions are located within a few kilometres from the coast, and mainly in estuarine waters.

No scuba diving or snorkelling sites have been identified in the Joseph Bonaparte Gulf as the presence of saltwater crocodiles and other potentially dangerous fauna generally makes these waters unsuitable for such activities.

4.10 Timing of key ecological and socio-economic sensitivities

Timing of key ecological and socio-economic sensitivities relevant to the Operational Area and PEZ are provided in Table 4-7.

Table 4-7: Timing of key sensitivities relevant to the Operational Area and PEZ

Key:												
Sensitivity/activity occurs												
Peak period (if known)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Environmental sensitivity												
Marine mammals												
Indo-Pacific/Spotted bottlenose dolphin: breeding – dry season (Darwin Harbour)												
Indo-Pacific humpback dolphin: breeding and foraging (Darwin Harbour)												
Australian snubfin dolphin: breeding, calving, resting and foraging (Darwin Harbour, Ord River, Cape Londonderry)												
Marine turtles (stocks are defined as per the Recovery Plan for Marine Turtles in Australia, DEE 2017a)												
Flatback turtle: Nesting (Cape Domett stock)												
Flatback turtle: Nesting (Arafura Sea stock [including Tiwi Islands])												
Flatback turtle: Nesting (undefined north Kimberley islands stock)												
Green turtle: Nesting (North West Shelf stock [including Kimberley])												

Key:												
Sensitivity/activity occurs												
Peak period (if known)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Environmental sensitivity												
Green turtle: Nesting (Cobourg Peninsula/Tiwi Islands stock)												
Olive ridley turtle: Nesting (NT stock)												
Olive ridley turtle: Nesting (Kimberley stock)												
Foraging: Loggerhead, olive ridley, green, flatback turtles												
Seabirds and migratory shorebirds												
Lesser crested tern: breeding (Kimberley)												
Crested tern: breeding (Tiwi Islands)												
Lesser frigatebird: breeding (Kimberley)												
Commercial fish and prawn species												
Banana prawn spawning												
Juvenile banana prawn migration (southern Joseph Bonaparte Gulf)	Main cohort			Possible 2nd cohort							Main cohort	
Brown tiger prawn spawning												

Key:												
Sensitivity/activity occurs												
Peak period (if known)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Environmental sensitivity												
Grooved tiger prawn spawning												
Blue endeavour prawn spawning												
Red endeavour prawn spawning												
Fish spawning in NT waters												
Commercial fisheries												
Northern Prawn Fishery: Fishing Season	Closed season			Banana prawns *Closure area applies to Joseph Bonaparte Gulf *			Closed season	Tiger prawns				Closed season
NT Demersal Fishery (year-round)												
NT Offshore Net and Line Fishery (year-round)												
NT Spanish Mackerel Fishery (year-round)												
NT Aquarium Fishery (year-round)												

Key:												
Sensitivity/activity occurs												
Peak period (if known)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Environmental sensitivity												
Defence (timeframes are indicative)												
Operation Talisman-Sabre ("mid-2023")												
Exercise KAKADU (2022 and 2024)												
Exercise Singaroo (2022 and 2024)												
Tourism and recreation												
Tourism - cruises, lodges, wilderness camps and ecotours												
Recreational fishing												

4.11 Summary of values and sensitivities

4.11.1 Operational area

Table 4-8: Particular values and sensitivities potentially within the Operational Area

Value and sensitivity	Description
Receptors that are considered socially important as identified during stakeholder engagement (including social and cultural heritage).	Fisheries: Primarily the NT Demersal Fishery (trawl). Some limited fishing effort by the NPF (Cwlth), NT Offshore Net and Line Fishery, NT Spanish Mackerel Fishery and NT Aquarium Fishery within or adjacent to the Operational Area.
Benthic primary producer habitat, defined by the Western Australian Environmental Protection Authority (WA EPA) Environmental Assessment Guideline No. 3 *Environmental Assessment Guidelines for Protection of Benthic Primary Producer Habitat in Western Australia's Marine Environment* as functional ecological communities that inhabit the seabed within which algae (e.g. macroalgae, turf and benthic microalgae), seagrass, mangroves, corals, or mixtures of these groups, are prominent components.	None identified within Operational Area.
Regionally important areas of high diversity (such as shoals and banks).	None identified within Operational Area.
World heritage values of a declared World Heritage property within the meaning of the EPBC Act.	None identified within Operational Area.
National heritage values of a National Heritage place within the meaning of the EPBC Act.	None identified within Operational Area.
Ecological character of a declared Ramsar wetland within the meaning of the EPBC Act.	None identified within Operational Area.
Presence of a listed threatened species or listed threatened ecological community within the meaning of the EPBC Act.	A number of threatened species or migratory species have been identified as having the potential to transit through the Operational Area. These have been categorised as marine fauna: • marine mammals • marine reptiles • fishes and sharks • marine avifauna. Also refer to Appendix A (EPBC Act Protected Matters Report).
Presence of a listed migratory species within the meaning of the EPBC Act.	

Value and sensitivity		Description
Any values and sensitivities that exist in, or in relation to, part or all of:	a Commonwealth marine area within the meaning of the EPBC Act.	Productivity and diversity associated with planktonic communities and benthic communities.
	Commonwealth land within the meaning of the EPBC Act.	None identified within Operational Area.
BIAs associated with EPBC-listed species.		A turtle foraging BIA intersects the Operational Area, relating to green and olive ridley turtles in the Joseph Bonaparte Gulf.

4.11.2 PEZ

Table 4-9: Particular values and sensitivities potentially within the PEZ

Value and sensitivity	Description
Receptors that are considered socially important as identified during stakeholder engagement (including social and cultural heritage).	Commercial, traditional and recreational fisheries as identified in Section 4.9.6.
Benthic primary producer habitat, defined by the Western Australian Environmental Protection Authority (WA EPA) Environmental Assessment Guideline No. 3 *Environmental Assessment Guidelines for Protection of Benthic Primary Producer Habitat in Western Australia's Marine Environment* as functional ecological communities that inhabit the seabed within which algae (e.g. macroalgae, turf and benthic microalgae), seagrass, mangroves, corals, or mixtures of these groups, are prominent components.	Benthic primary producer habitats are described in Section 4.7.2 and include the Commonwealth marine parks and KEFs listed below.
Regionally important areas of high diversity (such as shoals and banks).	KEFs: Pinnacles of the Bonaparte Basin Carbonate bank and terrace system of the Sahul Shelf Carbonate bank and terrace system of the Van Diemen Rise. Benthic habitats: various banks and shoals, and coral reefs (Section 4.7.2) seagrasses at the Tiwi Islands and Vernon Islands. Shoreline habitats: islands, mangroves and sandy beaches (Section 4.7.3).
World heritage values of a declared World Heritage property within the meaning of the EPBC Act.	None identified.
National heritage values of a National Heritage place within the meaning of the EPBC Act.	None identified.
Ecological character of a declared Ramsar wetland within the meaning of the EPBC Act.	None identified.
Presence of a listed threatened species or listed threatened ecological community within the meaning of the EPBC Act.	A number of threatened species or migratory species have been identified as having the potential to transit through the PEZ. These have been categorised as marine fauna (Section 4.7.4):
Presence of a listed migratory species within the meaning of the EPBC Act.	

Value and sensitivity		Description
		marine mammals marine reptiles fishes and sharks marine avifauna. Also refer to Appendix A (EPBC Act Protected Matters Report).
Any values and sensitivities that exist in, or in relation to, part or all of:	a Commonwealth marine area within the meaning of the EPBC Act.	Productivity and diversity associated with planktonic communities and benthic communities.
	Commonwealth land within the meaning of the EPBC Act.	Quail Island Bombing Range.
BIAs associated with EPBC-listed species.		A number of BIAs are present within the PEZ. These are mainly associated with coastlines and the adjacent shallow waters and include: Marine reptiles turtle nesting, internesting and foraging BIAs for flatback turtle, olive ridley turtle, green turtle and loggerhead turtles. Fish and sharks whale shark foraging BIA. Marine avifauna breeding and associated foraging BIAs for crested tern, lesser crested tern and lesser frigate bird.

5 STAKEHOLDER CONSULTATION

INPEX has been a member of the Australian business community since 1986 and during this time has engaged on a regular basis with stakeholders in the NT, WA and Commonwealth jurisdictions on a broad range of activities.

INPEX actively engages with a broad cross section of community, industry and government stakeholders in its key areas of operations which include Broome and the Kimberley region of WA and in Darwin in the NT. INPEX provides regular updates on its business activities through meetings with stakeholders, community forums and various communication collaterals.

INPEX also participates in industry forums, conferences and community meetings in order to facilitate opportunities for meaningful engagement about current and future activities that may have the potential for social and environmental impacts.

Through its corporate webpage (http://www.inpex.com.au), social media and publications, INPEX provides company and project-related information on business activities including employment and business opportunities and community investment programs for local and Aboriginal and Torres Strait Islander communities.

INPEX's awareness of the functions, interests or activities of relevant persons supports the development of management plans that consider and address any environmental, social or economic objections or claims about the proposed activity.

INPEX's process for stakeholder engagement (consultation) in the development and implementation of an EP and relevant management plans is shown in Figure 5-1 and further described in this section.

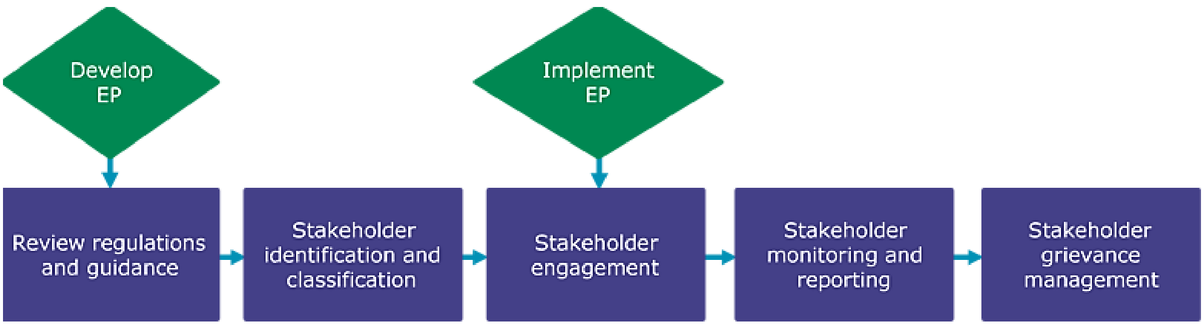


Figure 5-1: Process for stakeholder engagement (consultation) for development and implementation of an EP

5.1 Regulatory requirements and guidelines

As a first step in EP development, INPEX reviewed the following documents to prepare for stakeholder consultation on the proposed activity:

- Offshore Petroleum Greenhouse Gas Storage (E) Regulations
- NOPSEMA policies, guidance and information papers related to environment plan development, including:
  - PL1347 – Environment plan assessment policy – 19 May 2020 (NOPSEMA 2020b)
  - GL1721 - Environment plan decision making – 10 June 2021 (NOPSEMA 2021a)

  - GL1887 – Consultation with Commonwealth agencies with responsibilities in the marine area – 3 July 2020 (NOPSEMA 2020c)
  - GN1344 - Environment plan content requirements - 11 September 2020 (NOPSEMA 2020d)
  - GN1488 - Oil pollution risk management - 7 July 2021 (NOPSEMA 2021b)
  - GN1847 – Responding to public comment on environment plans – 11 September 2020 (NOPSEMA 2020e)
- Guidance issued by relevant stakeholders (as known or provided to INPEX), including:
  - Australian Government Guidance: Offshore Petroleum and Greenhouse Gas Activities: Consultation with Australian Government agencies with responsibilities in the Commonwealth Marine Area
  - AFMA: Petroleum industry consultation with the commercial fishing industry
  - WA DPIRD: Guidance statement for oil and gas industry consultation with the Department of Fisheries
  - WA Department of Transport (WA DoT): Offshore Petroleum Industry Guidance Note – Marine Oil Pollution: Response and Consultation Arrangements
- INPEX stakeholder engagement procedures and guidelines developed in line with IFC Stakeholder Engagement: A Good Practice Handbook for Companies doing Business in Emerging Markets (2007) and the International Association for Public Participation (IAP2) public participation spectrum.

5.2 Stakeholder identification and classification

With an understanding of the general requirements and expectations for consultation, INPEX conducted stakeholder identification and classification activities.

A list of all the potential stakeholders, taken from INPEX Australia’s corporate stakeholder register was used as the starting point and formed the basis for identification of various groups of stakeholders. This list includes authorities, business and civil society in an attempt to not overlook or exclude any particular type of stakeholder. Specific to this activity, ‘relevant persons’ were then identified and classified, to determine a suitable engagement priority and method.

Considerations during the initial identification exercise covered legislative and regulatory consultation requirements and contractual obligations. Additionally, the following aspects were considered when identifying stakeholders and assigning a level of interest:

HSE concerns and sensitivities

financial and economic relationships

social investment/impact

socio-cultural concerns and sensitivities

employment/local content.

Key INPEX personnel, including subject matter experts (SMEs) from business areas such as team members in public affairs, corporate affairs, environment, government affairs and Aboriginal affairs undertook a collaborative discussion to outline the requirement for engagement and establish the context of the proposed activities. The identification of relevant persons was completed in accordance with Regulation 11A(1) of the OPPGS (E) Regulations and INPEX’s stakeholder engagement procedures and guidelines.

The following questions were considered during the identification of relevant persons to prompt collaborative discussions between SMEs and inform a decision which was then recorded in an activity specific register specific:

Can the stakeholder provide information or assistance in the design or development of the activities?

Is the stakeholder directly or indirectly adversely affected by the activities including flow-on impacts? (this covers planned and unplanned activities)

Does the stakeholder have the ability to directly or indirectly influence the scope or performance of the activities?

Does the stakeholder have a specific interest in the activities or has INPEX committed to keep the stakeholder informed on such activities?

Would the stakeholder's opposition to the activities be detrimental to the successful execution of the activities?

Has the stakeholder previously expressed a desire not to be consulted in unplanned activities or planned activities?

INPEX treats stakeholder identification (and subsequent activities) as an iterative process whereby INPEX may become aware of relevant persons both during the process of consultation and also after the development and submission of an EP. INPEX acknowledges that relevant persons may be identified during an EP assessment period and also during the proposed activity.

Supplementary to INPEX's own stakeholder identification process outlined above, all exploration activities are required to complete a period of public comment, where the activity is advertised, and the EP made publicly available for a period of 30 days on NOPSEMA's website. Upon completion of the public comment period, INPEX is required to provide a written report on the consultation outcomes and engage with stakeholders as required.

5.2.1 Definition of 'relevant persons'/relevant stakeholders

In identifying relevant persons to be consulted on the proposed activity, INPEX prescribes to the definition provided under Subregulation 11A(1) of the OPGGS (E) Regulations, being:

a. each Department or agency of the Commonwealth to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant

b. each Department or agency of a State or the Northern Territory to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant

c. the Department of the responsible State Minister, or the responsible Northern Territory Minister

d. a person or organisation whose functions, interests or activities may be affected by the activities to be carried out under the environment plan, or the revision of the environment plan

e. any other person or organisation that the titleholder considers relevant.

5.2.2 Relevant activity

In determining who is a relevant stakeholder, it was necessary for INPEX to determine what constitutes a relevant activity, and for which activities a stakeholder should be engaged.

Greenhouse gas activity (planned activity)

The OPGGS (E) Regulations require that consultation be undertaken to ensure that persons who may be affected by a greenhouse gas activity are given the opportunity to inform the titleholder how they may be affected and to allow the titleholder to assess and address any objections or claims about that activity in the preparation of environment submissions.

Regulation 4 of the OPGGS (E) Regulations defines a greenhouse gas activity as:

"operations or works in an offshore area undertaken for the purpose of:

f. exercising a right conferred on a greenhouse gas titleholder under the Act by a greenhouse gas title; or

g. discharging an obligation imposed on a greenhouse gas titleholder by the Act or a legislative instrument under the Act."

When identifying relevant persons, INPEX considers which stakeholders perform a function in the relation to – or have a function, activity or interest that may be impacted by – the planned activity.

The planned activity for this EP is a 3D MSS to be undertaken in Commonwealth waters. Therefore, in determining who is a relevant person for engagement, INPEX sought to identify and engage with stakeholders whose functions, interests or activities could be affected by the 3D MSS activities described in Section 3 of this EP.

Unplanned event/activity (emergency conditions)

INPEX undertakes a more targeted approach to consultation with stakeholders in relation to unplanned emergency conditions, e.g. a loss of containment of hydrocarbons during the 3D MSS.

Stakeholders who may perform a function in INPEX's planning for, or management of an unplanned activity, and whose information is integral to the development of those management plans, are engaged during the development of this EP and the INPEX *Browse Regional OPEP*.

Stakeholders whose functions, interests or activities otherwise overlap the PEZ for the unplanned activity are not engaged during the development of those plans but may be engaged in the event of an unplanned emergency condition.

This approach has been adopted to reduce consultation fatigue for stakeholders who will not be impacted by the planned activity.

INPEX will engage contrary to this approach where a stakeholder has expressed a significant (high to very high) level of concern about unplanned loss of containment events and wishes to understand more about the potential impact and planned response activities.

INPEX maintains an extended stakeholder list which includes stakeholders who may have a function, activity or interest that falls within the PEZ, but for the purpose of the development of these plans, engages with stakeholders as outlined in Table 5-1.

Table 5-1: Classification and method of engagement with stakeholders in relation to an unplanned oil spill event and oil spill response

Stakeholder category	Method of engagement	Stakeholders
Government departments, agencies or organisations with functions or roles directly relevant to emergency and oil spill preparedness and response	Involve / consult regarding the proposed activity and potential unplanned emergency conditions during the preparation of the EP and INPEX *Browse Regional OPEP*.	AMSA WA DoT WA DPIRD WA Department of Biodiversity, Conservation and Attractions (DBCA) NT Department of Infrastructure, Planning and Logistics (DIPL) Australian Marine Oil Spill Centre (AMOSC)
Stakeholders where land access is required to be agreed prior to a response to an unplanned event being executed.	Involve and consult (in conjunction with the Control Agency) in the event of an unplanned emergency condition (i.e., oil spill) that has the potential to affect their functions, activities or interests.	Landowners Native title holders Aboriginal and Torres Strait Islander communities
Stakeholders whose level of interest (or expectation) in relation to a potential oil spills and oil spill response for the planned activity is high or very high.	Inform regarding the proposed activity and potential unplanned emergency conditions during the preparation of the EP and INPEX *Browse Regional OPEP*.	As determined during stakeholder identification process.
Stakeholders whose level of interest (or expectation) in relation to a potential oil spills and oil spill response for the planned activity is low or medium.	To be informed only in the event of an unplanned emergency condition (i.e. oil spill) that has the potential to affect their functions, activities or interests.	As determined during stakeholder identification process.

5.2.3 Commercial fishery stakeholder identification and classification

In addition to the process outlined above for planned activities and unplanned events, identification of relevant commercial fishing stakeholders distinguishes between:

- fisheries that overlap the planned activity; and
- fisheries that overlap the PEZ but not the location of the planned activity.

INPEX used a variety of resources (e.g. data files and fishery reports) to identify and classify stakeholders according to these criteria.

With the view to minimise stakeholder fatigue, INPEX restricted engagement activities to licence holders in fisheries that overlap the area (location) of the planned activity. INPEX also considered if and where licence holders are active (or potentially active) within a fishery to assess whether that licence holder should be engaged.

In summary, identification of and engagement with commercial fishing stakeholders was conducted as follows:

- Government authorities (AFMA, DCCEEW, WA DPIRD and NT DITT) were engaged regarding the proposed activity and engagement with commercial fishing stakeholders. Materials made available by government authorities, e.g. WA FishCube (fishing effort) data files and fishing reports, were used in fisheries determinations.
- Fishing industry associations that represent fisheries with licence areas that overlap the proposed activity (e.g. Commonwealth Fisheries Association, etc.) were consulted regarding the proposed activity and engagement with their members.
- Licence holders in commercial fisheries were engaged/not engaged according to the following criteria:
  - Active or potentially active licence holders in commercial fisheries whose activities overlap or are very close to the proposed activity were considered to be relevant stakeholders, and were accordingly engaged during the development of the EP.
  - Licence holders in commercial fisheries that overlap or are close to the planned activity, but whose activities or interests are not expected to be affected by the proposed activity are not considered to be relevant stakeholders. Such licence holders were not engaged during the development of the EP, but the industry associations representing these fisheries were informed. An example would be where the licence holder fishes in a distant part of that fishery, e.g. off the southern coast of Australia.
  - Licence holders in commercial fisheries that overlap the broader PEZ but not the area of the proposed activity are not considered affected parties/relevant stakeholders and were therefore not informed during the development of the EP.

Licence holders that are not considered to be relevant to the planned activity are included in the expanded list of stakeholders who would be informed in the event of an unplanned emergency condition.

Table 5-2 presents the commercial fisheries classified according to their relevance to the planned activity or an unplanned emergency condition. Commonwealth fisheries data for the period 2010—2020, confirmed that the only Commonwealth-managed fishery that actively fishes in the Joseph Bonaparte Gulf is the NPF. Preliminary fisheries data for the period 2016—2020, provided by the NT DITT indicated that several NT commercial fisheries may be active within or adjacent to the Operational Area, including the NT Demersal Fishery, NT Offshore Net and Line Fishery, NT Spanish Mackerel Fishery, NT Aquarium Fishery, NT Pearl Oyster Managed Fishery, NT Jigging Fishery and NT Development (small pelagic) Fishery. Licence holders within these fisheries were consulted directly. During preparation of this EP, finer resolution fisheries data was acquired from the NT DITT that confirmed the only fisheries that have previously fished within the Operational Area are the NT Demersal Fishery and NT Offshore Net and Line Fishery (refer Section 4.9.6 and Table 4-4).

Table 5-2: Classification of commercial fishery licence holders

Fishery	**Relevance and process of engagement**
Commercial fisheries licence areas overlapping or close to the planned activity area and with licence holder activities or interests that may be affected by the planned activity.	
Northern Prawn Fishery (Cwlth)	Relevant. Licence holders directly consulted.
NT Demersal Fishery	

Fishery	**Relevance and process of engagement**
NT Offshore Net and Line Fishery	
NT Spanish Mackerel Fishery	
NT Aquarium Fishery	
NT Pearl Oyster Managed Fishery	
NT Jigging Fishery	Licence holders directly consulted, but during the development of this EP were found not to be affected. Licence holders to be informed in the event of an unplanned emergency condition.
NT Development (small pelagic) Fishery	
Commercial fisheries licence areas overlapping the planned activity area, but licence holder activities or interests are not expected to be affected by the planned activity.	
Western Tuna and Billfish Fisheries (Cwlth)	Not affected. Licence holders not consulted during the development of the EP; however, representative industry associations were informed, and each fishery's interests considered in the development of the EP. Licence holders to be informed in the event of an unplanned emergency condition.
Southern Bluefin Tuna Fishery (Cwlth)	
Western Skipjack Fishery (Cwlth)	
Commercial fisheries licence areas overlapping the PEZ but not the planned activity area.	
NT Coastal Line Fishery	Not affected. Licence holders not consulted during the development of the EP, but each fishery's interests considered in the development of the EP. Licence holders to be informed in the event of an unplanned emergency condition.
NT Coastal Net Fishery	
NT Barramundi Fishery	
NT Trepang Fishery	
NT Mud Crab Fishery	
NT Bait Net Fishery	
WA Pearl Oyster Managed Fishery (Zone 4)	
WA Marine Aquarium Fish Managed Fishery	
WA Specimen Shell Managed Fishery	
WA Sea Cucumber Managed Fishery	
WA Joint Authority Northern Shark Fishery	

5.2.4 Stakeholder classification

Stakeholders were then classified based on their level of interest in/potential impact by, and influence over, the proposed activity. The purpose of this activity was to determine a 'priority' for consultation that was appropriate to the classification. Priority levels are shown in Table 5-3.

Table 5-3: Engagement classification

Priority	Interest/potential impact level and/or Influence level	Stakeholder classification (engagement priority)
Level 1	(Both) High to very high	**Collaborate/empower**: partner with stakeholder on each aspect of the decision; allow stakeholder (regulatory or approvals bodies) to make the final decision
Level 2	(Either) High to very high	**Consult/involve**: ensure stakeholder concerns and expectations are consistently understood and considered, and obtain feedback from stakeholders on analysis, alternatives and/or decisions
Level 3	(Both) Low to medium	**Inform**: provide balanced, objective, timely and consistent information to stakeholder

Stakeholders who are relevant only in the event of unplanned emergency conditions were classified separately based on their role or function in relation to unplanned emergency conditions or based on their level of interest and influence in such unplanned emergency conditions.

5.3 Stakeholder engagement

Following the stakeholder identification and classification exercise, an engagement plan was developed to register identified stakeholders and the following information:

- the activity/ies (planned and unplanned) for which they have been identified as relevant
- the activities on which they should be engaged
- the function, activity or interest that may be affected by the relevant activity
- their assigned classification (priority for engagement)
- the proposed manner of engagement (i.e. modes, timing, and by whom).

Those INPEX personnel responsible for engagement were provided with a copy of the plan and instructions on how to carry out the necessary engagement.

INPEX prepared a consultation information sheet to provide relevant stakeholders with important details of the proposed activity. The information sheet included the following information:

- description of the activity, including location and map
- schedule
- methodology (i.e. how the activity will be undertaken, as well as general logistics and safety information)
- environmental management approach

- enquiries and feedback information.

The accompanying email (or cover letter) provided more information relevant to the functions, activities or interests of the stakeholder receiving the information sheet. Additional information was also sent to stakeholders in subsequent communications, as requested by the stakeholder and/or as the information became available.

5.4 Stakeholder monitoring and reporting

Using the stakeholder engagement plan as a guide, INPEX retains a record of all communications sent and received as part of the stakeholder engagement activity. This includes email correspondence, telephone call logs, letters and minutes of meetings.

All queries and feedback from stakeholders are logged, and where applicable, forwarded for follow up. All responses provided to stakeholders are appropriate to the nature of their communication, e.g. technical queries are investigated by area experts and responses provided.

5.4.1 Relevant matters, objections and claims

During stakeholder consultation, each meeting, phone call or piece of correspondence received from a stakeholder was assessed by INPEX for relevant information or for objections, claims or concerns raised regarding the activity. INPEX's assessment of relevance and assessment of merit considered four broad categories:

objection, claim or concern has merit – the objection, claim or concern raised is relevant to both the planned activity and the stakeholder's functions, activities or interests. The matter has merit if there is a reasonable / scientific basis for related effects or impacts to occur and/or there is reasonable basis for the matter to be addressed in the EP.

objection, claim, or concern does not have merit – the objection, claim or concern raised may be relevant to the planned activity or the stakeholder's functions, activities or interests, however, the matter raised has no credible or scientific basis.

relevant matter – the matter raised does not fit the criteria descriptions for objections, claims or concerns with/without merit. However, the matter raised is relevant to the planned activity, comprises a request to INPEX for further relevant information, or provides information to INPEX that is relevant to the activity or the EP.

not a relevant matter – correspondence does not relate to the planned activity or the stakeholder's functions; interests or activities being affected by the activity. Non-relevant matters may also be generic in nature with no specific issues raised (e.g. salutations, acknowledgements, meeting arrangements, etc.).

A summary of all stakeholder consultation undertaken, and the full assessment relevance and merit are provided in Appendix B. The actual records of correspondence are provided in a 'Sensitive Matters Report' that is submitted to NOPSEMA separately to this EP.

An overview of feedback received from stakeholders that resulted in material inputs to the EP is provided in Table 5-4.

Table 5-4: Summary of relevant matters, objections, claims or concerns from stakeholder consultation

Stakeholder	Summary of material stakeholder feedback	Summary of INPEX action
AMSA (nautical advice)	AMSA requested: The Master notify AMSA's Joint Rescue Coordination Centre (JRCC) for	The relevant notifications requested by AMSA have been

Stakeholder	Summary of material stakeholder feedback	Summary of INPEX action
	promulgation of radio-navigation warnings at least 24-48 hours before operations commence. The JRCC be advised when operations start and end. The Australian Hydrographic Office (AHO) be contacted no less than four working weeks before operations to promulgate the appropriate Notice to Mariners.	adopted as controls in Section 7.2 and Section 9.8.3 of the EP.
AMSA (first strike capabilities, vessel spill scenario)	With regard to petroleum titleholder (TH) activation of 'first strike' capabilities under a TH OPEP, it was discussed: - AMSA is Control Agency – however AMSA position is that TH should activate all TH OPEP 'first strike' capabilities, where there is no 'risk' of additional environmental harm, associated with the mobilisation/activation of that capability. -TH mobilised capabilities can be 'turned-off' at any time, as directed by AMSA. -Whilst initially mobilised by the TH, operational control of these capabilities will be taken over by AMSA as the Control Agency, as the scenario evolves and IMT's become established. Transfer of control of THs capabilities to AMSA will occur via consultation between the TH IMT and the AMSA IMT. -AMSA agreed with the following amendment: 1. INPEX will advise AMSA of the commencement and completion of each step. 2. INPEX will note that cost recovery will be against the polluter's insurance (i.e. ship). 3. Fixed wing aerial dispersant (FWAD) will be activated through AMSA contract and control for ship-sourced incident.	INPEX will advise AMSA of the commencement and completion of each step in the event of a vessel collision spill scenario. INPEX noted that cost recovery will be against the polluter's insurance (i.e., ship). FWAD will be activated through AMSA contract and control for ship-sourced incident. The INPEX *Browse Regional OPEP* has been updated to reflect these requirements.
DAWE (Biosecurity)	Stakeholder requested INPEX provide information on interactions that project vessels/installations will have with domestic vessels during the proposed activities and how they will be	INPEX confirmed to DAWE that the exact vessels to be contracted to undertake the proposed activities are unknown at present. Therefore, INPEX cannot provide

Stakeholder	Summary of material stakeholder feedback	Summary of INPEX action
	managed. This information was requested via the completion of a 'Questionnaire for Biosecurity Exemptions for Biosecurity Control Determination'.	the required information at this stage. However, INPEX will provide all the requested information at least 4 weeks prior to the commencement of activities as described in Section 9.8.3.
Director of National Parks (DNP)	DNP noted that the Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Titleholders are expected to consider the impacts and risks of activities in the context of the North-west Marine Park Network Management Plan objectives and values. The EP should: - Identify and manage all impacts and risks on Australian marine park values (including ecosystem values) to an acceptable level and consider 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 requested: - Further detail regarding the identification and management of risks to natural values, including, but not limited to, the Flatback, Loggerhead and Olive Ridley turtles which are present and display behaviours including foraging and migration within the acreage and proposed Operational Areas. Matters addressed should include activity timing, cumulative impacts with other known activities within the region, noise interference, vessel disturbance and light pollution. - Confirm that equipment would be stowed (such as seismic streamers) when entering and exiting the operational area within the Oceanic Shoals Marine Park to minimise potential impact. Notification to be provided to DNP in the event of pollution incidents which occur within a marine park or are likely to impact on a marine park.	Potential impacts and risks of activities have been considered in the context of the North-west Marine Park Network Management Plan objectives and values. Noise interference is assessed in Section 7.1. Cumulative impacts are assessed in Section 7.3. Vessel disturbance is assessed in Section 7.4.2. Light pollution is assessed in Section 7.5.1. The planned activity does not require entry into the Oceanic Shoals Marine Park refer to Section 1.3. The requirement to notify the DNP in the event of a spill impacting on a marine park is incorporated in the INPEX Browse Regional Oil Pollution Emergency Plan.
Department of Defence	Defence confirmed current planned military exercises in the NAXA for 2022, 2023 and 2024 and requested that INPEX provide as much advance	INPEX will provide advance details in relation to the nature and scale of the activities including vessel

Stakeholder	Summary of material stakeholder feedback	Summary of INPEX action
	notice as possible for any planned activities by INPEX or contractors in the NAXA (i.e.: five to six weeks' notice). Patrol boats conduct regular training in the NAXA area including live firings; however, these are not usually programmed until six to eight weeks prior and will be included in the Notice to Airmen (NOTAMs). Defence recommend INPEX check these notices regularly.	size, survey location and proposed dates for scheduled activities. These requirements have been considered in Section 7.2 and Section 9.8.3 of the EP.
Department of Mines, Industry Regulation and Safety WA (DMIRS)	Requested INPEX send through activity commencement and cessation notifications. DMIRS also highlighted Consultation Guidance Note in relation to the reporting of incidents that could potentially impact on any land or water under State jurisdiction.	DMIRS's request to be notified of the activity commencement has been incorporated into Section 9.8.3 of the EP.
Northern Territory Seafood Council (NTSC)	NTSC provided assistance with identifying relevant stakeholders and informed potentially affected stakeholders INPEX had provided a claim process for review.	INPEX contacted relevant stakeholders identified by the NTSC. INPEX advised that engagement with key potentially affected NT fisheries (e.g. Demersal, Spanish Mackerel and Offshore Net and Line) had only resulted in received feedback from NT Demersal Fishery licence holder and Northern Prawn Fishery Industry (NPFI). INPEX provided a draft claim process for review.
NT Department of Industry, Tourism and Trade (DITT)	Provided data and information on fisheries catch and effort. Advised that peak fish spawning in the region likely occurs between September and March and recommended that survey activities should avoid this period to prevent negative impacts to fish stocks.	Potential impacts to commercial fish stocks, including spawning and recruitment, have been assessed in Section 7.1.6. The potential risk has been assessed as low given the small proportion of the stock area and spawning period when disturbance may occur, and given natural variability in spawning and recruitment. The 3D MSS is provisionally expected to be conducted in Q2 2023, which will avoid the peak spawning period; however, an exact start date is subject to vessel availability, operational efficiencies, and weather, other site survey and drilling activities

Stakeholder	Summary of material stakeholder feedback	Summary of INPEX action
		that INPEX plan to undertake within the permit area, as well as potential Department of Defence exercises that may occur. Given the already low risk to commercial fish stocks, and the above mentioned scheduling uncertainties, INPEX does not consider it practicable to commit to undertaking the 3D MSS outside of the peak spawning period.
NT Demersal Fishery licence holder	Stakeholder has a vessel that regularly fishes within and north of the Operational Area throughout the year. To their knowledge, there are no other licence holders using the area. Crimson snapper and saddletail snapper are the main species caught. There is some overlap of the proposed Operational Area and the grounds targeted by the stakeholder, but there are options to fish/trawl in alternative areas to avoid contact with survey vessels if they are on water at the same time. A 2 week notice prior to the activity activity commencing would assist in planning for the stakeholder and VSat is the best form of communication for the vessel masters when on water to avoid vessel interactions. Stakeholder and INPEX met via TEAMS to discuss a draft claim process (adjustment protocol) which had been provided to the stakeholder for review.	INPEX has captured the information provided by the stakeholder in the impact assessment in Section 7.2.1. Commercial fishers will be notified of the commencement and completion of survey activities, as described in Section 9.8.3, and daily lookaheads will be available, as per Section 7.2.1. In the event that fishers are impacted and experience a loss of catch, INPEX has developed a commercial fisheries claim process, as per Section 9.6.1.
Northern Prawn Fishery Industry (NPFI)	NPFI does not support any activities by oil and gas companies being undertaken in the Joseph Bonaparte Gulf (JBG) during the period from 1 August and 1 December each year (tiger prawn fishing season) given this is the only time period in which NPF fishers can access the JBG fishery. Due to the JBG being closed to NPF fising activities between 1 April and 15 June (banana prawn fishing season), NPFI anticipate a potential increase in the number of vessels that fish in or around the JBG in August/September and potentially into October, subject to	INPEX has captured the information provided by the stakeholder in the impact assessment in Section 7.2.1. INPEX notes NPFI's request for activities to be undertaken in the JBG outside the period from 1 August and 1 December. However, based on historical fishing effort data and fishery publications, INPEX understands that the 3D MSS will not be taking place in a location that is of particular significance for prawns (in terms of biology, recruitment) or for fishing activities. Fishing effort in this location has historically been

Stakeholder	Summary of material stakeholder feedback	Summary of INPEX action
	catch rates (compared to before 2021 JBG closure implementation).	very low or non-existent in some years. INPEX notes that there is a new closure in place in the JBG for the banana prawn fishing season and the potential for an increase in the number of vessels fishing during the tiger prawn season, which could result in increased fishing effort in the JBG. However, on the basis that key target areas for prawns have consistently been outside of the Operational Area in previous years, there is no apparent reason why the relative distribution of tiger prawns and associated fishing effort in the JBG would change significantly. While an increase in fishing effort is possible, effort in the Operational Area is expected to remain low relative to other areas of the JBG. The 3D MSS is provisionally expected to be conducted in Q2 2023, which is consistent with the timing requested by NPFI; however, an exact start date is subject to vessel availability, operational efficiencies, and weather, other site survey and drilling activities that INPEX plan to undertake within the permit area, as well as potential Department of Defence exercises that may occur. Given the limited potential for impact and low risk to the NPF, INPEX does not consider committing to activities outside the period from 1 August and 1 December to be practicable. Commercial fishers will be notified of the commencement and completion of survey activities, as described in Section 9.8.3, and daily lookaheads will be available, as per Section 7.2.1. In the event that fishers are impacted and experience a loss of catch, INPEX has developed a commercial fisheries claim process, as per Section 9.6.1.

5.5 Stakeholder grievance management

A grievance is a complex stakeholder objection or claim ('relevant matter') which has progressed beyond management through the Stakeholder Monitoring and Reporting process.

In line with grievance management as described in the INPEX Community Grievance Management Procedure, a relevant matter that cannot be resolved with the concerned stakeholder (grievant) by the applicable contact person (supported by area experts where required) will be referred to the INPEX Community Relations Working Group (CRWG) for advice and resolution before a response is made to the grievant.

If the resolution proposed by the INPEX CRWG is unacceptable to the grievant, a third-party mediator may become involved to facilitate a resolution between the parties.

In relation to engagement activities for this EP, all stakeholder enquiries were either dealt with as outlined above or are ongoing due to the iterative process of engagement being applied.

5.6 Ongoing consultation

Ongoing consultation activities ensure that INPEX develops and maintains a current and comprehensive view of stakeholder functions, interests and activities, and provide a forum for enquiries, objections or claims by relevant persons in the lead up to and during the conduct of a planned activity.

Ongoing consultation for the proposed activity described in this EP is outlined in the implementation strategy (Section 9.8.3).

6 ENVIRONMENTAL IMPACT AND RISK ASSESSMENT METHODOLOGY

In accordance with Division 2.3, Regulation 13(5) of the OPGGS (E) Regulations, an environmental risk assessment was undertaken to evaluate impacts and risks arising from the activities described in Section 3. This section describes the process in which impacts and risks were identified. A summary of the outcomes from this process are included in Section 7 and Section 8.

An environmental hazard identification (HAZID) workshop was undertaken for the activity. The workshop involved environmental, compliance, health, safety, emergency response, and geophysics personnel.

The workshop was undertaken in accordance with INPEX health, safety and environment (HSE) Risk Management processes. The approach generally aligned to the processes outlined in ISO 31000:2009 *Risk Management – Principles and guidelines* (Standards Australia/ Standards New Zealand, 2009) and Handbook 203:2012 *Managing environment-related risk* (Standards Australia/Standards New Zealand 2012).

The environmental impact and risk evaluation process has been undertaken in nine distinct stages:

1. the establishment of context
2. the identification of aspects, hazards and threats
3. the identification of potential consequences (severity)
4. the identification of existing design safeguards and control measures
5. proposal of additional safeguards (ALARP evaluation)
6. an assessment of the likelihood
7. an assessment of the residual risk
8. an assessment of the acceptability of the residual risk
9. the definition of environmental performance outcomes, standards and measurement criteria.

6.1 Establishment of context

The first stage in the process involved a review of legislative requirements including government policies and guidelines (Section 2 *Environmental Management Framework*). Following this the scope of the activity was defined and the existing environment reviewed to identify particular values and sensitivities of that environment. The outcomes of these exercises are presented in Section 3 *Description of Activity* and Section 4 *Existing Environment*, of this EP.

6.2 Identification of aspects, hazards and threats

An assessment was undertaken to identify the aspects associated with the activity. An aspect is defined by ISO 14001: 2015 *Environmental Management Systems (EMS)* as:

"An element or characteristic of an activity, product, or service that interacts or can interact with the environment".

The aspects were grouped to align with the INPEX BMS environment standards. A summary of the aspects identified for the activity were as follows:

- noise and vibration
- social and cultural heritage protection

- cumulative seismic survey impacts[5]
- biodiversity and conservation protection
- emissions and discharges
- waste management
- loss of containment
- emergency conditions.

Hazards are defined by the *INPEX HSE Hazard and Risk Management Standard* as:

"A physical situation with the potential to cause harm to people, damage to property, damage to the environment".

As the definition suggests, for an environmental risk or impact to be realised, there needs to be a chance of exposing an environmental value or sensitivity to a hazard. If there is no credible exposure of the value or sensitivity, there is no risk of harm or damage. Subsequently, there is no potential for impact (or consequence).

Given the various receptors present in the environment, they have been refined to environmentally sensitive or biologically important receptors (values and sensitivities). They have been selected using regulations, government guidance and stakeholder feedback.

For the purposes of the evaluation, environmental values and sensitivities to be considered include the following:

- receptors that are considered socially important as identified during stakeholder engagement (including social and cultural heritage)
- benthic primary producer habitat, defined by the Western Australian Environmental Protection Authority (WA EPA) Environmental Assessment Guideline No. 3 *Environmental Assessment Guidelines for Protection of Benthic Primary Producer Habitat in Western Australia's Marine Environment* as functional ecological communities that inhabit the seabed within which algae (e.g. macroalgae, turf and benthic microalgae), seagrass, mangroves, corals, or mixtures of these groups, are prominent components
- regionally important areas of high diversity (such as shoals and banks)
- particular values and sensitivities as defined by Regulation 13(3) of the OPGGS(E) Regulations 2009:
  - the world heritage values of a declared World Heritage property within the meaning of the EPBC Act
  - the national heritage values of a National Heritage place within the meaning of the EPBC Act
  - the ecological character of a declared Ramsar wetland within the meaning of the EPBC Act
  - the presence of a listed threatened species or listed threatened ecological community within the meaning of the EPBC Act
  - the presence of a listed migratory species within the meaning of the EPBC Act
  - any values and sensitivities that exist in, or in relation to, part or all of:

[5] Cumulative seismic survey impacts has been identified in addition to the INPEX BMS environment standards Cumulative impacts of past and proposed seismic surveys in the Bonaparte Basin have been considered in the context of underwater noise and vibration and the physical interaction of survey vessels and equipment with commercial fisheries and other marine users.

  - a Commonwealth marine area within the meaning of the EPBC Act – Note that this value and sensitivity includes receptors (e.g. planktonic and benthic communities) that, when exposed, have the potential to affect regionally significant ecological diversity and productivity from benthic and planktonic communities
  - Commonwealth land within the meaning of the EPBC Act.
- biologically important areas associated with EPBC-listed species.

6.3 Identify potential consequence

In sections 7 and 8, for each aspect, the greatest consequence (or potential impact) of an activity, is evaluated with no additional safeguards or control measures in place. This allows the assessment to be made on the maximum foreseeable exposure of identified values and sensitivities to the hazard taking into account the extent and duration of potential exposure. The consequence is defined using the INPEX Risk Matrix (Figure 6-1).

Given that the receptors, identified as particular values and sensitivities are the most regionally significant or sensitive to exposure, these are considered to present a credible worst-case level of consequence to assess against for environmental impact and impacts to cultural and social heritage.

6.4 Identify existing design safeguards/controls

Control measures associated with existing design are then identified to prevent or mitigate the threat and/or its consequence(s). These controls may relate to the implementation strategy of this EP and have relevant environmental performance outcomes and standards presented in Section 9.

6.5 Propose additional safeguards (ALARP evaluation)

Where existing safeguards or controls have been judged during the evaluation as inadequate to manage the identified hazards (on the basis that the criteria for acceptability is not met as defined in Section 6.8), additional safeguards or controls are proposed.

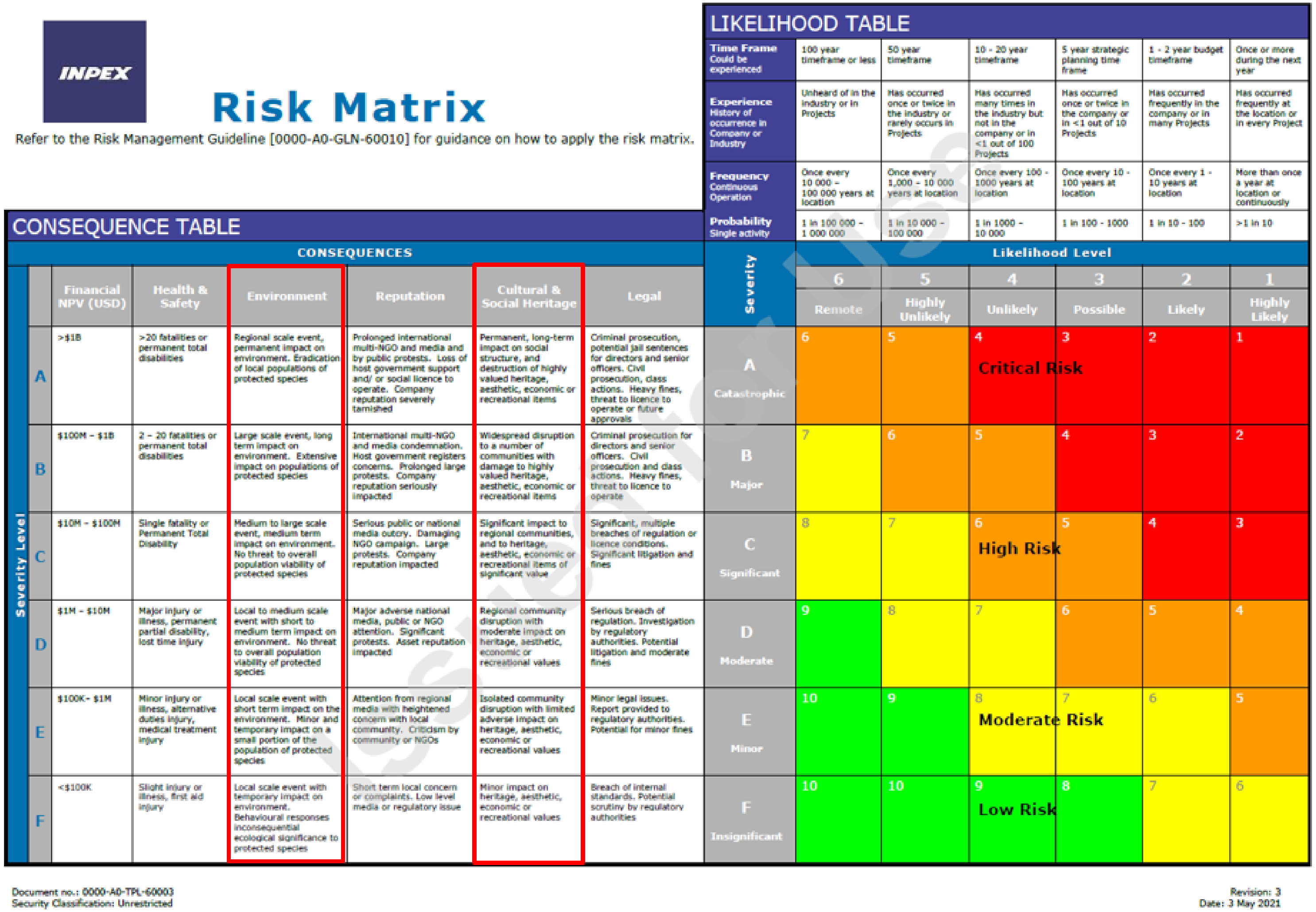
The INPEX *HSE Hazard and Risk Management Standard* describes the process in which additional engineering and management control measures are identified, taking account of the principle of preferences illustrated in Figure 6-2. The options were then systematically evaluated in terms of risk reduction. Where the level of risk reduction achieved by their selection was determined to be grossly disproportionate to the “cost” of implementing the identified control measures, the control measure will not be implemented, and the risk is considered ALARP. Cost includes financial cost, time or duration, effort, occupational health and safety risks, or environmental impacts associated with implementing the control.

6.6 Assess the likelihood

The likelihood (or probability) of a consequence occurring was determined, taking into account the control measures in place. The likelihood of a particular consequence occurring was identified using one of the six likelihood categories shown in Figure 6-1.

6.7 Assess residual risk

Once any additional controls/safeguards have been considered, the residual risk is then evaluated and ranked.



INPEX

Risk Matrix

Refer to the Risk Management Guideline [0000-A0-GLN-60010] for guidance on how to apply the risk matrix.

LIKELIHOOD TABLE

Time Frame Could be experienced	100 year timeframe or less	50 year timeframe	10 - 20 year timeframe	5 year strategic planning time frame	1 - 2 year budget timeframe	Once or more during the next year
Experience History of occurrence in Company or Industry	Unheard of in the industry or in Projects	Has occurred once or twice in the industry or rarely occurs in Projects	Has occurred many times in the industry but not in the company or in <1 out of 100 Projects	Has occurred once or twice in the company or in <1 out of 10 Projects	Has occurred frequently in the company or in many Projects	Has occurred frequently at the location or in every Project
Frequency Continuous Operation	Once every 10 000 – 100 000 years at location	Once every 1,000 – 10 000 years at location	Once every 100 - 1000 years at location	Once every 10 - 100 years at location	Once every 1 - 10 years at location	More than once a year at location or continuously
Probability Single activity	1 in 100 000 – 1 000 000	1 in 10 000 – 100 000	1 in 1000 – 10 000	1 in 100 - 1000	1 in 10 - 100	>1 in 10

CONSEQUENCE TABLE

Severity Level	Financial NPV (USD)	Health & Safety	Environment	Reputation	Cultural & Social Heritage	Legal
A	>$1B	>20 fatalities or permanent total disabilities	Regional scale event, permanent impact on environment. Eradication of local populations of protected species	Prolonged international multi-NGO and media and by public protests. Loss of host government support and/ or social licence to operate. Company reputation severely tarnished	Permanent, long-term impact on social structure, and destruction of highly valued heritage, aesthetic, economic or recreational items	Criminal prosecution, potential jail sentences for directors and senior officers. Civil prosecution, class actions. Heavy fines, threat to licence to operate or future approvals
B	$100M - $1B	2 - 20 fatalities or permanent total disabilities	Large scale event, long term impact on environment. Extensive impact on populations of protected species	International multi-NGO and media condemnation. Host government registers concerns. Prolonged large protests. Company reputation seriously impacted	Widespread disruption to a number of communities with damage to highly valued heritage, aesthetic, economic or recreational items	Criminal prosecution for directors and senior officers. Civil prosecution and class actions. Heavy fines, threat to licence to operate
C	$10M - $100M	Single fatality or Permanent Total Disability	Medium to large scale event, medium term impact on environment. No threat to overall population viability of protected species	Serious public or national media outcry. Damaging NGO campaign. Large protests. Company reputation impacted	Significant impact to regional communities, and to heritage, aesthetic, economic or recreational items of significant value	Significant, multiple breaches of regulation or licence conditions. Significant litigation and fines
D	$1M - $10M	Major injury or illness, permanent partial disability, lost time injury	Local to medium scale event with short to medium term impact on environment. No threat to overall population viability of protected species	Major adverse national media, public or NGO attention. Significant protests. Asset reputation impacted	Regional community disruption with moderate impact on heritage, aesthetic, economic or recreational values	Serious breach of regulation. Investigation by regulatory authorities. Potential litigation and moderate fines
E	$100K- $1M	Minor injury or illness, alternative duties injury, medical treatment injury	Local scale event with short term impact on the environment. Minor and temporary impact on a small portion of the population of protected species	Attention from regional media with heightened concern with local community. Criticism by community or NGOs	Isolated community disruption with limited adverse impact on heritage, aesthetic, economic or recreational values	Minor legal issues. Report provided to regulatory authorities. Potential for minor fines
F	<$100K	Slight injury or illness, first aid injury	Local scale event with temporary impact on environment. Behavioural responses inconsequential ecological significance to protected species	Short term local concern or complaints. Low level media or regulatory issue	Minor impact on heritage, aesthetic, economic or recreational values	Breach of internal standards. Potential scrutiny by regulatory authorities

Severity	Likelihood Level: 6 Remote	5 Highly Unlikely	4 Unlikely	3 Possible	2 Likely	1 Highly Likely
A Catastrophic	6	5	4 Critical Risk	3	2	1
B Major	7	6	5	4	3	2
C Significant	8	7	6 High Risk	5	4	3
D Moderate	9	8	7	6	5	4
E Minor	10	9	8 Moderate Risk	7	6	5
F Insignificant	10	10	9 Low Risk	8	7	6

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Figure 6-1: INPEX risk matrix

Most Preferred → Least Preferred			
	Elimination		Removal of the hazard or sensitive receptor
	Substitution		Replacement of highly hazardous materials / approaches with less hazardous materials / approaches
	Engineering	**Prevention**	Design measures that reduce the likelihood of a hazardous event occuring
		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 should a hazardous event occur
		Response Equipment	Design measures or safeguards that enable clean-up / response following the realisation of a hazardous event
	Procedures & Administration		Management systems and work instructions used to prevent or mitigate environmental exposure to hazards

Figure 6-2: ALARP options preferences

6.8 Assess residual risk acceptability

Potential environmental impacts and risks are only deemed acceptable once all reasonably practicable alternatives and additional measures have been taken to reduce the potential impacts and risks to ALARP.

INPEX has determined that risks rated as "Critical" are considered too significant to proceed and are therefore, in general, unacceptable. In alignment with NOPSEMA's *Environment Plan Decision Making Guideline* (NOPSEMA 2021a), INPEX considers that when a risk rating of "Low" or "Moderate" applies, where the consequence does not exceed "C" (Significant) and where it can be demonstrated that the risk has been reduced to ALARP, that this defines an acceptable level of impact.

Through implementation of this EP, impacts to the environment will be managed to ALARP and acceptable levels and will meet the requirements of Section 3A of the EPBC Act (principles of ecologically sustainable development) as shown in Table 6-1.

Table 6-1: Principles of ecological sustainable development (ESD)

Principles of ESD	Demonstration
a) decision-making processes should effectively integrate both long-term and	The INPEX environmental policy (Figure 9-2) INPEX *HSE Hazard and Risk Management Standard* and the INPEX BMS (Section 9) consider

short-term economic, environmental, social and equitable considerations;	both long-term and short-term economic, environmental, social and equitable considerations.
(b) if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;	No threat of serious or irreversible environmental damage is expected from the activity. Scientific knowledge is available to support this and processes are in place to ensure that INPEX remains up-to-date with scientific publications (Section 9.13).
(c) the principle of inter-generational equity - that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations;	The health, diversity and productivity of the environment shall be maintained and not impacted by the activity.
(d) the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making;	Biological diversity and ecological integrity will not be compromised by the activity.
(e) improved valuation, pricing and incentive mechanisms should be promoted.	N/A

Consequently, the potential environmental impacts and risks associated with implementing the activity were determined to be acceptable if the activity:

- complies with relevant environmental legislation and corporate policies, standards, and procedures specific to the operational environment
- takes into consideration stakeholder feedback
- is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values
- takes into consideration conservation management documents
- does not compromise the relevant principles of ESD; and
- the predicted level of impact does not exceed the defined acceptable level, in that the environmental risk has been assessed as "Low" or "Moderate", the consequence does not exceed "C – Significant" and the risk has been reduced to ALARP.

6.9 Definition of performance outcomes, standards and measurement criteria

As defined in Regulation 4 of the OPGGS (E) Regulations, INPEX has used environmental performance outcomes and performance standards to address potential environmental impacts and risks identified during the risk assessment.

Environmental performance outcomes, standards, and measurement criteria that relate to the management of the identified environmental impacts and risks are defined as follows:

- Environmental performance outcome means a measurable level of performance required for the management of environmental aspects of an activity to ensure that environmental impacts and risks will be of an acceptable level.
- Environmental performance standard means a statement of the performance required of a control measure.

- Measurement criteria are used to determine whether each environmental performance outcome and environmental performance standard has been met.

7 IMPACT AND RISK ASSESSMENT

Following the environmental impact and risk assessment methodology described in Section 6, the aspects, hazards and threats have been systematically identified. The aspects (and associated hazards) with the potential for impact or risk in relation to relevant identified values and sensitivities are discussed in this Section and in Section 8.

7.1 Noise and vibration

During the Bonaparte Basin 3D MSS, the seismic source will emit short-duration, high-amplitude pulses of sound. The peak sound energy is typically at frequencies below 200 Hz, although higher frequency and broadband components of the sound are also produced. The sound produced by the seismic source is primarily directed downwards, towards the seabed, to obtain information about the geology underlying the seabed. However, horizontal sound propagation will also occur, which has the potential to affect environmental and socio-economic receptors.

The assessment of underwater noise impacts from seismic sound exposure is divided into the following sections:

- planktonic communities – Section 7.1.4
- benthic communities – Section 7.1.5
- fishes – Section 7.1.6
- marine mammals – Section 7.1.7
- marine reptiles – Section 7.1.8
- marine avifauna – Section 7.1.9.

Potential impacts to commercial fisheries from underwater noise and physical interactions with the survey vessels are assessed separately in Section 7.2.1.

7.1.1 Fundamentals of underwater noise

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 micropascal (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 metric terminology

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 7-1); 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 7-1); 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 7-1); 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 µPa^2·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.

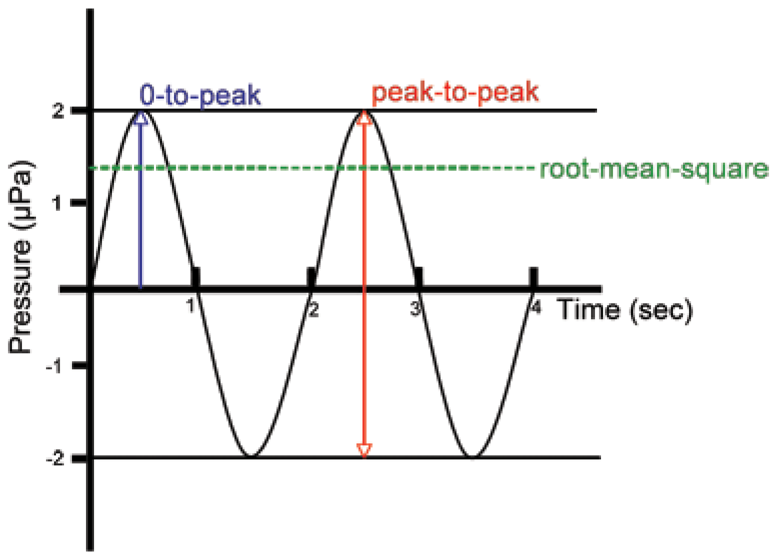

Figure 7-1 Simplified sound wave and sound pressure metrics (University of Rhode Island and Inner Space Center 2017)

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 & 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 & 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 & 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 & 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 & 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 (U.S. NMFS 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. 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.

7.1.2 Acoustic modelling

To assess the potential magnitude and extent of impacts from underwater noise produced during the Bonaparte Basin 3D MSS, INPEX commissioned JASCO Applied Sciences (JASCO) to model the source levels and sound propagation at several locations that were representative of the different water depths, bathymetry and seabed properties within the Acquisition Area (Muellenmeister et al. 2022; Appendix C).

The modelling study first undertook a comparison of the acoustic source levels and directivity of four potential seismic sources. The seismic source with the greatest source levels was then selected to provide the most conservative estimates for modelling sound propagation. This included modelling both single-pulse sound metrics and accumulated sound exposures in order to assess potential behavioural and physical impacts against various threshold criteria for different marine fauna.

Acoustic source level comparison

The loudest seismic source is not necessarily the source with the largest total volume. The sound levels that propagate from the seismic source depend not only on total volume of the seismic source, but the configuration and geometric layout of the individual guns in the array.

Source modelling considered four different seismic sources, between approximately 2,500 in^3 and 3,300 in^3, the range considered suitable to ensure adequate seismic imaging of the required geological targets. The sources were selected based on sources provided to INPEX from prospective seismic contractors, as well as a review of other recent seismic survey EPs that have included dual and triple seismic sources of equivalent total volume. A 2,480 in^3 source was included, to represent the likely lowest possible volume of a triple source, while three other sources, a 3,050 in^3, 3,090 in^3 and 3,280 in^3, were modelled to allow for the comparison of the larger and potentially louder sources that could be selected for the Bonaparte Basin 3D MSS.

JASCO's acoustic array source model was used to predict the horizontal and vertical overpressure signatures and corresponding power spectrum levels for the three different seismic sources. Table 7-1 presents the PK and SEL source levels corresponding with each seismic source in the broadside (perpendicular to the tow direction), endfire (along the tow direction), and vertical directions. Horizontal directivity plots were also reviewed to assess which source had the potential for the greatest horizontal sound propagation.

In the horizontal plane, the broadside source levels emitted from a seismic source are typically louder than the endfire levels. The four seismic sources produced very similar PK source levels in the broadside direction (±1.3 dB), with the 3,280 in^3 source producing the highest PK levels. However, the 3,050 in^3 source was notably louder than the other seismic source options in the endfire and vertical directions (both PK and SEL). Muellenmeister et al. (2022) further evaluated per-pulse sound propagation fields and determined that the geometric configuration of the 3,050 in^3 source was most likely to produce the largest ranges to acoustic impact thresholds overall. The 3,050 in^3 source was, therefore, selected as the source for modelling and assessing single-pulse and accumulated sound metrics.

Table 7-1: Per-pulse peak source level comparison for four representative seismic source options (Muellenmeister et al. 2022)

Total volume (in^3)	Direction	Peak source pressure level ($L_{S,pk}$) (dB re 1 µPa m)	Per-pulse source SEL ($L_{S,E}$) (dB 1 µPa^{2}m^{2}s)
			10-25,000 Hz
2,480	Broadside	248.2	223.5
3,050	Broadside	248.3	224.4

3,090	Broadside	249.5	224.9
3,280	Broadside	249.4	224.8
2,480	Endfire	244.6	221.9
3,050	Endfire	247.7	224.8
3,090	Endfire	245.8	222.5
3,280	Endfire	244.5	222.7
2,480	Vertical	254.1	227.1
3,050	Vertical	258.2	230.7
3,090	Vertical	255.2	228.2
3,280	Vertical	255.4	228.4

Acoustic modelling scenarios

JASCO designed the acoustic modelling study to take into consideration key survey factors, such as the location of key environmental and social receptors, and the range of water depths across the Active Source Area. Two standalone single impulse sites and single representative accumulated sound exposure scenario were defined (Figure 7-2) based upon the acquisition parameters described in Section 3.3. Water depths of single impulse sites were 77 m to 97 m. Seafloor sound levels also were assessed at three different representative depths (65, 85 and 100 m). The location and orientation of of the single impulse sites were selected based on the preliminary survey line plan in Figure 3-2 and are considered representative of the potential sound propagation characteristics and the range of water depths in the Active Source Area (67 – 106 m).

Sound energy accumulated from multiple pulses has also been modelled. 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, 24 hours was the period used for modelling and in this assessment.

Importantly, the 24-hour accumulated sound metric reflects the dosimetric impact of noise levels within 24 hours based on the assumption that an animal is consistently exposed to such noise levels at a fixed position. More realistically, marine mammals and many fish (pelagic and some demersal) would not stay in the same location or at the same range for 24 hours. Popper et al. (2014) discuss the complexity in determining a relevant sound exposure period of mobile acoustic sources such as seismic surveys, as the levels received by the receptor change between impulses due to the mobile source. For marine mammals and many fish, sound exposures at the closest point to the seismic source are the primary exposures contributing to a receptor’s accumulated level (Gedamke et al. 2010). Hence, thresholds based on a 24-hour exposure period are considered to be a conservative measure of potential effect.

The locations of the single impulse sites and the accumulated SEL scenario were selected to provide the greatest sound propagation radii from the seismic source towards both shallow water receptors and deep-water receptors relevant to the survey, including:

internesting marine turtle BIAs and habitat critical to the survival of marine turtles in nearshore waters

coastal dolphin species in nearshore waters

marine turtle foraging BIAs in offshore waters

Oceanic Shoals MP and Joseph Bonaparte Gulf MP.

Modelling sites are also considered to be representative of the water depths and areas of relevance to commercial fisheries that operate in or near the Operational Area.

Table 7-2 outlines the key model input parameters considered in the acoustic modelling. Further detail on modelling parameters and methods is provided in Muellenmeister et al. (2022; Appendix C).

The JASCO acoustic modelling provides reliable results to support the impact assessment. The models have previously been extensively tested and validated (refer to Section 7.1.3) and the models are consistently found to show good agreement with measured sound levels. One such validation study (McPherson and Martin 2018) was undertaken in 2018 at a location approximately 120 km west of the Active Source Area (permit WA-522-P) with comparable water depths and seabed geoacoustics.

Acoustic Modelling Results

The horizontal ranges (R_{max} and $R_{95\%}$) associated with unweighted SPL and per-pulse SEL isopleths (contours of equal sound level) are presented in Table 7-3Table 7-3. R_{max} refers to the maximum range to the given sound level in all directions. $R_{95\%}$ is the range to the given sound level in 95% of all directions, after the 5% farthest points have been excluded. For example, in some cases, a sound level contour might have small or anomalous protrusions in some directions. In cases such as this, R_{max} can over-represent the area exposed to such sound levels, and $R_{95\%}$ may be more representative. R_{max} better represents the sound levels received in the specific directions that the maximum sound levels extend towards.

Figure 7-3 presents the unweighted SPL isopleths for the two single impulse modelling locations. These represent the maximum levels at any depth within the water column (maximum-over-depth SPL isopleths).

The single pulse and accumulated sound exposure modelling results are discussed in more detail in the context of different receptors in the relevant impact and risk assessment sections below.

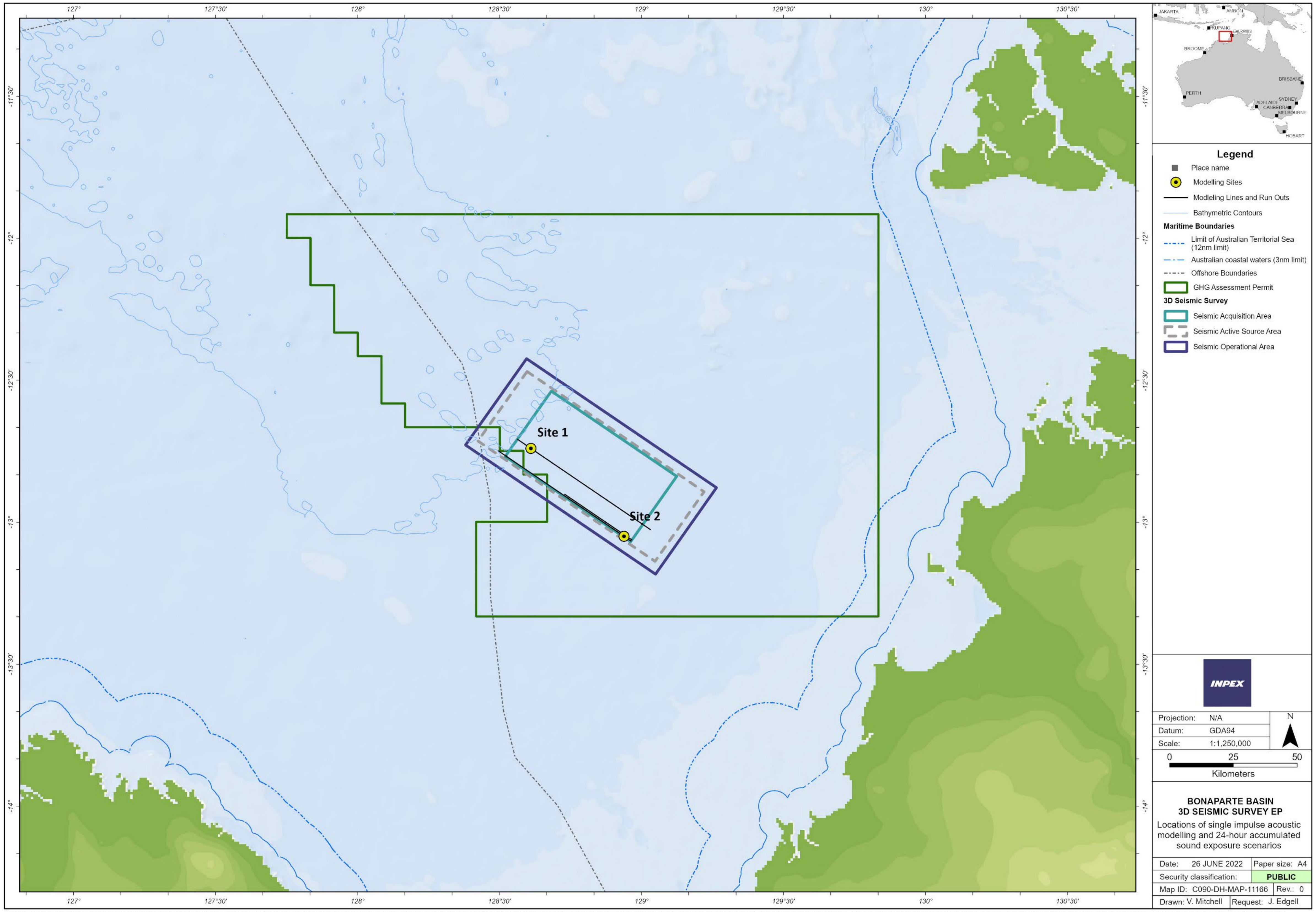

Figure 7-2: Locations of single impulse modelling sites and accumulated SEL scenario.

Table 7-2: Key model input parameters

Parameter	Input Data	Rationale
Seismic source	3,050 in^3	Representative of the source volumes that may be used during the survey (between approximately 2,500 in^3 and 3,300 in^3). The 3,050 in^3 source was selected as, based on source comparison work undertaken by JASCO for four representative source arrays, the 3,050 in^3 source was found to produce the farthest sound propagation. Results may therefore be conservative for sources with lower source levels.
Tow depth	8 m	The modelled 8 m tow depth is considered to be representative of the 6 – 8 m tow depth considered in this EP. While limited variation in results is expected between 6 m and 8 m tow depth, the deeper end of the tow depth range was selected to support the greatest propagation of low frequency energy towards the seabed.
SPI	12.5 m (5.4 seconds)	Representative of the SPI for a triple source acquisition and the most frequent SPI considered in this EP. Accumulated SEL results will be conservative for an acquisition that uses a larger SPI (e.g. dual source with 18.75 m SPI).
Vessel speed	4.5 knots	Standard seismic survey vessel speed. The accumulated SEL scenario was determined based upon the acquisition that would take place along sail lines in a 24-hour period at a speed of 4.5 knots.

Table 7-3 Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the source to modelled maximum-over-depth SPL and per-pulse SEL isopleths

SPL (Lp; dB re 1 µPa)	Site 1 (77 m depth)		Site 2 (97 m depth)		Per-pulse SEL (L_E; dB re 1 µPa²·s)	Site 1 (77 m depth)		Site 2 (97 m depth)	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.05	0.05	0.05	0.05	200	0.05	0.05	0.05	0.05
190	0.23	0.21	0.22	0.20	190	0.26	0.24	0.26	0.23
180	0.85	0.77	0.85	0.78	180	1.08	0.97	0.93	0.85
170	3.67	2.94	3.55	2.84	170	4.13	3.46	4.20	3.38
160	9.84	7.81	9.96	7.76	160	11.9	9.66	11.6	9.50
150	24.6	20.3	24.9	20.3	150	29.5	24.0	28.9	23.4
140	69.8	53.2	65.4	48.6	140	79.3	61.2	78.1	56.4

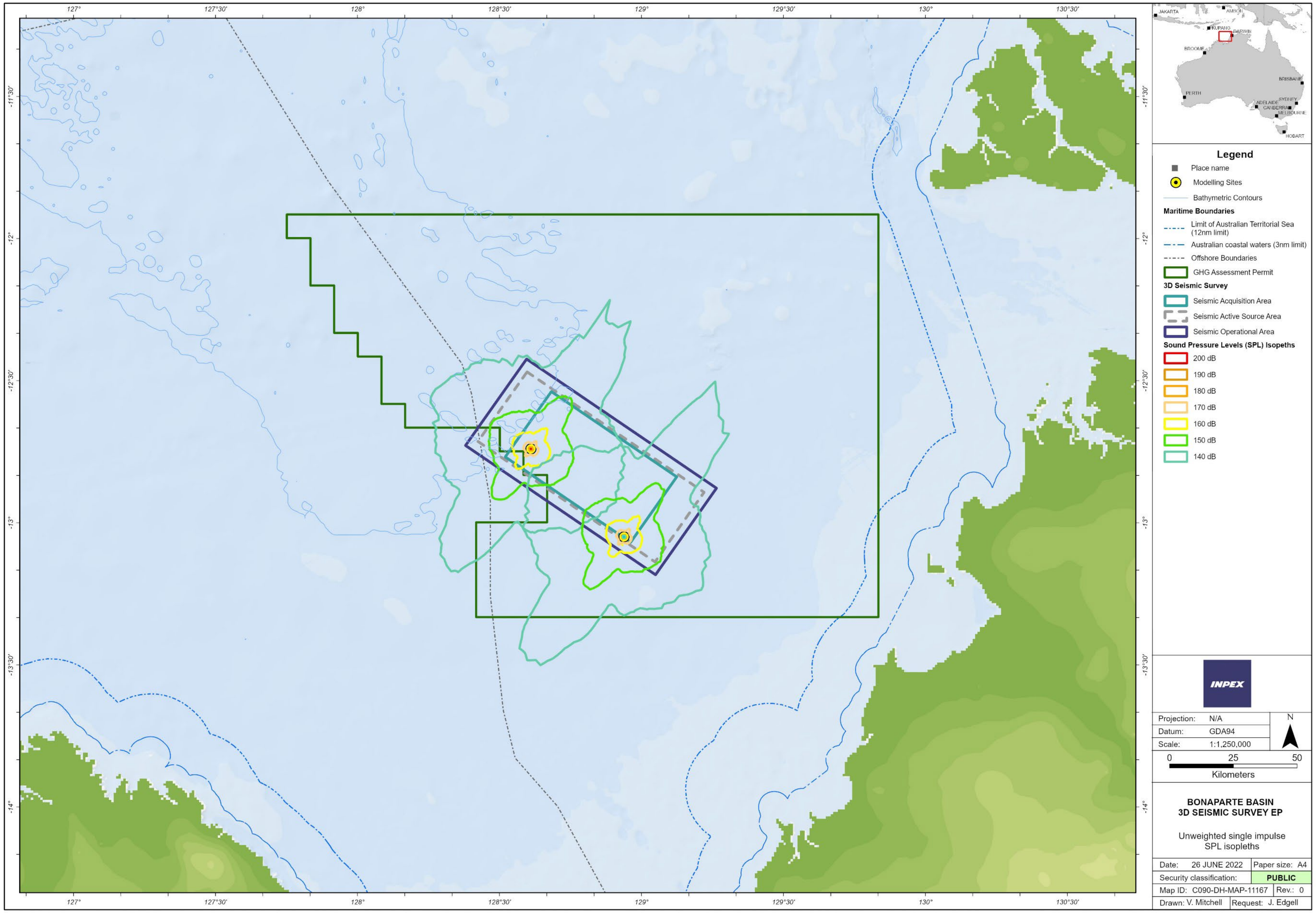

Figure 7-3: Unweighted maximum-over-depth SPL isopleths modelled from the single impulse modelling locations.

7.1.3 Acoustic sound source verification and assurance

At the time of preparing this EP, the seismic contractor and the specific seismic source are not confirmed, but are intended to be up to approximately 3,300 in^3.

INPEX has evaluated four representative seismic source options and modelled the sound propagation from the worst-case seismic source option. INPEX will also implement a control measure to verify that the seismic source selected for the Bonaparte Basin 3D MSS will have an acoustic output that is comparable to or less than the source levels assessed and deemed to be acceptable in this EP.

This is considered to be an appropriate and practicable control measure to implement to manage the potential impact and risk to all receptors exposed to the effects of underwater noise. An ALARP assessment has been undertaken of the available sound source verification options and an environmental performance standard is provided in Table 7-4.

Table 7-4: ALARP evaluation – sound source verification

Proposed sound source verification control measures (ALARP Evaluation)		
Control measure	Used?	Justification
Define the maximum source volume for the survey	No	The Bonaparte Basin 3D MSS will be acquired using a source volume of between approximately 2,500 in^3 and 3,300 in^3, depending upon the final source configuration selected. At present, a seismic contractor has not been selected. Potential contractors have provided details of potential source volumes which vary from 2,480 in^3 to 3,280 in^3. It is not possible for INPEX to commit to an exact source volume at this stage. The source levels and directivity of sound as it propagates is not determined by source volume alone. The volume and position of individual source elements within the array (the source layout and geometry) influences the source levels and the propagated sound levels. i.e. a larger source volume does not necessarily mean it is the loudest or the worst-case. Therefore, it is more meaningful to implement a control whereby the source levels of the selected seismic source will be validated against the source modelled and used for the risk assessment in this EP (see below).
Undertake acoustic source modelling to confirm that the far-field source level specifications of the seismic source selected for the Bonaparte Basin 3D MSS are consistent with those assessed in this EP.	Yes	In the event that seismic source options considered for the Bonaparte Basin 3D MSS have not already been evaluated in Table 7-1, INPEX will undertake source modelling using the same JASCO Airgun Array Source Model (AASM) to confirm if the source specifications are appropriate.

Proposed sound source verification control measures (ALARP Evaluation)		
		Predictions from JASCO's AASM and propagation models have been extensively validated against experimental data from a number of underwater acoustic measurement programs conducted by JASCO globally, including Australia, the United States, Canada, Greenland and Russia (e.g. Hannay & 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, 2012b; Matthews & MacGillivray 2013; Martin et al. 2015; Racca et al. 2015; Martin et al. 2017a, 2017b; Warner et al. 2017; MacGillivray 2018; McPherson et al. 2018). The large number of measurement programs conducted by JASCO across a range of environments has allowed for a rigorous assessment of the performance of acoustic source and propagation models, and a process of continuous improvement to be in place. The models are consistently found to provide reliable predictions. A recent verification study was also undertaken by JASCO for four different seismic sources ranging up to 3,090 in^3 in north-western Australian waters and the measured data showed good agreement with the modelling in all cases (McPherson et al. 2018). With regards to the airgun array sound source specifications, there is little to no uncertainty in the source model when the airgun array is a standard type (MacGillivray 2018; McPherson et al. 2018), as is the case for the Bonaparte Basin 3D MSS.

Proposed sound source verification control measures (ALARP Evaluation)		
		The four seismic sources evaluated using the AASM in Table 7-1 resulted in different PK and SEL source levels in the horizontal and vertical plane. Consequently, the 3050, 3090, and 3280 in^3 seismic sources required further comparison to determine the worst case source for assessment. This is due to the fact that the 3090 in^3 source results in the greatest PK and SEL levels in the broadside direction, while the slightly smaller 3050 in^3 source leads to much higher PK and SEL values both in the endfire and vertical direction. Since the 3280 in^3 seismic source PK value in the broadside direction is barely smaller than the one of the 3090 in^3 seismic source, it was also included for further analysis. Complimentary sound propagation models were used by JASCO to compare the acoustic fields of these three sources in terms of in terms of PK, SEL and SPL over distance in a representative environment. While all three sources produced similar PK levels (representative of potential injurious levels at close range), the 3050 in^3 source consistently produced the highest SELs and SPLs at the farthest distances away from the source. The 3050 in^3 source was therefore selected as the worst-case source for modelling and impact assessment as it represents larger ranges to behavioural disturbance and SEL24h criteria. Therefore, in the event that the seismic source is selected for the Bonaparte Basin 3D MSS is different to the modelled source options, acoustic modelling will be undertaken by JASCO to confirm that the far-field horizontal source level specifications of the seismic source selected for the 3D seismic survey are consistent with those assessed and considered to be acceptable in this EP.

Proposed sound source verification control measures (ALARP Evaluation)		
		The seismic sources evaluated in Table 7-1 produce PK source levels in the horizontal plane ranging from 244.5 to 249.5 dB re 1 µPa m and source SEL in the horizontal plane ranging from 221.9 to 224.9 dB re 1 µPa^{2}m^{2}s. Should the JASCO AASM model show that the seismic source selected for the survey results in PK source levels in the horizontal plane of 250 dB re 1 µPa m or less, and SEL source levels in the horizontal plane of 225 dB re 1 µPa^{2}m^{2}s or less, then the seismic source is considered to be consistent with the source assessed and deemed acceptable in this EP (within less than 0.5 dB). Should source levels exceed these threshold values, complimentary propagation models may be used to further assess the selected source to ascertain that the acoustic fields do not result in a significant increase in impact or risk, and that there is no reduction in the effectiveness of controls and performance standards provided in this EP to reduce impacts and risks to ALARP and acceptable levels. If the selected source is predicted to result in larger source levels and/or significantly larger acoustic fields, then the seismic source will be modified or a new seismic source slected such that it meets these criteria.
In-situ sound source verification / ground-truthing measurements	No	In-situ measurement campaigns may involve either verification of source levels or ground truthing of received (i.e. propagated) levels. Sound source verification involves conducting a field measurement program which concentrates on understanding the sound source levels in order to compare and verify them against the far-field source specifications predicted by the source model. As indicated above, the JASCO AASM has already been extensively verified globally and has recently been verified in waters off north-western Australia for four different seismic sources ranging up to 3,090 in^3, all showing good agreement with the modelling (McPherson et al. 2018). There is little to no uncertainty when the airgun array is a standard type (MacGillivray 2018; McPherson et al. 2018), as is the case for the Bonaparte Basin 3D MSS.

Proposed sound source verification control measures (ALARP Evaluation)		
		Ground-truthing of received levels is highly complex and sensitive to differences in the regional environment, including sound speed profile, seabed geology and bathymetry and so requires measurements to be undertaken in the same location as the modelling or at a location with similar characteristics in order to be relevant. A reliable and meaningful comparison is also difficult without interrogation of the measured data to validate and re-run the model; inevitably, there may be circumstances where variations in environmental parameters (e.g. localised bathymetric features) may result in occasional exceedances of predicted received levels along some azimuths but may be within predicted levels at other times. However, relatively small disparities between in-situ measurements and model predictions do not necessarily equate to an increased magnitude of impact and the process of establishing meaningful acceptance criteria for any differences is a complex one. While it is possible to conduct ground-truthing of received levels (e.g. Racca et al. 2015; Bröker et al. 2015; Nowacek & Southall 2016), it is not possible to conduct ground-truthing methods in short timeframes to inform adaptive mitigation during a seismic survey. The merits and limitations of different in-situ sound measurement methods are addressed in further detail in the Report of the Acoustic Ground-Truthing Technical Working Group as part of New Zealand's 2015–2016 Seismic Code of Conduct Review process (Department of Conservation 2016). The overall consensus of the technical working group was that in-situ measurements should not be required for adaptive management during all surveys, but may be applied in unique or specific circumstances. In-situ measurements can be implemented, if appropriate, to verify modelling and implement adaptive management if the model predictions, or the effectiveness of a particular control measure, or the acceptable level of impact is heavily dependent upon a high level of model precision and accuracy. Otherwise, the cost and time spent conducting the measurements is not commensurate with the level of risk. In the case of the INPEX Bonaparte Basin 3D MSS, the proposed control measures outlined in the following sections of this EP do not rely on very high levels of model precision (e.g. tens or hundreds of metres), nor are adaptive management measures deemed necessary given the other control measures proposed.

Proposed sound source verification control measures (ALARP Evaluation)		
		An in-situ sound source verification or received level measurement campaign would require days-to-weeks to complete in advance of the survey commencing and could potentially cost in the order of many hundreds of thousands of dollars, depending on the methods to be implemented and the vessels and time required. The potential cost and delay to the survey is disproportionate to the level of risk given the minimal environmental benefit that would be gained in the case of the Bonaparte Basin 3D MSS. Therefore, in-situ measurements are not considered necessary or practicable.

Environmental performance outcomes	**Environmental performance standards**	**Measurement criteria**
Operate a seismic source with an acoustic output that is consistent with the seismic source assessed and considered to be acceptable in this EP.	Prior to commencement of the INPEX Bonaparte Basin 3D MSS, acoustic modelling will be undertaken by JASCO to confirm that the specifications of the seismic source selected for the 3D seismic survey are consistent with those assessed and considered to be acceptable in this EP[6].	Seismic source characteristics (source element types, volumes and x, y, z positions) to be provided by prospective seismic contractors during the contract tender and evaluation stage. Documentation demonstrates that acoustic modelling has been undertaken for the selected seismic source and confirms that the specifications of the seismic source selected for the 3D seismic survey are consistent with those assessed and considered to be acceptable in this EP.

[6] Should the JASCO AASM model show that the seismic source selected for the survey results in PK source levels in the horizontal plane of 250 dB re 1 μPa m or less, and SEL source levels in the horizontal plane of 225 dB re 1 $\mu Pa^2 m^2 s$ or less, then the seismic source is considered to be consistent with the source assessed and deemed acceptable in this EP (within less than 0.5 dB). Should source levels exceed these threshold values, complimentary propagation models may be used to further assess the selected source to ascertain if there is a significant increase in received sound levels. This will support the assessment of whether there is the potnetial for a significant increase in impact or risk, and if the effectiveness of any controls and performance standards provided in this EP to reduce impacts and risks to ALARP and acceptable levels may be compromised. If the selected source is predicted to result in larger source levels and/or significantly larger acoustic fields, or the effectiveness of existing controls and performance standards is compromised, then the seismic contractor will be required to mofify the seismic source or a new seismic source selected such that it meets these criteria.

7.1.4 Underwater noise and vibration – Planktonic communities

Receptor sensitivity to sound and sound exposure thresholds

Planktonic organisms have limited or no swimming ability and are transported by currents and winds. They therefore have limited or no ability to avoid seismic sound sources.

Similar to invertebrates and a number of types of fishes; plankton, eggs and larvae will be sensitive to particle motion effects associated with rapid pressure changes at close range to the seismic source (Larson 1985; Wardle et al*.* 2001; Popper et al. 2014). Phytoplankton are mostly single-celled plant organisms that do not have hearing structures and are generally considered to have the same density as the surrounding water; so sudden pressure changes associated with seismic activity are not known to cause significant physical damage. Some zooplankton are able to sense pressure changes to some degree. Swim bladders may also develop during the larval stages of some fish species, rendering larvae susceptible to pressure-related injuries such as barotrauma (Popper et al. 2014). Data on the effects of sound upon eggs and larvae containing gas bubbles is, therefore, largely focused on barotrauma rather than actual hearing. Very few publications have considered the effects of particle motion or vibration on plankton (Popper et al. 2014).

Few studies have found significant negative impacts on zooplankton, fish eggs, larvae or fry, and most have reported that impacts occur within a few metres or tens of metres from the source (Kostyuchenko 1973; Dalen & Knutsen 1987; Holliday et al. 1987; Kosheleva 1992 cited in Parry et al*.* 2002; Pearson et al. 1994; Turnpenny & Nedwell 1994; Booman et al. 1996; Payne 2004; Payne et al. 2009). These studies included exposures to sound pressures up to approximately 242 dB re 1 µPa, comparable to those considered for the INPEX Bonaparte Basin 3D MSS. Larval stages of fish are often perceived to be more sensitive to stressors than adult stages, but exposure to seismic sound does not appear to result in any differences in larval mortality or abundance for fishes, crabs or scallops (Carroll et al. 2017).

Kostyuchenko (1973) found up to a 17% increase in mortality of fish eggs of various species exposed to a seismic source, but no effect beyond 10 m. Kosheleva (1992, cited in Turnpenny & Nedwell 1994) also reported that eggs and larvae died within 1 m of a seismic source producing sound pressures of 220-240 dB re 1 µPa, but no injuries were reported at greater distances. Dalen and Knutsen (1987) exposed eggs, larvae and post-larval stages of cod exposed to seismic source elements with source levels of 222—231 dB re 1 µPa at 1 m. At ranges of 1—10 m from the source, some specimens indicated temporarily impaired balance following exposure but with rapid recovery. Mortality was only observed in just one of the three exposure experiments, with 90% mortality when exposed at a distance of 2 m from the seismic source, but no significant impacts at a distance of 6 m. Overall, there was no significant change in the survival of eggs.

Holliday et al. (1987) obtained mixed results during studies undertaken over a two-year period, with eggs and larvae exposed to sound pressures of 221 – 235 dB re 1 µPa at 1.5 m from a seismic source. Either no significant impact was observed or a 9% reduction in the survival of eggs. Pearson et al. (1994) reported no effects to crab larvae exposed to sound pressures up to 231 dB re 1 µPa at 1 m from a seismic source. Booman et al. (1996) exposed fish eggs and larvae to sound pressures of 220 – 242 dB re 1 µPa. High rates of mortality were observed at distances of 1.4 m from the seismic source, but low or no mortality rates were observed at distances of 5 m.

In a review of the above studies, Payne et al*.* (2004) noted that injury and mortality to eggs and larvae is likely to be limited to within 5 m of the seismic source. Payne et al. (2009) found no statistical differences between controls and exposed larvae following exposure to mean sound pressure levels of 205 dB re 1 µPa PK-PK, positioned 0.5 m from the seismic source element.

The effects of an operating 3D seismic array on plankton were investigated by Parry et al. (2002). Vertical plankton tows (0 – 20 m depth) were taken along transects running parallel and adjacent to seismic survey lines. Plankton tows along the impact transect were made within 30–60 minutes of the seismic pass. Parry et al. (2002) found no detectable impacts on plankton based on their species composition and live/dead state.

Day et al. (2016a) found no effects on the mortality, abnormality, competency, or energy content of lobster larvae after exposure of early embryonic stages to 209-212 dB re 1µPa PK-PK. Pearson et al. (1994) exposed crab larvae to single pulses from a seismic source array. For immediate and long-term survival and time to moult, this study did not reveal any statistically significant differences between the exposed and unexposed larvae, even those exposed within 1 m of the seismic source.

Impacts to larvae have been identified following intense and lengthy periods of exposure to low-frequency sound. Tank experiments by Aguilar de Soto et al. (2013) showed evidence of morphological abnormalities in early stage scallop larvae from simulated seismic signals. However, the lengthy exposure period of 3 second pulse intervals for an exposure duration of 90 hours and at 1 m distance from sound source is not realistic of an actual survey. Christian et al. (2003) found major developmental differences between control and treatment groups of snow crab eggs exposed to a peak pressure level of 216 dB re 1 µPa every 10 seconds for 33 minutes. Again, the exposure to a constant peak pressure level for a prolonged period is not realistic of an actual survey where the source is moving and so does not remain in one place.

Hawkins (2014) used continuous sonar to record zooplankton layers, comprising copepods, cladocerans, decapod larvae, gastropod larvae and bivalve larvae, exposed to playback of pile driving sound (pile driving sound typically has a more rapid rise time, more frequent strike rates and therefore a greater sound exposure regime than a seismic survey). Zooplankton layers responded to sound by showing a 'dent' in the top of the layer at the onset of the sound sequence, although the change in depth often did not persist for the whole duration of the sound exposure and zooplankton distribution quickly returned to normal.

Therefore, physical impacts to planktonic organisms have typically been found to be limited to within approximately 10 m of the seismic source. Using this 10 m impact range, a study by McCauley (1994) calculated the impact in a seismic survey area, assuming plankton mortality of 100% within 10 m of a seismic source. This suggested that the total mortality due to seismic testing would impact less than 1% of plankton in the survey area. DNV Energy (2007) and Hawkins & Popper (2012) conducted comprehensive reviews of a number of scientific studies, including those by Kostyuchenko (1973), Dalen and Knutsen (1987), Booman et al. (1996) and Saetre and Ona (1996); the effects of seismic activities on eggs and larvae were predicted to result in average and worst-case mortality rates of 0.0012% and 0.45% per day respectively, which were not deemed significant when compared to a natural mortality rate of 5-15% per day, as applicable to most species during early life stages.

Based on the available data, Popper et al. (2014) proposed a precautionary threshold for mortality of fish eggs and larvae of >207 dB re 1 µPa PK, and noted this is likely to be conservative.

A study by McCauley et al. (2017) suggested the potential for zooplankton mortality to increase two- to three-fold out to a distance of 1.2 km from a single seismic source element, with an estimated decline in zooplankton abundance of up to 64% and a "hole" in the zooplankton backscatter observed via acoustic detection methods. The 1.2 km range corresponded with pressure levels of 178 dB re 1 µPa PK-PK (McCauley et al. 2017). However, the extent of such impacts are inconsistent with previously documented effects to plankton. McCauley et al*.* (2017) highlight some limitations to the findings of this research that have raised further questions from industry and the scientific community (e.g. Richardson et al. 2017; IAGC 2017) and a need for the study to be replicated before conclusions regarding effects to zooplankton can be made, particularly in relation to the following:

- There was no evidence of attenuation of impacts with distance from the source with no consistent decline in the proportion of zooplankton that were killed with increasing distance from the source.
- Sonar backscatter data indicated an immediate decline in zooplankton abundance (the "hole" in the data). However, if the zooplankton had been killed, they would not have sunk from the surface layers of the water column immediately, suggesting that some zooplankton may have moved, or they may have simply reorientated themselves to the sonar in response to the seismic pulses, which raises questions over the occurrence, magnitude and extent of mortal impacts.
- The study was based on a relatively small number of tow samples on two separate days. On the second day, even before the use of the seismic source element, the zooplankton net tow abundance counts were significantly lower than the first day and, therefore, it is difficult to draw reliable conclusions from this data. On the second day almost all values at 80 metres range presented greater plankton abundance from exposed samples and lower abundance of control samples, indicative of a potential flaw in the sampling scheme and analysis protocol.

Further research, including duplication of the McCauley et al. (2017) experiments, is therefore proposed by industry to explore these matters further, but is yet to be completed.

A study by Fields et al. (2019) exposed zooplankton (copepods) to seismic pulses at various distances up to 25 m from a seismic source. The source levels produced were estimated to be 221 dB re 1 µPa^2.s SEL and comparable to the far-field source levels predicted for the source options being considered for the INPEX Bonaparte Basin 3D MSS (which range between approximately 222 and 225 221 dB re 1 µPa^2.s SEL in the horizontal plane). The study observed an increase in immediate mortality rates of up to 30% of copepods in samples compared to controls at distances of 5 m or less from the airguns. Mortality one week after exposure was significantly higher by 9% relative to controls in the copepods placed 10 m from the airguns. Fields et al. (2019) also reported that no sublethal effects occurred at any distance greater than 5 m from the seismic source. The findings of the study are consistent with numerous other field studies, as referenced previously, indicating that the potential effects of seismic pulses to zooplankton are limited to within approximately 10 m from the seismic source. Fields et al. (2019) note that the findings of the McCauley et al. (2017) study are difficult to reconcile with the body of other available research. The findings of the McCauley et al. (2017) study may, therefore, provide an overly conservative estimate of the potential effects of seismic pulses to zooplankton.

Day et al. (2021) examined the potential impacts of seismic surveys on the larval stages of southern rock lobster 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 $\mu Pa^2 \cdot s$ per-pulse SEL, and SELcum of 201 to 205 dB re $\mu Pa^2 \cdot s$, comparable to the previous study by Day et al. (2016a) (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.

While research generally suggests limited impacts to plankton beyond approximately 10 m distance from seismic sources, the precautionary Popper et al. (2014) threshold for larval mortality of >207 dB PK has been selected to indicate the magnitude and extent of potential impacts from the INPEX Bonaparte Basin 3D MSS. The research by McCauley et al. (2017) and Day et al. (2021) is also discussed in the assessment of impacts and risks in this EP, in order to address any scientific uncertainty and provide another level of conservatism regarding potential sub-lethal effects on zooplankton and larvae.

Table 7-5: Impact and risk evaluation – underwater noise and vibration – planktonic communities

<table>
<tr><th colspan="2">Identify hazards and threats</th></tr>
<tr><td colspan="2">Impulsive sound emitted from the seismic source has the potential to result in the mortality or physical impairment of plankton, including eggs and larvae. If changes to planktonic communities are extensive, they may indirectly affect higher trophic level species such as invertebrates, fishes and marine mammals that target plankton as a food source or result in potential impacts to the eggs and larvae of various organisms, which could in turn impact recruitment.</td></tr>
<tr><th>Potential consequence</th><th>Severity</th></tr>
<tr><td>The particular values and sensitivities with the potential to be impacted by underwater noise are:
• zooplankton communities
• fish and invertebrate eggs and larvae.
Planktonic communities comprise phytoplankton and zooplankton, including fish eggs and larvae. Phytoplankton and zooplankton are a source of primary and secondary productivity, and key food sources for other organisms in the oceans.
Zooplankton recorded in the Joseph Bonaparte Gulf by ERM in the wet and dry seasons of 2010 and 2011, in waters to the south-west of the Operational Area indicated that copepods represented the most dominant group within the macro-zooplankton assemblage (ERM 2011). Larval fishes during both seasons were dominated by commercially targeted Serranidae (cods) and Lutjanidae (snappers). Larval fish density also varied seasonally with the 2011 dry season (May 2011) recording the highest densities of larval fishes in the zooplankton (ERM 2011). This seasonal effect is consistent with the notion of an extended spawning season (and possibly planktonic larval duration) of the reef species dominating the larval fish assemblage in the study area at this time (ERM 2011).
Potential impacts and risks to plankton are generally understood to be limited and highly localised (see above). Applying the likely-precautionary impact thresholds proposed by Popper et al. (2014), the acoustic modelling undertaken by JASCO (Muellenmeister et al. 2022; Appendix C) for the Bonaparte Basin 3D MSS indicates that potential for mortality to eggs and larvae could occur within approximately 180 – 190 m from the seismic source, depending on location and water depth.
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 NWMR and 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 & Hutchings 1996; Holliday et al. 2011; McKinnon et al. 2008; Pearce et al. 2000; Sutton & Beckley 2017).</td><td>Insignificant (F)</td></tr>
</table>

The natural life span, growth, reproduction and mortality rates are important factors that influence this natural variability. Copepods have been found to comprise up to 75 – 85 % of zooplankton communities in the continental shelf waters of the Kimberley region, with chaetognaths, euphausiids and cladocerans also common in tropical Australian waters (Timms 1988; Holliday et al. 2011; McKinnon et al. 2015, Richardson et al. 2017). Information on life spans in the open ocean is limited, but under favourable conditions in tropical and sub-tropical environments these common zooplankton taxa have lifespans in the order of a few weeks and sometimes to several months, during which reproduction occurs frequently (Hawkins 1962; Gómez-Gutierrez et al. 1995; Delbare et al. 1996; Yamaguchi & Ikeda 2000; Pietrzak et al. 2013; Terazaki et al. 2013; Escribano et al. 2013; Tang et al. 2014). The embryonic and pelagic larval durations of numerous broadcast spawning fish species typical of the region is in the order of days to weeks, for example tropical snappers and emperors such as red emperor, goldband snapper and stripey snapper have a planktonic phase of approximately 30-40 days prior to settlement on suitable habitat, with regular replenishment from multiple spawning events in a season (Stobutzki & Bellwood 1997; Zapata & Herrón 2002; DiBattista et al. 2017). However, due to environmental factors such as predation, food availability, and water temperature, the life spans of zooplankton are often significantly shorter and natural mortality rates can be high. In a review of natural mortality estimates by Houde & Zastrow (1993), the mean mortality rate for marine fish larvae was estimated to be 21.3% per day. Saetre & Ona (1996) estimated 5-15% zooplankton mortality per day based on available research. Richardson et al. (2017) determined a natural mortality rate of 19% per day, derived from data in McCauley et al. (2017). Tang et al. (2014) reported mortality rates of 11.6% (average minimum) to 59.8% (average maximum) in marine environments based on a review of available research, and in some instances 100% of samples were found to die within a day. These mortalities are only partly the result of predation; non-predatory factors have been estimated to account for 25% to 33% of the total mortality among marine copepods on average (and higher in some instances) (Hirst & Kiørboe 2002; Tang et al. 2014; Dubovskaya et al. 2015). Given the level of natural variability in planktonic communities, the effect of the seismic source is expected to be negligible. The seismic source will be transient (i.e. continually moving across the Acquisition Area) and, if operation of the seismic source coincides with areas of increased plankton or larvae biomass, the extent of potential mortality (up to 180 – 190 m) is minimal. However, the study by McCauley et al. (2017) implies that the extent of impacts to plankton, eggs and larvae could be significantly greater than the 160 – 230 m ranges indicated by the application of the Popper et al. (2014) threshold. Impacts to zooplankton in the McCauley et al. (2017) study corresponded with a sound pressure of just 178 dB re 1 μPa PK-PK and effects ranges in the order of kilometres, which is highly unrealistic given the physiology and limited sensitivity of plankton, eggs and larvae. Even so, to apply a precautionary approach to this assessment, the McCauley et al. (2017) results are discussed, but it is important to put these distances and impacts into a real-world context. A study by the Commonwealth Scientific and Industrial Research Organisation (CSIRO; Richardson et al. 2017) estimated the spatial and temporal impact of seismic activity on zooplankton biomass on the Northwest Shelf from a large-scale 3D seismic survey, considering the mortality estimates in McCauley et al. (2017) study while also accounting for typical growth rates, natural mortality rates, and the ocean circulation in the region.	

Richardson et al. (2017) took into account that the seismic source and associated impact radii for zooplankton would be constantly moving across the survey area, and would not return along a parallel line for several hours, during which time the movement of zooplankton with currents would have introduced new zooplankton to the survey area, while any "holes" would move down current and also gradually become re-populated by zooplankton from non-impacted areas. The results of the simulations showed that the impact of the seismic survey on zooplankton biomass was greatest in the immediate vicinity of the survey area where 22% of the zooplankton biomass was removed. Further, it was predicted that a reduction of 14% and 2% in zooplankton biomass would occur at distances of 15 km and 150 km from the survey area, respectively. Relative to the natural mortality rates described above, impacts do occur but the reduction in plankton biomass is limited and is likely to be within natural variation. For example, the natural mortality rate of 19% plus the 22% reduction observed to occur in the immediate vicinity of the survey area (41%) is still within the 5—60% range of natural mortality rates observed in other studies. Taking into account natural recovery and recruitment rates, the time to recovery within 15 km of the survey area was predicted to be approximately three days after the end of the survey (Richardson et al. 2017). 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). Richardson et al. (2017) also observed that zooplankton biomass generally showed a decline within the survey area until Day 22 of the simulations, and then increased relatively until the end of the simulated survey on Day 36; this reflects the movement of water through the survey area and the recovery of the zooplankton biomass as it moves into non-impacted areas, which indicates that beyond ~22 days, the duration of a seismic survey may not contribute any additional change in overall biomass in the region relative to natural mortality rates and rates of recovery. The main finding of the CSIRO study (Richardson et al. 2017) was there was a significant impact from seismic activity to zooplankton populations on a local scale only, but on a regional scale the impacts were minimal and were not discernible over the NWMR. This is important given that the distribution of planktonic communities and the spawning of fish stocks in these continental shelf waters typically occurs on a regional scale. It is also important to note that the example modelled by Richardson et al. (2017) was a 3D seismic survey covering an area of 80 km x 36 km with adjacent acquisition lines spaced 600 m apart, therefore resulting in the seismic source passing along a parallel line approximately every 8 – 10 hours. These survey parameters provide for an exposure regime that is comparable to the Bonaparte Basin 3D MSS. Therefore, even adopting a highly precautionary sound exposure threshold and the impact ranges inferred by the McCauley et al. (2017) study, mortality impacts on plankton biomass will be only be discernible locally. Impacts are expected to be insignificant at a regional scale relative to the natural spatial and temporal variability in plankton abundance, and the very high rates of natural mortality. Impacts to zooplankton as a food resource for other species is also expected to be localised and short-term. Even after plankton die, their carcasses may remain in the water column for several days where they are scavenged by pelagic organisms before any remaining carcasses sink to the seafloor to be consumed by opportunistic benthic organisms (Kirillin et al. 2012; Tang et al. 2014; Dubovskaya et al. 2015). Therefore, zooplankton are still available as a food source for other organisms after they die.	

In terms of the potential indirect impacts to the recruitment of fishes and invertebrates, various species spawn and release eggs on the continental shelf at various times throughout the year. These life stage events typically occur at a regional or sub-regional scale and over many months, with individuals spawning regularly throughout their respective spawning seasons and releasing millions of eggs each season (Section 4.9.6). Commercially significant fish larvae occur across the continental shelf and in the deeper waters beyond the continental shelf break (Holliday et al. 2011). Many of these species show evidence of biological connectivity and stock recruitment over hundreds and even thousands of kilometres, and in some cases across northern Australia (Section 4.9.6). Therefore, fish stock recruitment is not expected to be significantly impacted as a result of localised mortalities associated with the transient seismic source; especially when compared with mortalities from other natural causes that can occur ubiquitously across the entire region. As with impacts to other zooplankton, impacts to the eggs and larvae of the various fish stocks over the distances and timeframes associated with spawning events are not expected to be significant at a regional level. Some localised mortality to eggs and larvae may occur as the seismic source transits across the Acquisition Area, but this is unlikely to be discernible from the natural variability in mortality rates, such as from predation and other environmental factors. Therefore, no discernible impacts on larval populations and fish stock recruitment are expected. Impacts to key commercial fish species, including impacts to spawning fishes, are assessed in more detail in Section 7.1.6. Commercially targeted prawns spawn in the Joseph Bonaparte Gulf with banana prawn nursery grounds located in coastal waters. Day et al. (2021) found no evidence of elevated mortality for larval and juvenile rock lobster exposed to seismic impulses up to 500 m from the source. Therefore, it is possible that similarly there would be no direct mortality to prawn larvae, further supporting that the Popper et al. (2014) threshold for mortality/injury is conservative. However, Day et al. (2021) did report increased intermoult duration at 500 m from the seismic source, which suggests potential sub-lethal effects such as impaired development and growth could occur. Similar impacts to prawn larvae may occur, and therefore potential sub-lethal impacts could result in hindered development and/or increased predation of some prawn larvae. Impacts to commercial prawn species are assessed in more detail in Section 7.1.5. Overall, potential impacts to planktonic communities are expected to be localised and temporary. Most scientific studies indicate that plankton will only be impacted within tens of metres of the seismic source; however, the assessment of impacts and risks has also considered highly conservative estimates of potential impacts over hundreds of metres to several kilometres from the seismic source. Even at these ranges, impacts are expected to be insignificant at a regional scale relative to the natural spatial and temporal variability in plankton abundance and the very high rates of natural mortality. The short life cycle and rapid turnover of many zooplankton also means there is potential for subsequent recruitment and rapid recovery. No long-term population or community level impacts are expected. As such, the consequence of seismic source exposure to planktonic communities is considered to be Insignificant (F).	
Identify existing design and safeguards/controls measures	
The seismic source levels will be limited to the minimum required to achieve the objectives of the survey. The seismic source specification will be verified prior to commencement of the Bonaparte Basin 3D MSS (Section 7.1.3). The Active Source Area has been defined to cover the minimum possible area to achieve the objectives of the survey.	

Propose additional safeguards/control measures (ALARP Evaluation)			
Hierarchy of control	Control measure	Used?	Justification
Elimination	No use of a seismic source (i.e. no sound emissions).	No	The Bonaparte Basin 3D MSS cannot be achieved without using a seismic source. Elimination of the seismic source is not possible.
Substitution	None identified	N/A	N/A
Engineering	Design the Bonaparte Basin 3D MSS so that lines are only acquired perpendicular to the prevailing current direction	No	As identified by Richardson et al. (2017), surveys conducted into or across the prevailing current direction are theoretically less likely to impact the same zooplankton populations multiple times. Impacts to zooplankton are greater when ocean circulation carries zooplankton in the same direction that a seismic survey is acquired, as the zooplankton will be exposed multiple times to the seismic source. Attempting to design and acquire the survey into or across the prevailing current direction is not possible. The Bonaparte Basin 3D MSS line plan has been proposed to optimise the geophysical data that will be acquired during the survey. The costs and complexity of attempting to implement this option are grossly disproportionate and highly impracticable when compared to the already low level of risk posed by the survey to planktonic communities.
Procedures & administration	Limit seismic acquisition to daylight hours only	No	As identified by Richardson et al. (2017), conducting survey activities during the day rather than the night may minimise impacts on zooplankton. This is because zooplankton migrate vertically in the water column to balance food intake and predation risks, and are generally found at greater depths during the day. Therefore, fewer zooplankton may occur near the surface during the day than at night. Although some vertical attenuation of sound with depth beneath seismic sources does occur, sound pressure levels near the seismic source will only be slightly reduced over the depth ranges that zooplankton migrate in the vertical plane and so limited differences in received sound pressure levels and ranges to impact are expected.

			Such a control would also add major scheduling constraints, potentially doubling the overall survey duration. The costs of implementing this, as well as the increased potential for other impacts and risks as a result of the extended survey duration, is grossly disproportionate when compared to the already low level of risk to planktonic communities. This option is not practicable.
Identify the likelihood			
Research into the effects of seismic on planktonic communities generally indicates impact may occur within a few metres or a few tens of metres from the seismic source. The assessment of consequence to planktonic communities assumes more conservative ranges to impact over hundreds of metres to several kilometres from the seismic source. Impacts to planktonic communities over these ranges is unlikely, but the likelihood of the Insignificant consequences occurring is conservatively ranked as Possible (3).			
Residual risk summary			
Based on a consequence of Insignificant (F) and a worst-case likelihood of Possible (3) the residual risk is Low (8).			

Consequence	Likelihood	Residual risk
Insignificant (F)	Possible (3)	Low (8)

Assess residual risk acceptability

Legislative requirements

N/A – There are no specific legislative requirements applicable to managing the effects of seismic surveys in relation to planktonic communities.

Stakeholder consultation

Fisheries stakeholder feedback during preparation of this EP was received from the NT DITT, NTSC, NPFI and NT Demersal Fishery licence holders (Table 5-4). However, concerns raised related primarily to disruption to commercial fishing operations rather than impacts of seismic to plankton and secondary impacts to the food chain, larvae and recruitment. No other stakeholders raised any concerns, objections or claims in relation to impacts to plankton.

Australian Marine Park management objectives and values

The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Potential impacts to planktonic communities are expected to be localised and temporary. Impacts are expected to be insignificant at a regional scale and will not extend to either MP. No population or community level impacts or food chain impacts are expected that would impact marine park values.

Conservation management plans / threat abatement plans

Several conservation management plans have been consulted in the development of this EP. However, none of the recovery plans or conservation advice documents are specifically relevant to the effects of seismic or other anthropogenic noise on planktonic communities.

ALARP summary

<table>
<tr><td colspan="3">Although the level of environmental risk is assessed as Low, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond the existing design can reasonably be implemented to further reduce the risk of impact.
Acceptability summary
Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because:
• the activity demonstrates compliance with legislative requirements/industry standards;
• the activity takes into account stakeholder feedback;
• the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
• the activity is managed in a manner that is consistent with the intent of conservation management documents;
• the activity does not compromise the relevant principles of ESD; and
• the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as “Low”, the consequence does not exceed “C – Significant” and the risk has been reduced to ALARP.</td></tr>
<tr><th>Environmental performance outcomes</th><th>Environmental performance standards</th><th>Measurement criteria</th></tr>
<tr><td>N/A no controls identified</td><td></td><td></td></tr>
</table>

7.1.5 Underwater noise and vibration – Invertebrate communities

Receptor sensitivity to sound and sound exposure thresholds

Marine invertebrates, and particularly fixed or sessile benthic organisms, generally have far lower mobility than pelagic vertebrates, and are often limited to particular habitats. As such, they generally have less ability to avoid an approaching seismic sound source. However, marine invertebrates are generally considered to have limited sensitivity to sound. Marine invertebrates lack a gas-filled bladder and are unable to detect the pressure component of sound waves (Parry & 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 & Gason 2006; André et al. 2016; Roberts et al. 2016; Edmonds et al. 2016; Carroll et al. 2017; Popper & 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.

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).

Published exposure criteria do not currently exist for acoustic impacts to invertebrates but the available literature provides an indication of the sound levels and distances over which impacts may occur.

Crustaceans

Crustaceans (including crabs, shrimps, prawns and scampi) detect sound vibrations at close range through their statocysts. Several studies have been undertaken on decapod crustaceans (lobsters, prawns, crabs), both in Australia and internationally, with a range of effects to no effects identified, though none have found any evidence of increased mortality due to acoustic impacts from seismic exposure. A range of physiological responses have been identified in some studies, however, the received sound levels are typically at levels that would be received within a few tens of hundreds metres from the sound source or have been from repeated exposure at the same sound levels, which is not realistic in an actual seismic survey. Outcomes of key studies are summarised below.

Lethal effects have not been observed in studies of exposure of lobsters, crabs or shrimps (Christian et al. 2003; Andriguettto-Filho et al. 2005; Parry and Gason 2006; Payne et al. 2007; Day et al. 2016a). No behavioural response or evidence of animals migrating out of a seismic survey area have been reported in snow crabs (Christian et al. 2003) or in shrimp (Celi et al. 2013).

A pilot study on snow crabs (Christian et al. 2003) exposed captive adult male crabs and egg-bearing female crabs to approximately 197–237 dB re 1 µPa PK-PK and SELs of <130–187 dB re 1 µPa²s. The crabs were exposed to 200 pulses over a 33-minute period. No acute or chronic (12 weeks post-exposure) mortality impacts were observed in the adult crabs. Stress indicators in the snow crabs also showed no evidence of significant acute or chronic impacts. The crabs also did not exhibit any overt startle response during the exposure period or avoidance of the area following exposure.

DFO (2004) also exposed caged egg-bearing crabs to 132 hours of impulses from a seismic survey with maximum received sound levels of approximately 190 dB re 1 µPa PK. Neither acute nor chronic lethal or sub-lethal injury to the female crabs or crab embryos were observed up to five months following exposure.

Payne et al. (2007) conducted a pilot study of the effects of exposure to seismic sound on various health indicators of American lobster. Adult lobsters were exposed at approximately 2 m range from a seismic source for either 20 or 200 times to average pressures of 202 dB re 1µPa PK-PK or 50 times to 227 dB re 1µPa PK-PK, and then monitored over several months for changes to survival, food consumption, turnover rate, and serum biochemistry. No immediate or delayed mortality was observed, nor damage to mechano-sensory systems and the ability of lobsters to right themselves when turned over. There was evidence of a decrease in serum enzymes and increases in food consumption in the weeks to months post exposure, which may indicate stress effects or potential osmo-regulatory disturbance. The results therefore indicate the potential for sub-lethal effects but there were no obvious impacts to long-term survival and, therefore, limited ecological implications. Payne et al. (2008) did not observe any startle responses in aquarium experiments with lobsters and shrimp exposed to approximately 200 dB re 1µPa PK-PK.

Robert & Elliot (2017) reviewed research on particle motion effects to invertebrates, specifically vibration in the seabed, noting studies on particle motion reception in crustaceans, including Goodall et al. (1990) who studied the response threshold of Norwegian scampi to acoustic stimuli. It was found that the source of the vibration had to be <1 m away (in the acoustic near field) to initiate a response, confirming that the subjects were detecting particle motion, greater in the near field, rather than pressure. Distinct and reliable responses were exhibited in both the laboratory and the field in response to certain stimuli at low frequencies of 20–200 Hz and ground accelerations of 0.01 – 1.4 m/s^2. The sensitivity of the receptor systems in crustaceans has been noted to be much less compared to fish (up to 10^5 times lower in terms of particle velocity) (Goodall et al. 1990; Fay & Simmons 1998).

Research undertaken by Day et al. (2016a, 2016b, 2019) over three years in Australian waters, exposed captive southern rock lobster to multiple passes of a seismic source element in 10-12 m water depths. Maximum received sound exposures were 209-213 dB re 1µPa PK-PK, equivalent to a full-scale commercial array (3,100 cui) passing within approximately 100–500 m. 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.

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.

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 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 & Gardner 2009; Kordjazi et al. 2015). Therefore, the levels of statocyst impairment reported in the Day et al. (2016a, 2016b) study appear not to be impacting on the survival of the lobster population. Therefore, any population-level survivability effects from statocyst impairment are not significant and wider ecological implications are likely to be negligible.

The implications of the reduced haemocyte counts reported by Day et al. (2016a, 2016b) as an indicator for immune function are difficult to predict. It is noted that haemocyte counts in some lobsters in the experiment recovered to double the number of haemocytes observed in control lobsters at 365 days post-exposure, which may indicate possible recovery of immune function in response to pathogens. Other research has shown considerable variation in crustacean haemocyte counts in response to changes in environmental parameters such as salinity, temperature, dissolved oxygen, water quality and bacteria (Verghese et al. 2007; Phillips 2008; Leema et al. 2010), nutritional status (Pascuel et al. 2006), sickness (Fotedar & Evans 2011; Sequeira et al. 1996), and other anthropogenic sound such as vessel noise (Celi et al. 2014; Filiciotto et al. 2014). Chandrapavan et al. (2011) observed decreases in haemocyte levels in lobsters of between approximately 57% to 72% during their natural moult cycle, which are proportionally comparable or higher than the 23% to 60% decreases reported by Day et al. (2016a). Jussila et al. (1997) found that the stress of fishing, capture, handling and transporting live lobsters increased haemocyte counts by 200% in the short-term and then led to a decline of up to 55%. Therefore, while the physiological changes observed by Day et al. (2016a, 2016b) as a result of seismic exposures are linked to immune function and stress response, the changes are likely within the range of variation that can occur from a range of other common natural and anthropogenic stressors, which generally do not affect survival.

Day et al. (2021) exposed rock lobster puerulus (post larvae stage) to a full commercial scale seismic survey at a range of 500 m from the vessel sail line. Maximum received sound exposures were 203-219 dB re 1μPa PK-PK, 181 to 190 dB re 1 $\mu Pa^2 \cdot s$ per-pulse SEL, and SELcum of 201 to 205 dB re $\mu Pa^2 \cdot s$. Exposure did not result in any elevated mortality for puerulus, but reduced their righting ability and increased inter-moult period, suggesting potentially slowed development and increased physiological stress.

Molluscs and echinoderms

Molluscs include benthic invertebrates such as marine bivalves (e.g. scallops, oysters, mussels and clams) and gastropods (e.g. sea snails/trochus, sea slugs and nudibranchs). Echinoderms include feather stars, sea stars, brittle stars, sea urchins and sea cucumbers. Like crustaceans, the mechanism of impacts for molluscs and echinoderms are unlikely to be from sound pressure, but rather from particle motion. The physiology and sensory structures of different marine bivalves and echinoderms is similar and so results of studies on the effects of seismic are considered to be broadly representative for species other than those studied.

Wardle et al. (2001) monitored molluscs and echinoderms on a shallow water reef exposed to seismic sound with peak sound pressure levels of 218, 210 and 195 dB re 1 µPa at distances of 5 m, 16 m and 109 m respectively. Video observations made over two weeks indicated that the sound did not result in invertebrates moving away from the reef and there was little effect on their day-to-day behaviour.

Kosheleva (1992; cited in Parry & Gason 2006) 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; cited in Parry & Gason 2006) 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 would not occur during the INPEX Bonaparte Basin 3D MSS.

Recent Australian studies (Przeslawski et al. 2016, 2018; Day et al. 2016b, 2017) have focussed on commercial scallops. 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 μPa^2.s per-pulse SEL, and SEL_{cum} of 188 to 198 dB re $1\mu Pa^2$.s. The study also predicted ground acceleration of up to 37.57 m/s^2. 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 6-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 behavioural patterns during exposure, through a reduction in classic behaviours and demonstration of a non-classic “flinch” response to seismic signals. Furthermore, following exposure scallops showed an increase in recessing into sediment following exposure (Day et al. 2017).

Przeslawski et al. (2016, 2018) examined the short-term impacts on scallops and other marine invertebrates from a 2,530 in^3 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. Przeslawski et al. (2018) concluded that there was no evidence of increased scallop mortality, or effects on scallop shell size, adductor muscle diameter, gonad size, or gonad stage due to the seismic sound from an actual seismic survey. Przeslawski et al. (2018) concluded that the study provided no clear evidence of adverse effects on scallops, fish, or commercial catch rates due to the seismic survey.

Corals, sponges and soft filter feeders

The primary mechanisms for injury of corals from exposure to high amplitude sound are understood to be: (1) breaking of the external coral skeleton that could also damage the polyp tissue, and (2) rupture or tearing of polyp tissues (Hastings 2008). The forces required to cause such injuries were predicted by Hastings (2008) to be in excess of 260 dB re 1 µPa PK-PK. Sponges and soft filter feeder invertebrates are a similar density as water and do not contain air cavities that might respond to rapid pressure changes.

Hastings et al. (2008), Battershill et al. (2008) and Heyward et al. (2018b) investigated the effects of the Woodside Maxima 3D MSS on hard corals in water depths of approximately 40-60 m within south Scott Reef lagoon. Corals received maximum sound pressure levels of 226 dB re 1µPa PK. 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. Soft corals were also examined, with particular notice taken of soft coral morphology and polyp extension immediately after seismic passes. No change on soft coral abundance was detected and there was no evidence of a behavioural response, such as polyp withdrawal or flaccidity (Battershill et al. 2008; Heyward et al. 2018b).

The Gigas 2D Pilot OBC MSS coral monitoring study (SKM 2008) examined the potential for physical damage to a range of shallow water corals in north Scott Reef lagoon from seismic source emissions. This survey had a measured at source SEL of 206 dB re 1 µPa^2.s (McCauley 2008). The study concluded that sound emissions did not cause significant injury, tissue damage, sub-lethal stress or mortality to coral colonies, even when colonies are within a few metres of the seismic source (SKM 2008).

Similarly, a survey of coral reefs in Brunei that were subjected to seismic noise did not detect any damage to hard or soft corals, sponges or other sessile benthic organisms (IEC 2003).

Table 7-6: Impact and risk evaluation – underwater noise and vibration – invertebrate communities

<table>
<tr><th colspan="2">Identify hazards and threats</th></tr>
<tr><td colspan="2">Impulsive sound emitted from the seismic source has the potential to result in physical injury or physiological changes to marine invertebrates in close proximity to the seismic source. If changes to invertebrate communities are extensive, they may indirectly affect higher trophic level species such as fish and marine turtles that target invertebrates as a food source.
Extensive impacts to commercially significant prawns could impact recruitment and the sustainability of the stocks.</td></tr>
<tr><th>Potential consequence</th><th>Severity</th></tr>
<tr><td>The particular values and sensitivities with the potential to be impacted by underwater noise are:
• soft-sediment benthic invertebrate communities
• commercially significant prawn stocks in the Joseph Bonaparte Gulf (including spawning and recruitment).
The Operational Area includes relatively uniform and featureless bathymetry and the benthic communities that are expected to occur are predominantly soft sediments (sand, gravel and mud) with infauna and sparse epifauna. There are no banks, shoals, reefs or pinnacles within the Operational Area. The closest pinnacle feature, part of the Pinnacles of the Bonaparte Basin KEF, is located 8 km north-west of the Operational Area and 11 km from the Active Source Area.
Soft-sediment benthic communities
Although formal 'no impact' threshold criteria do not currently exist for benthic invertebrates exposed to seismic sound emissions, the research detailed above provides an indication of the types of impacts that may occur and the associated sound pressures. Table 7-7 provides PK-PK levels relevant to invertebrates and the horizontal distances over which these sound levels are predicted to be exceeded at the seabed, based on the modelling completed for INPEX by JASCO (Muellenmeister et al. 2022; Appendix C). The majority of research indicates that impacts to marine invertebrates (if any) are limited to within a few metres or a few tens of metres of the seismic source, at most. However, the levels reported by Day et al. (2016a, 2016b, 2017) and Payne et al. (2007) are presented to provide the most conservative estimates for potential sub-lethal effects or mortality to some invertebrates, noting that other studies (e.g. Kosheleva 1992; Christian et al. 2003; Wardle et al. 2001; Przeslawski et al. 2016, 2018) found no evidence of impacts to invertebrates following exposure to higher sound levels than those presented in Table 7-7. For crustaceans, a PK-PK sound level of 202 dB re 1 μPa (Payne et al. 2008) is considered to be associated with no effect.</td><td>Insignificant (F)</td></tr>
</table>

Table 7-7 Maximum (R_{max}) horizontal distances (in m) from the 3,050 in^3 source to modelled seafloor PK-PK relevant to benthic invertebrates in continental shelf waters (Muellenmeister et al. 2022)

PK-PK (L_{pk-pk}) (dB re 1 μPa)	Relevance	Distance R_{max} (m)		
		65 m depth	85 m depth	100 m depth
213	Crustaceans – Sub-lethal effects (Day et al. 2016a, 2017, 2019)	168	160	161
212	Bivalves – Sublethal effects and chronic mortality (Day et al. 2016b, 2017)	189	189	186
210	Crustaceans – Sub-lethal effects (Day et al. 2016a, 2019)	264	258	253
209		282	302	294
202	Crustaceans – No effect (Payne et al. 2007)	605	684	514

Impacts to sponges and soft filter feeders are not expected as the physical structure of sponges and soft filter feeders are not sensitive to rapid sound pressure changes. The sound level of 226 dB re 1μPa PK reported by Heyward et al. (2018b) as having no impact on hard and soft corals is not predicted to be exceeded at the seabed directly beneath the seismic source in any water depth (Muellenmeister et al. 2022; Appendix C). Therefore, the health and structural integrity of any sponges, filter feeders or soft corals that may occur will not be impacted. These types of epibenthos provide habitat for a range of other benthic invertebrates and so the habitat structures underpinning these benthic communities will not be affected.

Based on the above body of research, it is possible that some benthic invertebrate species may experience sub-lethal effects or a small increase in mortality rates in the weeks or months following seismic exposure at close range. Sessile (immobile) invertebrates may be most vulnerable as they cannot avoid the approaching seismic source. Based on the modelling results presented in Table 7-7, some chronic mortality may occur in some organisms at ranges up to 190 m, and sub-lethal effects are possible at ranges in the order of approximately 500—600 m from the seismic source, depending on water depth.

Should chronic lethal and sub-lethal effects occur in a small proportion of sessile invertebrates in the weeks and months following exposure, the continuous natural cycle of death, recovery and recruitment of invertebrates from adjacent sediments will occur in parallel over these same timescales. Therefore, it is questionable whether any impacts from seismic exposure would be detectable from natural fluctuations in relative abundance, benthic community composition and structure. During the survey, there may be situations when the seismic source must be shutdown (e.g. as mitigation for marine fauna sightings). Should this occur, the seismic vessel will return later in the survey to complete infill of sections of acquisition line that have been missed. In doing so, the survey vessel run-in over the line may result in operation of the seismic source over a small stretch of seabed that have been previously exposed to sound from the seismic source. It is possible that repeat exposures could result in a small increase in the proportion of organisms that experience sub-lethal effects or chronic mortality. For example, Day et al. (2016b, 2017) observed 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 6-year mean of 38% (Day et al. 2017). 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. Consequently, indirect impacts on higher trophic level species that target benthic invertebrates as a food source are also not expected. For example, benthic organisms are a key food source for demersal fish species such as snappers, emperors and groupers; following the passing of the seismic source, benthic invertebrates are still available to be foraged and any chronic mortality that occurs over the weeks or months following exposure is expected to be negligible in the context or natural mortality and recruitment. No effects are expected at pinnacles within the Pinnacles of the Bonaparte Basin KEF, located 11 km from the Active Source Area. Given the localised extent and temporary nature of potential impacts to benthic invertebrate communities, and the potential for subsequent recruitment and recovery (over weeks or months), no long-term population or community level impacts are expected. As such, the consequence of seismic exposures to benthic invertebrate communities is considered to be Insignificant (F). **Commercially significant prawn stocks (including spawning and recruitment)** The most commercially and economically significant invertebrate species in the Joseph Bonaparte Gulf are prawns, targeted by the NPF. Species caught include white banana prawns, red-legged banana prawns, brown tiger prawns, grooved tiger prawns, blue endeavour prawns and red endeavour prawns. Banana prawns and tiger prawns are indicator stocks for the fishery, while endeavour prawns are a non-target (but still retained) catch species. Historically, the Joseph Bonaparte Gulf has been particularly significant for banana prawns, with the Joseph Bonaparte Gulf contributing about 65% of the NPF's red-legged banana prawn catch and around 20% of the NPF's total banana prawn catch (both banana prawn species combined) (Loneragan et al. 2002).	

White banana prawns can generally be found at depths of 16 – 25 m but can occur to depths of 45 m. Red-legged banana prawns are found at depths of 35 – 90 m (AFMA 2021). Tiger prawns inhabit shelf waters to depths of 200 m but make up a smaller component of the catch in the Joseph Bonaparte Gulf. Red-legged banana prawns targeted by the NPF have the potential to occur in the shallower parts of the Operational Area, but tiger prawns are the species most likely to be present in the water depth ranges of the Operational Area (65 – 106 m). In the case of both species the Operational Area has not previously been an area where any significant levels of fishing effort or catch have occurred. Based on 2010 to 2020 ABARES fishing data and shot data provided by NPFI, most fishing effort in the Joseph Bonaparte Gulf has historically occurred over 55 km south-west of the Active Source Area. Therefore, it is indicated that the waters of the Operational Area do not frequently support significant populations of prawns. The biological stock structure of the banana and tiger prawn species is uncertain. There is some evidence that there may be separate biological stocks within the NPF, however, the boundaries of these biological stocks are unknown. In the Joseph Bonaparte Gulf, a single separate stock for banana prawns is assumed for stock assessment purposes, although stock status for the species is reported by ABARES at the management unit level (the whole of the Northern Prawn Fishery from the Kimberley region of WA to north-east Queensland) (Parsa et al. 2020). Both the banana prawn and tiger prawn stocks are assessed as being sustainable (Larcombe et al. 2018; Parsa et al. 2020). Although biological stock boundaries are uncertain and a stock–recruitment relationship is not established, the status of the stocks is based on a weight-of-evidence approach, with the harvest strategy in the NPF designed to ensure adequate remaining spawning biomass closing the fishing seasons if catch rates fall below set catch-rate trigger levels. The species has shown resilience to fishing pressure, with strong subsequent recruitment following historical high levels of catch and fishing mortality. The stock biomass is therefore unlikely to be depleted and that recruitment is unlikely to be impaired (Larcombe et al. 2018; Parsa et al. 2020). The assessment of impacts to spawning and recruitment of banana and tiger prawn stocks in the Joseph Bonaparte Gulf considers: • potential effects to the adult spawning biomass, specifically adult female prawns berried with eggs • potential effects to eggs and larvae dispersed in the water column • potential effects to migrating juveniles recruiting to the adult stocks. While some studies have been undertaken into the effects of seismic on prawn/shrimp, it is acknowledged that many studies have focused on crabs or lobsters and so there is some level of uncertainty in using these results in the prediction of impacts to prawns. However, given the similar physiology of decapod crustaceans such as prawns, lobsters and crabs, the information is considered to be relevant. <u>Effects to adult female prawns berried with eggs</u>	

Impacts on prawns are assessed based on research undertaken on seismic exposures to a variety of decapod crustaceans, including lobster, shrimp and crab. As summarised in Table 7-7, lethal effects have not been observed in studies of exposure of lobsters, crabs or shrimps (Christian et al. 2003; Andriguettto-Filho et al. 2005; Parry and Gason 2006; Payne et al. 2007; Day et al. 2016a). No behavioural response or evidence of animals migrating out of a seismic survey area have been reported in snow crabs (Christian et al. 2003) or in shrimp (Celi et al. 2013). A number of studies have exposed female crustaceans bearing eggs to sound pressures of approximately 196–237 dB re 1 μPa PK-PK, with no reports of acute or chronic mortality in the adult lobsters and no mortality of embryos (Christian et al. 2003; DFO 2004). Day et al. (2016a, 2016b) also reported that exposures equivalent to approximately 211 dB re 1 μPa (PK-PK) did not impact the condition or development of eggs carried by female lobsters, or the size or morphology of the larvae once hatched. Therefore, potential exposure of berried females to the seismic source is unlikely to result in any mortalities to adult females in addition to natural or fishing mortalities and, therefore, no reduction in the adult spawning biomass. Significant impacts to eggs carried by the females are also unlikely to occur, with berried eggs protected by adults expected to be less sensitive than dispersed planktonic eggs. The consequence is considered to be Insignificant (F). <u>Effects to eggs and larvae dispersed in the water column</u> Female prawns produce hundreds of thousands of eggs each year, released in batches over multiple spawning events. Prawns in the Joseph Bonaparte Gulf spawn to some degree throughout the entire year. Banana prawns have two peak spawning periods, September—November and March—May. Brown tiger prawns have a spawning peak between July and October. Grooved tiger prawns have a spawning peak in August—September, with a secondary peak in February. Fertilised eggs disperse in the water column and are carried by tides and currents. Larvae hatch within 24 hours and some larvae will eventually settle in nursery habitats in shallow coastal waters (e.g. mangroves, creeks and seagrass beds). Loneragan et al. (2002) found that offshore spawning resulted in the advection of banana prawn larvae over large distances in the Joseph Bonaparte Gulf before settlement in their nursery habitats. Less than 1% of larvae survive the 2—4 week offshore planktonic larval phase. The majority of larvae will either not reach appropriate settlement habitat, or may be lost to predation or other natural factors. During the egg and larval dispersal phase, some eggs and larvae may be impacted by seismic impulses emitted during the Bonaparte Basin 3D MSS. As described in Section 7.1.4, mortality and injury to zooplankton, including eggs and larvae, is likely limited to metres to tens of metres from a seismic source, although based on the Popper et al. (2014) threshold for eggs and larvae, some mortality impacts could occur in the water column up to 190 m from the seismic source. To assess the potential impacts to dispersed prawn eggs and larvae, the overlap of the survey and proportion of suitable spawning habitat for the Joseph Bonaparte Gulf prawn stocks has been considered. The assessment considers the spawning range of the two indicator species red-legged tiger prawns (35—90 m water depth) and tiger prawns (up to 200 m water depth). White banana prawns occur in water depths less than 45 m and so will not be impacted by the survey. The area of the Joseph Bonaparte Gulf that corresponds with the red-legged banana prawn depth range is approximately 40,000 km^2. The area of the Joseph Bonaparte Gulf that corresponds with the tiger prawn depth range is approximately 65,000 km^2. Some level of spawning may occur throughout this area, although greater spawning biomass is expected in the areas that have historically been targeted for prawns by the NPF (based on the 2010—2020 NPF fishing intensity data), over 55 km from the Active Source Area.	

In any 24 hour period of seismic data acquisition, during which eggs and/or larvae released from the adult spawning stock may drift through the survey area, the potential effects footprint associated with the 190 m range for potential mortality (based on the Popper et al. 2014 threshold) applied to sail lines would be equivalent to approximately 40 km^2, equal to or less than 0.1% of the areas in the Joseph Bonaparte Gulf where banana prawns and tiger prawns may occur respectively. Recent findings by Day et al. (2021) into lobster larvae may indicate that no direct mortality of larvae will occur; however, development of larvae may be impacted out to at least 500 m from the seismic source. It is acknowledged that the Day et al. (2021) study could not establish the maximum range to effects and it is based on the effects of seismic on rock lobster larvae and some differences may apply to prawn larvae. Therefore, a more conservative distance of 1 km from the seismic source has been applied. Day et al. (2021) did not find evidence of elevated mortality for lobster larvae, and it is not known whether impacts to development will compromise their survival in anyway. However, for the purposes of this assessment and to account for potential uncertainty into the effects of seismic on prawn aggs and larvae, it is conservatively assumed that prawn eggs and larvae within the 1 km range could be compromised from impaired development and survival. In any 24 hour period of seismic data acquisition, during which eggs and/or larvae released from the adult spawning stock may drift through the survey area, the potential effects footprint associated with the 1 km range applied to sail lines would be equivalent to approximately 640 km^2, 1.6% and 0.98% of the areas in the Joseph Bonaparte Gulf where banana prawns and tiger prawns may occur respectively. Given the proposed survey duration includes approximately 40 days of seismic data acquisition, the temporal overlap with the banana prawn and tiger prawn peak spawning periods is approximately 22% and 45% respectively. Therefore, the total spatio-temporal overlap with prawn spawning areas and peak spawning periods is just 0.35% for red-legged banana prawns (1.6% of the area may be exposed for 22% of the peak spawning period), 0.29% for brown tiger prawns (0.98% of the area may be exposed for 30% of the peak spawning period), and 0.44% for grooved tiger prawns (0.98% of the area may be exposed for 45% of the peak spawning period). Note that this proportion of the stocks relates to potential impaired development and survival rates, as reported in Day et al. (2021), not necessarily mortality. In the context of natural larvae mortality (potentially higher than 99% natural mortality given the less than 1% settlement rate) and naturally variable annual recruitment rates, the potential risk of the Bonaparte Basin 3D MSS on dispersed prawn eggs and larvae in the Joseph Bonaparte Gulf is considered to be Insignificant (F). <u>Effects to migrating juveniles recruiting to the adult stocks</u> Migration of the juvenile prawns occurs throughout the coastal waters of the Joseph Bonaparte Gulf and is thought to be triggered by rainfall and river discharge. The migration of juvenile red-legged banana prawns has been recorded to occur in the southern and eastern parts of the Joseph Bonaparte Gulf in areas that have been closed to fishing in recent years. Loneragan et al. (2002) defined a probable advection envelope for post-larval juvenile prawns that extends to the main prawn habitats and fishing areas over 55 km south-west of the Active Source Area. As the Active Source Area is located at the deeper extent of this species, the migration of juveniles is likely to be completely avoided with no impacts to the recruitment of this stock.	

The migration route for tiger prawns has not been defined but it is possible that some post-larval juveniles could recruit to the adult stock in deep waters overlapped by the Active Source Area. However, exposure of juveniles to the seismic source is not expected to result in direct mortality; exposure may lead to potential impaired development and some reduction in survival rates, as reported in Day et al. (2021), with the spatio-temporal overlap again being equivalent to approximately 0.29% and 0.44% of brown tiger prawns and grooved tiger prawns, respectively. In the context of naturally variable annual recruitment rates, the potential risk of the Bonaparte Basin 3D MSS on prawn stocks is considered to be Insignificant (F).			
Identify existing design and safeguards/controls measures			
The seismic source levels will be limited to the minimum required to achieve the objectives of the survey. The seismic source specification will be verified prior to commencement of the Bonaparte Basin 3D MSS (Section 7.1.3). The Active Source Area has been defined to cover the minimum possible area to achieve the objectives of the survey. The Active Source Area avoids any KEFs or other areas of significant areas of benthic habitat.			
Propose additional safeguards/control measures (ALARP Evaluation)			
Hierarchy of control	Control measure	Used?	Justification
Elimination	No use of a seismic source (i.e. no sound emissions).	No	The Bonaparte Basin 3D MSS cannot be achieved without using a seismic source. Elimination of the seismic source is not possible.
	Exclude sensitive benthic communities	No	The Active Source Area already avoids any areas of significant benthic habitat. The nearest pinnacle feature is over 11 km away. The Active Source Area also avoids any waters where commercial prawns have historically been fished, suggesting the area does not frequently support significant populations of prawns.
Substitution	None identified	N/A	No additional substitution controls were identified that would practicably reduce the risk to benthic communities.

Engineering	Include a time interval prior to repeat survey of overlapping sail lines in sensitive locations (including infill activities) to allow for potential recovery of benthic invertebrates.	No	Infill activities may be required if the survey vessel has to return to complete a section of line that was missed during a period of shut down, and will result in some overlap. Repeat exposures may result in an incremental increase in impacts to benthic organisms. For example, Day et al. (2017) reports 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 compared with 3.6—3.8% mortality in control scallops (no seismic exposure). Sub-lethal impacts may also be more prevalent in areas exposed to the seismic source more than once. It is important to note that benthic communities are expected to recover from such impacts, even if slight increases in the proportion of affected organisms does occur as a result of multiple exposures. Should lethal and chronic sub-lethal impacts occur in the weeks and months following exposure, the continuous natural cycle of death, recovery and recruitment of invertebrates from adjacent sediments will occur 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. Overall, the inherent risk to benthic communities is already low. Given that both impacts to benthic organisms and recovery are expected to occur over timescales of weeks or months, the option of delaying repeat survey of overlapping sail lines in any location is not practicable.

	Increased source point interval	No	The proposed source point interval is 12.5 m to 18.75 m. Increasing the shot point interval would result a noticeable loss in data quality and complexities during post-processing. Increasing the interval is also unlikely to achieve much additional environmental benefit in terms of the footprint of seismic impacts to benthic invertebrate communities, as sub-lethal impacts may occur to some species up to tens or hundreds of metres from each pulse. Increasing the interval would result in the quality of the seismic data being too poor to use. Therefore, this option is not practicable and is considered disproportionate to the already low level of risk to invertebrate communities.
Procedures & administration	Schedule survey to avoid or limit temporal overlap with prawn spawning.	No	Prawns in the Joseph Bonaparte Gulf spawn to some degree throughout the entire year. Banana prawns have two peak spawning periods, September—November and March—May. Brown tiger prawns have a spawning peak between July and October. Grooved tiger prawns have a spawning peak in August—September, with a secondary peak in February. Therefore, it is not possible to avoid prawn spawning completely and gaps between peak spawning periods for the various species are not long enough to accommodate the potential 65-day total survey duration that is proposed. This option is not practicable and is considered disproportionate to the already very low level of risk to prawn spawning and recruitment.
Identify the likelihood			
Research into the effects of seismic on benthic invertebrates indicates different results, with a range of impacts occurring at distances of a few metres or potentially up to hundreds of metres. Impacts may be limited to just a few metres from the survey acquisition lines in some cases, but the assessment of consequence assumes the more conservative ranges to impact over hundreds of metres. With the above described controls in place, the likelihood of temporary and localised impacts (hundreds of metres) to benthic invertebrate communities and potential impaired development and survival of prawn eggs and larvae, with Insignificant consequence, is considered Possible (3).			
Residual risk summary			
Based on a consequence of Insignificant (F) and a worst-case likelihood of Possible (3) the residual risk is Low (8).			

Consequence	Likelihood	Residual risk
Insignificant (F)	Possible (3)	Low (8)

Assess residual risk acceptability

Legislative requirements

N/A – There are no legislative requirements applicable to managing the effects of seismic surveys in relation to benthic invertebrate communities.

Stakeholder consultation

Fisheries stakeholder feedback during preparation of this EP was received from the NT DITT, NTSC, NPFI and NT Demersal Fishery licence holders (Table 5-4). However, concerns raised related primarily to disruption to commercial fishing operations rather than impacts of seismic to invertebrates or commercial prawn stocks. No other stakeholders raised any concerns, objections or claims in relation to impacts to invertebrates.

Australian Marine Park management objectives and values

The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Impacts of seismic exposure to marine invertebrates will be limited to tens of metres horizontal distance from the seismic and no impacts to marine park values will occur.

Conservation management plans / threat abatement plans

Several conservation management plans have been consulted in the development of this EP. However, none of the recovery plans or conservation advice documents are specifically relevant to the effects of seismic or other anthropogenic noise on invertebrates communities.

ALARP summary

Although the level of environmental risk is assessed as Low, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact.

Acceptability summary

Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because:

- the activity demonstrates compliance with legislative requirements/industry standards;
- the activity takes into account stakeholder feedback;
- the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
- the activity is managed in a manner that is consistent with the intent of conservation management documents;
- the activity does not compromise the relevant principles of ESD; and
- the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as “Low”, the consequence does not exceed “C – Significant” and the risk has been reduced to ALARP.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
N/A - no controls identified		

7.1.6 Underwater noise and vibration – Fishes

Receptor sensitivity to sound and sound exposure thresholds

Fishes may use sound to communicate, locate prey, detect predators, and as a cue for orientation (McCauley & Cato 2000). Fishes vary in their vocalisations and hearing abilities even within families, but generally hear best at low frequencies below 1 kHz (Ladich 2000). The structure and function of the auditory system in fishes has been extensively reviewed, and different fishes may detect the pressure and particle acceleration components of sound to varying degrees (Fay & Popper 2000; Popper et al. 2003; Nedwell et al. 2004; Popper & Fay 2011; Popper et al. 2014; Nedelec et al. 2016; Salgado Kent et al. 2016; Carroll et al. 2017; Popper & Hawkins 2018).

The hearing sensitivity of bony fishes varies between families and species. Hearing sensitivity is a function of specialised auditory structures in the inner ear (otoliths surrounded by an epithelium of hair cells) and, if present, the swim bladder (Finneran & 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 of fishes and is more pronounced in some groups of fishes than others. The lateral line system responds to water displacements (particle motion) produced in the near-field of a sound source, as well as to tiny water currents set up by the fish's own motions (Nedwell et al. 2004). Therefore, all fish are sensitive to the particle motion component of sound at close range from a seismic source or other sound source, while some more specialised fishes with a swim bladder involved in their 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; Hawkins & Popper 2016; Carroll et al. 2017).

Three categories of fishes have been defined by Popper et al. (2014) based on their hearing sensitivity:

1. Group I: Fishes with no swim bladder or other gas chamber – These fishes are less susceptible to barotrauma than fishes with a gas-filled space as they can only detect particle motion at close range, not sound pressure changes. However, some tissue barotrauma is possible from exposure to extreme sound pressure changes.
2. Group II: Fishes with swim bladders, but without a direct connection between the swim bladder and the inner ear – These fishes' hearing does not involve the swim bladder or other gas volume. Hearing primarily involves particle motion at close range, not sound pressure. However, the presence of a gas-filled swim bladder means that some limited indirect detection of sound pressure may be possible, and the swim bladder is susceptible to barotrauma if exposed to rapid and intense pressure changes.
3. Group III: Fishes with a swim bladder or other gas volume connected directly to the inner ear – These fishes are able to detect both sound pressure as well as particle motion, and are susceptible to barotrauma.

The third, most sensitive group of fishes relates predominantly to freshwater Otophysi fishes such as carp, minnows, catfish and piranhas, as well as freshwater Cichlids (Popper & Fay 1993; Nedwell et al. 2004; Schulz-Mirbach et al. 2012; Popper et al. 2014; Popper et al. 2019). In marine fishes, 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 such as Pomacentridae (e.g. damsel fishes and clown fishes), Holocentridae (soldierfishes and squirrelfishes) and Haemulidae (e.g. grunters and sweetlips) (Nedwell et al. 2004; Braun & Grande 2008; Popper et al. 2014; Popper & Hawkins 2019). However, most 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. This is true of the demersal snapper, emperor, cod and grouper species that occur in the Operational Area, as well as some tuna and billfish species.

Fish species that lack a gas-filled cavity altogether, include elasmobranchs (e.g. sharks and rays), some flat fishes, some gobies, some tunas, mackerels and other pelagic and deep-sea species (Casper et al. 2012; Popper et al. 2014). This is true of the sharks, mackerel species and some tuna species that occur in the Operational Area.

Popper et al. (2014), a working group of leading experts in underwater acoustics, developed sound exposure guidelines for fishes and sea turtles that are approved by the Accredited Standards Committee S3/SC 1 Animal Bioacoustics and registered with the American National Standards Institute (ANSI). The technical report proposes sound exposure guidelines for potential noise impacts on fish, including impacts resulting from seismic surveys and other comparable high-amplitude, low frequency impulsive sound signals such as pile driving. Popper et al. (2014) proposed sound exposure criteria for the following effects:

- mortality, including injury leading to death;
- recoverable injury, including injuries unlikely to result in mortality, such as hair cell damage and minor haematoma;
- temporary threshold shift (TTS) in hearing ability; and
- behavioural and masking effects.

The sound exposure criteria proposed by Popper et al. (2014) for fishes are presented in Table 7-8. Many of the criteria are dual metrics, requiring consideration of both the peak pressure (PK), and the accumulated sound exposure level (SEL_{cum}) resulting from exposure to multiple pulses of sound from the seismic source.

Table 7-8 Sound exposure criteria for fishes (Popper et al. 2014)

Fish Hearing Category	Mortality and Potential Mortal Injury	Impairment			Behaviour *
		Recoverable Injury	TTS	Masking *	
Group I Fish: no swim bladder	>219 dB SELcum or >213 dB PK	>216 dB SELcum or >213 dB PK	>>186 dB SELcum	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low

Fish Hearing Category	Mortality and Potential Mortal Injury	Impairment			Behaviour *
		Recoverable Injury	TTS	Masking *	
Group II Fish: swim bladder not involved in hearing	210 dB SELcum or >207 dB PK	203 dB SELcum or >207 dB PK	>>186 dB SELcum	N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Group III Fish: swim bladder involved in hearing	207 dB SELcum or >207 dB PK	203 dB SELcum or >207 dB PK	186 dB SELcum	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate
* Relative risk (high, moderate, low) is given for masking and behavioural impacts to fish at three general distances from a seismic source, defined in relative terms as near (N; tens of metres), intermediate (I; hundreds of meters), and far (F; thousands of metres). >> indicates levels ‘much greater than’.					

Potential injury and mortality

At the time of developing the ANSI sound exposure guidelines, no quantified data on injury and mortality from seismic sources on fishes had been reviewed by the Working Group. Therefore, the Popper et al. (2014) exposure guidelines for mortality/potential mortal injury and recoverable injury for fishes 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 & Popper 2005; Popper et al. 2006).

Environmental Resources Management Australia undertook a detailed literature review of potential fish mortality and physical injury as a result of exposure to seismic sources (ERM 2017). A total of twenty-eight papers or reports relating to the findings of experimental and opportunistic laboratory and in situ studies on mortality, potential mortal injury and physical damage effects of seismic source exposure on fishes, conducted worldwide between 1972 and 2014, were reviewed. Of the studies covered in the literature review only three observed direct mortality of exposed fish (Weinhold & Weaver 1972; Matishov 1992; Booman et al. 1996). 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. Nine studies covered in the literature review found some evidence of damage to one or more organs in exposed fish, including damage to swim bladders, ablated ear cells, internal bleeding, or blindness. Most damage occurred upon exposure at distances up to 3—4 m from the source. The literature review found a further 16 studies that reported no mortality or physical damage in any fishes exposed to seismic pulses, including to fishes exposed in cages.

Of the studies reviewed by ERM (2017) that resulted in mortality, received sound levels ranged from 220—241 dB re 1 µPa PK. It is also important to note that other studies reported no mortality, and in some cases no physical injury at levels as high as 246 dB re 1 µPa PK. For example, Fanta (2004) found no mortality or physical damage in 15 different coral reef fish species exposed in cages to 215—235 dB re 1 µPa PK from a 3,090 in^3 commercial seismic array at a minimum distance of 45 m. Given the reviewed literature indicates that mortality and physical injury only occur within a few metres of the seismic source, 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 effects to fishes from exposure to underwater noise from seismic surveys.

In many cases, the potential for physical injury and impairment impacts to occur may be dependent on fishes' abilities to move and avoid very high sound levels, and so the potential for physical trauma to occur is typically limited to situations where fish do not or cannot avoid such exposures (e.g. experiments involving captive fish that may not be representative of free-swimming fish). For example, Wardle et al. (2001) exposed free-swimming marine fish (juvenile saithe and Atlantic cod*,* adult pollock and adult mackerel) inhabiting a small reef system, to seismic airguns with a sound peak pressure of 195—218 dB re 1 µPa PK. No mortality was observed at these levels, even though some of these species are members of the Gadidae family and have a connection between the swim bladder and inner ear.

Of particular relevance to commercially targeted demersal snapper species in the Operational Area, McCauley and Salgado Kent (2007, cited in Santos Ltd 2018) undertook a study in collaboration with the Northern Territory Department of Fisheries to observe the potential impacts of seismic sound exposure on goldband snapper. The study used a series of commercial fish traps set at increasing ranges adjacent to three seismic survey lines in 90—110 m water depth in the Timor Sea. The seismic vessel towed two 3,090 in^3 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 mortality or mortal injury was identified at these levels.

Despite mortality being a theoretical possibility for fish exposed to seismic sound, Popper et al. (2014) and Carroll et al. (2017) note that physical injury leading to death from seismic sound exposure is likely to be limited to extreme cases and has not been observed in any free-swimming fishes exposed during an actual seismic survey.

Juveniles may have similar hearing sensitivity as adults, but are potentially more at risk of tissue damage than adult fishes as their smaller size means they have less inertial resistance to the particle motion effects of a passing sound wave in the water column (Popper & Hastings 2009; Popper et al. 2016). However to date, research into the effects of sound on fishes has been conducted on both juvenile and adult fish and overall the exposure thresholds and available research is considered broadly representative of both juvenile and adult stages.

Temporary hearing impairment

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).

The nature and magnitude of TTS in fishes is described in Popper et al*.* (2014), as follows:

"TTS has been demonstrated in some fishes, and its extent is of variable duration and magnitude. However, sensory hair cells are constantly added in fishes (e.g., Corwin 1981; 1983; Popper and Hoxter 1984; Lombarte and Popper 1994) and also replaced when damaged (Lombarte et al. 1993; Smith et al. 2006; Schuck and Smith 2009), unlike in the auditory receptors of mammals. When sound-induced hair cell damage occurs in fishes, its effects may be mitigated over time by the addition of new hair cells (Smith et al. 2006; 2011; Smith 2012; 2015).

After termination of a sound that causes TTS, normal hearing ability returns over a period that is variable, depending on many factors, including the intensity and duration of sound exposure (e.g., Popper and Clarke 1976; Scholik and Yan 2001; 2002a; 2002b; Amoser and Ladich 2003; Smith et al. 2004a; 2004b; 2006; 2011; Popper et al. 2005; 2007). While experiencing TTS, fishes may have a decrease in fitness in terms of communication, detecting predators or prey, and/or assessing their environment."

The impact threshold of 186 dB re 1 μPa^2·s proposed by Popper et al. (2014) is based on data from Popper et al. (2005) where exposure of a freshwater fish species with a connection between the swim bladder and inner ear to an SELcum of 186 dB re 1 μPa^2·s resulted in approximately 20 dB difference in hearing threshold. Fish that showed TTS recovered to normal hearing levels within 18–24 hours.

McCauley et al. (2003) demonstrated that repeated sound exposure at a maximum received level of 212 dB re 1μPa PK-PK and closest point of approach of 5—15 m during trials, caused extensive damage to the sensory hair cells in the inner ear of caged pink snapper with no evidence of repair or replacement of damaged hair cells up to 58 days post-exposure. The SELcum level is not given in the study. The study did not examine if the hair cell damage had any effects on fishes' hearing. The study acknowledged that the fish were caged and therefore not able to swim away from sound source, and that the monitoring video suggested the fish would have fled the sound source if possible.

Hair cell damage and hearing impairment in a number of reef species, including the bluestripe snapper, were examined following exposure from a 2,055 in^3 seismic source during Woodside's Maxima 3D MSS in Scott Reef lagoon (McCauley 2008). The study found, there was statistically more ear damage in exposed fishes compared to control fishes, but the damage was marginal, and it was suggested that <1% of the exposed fishes' hearing capability was impaired (McCauley 2008). A study of auditory brainstem response (ABR) in four species of tropical reef fishes, including the pinecone soldierfish (a species which has a swim bladder connection with the inner ear), showed that none of the four species experienced any TTS following exposure to 190 dB re 1 μPa2·s SELcum (Hastings et al. 2008; Hastings & Miksis-Olds 2012).

McCauley & Salgado Kent (2007, cited in Santos Ltd 2018) found an apparent increasing trend in hair cell damage in goldband snapper from received sound exposure levels greater than ~190 dB re 1 μPa^2·s; however, McCauley & Salgado Kent (2007, cited in Santos Ltd 2018)note that the results of this study should be treated with caution due to the limited number of samples. Other studies (e.g. Popper & Hastings 2009; Song et al. 2008) indicate that TTS may occur at single pulse levels as high as 205—210 dB re 1μPa (PK).

Therefore, the 186 dB re 1 μPa^2·s threshold for TTS proposed by Popper et al. (2014) is considered appropriate and is potentially conservative for many types of 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 intense sound pressures at ranges where TTS may occur. If TTS does occur, the effects are temporary and fish will recover.

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 & Popper 2016). 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), seeking refuge in reefs and temporary avoidance of an area (Simmonds & MacLennan 2005; McCauley et al. 2000; Fewtrell & 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 & Popper 2016). The potential extent and duration of behavioural effects based on studies of seismic exposure are summarised below.

Pearson et al. (1992) exposed captive 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. 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. However, 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 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 in^3 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. Increased biochemical stress levels were measured in some fish following exposure, returning to normal levels within 72 hours of exposure. It is noted that exposures of fish in the wild would likely result in avoidance of high sound levels prior to the seismic source approaching to as close a range and to as high sound levels as the captive fish in the experiment were exposed to.

The studies associated with Woodside's Maxima 3D survey at Scott Reef included a component that examined how the behaviour of fish exposed to seismic signals changed. A summary of results relevant to how the behaviour of fish exposed to seismic signals changed is as follows (Woodside 2011a; Miller & Cripps 2013):

- Behavioural observations of free-swimming fish:
  - At close range, airgun noise emissions appeared to have caused prominent, short term, effects on fish behaviour. As the vessel approached, fish ceased normal behaviours and moved downward from the water column towards the seabed.
  - Fish began to feed and behave normally again within 20 minutes after the passage of the survey vessel. Once the vessel had travelled beyond a distance of ~1.5 km fish numbers and behaviour had returned to normal, baseline levels.
- Behavioural observations of caged fish:
  - Alarm responses were too infrequent to analyse.
  - Agitation levels increased with increasing received sound exposure level for squirrelfish and soldierfish species but were not detectable for the bluestripe sea perch.

- Sonar observations of free-swimming fish:
  - Individual fish tended to move lower in the water column towards the seabed on approach of the operating airgun array, consistently out to 400 m either side of the survey test line.
  - Within 200 m of the survey test line, fish schools moved to the seabed after passage of the operating seismic source and stayed significantly closer to the seabed out to 63 minutes post-exposure.
- Fish choruses:
  - For the period overlapping the survey, fish choruses followed normal predictable and relatively smooth trends with regards to timing and chorus level (at daily, lunar and seasonal scales), suggesting that in the long term the survey had little effect on the fish which produced the choruses.
- Fish diversity and abundance:
  - Shallow reef-slope fish surveys using underwater visual census:
    - No significant decreases were detected in the diversity and abundance of both sound pressure-sensitive Pomacentridae (damsel fishes and clown fishes) and non-Pomacentridae fish species after the seismic survey compared to the long-term temporal trend before the survey.
  - Analysis of baited remote underwater video stations:
    - There were no detectable effects of the seismic survey on the diversity and abundance of deeper water fish communities at the spatial and temporal scales examined.
    - There were no signs of loss of individuals or of systematic re-distribution of individuals and species at any of the time scales examined.

Wardle et al. (2001) exposed tagged, free-swimming marine fish (i.e. juvenile cod and saithe, adult pollock from the sound pressure-sensitive family Gadidae and adult mackerel from the relatively insensitive family Scombridae) inhabiting an inshore reef to sounds from a seismic source (195—218 dB re 1 µPa PK). The study used underwater video techniques and found:

- Fish exhibited a startle response (momentarily performed "C-turns") to all received levels, but no avoidance behaviour or any other longer lasting effects were observed.
- Fish showed no signs of moving away from the reef.
- Slight changes were recorded to the long-term day-to-night movements of two tagged pollack, particularly when located within 10 m of their normal living positions.
- Exposure to the seismic noise did not interrupt a diurnal rhythm of fish gathering at dusk and had little effect on the day-to-day behaviour of the resident fish.

Sivle et al. (2016) undertook a pilot study to explore different sound source characteristics and experimental design options for evaluating behavioural reactions in mackerel. Sivle et al. (2016) exposed caged mackerel to a range of playback sounds at close range (2—7 m), including filtered playback of seismic pulses recorded at a distance of 8 km with an SEL of 144 dB re 1 μPa2·s. In the majority of tests undertaken, mackerels did not react to the seismic sound stimulus. Minor startle responses were observed from a small number of individuals in schools in 20% of the tests conducted; a weak or moderate increase in swimming speed was observed in some individuals in schools in 45% of tests conducted; and a weak change in schooling behaviour was observed in a small number of individuals in schools in 10% of tests conducted. In all cases, reactions only lasted for the duration of the exposure and returned to normal as soon as the exposure ceased. Therefore, the experiment indicates that some mackerels may show an awareness of seismic sound at these levels. However, Sivle et al. (2016) note that mackerel are not sensitive to sound pressure, but to particle acceleration, which is likely a key stimulus in their close-range experiments. Sivle et al. (2016) also note that the sound playback technique that they used had limitations and was not representative of a real seismic signal, suggesting that future experiments should instead use a real seismic source in order to obtain more conclusive results. Therefore, the observations made by Sivle et al. (2016) should be interpreted with caution and may not be representative of mackerels' ability to detect propagating sound pressure signals at long distances (i.e. kilometres) from a real seismic survey.

McCauley et al. (2000, 2003) reported that trials involving captive fishes (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 were suggested to commence when sound levels exceeded approximately 151 dB re 1 μPa^2.s SEL (approximately 160 dB re 1 μPa SPL). 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 potential 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 μPa^2.s SEL (approximately 168—181 dB re 1 μPa SPL). In situations where a behavioural response was observed, fishes 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. (2000) and by Fewtrell & McCauley (2012).

McCauley and Salgado Kent (2007, cited in Santos Ltd 2018) 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 in^3 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 which 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. Paxton et al. (2017) 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. Paxton et al. (2017) 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. Despite no clear visual evidence of behavioural responses in fishes during the seismic survey, Paxton et al. (2017) 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, red emperor, and brownstripe snapper. The hearing category of these types of fish is '*Group II Fish: Swim bladder not involved in hearing*'. The species assemblage and hearing category are similar to the demersal species that occur in the Operational Area and that are targeted by the NT Demersal Fishery (e.g. saddletail snapper, crimson snapper, red emperor).

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 $\mu Pa^2 \cdot s$, 130—160 dB re 1 $\mu Pa^2 \cdot s$ and 115—125 dB re 1 $\mu Pa^2 \cdot s$, 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 (Meekan et al. 2021). 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, or on their willingness to feed (Meekan et al. 2021). 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 & Hawkins 1969).

Slotte et al. (2004) monitored the effects of a 3,090 in^3 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 fishes' natural migration patterns, food availability 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 Engås et al. (1996) and Engås and Løkkeborg (2002) hypothesise may be the result of an avoidance response. Some differences in abundance were still detectable within the survey area 5 days after the survey was completed (Engås et al. 1996; Engås & 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 6-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; however, both the 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. Davidsen et al. (2019) 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/s2, 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 (2020, 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 are 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. 199; McCauley et al. 2000, 2003; Slotte et al. 2004; Fewtrell & McCauley 2012; Miller & 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 & MacLennan 2005; McCauley et al. 2000, 2003; Fewtrell & 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 tolerate gradual increases in sound levels and habituate to repeated sound exposures (Chapman & Hawkins 1969; McCauley et al. 2000; Boeger et al. 2006; Fewtrell & 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 & McCauley 2012; Miller & 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 caught by the NT Demersal 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 & 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 receive sound, Popper et al. (2014) do not define exact sound level thresholds or ranges at which masking and behavioural responses may occur. Instead, Popper et al. (2014) uses relative risk criteria (Table 7-8) that range from high to low. For these criteria the ranges, relative to the source, were quantified as near (within tens of metres), intermediate (within hundreds of metres) and far (within thousands of metres). These criteria do not use specific acoustic thresholds, but instead gauge impacts based on general distances from the noise source. It is difficult to predict the population impacts due to behavioural response because behaviour is context dependent. Behavioural responses of wild animals to sound are likely to vary by species, size, and age class, with animal motivation, and in different contexts. Behaviour may be more strongly related to the particular circumstances of the animal, the activities in which it is engaged, and the context in which it is exposed to sounds (Ellison et al. 2012; Peña et al. 2013).

Therefore, no specific impact thresholds have been selected for the assessment in this EP for masking and behavioural effects; instead these are assessed more qualitatively, by assessing relative risk rather than by specific sound level thresholds, as proposed by Popper et al. (2014; Table 7-8), but also taking into account the results of the various studies above for context where relevant.

Table 7-9: Impact and risk evaluation – underwater noise and vibration – fishes

<table>
<tr><th colspan="2">Identify hazards and threats</th></tr>
<tr><td colspan="2">Impulsive sound emitted from the seismic source may have the potential to impact fishes in the following ways:
• mortal injury or recoverable injury to fish at very close range to the seismic source
• temporary hearing impairment (temporary threshold shift; TTS) experienced by fish exposed to high sound levels for prolonged periods
• behavioural impacts resulting from disturbance, or masking or interfering with biologically important sounds.
The following assessment considers the potential impacts to fish behaviour and spawning fishes; however, the potential impacts to fish eggs and larvae are addressed separately in Section 7.1.4 Planktonic communities.</td></tr>
<tr><th>Potential consequence</th><th>Severity</th></tr>
<tr><td>The particular values and sensitivities with the potential to be impacted by underwater noise are:
• demersal fish species (e.g. Saddletail snapper, crimson snapper, goldband snapper, red snapper), as targeted by the NT Demersal Fishery
• pelagic fish species (e.g. Spanish mackerel and grey mackerel), as targeted by the NT Offshore Net and Line Fishery and NT Spanish Mackerel Fishery
• shark and ray species, including sharks targeted by the NT Offshore Net and Line Fishery and other shark species of conservation significance, such as whale sharks (and sawfish and river sharks in coastal and estuarine waters located outside of the Operational Area).
• The following assessment also considers the potential impacts to the spawning and recruitment of commercially significant fish species.
The maximum horizontal distances (Rmax) at which sound levels predicted by modelling (Muellenmeister et al. 2022; Appendix C) to exceed the Popper et al. (2014) thresholds for mortality, injury and TTS are presented in Table 7-10. The table presents the maximum horizontal distance over all modelled depths above the seafloor (‘maximum-over-depth’) and the maximum horizontal distance at the seabed. Maximum-over-depth values are relevant to pelagic fish species in the water column, while the seabed values are relevant to benthic and demersal species.
The SELcum threshold criteria, modelled for a 24-hour period, was also examined in relation to the potential for mortality and injury, but either the thresholds were not exceeded (i.e. seabed), or the horizontal ranges associated with these thresholds were equal to or less than those produced by the peak (PK) sound pressure produced by a single seismic pulse. Therefore, the PK ranges from a single pulse are the most relevant metric to assessing the potential for mortality and injury.</td><td>Minor (E)</td></tr>
</table>

Table 7-10 Maximum (R_{max}) horizontal distances predicted by acoustic modelling to exceed the Popper et al. (2014) thresholds for mortality, injury and hearing impairment

Fish Hearing Category	Potential Impact	Impact Threshold	R_{max} Distance (km)	
			Maximum-over-depth	Seabed
I Fish: No swim bladder	Mortality/PMI	219 dB re 1 µPa²·s (SEL_{24h})	0.07	-
		213 dB re 1 µPa (PK)	0.07	0.09
	Recoverable injury	216 dB re 1 µPa²·s (SEL_{24h})	0.07	-
		213 dB re 1 µPa (PK)	0.07	0.09
	TTS	186 dB re 1 µPa²·s (SEL_{24h})	10.6	8.3
II Fish: Swim bladder not involved in hearing	Mortality/PMI	210 dB re 1 µPa²·s (SEL_{24h})	0.07	-
		207 dB re 1 µPa (PK)	0.19	0.21
	Recoverable injury	203 dB re 1 µPa²·s (SEL_{24h})	0.28	0.28
		207 dB re 1 µPa (PK)	0.19	0.21
	TTS	186 dB re 1 µPa²·s (SEL_{24h})	10.6	8.3
III Fish: Swim bladder involved in hearing	Mortality/PMI	207 dB re 1 µPa²·s (SEL_{24h})	0.07	0.03
		207 dB re 1 µPa (PK)	0.19	0.21
	Recoverable injury	203 dB re 1 µPa²·s (SEL_{24h})	0.28	0.28
		207 dB re 1 µPa (PK)	0.19	0.21
	TTS	186 dB re 1 µPa²·s (SEL_{24h})	10.6	8.3

A dash indicates that the threshold was not reached.

Demersal fish species

The various species of demersal tropical snappers (Lutjanidae) and emperors (Lethrinidae) that may occur in the Jospeh Bonaparte Gulf and are targeted by the NT Demersal Fishery do not possess a mechanical connection between the swim bladder and inner ear. These species are considered hearing generalists and are primarily sensitive to particle motion rather than sound pressure (Tavolga & Wodinsky 1963; Higgs et al. 2006; Braun & Grande 2008; Engineering-Environmental Management, Inc. 2008; United States Department of the Navy 2008; Popper 2012; Caiger et al. 2012). Therefore, these species of fish are considered to belong to the group of fishes 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).

As shown in Table 7-10, the potential for recoverable injury, potential mortal injury or mortality in Group II fishes (with a swim bladder not involved in hearing) is limited to within 210 m from the seismic source, based on the single pulse PK thresholds, and recoverable injury within 280 m from the seismic source, based on 24 hours of accumulated sound exposure. Therefore, injury effects could occur to demersal fishes in close proximity to the seismic source within or adjacent to the Active Source Area. It is again highlighted that the Popper et al. (2014) thresholds for injury and mortality are likely to be highly conservative, and studies have indicated that much higher received sound levels up to 246 dB re 1 µPa PK have not resulted in injury or mortality. The potential for mortality and injury is therefore likely to be limited to within very close proximity of the seismic source (ERM 2017). However, the potential for mortality and injury to occur is dependent on fishes' abilities to move and avoid very high sound levels. The demersal and pelagic fish assemblages that are expected to be present in the Operational Area are generally wide-ranging, free-swimming species. The demersal fish assemblages that are typical of the habitats in the Operational Area (predominantly snappers and emperors), despite exhibiting particular habitat preferences and some fidelity to an area, are typically mobile with home ranges in the order of kilometres (Ovenden et al. 2004; Moran et al. 2004; Newman et al. 2008; Parsons et al. 2011; Harasti et al. 2015). The available studies on the behaviour of both captive and free-swimming fishes exposed at close range to seismic surveys (as described previously in this section) generally indicate an increased level of startle response and increased swimming activity with increased sound levels or in response to exposure at close range. It is highly unlikely that demersal fishes will remain within range of the seismic source where mortality/injury can occur. Injury or mortality may only occur in the immediate vicinity of the seismic source in the unlikely event that the seismic source commences operation suddenly at full power without the opportunity for fishes to avoid increasing sound levels (i.e. no soft-start management measures). The maximum predicted distance to the TTS thresholds is 8.3 km at the seabed, based on the cumulative SEL24h threshold. However, Popper et al. (2014) note that the threshold is unweighted and therefore accounts for a broader range of sound frequency and energy than is detectable by the fish. Popper et al. (2014) also note that actual threshold for in Group II fishes (with a swim bladder not involved in hearing) is not yet known but is expected to be significantly greater than the current 186 dB re 1 µPa2·s level. Therefore, the actual horizontal ranges to TTS in this group of fishes may only be a few kilometres or less. The SEL24h threshold also represents an unlikely worst-case scenario, as more realistically fish would not stay in the same location or at the same range for a period of 24-hours. In his expert review of the TTS effects to demersal fishes for the Santos Bethany 3D MSS, located north-east of the Bonaparte Basin 3D MSS Operational Area, Popper (2018) noted: It is highly unlikely that there would be physical damage to fishes as a result of the survey unless the animals are very close to the source (perhaps within a few metres). Most fishes in the region, being species that do not have hearing specialisations, are not likely to have much (if any) TTS as a result of the survey. If TTS occurs, the duration of exposure to the most intense sounds that could result in TTS will be over just a few hours. Thus, applying accumulation of sound energy over periods longer than a few hours is probably not appropriate.	

If TTS occurs, its level is likely to be sufficiently low that it will not be possible to easily differentiate it from normal variations in hearing sensitivity. Even if fishes do show some TTS, recovery will start as soon as the most intense sounds end, and recovery is likely to even occur, to a limited degree, between seismic pulses. Based on very limited data, recovery within 24-hours (or less) is very likely. Nothing is known about the behavioural implications of TTS in fishes in the wild. However, since the TTS is likely to be transitory, the likelihood of it having a significant impact on fish fitness and survival is very low. Popper et al. (2014) indicate that the potential for behavioural impacts in this 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, behavioural responses are considered likely to occur within tens or hundreds of metres from the seismic source. The fishes' awareness of the 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 behavioural responses (startle or avoidance) are more likely to be limited to a short period (less than an hour) when the seismic source passes close by. As the seismic source will be transient (i.e. continuously moving) during seismic data acquisition, demersal fishes will only be exposed to significant sound levels for a relatively short period of time as the seismic survey vessel passes nearby before sailing away again. Fish behaviours may return to normal within less than an hour (sometimes just minutes) of the seismic survey vessel passing (Wardle et al. 2001; Woodside 2011a, 2011b; Miller & Cripps 2013). Limited data on biochemical stress indicators in fishes exposed to seismic sound indicates there may not be any discernible change (e.g. McCauley et al. 2000, 2003). However, if fishes were to experience stress as a result of sound exposure, levels may return to normal within 72 hours (Santulli et al. 1999). 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 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** Key pelagic fish species that may occur in the Operational Area include Spanish mackerel and grey mackerel, targeted by the NT Spanish Mackerel Fishery and the NT Offshore Net and Line Fishery. These species do not possess a swim bladder (Casper et al. 2012; Popper et al. 2014), indicating that they are sensitive only to the particle motion component of sound at close range to a sound source.	

As shown in Table 7-10, the maximum predicted Rmax distances for recoverable injury, potential mortal injury or mortality in Group I fishes (no swim bladder) within the entire water column is 70 m. The maximum predicted distance to TTS was 10.6 km within the water column, based on the cumulative SEL24h threshold. As with Group I demersal fishes, assessed above, Popper et al. (2014) note that the TTS threshold for Group I fishes is expected to be significantly greater than the current 186 dB re 1 µPa2·s level. Therefore, the actual horizontal ranges to TTS in this group of pelagic fishes is likely to be limited. Pelagic fishes such as mackerel are free-swimming and highly vagrant, travelling distances of tens or hundreds of kilometres. Therefore, pelagic fishes can reasonably be expected to exhibit an avoidance response and swim away from the approaching seismic source before sound levels approach levels that may result in mortality, injury or TTS.

Popper et al. (2014) indicate that the potential for behavioural impacts in fishes that do not possess a swim bladder 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, behavioural responses in species such as mackerel are considered likely to occur within tens or hundreds of metres from the seismic source. The extent and duration of behavioural impacts to large pelagic fishes in the Operational Area is likely to be similar or less than those predicted for demersal fishes. In addition, the transient nature of the seismic source and the highly mobile nature of pelagic fish species means that behavioural avoidance responses and effects on distribution will be incidental, localised and of short duration.

It is acknowledged that the large predatory pelagic fishes target smaller pelagic fishes as prey such as herrings or sardines which have a swim bladder connection in their hearing and may therefore be more sensitive to sound from the seismic source than mackerels. These more sensitive baitfish may exhibit a behavioural response and some level of avoidance over several kilometres from the seismic source. Again, given the highly transient nature of the survey and pelagic fishes, the impacts will be short-term and relatively insignificant, but may result in predatory pelagic species such as mackerel following the food source, which may result in changes in distribution over several kilometres. While changes in fish behaviours may be limited to a few minutes or hours, the duration of changes in fish distribution may vary. For example, Wardle et al. (2001) observed that the distribution of mackerels showed no sign of moving away from the reef where they were being studied, whereas studies into more sound sensitive herring and cod species reported that their distribution may potentially remain altered for days following exposure (e.g. Slotte et al. 2004; Engås et al. 1996 and Engås & Løkkeborg 2002).

Sharks and rays

Key shark species that may occur in the Operational Area include blacktip and sandbar sharks caught by the NT Offshore Net and Line Fishery, as well as conservation significant shark and ray species, which include whale sharks, manta rays, sawfish and river sharks. A BIA for foraging whale sharks is overlapped by the western margin of the PEZ but does not overlap the Operational Area. Instead, whale sharks in the Operational Area are likely to be limited to occasional transient individuals. Due to their ecology, sawfish and river sharks (generally estuarine rather than open-ocean species) are not expected to occur in the Operational Area in significant numbers and no disturbance will occur in their key foraging, breeding and nursery habitats in coastal and estuarine waters.

No sound exposure thresholds currently exist for acoustic impacts from seismic sources to sharks and rays, which are sensitive only to particle motion. However, as a conservative approach the Popper et al. (2014) guidelines for fish with no swim bladder have been used for this assessment. As shown in Table 7-10, the maximum predicted Rmax distances for recoverable injury, potential mortal injury or mortality in Group I fishes (no swim bladder) within the entire water column is 70 m. The maximum predicted distance to TTS was 10.6 km within the water column, based on the cumulative SEL24h threshold. However, given the free-swimming and highly vagrant nature of sharks, as well as their lack of sensitivity to sound pressure, injury and significant levels of TTS are not expected to occur. Shark species are highly vagrant and naturally cover large distances, and as such, short-term exposures from the transient seismic source is expected to result in only localised behavioural responses and movements of sharks. The research by Bruce et al. (2018), which tagged two commercially targeted shark species (broadnose shark and school shark) and monitored their movements in response to a seismic survey in Australian waters, noted that both control sharks and exposed sharks moved freely in and out of the study area, which indicates no changes in behaviour or distribution as a result of seismic sound exposure.

Spawning and recruitment of commercially significant fish species

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 & Popper 2017). This impact assessment is focused on fish spawning and recruitment for relevant key indicator commercial fish stocks.

Section 4.9.6 includes descriptions of the key indicator fish species that are relevant to the 3D MSS, which include demersal species targeted by the NT Demersal Fishery, Spanish mackerel targeted by the NT Spanish Mackerel Fishery, and blacktip sharks and grey mackerel targeted by the NT Offshore Net and Line Fishery.

Key indicator demersal fish species, include:

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

The status of these stocks is used by fisheries managers as an indicator of the sustainability status within the broader suite of demersal scalefish species exploited in the region.

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).

It is noted that pelagic scalefish species and shark species are also caught in the region, including Spanish mackerel, grey mackerel and blacktip sharks caught by the NT Spanish Mackerel Fishery and the NT Offshore Net and Line Fishery. As noted in Section 4.9.6, Spanish mackerel and grey mackerel primarily aggregate in water depths less than 50 m, while shark species typically move into shallow coastal waters and nursery grounds to give birth. Given the localised impacts that are predicted above for these pelagic scalefish and shark species, impacts on the reproductive behaviours and recruitment of these stocks are not considered further.

It is also noted that approximately 0.5 km2 of the Active Source Area extends into WA jurisdiction (Kimberley management unit). However, the overlap with the Kimberley stocks is considered to be negligible and assessment of impacts to the Joseph Bonaparte Gulf stocks in NT jurisdiction are considered to be representative of the worst-case impacts. Therefore, impacts on the Kimberley stocks are not assessed further. The following assessment considers the potential magnitude of effects to fish spawning behaviours, and therefore the potential influence of the 3D MSS on recruitment success and the sustainability of key indicator fish species. The assessment considers: • spatio-temporal analysis – to provide context on the proportion of the spawning biomass that may be exposed during the 3D MSS • consideration of the natural variability in fish distribution, spawning biomass and recruitment • consideration of the sustainability status of the fish stocks and fisheries. <u>Spatio-Temporal Analysis</u> A spatio-temporal analysis has been conducted to determine the overlap between the 3D MSS and the principal spawning ranges and periods of key indicator demersal 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 spatio-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 exposed and disturbed 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 as follows: **Spatial overlap is based on the area of ensonification from one week (seven days) of acquisition lines with a precautionary 5 km buffer applied to account for possible uncertainty about the range to disturbance to fish.** This approach accounts for an area that will be encircled during a typical racetrack line acquisition and therefore subject to sound exposure from the seismic source. A week of racetrack was selected as this reflects an area where the seismic survey vessel will acquire consecutive, adjacent lines within proximity to the same general area of seabed and groups of demersal fishes. The seven-day timeframe is also precautionary in order to account for scientific uncertainty in relation to the duration and recovery of behavioural disturbances in fishes. It provides a conservative reflection of the longest duration changes in fish behaviour or fish distribution (approximately five days, as noted by Slotte et al. (2004); Engås et al. (1996); Engås & Løkkeborg (2002)), noting that such changes are limited to studies that focused primarily on migrating sound pressure-sensitive types of fish with a swim bladder-ear connection (Clupeidae, Gadidae). Behavioural changes in the demersal and pelagic fish species considered in this assessment typically return to normal within minutes or hours following exposure, whilst noting that during the racetrack formation, the same groups of fish may be exposed again when the seismic source returns to acquire an adjacent line nearby. Within any seven-day period, the seismic survey vessel (travelling at a speed of approximately 4.5 knots [8.3 km/hr]) will cover a total line distance of approximately 1,400 km.	

It is also appropriate to consider a week of acquisition lines, given that over the duration of each survey, the seismic survey vessel would gradually move across the survey area; following a week, the racetrack would have progressed sufficiently far that it would no longer disturb the same areas and groups of demersal fishes as may be disturbed at the start of the racetrack. Therefore, this seven-day scenario already provides a highly conservative reflection of the spawning area that may be exposed at any time during the survey, and accounting for a larger area would be a significant over-representation. To apply an additional level of conservatism and account for uncertainty concerning the exact range over which fish may be disturbed, a 5 km buffer has been applied to the racetrack formation. This accounts 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). Overall, the seven-day scenario and 5 km sound exposure buffer would result in an area of disturbance of approximately 1,350 km2. **The spatial extent of the spawning areas for each key indicator fish species has been estimated based on each species depth range within the relevant management unit for which each stock is assessed.** As described in Section 4.9.6, some level of genetic connectivity has been confirmed for fish stocks across large areas or northern Australia (hundreds of thousands of square kilometres compared with the tens of thousands of square kilometre stock management unit areas considered in the analysis). The biological connectivity of the key indicator species generally extend across northern Australia, usually covering the waters of WA, the NT and Queensland. However, the boundaries of the larger biological stocks are not clearly defined and it is noted that genetic connectivity and recruitment within the biological stock ranges occurs over many 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 beyond the limits of the stock management units, but potentially not across the entire biological stock area. To address any potential uncertainty in the biological connectivity and stock ranges, the Joseph Bonaparte Gulf stock management unit, as defined in the 'Stock/Management unit determination in the Northern Territory offshore snapper fisheries' (Saunders et al. 2022), has been selected to provide an indication of the proportion of the stocks that may be affected in a single spawning season. Referencing the stock management unit also allows the results to be considered in relation to the annual fish stock status assessments, which are also reported per management unit (an approach that is recognised as being a conservative approach for fishery management purposes (Gaughan et al. 2018)). As a result, the spatial overlaps accounted for in the spatio-temporal analysis may overestimate the percentage of spawning area available to each stock.	

The spatio-temporal analysis is a simplistic approach that assumes that fish spawning in the area and period of exposure will be completely compromised. In reality, it is possible that fishes may continue to spawn regardless, may move away from the seismic source and spawn 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 will occur.

The Bonaparte Basin 3D MSS is assumed to take place within the peak spawning periods of each species. During stakeholder consultation, NT DITT advised that the warmer months of the year (approximately September through to the end of March) likely coincides with the peak spawning activity of many species. The 3D MSS is provisionally expected to be conducted in Q2 2023, which would avoid peak spawning completely. However, for contingency purposes, subject to seismic survey vessel availability, operational efficiencies, and weather, this EP allows for the activity to occur anytime during calendar years 2023 and 2024. Therefore, to address this uncertainty, it is assumed that the survey will take place during the spawning period and the maximum 31% temporal overlap (65-day survey duration within the 212-day peak spawning period) .

Given the assumptions, the following analysis provides a highly conservative indication of the proportion of each indicator fish stock that may be exposed. This provides useful context for the impact assessment, but the extent and duration of actual impacts will likely be significantly smaller.

Table 7-11 presents the spatial and temporal overlap with the spawning areas and periods of key indicator species based on each species' principal depth range within the Joseph Bonaparte Gulf management unit. The maximum spatio-temporal overlap of the 65-day duration 3D MSS ranges from 0.6% to 1.7%.

During stakeholder consultation, a NT Demersal Fishery licence holder (whose vessel routinely fishes in the Joseph Bonaparte Gulf) identified that approximately 85% of the annual catch from the trawl area overlapped by the Operational Area is saddletail snapper. Therefore, this stock is likely the most representative for this area, and the spatio-temporal overlap with this species represents disturbance to less than 1% of spawning within the Joseph Bonaparte Gulf stock. The spatio-temporal overlap with goldband snapper is slightly higher (1.7%) due to the deeper water depths of this species, which are not as widely occurring in the relatively shallow Joseph Bonaparte Gulf as the depth ranges of other species. Goldband snapper represents a less significant component of the demersal fish assemblage in the Joseph Bonaparte Gulf; for example, the stock assessment for goldband snapper references a spawning biomass in the Joseph Bonaparte Gulf of 320 tonnes, compared with 4,800 tonnes in the neighbouring Timor Sea management unit and 3,700 tonnes in the Arafura Sea management unit (Trinnie et al. 2021).

Table 7-11: Spatio-temporal overlap with demersal fish stock spawning in the Joseph Bonaparte Gulf

	Saddletail snapper	Crimson snapper	Goldband snapper	Red emperor
Depth range (m)	5 – 100	5 – 100	50 – 200	10 – 180
Area within Joseph Bonaparte Gulf management unit (km^2)	44,255	44,255	24,455	50,000
Spatial overlap (%)	2.8	2.8	5.5	1.8
Temporal overlap with September–March peak spawning (%)	31	31	31	31
Total spatio-temporal overlap (%)	**0.9**	**0.9**	**1.7**	**0.6**

Natural Variability in Spawning Biomass and Recruitment

To provide further context, natural levels of variability in spawning and recruitment has been considered. 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 and 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 the 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 in the Kimberley management unit 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 less than 2% of spawning biomass in the Joseph Bonaparte Gulf 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 Fisheries Research and Development Corporation (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.

Table 7-12 summarises the Joseph Bonaparte Gulf stock assessments of the assessed fish species, as published online by the FRDC. Overall, saddletail snapper and goldband snapper 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. Crimson snapper and red emperor stocks in the Joseph Bonaparte Gulf are undefined given that the spawning biomass of these stocks has never been quantified.

Table 7-12: Stock assessment summaries

Fish Species	Stock Assessment Summary
Saddletail snapper (Saunders et al. 2021a)	The peak harvest between 2012 and 2019 (352 tonnes) represents approximately 5% of the estimated spawning biomass of this stock (6,677 tonnes). This evidence suggests that the biomass of this stock is unlikely to be depleted and that recruitment is unlikely to be impaired. Therefore, the Joseph Bonaparte Gulf stock is classified as a **sustainable** stock.
Crimson snapper (Saunders et al. 2021b)	The peak harvest between 2012 and 2019 was 99 tonnes in 2018. Previous surveys of this stock have not been able to quantify the spawning biomass. Consequently, it is unknown what impact catches have on the biomass of this stock. Therefore, there is insufficient evidence to classify the status of this stock and the Joseph Bonaparte Gulf stock is classified as an **undefined** stock.

Goldband snapper (Trinnie et al. 2021)	The harvest in 2019 (27 tonnes) represents approximately 8% of the estimated spawning biomass of this stock (320 tonnes). This evidence suggests that the biomass of this stock is unlikely to be depleted and that recruitment is unlikely to be impaired. Therefore, Goldband Snapper in the Joseph Bonaparte Gulf is classified as a **sustainable** stock.
Red emperor (Newman et al. 2021)	The peak harvest between 2012 and 2019 was 12 tonnes in 2019. Previous surveys of this stock have not been able to quantify the spawning biomass. Consequently, it is unknown what impact catches have on the biomass of this stock. Therefore, there is insufficient evidence to classify the status of this stock and the Joseph Bonaparte Gulf stock is classified as an **undefined** stock.

Based on the above information and the highly conservative assessment, potential disturbance to a small proportion (up to 1.7%) of the demersal fish stocks in the Joseph Bonaparte Gulf is not expected to result in any population level impacts. In the context of natural variability in spawning and recruitment, the proportion of the spawning biomass exposed to the seismic source is negligible.

Summary

Overall, the predicted worst-case impacts to fishes resulting from the Bonaparte Basin 3D MSS are:

- potential mortality or injury as a result of short-term exposure to the seismic source is highly unlikely to occur
- a low level of TTS in some fishes is possible if they do not actively avoid the approaching seismic source, although recovery is likely to occur quickly (within 24 hours or less) and the potential for such effects to have significant implications on the fishes' fitness and survival is low
- temporary changes in behaviour may return to normal within minutes or hours in most cases; and
- localised disruption to individual groups of spawning fishes within a few kilometres of the operating seismic source, but this is not expected to have a detrimental population level impact given that spawning and stock connectivity occurs over large geographic areas, over several months, involves the production of millions of eggs over multiple spawning events, and shows extremely high natural variation.

The consequence of these local scale and short-term impacts, which will affect a small proportion of fish populations at a time, is assessed as Minor (E).

Identify existing design and safeguards/controls measures			
The seismic source levels will be limited to the minimum required to achieve the objectives of the survey. The seismic source specification will be verified prior to commencement of the Bonaparte Basin 3D MSS (Section **7.1.3**). The Active Source Area has been defined to cover the minimum possible area to achieve the objectives of the survey. The Active Source Area avoids any KEFs or other areas that may support regionally significant fish assemblages.			
Propose additional safeguards/control measures (ALARP Evaluation)			
Hierarchy of control	Control measure	Used?	Justification
Elimination	No use of a seismic source (i.e. no sound emissions).	No	The Bonaparte Basin 3D MSS cannot be achieved without using a seismic source. Elimination of the seismic source is not possible.
Substitution	Use alternative seismic technologies to reduce potential impacts to fishes	No	Alternative technologies such as 'eSource' and 'e-seismic' have been considered. These technologies are relatively new technologies which are designed to limit the component of sound levels at frequencies higher than the frequencies essential for seismic exploration. The higher frequency components of the sound can be harmful to fishes at very high intensities (i.e. close to the source). However, presently there is only one vessel globally with the eSource capability and it is currently impossible to commit to a single seismic operator at this stage. To replace or update the seismic array on another vessel would cost in the order of US$2 million for the new hardware. Marine vibroseis is another emerging technology that may reduce sound output but currently, this technology is not widely or commercially available. Given the free-swimming nature of fishes typical of the Operational Area, the potential for injury or impairment to fishes is already very low. Therefore, the identified alternative technologies may have limited environmental benefit and would attract a commercial and financial cost that is not justified.

Engineering	Include a time interval prior to repeat survey of overlapping sail lines (i.e. infill activities) to allow for potential recovery of fish to repeated behavioural disturbance and cumulative sound exposures.	No	Infill activities may be required if the survey vessel has to return to complete a section of line that was missed during a period of shut down, which will result in some overlap. Repeat exposures of fish to the seismic source may result in repeated behavioural disturbance an increase in the accumulated sound energy that fish receive and therefore increased potential for hearing impairment (TTS). The demersal and pelagic fish that are characteristic of the seabed habitats in the Active Source Area are mobile, free-swimming species that are able to move to avoid significant exposures that may result in TTS. The potential consequence and risk is therefore already assessed as low. The survey line acquisition sequence will be determined by specialist planning software such as SurvOpt which optimises the acquisition so that lines are completed in an efficient order. Implementing a time delay prior to acquiring overlapping sail lines in sensitive locations would introduce complexities and potentially cause delays. Given that the risk of behavioural disturbance and TTS in fish is already low and the complexity (and potential cost and delay) involved in implementing this control, it is not considered practicable.
Procedures & administration	Soft-start procedures to provide receptors with advanced opportunity to move away from the seismic source.	Yes	Soft-start procedures, involving the gradual ramp up of the seismic source to full power over a period of 30 minutes, will provide fish with the opportunity to move away from the seismic source and avoid injury, which could otherwise occur if the seismic source was started at full volume. Soft-start procedures will already be implemented in accordance with EPBC Policy Statement 2.1 for cetaceans.
	Schedule seismic acquisition to avoid key fish spawning periods	No	Fish offshore from the NT may spawn throughout the year, and NT DITT have advised that peak spawning likely occurs September to March.

			The 3D MSS is provisionally expected to be conducted in Q2 2023, which will avoid the peak spawning period; however, an exact start date is subject to vessel availability, operational efficiencies, and weather, other site survey and drilling activities that INPEX plan to undertake within the permit area, as well as potential Department of Defence exercises that may occur. Fish spawning has been assessed in detail, noting the importance of spawning and recruitment of fish stocks, but also noting fishes' sensitivity to seismic sound. As noted in the above consequence assessment, occasional localised disturbances of groups of spawning demersal fishes may occur, but this is not expected to have a significant impact on the stocks, due to their high fecundity (each female producing millions of eggs per season or per spawning event); the occurrence of multiple spawning events over extended spawning seasons (many months); and the stocks' biological connectivity through recruitment from across the region. Multiple and broadcast spawning strategies, by their very nature, are carried out by fishes to spread the naturally high risk of mortality and maximise the potential opportunity for egg and larval survival over large areas and long timeframes. Given the already low risk to commercial fish stocks, and the above mentioned scheduling uncertainties, INPEX does not consider it practicable to commit to undertaking the 3D MSS outside of the peak spawning period.

Identify the likelihood

With the above described soft-start control in place, the potential for injury and hearing impairment in fishes is substantially reduced. Injury and mortality in particular are expected to be prevented. Behavioural impacts are still expected to occur. The likelihood of localised and short-term impacts to fish behaviours and spawning, with Minor consequences, is considered Possible (3).

Residual risk summary

Based on a consequence of Minor (E) and a worst-case likelihood of Possible (3) the residual risk is Moderate (7).

Consequence	Likelihood	Residual risk
Minor (E)	Possible (3)	Moderate (7)

Assess residual risk acceptability
Legislative requirements N/A – There are no legislative requirements applicable to managing the effects of seismic surveys in relation to fishes. **Stakeholder consultation** Feedback was received from NT DITT (Table 5-4) advising that peak fish spawning in the region likely occurs between September and March and requesting that survey activities should avoid this period to prevent negative impacts to fish stocks. This has been considered in the risk assessment and the level of impact to commercial fish stocks is acceptable because impacts to spawning and recruitment are within the realms of natural variability. The 3D MSS is provisionally expected to be conducted in Q2 2023, which will avoid the peak spawning period; however, an exact start date is subject to vessel availability, operational efficiencies, and weather, other site survey and drilling activities that INPEX plan to undertake within the permit area, as well as potential Department of Defence exercises that may occur. Given the already low risk to commercial fish stocks, and the above mentioned scheduling uncertainties, INPEX does not consider it practicable to commit to undertaking the 3D MSS outside of the peak spawning period. A response has been provided to NT DITT. INPEX therefore considers that stakeholder concerns have been adequately addressed. **Australian Marine Park management objectives and values** The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Sound produced during the 3D MSS is not expected to effect fish within the marine parks and will not impact marine park values. **Conservation management plans / threat abatement plans** Several conservation management plans have been consulted in the development of this EP. However, none of the recovery plans or conservation advice documents are relevant to the effects of seismic or other anthropogenic noise on fish assemblages. In recognition of the Conservation Advice for Whale Sharks, the proposed soft-start control minimises the potential for impacts to whale sharks and this species is not expected to be prevented from foraging within the BIA or displaced along their migration route. INPEX has also considered WA DPIRD's ecological risk assessment of seismic impacts to marine finfish and invertebrates (Webster et al. 2018) during this assessment. **ALARP summary** Given the level of environmental risk is assessed as Moderate, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact. **Acceptability summary** Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because: • the activity demonstrates compliance with legislative requirements/industry standards; • the activity takes into account stakeholder feedback; • the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;

• the activity is managed in a manner that is consistent with the intent of conservation management documents; • the activity does not compromise the relevant principles of ESD – i.e. there are no long-term impacts to spawning biomass or changes in recruitment of the stocks that are not within the realms of natural variation; and • the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as "Moderate", the consequence does not exceed "C – Significant" and the risk has been reduced to ALARP.		
Environmental performance outcomes	**Environmental performance standards**	**Measurement criteria**
Undertake seismic acquisition in a manner that prevents injury and population/stock level impacts to fishes resulting from seismic sound emissions.	Soft start procedures will be conducted in accordance with Part A of EPBC Act Policy Statement 2.1, specifically, the seismic source will commence operating at low power and will increase to full power over a period of 30 minutes.	Marine Fauna Observer (MFO) report confirms that soft start procedures were conducted.

7.1.7 Underwater noise and vibration – Marine mammals

Receptor sensitivity to sound and sound exposure thresholds

Cetaceans are considered to include some of the most sensitive species to underwater sound. Cetaceans utilise their highly sensitive acoustic senses to monitor their environment and for communication, socialising, breeding and foraging.

Potential hearing impairment

The hearing sensitivity and acoustic thresholds for potential hearing impairment in marine mammals have been the subject of various comprehensive reviews of the available scientific literature by groups of internationally-recognised experts in the subject (e.g. Southall et al. 2007, 2019; Finneran 2015, 2016; U.S. NMFS 2016, 2018).

Southall et al. (2007) was the first of these studies to categorise three functional hearing groups based on the frequency hearing ranges of cetaceans (low, mid and high-frequency). Low-frequency cetaceans (LFC), generally comprising mysticetes (baleen whales), such as humpback whales and blue whales, are able to hear sound within a frequency range of a few Hz to a few tens of kHz, which coincides with the frequency range of impulsive seismic signals. Mid-frequency cetaceans (MFC), including odontocetes (toothed whales) such as dolphins and sperm whales, and high-frequency cetaceans (HFC) such as porpoises and some specialised dolphin and whale species, are considered to have their peak hearing sensitivity at frequencies greater than several kHz. Therefore, MFC and HFC are less sensitive to low frequency seismic signals, although some sound is still audible to them.

Southall et al. (2007) developed sound exposure thresholds for permanent threshold shift (PTS) and temporary threshold shift (TTS) in marine mammals exposed to seismic sources. PTS and TTS are shifts in an animal's hearing threshold as a result of prolonged and/or intense sound. It should be noted that PTS effects in marine mammals are theoretical and have never been known to occur in either captive or wild animals. The thresholds proposed by Southall et al. (2007) comprised dual metric criteria, requiring consideration of both the instantaneous peak pressure (PK) and the sound exposure level accumulated over a 24-hour period (SEL_{24hr}). The SEL_{24hr} thresholds proposed by Southall et al. (2007) were frequency weighted according to the three functional hearing groups (LFC, MFC and HFC) (m-weighting).

The TTS sound exposure threshold developed by Southall et al. (2007) (183 dB re 1 μPa^2.s) was subsequently used by the Australian government to derive a single-pulse SEL exposure threshold of 160 dB re 1 μPa2.s for 95% of seismic pulses at a 1 km range, as specified in EPBC Policy Statement 2.1 – Interaction between offshore seismic exploration and whales (EPBC Policy Statement 2.1; DEWHA 2008a). The Commonwealth (DEWHA 2008a) threshold is used by industry and regulators in Australia for the assessment of impacts from seismic activities and to determine appropriate mitigation zones to minimise the likelihood of TTS in mysticetes and large odontocetes.

More recently, U.S. Navy technical reports by Finneran (2015, 2016) proposed new auditory weighting functions and the U.S. NMFS (2016, 2018) undertook a comprehensive review of PTS and TTS dual metric criteria for marine mammals and revised the threshold criteria for each frequency-weighted functional hearing category of cetacean. M-weighting curves, as per Southall et al. (2007), are no longer used but replaced by more accurate auditory weighting functions reflecting the increased knowledge about hearing-related parameters for various species of the different functional hearing groups.

Southall et al. (2019) also revised the Southall et al. (2007) marine mammal sound exposure criteria. The PTS and TTS exposure criteria in U.S. NMFS (2018) and Southall (2019) are identical. The auditory weighting functions for the different functional hearing categories are also identical supporting the most recent (U.S. NMFS 2018) criteria. The auditory weighting functions and the different functional hearing categories of cetaceans are identical in both U.S. NMFS (2018) and Southall et al. (2019); however, each uses slightly different terminology. The LFC, MFC and HFC categories described in U.S. NMFS (2018) are termed LFC, HFC and very high frequency cetaceans (VHFC), respectively in Southall et al. (2019). Southall et al. (2019) explain that, pending further knowledge and future studies, it may be possible to reassign some species to new functional hearing groups, MFC and very low frequency cetaceans (VLFC). However, based on the current latest knowledge, the three existing hearing categories reflect the most up to date knowledge. To avoid confusion, the Southall et al. (2019) hearing categories (LFC, HFC and VHFC) are applied throughout the assessment in this EP.

The EPBC Policy Statement 2.1 (DEWHA 2008a) criteria has been evaluated in this EP when considering potential control measures to mitigate TTS, with consideration also given to the more recently proposed Southall et al. (2019) threshold criteria for PTS and TTS (Table 7-13).

Table 7-13 TTS and PTS dual metric criteria for cetaceans to impulsive sound (Southall et al. 2019)

Functional hearing category	PTS	TTS
Low-frequency cetaceans (Generalized hearing range from 7 Hz to 35 kHz, but mainly sensitive between 200 Hz and 19 kHz)	PK: 219 dB re 1 μPa Frequency-weighted SEL_{24hr}: 183 dB re 1 $μPa^2$.s	PK: 213 dB re 1 μPa Frequency-weighted SEL_{24hr}: 168 dB re 1 $μPa^2$.s
High-frequency cetaceans (Generalized hearing range from 150 Hz to 160 kHz, but mainly sensitive between 8.8 kHz and 110 kHz)	PK: 230 dB re 1 μPa Frequency-weighted SEL_{24hr}: 185 dB re 1 $μPa^2$.s	PK: 224 dB re 1 μPa Frequency-weighted SEL_{24hr}: 170 dB re 1 $μPa^2$.s
Very high-frequency cetaceans (Generalized hearing range from 275 Hz to 160 kHz, but mainly sensitive between 12 kHz and 140 kHz)	PK: 202 dB re 1 μPa Frequency-weighted SEL_{24hr}: 155 dB re 1 $μPa^2$.s	PK: 196 dB re 1 μPa Frequency-weighted SEL_{24hr}: 140 dB re 1 $μPa^2$.s

Behavioural response

The context of sound exposure plays a critical and complex role in behavioural responses in marine mammals (Gomez et al. 2016). For example, different species (and different individuals or groups within a species) may respond differently to varying levels of sound depending on their behaviours and motivation at the time (e.g. foraging, socialising, resting and reproduction) and other factors such as the type of sound, duration of exposure, and the suddenness of the onset of the received sound (Gomez et al. 2016). Currently, there are no specific received level thresholds for reliably assessing or regulating stress responses. Impact assessment is primarily focussed on responses that may impact survival, lead to significant life stage impacts or displacement from biologically important areas, so a threshold for behavioural disturbance based on cetacean avoidance reactions to seismic is more commonly adopted as a proxy for such effects (Gomez et al. 2016).

Cetaceans have been observed to exhibit varying behavioural responses (ranging from, for example, momentary pauses in vocalisations and changes in body orientation, to changes in travel direction and behavioural avoidance) to received SPLs of 140 and 180 dB re 1 µPa and as low as 110 dB re 1 µPa in some instances (Southall et al. 2007; Gomez et al. 2016). Higher received levels are not always associated with stronger behavioural responses and vice versa, and a clear dose-response relationship has not been identified (Southall et al. 2007; Gomez et al. 2016). In addition, a behavioural response does not necessarily equate to a significant avoidance or deviation in cetacean movements that would actually displace individuals or the population from the wider area.

Humpback whales have been demonstrated to have variable responses to seismic noise. Malme et al. (1985) reported feeding humpback whales responded to levels of 150—169 dB re. 1 µPa. McCauley et al. (1998) observed that migrating and feeding humpback whales showed behavioural responses at received SPLs of 150—170 dB re 1µPa. McCauley et al. (2000, 2003) note that some resting female humpback whales with calves display avoidance reactions at approximately 140 dB re 1 µPa SPL, though other cohorts reacted at higher levels (157—164 dB re 1 µPa SPL) and some males were even attracted towards the seismic source at received levels up to 179 dB re 1 µPa SPL.

Malme et al. (1984, cited in Southall et al. 2007) observed behavioural responses in groups of migrating gray whales in response to 140—180 dB re 1 µPa SPL during three decades of seismic survey activity off the coast of California. Gisiner (2017) notes that during the same period of the Malme et al. (1984) study, the same gray whale population increased dramatically in number from 2,000 to 26,000 animals, and whatever response there was by the gray whales to that seismic survey activity, it apparently had little to no discernible impact on gray whale survival or reproduction.

Malme et al. (1988) found that feeding gray whales in the Bering Sea exhibited onset of feeding interruption around received levels of 163 dB re 1 µPa SPL and that about half of the whales stopped feeding and moved away at received levels averaging 173 dB re 1 µPa SPL.

Richardson et al. (1999) observed migrating bowhead whales show a strong avoidance reaction to lower SPLs of 120—130 dB re 1 µPa. However, bowhead whales were found to be more tolerant of seismic noise while they were feeding and remained in the area until levels exceeded 160 dB re 1µPa (Richardson et al. 1986; Miller et al. 2005).

Dunlop et al. (2017) reported that migrating humpback whales were likely to deviate from their course within 3 km of a small volume seismic source, in response to a received SEL of 140 dB re 1 $\mu Pa^2.s$ (approximately 156 dB re 1 µPa SPL). However, the relationship observed between dose and response was not a simple one. The reported deviations were typically short-term and localised. The average deviation from the operating sound source was approximately 500 m, only 100 m (±75 m) further from the sound source than when whales were observed avoiding the vessel without the seismic source operating (Dunlop et al. 2017; Gisiner 2017). Maximum deviations were between 1,500 m to 1,800 m; however, this larger deviation involved the group of whales approaching the source (potentially out of curiosity), not avoiding it, and therefore, a reported change in movement behaviour did not necessarily result in avoidance of the source (Dunlop et al. 2017; Gisiner 2017). Such small and inconsistent deviations are generally insignificant within the larger context of a migration that occurs over months and thousands of kilometres (Gisiner 2017).

U.S. NMFS and NOAA have recommended behavioural response criteria of 160 dB re 1 µPa (unweighted) SPL for a likely significant behavioural response from cetaceans (NOAA 2019). More recently, Southall et al. (2021) provided recommendations and discussed nuances of assessing behavioural response, but did not recommend new numerical thresholds for onset of behavioural responses for marine mammals.

The NOAA (2019) 160 dB re 1 µPa SPL threshold is selected as the level at which some significant behavioural responses may occur, such as avoidance by migrating and transient animals. This is broadly representative of the majority of observations reported in the literature cited above. In the risk assessment, the threshold has been applied to unweighted sound levels, as per NOAA (2019), but the acoustic modelling commissioned by INPEX has also considered response levels weighted according to the functional hearing groups of cetaceans, which are more biologically relevant. It is stressed that while these levels are considered in the assessments to provide an indication of behavioural response, such behaviours do not necessarily equate to a material impact in the context of broader distributions, migration routes, feeding areas or other life stage behaviours.

Masking

Acoustic masking may occur when a noise impedes the ability of an animal to perceive a signal (Wood et al. 2012; Erbe et al. 2016). For this to occur the noise must be loud enough, have similar frequency content to the signal, and must happen at the same time (Wood et al. 2012). The sound generated by seismic surveys comprises brief, low frequency pulses (in the order of tens of milliseconds), occurring several seconds apart. At great distances from the seismic source, sound levels will be quieter, but transmission of the sound via multiple pathways (water, seabed) and reverberation mean that the pulse duration increases and can be greater than 1 second in length. However, given the short pulse duration relative to the duration of marine mammal vocalisations (several seconds to several minutes or longer), marine mammals are likely to be able to detect calls in between seismic pulses, despite some acoustic features of these vocalisations potentially being obscured (Wood et al. 2012). The short, intermittent pulse duration relative to the 5.4 second or 8 second source point interval proposed for the Bonaparte Basin 3D MSS means that the potential for masking is limited.

In addition, Wood et al. (2012) and Erbe et al. (2016) highlight studies that have documented masking compensation strategies (responses the animals use to overcome the masking effects of anthropogenic or natural noise disturbances). For example, in response to anthropogenic noise, humpback whales have increased the duration of their calls (Miller et al. 2000), right whales have altered the pitch of their calls (Parks et al. 2007), and blue whales have called more or less often (Di Iorio & Clark 2009). Currently, there are no specific received level thresholds for reliably assessing or regulating masking responses to seismic noise (Gomez et al. 2016).

Table 7-14: Impact and risk evaluation – underwater noise and vibration – marine mammals

Identify hazards and threats

Without adequate control measures in place, high intensity impulsive sound emitted from the seismic source has the potential to impact marine mammals in the following ways:

- hearing impairment, including permanent threshold shift (PTS) or temporary threshold shift (TTS)
- behavioural disturbance.

Potential consequence	Severity
The particular values and sensitivities with the potential to be impacted by underwater noise are: • EPBC Act listed threatened and/or migratory species of cetacean Although not a listed threatened or migratory species under the EPBC Act, Omura's whales also have the potential to be impacted given they may be present in the Joseph Bonaparte Gulf and the wider region throughout the year. The Operational Area is not known to support significant numbers of any cetacean species and it does not provide unique habitat for known aggregations or sensitive life stages for listed threatened and/or migratory species. There are no identified BIAs for marine mammals within the Operational Area or the wider PEZ. The maximum horizontal distances (Rmax) at which sound levels predicted by modelling (Muellenmeister et al. 2022; Appendix C) may exceed the Southall et al. (2019) thresholds for PTS and TTS are presented in Table 7-15. No VHFC species are known to occur in the region, hence results are shown only for LFC (baleen whales) and HFC (toothed whales and dolphins). Figure 7-4 presents the maximum-over-depth SEL24hr contours associated with PTS and TTS for LFC. **Error! Not a valid result for table.**Figure 7-5 presents the unweighted 160 dB re 1 µPa SPL marine mammal behavioural response contours.	Minor (E)

Table 7-15 Maximum (R_{max}) horizontal distances predicted by acoustic modelling to exceed the Southall et al. (2019) effects thresholds for PTS and TTS

Functional Hearing Category	Threshold Criteria	Distance R_{max}
PTS		
LFC (baleen whales)	PK: 219 dB re 1 µPa	40 m
	Frequency-weighted SEL_{24hr}: 183 dB re 1 $\mu Pa^2.s$	9.2 km
HFC (toothed whales and dolphins)	PK: 230 dB re 1 µPa	Not exceeded
	Frequency-weighted SEL_{24hr}: 185 dB re 1 $\mu Pa^2.s$	Not exceeded

TTS		
LFC (baleen whales)	PK: 213 dB re 1 µPa	70 m
	Frequency-weighted SEL_{24hr}: 168 dB re 1 µPa^2.s	78.9 km
HFC (toothed whales and dolphins)	PK: 224 dB re 1 µPa	Not exceeded
	Frequency-weighted SEL_{24hr}: 170 dB re 1 µPa^2.s	60 m

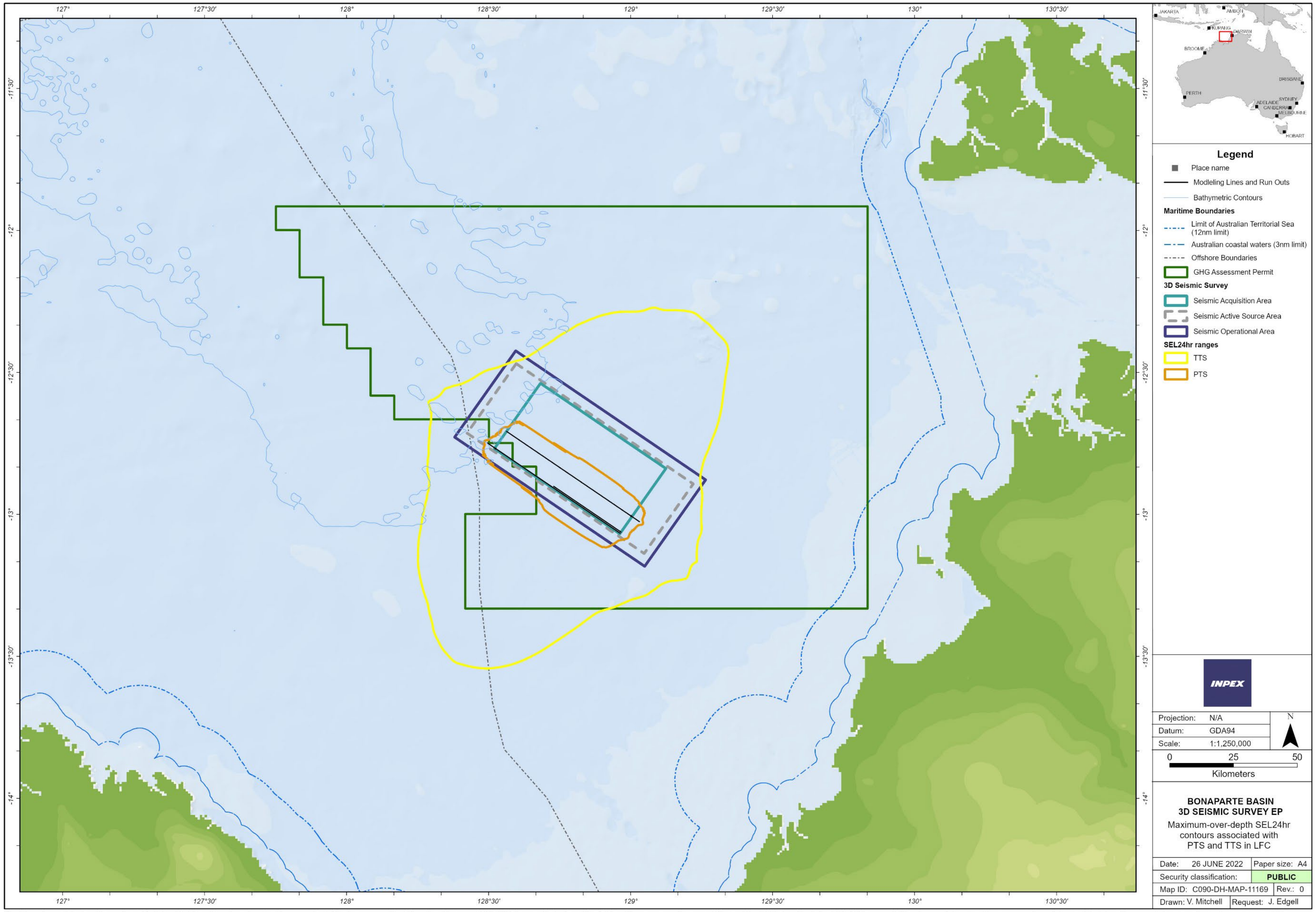

Figure 7-4: Maximum-over-depth SEL_{24hr} contours associated with PTS and TTS in LFC

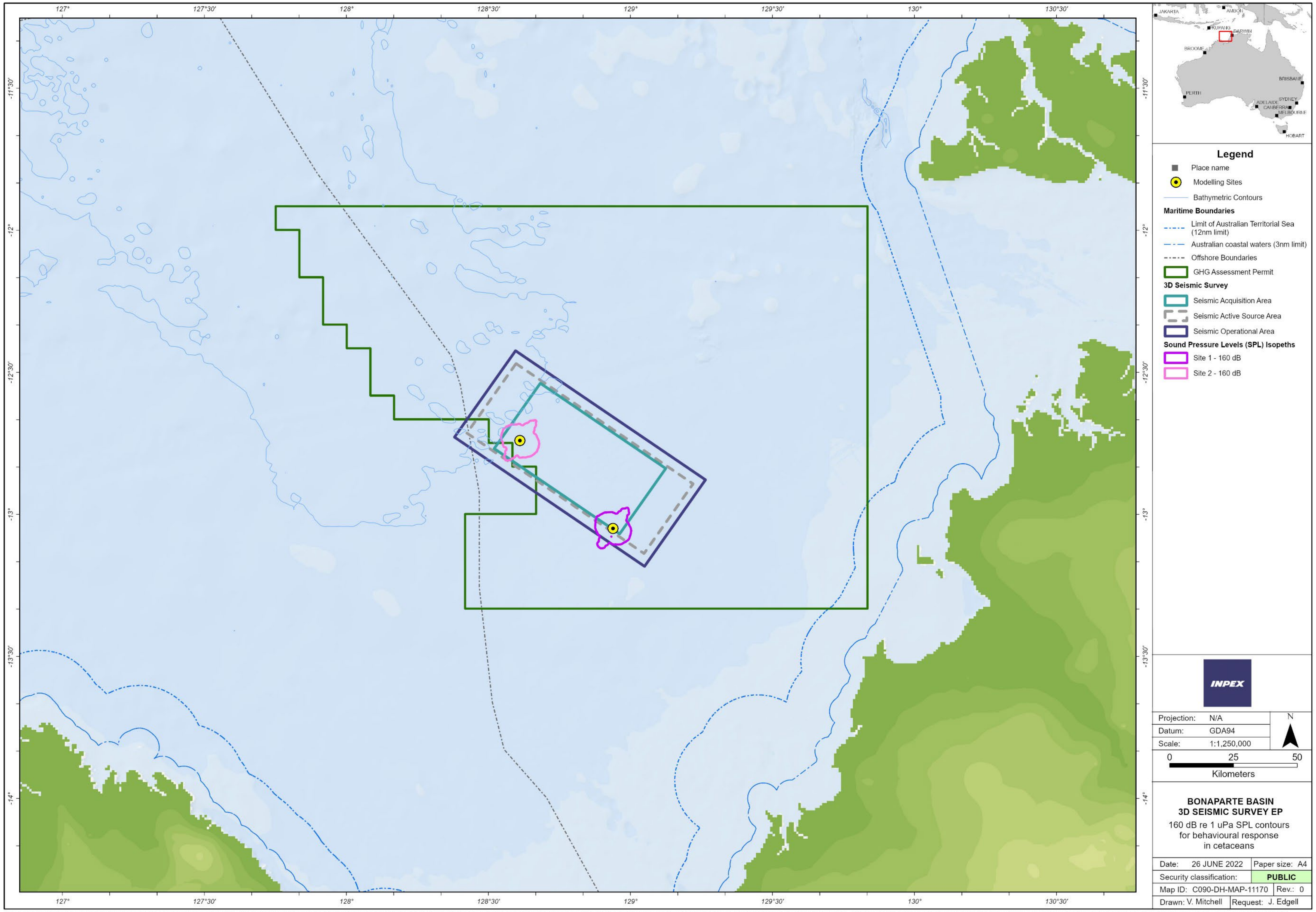

Figure 7-5: Unweighted 160dB re 1 µPa SPL marine mammal behavioural response contours

As shown in Table 7-15, LFC such as pygmy fin, sei, blue, Bryde's and humpback whales (and potentially Omura's whales) are predicted to have potential to experience PTS at a maximum distance of 9.2 km from the nearest survey line, based on application of the multiple pulse SEL24hr threshold across all water depths modelled (maximum-over-depth). However, it is predicted that PTS may be experienced within 40 m based on the single pulse PK metric. For HFC (e.g. dolphins), the single pulse PK multiple pulse SEL24hr thresholds were not exceeded.

The maximum predicted distance to the TTS thresholds for LFC is 78.9 km from the nearest survey line, based on application of the multiple pulse SEL24hr threshold. This distance relates to waters located broadside to the survey lines, where sound accumulates more readily; ranges to TTS in waters located endfire of the survey lines are less (approximately 30 km based on the modelled seismic source) as accumulated sound exposure are based upon fewer pulses received towards the ends of each survey line (Figure 7-4). The zone of potential TTS effects does not overlap any marine mammal BIAs in the region. For HFC, TTS effects from the single pulse PK metric are not exceeded, while the potential range to TTS based on the multiple pulse SEL24hr threshold is 60 m (i.e. limited to within immediate proximity of the source).

As discussed above, the 24-hour SEL is a cumulative metric that reflects the dosimetric (measured dose) impact of noise levels over a period of 24 hours based on the assumption that an animal is consistently exposed to such noise levels at a fixed position. More realistically, whales would not stay in the same location or at the same range for 24 hours. This would particularly be the case for an animal migrating through offshore waters that don't represent critical habitat or a narrow restricted migratory pathway. The predicted ranges are also conservative as they are maximum-over-depth values, corresponding with sound propagation at water depths of approximately 60 m (Muellenmeister et al. 2022), whereas animals may spend a significant amount of time during any 24-hour period swimming at or near the surface where sound propagation ranges are significantly less.

Therefore, a reported radius for SEL24hr criteria does not mean that a whale travelling within this radius of the source will experience PTS or TTS, but rather that an animal could be exposed to the sound levels associated with these effects if it remained in that range for 24 hours (Muellenmeister et al. 2022). The concept of an individual whale remaining within a range of 9.2 km (maximum predicted distance for PTS, based on the SEL24hr metric) from the operating seismic source (which is moving) for a full 24-hour period, or even for a few hours, is not credible. Should an individual remain within the range for potential impact, some recoverable TTS could occur. However, the likelihood of TTS occurring is reduced 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 EPBC Policy Statement 2.1.

Behavioural impacts, such as behavioural avoidance, are more likely to occur if cetaceans pass near the active seismic source. The predicted maximum distance to the NMFS (2019) marine mammal behavioural threshold (single-pulse 160 dB re 1 µPa unweighted SPL), for all types of cetacean, is approximately 10 km, across all water depths modelled. This threshold represents potential significant behavioural effects, such as active avoidance, although it is acknowledged that some level of behavioural response and avoidance may also occur at greater distances depending upon the context and behaviour of individual animals at the time.

At their closest points, the migration, calving and resting BIAs for humpback whale are located over 400 km south-west from the Operational Area and so only occasional individuals are expected to travel the additional distance towards the Joseph Bonaparte Gulf and waters offshore from the NT. Blue whales, specifically the sub-species pygmy blue whale, are also unlikely to occur in the Operational Area. The Operational Area is outside of the known distribution and core range for the species, and the pygmy blue whale migration BIA is located 300 km north-west of the Operational Area at its closest point. Impulsive sound produced during the 3D MSS is unlikely to be discernible from background levels at these locations and no impacts to the pygmy blue whale and humpback whale populations in their respective BIAs are expected. Although not a listed threatened or migratory species under the EPBC Act, Omura's whales have been considered in this assessment given they may be present in the Joseph Bonaparte Gulf and the wider region throughout the year. Although potentially transient to some degree, their movements and behaviours throughout the region are uncertain so key behaviours and life stages such as breeding, feeding, and migration in or through the Joseph Bonaparte Gulf cannot be confirmed or ruled out. Similar species to Omura's whales, such as Bryde's whales have swim speeds of between 2 and 7 km/hour while feeding, but can swim as fast as 20 to 25 km/hour (Kato 2002). Sei whale swim speeds may be similar with top speeds reported to be 55 km/hour over short distances (NOAA Fisheries n.d.). As such, Omura's may be capable of moving away from the active seismic source before significant hearing impairment or injury occurs. Given the proposed observation, soft-start, low power and shut-down procedures, and other procedures that will be implemented in accordance with Part A of EPBC Act Policy Statement 2.1, the risk of PTS or TTS from acute close range exposures is reduced. Given the species' likely swim speeds, behavioural avoidance is also possible prior to the onset of PTS or significant levels of TTS occurring (up to a maximum of 9.2 km and 78.9 km respectively based on 24 hours of exposure). The coastal waters of the Joseph Bonaparte Gulf and Darwin Harbour are breeding/calving/resting BIAs for coastal dolphin species, including Indo-Pacific humpback dolphin, Australian snubfin dolphin and spotted bottlenose dolphin. The BIAs are not located within the PEZ; however, these species represent important populations in region. Given their coastal distribution, Indo-Pacific humpback dolphins and Australian snubfin dolphins are unlikely to occur in the deep offshore waters of the Operational Area, but may occur in nearshore waters.	

For HFC such as dolphins the maximum predicted distance to TTS effects is only 60 m, based on the multiple pulse SEL24hr threshold. This is not a credible scenario, as a dolphin would not remain within 60 m for a 24-hour period. Dolphins that may occur from time to time in the offshore waters of the Operational Area, may experience behavioural disturbance and exhibit an avoidance response within approximately 10 km of the seismic source, based on the NOAA (2019) unweighted 160 dB re 1 µPa SPL behavioural response threshold. However, dolphins are HFC and are less likely to respond to low frequency seismic pulses than LFC. For example, Muellenmeister et al. (2022; Appendix C) predicted the weighted 160 dB re 1 µPa SPL ranges HFC, to account only for the sound energy that is within the frequency range for this group; the weighted 160 dB re 1 µPa SPL level is not exceeded beyond the seismic source array itself, reflecting how most energy is emitted at frequencies lower than the hearing range of most dolphins and toothed whales. There is no potential for any PTS, TTS or behavioural effects to occur in the coastal BIAs for Indo-Pacific humpback dolphin, Australian snubfin dolphin and spotted bottlenose dolphin, which are located at Darwin Harbour, Cambridge Gulf and King George River, approximately 160 km, 185 km and 170 km from the Active Source Area respectively. Sound is expected to fall below background levels before reaching these coastal locations. Ambient background noise levels in the nearshore waters of the Kimberley, for example, are consistently between 85 – 110 dB re 1 µPa SPL, increasing at times to in excess of 130 dB re 1 µPa SPL as a result of biological noise, tidal currents and movement of sediment, and occasionally other anthropogenic noise sources (McCauley 2011, 2012; McPherson et al. 2016b).

Overall, the potential impacts of sound emissions from the seismic source to cetaceans at any one time during the 3D MSS are considered to be temporary behavioural changes (e.g. avoidance) by transient individuals. There is some limited potential for recoverable TTS effects to occur in LFC species should they remain within a maximum distance of 78.9 km of the survey. However, given that the offshore waters of the Joseph Bonaparte Gulf are not known to support any significant aggregations of any cetacean species, animals are likely to be transient, and some level of behavioural avoidance is likely to occur, the potential for such TTS effects to occur is limited. Based on the impact assessment, no long-term or population impacts to cetaceans are predicted, thus the consequence level is assessed as Minor (E).

Identify existing design and safeguards/controls measures

The seismic source levels will be limited to the minimum required to achieve the objectives of the survey. The seismic source specification will be verified prior to commencement of the Bonaparte Basin 3D MSS (Section 7.1.3).

Consistent with the requirements of Part A of EPBC Act Policy Statement 2.1, the following precaution zones will be applied:

- Observation zone: 3+ km horizontal radius from the seismic source
- Low power zone: 2 km horizontal radius from the seismic source
- Shut-down zone: 500 m horizontal radius from the seismic source
- Consistent with the requirements of Part A of EPBC Act Policy Statement 2.1, the following procedures will be applied:
- Pre-Start-up Visual Observations (30 minutes)
- Start-up Delay Procedures (if sighting)
- Soft-start Procedures (30 minutes)

- Operational Shut-down and Low-power Procedures
- Night-time and Low Visibility Procedures
- Seismic survey vessel crew will be briefed in marine fauna observations, distance estimation and procedures
- Cetacean sighting and compliance reports to be submitted to the Department of Climate Change, Energy, the Environment and Water (DCCEEW) within 2 months of survey completion

Propose additional safeguards/control measures (ALARP Evaluation)

Hierarchy of control	Control measure	Used?	Justification
Elimination	No use of a seismic source (i.e. no sound emissions).	No	The Bonaparte Basin 3D MSS cannot be achieved without using a seismic source. Elimination of the seismic source is not possible.
Substitution	None identified	N/A	No additional substitution controls were identified that would practicably reduce the risk to marine mammals.
Engineering	None identified	N/A	No additional engineering solutions were identified that would practicably reduce the risk to marine mammals.
Procedures & administration	Trained and dedicated marine fauna observers (MFOs) on board the seismic survey vessel.	Yes	Consistent with Part B of EPBC Policy Statement 2.1 (additional management measures that may be considered where the likelihood of encountering whales is moderate to high), trained MFOs will undertake marine fauna observations during the Bonaparte Basin 3D MSS. Two MFOs will be on board the survey vessel (in addition to briefed crew members) to alternate shifts during daylight hours to manage fatigue and provide some redundancy in the event one MFO is unavailable. The MFOs will have previous MFO experience on at least 2 commercial and/or scientific voyages.
	Implement procedures for unplanned source deactivation (periods of silence)	Yes	There is no grace period defined in the EPBC Act Policy Statement 2.1. Therefore, INPEX will implement Section 2.1.7 of the 2017 Joint Nature Conservation Committee (JNCC) guidelines for minimising the risk of injury to marine mammals from geophysical surveys, in an unplanned seismic source deactivation, which has not been caused by whales or dolphins within their respective low power or shutdown zones.

			In the event that the seismic source ceases operating unexpectedly, (e.g. due to a technical problem), the seismic source can resume operating in less than ten minutes without the need for a soft-start, provided that no whales or dolphins have been detected in the low power or shutdown zones during the deactivation period.
	Use dedicated marine fauna observer vessels or spotter aircraft	No	Given the proposed scheduling of the Bonaparte Basin 3D MSS, other proposed control measures and the already acceptable level of risk to marine mammals, the cost of this option was considered grossly disproportionate to the limited additional benefit that would be gained. MFOs on board the survey vessel will already provide coverage of the area surrounding the seismic source to an effective and proven industry standard. Aerial observations at great distances offshore, such as the pygmy blue whale migration BIA, are not practicable as flight time and fuel is limited. The cost of an additional dedicated vessel or an aircraft to undertake additional marine fauna observations for the duration of the Bonaparte Basin 3D MSS would likely cost hundreds of thousands of dollars and introduce additional health and safety risks. Implementing an additional dedicated vessel or an aircraft would make the survey commercially unviable.
	Passive Acoustic Monitoring (PAM)	No	PAM was considered as an additional measure to detect marine mammals during night-time and low visibility conditions and/or during sensitive periods, consistent with Part B of EPBC Policy Statement 2.1 (additional management measures that may be considered where the likelihood of encountering whales is moderate to high). There are no known aggregation areas within or in close proximity to the Operational Area for foraging, breeding, calving or resting habitat for a listed threatened or migratory cetacean species / cetacean species with a recovery plan or conservation advice in place. Therefore, limited benefit would be provided by using PAM to detect this species in the Operational Area.

			PAM is dependent upon animals vocalising. Therefore, the method is only effective at detecting vocalizing cetaceans and is also dependent on environmental conditions. PAM is most effective for detecting odontocetes (toothed cetaceans, e.g. orcas, dolphins, sperm whales) that produce clicks and whistles that can be more readily differentiated from low frequency seismic impulses and vessel noise than low frequency calls by baleen whales (e.g. humpback, pygmy blue, fin, sei, Bryde’s, Omura’s). Sophisticated PAM systems are required to effectively filter low frequency cetacean calls (e.g. humpback, pygmy blue, fin, sei, Bryde’s, Omura’s) and such systems are not readily available on all seismic vessels. PAM may require two PAM operators to cover redundancy and fatigue on board the vessel. Costs for engaging a trained PAM operator for the survey are approximately US$50,000. The significant additional cost of having a qualified PAM operator on board for the duration of the survey when there may be few or no detections of listed threatened or migratory species was determined to outweigh any limited additional benefit that PAM might provide, particularly given the proposed soft-start, night time and low visibility procedures. Therefore, taking into account this cost and uncertainty, the use of PAM was not considered commensurate with the limited additional benefit that may be gained.
	Undertake additional pre-start visual observations during equipment deployment	Yes (for Omura’s whales)	Increased duration of pre-start visual observations could increase detectability of marine fauna in the Operational Area. However, for most species there is limited benefit in conducting extended pre-start visual observations. The Joseph Bonaparte Gulf does not provide unique habitat for any deep or long diving cetacean species or other marine fauna, for which extended observation periods might be of benefit. In the additional time that would be given to observations, the seismic vessel will have transited a significant distance and so observations made at the start of the pre-start phase may not actually reflect fauna presence at the time of start up.

			Extended pre-start visual observations could, however, be of benefit for detecting Omura's whales. Omura's whales are not a listed threatened or migratory species and they do not have a recovery plan or conservation advice in place. They are a recently identified species that has been detected in the Joseph Bonaparte Gulf previously, however, they are notoriously elusive. Therefore, extended pre-start observations would provide some benefit in helping to determine if the species is present in the Joseph Bonaparte Gulf prior to start up. It is therefore proposed that an MFO will conduct observations during the period that the seismic source and streamers are being deployed from the vessel. While observations may record all fauna, the primary purpose would be to look for Omura's whales.
	Implementation of EPBC Policy Statement 2.1 (partial part B.6 – adaptive management)	Yes (for Omura's whales)	Consideration has been given to the controls provided for in Part B of the EPBC Policy Statement 2.1, including adaptive management. The additional management measures described in Part B are designed to ensure that impacts and interference to whales are avoided/and or minimised for seismic surveys operating in areas where the likelihood of encountering whales is moderate to high. There are no known aggregation areas within or in close proximity to the Operational Area for foraging, breeding, calving or resting habitat for a listed threatened or migratory cetacean species / cetacean species with a recovery plan or conservation advice in place. However, adaptive management may be a useful approach for managing the potential presence of Omura's whales. Omura's whales are not a listed threatened or migratory species and they do not have a recovery plan or conservation advice in place. They are a recently identified species that has been detected in the Joseph Bonaparte Gulf and elsewhere off north-west Australia, however, their life history and whether they utilise the Joseph Bonaparte Gulf for any important behaviours or life stages is uncertain. By implementing adaptive management measures, the potential for injury/PTS/TTS or interference to this species can be reduced. Adopted adaptive management (for Omura's whales):

			In the event that an Omura's whale (or potential or suspected Omura's whale[7]) is observed during the survey, the following extended shut down procedures will be implemented with immediate effect and will apply for the remainder of the survey for confirmed, potential or suspected Omura's whale sightings: • The shut-down zone will be increased from 500 m to 2 km; and • The start-up delay / shut-down period will be increased from 30 minutes to 60 minutes. • In the event that there are three confirmed, potential/suspected Omura's whale sightings, in a 24-hour period, the seismic source will be shut down for 24 hours. • If, during the 24-hour shutdown period, a confirmed or potential/suspected Omura's whale is sighted, then the seismic source will remain shut down until there has been 24 hours with no confirmed, or potential/suspected Omura's whale sightings. Operations may recommence provided there has been no confirmed, or potential/suspected Omura's whale sightings for 24 hours since the last sighting event, and start-up of the seismic source will commence according to EPBC Act Policy Statement 2.1, A.3.2 Soft-Start Procedure.
	Apply a precautionary shut down zone around the seismic source to prevent injury and hearing impairment impacts to dolphins	Yes	EPBC Policy Statement 2.1 was developed specifically to apply to baleen whales and large odontocete whales. Therefore, it was considered whether it would be practicable to apply similar procedures to dolphins. Smaller dolphin species have peak hearing sensitivities in the mid to high frequency ranges and are likely to be less disturbed by low frequency seismic pulses and less vulnerable to acoustic trauma. Accordingly, EPBC Policy Statement 2.1 does not normally apply to encounters with small dolphins.

[7] Due to the similarities between Omura's whale and Bryde's whale (*Balaenoptera edeni*), sei whale (*Balaenoptera borealis*) and fin whale (*Balaenoptera physalus*), a sighting of any of these species, or an unidentified medium to large cetacean will be treated as a potential or suspected Omura's whale for the purpose of providing a precautionary approach to managing impacts to Omura's whales. The approach would indirectly provide additional protection to listed threatened and / or migratory Bryde's, sei and fin whales if they are observed during the survey.

			Modelling predicts that sound levels that result in PTS/TTS impacts to HFC such as dolphins will not be reached, except for potential TTS effects within 60 m of the source as a result of 24-hours of accumulated sound exposure. Therefore, PTS/TTS effects are highly unlikely to occur to dolphins. In addition, the offshore location of the Bonaparte Basin 3D MSS is not sensitive habitat for dolphins. Dolphin species have been known to approach seismic survey vessels and ride the bow wake for short periods before moving away again without apparent trauma. Depending on the size of the survey vessel, the bow may be within less than 100 m of the towed seismic source, at times making it difficult to practically implement a shut-down zone. Dolphins are highly mobile creatures and are expected to avoid the seismic source at distances where received sound levels are high enough to result in significant impacts. Soft-start procedures will be implemented and provide opportunity for dolphins to move away before the source is operated at full volume. Even so, as a precautionary measure to account for potential uncertainty in dolphin hearing ranges and as a means of meeting the legislative requirement to not injure any cetacean within the Australian Whale Sanctuary, a shut down zone of 100 m radius will be applied around the seismic source for dolphins.
Identify the likelihood			
The Operational Area is not known to support significant numbers of any cetacean species and it does not provide unique habitat for known aggregations or sensitive life stages for listed threatened and/or migratory species. Cetaceans passing within or near to the Operational Area are likely to be transient. Many of the LFC species, such as sei, blue, fin, bryde's and humpback whales are migratory and the Joseph Bonaparte Gulf is located outside of the key migration routes for species such as blue whale and humpback whale. HFC species, such as listed dolphin species predominantly occupy coastal waters in the Joseph Bonaparte Gulf where they will not be impacted. Therefore, the likelihood of Minor consequences to marine mammal species is considered Possible (3).			
Residual risk summary			
Based on a consequence of Minor (E) and a likelihood of Possible (3), the residual risk is also Moderate (7).			
Consequence	Likelihood	Residual risk	

Minor (E)	Possible (3)	Moderate (7)
Assess residual risk acceptability		

Legislative requirements

The proposed control measures exceed the required standards and control measures set out in Part A of EPBC Policy Statement 2.1.

The proposed control measures reduce the potential for PTS and TTS and, therefore, meet the requirement to not injure any cetacean within the Australian Whale Sanctuary.

Stakeholder consultation

During consultation with relevant stakeholders, no specific concerns, objections or claims were raised regarding the potential underwater noise impacts to marine mammals.

Australian Marine Park management objectives and values

The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Received sound levels within the marine parks are predicted to be below 140 dB re 1 µPa SPL, therefore, no PTS, TTS or significant behavioural effects will occur within the marine park boundaries. Received sound levels may be audible to cetaceans in the marine parks, but at levels that are unlikely to be significant. Marine mammals are not listed as a natural value of the Oceanic Shoals MP. Foraging habitat for Australian snubfin dolphin is listed as a natural value of the Joseph Bonaparte Gulf MP. Received sound levels are not expected to be audible to this HFC species, which predominantly inhabits coastal waters. Therefore, no long term impacts to marine mammal values are expected and activity will be undertaken in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values.

Conservation management plans / threat abatement plans

The Blue Whale Conservation Management Plan states 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 Conservation Management Plan, with reference to EPBC Act Policy Statement 2.1, also advises that seismic surveys should not result in disturbance in biologically important areas at biologically important times. The pygmy blue whale migration BIA is located over 300 km from the Operational Area and PTS or TTS (i.e. injury) impacts or behavioural effects are not predicted to occur to pygmy blue whales as they migrate along the continental slope. The Operational Area is not located near a known foraging area and is unlikely to provide for opportunistic foraging given the distance from the species migration route.

Approved Conservation Advice for Sei and Fin whales do not specify required standards for managing noise impacts from seismic surveys, but they do recognise anthropogenic noise as a potential threat to the species. No significant or long-term disturbance, or injury, to sei or fin whales from noise emissions is expected as a result of the seismic survey.

ALARP summary

Given the level of environmental risk is assessed as Moderate, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact.

Acceptability summary

<table>
<tr><td colspan="3">Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because:
the activity demonstrates compliance with legislative requirements/industry standards;
the activity takes into account stakeholder feedback;
the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
the activity is managed in a manner that is consistent with the intent of conservation management documents;
the activity does not compromise the relevant principles of ESD; and
the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as “Moderate”, the consequence does not exceed “C – Significant” and the risk has been reduced to ALARP.</td></tr>
<tr><th>Environmental performance outcomes</th><th>Environmental performance standards</th><th>Measurement criteria</th></tr>
<tr><td rowspan="2">Undertake seismic acquisition in a manner that is consistent with EPBC Policy Statement 2.1 and prevents injury and interference to cetaceans.</td><td>Consistent with Part A of EPBC Policy Statement 2.1, the following precaution zones will be applied:
Observation zone: 3+ km horizontal radius from the seismic source.
Low power zone: 2 km horizontal radius from the seismic source.
Shut-down zone: 500 m horizontal radius from the seismic source.</td><td>MFO report confirms that the precaution zones are implemented in accordance with Part A of EPBC Policy Statement 2.1.</td></tr>
<tr><td>Consistent with Part A of EPBC Policy Statement 2.1, the following procedures will be applied:
A.3.1 Pre-Start-up Visual Observations (30 mins)
A.3.2 Soft-start Procedures (30 mins)
A.3.3 Start-up Delay Procedures (if sighting)</td><td>MFO report confirms that procedures implemented in accordance with Part A of EPBC Policy Statement 2.1.</td></tr>
</table>

	• A.3.4 and A.3.5 Operational Shut-down and Low-power Procedures • A.3.6 Night-time and Low Visibility Procedures • A.4 Cetacean sighting reports within 2 months of completion of the survey.	Communication record confirms cetacean sighting reports provided to DCCEEW within 2 months of completion.
	In the event that the seismic source ceases operating unexpectedly, (e.g. due to a technical problem), the seismic source can resume operating in less than ten minutes without the need for a soft-start, provided that no whales or dolphins have been detected in the low power or shutdown zones during the deactivation period.	Survey logs confirms source activation/deactivation periods. MFO report confirms no marine fauna observed in the low power or shutdown zones during the deactivation period.
	A minimum of two trained and dedicated MFOs will be available on board the seismic survey vessel to manage shift duties during daylight hours during the survey.	MFO report confirms two MFOs were on board the seismic vessel for daylight visual observations during the survey.
	MFOs will have previous experience on at least two commercial and/or scientific voyages.	Curriculum Vitae of the MFOs engaged for the survey confirms MFOs have previous experience on at least two commercial and/or scientific voyages.
	An MFO will undertake marine fauna observations in daylight hours during the deployment of the seismic source and streamers.	Completed marine fauna sighting datasheet MFO records/reports

	• In the event that an Omura's whale (or potential or suspected Omura's whale) is observed during the survey, the following extended shut down procedures will be implemented with immediate effect and will apply for the remainder of the survey for confirmed, potential or suspected Omura's whale sightings:
	  ○ The shut-down zone will be increased from 500 m to 2 km; and
	  ○ The start-up delay / shut-down period will be increased from 30 minutes to 60 minutes.
	• In the event that there are three confirmed, potential/suspected Omura's whale sightings, in a 24-hour period, the seismic source will be shut down for 24 hours.
	• If, during the 24-hour shutdown period, a confirmed or potential/suspected Omura's whale is sighted, then the seismic source will remain shut down until there has been 24 hours with no confirmed, or potential/suspected Omura's whale sightings5. Operations may recommence provided there has been no confirmed, or potential/suspected Omura's whale sightings for 24 hours since the last sighting event, and start-up of the seismic source will commence according to A.3.2 Soft-Start Procedure.
		Vessel logs with records of all shut down procedures.
		MFO records/reports (daily, weekly) show that adaptive management procedures are followed during survey

Undertake seismic acquisition in a manner that prevents injury to dolphins.	A shut down zone of 100 m radius will be applied to dolphins.	MFO report confirms that 100 m shut down zone implemented for dolphins.

7.1.8 Underwater noise and vibration – Marine reptiles

Receptor sensitivity to sound and sound exposure thresholds

Marine turtles are not considered to be as sensitive to sound as cetaceans. Turtles do not have an external ear but detect sound through bone-conducted vibration in the skull and by using their shell as a receiving surface (Lenhardt et al. 1985). The ear of marine turtles appears to be adapted to detect sound in water, with the retention of air in the middle ear suggesting that they are able to detect sound pressure (Popper et al. 2014). Turtles have been shown to respond to low frequency sound, with indications that they have the highest hearing sensitivity within a narrow frequency range 100 to 700 Hz (Bartol & Musick 2003), which coincides with the frequency range of seismic signals (<250 Hz).

There is a paucity of data on the sound levels produced by seismic surveys that may result in mortality, injury or hearing impairment in turtles. As a conservative approach and in the absence of data specific to the effects of seismic impulses on turtles, Popper et al. (2014) recommend applying the thresholds developed for mortality and mortal injury to fishes to turtles as well (see Section 7.1.6). Therefore, Popper et al. (2014) suggest that injury to turtles resulting from seismic impulses may occur for sound exposures above 207 dB re 1 μPa (PK) or above 210 dB re 1 $\mu Pa^2 \cdot s$ (SEL_{24hr}). However, Popper et al. (2014) suggest that recoverable injury and TTS is likely within tens of metres of a seismic source, which is generally less than the distance associated with their proposed mortal injury threshold, hence there is some discrepancy. Popper et al. (2014) also note that turtles are highly resistant to high-intensity explosives, making it likely that they would also be resistant to damage from seismic airguns. Explosives typically produce pressure waves with a more rapid rise time and over pressure signal (and, therefore, likely greater potential for harm) than seismic impulses. Popper et al. (2014) proposed a threshold for injury from explosives of 229–234 dB re 1 μPa (PK). However, seismic impulses have lower peak pressures (and rise time) than explosives, and as such are less likely to cause injury, therefore the potential for injury at 207 dB re 1 μPa (PK) is highly unlikely. This threshold is conservative and is unlikely to represent the levels where mortality and injury may occur.

Finneran et al. (2017) presented revised thresholds for turtle injury, considering both PK and frequency weighted SEL. This work considered Popper et al. (2014), and that the working group assumed turtles to be similar to fish and defines both a weighting function and TTS exposure function parameters for turtles. Finneran et al. (2017) presents the US Navy Phase III thresholds for PTS and TTS which recognise turtles sensitivity to sound and frequency weighted hearing capabilities. The PTS and TTS onset thresholds proposed by Finneran et al. (2017) are presented in Table 7-16 and have been used in this assessment.

For comparaison, Popper et al. (2014) recommend that potential for hearing impairment and behavioural disturbance to turtles be assessed qualitatively rather than based strictly on a specific threshold. For hearing impairment, including PTS and TTS, Popper et al. (2014) rated the likelihood as high in the near-field (tens of metres from the seismic the source) and low in the intermediate to far-field (hundreds to thousands of metres from the seismic source). Similarly, the likelihood of behavioural disturbance was rated as high in the near-field (tens of metres), moderate in the intermediate-field (hundreds of metres) and low in the far-field (thousands of metres).

McCauley et al. (2000) found that turtles showed behavioural responses (i.e. increased swimming behaviour) to an approaching seismic source at received sound levels of approximately 166 dB re 1 µPa SPL, and a stronger avoidance response at around 175 dB re 1 µPa SPL. Similarly, Moein et al. (1995) monitored the behaviour of penned loggerhead turtles to seismic sources operating at 175—179 dB re 1 µPa SPL at 1 m. Avoidance of the seismic source was observed at first exposure, but the turtles habituated to the sound over time. The 166 dB re 1 µPa SPL has been used by the U.S. NMFS as the threshold level for a behavioural disturbance response (NSF 2011). Finneran et al. (2017) identified 175 dB re 1 µPa SPL as the level at which marine turtles are expected to actively avoid seismic exposures. However, the Recovery Plan for Marine Turtles in Australia (DEE 2017a) acknowledges the 166 dB re1 µPa SPL reported by McCauley et al. (2000) as the level that may result in a behavioural response to marine turtles. Therefore, the following impact assessment adopts the lower and more conservative threshold (Table 7-16).

Table 7-16 Impact threshold criteria for marine turtles

Finneran et al. (2017)				**NSF (2011)**
PTS onset thresholds (received level)		**TTS onset thresholds (received level)**		**Behaviour**
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)	**SPL** (Lp; dB re 1 µPa)
204	232	189	226	166

Table 7-17: Impact and risk evaluation – underwater noise and vibration – marine reptiles

<table>
<tr><th colspan="2">Identify hazards and threats</th></tr>
<tr><td colspan="2">High intensity impulsive sound emitted from seismic sources has the potential to impact marine reptiles in the following ways:
• hearing impairment (PTS/TTS) at close range to the seismic source
• behavioural disturbance impacts.</td></tr>
<tr><th>Potential consequence</th><th>Severity</th></tr>
<tr><td>The particular values and sensitivities with the potential to be impacted by underwater noise include:
• foraging green turtles and olive ridley turtles within a foraging BIA overlapped by the Operational Area
• foraging flatback turtles and loggerhead turtles associated with a foraging BIA approximately 10 km west of the Operational Area.
The acoustic modelling (Muellenmeister et al. 2022; Appendix C) predicts that the Finneran et al. (2017) single impulse criteria of 232 dB re 1 µPa (PTS) and 226 dB re 1 µPa (TTS) were not exceeded at a distance greater than 20 m from the centre of the seismic array. Because the array is not a point source, the actual effect range from the edge of the array will be less than 20 m. Therefore, it is highly unlikely that a marine turtle would be exposed at such close range given that the source is towed directly behind the seismic vessel and some attempt to swim away from the approaching vessel and/or increasing sound levels from the seismic source is likely. Based on SEL_{24hr} results, PTS may occur within 70 m and TTS may occur within 4.85 km of the seismic source, which is unlikely to occur given the transient nature of both the seismic vessel and marine turtles. The NMFS criterion (NSF 2011; McCauley et al. 2000a) for a behavioural response in marine turtles (166 dB re 1 µPa SPL) could be exceeded up to 5.6 km of the operating seismic source (Figure 7-6). The McCauley et al. (2000a, 2000b) threshold (175 dB re 1 µPa SPL) for a behavioural disturbance (i.e. increase in swimming behaviour) could also be exceeded within approximately 1.9 km from the operating seismic source.
Behavioural disturbances to marine turtles are expected to be temporary and localised and affect a relatively small number of individuals. These disturbances are not expected to affect a significant proportion of populations in the Joseph Bonaparte Gulf. The Active Source Area is located over 35 km from the nearest turtle internesting BIA or habitat critical to the survival of marine turtles, where received sound levels are predicted to be below 140 dB re 1 µPa SPL and no impacts are predicted. Therefore, internesting will continue such that the stocks will not be compromised. Similarly, the Active Source Area is located over 32 km from the Oceanic Shoals MP and over 60 km from the Joseph Bonaparte Gulf MP, where turtle foraging habitats are designated as natural conservation values. No impacts are predicted to marine turtles in the marine parks.
Therefore, impacts are expected to be limited to transient and foraging marine turtles associated with the turtle foraging BIA overlapped by the Operational Area and the foraging BIA located to the west of the Operational Area. The foraging BIA overlapped by the Operational Area comprises an area of 42,200 km^2 of the Joseph Bonaparte Gulf, of which 1,600 km^2 (3.8%) is overlapped by the Active Source Area.</td><td>Minor (E)</td></tr>
</table>

Despite overlapping the foraging BIA, it is unlikely that the Active Source Area Area represents important foraging habitat given water depths range from 67 m to 105 m. This is deeper than the preferred range for many foraging marine turtles. A study of the marine turtle bycatch of the NPF, which included the waters of the southern JBG, recorded five species: flatback (59% of the total), loggerhead (10%), olive ridley (12%), green (8%) and hawksbill (5%). They identified that marine turtle catches varied with water depth: the highest catch rates were from trawls in water between 20 and 30 m deep, and relatively few turtles (10%) were captured in water deeper than 40 m (Poiner and Harris 1996). Dietary samples of olive ridley turtles from the eastern Joseph Bonaparte Gulf indicate foraging depths of less than 14 m (Conway 1994 reported in Whiting et al. 2007) and satellite tracking data reviewed in recent studies (Ferreira et al. 2020; Thums et al. 2021) concluded that the spatial extents of foraging BIAs are considered to potentially underestimate the distribution of foraging turtles. In particular, green turtles predominantly forage over more complex substrates and habitats in sahllow coastal areas, and olive ridley turtle foraging is not common in the offshore waters of the Operational Area (Thums et al. 2021). However, flatback turtles are reported to forage in areas of the Joseph Bonaparte Gulf with bare substrate and may potentially forage in deeper waters depths (Thums at al. 2021), such as those found in the Operational Area. In addition, Santos (2021) reports that MFOs onboard the seismic vessel during Santos' Beehive 3D MSS, located closer to turtle nesting beaches in the southern Joseph Bonaparte Gulf reported just 15 turtles over the 20-day duration of the survey, averaging 1.3 turtles every day. Therefore, it is unlikely that the Active Source Area (water depth range of 67 – 105 m) is a significant foraging area for marine turtles. Marine turtles encountered during the 3D MSS are more likely to be transient individuals. Disturbances to marine turtles will be short term given the transient nature of both the seismic vessel and marine turtles. For example, based on the modelled ranges for behavioural response (up to 5.6 km) and behavioural disturbance (up to 1.9 km), an individual turtle may respond to the seismic source for approximately one hour and exhibit stronger signs of disturbance for approximately 30 minutes as the seismic vessel passes and foraging behaviours are expected to resume quickly. At any one time, the potential for behavioural responses to occur up to 5.6 km from the seismic source represents an area of approximately 80 km^2 where turtle foraging maybe temporarily disturbed at any one time, which is 0.19% of the defined turtle foraging BIA. Therefore, greater than 99% of the foraging BIA will remain undisturbed at any one time. No long-term or widespread disturbances to marine turtle populations are expected. Should behavioural disturbances occur to foraging marine turtles, it will likely be limited to one-off disturbances to individuals or discrete groups given the transient nature of both the seismic vessel and marine turtles. Therefore, biologically important foraging behaviours will continue within the foraging BIAs. The survey is not expected to result in the decreased availability of prey and is not expected to result in the displacement of turtles from foraging BIAs. Based on the impact assessment, no long term or population impacts to marine turtles are predicted. The effects of sound emitted during the survey will not extend into any internesting BIAs, habitat critical to the survival of marine turtles, or foraging habitat in the marine parks. Behavioural effects to individual or small groups of transient and foraging marine turtles may occur within the foraging BIA; however, over 99% of the BIA will remain undisturbed at any one time and biologically important foraging behaviours will continue within the wider BIA. Therefore, the consequence level is assessed as Minor (E).	

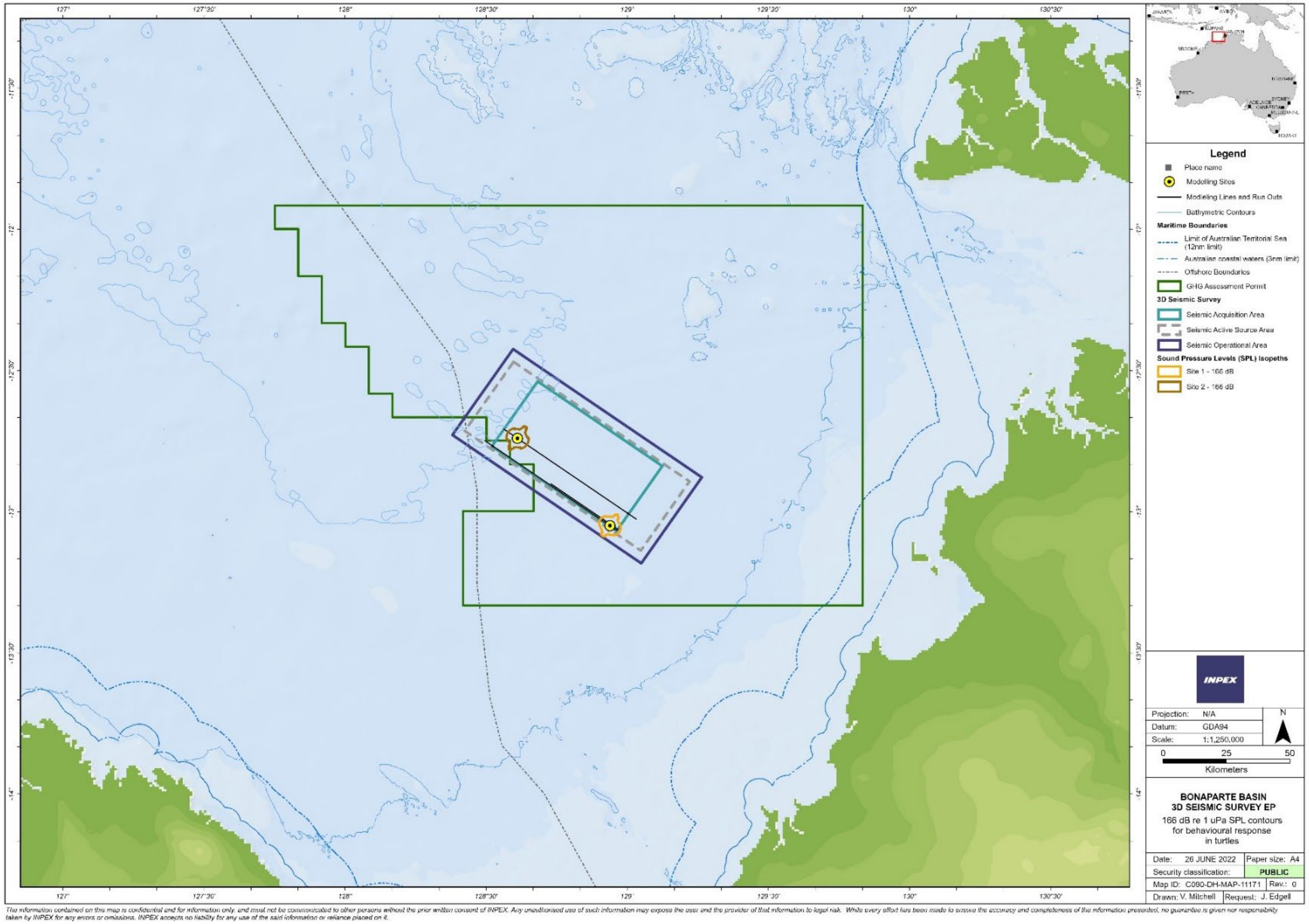

Figure 7-6: 166 dB re 1 µPa SPL marine turtle behavioural response contours

Identify existing design and safeguards/controls measures			
The seismic source levels will be limited to the minimum required to achieve the objectives of the survey. The seismic source specification will be verified prior to commencement of the Bonaparte Basin 3D MSS (Section 7.1.3).			
Propose additional safeguards/control measures (ALARP Evaluation)			
Hierarchy of control	Control measure	Used?	Justification
Elimination	No use of a seismic source (i.e. no sound emissions).	No	The Bonaparte Basin 3D MSS cannot be achieved without using a seismic source. Elimination of the seismic source is not possible.
	Exclude seismic acquisition within turtle foraging BIAs.	No	Approximately 60% of the Active Source Area and 100% of planned acquisition lines overlap with the turtle foraging BIA. Therefore, it is not possible to exclude seismic acquisition within turtle foraging BIAs.
Substitution	None identified	N/A	N/A
Engineering	None identified	N/A	N/A
Procedures & administration	Schedule the survey to avoid turtle foraging in the foraging BIA	No	Turtle foraging occurs year-round within the foraging BIA. Therefore, it is not possible to schedule the survey to avoid foraging turtles.
	Apply soft-start procedures	Yes	Consistent with the controls applied for whales, soft-start procedures consistent with EPBC Policy Statement 2.1 will be implemented, which will allow turtles with an opportunity to avoid the seismic source before it is operated at full volume, thus reducing the risk of injury and hearing impairment.

	Apply a precautionary shut down zone around the seismic source to prevent hearing impairment impacts to marine turtles	Yes	Small numbers of turtles may be transiting through the survey area. In order to reduce the potential risks to turtles, a 500 m turtle observation zone and a 100 m turtle shut-down zone is considered to be a practicable measure to implement. A 100 m shutdown zone is considered to be conservative given that PTS and TTS effects are predicted to be limited to less than 20 m from the seismic source for a single impulse. Based on SEL_{24hr} results, PTS may occur within 70 m and TTS may occur within 4.85 km of the seismic source. Observing for turtles at distances greater than 500 m from the source (which itself is towed a short distance behind the vessel) becomes challenging due to the small size of turtles' heads above the surface, even in calm conditions, and is not considered practicable. The seismic source will be shut down, or start-up will be delayed for 15 minutes, if a turtle is observed within the shut-down zone. Operation of the seismic source using soft-start shall only resume when 15 minutes have lapsed since the turtle sighting or the turtle has been observed to move outside the shutdown zone. Over the course of 15 minutes, the seismic survey vessel will travel approximately 2 km from the sighting location at a speed of 4.5 knots. Given that turtles are slow swimming relative to the survey vessel and due to their limited sensitivity to sound (impairment impacts limited to <20 m from the seismic source), the shut-down and start-up delay is considered highly protective against PTS and TTS effects. The 2 km distance that the vessel will travel from the sighting location is also greater than the 1.67-1.93 km modelled R_{max} for the 175 dB SPL significant behavioural disturbance threshold. Therefore, the shut-down / start-up delay duration is also considered to limit significant behavioural disturbance effects. The benefit of turtle shut-down procedures is considered to outweigh the cost. Further start up delay is not considered practicable, as it could result in significant periods of shut-down when turtle are not close enough to the seismic source to experience hearing impairment impacts. Multiple shut-downs and delays could extend the overall

<table>
<tr><td rowspan="2"></td><td></td><td></td><td>survey duration at significant cost (tens of thousands of dollars per day that the survey is extended).</td></tr>
<tr><td>Night time and low-visibility procedures for turtles.
Start-up of the seismic source (according to the soft-start procedure) may only commence at night-time or at other times of low-visibility provided:
• There have not been 3 or more shut-downs for turtles during the preceding 24 hour period; and
• There have been no turtle sightings within the 500 m turtle observation zone during the 2 hour period prior to night time or low visibility conditions.</td><td>Yes</td><td>Visual observations and shutdown procedures for marine turtles are effective during daylight (during periods of good visibility). However, observations for turtles cannot be effectively conducted at night time or during periods of low-visibility. Therefore, implementation of night time and low visibility procedures, such that start-up and operation of the seismic source may only commence at night-time or at other times of low-visibility if there have not been 3 or more shut-downs and adequate daylight observations have taken place beforehand, provide a practicable means to reduce the likelihood of exposing significant numbers turtles to PTS/TTS effects and close-range behavioural effects</td></tr>
<tr><td colspan="4">Identify the likelihood</td></tr>
<tr><td colspan="4">With the above control measures in place, the potential for PTS/TTS impacts and short-term behavioural disturbance to transient and foraging marine turtles in the foraging BIA is further reduced. The likelihood of Minor consequences to foraging marine turtles is considered Highly unlikely (5).</td></tr>
<tr><td colspan="4">Residual risk summary</td></tr>
<tr><td colspan="4">Based on a consequence of Minor (E) and a likelihood of Highly unlikely (5), the residual risk is Low (9).</td></tr>
</table>

Consequence	Likelihood	Residual risk
Minor (E)	Highly unlikely (5)	Low (9)

<table>
<tr><td>Assess residual risk acceptability</td></tr>
<tr><td>Legislative requirements
The proposed control measures are consistent with requirements of the Recovery Plan for Marine Turtles in Australia (DEE 2017a).
Stakeholder consultation
During consultation with relevant stakeholders, the Director of National Parks requested further detail regarding the identification and management of risks to natural values of the Oceanic Shoals MP and the Joseph Bonaparte Gulf MP, including, but not limited to, the flatback, loggerhead and olive ridley turtles which are present and display behaviours including foraging and migration.</td></tr>
</table>

A response has been provided to the Director of National Parks. INPEX therefore considers that stakeholder concerns have been adequately addressed.

Australian Marine Park management objectives and values

The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Received sound levels within the marine parks are predicted to be below 140 dB re 1 µPa SPL, therefore, no PTS, TTS or behavioural effects to marine turtles will occur within the marine park boundaries. Therefore, no long term impacts to marine turtle values are expected and activity will be undertaken in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values.

Conservation management plans / threat abatement plans

Consistent with the Recovery Plan for Marine Turtles in Australia (DEE 2017a), seismic acquisition will not occur inside important internesting habitat during the nesting season and turtles will not be displaced from identified habitat critical to the survival marine turtles. The nearest turtle internesting BIA and habitat critical area are located over 35 km from the Active Source Area and no impacts are expected in these areas.

The Recovery Plan also states that in accordance with EPBC Act Policy Statement 2.1 – Interactions between Offshore Seismic Exploration and Whales, all seismic survey vessels operating in Australian waters must undertake a soft start during surveys irrespective of location and time of year of the survey. Soft-starts (as well as turtle shut-down procedures, which exceed this requirement) will be implemented during the 3D MSS.

Potential disturbances to turtles in the foraging BIA will be localised and short term and, therefore, biologically important foraging behaviours will continue within the foraging BIAs. Additional night time / low-visibility procedures will be implemented to further reduce the potential for disturbance to foraging turtles in the foraging BIA. Therefore, no impacts to foraging behaviours, to the extent that the recovery of the stock is compromised, will occur.

ALARP summary

Given the level of environmental risk is assessed as Moderate, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact.

Acceptability summary

Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because:

- the activity demonstrates compliance with legislative requirements/industry standards;
- the activity takes into account stakeholder feedback;
- the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
- the activity is managed in a manner that is consistent with the intent of conservation management documents;
- the activity does not compromise the relevant principles of ESD; and
- the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as "Moderate", the consequence does not exceed "C – Significant" and the risk has been reduced to ALARP.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
Undertake seismic acquisition in a manner that is consistent with the Recovery Plan for Marine Turtles in Australia 2017-2027	Soft start procedures will be conducted in accordance with Part A of EPBC Policy Statement 2.1	MFO report confirms that soft start procedures were conducted in accordance with Part A of EPBC Policy Statement 2.1.
	A 500 m radius observation zone and 100 m radius shut down zone will be applied to turtles. The seismic source will be shut-down if a turtle is observed within the 100 m shut-down zone during start-up or full power operation of the seismic source. The seismic source will be shut down, or start-up will be delayed, for 15 minutes if a turtle is observed within the shut-down zone. Operation of the seismic source using soft-start shall only resume when 15 minutes have lapsed since the turtle sighting or the turtle has been observed to move outside the shutdown zone.	MFO report confirms that 100 m shut down zone applied for turtles.
	Start-up of the seismic source (according to the A.3.2 Soft-Start Procedure) may only commence at night-time or at other times of low-visibility provided: • There have not been 3 or more shut-downs for turtles during the preceding 24 hour period; and • There have been no turtle sightings within the 500 m turtle observation zone during the 2 hour period prior to night time or low visibility conditions.	Vessel logs with records of all soft starts, shut down procedures and timing of acquisition. MFO records/reports (daily, weekly) show that night time and low visibility procedures are followed for turtles.

7.1.9 Underwater noise and vibration – Marine avifauna

Table 7-18: Impact and risk evaluation – underwater noise and vibration – marine avifauna

<table>
<tr><th colspan="2">Identify hazards and threats</th></tr>
<tr><td colspan="2">Seabirds and migratory shore birds may potentially be affected by the Bonaparte Basin 3D MSS in the following way:
Direct disturbance to avifauna foraging near the operating seismic source, which may momentarily expose birds to seismic sound and result in a startle response.
Indirect effects to foraging avifauna associated with behavioural responses in fishes that avifauna target as prey.</td></tr>
<tr><th>Potential consequence</th><th>Severity</th></tr>
<tr><td>The particular values and sensitivities with the potential to be impacted by underwater noise are foraging avifauna, noting that there are no BIAs for marine avifauna overlap with the Operational Area. The nearest BIA for avifauna is located over 135 km from the Operational Area. While foraging is more likely to occur in nearshore waters in the Joseph Bonaparte Gulf, some seabirds may forage in offshore waters.

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

It is noted that the behaviour and distribution of some fishes may be affected for short periods during and after exposure to the seismic source (Section 7.1.6). This may result in short-term and localised changes in the distribution of target prey species. However, these effects are unlikely to be discernible to foraging birds in the context of the normal movements and variation in the distribution of fishes.

Therefore, impacts to avifauna populations are not anticipated and the potential consequence is assessed to be Insignificant (F).</td><td>Insignificant (F)</td></tr>
<tr><th colspan="2">Identify existing design and safeguards/controls measures</th></tr>
</table>

The seismic source levels will be limited to the minimum required to achieve the objectives of the survey. The seismic source specification will be verified prior to commencement of the Bonaparte Basin 3D MSS (Section 7.1.3).			
Propose additional safeguards/control measures (ALARP Evaluation)			
Hierarchy of control	Control measure	Used?	Justification
Elimination	No use of a seismic source (i.e. no sound emissions).	No	The Bonaparte Basin 3D MSS cannot be achieved without using a seismic source. Elimination of the seismic source is not possible.
Substitution	None identified	N/A	N/A
Engineering	None identified	N/A	N/A
Procedures & administration	None identified	N/A	N/A
Identify the likelihood			
The likelihood short-term and localised direct and indirect effects to marine avifauna, with Insignificant (F) consequence, is considered to be Possible (3).			
Residual risk summary			
Based on a consequence of Insignificant (F) and a likelihood of Possible (3), the residual risk to marine avifauna is Low (8)			

Consequence	Likelihood	Residual risk
Insignificant (F)	Possible (3)	Low (8)

Assess residual risk acceptability

Legislative requirements

N/A – There are no specific legislative requirements applicable to managing the effects of seismic surveys in relation to avifauna.

Stakeholder consultation

During consultation with relevant stakeholders, no specific concerns, objections or claims were raised regarding the potential impacts to marine avifauna.

Australian Marine Park management objectives and values

The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. No impacts to marine avifauna will occur with the marine parks as a result of underwater noise.

Conservation management plans / threat abatement plans

No specific conservation advice is available in relation to underwater acoustic disturbance to avifauna. However, no significant impacts to avifauna are predicted.

ALARP summary

Although the level of environmental risk is assessed as Low, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond the existing design can reasonably be implemented to further reduce the risk of impact.

Acceptability summary

Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because:

- the activity demonstrates compliance with legislative requirements/industry standards;
- the activity takes into account stakeholder feedback;
- the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
- the activity is managed in a manner that is consistent with the intent of conservation management documents;
- the activity does not compromise the relevant principles of ESD; and
- the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as “Low”, the consequence does not exceed “C – Significant” and the risk has been reduced to ALARP.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
N/A - no controls identified		

7.2 Social and cultural heritage protection

7.2.1 Commercial fisheries

Table 7-19: Impact and risk evaluation – commercial fisheries

<table>
<tr><th colspan="2">Identify hazards and threats</th></tr>
<tr><td colspan="2">The Bonaparte Basin 3D MSS has the potential to interact with commercial fishing activities. The potential effects to commercial fisheries relate to two aspects of the activity, physical presence and underwater sound exposure.
The physical presence and movement of the seismic survey vessel and towed streamer along pre-determined acquisition lines has the potential to encounter fishing vessels during the survey. As a result, the Bonaparte Basin 3D MSS has the potential to interact with fishing vessels in the Operational Area, which may result in direct disruption to fishing activities in the following ways:
• reduced access to some fishing grounds and resources in the area where the seismic survey vessel is operating
• temporary displacement of fishing vessels to other areas, which has the potential to result in increased costs of operation.
Increased sound levels associated with operation of the seismic source may modify the behaviour, local abundance and distribution of fish species during and for a period following the passing of the seismic survey vessel. Therefore, effects to fishes may indirectly affect fishery catch rates if fishing occurs in these locations at the same time.</td></tr>
<tr><th>Potential consequence</th><th>Severity</th></tr>
<tr><td>The particular values and sensitivities with the potential to be impacted include Commonwealth and Territory-managed commercial fisheries which operate in the Joseph Bonaparte Gulf. As identified in Section 4.9.6, the fisheries that access the same waters as the Operational Area are:
• NT Demersal Fishery
• NT Spanish Mackerel Fishery
• NT Offshore Net and Line Fishery
• Northern Prawn Fishery (Cwlth).
Some limited fishing effort has also been undertaken in the Operational Area by the NT Aquarium Fishery, a fishery that uses diving and hand collection methods. Some limited historical fishing effort by the NT Pearly Oyster Fishery has also taken place at Flat Top Bank approximately 45 km from the Operational Area. Therefore, the potential impacts of underwater noise on divers using scuba or hooka apparatus has also been assessed.
No other commercial fisheries are expected to be active within the Operational Area during the Bonaparte Basin 3D MSS. The licence areas of a number of other Commonwealth, NT and WA-managed commercial fisheries overlap the Operational Area, but fishing effort does not normally occur in the same waters.</td><td>Minor (E)</td></tr>
</table>

The potential for impacts to commercial fisheries due to seismic surveys in Australia is a contentious issue. Both industries have rights to access resources in the Australian EEZ, and neither industry has exclusive rights over the other. During the Bonaparte Basin 3D MSS, the seismic survey vessel will typically move along planned seismic lines at a constant speed of approximately 4.5 knots, and will proactively and collaboratively manage situations where there is the potential for interactions between vessels active in the Operational Area. No legislated exclusion zone is enforced around the seismic survey vessel. However, when towing equipment, the survey vessel is classed as a vessel limited in its ability to manoeuvre and so seismic vessels typically request that other vessels, including commercial fishing vessels, avoid coming within 3 nm (5.6 km) of the seismic vessel and towed equipment. As outlined in Section 7.1.6, it is highly unlikely that any commercially targeted pelagic or demersal fishes will be injured or killed by the seismic source. There is the potential for fish in close proximity to the seismic array to temporarily modify their behaviour in areas of increased sound levels resulting from seismic operations, which may include avoidance, modified schooling behaviours, or changes in local abundance and distribution. Fish behaviours may be altered within tens or hundreds of metres from the operating seismic source, or over a few kilometres for some more sensitive species. Therefore, fishery catch rates may be temporarily altered in areas recently exposed to sound from the passing seismic source. The potential effects to the behaviours, local distribution and catchability of fishes may last for minutes or hours (or at worst days) after the active seismic source passes a particular site. The combined effects of physical interactions and the short-term effects following exposure to seismic sound may result in disruption to fisheries. As noted by Salgado Kent et al. (2016), “The issue of changes in commercial fisheries catch rates due to seismic surveys is almost always contentious in Australia”. Salgado Kent et al. (2016) acknowledge that there has been some effort to relate fisheries catch data to seismic survey effort and identify if impacts have occurred, but to date none of the Australian efforts to relate fin-fish catch rates with seismic surveys have yielded meaningful results. Short-term effects on fishes may translate into short-term effects on commercial and recreational catches within and around a seismic survey area. However, sound effects on fishing catches are not often clearly evident because of the lack of determination between the effects of a seismic survey and natural movements and changes in fish. A critical review of the potential impacts of marine seismic surveys (Carroll et al. 2017) noted that the potential effects of seismic surveys on fish distribution, local abundance or fisheries catch rates has been examined for some fish species with varying results, possibly due to gear- and species-specific effects. Of all the studies reviewed, some have found either positive, inconsistent, or no effects of seismic surveys on catch rates or abundance (Carroll et al. 2017). **NT Demersal Fishery** As described in Section 4.9.6, the NT Demersal Fishery targets a range of demersal snappers and emperors, including saddletail snapper, crimson snapper, goldband snapper and red emperor. The NT Demersal Fishery is the main fishery that regularly accesses the waters of the Operational Area. The majority of fishing activity that takes place in the multi-gear area overlapping the Operational Area is trawling, with very limited trap and line activity. During stakeholder consultation, a licence holder in the fishery confirmed that they operate a vessel that regularly fishes within and north of the Operational Area throughout the year. To their knowledge, there are no other licence holders using the area.	

Historic fishing effort data (2016 – 2020) provided by NT DITT confirms that the Operational Area overlaps an area of consistent trawl effort with approximately 345 – 1,400 hours of effort per year within the Operational Area. The Operational Area overlaps with 2% of the 10 nm fishing blocks that have been fished by the NT Demersal Fishery between 2016 and 2020. In terms of effort, the number of hours fished in the blocks overlapped by the Operational Area represents 6% of the hours fished throughout the fishery. However, the potential for interaction with commercial fishing vessels may be significantly over-represented by the Operational Area, as survey activities will not occupy the entire Operational Area for the duration of the survey. The potential for interaction is instead limited to the area near where the seismic survey vessel is operating. To provide a more representative area of where interaction with commercial fishing activity may occur, the impact assessment considers a single week's worth of seismic acquisition lines in the racetrack with a 3 nm (5.6 km) buffer applied to represent the avoidance distance typically requested of other vessels. Based on this rationale, the estimated spatial extent of potential disturbance is approximately 2,070 km² (Figure 7-7). Fishing vessels will not be excluded from this entire area and may continue to fish in this area to some degree. However, it is acknowledged that anticipating the seismic survey vessel's movements in order to access the area to fish in the immediate vicinity of the survey activities would be challenging and, therefore, there is the potential for displacement or reduced fishing effort and catch levels to occur in the vicinity of the broader racetrack. This approach provides a conservative indication of the potential extent of impacts to commercial fisheries as a result of physical interaction. Following seven days of acquisition, the seismic survey vessel will have progressed to a different part of the survey area and so the area of potential interaction is not expected to be any larger. Based on the above approach and the area of potential interaction presented in Figure 7-7, combined with the 65-day duration of the survey relative to the year-round fishing effort, the potential interaction represents 0.6% of fishing effort in the fishery. In terms of the potential level of displacement that may occur to the single trawl vessel that access the fishing ground in the Joseph Bonaparte Gulf, the area of potential interaction represents 16% of the area fished and 18% of the 2016-2020 fishing effort (hours). Accounting for the 65-day duration of the survey relative to the year-round fishing effort, the potential interaction represents 3% of the year-round fishing effort undertaken by the fishing vessel in this area. It is noted that the most heavily fished blocks lie to the north of the Operational Area. During stakeholder consultation, the fishery licence holder acknowledged that there are options to trawl in alternative areas to the north of the Operational Area. The presence of the seismic survey activity may result in the fisher trawling a reduced area in the blocks to the north but key grounds will still be accessible. As described in Section 7.1.6, the demersal snappers and emperors targeted by the NT demersal fishery are hearing generalists. As such, behavioural effects are expected to be limited to within hundreds of metres to a few kilometres of the seismic source as it passes, with the effects limited to minutes or hours in most cases. The recent study by 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. Therefore, the extent and duration of impacts to fish behaviour and catchability are not expected to be any greater than the area and duration of the survey activities.	

Therefore, impacts to the NT Demersal Fishery and the individual licence holder that fishes in the Joseph Bonaparte Gulf are likely to be relatively localised and temporary, despite this being the key fishing activity in the Operational Area.	

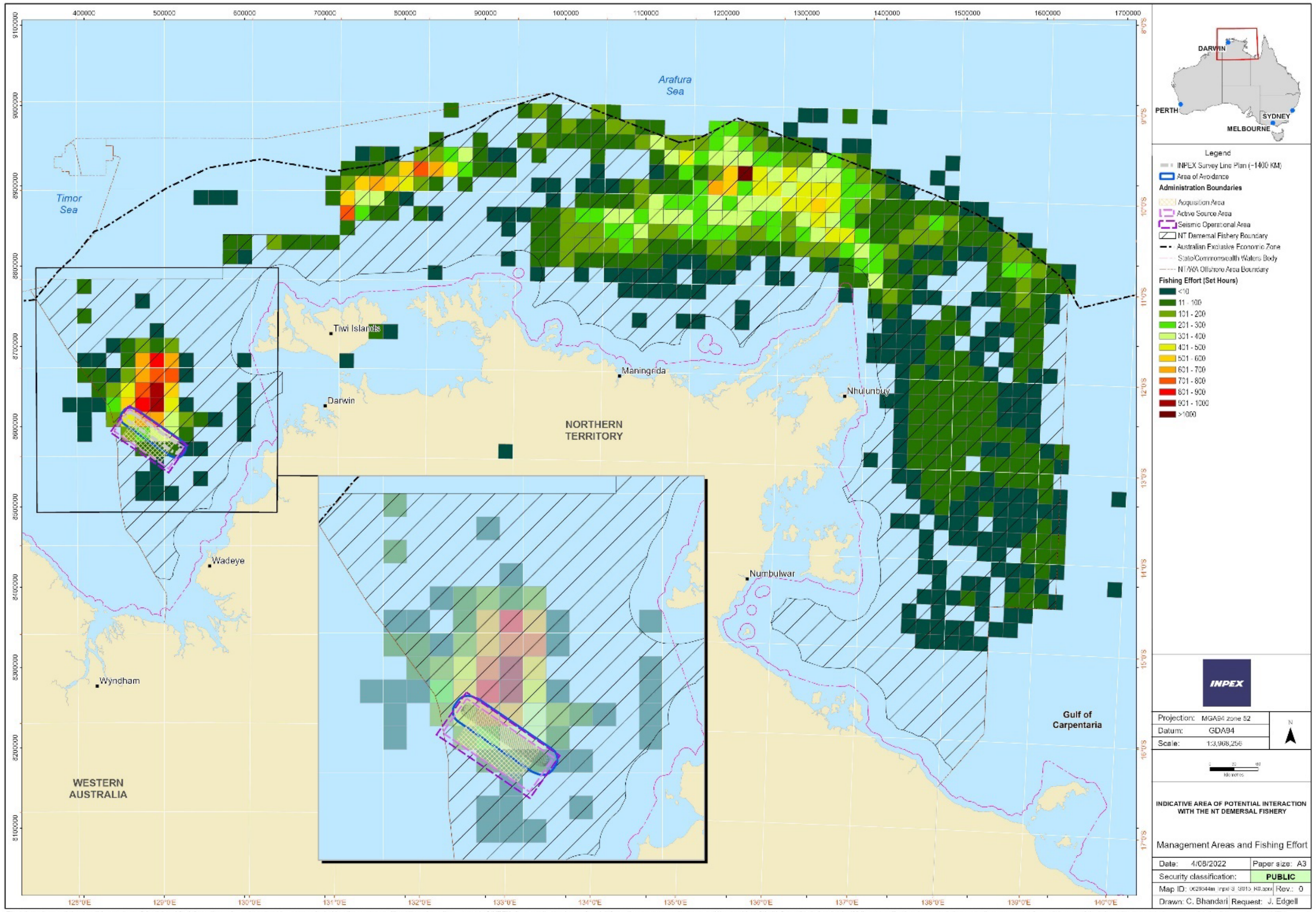

Figure 7-7: Indicative area of potential interaction with the NT Demersal Fishery

NT Spanish Mackerel Fishery

As described in Section 4.9.6, the NT Spanish Mackerel Fishery has previously fished in the Operational Area, but effort has been limited to waters on the south-eastern edge of the Operational Area and closer towards the coast. Fishing in the Operational Area has been infrequent, with a total of 39 hours of effort in 2016, 10 hours of effort in 2017, and 28 hours of effort in 2019. No effort occurred within the Operational Area in 2018 or 2020. Therefore, interactions with vessels in this fishery will be very infrequent or may not occur at all.

Adopting a similar approach as that presented above for the area of potential interaction with the NT Demersal Fishery, the potential area of interaction with the NT Spanish Mackerel Fishery during seven days of acquisition represents just 0.2% of the total fishing effort throughout the fishery. Accounting for the 65-day duration of the survey relative to the year-round fishing effort, the potential interaction represents 0.04% of fishing effort in the fishery. Therefore, limited interaction and impact is expected to this fishery.

As described in Section 7.1.6, mackerels do not have a swim bladder and, therefore, their hearing is not sensitive to sound pressure. As a result, mackerels would have to be very close to the seismic source (tens or hundreds of metres) for any significant behavioural responses in mackerel to take place. It is acknowledged that small pelagic bait fish species (e.g. herring and other clupeid species), which are targeted as prey by mackerels, may be more sensitive to sound. The abundance and distribution of these baitfish could be affected over a larger distance and for longer durations than the mackerel, which could indirectly lead mackerels to follow the food source further distances away from the operating seismic source than they would be affected themselves. Should this occur, such effects could occur over several kilometres and potentially last for a number of days. Noting however that fishing effort is more concentrated in shallower waters than the Operational Area, such effects may have limited impact on fishing effort and catch nearer to shore.

NT Offshore Net and Line Fishery

As described in Section 4.9.6, the NT Offshore Net and Line Fishery targets grey mackerel and blacktip sharks. Fishing has previously occurred in the eastern part of the Operational Area. However, fishing has been highly infrequent, with a total of 15 hours of effort in 2016, 3 hours of effort in 2017, 5 hours of effort in 2019 and 35 hours of effort in 2020. No effort occurred within the Operational Area in 2018. Therefore, interactions with vessels in this fishery will be very infrequent or may not occur at all.

Adopting a similar approach as that presented above for the area of potential interaction with the NT Demersal Fishery, the potential area of interaction with the NT Offshore Net and Line during seven days of acquisition represents just 0.3% of the total fishing effort throughout the fishery. Accounting for the 65-day duration of the survey relative to the year-round fishing effort, the potential interaction represents 0.05% of fishing effort in the fishery. Therefore, limited interaction and impact is expected to this fishery.

As described in Section 7.1.6, mackerels and sharks are highly mobile and any significant behavioural responses would be limited to tens or hundreds of metres from the seismic source. Small pelagic bait fish species (e.g. herring and other clupeid species), which are targeted as prey by mackerels, may be more sensitive to sound. Such effects could occur over several kilometres and potentially last for a number of days. Noting however that fishing effort is more concentrated in shallower waters than the Operational Area, such effects may have limited impact on fishing effort and catch nearer to shore. **Northern Prawn Fishery** NPF fishing effort in the Joseph Bonaparte Gulf has historically occurred >50 km south-west of the Operational Area. Fishing effort in waters overlapped by the Operational Area has never been fished by more than 5 vessels in a year. Fishing effort data provided by the NPFI during stakeholder consultation for the EP is consistent with the ABARES data and confirms limited or no fishing effort within the Operational Area. Previously, the fishery operated during two seasons; the first season was the banana prawn season and ran from 1 April to 15 June. The second season was tiger prawn season and ran from 1 August to 1 December. However, since 2021 the Joseph Bonaparte Gulf has been closed to fishing during the banana prawn season. The Operational Area lies mainly to the north of the closure area, but overall activity during the banana prawn season is expected to reduce. NPFI note that due to the Joseph Bonaparte Gulf being closed to NPF fishing activities between 1 April and 15 June, there may be an increase in the number of vessels that fish in or around the Joseph Bonaparte Gulf in the tiger prawn fishing season. However, on the basis that key target areas for prawns have consistently been outside of the Operational Area in previous years, but there is no apparent reason why this the relative distribution of tiger prawns and associated fishing effort in the Joseph Bonaparte Gulf would affect change significantly. While an increase in fishing effort is possible, effort in the Operational Area is expected to remain low relative to other areas of the Joseph Bonaparte Gulf. As assessed in Section 7.1.5, no discernible impacts are expected to prawn stocks and the catchability of prawns is not expected to be impacted. **Diver-based fisheries** The NT Aquarium Fishery and the NT Pearl Oyster Fishery both operate as hand collection/diver fisheries. The NT Aquarium Fishery has reportedly fished a single 10 nm block on the north-east edge of the Operational Area (one hour fishing effort in 2020). This block is located in water depths in excess of 80 m and is not associated with any obvious bathymetric features that would be accessible to divers so it is unclear if this is accurate or an error in the data. The NT Pearl Oyster Fishery has had very limited fishing effort at Flat Top Bank, between approximately 45 km and 95 km north-east of the Operational Area. The reported fishing effort and appears to be exploratory. There is limited potential for the 3D MSS to impact these fisheries through physical interaction between vessels. However, divers exposed to high levels of underwater sound can suffer from dizziness, hearing damage or other injuries to other sensitive (mainly air-filled) organs, depending on the frequency and intensity of the sound. 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). In the event that seismic activities occur near dive sites, there is the potential for divers to be displaced.	

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 SPL 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. Based on the acoustic modelling (Muellenmeister et al. 2022; Appendix C), the 145 dB re 1 µPa SPL could be exceeded up to a maximum of 24 40.7 km from the seismic source. This distance relates to maximum-over-depth levels and so does not necessarily mean a diver in the upper 30 m of the water column or on a shallow reef or bank would be exposed to such levels. This distance also represents the range along a single azimuth to the north-east of the sail lines, which would be experienced for a short period, not prolonged exposure; the distance along other azimuths is generally several kilometres less. The UK Diving Medical Advisory Committee (DMAC) guidance note “Safe Diving Distance from Seismic Surveying Operations” (DMAC 2019) suggests 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. On this basis, there is the potential for divers operating within the NT Aquarium Fishery and the NT Pearl Oyster Fishery to be temporarily displaced, subject to if and when any fishing takes place. Overall, based on the assessments of all individual fisheries above, potential interactions with the NT Demersal Fishery and potentially an increased number of trawl vessels in the NPF present the worst-case consequence of all the fisheries active in the area. The potential impacts to the NT Spanish Mackerel and NT Offshore Net and Line Fishery are expected to be negligible. In the event that the seismic vessel and towed equipment are required to sail outside of the Operational Area, there is potential for interaction with fishers operating in other parts of the fisheries. On the basis that the Bonaparte Basin 3D MSS may potentially result in some localised and temporary disruption to fishing effort. The overall consequence of the Bonaparte Basin 3D MSS to fisheries is considered to be Minor (E).	
Identify existing design and safeguards/controls measures	
The seismic source levels will be limited to the minimum required to achieve the objectives of the survey. The seismic source specification will be verified prior to commencement of the Bonaparte Basin 3D MSS (Section 7.1.3). Ongoing stakeholder notifications/consultation with relevant stakeholders as per Section 9.8.3 and Table 9-5.	

Seismic and support vessels fitted with lights, signals, AIS transponders and navigation equipment as required by the Navigation Act 2012 and associated Marine Orders (consistent with COLREGS requirements).			
Propose additional safeguards/control measures (ALARP Evaluation)			
Hierarchy of control	Control measure	Used?	Justification
Elimination	No use of a seismic source (i.e. no sound emissions).	No	The Bonaparte Basin 3D MSS cannot be achieved without using a seismic source. Elimination of the seismic source is not possible.
Substitution	None identified	N/A	N/A
Engineering	None identified	N/A	N/A
Procedures & administration	Schedule seismic acquisition to avoid the tiger prawn fishing season and prevent impacts to the NPF.	No	The NPF is the only fishery in the Joseph Bonaparte Gulf that operates on a seasonal basis. During stakeholder consultation NPFI requested for activities to be undertaken outside the period from 1 August and 1 December each year (tiger prawn fishing season) given this is the only time period in which NPF fishers can access the Joseph Bonaparte Gulf. However, based on historical fishing effort data and fishery publications, INPEX understands that the 3D MSS will not be taking place in a location that is of particular significance for prawns (in terms of biology, recruitment) or for fishing activities. Fishing effort in this location has historically been very low or non-existent in some years. INPEX notes that there is the potential for an increase in the number of vessels fishing during the tiger prawn season. However, on the basis that key target areas for prawns have consistently been outside of the Operational Area in previous years, there is no apparent reason why the relative distribution of tiger prawns and associated fishing effort would change significantly. While an increase in fishing effort is possible, effort in the Operational Area is expected to remain low relative to other areas of the Joseph Bonaparte Gulf.

			The 3D MSS is provisionally expected to be conducted in Q2 2023, which is consistent with the timing requested by NPFI; however, an exact start date is subject to vessel availability, operational efficiencies, and weather, other site survey and drilling activities that INPEX plan to undertake within the permit area, as well as potential Department of Defence exercises that may occur. Given the limited potential for impact and low risk to the NPF, INPEX does not consider committing to activities outside the period from 1 August and 1 December to be practicable.
	Notification of the commencement and completion of the seismic survey provided to commercial fishers.	Yes	Engagement with fishers will be ongoing to provide stakeholders with information the commencement, progress and completion of the 3D seismic survey. This will also provide the necessary channels by which fisheries stakeholders may seek further information or clarification on issues of concern or provide feedback to INPEX. Notification will be sent to fisheries stakeholders 3 weeks prior to commencement of the 3D seismic survey, communicating the general location where acquisition will commence, the expected start date and survey duration, and may include other details such as IMO vessel numbers, and vessel radio and satellite phone communication details. Notification will also be provided to fisheries stakeholders within 2 weeks of completion of the 3D seismic survey. These measures are considered practicable and an effective way of communicating and coordinating the survey activities with other industries. Refer Section 9.8.3 and Table 9-5 for relevant EPO and EPS.

	Provide daily lookahead reports	Yes	In addition to survey commencement and completion notifications, detailed information can be provided to fishers to assist them in understanding the specific locations where the survey vessel will be operating within the next 48-hour period. This may assist fishers in targeting specific fishing grounds away from the proposed acquisition lines during these periods. The option of daily look-ahead reports will be offered to fisheries stakeholders as an option, and sent to stakeholders who request/register to receive them. The look-ahead reports include: • a summary of the acquisition lines completed in the previous 24 hours; • the locations of acquisition lines proposed to be acquired in the 48 hours ahead; and • a summary of any changes or delays experienced or foreseen (e.g. weather, downtime). This information is likely to be helpful for not only the fishery licence holders, but also the fishing vessel crews and shore base personnel.
	Vessels to be fitted with AIS systems and radars that include AIS (virtual or installed) marking of the location of streamer tail buoys.	Yes	Seismic tail buoys can be readily equipped with virtual or installed AIS, providing an additional level of visibility to other marine users.

	Notifications and/or joint risk assessment with NT Aquarium Fishery and NT Pearl Oyster Fishery stakeholders.	Yes	The UK Diving Medical Advisory Committee (DMAC) guidance note "Safe Diving Distance from Seismic Surveying Operations" (DMAC 2019) recommends that where diving and seismic activity occur within 45 km of each other, all parties should be made aware of the planned activity. Where diving and seismic activities occur within 30 km of each other, a joint risk assessment should be conducted, and planning/mitigation agreed between parties. Refer Section 9.8.3 and Table 9-5 for relevant EPO and EPS.
	Towed streamers and seismic source array recovered if the seismic vessel is required to transit outside of the Operational Area.	No	Towing of equipment is permitted outside of the Operational Area in accordance with maritime law. Recovering towed equipment reduces the risk of interactions with other marine users in the event that the seismic vessel is required to sail outside of the Operational Area. However, towed equipment can take in the order of 3-4 days to recover on board the seismic vessel and a similar amount of time to redeploy and test. Therefore, recovery of towed equipment may result in significant lost time during the survey window and is a significant cost (1.5 to 2 million USD). In the event that equipment deployment/ recovery cannot be completed within the Operational Area, or the seismic vessel is required to depart the Operational Area urgently due to weather or mechanical issues, recovery may not be possible. The Vessel Master will take whatever action they feel necessary to prevent threats to life on board the vessel or damage to the vessel or equipment. Recovery of equipment is therefore the Vessel Master's decision, not INPEX's.

	Only deploy towed equipment in the operational area to avoid commercial fishing operators	No	During mobilisation to, and demobilisation from the Operational Area, the seismic vessel may have seismic equipment deployed in the water, as permitted under maritime law. Similarly, at any time during the survey, the seismic survey vessel may depart the Operational Area if, in the opinion of the vessel master, the safety of the vessel and crew is at risk e.g. in the event of sea/weather conditions restricting manoeuvring capabilities. In the event that the seismic vessel is required to depart the Operational Area urgently due to weather or mechanical issues, recovery of towed equipment may not be possible. The Vessel Master will take whatever action they feel necessary to prevent threats to life on board the vessel or damage to the vessel or equipment. Recovery of equipment is therefore the Vessel Master's decision, not INPEX's. In addition, deployment and recovery of towed equipment can each take in the order of three days to complete. Therefore, recovery of towed equipment may result in significant lost time during the survey window and is a significant cost (1.5 to 2 million USD). Therefore, it is not always practicable for towed seismic equipment to be recovered and stowed while the survey vessel outside of the Operational Area. Notifications to fishers are already in place and the addition of this control does not reduce the likelihood, given the additional potential costs.
	Develop a claim process for assessing claims by stakeholders for displacement or loss or catch.	No	A claim assessment process will not reduce the consequence, or the likelihood, of potential environmental impact. It is therefore an inappropriate control measure to prevent or reduce environmental risk.

			However, as part of the implementation strategy (See Section 9.6.1) INPEX is in consultation with commercial fishing stakeholders to develop a claim process prior to the activity commencing, should it not be possible to avoid impacts.

Identify the likelihood

With the above described controls in place, the likelihood of the Bonaparte Basin 3D MSS causing occasional disruption to commercial fisheries, with Minor consequence, is reduced, but is considered Likely (2).

Residual risk summary

Based on a consequence of Minor (E) and a worst-case likelihood of Likely (2) the residual risk is Moderate (6).

Consequence	Likelihood	Residual risk
Minor (E)	Likely (2)	Moderate (6)

Assess residual risk acceptability

Legislative requirements

N/A – There are no legislative requirements applicable to managing the effects of seismic surveys in relation to commercial fisheries.

Stakeholder consultation

Fisheries stakeholder feedback during preparation of this EP was received from the NT DITT, NTSC, NPFI and a NT Demersal Fishery licence holder (Table 5-4). Matters raised related to the potential disruption to commercial fishing operations rather than impacts of seismic to target species.

NPFI requested for activities to be undertaken outside the period from 1 August and 1 December each year (tiger prawn fishing season). The 3D MSS is provisionally expected to be conducted in Q2 2023, which is consistent with the timing requested by NPFI; however, an exact start date is subject to vessel availability, operational efficiencies, and weather, other site survey and drilling activities that INPEX plan to undertake within the permit area, as well as potential Department of Defence exercises that may occur. Given the limited potential for impact and low risk to the NPF, INPEX does not consider committing to activities outside the period from 1 August and 1 December to be practicable. A response has been provided to the NPFI.

The NT Demersal Fishery licence holder advised that they have a vessel that regularly fishes within and north of the Operational Area throughout the year. To their knowledge, there are no other licence holders using the area. There is some overlap of the proposed Operational Area and the grounds targeted by the stakeholder, but the licence holder acknowledged there are options to fish/trawl in alternative areas to avoid contact with survey vessels if they are on water at the same time. INPEX has captured the information provided by the stakeholder in the impact assessment.

INPEX therefore considers that relevant matters and stakeholder objections/claims and concerns have been adequately addressed and that the level of impact to commercial fisheries is acceptable.

In addition to the proposed control measures, INPEX is consulting with stakeholders to develop a claim process.

Australian Marine Park management objectives and values

The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. No impacts will occur to commercial fisheries or fish species within the marine parks.

Conservation management plans / threat abatement plans

Several conservation management plans have been consulted in the development of this EP. However, none of the recovery plans or conservation advice documents are relevant to the effects of seismic surveys on commercial fisheries.

ALARP summary

Given the level of environmental risk is assessed as Moderate, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact.

Acceptability summary

Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because:

- the activity demonstrates compliance with legislative requirements/industry standards;
- the activity takes into account stakeholder feedback – all stakeholder objections, claims or concerns and relevant matters have been addressed and stakeholders have been provided with a response;
- the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
- the activity is managed in a manner that is consistent with the intent of conservation management documents;
- the activity does not compromise the relevant principles of ESD –i.e. no long-term impacts to fishing activities, fishing catch rates or the target stocks are expected that are not in the realm of normal variation; and
- the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as "Moderate", the consequence does not exceed "C – Significant" and the risk has been reduced to ALARP.

Defined Acceptable Level: No preventable displacement to commercial fisheries

In addition to the minor predicted impacts to commercial fisheries, INPEX has proposed a series of control measures to reduce the potential for interactions and subsequent impacts to catch rates. These include measures that practically allow for both the Bonaparte Basin 3D MSS and commercial fishing to occur in the region, including dividing the survey into two separate areas to provide fishers with access to alternative and viable fishing grounds, advanced notifications, and ongoing communications through daily lookahead reports and on-the-water communications.

With these controls in place, any unforeseen displacement or impacts to commercial fishing activities should be preventable and fishers should be able to continue to fish and achieve acceptable catch rates elsewhere.

Environmental performance outcomes	Environmental performance standards	Measurement criteria

No preventable displacement to commercial fisheries will occur	Daily lookahead reports will be provided to stakeholders who register to receive them. The reports will include: • a summary of the acquisition lines completed in the previous 24-hour period • the locations of acquisition lines proposed to be acquired in the 48 hours ahead • a summary of any changes or delays experienced or foreseen (e.g. weather, downtime).	Copies of daily lookahead reports and communication records confirm daily reports are provided to stakeholders who register to receive them.
	Vessels will maintain appropriate lighting, day shapes, and signals to indicate that the seismic survey vessel is towing and is therefore restricted in its ability to manoeuvre, in compliance with COLREGS, the Navigation Act 2012 and associated Marine Orders.	Vessel records confirm no records of survey or support vessels failing to comply with appropriate navigation, lighting, day shape and signal requirements under COLREGS, the Navigation Act 2012 or its associated Marine Orders.
	A 24-hour visual, radio/satellite and radar watch will be maintained by survey vessels operating in the Operational Area.	Vessel records confirm that a 24-hour visual and radar watch is maintained, and radio/satellite communications with other third-party vessels.
	The towed streamer will be clearly marked with a tail buoy with light and radar reflector.	Vessel premobilisation inspection confirms that the streamer is mobilised with a tail buoy with a light and radar reflector.

7.2.2 Other marine users

Table 7-20: Impact and risk evaluation – Physical presence of vessels resulting in disruption to other marine users

<table>
<tr><th colspan="2">Identify hazards and threats</th></tr>
<tr><td colspan="2">The physical presence of the seismic survey vessel and the towed streamers (potentially 7 – 10 km in length, with the ends extending up to 11 km behind the vessel), as well as associated support vessels, has the potential to cause disruption to other marine users in the Operational Area, including commercial shipping, recreational and traditional fishers, other petroleum support vessels in the region, tour operators and the Australian Defence Force.
Potential indirect impacts to tourism operators near the coast are also evaluated in the following risk assessment.</td></tr>
<tr><th>Potential consequence</th><th>Severity</th></tr>
<tr><td>The particular values and sensitivities with the potential to be impacted by physical presence of the vessels are:
• Shipping, other operators, recreational / traditional fishers and tour operators
• defence.
Other marine users in the vicinity of the survey may be impacted by vessel presence because of the loss of navigable space available to conduct their activities. The implications of such disruptions include changes to sailing routes and journey times, or reduced ability to fish in an area. The worst-case consequence from a loss of access to an area could result in economic losses and/or potential reduction in employment levels.
Shipping recreational / traditional fishers and tour operators
The seismic vessel will typically move along planned seismic acquisition lines at a constant speed of approximately 4.5 knots. There are no regulatory or enforced exclusion zones applied to the survey vessel, but due to the seismic survey vessel's classification as a vessel limited in its ability to manoeuvre while towing equipment, other marine users may be asked to take measures to avoid the seismic vessel and towed equipment to avoid interaction.
The proximity of the Darwin Port to South East Asia makes the surrounding area a key shipping region. Vessel traffic data shows high traffic shipping volumes in close proximity to Darwin Harbour, around operating petroleum fields and along key shipping routes to and from South-east Asia. Vessel traffic also passes through the southern part of the Operational Area between Darwin and Kalumburu, and also between Darwin and the INPEX Ichthys and Shell Prelude offshore LNG facilities. Most vessels are likely to transit through the Operational Area, because due to the distance offshore, no recreational fishing is expected to occur. Occasional charter vessels may fish in the Operational Area opportunistically. If a charter vessel is fishing in waters recently exposed to sound from the seismic source, the effects would be incidental, localised and short term.
Other fishing activities, such as traditional Aboriginal fishing, are known to occur along the NT and WA coastlines. As with recreational fishing, due to the remoteness and predominantly deep offshore waters, interactions in the survey area resulting in the loss of navigable space in which to conduct fishing activities is not expected to occur.</td><td>Insignificant (F)</td></tr>
</table>

The Operational Area does not include any locations of specific interest for tourism, although coastal waters and locations adjacent to the Operational Area may be used by tourism operators from time to time. Most tourism activities in the region occur predominantly in State/Territory waters adjacent to population centres, such as Darwin. Tourism in the region typically peaks during the dry season (May to October). A number of luxury cruise operators access Kimberley coastal waters to the south-west of the Operational Area, operating from late February/March to October/early November to avoid the wet season. Some Kimberley cruises extend to the coastal waters of the Joseph Bonaparte Gulf, visiting coastal locations approximately 180 km or more from the Operational Area. Cruise itineraries do not include offshore waters, although operators may occasionally transit through the Operational Area between Darwin and the Kimberley coastline. No impacts are expected to the tourism industry. The majority of shipping traffic in the Operational Area is of low to moderate intensity (averaging approximately 1-2 vessels per day) and is predominantly associated with the Port of Darwin. Given that the proposed sail lines of the survey vessel will be oriented in a north-west to south-east direction, the vessel will routinely cross commercial vessel traffic routes to and from Darwin. The Bonaparte Basin 3D MSS will tow streamers extending up to 11 km behind the vessel, with a streamer spread between approximately 825 m and 1,500 m. An area of avoidance of 3 nm around the seismic vessel and streamers is typically requested of other vessels. Other marine user vessel encounters that occur in line with the seismic survey vessel will require a minor deviation of course to give way to the vessel. Vessels that are sailing crossways to the survey sail line will need to deviate a greater distance, although as the vessel is moving, the deviation is likely to be less than the full length of the streamers. Commercial vessel masters are familiar with procedures for operating in the vicinity of a vessel restricted in its ability to manoeuvre and the seismic survey vessel and support vessel masters and crews operate in areas of the world with significantly higher vessel traffic without significant issue. No significant navigational implications or long-term changes in shipping traffic patterns are expected. The Bonaparte Basin is an established hydrocarbon province with a number of commercial operations. During the Bonaparte Basin 3D MSS, the survey vessel will enter the permits of other petroleum titleholders in the form of retention leases (WA-6-R, NT/RL1) and an exploration permit (NT/P88). The survey vessel has the potential to disrupt activities and vessel movements in these areas. No offshore facilities are within range of the Operational Area such that commercial dive operations at the facility could be exposed to seismic pulses as a result of the Bonaparte Basin 3D MSS. The closest facility is the Blacktip platform situated approximately 100 km south-west of the Operational Area. The Operational Area overlaps with practice and training areas that comprise the North Australian Exercise Area (NAXA), a maritime military zone and restricted airspace. The NAXA is used by the Royal Australian Air Force and the Royal Australian Navy for military operations, including live weapons and missile firings. Operation Talisman-Sabre is a major international activity scheduled to occur in mid-2023, but exact timing is not confirmed. The NAXA is also the primary location of the biennial KAKADU training exercise that is understood to be planned for September 2022 and then again in 2024. Exercise Singaroo is conducted immediately following KAKADU in the same areas. During these exercises, access to NAXA may be restricted to all vessels and aircraft. In addition to major training exercises, patrol boats regularly conduct training in the NAXA area that includes live firings; however, these are not usually programmed until six to eight weeks prior.	

The seismic survey vessel is not expected to interfere with Defence activities, although military exercises and training may result in closures or restrictions on the Bonaparte Basin 3D MSS in some or all parts of the Operational Area. Overall, the potential consequence of occasional interactions with other marine users is assessed as Insignificant (F).			
Identify existing design and safeguards/controls measures			
Ongoing stakeholder notifications/consultation with relevant stakeholders as per Section 5.6 and Table 9-5. Seismic and support vessels fitted with lights, signals, AIS transponders and navigation equipment as required by the *Navigation Act 2012* and associated Marine Orders (consistent with COLREGS requirements).			
Propose additional safeguards/control measures (ALARP Evaluation)			
Hierarchy of control	Control measure	Used?	Justification
Elimination	Eliminate the use of vessels and towed equipment	No	The use of vessels and towed equipment to undertake the activity cannot be eliminated. No other practicable elimination options were identified.
Substitution	Alter timing to avoid scheduled military exercises	Yes	Safety of survey vessels, personnel and equipment, as well as military.
Engineering	None identified	N/A	N/A
Procedures & administration	Vessels to be fitted with AIS systems and radars that include AIS (virtual or installed) marking of the location of streamer tail buoys.	Yes	Seismic tail buoys can be readily equipped with virtual or installed AIS, providing an additional level of visibility to other marine users.
	Seismic acquisition in other titleholders' exploration permits will be undertaken in accordance with Ingress Agreements with the relevant titleholders and an Access Authority granted by NOPTA.	Yes	Seismic acquisition in other titleholders' exploration permits will be undertaken in accordance with Ingress Agreements with the relevant titleholders and an Access Authority granted by NOPTA.
Identify the likelihood			
The likelihood of potential disruptions to other marine users with Insignificant (F) consequence is considered Possible (3).			
Residual risk summary			

Based on a consequence of Insignificant (F) and a likelihood of Possible (3) the residual risk is Low (8).		
Consequence	Likelihood	Residual risk
Insignificant (F)	Possible (3)	Low (8)
Assess residual risk acceptability		

Legislative requirements

All requirements under the *Navigation Act* and associated Marine Orders for navigation, collision, and support vessels are identified as control measures.

Stakeholder consultation

No stakeholder concerns have been raised regarding potential impacts and risks from the physical presence of vessels in the project area. During stakeholder consultation AMSA noted that there may be considerable traffic in the proposed project area and requested that all relevant notifications be adopted as controls in this EP, therefore, these requirements have been adopted. All vessels are required to comply with the Navigation Act 2012, and associated Marine Orders, which are consistent with the COLREGS requirements. Stakeholder engagement during the development of this EP with Defence (Table 5-4) confirmed the schedule of exercises in 2022, 2023 and 2024. INPEX will adhere to Defence requirements during exercises and provide adequate notification of activities and timing. Ongoing consultation will continue with Defence throughout the implementation of this EP (refer to Section 9.8.3).

Australian Marine Park management objectives and values

The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. No impacts will occur to socio-economic values within the marine parks.

Conservation management plans / threat abatement plans

Several conservation management plans have been consulted in the development of this EP (Appendix A). None of the recovery plans or conservation advice documents are relevant to the physical presence of vessels disrupting shipping or fishing operators.

ALARP summary

Although the level of environmental risk is assessed as Low, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact.

Acceptability summary

Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because:

- the activity demonstrates compliance with legislative requirements/industry standards
- the activity takes into account stakeholder feedback
- the activity is managed in a manner that is consistent with the intent of conservation management documents
- the activity does not compromise the relevant principles of ESD

- the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as "Low", the consequence does not exceed "C – significant" and the risk has been reduced to ALARP.

Environmental performance outcomes	**Environmental performance standards**	**Measurement criteria**
Prevent adverse interactions between other marine users	Vessels will maintain appropriate lighting, day shapes, and signals to indicate that the seismic survey vessel is towing and is therefore restricted in its ability to manoeuvre, in compliance with COLREGS, the *Navigation Act 2012* and associated Marine Orders.	Vessel records confirm no records of survey or support vessels failing to comply with appropriate navigation, lighting, day shape and signal requirements under COLREGS, the *Navigation Act 2012* or its associated Marine Orders.
	A 24-hour visual, radio/satellite and radar watch will be maintained by survey vessels operating in the Operational Area.	Vessel records confirm that a 24-hour visual and radar watch is maintained, and radio/satellite communications with other third-party vessels.
	Vessels to be fitted with AIS systems and radars that include AIS (virtual or installed) marking of the location of streamer tail buoys.	Pre-mobilisation audit/checklist confirms that the streamer is mobilised with AIS marking of tail buoys.
	The towed streamer will be clearly marked with a tail buoy with light and radar reflector.	Vessel premobilisation inspection confirms that the streamer is mobilised with a tail buoy with a light and radar reflector.
	Prior to commencement of the Bonaparte Basin 3D MSS, ingress agreements and Access Authorities will be confirmed for petroleum permit areas / licence areas held by other petroleum titleholder that the Bonaparte Basin 3D MSS will access.	Approved ingress agreements and Access Authorities.
	No survey activity during scheduled military exercises with NAXA.	Documented correspondence with DoD does not identify scheduled military exercises during the survey timeframe. Survey records confirm survey start and end dates.

7.3 Cumulative seismic survey impacts (noise and physical presence)

Table 7-21: Impact and risk evaluation – Cumulative impacts (Noise and physical presence)

Identify hazards and threats

Cumulative impacts from seismic surveys can potentially occur when:

- multiple seismic surveys occur in a region concurrently (at the same time), leading to an increase in sound exposure to the same receptors; or
- seismic surveys occur successively (one after the other) in the same area when the timeframe between surveys is less than the recovery rate of any potential impacts to receptors from the previous survey.

The hazard and threats of the cumulative effects of physical presence and seismic sound from concurrent or successive seismic surveys are the same as those assessed in Sections 7.1 and 7.2, involving potential physical and behavioural impacts to biological receptors, and disruption to stakeholders.

Cumulative impacts associated with light and vessel discharges are assessed in sections 7.5.1 and 7.5.3.

Potential consequence | **Severity**: Insignificant (F)

The particular values and sensitivities with the potential to be compounded by cumulative impacts include:

- planktonic communities
- commercial fisheries
- EPBC Act listed species (including foraging green turtles and olive ridley turtles within a foraging BIA overlapped by the Operational Area foraging flatback turtles and loggerhead turtles associated with a foraging BIA approximately 10 km west of the Operational Area).

Past seismic surveys

A review of data available on the National Offshore Petroleum Information Management System (NOPIMS) website has confirmed the seismic surveys that have previously been undertaken in the Joseph Bonaparte Gulf and wider Bonaparte Basin in the last 5 years (since 2018). These surveys are summarised in Table 7-22 and presented in Figure 7-8.

Table 7-22: Seismic surveys undertaken in the Bonaparte Basin (2018 – 2022)

Survey Name	Acquisition Period(s)	Distance from Operational Area
Polarcus Zenaide 3D MSS	18/01/2018 - 18/04/2018	95 km west-south-west
Santos Bethany 3D MSS	11/05/2018 - 23/07/2018	145 km north
Santos Beehive 3D MSS	23/07/2018 - 11/08/2018	75 km south

Polarcus Petrelex 3D MSS	1/12/2019 - 16/01/2020	935 km^2 overlap with Acquisition Area
Santos Petrel Sub-Basin SW 3D MSS	01/03/2022 - 23/03/2022	30 km south-west
Woodside Galactic Hybrid 2D	12/05/22- 28/05/22	220 km north-east

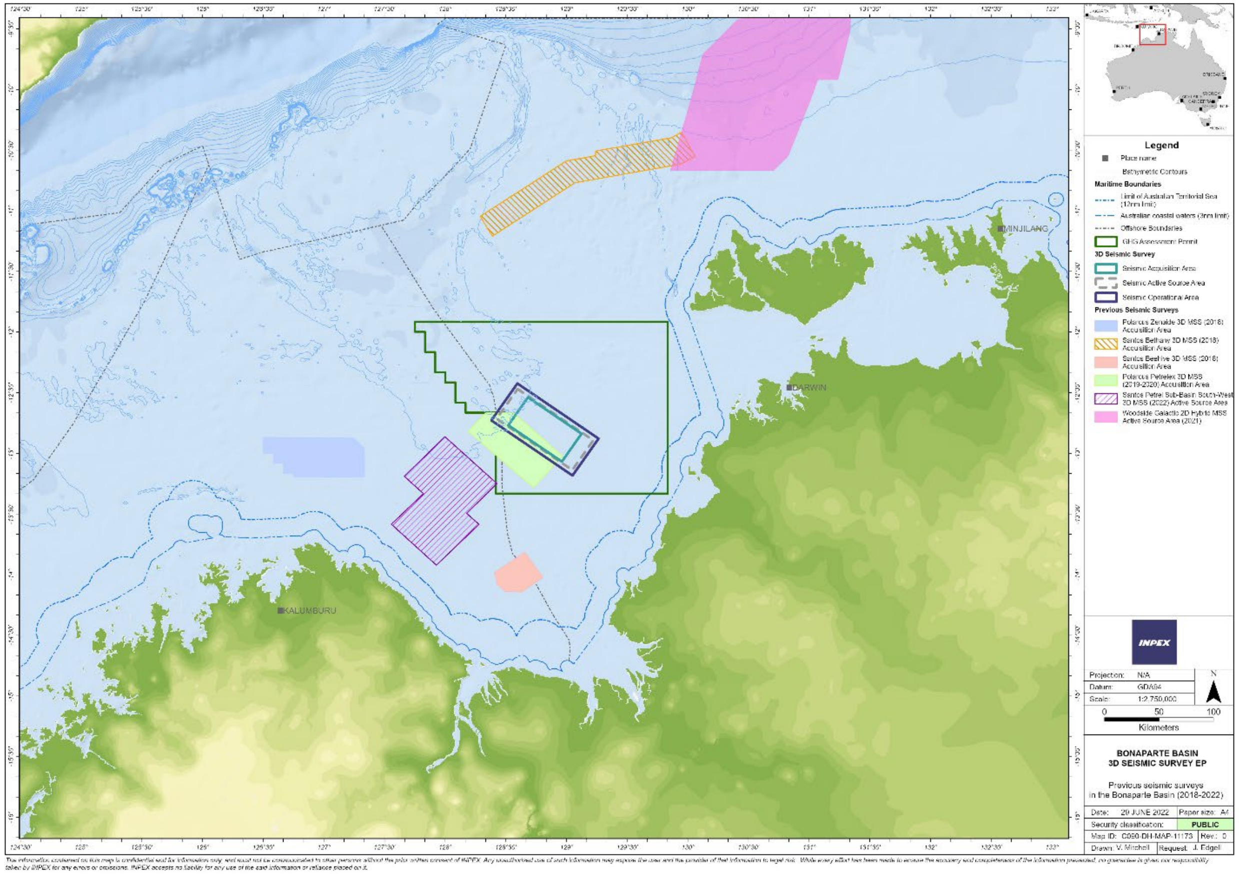

Figure 7-8: Seismic surveys undertaken in the Bonaparte Basin (2018 – 2022)

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 in Section 7.1. 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. Given the time that has elapsed since the last survey overlapping with the Bonaparte Basin 3D MSS (the Polarcus Petrelex 3D MSS, which was completed in January 2020), all receptors are expected to have recovered from the effects of previous surveys. The Santos Petrel Sub-Basin SW 3D MSS was the most recent survey to be undertaken (completed in March 2022), but this is located 30 km from the Bonaparte Basin 3D MSS and there are no overlapping benthic communities; even so, benthic communities that were exposed during the Santos Petrel Sub-Basin SW 3D MSS are likely to have completely recovered prior to the commencement of the Bonaparte Basin 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 the Bonaparte Basin 3D MSS. Commercial fisheries will have been exposed to underwater noise emissions and the physical presence of past surveys in the region. Each of the past surveys will have had a different level of interaction with different fisheries and each would have occurred at separate times, given none of the identified past surveys took place at the same time as another. For example: • Polarcus Zenaide 3D MSS – Located in WA (Kimberley) waters in an area where the WA Mackerel managed Fishery operates and some limited effort from the WA Northern Demersal Scalefish Managed Fishery has occurred. While the Bonaparte Basin 3D MSS overlaps with WA offshore waters slightly, it does not overlap with areas previously fished by WA fisheries. The Zenaide 3D MSS had some limited overlap with the NPF, but similar to the Bonaparte Basin 3D MSS, it was in an area where fewer than five vessels have fished, rather than an area of high intensity fishing. • Santos Bethany 3D MSS – Located in the Oceanic Shoals MP, this survey mainly overlapped with the NT Timor Reef Fishery and the NT Demersal Fishery, albeit an area of the NT Demersal Fishery accessed by different vessels and licence holders than the area INPEX now understands from relevant stakeholders is fished in the Bonaparte Basin 3D MSS Operational Area. • Santos Beehive 3D MSS – Located in the south of the Joseph Bonaparte Gulf, the survey again overlapped with the NPF, as well as some areas of low fishing effort by the NT Spanish Mackerel Fishery and the NT Offshore Net and Line Fishery. • Polarcus Petrelex 3D MSS – Overlaps with the Bonaparte Basin 3D MSS and so will have resulted in interaction with similar fishing vessels in the NT Demersal Fishery, as well as areas of very infrequent fishing by the WA Mackerel managed Fishery and the WA Northern Demersal Scalefish Managed Fishery. The survey was undertaken outside of the NPF fishing seasons and so avoided interactions with the NPF.	

• Santos Petrel Sub-Basin SW 3D MSS – Overlaps with areas of very infrequent fishing by the WA Mackerel managed Fishery and the WA Northern Demersal Scalefish Managed Fishery, as well as an area of significant fishing intensity by the NPF, although the survey was undertaken outside of the NPF fishing seasons and so avoided interactions with fishing vessels. Woodside Galactic Hybrid 2D- primarily overlaps with the NT Timor Reef Fishery, which the Bonaparte Basin 3D MSS does not overlap. The Woodside Galactic 2D Hybrid MSS has some limited overlap with the NT Demersal Fishery, NT Spanish Mackerel Fishery, NT Offshore Net and Line Fishery, NT Aquarium Fishery and the NPF. Therefore, there is some limited potential for cumulative effects to occur to these fisheries due to experiencing successive seismic surveys in the region, although the two separate areas may be accessed by different fishers. Based on the above, surveys for the most part have limited cumulative impacts on the same groups of fishers in the various different fisheries, either due to location or timing, although some fishers may have encountered more than once of the surveys. Fishery catch and effort data available for the NPF, NT and WA managed fisheries is either of too coarse a scale or restricted by confidentiality limitations (i.e. less than five licence holders per year) to be able to provide any indication of whether surveys have altered fishing effort or catch levels significantly. Therefore, it has not been possible to determine if the occurrence of past seismic surveys has materially impacted the performance of commercial fisheries. 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. Interactions with commercial fisheries will also have been temporary. **Planned seismic surveys** One other seismic survey has been identified from the NOPSEMA website that is proposed within the Bonaparte Basin (Figure 7-9); Schlumberger Bonaparte 3DMC MSS – EP currently under assessment by NOPSEMA. The survey is located 260 km west from the Bonaparte Basin 3D MSS. The survey may commence as early as September 2022 and will be completed before 30 June 2024. It is estimated to take between approximately 120 to 190 days to acquire. The survey area overlaps with different benthic communities, different fish stocks (Timor Sea stock management unit) and different habitat areas for marine fauna such as turtles and cetaceans.	

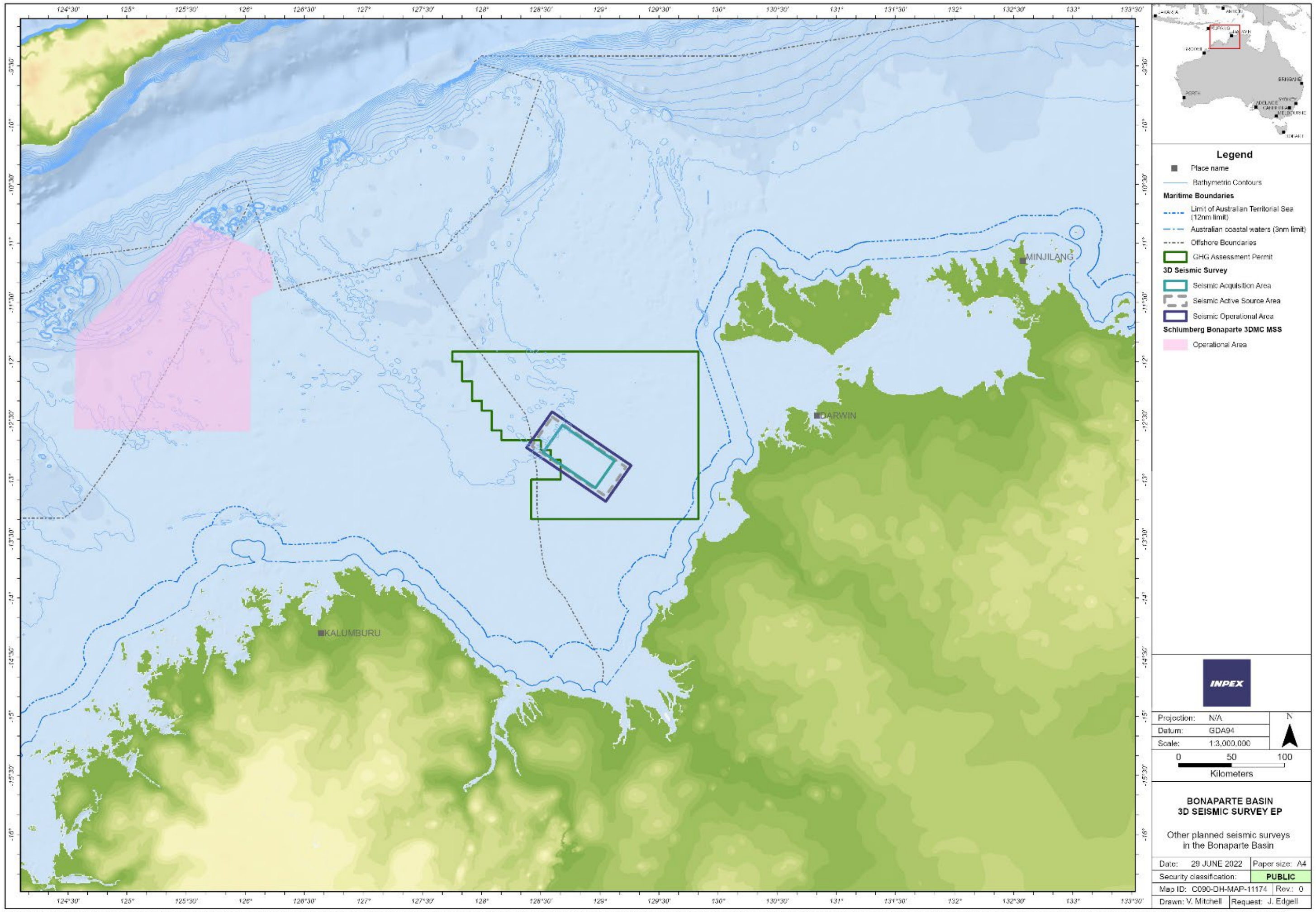

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Figure 7-9: Planned seismic surveys in the Bonaparte Basin

The Schlumberger Bonaparte 3DMC MSS could take place in the same timeframe as the INPEX Bonaparte Basin 3D MSS. It is important to note that, while the other seismic survey has the potential to occur during the validity period of the Bonaparte Basin 3D MSS EP, the two surveys may not occur at the same time. Should both surveys be undertaken simultaneously, the distance between the two surveys means that the combined sound levels between the two surveys are likely to be well below levels that result in any impacts to marine fauna and other ecological receptors. For example, acoustic modelling demonstrates that sound propagated from the Bonaparte Basin 3D MSS are likely to be below or approaching 120 dB re 1 µPa SPL; even for the most sensitive LFC cetaceans who may be able to discern these levels from ambient background levels, they are unlikely to result in any significant response. It is noted that the proposed Schlumberger Bonaparte 3DMC MSS is located in adjacent to the Multiple Use Zone of the Oceanic Shoals MP and the INPEX Bonaparte Basin 3D MSS are located in close proximity to the Multiple Use Zone of the Oceanic Shoals MP. Neither survey overlaps with the marine park, but sound may propagate into the marine park. Should both surveys occur simultaneously, combined sound levels within the marine park and Turtle BIA's are not expected to be significant or result in any impacts to marine park values. The Schlumberger Bonaparte 3DMC MSS also overlaps with different fish stocks (Kimberley stock management unit), different fisheries, and different marine users in general. it is considered there is limited potential for cumulative impacts as a result of past or planned seismic surveys. Overall, the additional potential consequence to receptors from cumulative sound impacts from concurrent surveys, based on the worst-case, is considered to be Insignificant (F).	

Identify existing design and safeguards/controls measures

The seismic source levels will be limited to the minimum required to achieve the objectives of the survey. The seismic source specification will be verified prior to commencement of the Bonaparte Basin 3D MSS (Section 7.1.3).

Propose additional safeguards/control measures (ALARP Evaluation)

Hierarchy of control	Control measure	Used?	Justification
Elimination	None identified	N/A	N/A
Substitution	None identified	N/A	N/A
Engineering	None identified	N/A	N/A

Procedures & administration	During operation of the seismic source, a minimum separation distance of 40 km shall be maintained between the Bonaparte Basin 3D MSS seismic vessel and other operating seismic survey vessels should other seismic surveys in the Bonaparte Basin be identified over the life of the EP.	Yes	This measure will reduce the risk of cumulative impacts occurring and also preserves seismic data quality.
	Engaging with the titleholder/seismic survey operator conducting other potential seismic surveys in the NPF and NT Demersal Fishery at the same time as the Bonaparte Basin 3D MSS, to minimise displacement of commercial fishers.	Yes	This measure will reduce the potential for displacement with commercial fishing vessels, wherever practicable,

Identify the likelihood

Other seismic surveys that have occurred in the Bonaparte Basin previously and their receptors are well understood. Planned future surveys have also been identified, with limited potential for cumulative impacts to occur to the same receptors, irrespective of whether survey occur simultaneously of consecutively. Therefore, the likelihood of cumulative impacts with Insignificant (F) consequences occurring is considered Possible (3).

Residual risk summary

Based on a consequence of Insignificant (F) and a likelihood of Possible (3) the residual risk is Low (8).

Consequence	Likelihood	Residual risk
Insignificant (F)	Possible (3)	Low (8)

Assess residual risk acceptability

Legislative requirements

Even accounting for potential cumulative impacts, the Bonaparte Basin 3D MSS will be undertaken in a manner that is consistent with the objectives of the North-west Marine Parks Network Management Plan 2018 and protects the values of the Kimberley AMP and wider North-west Network.

Stakeholder consultation

During consultation with relevant stakeholders, the Director of National Parks requested further detail regarding the identification and management of risks (including cumulative impacts) to natural values of the Oceanic Shoals MP and the Joseph Bonaparte Gulf MP, including, but not limited to, the flatback, loggerhead and olive ridley turtles which are present and display behaviours including foraging and migration.

The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Limited potential for cumulative impacts from other seismic surveys has been identified. It is noted that the proposed Schlumberger Bonaparte 3DMC MSS is located in close proximity to the Multiple Use Zone of the Oceanic Shoals MP. Should both surveys occur simultaneously, combined sound levels within the marine park are not expected to be significant or result in any impacts to marine park values. INPEX therefore considers that relevant matters have been adequately addressed.

Australian Marine Park management objectives and values

The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. The proposed Schlumberger Bonaparte 3DMC MSS is also located in close proximity to the Multiple Use Zone of the Oceanic Shoals MP. Should both surveys occur simultaneously, combined sound levels within the marine park are not expected to be significant or result in any impacts to marine park values.

Conservation management plans / threat abatement plans

Several conservation management plans have been consulted in the development of this EP. However, none of these plans provide any specific guidance or requirements in relation to cumulative impacts from seismic surveys.

ALARP summary

Given the level of environmental risk is assessed as Low, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact.

Acceptability summary

Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because:

- the activity demonstrates compliance with legislative requirements/industry standards;
- the activity takes into account stakeholder feedback;
- the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
- the activity is managed in a manner that is consistent with the intent of conservation management documents;
- the activity does not compromise the relevant principles of ESD; and
- the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as “Low”, the consequence does not exceed “C – Significant” and the risk has been reduced to ALARP.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
Prevent cumulative impacts from concurrent seismic surveys	During operation of the seismic source, a minimum separation distance of 40 km shall be maintained between the Bonaparte Basin 3D MSS seismic vessel and other operating seismic survey vessels.	Survey records show no operation of the seismic source has occurred within 40 km of other operating seismic vessels.

No preventable displacement to commercial fisheries from concurrent seismic surveys will occur	Review NOPSEMA website to identify if any new Seismic EP's are proposed within the NPF or NT Demersal Fishery. If any are scheduled to occur at the same time as the Bonaparte Basin 3D MSS, INPEX will: • Consult with the titleholder/seismic survey operator conducting the activity on ways to minimise interference with relevant commercial fishers. • Provide the titleholder/seismic survey operator conducting the activity with proposed survey plans and vessel contact details, and the details of any agreed on-water vessel interaction protocols with commercial fishers. • Provide the titleholder/seismic survey operator conducting the activity with commencement and cessation notifications, and daily lookahead reports.	Record of INPEX review of NOPSEMA website for potential concurrent EP's. Consultation records demonstrate that INPEX has undertaken the relevant consultation and exchanged.

7.4 Biodiversity and conservation protection

7.4.1 Introduction of invasive marine species

Table 7-23: Impact and evaluation – Introduction of invasive marine species

<table>
<tr><th colspan="2">Identify hazards and threats</th></tr>
<tr><td colspan="2">IMS are non-indigenous marine plants or animals that have been introduced into a region beyond their natural range and have the ability to survive, reproduce and establish founder populations. IMS are widely recognised as one of the most significant threats to marine ecosystems worldwide. Shallow coastal marine environments in particular, are thought to be amongst the most heavily invaded ecosystems, which largely reflects the accidental transport of IMS by international shipping to marinas and ports where the preferred artificial hard structures are commonly found.
The introduction and establishment of IMS into the marine environment may result in impacts to benthic communities and associated receptors dependent on these including fishing, due to changes to the structure of benthic habitats and native marine organisms through predation and/or competition for resources, leading to a change in ecological function. Once IMS establish, spread and become abundant in coastal waters some species can have major ecological, economic, human health and social/cultural consequences (Carlton 1996, 2001; Pimental et al. 2000; Hewitt et al. 2011).
There are several pathways for the introduction and spread of IMS of concern associated with the activities covered in this EP including the mobilisation of vessels from international and domestic waters to the Operational Area.</td></tr>
<tr><th>Potential consequence</th><th>Severity</th></tr>
<tr><td>The particular values and sensitivities with the potential to be impacted by the introduction of IMS are:
• benthic communities – associated with KEFs, benthic primary producer habitat (BPPH) and shallow water coastal environments and marine parks
• commercial, recreational and traditional fishing.
The introduction and subsequent establishment of IMS could result in changes to the structure of benthic communities leading to a change in ecological function due to predation of native marine organisms and/or competition for resources. Once IMS establish, spread and become abundant in coastal waters some species can have major ecological, economic, human health and social/cultural consequences (Carlton 1996, 2001; Pimental et al. 2000; Hewitt et al. 2011).</td><td>Significant (C)</td></tr>
</table>

In order for an IMS to pose a biosecurity risk once present at a recipient location, viable IMS propagules and/or individuals must be able to transfer from the colonised area (e.g. a vessel hull), survive in the surrounding environment, find a suitable habitat, and establish a self-sustaining population. The Pinnacles of the Bonaparte Basin KEF, a unique seafloor feature, provides areas of hard substrate in an otherwise soft sediment environment and are therefore important for sessile species. Pinnacles typically rise steeply from depths of about 80 m and emerge to within 30 m of the water surface, allowing light dependent organisms to thrive. Pinnacles that rise to within at least 45 m of the water surface support more biodiversity. Communities include sessile benthic invertebrates including hard and soft corals, sponges, whips, fans, bryozoans and aggregations of demersal fish species such as snappers, emperors and groupers (DSEWPaC 2012b). The Pinnacles of the Bonaparte Basin KEF does not overlap the Operational Area, with the closest pinnacle approximately 8 km west at the closest point. Shallow water, coastal marine environments are susceptible to the establishment of invasive populations, with most IMS associated with artificial substrates in disturbed shallow water environments such as ports and harbours (e.g. Glasby et al. 2007; Dafforn et al. 2009a, 2009b). Aside from ports and harbours, other shallow water, pristine environments also at risk include offshore island and shoals such as those found in the PEZ. These areas may contain sensitive benthic habitats with a potential to be impacted by invasive populations. Vessel operations are a mechanism for such transfer of IMS propagules either through the uptake and discharge of high-risk ballast water containing IMS and/or via the presence of IMS within biofouling communities on hulls or submerged equipment. IMS propagules may also be transferred via natural dispersion. Natural dispersal mechanisms could involve a mobile life-history stage (such as actively swimming adults or larval stages) with sufficient swimming capacity and/or larval durations to directly reach suitable habitats in coastal waters. Natural dispersal from offshore locations for IMS with shorter pelagic dispersal capabilities to coastal areas is also theoretically possible via intermediate steps (stepping-stone dispersal), where intermediate populations establish in suitable habitats closer inshore, and subsequent generations then spread towards coastal regions. With consideration of the habitat preferences of IMS (shallow water environments), the closest shallow water habitats to the Operational Area are located on the Australian mainland approximately 100 km from the Operational Area. Support vessels transiting between the Operational Area and Darwin Port (Section 4.9.7) have the potential to act as vectors for the transfer of IMS propagules to sensitive benthic habitats in the PEZ and this may result in medium term impacts to benthic communities with a consequence rating of Significant (C). The transfer of IMS propagules via anthropogenic dispersal mechanisms and/or stepping-stone dispersal from vessels colonised with IMS, has the potential to affect commercial, traditional and recreational fishing which may result in a loss of revenue. Although no aquaculture is present, the NPF and several NT-managed fisheries are potentially active in the Operational Area. Recreational fishing also occurs in the Joseph Bonaparte Gulf with fishing activities (e.g. barramundi fishing) typically located near estuaries or in coastal waters. Other fishing activities that may be impacted include traditional Aboriginal fishing known to occur at the Tiwi Islands and in the North Kimberley Marine Park on the WA coast. Overall, the successful introduction of IMS may result in regional community disruption with a significant impact on economic or recreational values with a consequence rating of Significant (C).	

<table>
<tr><td colspan="3">In the event an IMS is translocated into the Operational Area, then transfers and subsequently establishes a self-sustaining population it is considered that the establishment of an IMS in WA/NT waters has the potential to result in a medium to large scale event with a medium-term impact on the environment, also potentially resulting in regional community disruption with significant impact on economic or recreational values with a consequence rating of Significant (C).</td><td></td></tr>
<tr><td colspan="4">Identify existing design and safeguards/controls measures</td></tr>
<tr><td colspan="4">Vessels have an antifouling coating applied that is in accordance with the prescriptions of the International Convention on the Control of Harmful Anti-fouling systems on ships, 2001, and the Protection of the Sea (Harmful Antifouling Systems) Act 2006 (Cwlth) (as appropriate to vessel class).
Vessels will have an approved ballast water management plan and valid ballast water management certificate, unless an exemption applies or is obtained.
Vessels will manage ballast water discharge using one of the following approved methods of management (DAWE 2020):
an approved ballast water management system
ballast water exchange conducted in an acceptable area, as defined in the Biosecurity (Ballast Water and Sediment) Determination 2019. For high risk ballast water, an acceptable area for ballast water exchange is defined as (DAWE 2020):
Vessels servicing an offshore facility: at least 500 m from the facility, and no closer than 12 nm from the nearest land
All other vessel movements: at least 12 nm from the nearest land and in water at least 50 m deep; not within 12 nm of the Great Barrier Reef or Ningaloo Reef ballast water exchange exclusion areas.
use of low risk ballast water (e.g. fresh potable water, water taken up on the high seas, water taken up and discharged within the same place)
retention of high-risk ballast water on board the vessel
discharge to an approved ballast water reception facility.
Complete a biofouling risk assessment (including immersible equipment) for vessels mobilised domestically, and implement mitigation measures commensurate to the risk, as appropriate to ensure the mobilisation of the vessel poses a low risk of introducing IMS in accordance with Figure 9-4.</td></tr>
<tr><td colspan="4">Propose additional safeguards/control measures (ALARP Evaluation)</td></tr>
<tr><th>Hierarchy of control</th><th>Control measure</th><th>Used?</th><th>Justification</th></tr>
<tr><td>Elimination</td><td>Eliminate use of vessels/submerged equipment to avoid the spread of IMS</td><td>No</td><td>The 3D MSS cannot be achieved without using vessels and submerged equipment. No practicable elimination controls were identified.</td></tr>
</table>

Substitution	Only use vessels and equipment already operating in Australian waters.	No	Limited seismic survey vessel availability in Australian waters may require a vessel to be contracted from overseas. Locations within Australia which harbour IMS and could act as a source for the further spread of IMS within Australian regions. Therefore, substituting to the use of a locally available vessels or equipment will not provide an environmental benefit.
Engineering	None identified	N/A	N/A
Procedures & administration	Complete a biofouling risk assessment (including immersible equipment) for vessels mobilised from international waters, and implement mitigation measures commensurate to the risk, as appropriate to ensure the mobilisation of the vessel poses a low risk of introducing IMS.	Yes	The completion of a biofouling risk assessment and the implementation of associated biofouling reduction and management measures reduce the likelihood of IMS translocation and subsequent potential for transfer and establishment. This approach is in accordance with the National Biofouling Management Guidelines for the Petroleum Production and Exploration Industry (MPSC 2018). A biofouling risk assessment is a desktop-based evaluation to determine the likelihood, and hence theoretical risk of a vessel acting as a vector for the transfer of IMS. It does not attempt to identify whether or not a vessel is actually carrying a pest species, but rather ranks vessels on a relative scale of High, Uncertain or Low/Acceptable risk, to identify which vessels may require further detailed investigation and/or management actions to reduce potential risk. The assessment, undertaken by an independent third-party IMS expert on behalf of INPEX, relies on the provision of accurate information from the vessel operator, which may include, but is not limited to, the following: • vessel specifications: vessel name, type, size and Flag State, etc. • movements: port of origin, voyage history, destination, transport method, evidence of recent dry-docking and/or inspection, etc. • anti-fouling coating: type (i.e. biocidal/non-biocidal), age, service life, application area, record of Antifouling Systems Certificate, etc.

			• inspection/cleaning: inspection and cleaning history including any relevant independent biofouling inspection reports, etc. • seawater systems: marine growth prevention systems present and functioning, maintenance records, evidence of chemically or manually cleaned seawater systems including last treatment date and chemicals used etc. • duration of stay: at overseas or interstate locations, and duration in WA coastal waters etc. Outcomes of the biofouling risk assessment may identify the need to implement mitigation measures such as limitations of time spent in coastal waters/or alongside and managing interactions with supply vessels, through to inspection and cleaning of hulls and submerged areas.
	Vessels will have a biofouling management plan and maintain a biofouling record book.	Yes	A biofouling management plan provides operational guidance for the planning and actions required to manage vessel biofouling, in addition to outlining measures for the control and management of vessel biofouling in accordance with the IMO Guidelines for the Control and Management of Ship' Biofouling to Minimize the Transfer of Invasive Aquatic Species (2012).
Identify the likelihood			
The likelihood of an IMS becoming successfully established at a recipient location depends on a range of factors including physical characteristics of the environment falling within the tolerance ranges of the IMS (i.e. salinity, temperature, nutrient availability, etc.), and the biological characteristics of the species and the natural environment (i.e. reproductive properties, presence of appropriate prey species, predation pressure, etc.). This potential is known to be dependent on a range of factors including propagule pressure, density of the colonised population, and a range of biotic interactions and abiotic factors specific to the local marine environment.			

For an IMS to establish a self-sustaining reproductive population in a recipient region, it must successfully pass through a series of stages along an invasion pathway, which include a range of selective filters. Selective filters affect the total number of organisms that can survive and successfully transition to the next stage of the invasion pathway. Offshore selective filters in the invasion pathway are likely to be more significant than for coastal environments, given there is little availability of artificial surfaces or suitable settlement habitats for propagules, and greater dilution of propagule plumes. As a result, in offshore oceanic environments propagule plumes from infrastructure colonised by IMS are likely to be highly dispersed with low densities of propagules present in the water column. In turn, if propagules are able to survive the extended periods necessary for them to be transferred to coastal waters, this is still likely to result in low densities of propagules encountering suitable habitat in shallow coastal environments. As a result, propagule pressure will be low and therefore establishment potential constrained. It is now widely accepted that 'propagule pressure' (or the number of individuals introduced), is a primary determinant of establishment success for introduced populations (Lockwood & Cassey 2005, Simberloff 2009). Propagule pressure is also important for the post-establishment success of IMS populations. As propagule pressure increases, it becomes more likely that the founder population will survive or has sufficient genetic variation to adapt to local conditions and establish a self-sustaining population (Lejeusne et al. 2014; Roman & Darling 2007) thereby becoming 'introduced'. Many propagules may be released but never survive to join local populations. Marine pests known to be present in WA and NT waters (including Darwin Port) and are described in Section 4.8 and Section 4.9.7. Vessels that may be mobilised from international waters or domestically are not considered to provide a likely source for the introduction and establishment of IMS. This is due to a number of factors including the lack of man-made infrastructure e.g. jetties/wharves in the Operational Area where the activity will occur, and the controls and procedures in place to manage ballast water exchange and biofouling risks. As such, there is a low potential for biofouling to occur and act as a potential inoculum for the establishment and subsequent spread of IMS. Adherence to the Australian Ballast Water Management Requirements (DAWE 2020) including the use of an approved ballast water management method also reduces the potential for the spread of IMS (Remote 6). Support vessels will use Darwin Port as the main supply base. The presence of jetties and wharves in ports, provides substrate for IMS, meaning that the ports could act as a source of IMS inoculum. However, resupply is typically undertaken within a relatively short timeframe (approximately 48 hours) therefore the potential for vessels to become colonised by biofouling communities is reduced. With the described controls in place, the potential spread of IMS via support vessels during the activity is considered to be Remote (6).		
Residual risk summary		
Based on a consequence of Significant (C) and a worst-case likelihood of Remote (6) the residual risk is Moderate (8).		
Consequence	Likelihood	Residual risk
Significant (C)	Remote (6)	Moderate (8)
Assess residual risk acceptability		
Legislative requirements		

Vessel ballast water will be managed in accordance with the intent of the Australian Ballast Water Management Requirements Version 8 (DAWE 2020) and the *Biosecurity Act 2015*. Biofouling will be managed through vessel and equipment risk assessments and mitigation measures, in accordance with the National Biofouling Management Guidelines for the Petroleum Production and Exploration Industry (Marine Pest Sectoral Committee 2018). All vessels that use ballast water are required to meet the Regulation D2 discharge standard of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) if they were constructed after 2017 or at their next renewal survey after September 2019. All ships must meet the D2 standard by 8th September 2024 and this will lead to an ongoing reduction in potential risk from ballast water discharges over the life of this EP. The control measures described are consistent with NOPSEMA's Information Paper: Reducing marine pest biosecurity risks through good practice and biofouling management, IP1899 (NOPSEMA 2020f).

Stakeholder consultation

During stakeholder engagement for the development of this EP, DAWE requested INPEX provide information on interactions that project vessels will have with domestic vessels during the proposed activities and how they will be managed. INPEX will provide this information via the completion of a 'Questionnaire for Biosecurity Exemptions for Biosecurity Control Determination' when the vessels to be contracted are known as described in Section 9.8.3.

Australian Marine Park management objectives and values

The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Proposed control measures reduce the risk of introduction of IMS to the marine environment and no risk of IMS to the Australian Marine Parks or impacts to marine park values are expected.

Conservation management plans / threat abatement plans

Species protected under the EPBC Act have conservation management plans, which have been considered in the development of this EP. IMS have been identified as a threat in many conservation management plans, with actions focusing on the prevention of their introduction. The control measures identified here are consistent with the actions described in the conservation management documentation.

ALARP summary

The level of environmental risk is assessed as Moderate, therefore a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact.

Acceptability summary

Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because:

- the activity demonstrates compliance with legislative requirements/industry standards;
- the activity takes into account stakeholder feedback;
- the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
- the activity is managed in a manner that is consistent with the intent of conservation management documents;
- the activity does not compromise the relevant principles of ESD; and

• the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as "Moderate", the consequence does not exceed "C – Significant" and the risk has been reduced to ALARP.		
Environmental performance outcomes	Environmental performance standards	Measurement criteria
No establishment of IMS of concern in the Commonwealth Marine Area or coastal waters via ballast water or biofouling attributable to the activity.	Vessels operating within Australian seas will manage ballast water discharge using one of the following approved methods of management including (DAWE 2020): • an approved ballast water management system; or • ballast water exchange conducted in an acceptable area; or • use of low risk ballast water (e.g. fresh potable water, water taken up on the high seas, water taken up and discharged within the same place); or • retention of high-risk ballast water on board the vessel; or • discharge to an approved ballast water reception facility; or • use of low risk ballast water (e.g. fresh potable water, water taken up on the high seas, water taken up and discharged within the same place).	Vessel ballast water management plan and ballast records confirm that an approved ballast water management option is available and has been used. Documentation of DAWE (2020) release from biosecurity control or low risk status.
	All vessels will have: • an approved ballast water management plan, unless an exemption applies or is obtained • a valid ballast water management certificate, unless an exemption applies or is obtained.	Ballast water management plan or record of exemption (if not automatic exemption) Valid ballast water management certificate or record of exemption (if not an automatic exemption).
	A biofouling risk assessment will be completed by an independent IMS expert for vessels, including immersible	Vessel-specific biofouling risk assessment and any records of mitigation measures

	equipment, prior to mobilisation from international waters. Where required, mitigation measures commensurate to the risk will be implemented to ensure the vessel mobilisation poses a low risk of introducing IMS.	implemented confirming the vessel presents a low risk.
	Domestic biofouling risk assessment for vessels mobilised from other regions in Australia, and implement mitigation measures commensurate to the risk, as appropriate to ensure the mobilisation of the vessel poses a low risk of introducing IMS in accordance with Figure 9-4.	Domestic biofouling risk assessment.
	Vessels will have a biofouling management plan to include elements of performance described in the IMO Guidelines for the Control and Management of Ship Biofouling to Minimize the Transfer of Invasive Aquatic Species (2012 Edition).	Biofouling Management Plan and record book
	Vessels (of appropriate class) will have an antifouling coating applied in accordance with the prescriptions of the International Convention on the Control of Harmful Anti-fouling Systems on Ships (2001) and the *Protection of the Sea (Harmful Antifouling Systems) Act 2006* (Cwlth).	Vessels (of appropriate class) have a current International Anti-fouling Systems certificate or a Declaration on Anti-fouling Systems.

7.4.2 Interaction with marine fauna

Table 7-24: Impact and risk evaluation – Physical presence of vessels and interaction with marine fauna

<table>
<tr><th colspan="2">Identify hazards and threats</th></tr>
<tr><td colspan="2">The physical presence and use of vessels and the towed streamers have the potential to result in collision (vessel strike) with marine fauna and/or collision or entrapment of marine turtles on the dilt float or tail buoy of the towed streamers while operating within the Operational Area.
There is also the potential for vessels and/or equipment involved in the 3D MSS to collide with marine fauna outside of the Operational Area if the seismic vessel is required to transit outside of the Operational Area with towed equipment deployed e.g. equipment deployment and recovery, or emergency demobilisation in the event of a cyclone or technical issues.
The potential impacts arising from the potential accidental loss of towed equipment and dropped objects are assessed separately in Section 7.6, but these are not expected to present a significant risk to marine fauna.</td></tr>
<tr><th>Potential consequence</th><th>Severity</th></tr>
<tr><td>The particular values and sensitivities with the potential to be impacted by vessel strike are:
• EPBC-listed species.
The seismic survey and support vessels have the potential to interact with transient, EPBC-listed species; specifically, marine mammals, whale sharks and turtles. A collision (vessel strike) with marina fauna may result in the injury or death of these animals.
Collisions between vessels and cetaceans occur more frequently where high vessel traffic and cetacean habitat overlap (Dolman & Williams Grey 2006). Vessel speed has been demonstrated as a key factor in collisions with marine fauna such as cetaceans and turtles, and it is reported that there is a higher likelihood of injury or mortality from vessel strikes on marine mammals when vessel speeds are greater than 14 knots (Laist et al. 2001; Vanderlaan & Taggart 2007). During the 3D MSS, the seismic vessel will be moving at low speed (4.5 knots), which reduces the likelihood of a fatal collision with marine fauna. Additionally, the approaching seismic source and/or vessel noise will provide some level of warning to marine fauna at the surface and alerts animals to move away from the oncoming vessel.</td><td>Minor (E)</td></tr>
</table>

The potential for vessel strike applies to all marine mammals, whale sharks and turtle species. The potential for collision with marine mammals during the activity is reduced as there are no BIAs for marine mammals that overlap the Operational Area. The closest cetacean BIA relates to the Indo-pacific humpback dolphin located approximately 145 km west of the breeding BIA (Figure 4-4). The species is unlikely to be present in the Operational Area based on the water depths (65 m to 106 m) as the species is mainly found in water less than 20 km from the nearest river mouth, and in water depths of less than 15 m to 20 m (DAWE 2022b). A few individuals have been observed in waters up to 30 m to 50 m deep, but these remained in close proximity (within 5 km) to the coast (DAWE 2022b). Omura's whale populations may be present within the Operational Area based on vocalisations detected in the Joseph Bonaparte Gulf (McCauley 2009, 2014). The reaction of whales to approaching ships is reported to be quite variable. Dolman and Williams Grey (2006) and Southall et al. (2007) indicate that some cetacean species can detect and change course to avoid a vessel. Other cetacean BIAs/migration corridors include humpback and pygmy blue whales (Figure 4-4) with the humpback whale calving BIA located over 400 km south-west: and the pygmy blue whale migration BIA approximately 300 km north-west of the Operational Area at the closest points. The pygmy blue whale is subject to a Conservation Management Plan (Appendix A). The Conservation Management Plan identifies that, since 2006, there have been two records of likely ship strikes of blue whales in Australia. In 2009 and 2010, there were blue whale strandings in Victoria, near the Bonney Upwelling with suspected ship strike injuries visible. Where blue whales are feeding at or near the surface, they are more susceptible to vessel strike. However, the open ocean environment allows for whales to invoke avoidance behaviour in threatening situations. The Blue Whale Conservation Management Plan highlights that minimising vessel collision is one of the top four priorities and requires assessment of vessel strike on blue whales, assures that incidents are reported in the National Ship Strike Database, and that control measures proposed will align with these priorities. Whale sharks do not breach the surface as cetaceans do; however, they are known to swim near to the water surface; hence, are susceptible to vessel strike. The foraging area for whale sharks (BIA) is located approximately 290 km west of the Operational Area at its closest point. Whale sharks are also subject to a Conservation Advice (Appendix A), which notes that the threat to the recovery of the species includes strikes from vessels. Turtles transiting the region are also at risk from vessel strike when they periodically return to the surface to breathe and rest. Only a small portion of their time is spent at the surface, with routine dive times lasting anywhere between 15 and 20 minutes nearly every hour. The presence of vessels has the potential to alter the behaviour of individual turtles. Some turtles have been shown to be visually attracted to vessels, while others show strong avoidance behaviour (Milton et al. 2003). The 3D MSS will not be acquired in turtle internesting BIAs or Habitat Critical during the nesting seasons. Therefore, the potential for the survey vessels to traverse areas where turtles aggregate in high numbers is reduced. A marine turtle foraging BIA overlaps the Operational Area relating to green turtles and olive ridley turtles. Flatback turtles and loggerhead turtles are also known to forage in an area approximately 10 km west of the Operational Area at the closest point.	

Although overlapping the BIA, it is unlikely that the Operational Area is the predominant foraging area for all marine turtle species given water depths range from 65 m to 106 m, which is deeper than the preferred range of generally less than 40 m based on NPF bycatch records (Poiner & Harris 1996). Dietary samples of olive ridley turtles from the eastern Joseph Bonaparte Gulf indicate foraging depths of less than 14 m (Conway 1994 reported in Whiting et al. 2007). Most turtle foraging is therefore expected to be associated shallower waters within the KEFs surrounding the Operational Area (Pinnacles of Bonaparte Basin, Carbonate Bank and Terrace System of the Sahul Shelf and Carbonate Bank and Terrace System of the Van Dieman Rise (DEWHA 2008b). Satellite tracking data reviewed in recent studies (Ferreira et al. 2020; Thums et al. 2021) concluded that the spatial extents of foraging BIAs are considered to potentially underestimate the distribution of foraging turtles. In particular, flatback turtles are reported to forage in areas of the Joseph Bonaparte Gulf with bare substrate and may potentially forage in deeper waters depths (Thums at al. 2021) such as those found in the Operational Area. Therefore, it is considered possible that green, olive ridley, flatback and loggerhead turtles may be present in the Operational Area year-round. Therefore, there is a potential for marine turtles to be impacted by vessels associated with the activity; however, any potential vessel strike to marine fauna is likely to be limited to isolated incidents. The slow speed of the vessels during the 3D MSS are also unlikely to cause the death of a turtle. As reported (DEE 2017a), although the outcome can be fatal for individual turtles, vessel strike (as a standalone threat) has not been shown to cause stock level declines.

Turtles are also potentially at risk of being struck or entrapped in the floats and buoys attached to the towed seismic streamer. Ketos Ecology (2009) provides anecdotal reports from seismic surveys undertaken in various parts of the world where turtles have become trapped on either the dilt float on the leading end of streamers or on the tail buoys several kilometres behind the vessel. The mechanism for such incidents is believed to involve turtles basking on the sea surface or foraging near the streamer. Dilt floats may strike a turtle, but their hydrodynamic shape makes them unlikely to trap a turtle. Tail buoys, however, have a subsurface frame structure which is used to stabilise the surface buoy. Ketos Ecology (2009) suggest that turtles may become trapped in the subsurface structure if they startle dive in front of the approaching buoy. Once a turtle is trapped on the structure, the moving water can hold it in place and it may not be able to escape. A trapped turtle usually results in drag and noticeable impact on streamer performance that survey crews sometimes detect and trapped turtles are sometimes freed, however, on some occasions the entrapment can be fatal.

Given the slow speeds (4.5 knots) at which the survey vessel will acquire the 3D MSS, there is limited potential for a vessel strike or entrapment to result in mortality to large marine fauna, although injury may occur. While there is potential for individual marine fauna to be impacted by vessels associated with the activity, any potential vessel strike or entrapment of marine fauna is likely to be an isolated event. In the event of the death of an individual cetacean or turtle, it would not be expected to have a significant effect at the population level (Minor E).

With reference to the Recovery Plan for Marine Turtles in Australia (DEE 2017a) based on the long-life span and highly dispersed life history requirements of marine turtles it is acknowledged that they may be subject to multiple threats acting simultaneously across their entire life cycle, such as increases in background light and noise levels. In considering cumulative impacts of threats on small or vulnerable stocks of marine turtles, it is likely that vessel strike may act as contributor to a stock level decline.

Identify existing design and safeguards/controls measures

Implementation of EPBC Regulations 2000 – Part 8 Division 8.1 (Regulation 8.05 – modified to include turtles). Vessel speed restrictions and separation distances maintained for whale sharks. Vessel crew will receive an induction/training to inform them of the requirements of EPBC Regulations 2000 – Part 8, Division 8.1 (Regulation 8.05) in accordance with Table 9-3 (INPEX Australia Support Vessels Marine Fauna Awareness Training).			
Propose additional safeguards/control measures (ALARP Evaluation)			
Hierarchy of control	Control measure	Used?	Justification
Elimination	Eliminate the use of vessels/towed equipment.	No	Vessels and towed equipment are required to undertake and support the 3D MSS. Therefore, no practicable elimination controls are available.
	Eliminate activity in turtle foraging BIA	No	Turtle foraging is a year-round activity and therefore cannot be avoided.
Substitution	None identified	N/A	N/A
Engineering	Turtle guards will be fitted on tail buoys or tail buoy design will be designed to prevent turtles becoming trapped.	Yes	A tail buoy will be fitted to the end of each streamer which controls the depth at which the streamers are towed. If the tail buoys have not been designed to avoid entrapment, they will be fitted with guards to prevent accidental entrapment of turtles.
Procedures & administration	Dedicated marine fauna observers (MFOs) on vessels	Yes	MFOs will be on board the seismic survey vessel. The use of dedicated MFOs onboard the seismic vessel may improve the ability to identify marine fauna at risk of collision.
	The seismic survey vessel will only deploy/tow streamers inside the Operational Area	No	During mobilisation to, and demobilisation from the Operational Area, the seismic vessel may have seismic equipment deployed in the water, as permitted under maritime law. Similarly, at any time during the survey, the seismic survey vessel may depart the Operational Area if, in the opinion of the vessel master, the safety of the vessel and crew is at risk e.g. in the event of sea/weather conditions restricting manoeuvring capabilities. In the event that the seismic vessel is required to depart the Operational Area urgently due to weather or mechanical issues, recovery of towed equipment may not be possible. The Vessel Master will take whatever action they feel necessary to prevent threats to life on board the vessel or damage to the vessel or equipment. Recovery of equipment is therefore the Vessel Master's decision, not INPEX's.

			In addition, deployment and recovery of towed equipment can each take in the order of three days to complete. Therefore, recovery of towed equipment may result in significant lost time during the survey window and is a significant cost (1.5 to 2 million USD). Therefore, it is not always practicable for towed seismic equipment to be recovered and stowed while the survey vessel outside of the Operational Area. Survey vessel activities outside of the Operational Area are not part of the defined activity. Instead, they will be undertaken in accordance with the *Navigation Act 2012*. The planned will not ocuur in the Oceanic Shoals MP (an important resting and foraging area for marine turtles) meeting the request received from the DNP for equipment be stowed when within the Oceanic Shoals MP (see Section 3.1). The risk of entrapment of marine turtles on the dilt floats and tail buoys of streamers is already very low.
Identify the likelihood			
Collisions between marine fauna and large vessels often go unnoticed and/or unreported (Cates et al. 2017). A preliminary examination of vessel collision reports between 1840 and 2015 was undertaken by Peel et al. in 2016, referenced in the National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Fauna (DEE 2017c). Peel et al. (DEE 2017c) identified 109 records of ship strike in Australian waters predominantly involving humpback whales (47%). The records showed that the majority of events were in Queensland, with 10 events recorded in WA waters between 1995 and 2015. This suggests that despite the growing presence of oil and gas activities on the north west shelf (NWS) and in the Timor Sea, and the steady increase (9% per year) in humpback whale numbers (Bejder et al. 2016), whale populations have not been affected by collisions with oil and gas related vessels. The likelihood is also further reduced as there are no identified BIAs for marine mammals within the Operational Area, EMBA or PEZ. Although overlapping a turtle foraging BIA, the Operational Area is not considered to be the predominant foraging area for turtles given water depths range from 65 m to 106 m, which is deeper than the preferred range for foraging turtles which is generally less than 40 m based on NPF bycatch records (Poiner & Harris 1996). Dietary samples of olive ridley turtles from the eastern Joseph Bonaparte Gulf indicate foraging depths of less than 14 m (Conway 1994, reported in Whiting et al. 2007). Satellite tracking data (Ferreira et al. 2020; Thums et al. 2021) concluded that the spatial extents of foraging BIAs are considered to potentially underestimate the distribution of foraging turtles. In particular, flatback turtles are reported to forage in areas of the Joseph Bonaparte Gulf with bare substrate and may potentially forage in deeper waters depths (Thums at al. 2021) such as those found in the Operational Area. Most turtle foraging is expected to be associated shallower waters within the KEFs surrounding the Operational Area (Pinnacles of Bonaparte Basin, Carbonate Bank and Terrace System of the Sahul Shelf and Carbonate Bank and Terrace System of the Van Dieman Rise (DEWHA 2008b)). Therefore, the controls described above are commensurate with the level of risk and the likelihood of a vessel strike or entrapment causing injury or death to EPBC-listed species is considered to be Highly Unlikely (5).			

Residual risk summary		
Based on a consequence of Minor (E) and a likelihood of Highly Unlikely (5) the residual risk is Low (9).		
Consequence	Likelihood	Residual risk
Minor (E)	Highly Unlikely (5)	Low (9)
Assess residual risk acceptability		

Legislative requirements

EPBC Regulations 2000 – Part 8, Division 8.1 (Regulation 8.05) will be implemented with regards to vessel speeds and separation distances.

Stakeholder consultation

During consultation with relevant stakeholders, the Director of National Parks requested further detail regarding the identification and management of risks (including cumulative impacts) to natural values of the Oceanic Shoals MP and the Joseph Bonaparte Gulf MP, including, but not limited to, the flatback, loggerhead and olive ridley turtles which are present and display behaviours including foraging and migration.

Australian Marine Park management objectives and values

The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Proposed control measures reduce the risk of interaction with marine fauna and no risk of interactions with marine fauna in Australian Marine Parks or impacts to marine park values are expected. Further, a control measure has been proposed to minimise the risk to marine turtles within the Oceanic Shoals MP and the Joseph Bonaparte Gulf MP, as well as other sensitive habitat outside of the Operational Area, despite such activities being outside of the scope of the defined activity.

Conservation management plans / threat abatement plans

Several conservation management plans have been considered in the development of this EP (Appendix A). Actions identified in the Blue Whale Conservation Management Plan and conservation advice documents for whale sharks regarding vessel strike incident reporting will be implemented and controls in this EP are in alignment with the intent of the National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Fauna (DEE 2017c).

ALARP summary

Although the level of environmental risk is assessed as Low, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact.

Acceptability summary

Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because:

- the activity demonstrates compliance with legislative requirements/industry standards;

- the activity takes into account stakeholder feedback;
- the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
- the activity is managed in a manner that is consistent with the intent of conservation management documents;
- the activity does not compromise the relevant principles of ESD; and
- the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as "Low", the consequence does not exceed "C – Significant" and the risk has been reduced to ALARP.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
No injury/ mortality of cetaceans, whale sharks or turtles resulting from interactions with vessels undertaking the activity.	Interactions between vessels and cetaceans will be consistent with EPBC Regulations 2000 – Part 8, Division 8.1 (Regulation 8.05) Interacting with cetaceans (modified to include turtles): Support vessels will not travel faster than 6 knots within 300 m of a cetacean or turtle (caution zone) and minimise noise. Support vessels will not approach closer than 50 m to a dolphin or turtle and/or 100 m for a whale (with the exception of bow riding). If a cetacean shows signs of being disturbed, support vessels will immediately withdraw from the caution zone at a constant speed of less than 6 knots.	Records of event reports if vessel strike occurs.
	Interactions between support vessels and whale sharks will be consistent with the Whale Shark Wildlife Management Program no. 57 (DPaW 2013); specifically, support vessels will not travel faster than 8 knots within 250 m of a whale shark (exclusive contact zone) and not approach closer than 30 m of a whale shark.	Records of breaches of whale shark code of conduct are documented.
	Turtle guards/deflectors will be fitted on tail buoys or tail buoys will be of another design that prevents turtles becoming trapped.	Pre-mobilisation inspection confirms that the turtle guards/deflectors are fitted on tail buoys or tail buoys are of another design that prevents turtles becoming trapped.

	A minimum of two trained and dedicated MFOs will be available on board the seismic survey vessel to manage shift duties during daylight hours during the survey.	MFO report confirms two MFOs were on board the seismic vessel for daylight visual observations during the survey.

7.5 Emissions and discharges

7.5.1 Light emissions

Table 7-25: Impact and risk evaluation – Change in ambient light levels from navigational lighting on the vessels

<table>
<tr><th colspan="2">Identify hazards and threats</th></tr>
<tr><td colspan="2">Light emissions associated with vessel lighting (for navigational and safe working condition requirements) have the potential to disturb light-sensitive marine fauna, specifically marine turtles, seabirds and migratory bird species, through localised attraction to light that may result in behavioural changes.</td></tr>
<tr><th>Potential consequence</th><th>Severity</th></tr>
<tr><td>The particular values and sensitivities identified as having the potential to be impacted by light emissions from navigational lighting are:
• marine turtles (foraging BIA)
• marine avifauna.
Behavioural changes reported in marine turtles exposed to increases in artificial lighting can include disorientation and interference during nesting (Pendoley 2005; DEE 2020). Disorientation of adult marine turtles or hatchlings has been known to result in risks to the survival of some individuals through excess energy expenditure or increased likelihood of predation (Witherington & Martin 2000; Limpus et al. 2003). The effect of light emissions resulting in disruption to turtle orientation and behaviour has been observed from up to 18 km away (DEE 2020) and the National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (DEE 2020) recommends that a 20 km buffer for assessment of impacts be considered around important habitat for turtles.</td><td>Insignificant (F)</td></tr>
</table>

A marine turtle foraging BIA overlaps the Operational Area relating to green turtles and olive ridley turtles. Flatback turtles and loggerhead turtles are also known to forage in an area approximately 10 km west of the Operational Area at the closest point. Although overlapping the BIA, it is unlikely that the Operational Area is the predominant foraging area for all marine turtle species given water depths range from 65 m to 106 m. This is deeper than the preferred range for foraging marine turtles which is generally less than 40 m based on NPF bycatch records (Poiner & Harris 1996). Dietary samples of olive ridley turtles from the eastern Joseph Bonaparte Gulf indicate foraging depths of less than 14 m (Conway 1994 reported in Whiting et al. 2007). Most turtle foraging is therefore expected to be associated shallower waters within the KEFs surrounding the Operational Area (Pinnacles of Bonaparte Basin, Carbonate Bank and Terrace System of the Sahul Shelf and Carbonate Bank and Terrace System of the Van Dieman Rise (DEWHA 2008b). Satellite tracking data reviewed in recent studies (Ferreira et al. 2020; Thums et al. 2021) concluded that although the spatial extent of marine turtle internesting areas was adequately covered by the defined internesting buffers and therefore afforded an appropriate level of protection, it was not the same for foraging areas. The spatial extents of foraging BIAs are considered to potentially underestimate the distribution of foraging turtles. In particular, flatback turtles are reported to forage in areas of the Joseph Bonaparte Gulf with bare substrate and may potentially forage in deeper waters depths (Thums at al. 2021), such as those found in the Operational Area. Therefore, it is considered possible that green, olive ridley, flatback and loggerhead turtles may be present in the Operational Area year-round. The closest turtle nesting beaches and internesting habitat is located at the Tiwi Islands approximately 145 km from the Operational Area. Therefore, based on this distance there will be no discernible effect on turtle hatchlings abilities to orientate to water. Although navigational light emissions from the vessels may be visible to foraging turtles within the Operational Area, significant exposure or changes in ambient light levels are not expected to affect the behaviour of the adult turtle population as adult turtles undertaking internesting, migration, mating or foraging activities do not use light cues to guide these behaviours (Woodside 2020). The offshore light emissions generated from vessel lighting is not expected to have a discernible effect on foraging turtles and the potential for light from vessels to attract marine turtles once they are at sea is not expected. The seismic survey vessel and support vessel will also be transient and will rarely remain in one location. Any impacts are considered to be at a local scale, with short-term, temporary impact on a small portion of a population (Insignificant F). Section 4.9.9 lists other petroleum operations that have the potential to occur in the exploration permits/retention leases overlapping or adjacent to the project area during the timeframe associated with the GHG activities described in this EP. As stated above, light emissions associated with the seismic and support vessel navigational lighting may be visible to foraging turtles within the project area. The Recovery Plan for Marine Turtles in Australia (DEE 2017a) states, based on the long-life span and highly dispersed life history requirements of marine turtles, they may be subject to multiple threats acting simultaneously across their entire life cycle, such as increases in background noise levels and vessel strike. In considering cumulative impacts of threats on small or vulnerable stocks of marine turtles, it is possible that light emissions may act as contributor to a stock level decline. Lighting from additional vessel traffic in the project area associated with other activities may be detectable but given that adult turtles do not use light cues to guide foraging, migration, internesting or migration behaviours (Woodside 2020) any cumulative impacts are expected to be Insignificant (F).	

As described in Section 4.7.4, the Operational Area is located within the EEA Flyway, an internationally recognised migratory bird pathway that covers the whole of Australia and its surrounding waters. The migration of marine avifauna through the EAA Flyway generally occurs at two times of year, northward between March and May and southward between August and November (Bamford et al. 2008; DEE 2017b). Artificial light can attract and disorient seabirds, disrupt foraging and potentially cause injury and/or death through collision with infrastructure (DEE 2020). Nocturnal birds are at much higher risk of impact (Wiese et al. 2001; DEE 2020); however, there are no threatened nocturnal migratory seabirds that use the EEA Flyway (DEWHA 2010). Marine avifauna are highly visually orientated. Where bird collision incidents have been reported by industry, low visibility weather conditions (cloudy, overcast and foggy nights) are usually implicated as the major contributing factor with few collision incidents on clear nights (Wiese et al. 2001). Where there is important habitat for seabirds within 20 km of a project, the National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (DEE 2020) recommends that consideration be given as to whether light is likely to have an effect on those birds. There are no BIAs for marine avifauna that overlap the Operational Area. Migratory shorebirds travelling the EAA Flyway may fly over the Operational Area, before moving on to the mainland (south) in the spring or Indonesia/Australian External Territories (north) in the autumn. It is possible that migratory birds may use ships and other offshore facilities in order to rest. However, the possibility of this occurring on the vessels associated with the activity in the Operational Area is considered to be low due to the presence of alternative habitat for resting and foraging, resulting in minimal deviation from migratory pathways and limited potential for behavioural disruption. Therefore, any impact to seabirds or migratory birds from light emissions associated with the vessels is considered to be of inconsequential ecological significance (Insignificant F).	

Identify existing design and safeguards/controls measures
Vessels are not stationary during routine seismic survey activities. Vessel personnel will receive an induction/training to inform them of the requirements to minimise external artificial lighting in accordance with Section 9.3.3 and Table 9-3.

Propose additional safeguards/control measures (ALARP Evaluation)			
Hierarchy of control	Control measure	Used?	Justification
Elimination	Do not use lighting at night-time.	No	Lighting is required for navigational and safety purposes and cannot be eliminated. This is in accordance with the Navigation Act 2012 and associated Marine Orders (which are consistent with COLREGS requirements). Unnecessary outdoor/deck lighting is already eliminated.

Substitution	Exclude vessel lighting during during sensitive periods for marine fauna.	No	In general, bird migrations occur over several months of the year: between March and May (northward) and between August and November (southward) (Bamford et al., 2008). Foraging turtles may be present in the Operational Area year-round. Vessel lighting is required year-round to ensure the safety of workers and the environment and cannot be eliminated for certain periods during the year. Therefore, substituting the timing of activities would offer no benefit as it is possible that there will be sensitive periods for marine avifauna and turtles on a year-round basis.
Engineering	Reduce light intensity and/or frequencies which may attract turtles.	No	Lighting will be designed in accordance with the relevant Australian and international standards to ensure that worker vessel safety is not compromised. The deployment of low-pressure sodium vapour lamps or other technologies which reduce/eliminate frequencies which have been shown to attract turtles would not result in any significant benefit regarding turtle hatchling attraction from the nesting beaches given the distance (145 km from closest nesting beaches) and the wave-front orientation cues (rather than light cues) of hatchlings once they are in the ocean. Additionally, adult turtles undertaking internesting, migration, mating or foraging activities are reported to not use light cues to guide these behaviours.
	Light shielding.	No	The deployment of light shielding on vessels to reduce light spill would not result in any significant benefit regarding turtle hatchling attraction from the nesting beaches given the distance (145 km) and wave front orientation cues (rather than light cues) of hatchlings once they are in the ocean. Similarly, for adult turtles, foraging behaviours are not known to be influenced by light cues.

Procedures & administration	Premobilisation review and planning of vessel lighting to be undertaken prior to activities (seismic survey) commencing.	No	Vessels will maintain appropriate navigational and deck lighting to provide safe working conditions. This is in accordance with the Navigation Act 2012 and associated Marine Orders (which are consistent with COLREGS requirements) As shown in Figure 4-7, the Operational Area does not overlap any avifauna foraging BIAs and the closest BIAs are over 175 km away. Navigational lighting on vessels may be visible to turtles in the foraging BIA that partly overlaps the Operational Area. However, given the water depths most turtle foraging is therefore expected to be associated shallower waters within the KEFs surrounding the Operational Area. Additionally, adult turtles undertaking internesting, migration, mating or foraging activities are reported to not use light cues to guide these behaviours. Therefore, this control is not considered necessary.
	Implementation of a seabird management plan to prevent seabird landings on vessels due to attraction from artificial lighting.	No	A seabird management plan to prevent seabird landings on vessels and to help manage birds appropriately is a recommendation as a consideration for vessels working in seabird foraging areas during breeding season (DEE 2020). As shown in Figure 4-7, the Operational Area does not overlap any avifauna foraging BIAs and the closest BIAs are over 175 km away therefore this control is not considered necessary.
	Implementation of a light management plan to prevent impacts to marine turtles from artificial lighting on vessels.	No	The effect of light emissions resulting in disruption to turtle orientation and behaviour has been observed from up to 18 km away (DEE 2020). Navigational lighting on vessels may be visible to turtles in the foraging BIA that partly overlaps the Operational Area. However, given the water depths most turtle foraging is therefore expected to be associated shallower waters within the KEFs surrounding the Operational Area. Additionally, adult turtles undertaking internesting, migration, mating or foraging activities are reported to not use light cues to guide these behaviours. Based on the short duration of activities (up to 65 days) any impacts to foraging turtles in the BIA are expected to be temporary and will not result in displacement from the foraging areas. Therefore, this control is not considered necessary.
Identify the likelihood			

Although light may potentially be visible, given the distance from the closest turtle nesting beaches (approximately 145 km at the Tiwi Islands) and short duration of the activities (up to 65 days), impacts to turtles from light emissions is Highly Unlikely (5). While impacts to seabirds from vessel lighting have been reported in the industry, given the presence of alternative resting/foraging habitat on the Australian mainland the likelihood of impact to these receptors from navigational lighting of the vessels is considered Highly Unlikely (5).		
Residual risk summary		
Based on a consequence of Insignificant (F) and a worst-case likelihood of Highly Unlikely (5) the residual risk is Low (10).		
Consequence	Likelihood	Residual risk
Insignificant (F)	Remote (5)	Low (10)
Assess residual risk acceptability		
Legislative requirements Navigational lighting is required under the Navigation Act 2012 (which is consistent with COLREGS requirements) for the safe operation of vessels. The vessels have been designed to meet Australian and international standards for safety purposes, including the requirements of the Navigation Act 2012. The National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds, published in 2020 (DEE 2020), has been used to ensure that the activities covered by this EP align with the guideline (see below conservation management plans/threat abatement plans). **Stakeholder consultation** During stakeholder consultation, the Director of National Parks requested more detail in relation to cumulative impacts. This has been considered in this assessment. The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Limited potential for cumulative impacts from other seismic surveys has been identified. It is noted that the proposed Schlumberger Bonaparte 3DMC MSS is located in close proximity to the Multiple Use Zone of the Oceanic Shoals MP. Should both surveys occur simultaneously, combined light levels within the marine park are not expected to result in any impacts to marine park values. INPEX therefore considers that relevant matters have been adequately addressed. **Australian Marine Park management objectives and values** The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Given the distance to these marine parks, no light impacts on marine fauna or avifauna in Australian Marine Parks or impacts to marine park values are expected. **Conservation management plans / threat abatement plans** Several conservation management plans have been considered in the development of this EP (refer Appendix A). DEE (2020) states that "natural darkness has a conservation value in the same way that clean water, air and soil has intrinsic value" and that artificial light has the potential to stall the recovery of a threatened species. The activities covered by this EP align with the guideline. **ALARP summary**		

<table>
<tr><td colspan="3">Although the level of environmental risk is assessed as Low, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact.
Acceptability summary
Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because:
the activity demonstrates compliance with legislative requirements/industry standards;
the activity takes into account stakeholder feedback;
the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
the activity is managed in a manner that is consistent with the intent of conservation management documents;
the activity does not compromise the relevant principles of ESD; and
the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as “Low”, the consequence does not exceed “C – Significant” and the risk has been reduced to ALARP.</td></tr>
<tr><th>Environmental performance outcomes</th><th>Environmental performance standards</th><th>Measurement criteria</th></tr>
<tr><td colspan="3">Refer to induction/training in Section 9.3.3 and Table 9-3.</td></tr>
</table>

7.5.2 Atmospheric emissions

Table 7-26: Impact and risk evaluation – atmospheric emissions from vessels

Identify hazards and threats	
Atmospheric emissions (GHG) such as CO_2 and CH_4; non-GHG such as sulphur dioxide and nitrogen oxides) will be generated through the use of combustion engines and ozone depleting substances (ODS) containing equipment on board the vessels. If present, onboard incinerators contribute atmospheric emissions. Atmospheric emissions produced from the vessel during the 3D MSS can reduce localised air quality, and subsequently expose marine avifauna to air pollutants. Atmospheric emissions from the activity will contribute to overall GHG concentrations. Expected direct GHG emissions have been estimated for the activity and are presented in Section 3.5.	
Potential consequence	**Severity**
The particular values and sensitivities identified as having the potential to be impacted by atmospheric emissions are: • climate • marine avifauna. The various sources of atmospheric emissions generated from the activity will add to overall global GHG concentrations. The contribution arising from vessels (such as from fuel use) will be short term and temporary in duration and insignificant in volume on a global scale. Therefore, the potential consequence is considered to be Insignificant (F). Atmospheric emissions decrease air quality. However, the open air conditions surrounding the vessels are expected to rapidly disperse emissions, hereby limiting reduced in air quality to the immediate vicinity of the vessels. As described in Section 4.7.4, the Operational Area is located within the EAA Flyway, an internationally recognised migratory bird pathway that covers the whole of Australia and its surrounding waters. The migration of marine avifauna through the EAA Flyway generally occurs at two times of year, northward between March and May and southward between August and November (Bamford et al. 2008; DEE 2017b). There are no BIAs for marine avifauna that overlap the Operational Area. The closest outer boundary of a marine avifauna BIA is 175 km away from the Operational Area at the closest point. No Ramsar sites overlap the Operational Area; the closest nationally important wetland (Finniss Floodplain and Fog Bay Systems) is located over 90 km from the Operational Area (Section 4.5.1). This site provides important habitat for marine avifauna including migratory species which could be expected to be encountered in low numbers as they are likely to transit through the Operational Area.	Insignificant (F)

In the absence of air quality standards or guidelines specifically for marine avifauna, human health air quality standards and guidelines have previously been used as a proxy for the assessment of atmospheric emissions from offshore production facilities and potential impacts to marine avifauna. The outcome of such assessments concluded that NO_2 concentrations may typically exceed long term (annual average) concentrations within a few km of the emissions source and that short-term (1 hour average) exposure levels may be exceeded within a few hundred metres (i.e., 200-400 m) of the emission source (RPS APASA 2014). This assessment was undertaken for a production facility and therefore any changes in air quality resulting from emissions generated by the vessels in the Operational Area are also predicted to be highly localised given the nature of the emissions are considerably less than those from a production facility. A review of the human health and environmental effects of the various air pollutants, as described in the National Pollutant Inventory, indicates that short-term exposures to significant concentrations of pollutants such as CO, NOx, SO_2, VOCs, and fine particles, could cause symptoms such as irritation to eyes and respiratory tissues, breathing difficulties, and nausea (Manisalidis et al. 2020). Limited literature has been published on the vulnerability of avian species to air pollutants. The avian respiratory system, unlike the mammalian respiratory system, is characterised by unidirectional airflow and cross-current gas exchange, features that improve the efficiency of respiration. Therefore, birds are more likely to be susceptible to high concentrations of reactive gases, aerosols and particles in the air than mammals; and are considered to be useful indicators of air quality (Sanderfoot & Holloway 2017). Exposure to air pollutants may cause respiratory distress in birds, increasing their susceptibility to respiratory infection and may impair the avian immune response (Sanderfoot & Holloway 2017). As a worst case, it is conservatively assumed that a small number of individual marine avifauna may develop some short-term symptoms if they remain in the immediate vicinity of an emissions source where the pollutants are most concentrated. However, rapid recovery is expected after individuals move away from the source and any symptoms are not expected to occur. Chronic exposures are not considered plausible given that marine avifauna would move away (i.e., continue migration or undertake foraging activities elsewhere). Overall, the consequence of temporary, localised changes in air quality that may be encountered by some birds is considered Insignificant (F).	
Identify existing design and safeguards/controls measures	
Vessels will comply with the air emission requirements of Marine Order 97 (as applicable to vessel and engine size, type and class) including sulfur content of fuel oil. Vessels (as applicable to vessel and engine size, type and class) will comply with ODS requirements of Marine Order 97. Vessels (as applicable to vessel, engine/propulsion size, type and class) will comply with energy efficiency requirements of Marine Order 97. Measurement and monitoring of emissions data to enable legislative reporting requirements under the NGER Act to be met for the activity Implementation of an INPEX Australia contractor emissions reduction program to assist contractors identify and implement areas where they can reduce emissions.	
Propose additional safeguards/control measures (ALARP Evaluation)	

Hierarchy of control	Control measure	Used?	Justification
Elimination	Eliminate the use of vessels.	No	Vessels are the only form of transport that can undertake the 3D MSS. Therefore, no practicable elimination controls are available.
	No onboard incineration of waste.	No	Prohibitive costs are associated with transporting waste to shore for landfill and/or incineration outweighs onboard incineration. Additionally, the health implications of onboard waste storage means this control is unfeasible.
Substitution	Replace any ODS systems	No	In accordance with MARPOL Regulation 12, no chlorofluorocarbon (CFC) or halon containing system or equipment is permitted to be installed on ships constructed on or after 19 May 2005 and no new installation of the same is permitted on or after that date on existing ships. Similarly, no hydrochlorofluorocarbon (HCFC) containing system or equipment is permitted to be installed on ships constructed on or after 1 January 2020 and no new installation of the same is permitted on or after that date on existing ships. Therefore, only older vessels are considered to potentially have ODS systems installed as confirmed on the IAPP certificate. The costs to retrofit ODS equipment and replace systems are not considered to be warranted given they are being phased out in accordance with MARPOL and it may restrict vessel selection and availability in the short term.
Engineering	None identified	N/A	N/A
Procedures & administration	Preventative maintenance system	Yes	Vessel contractors have a preventative maintenance system in place to ensure diesel powered, power generation equipment is maintained and operated within original equipment manufacturers' (OEM) specification.
	Voluntarily offset all GHG emissions associated with the activity.	No	As described in Section 3.5, the GHG emissions associated with the activity are indirect (scope 3) emissions for INPEX Australia.

			INPEX Australia has an offsets program in place to cover scope 1 and 2 emissions for the Ichthys Project as per the safeguard mechanism under the NGER Act. There is no safeguard mechanism baseline applicable to the activities covered by this EP as the activities relate to marine seismic survey and do not involve the recovery of hydrocarbons for production. Through implementation of INPEX Australia's contractor emissions reduction program, INPEX works with contractors and suppliers to reduce INPEX's scope 3 emissions. Given this existing control is in place to reduce scope 3 emissions it is not reasonable to introduce an additional offsetting control for emissions generated from this activity.

Identify the likelihood		
The likelihood of marine avifauna approaching and/or resting on exhaust vents on vessels during the activity and remaining in close enough proximity to be experience any symptoms of reduced air quality is Remote (6). Marine avifauna that may pass by near the vessels during the activity are unlikely to be in close enough proximity to be exposed to the emissions sources and are therefore unlikely to have any discernible symptoms. It is considered likely that they would move away from any emissions source if they began to experience discomfort or symptoms. No marine avifauna BIAs or critical habitats overlap the Operational Area. With the control measures described above in place, the potential changes to air quality and potential impacts to marine avifauna are reduced. Therefore, the likelihood of the described consequences to marine avifauna occurring is considered Remote (6).		
Residual risk summary		
Based on a consequence of Insignificant (F) and a likelihood of Remote (6) the residual risk is Low (10).		
Consequence	Likelihood	Residual risk
Insignificant (F)	Remote (6)	Low (10)
Assess residual risk acceptability		
Legislative requirements The activities and proposed management measures are compliant with industry standards, relevant international conventions and Australian legislation, specifically AMSA Marine Orders – Part 97: Marine Pollution Prevention – Air Pollution, the POTS Act, the *Navigation Act* 2012, and MARPOL 73/78, Annex VI. **Stakeholder consultation**		

No specific stakeholder concerns have been raised regarding potential impacts and risks associated with atmospheric emissions.

Australian Marine Park management objectives and values

The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Given the distance to these marine parks and the rapid dispersion of atmospheric emissions from survey vessels, no risk of impacts to Australian Marine Parks or impacts to marine park values are expected.

Conservation management plans / threat abatement plans

Several conservation management plans have been considered in the development of this EP. None of the recovery plans or conservation advice documents have specific threats relating to atmospheric emissions from vessels operating offshore.

ALARP summary

Although the level of environmental risk is assessed as Low, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact.

Acceptability summary

Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because:

- the activity demonstrates compliance with legislative requirements/industry standards;
- the activity takes into account stakeholder feedback;
- the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
- the activity is managed in a manner that is consistent with the intent of conservation management documents;
- the activity does not compromise the relevant principles of ESD; and the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as "Low", the consequence does not exceed "C – Significant" and the risk has been reduced to ALARP.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
Planned emissions and discharges from vessels undertaking the activity are in accordance with MARPOL requirements and industry good practice.	Vessels pre-mobilisation audits undertaken by a registered organisation confirm that marine diesel engines on board vessels >400 GT meet the requirements of Marine Order 97, (as applicable to the vessel, engine/propulsion size, type and class).	EIAPP certificate IAPP certificate Bunker delivery notes IMO type approval for waste incinerators where installed Training records for personnel responsible for operating waste incinerators IEE certificate

		SEEMP
	Fuel oil and marine diesel with 0.5% m/m sulfur content will be used.	INPEX fuel specification records confirm that fuel provided to vessels has 0.5% m/m sulfur content.
	Where present equipment or systems on board vessels >400 GT which contain ODS will be recorded and managed in accordance with MARPOL, Annex VI, Regulation 12 (as appropriate to vessel size, type and class.	ODS Record book
	Vessel contractor has a preventative maintenance system to ensure diesel powered, power generation equipment is maintained and operated within OEM specification.	Preventative maintenance system records

7.5.3 Routine discharges to sea

Sewage, grey water and food waste

Table 7-27: Impact and risk evaluation – Vessel sewage, grey water and food waste discharges

Identify hazards and threats	
Discharging treated sewage effluent, grey water and food waste has the potential to expose planktonic communities to changes in water quality from the introduction of nutrients. Such a change in water quality has the potential to result in reduced ecosystem productivity or diversity. These intermittent discharges will occur at the Operational Area which is located in the open ocean and more than 12 nm from the nearest land. The average volume of sewage and greywater expected from the vessels (including domestic wastewater) generated by a person per day is approximately 60 – 230 L (based on calculations in Huhta et al. 2009); therefore, depending on the capacity of the vessels and the number of persons on board, the total volume of sewage and greywater expected from the vessels may be in the order of 10 m^3 per day.	
Potential consequence	Severity
The particular values and sensitivities identified as having the potential to be impacted by sewage, grey water and food waste discharges are: • planktonic communities. A study undertaken to assess the effects of nutrient enrichment from the discharge of sewage in the ocean found that the influence of nutrients in open marine areas is much less significant than that experienced in enclosed, poorly mixed water bodies. The study also found that zooplankton composition and distribution in areas associated with sewage dumping grounds were not affected (McIntyre & Johnston 1975). When sewage effluent, grey water and food waste is discharged there is the potential for localised and temporary, changes in water quality within the Operational Area. The potential consequence on planktonic communities is a localised impact on plankton abundance in the vicinity of the point of discharge. Given the water depths (65 m to 106 m) and the transient nature of the survey vessels, oceanic currents will result in the rapid dilution and dispersion of these discharges. Therefore, the consequence is considered to be of inconsequential ecological significance (Insignificant F). If concurrent activities were to occur in the project area, sewage effluent, grey water and food waste discharge plumes associated with the use of vessels are not expected to overlap due to the transient movements of the vessels and in consideration of dilution and dispersion process with the open ocean. No cumulative impacts to planktonic communities from such discharges expected (Insignificant F).	Insignificant (F)
Identify existing design and safeguards/controls measures	
Vessels will manage the discharge of sewage effluent and grey water in accordance with Marine Order 96 (as appropriate to class)	

<table>
<tr><td colspan="12">Vessels will manage the discharge of garbage in accordance with Marine Order 95 (as appropriate to class)
Vessels will macerate food waste to a particle size of <25 mm before disposal.</td></tr>
<tr><th colspan="12">Propose additional safeguards/control measures (ALARP Evaluation)</th></tr>
<tr><th colspan="2">Hierarchy of control</th><th colspan="3">Control measure</th><th colspan="1">Used?</th><th colspan="6">Justification</th></tr>
<tr><td colspan="2">Elimination</td><td colspan="3">Eliminate discharges from vessels by storage of sewage, grey water and food waste on board and ship to the mainland for disposal.</td><td colspan="1">No</td><td colspan="6">The significant financial cost and health risks associated with storing sewage, grey water and food waste on vessels and transporting it to the mainland for the duration of the activity is grossly disproportionate to the low level of risk associated with this discharge, permitted under legislation. Additional environmental impacts would also be generated in terms of air emissions and onshore disposal.</td></tr>
<tr><td colspan="2">Substitution</td><td colspan="3">None identified</td><td colspan="1">N/A</td><td colspan="6">N/A</td></tr>
<tr><td colspan="2">Engineering</td><td colspan="3">None identified</td><td colspan="1">N/A</td><td colspan="6">N/A</td></tr>
<tr><td colspan="2">Engineering</td><td colspan="3">None identified</td><td colspan="1">N/A</td><td colspan="6">N/A</td></tr>
<tr><td colspan="2">Procedures & administration</td><td colspan="3">None identified</td><td colspan="1">N/A</td><td colspan="6">N/A</td></tr>
<tr><th colspan="12">Identify the likelihood</th></tr>
<tr><td colspan="12">Sewage and garbage discharges for the vessels will be in accordance with legislative requirements (MARPOL Annex IV & V, Marine Orders 95 and 96). Maceration of sewage and food waste to a particle size <25 mm prior to disposal will increase the ability of the discharges to disperse rapidly.
The effects of sewage discharged to the ocean have been relatively well studied (Gray et al. 1992; Weis et al. 1989) and toxic effects generally only occur where high volumes are discharged into a small and poorly mixed waterbody. The volumes discharged within the Operational Area are unlikely to cause toxic effects, especially considering the rapid dilution provided by the deep water and ocean currents.
Based on the expected high dispersion due to the open-ocean environment, localised impacts to plankton at the point of the planned discharge are considered to be Unlikely (4).</td></tr>
<tr><th colspan="12">Residual risk summary</th></tr>
<tr><td colspan="12">Based on a consequence of Insignificant (F) and a likelihood of Unlikely (4) the residual risk is Low (9).</td></tr>
<tr><th colspan="4">Consequence</th><th colspan="4">Likelihood</th><th colspan="4">Residual risk</th></tr>
</table>

Insignificant (F)	Highly Unlikely (4)	Low (10)
Assess residual risk acceptability		

Legislative requirements

Sewage, grey water and food waste discharges are standard practice in the offshore environment and the disposal at sea is permitted under AMSA (2013) Marine Orders – Part 96: Marine Pollution Prevention – Sewage, which gives effect to MARPOL 73/78, Annex IV and Marine Orders – Part 95: Marine Pollution Prevention – Garbage, which gives effect to MARPOL 73/78, Annex V.

Stakeholder consultation

During consultation with relevant stakeholders, the Director of National Parks requested further detail regarding the identification and management of risks to natural values of the Oceanic Shoals MP and the Joseph Bonaparte Gulf MP, including, but not limited to, the flatback, loggerhead and olive ridley turtles which are present and display behaviours including foraging and migration.

A response has been provided to the Director of National Parks. INPEX therefore considers that stakeholder concerns have been adequately addressed.

Australian Marine Park management objectives and values

The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Discharges are expected to disperse rapidly and no impacts to Australian Marine Parks or marine park values are expected.

Conservation management plans / threat abatement plans

Several conservation management plans have been considered in the development of this EP. Although some Conservation Management Plans list discharges as a threatening process, conservation advice or associated recovery plans specify actions relating to discharges of waste water. The maceraters will assist in reducing impacts from the discharge stream, consistent with the intent of the conservation management documents.

ALARP summary

Although the level of environmental risk is assessed as Low, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact.

Acceptability summary

Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because:

- the activity demonstrates compliance with legislative requirements/industry standards;
- the activity takes into account stakeholder feedback;
- the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
- the activity is managed in a manner that is consistent with the intent of conservation management documents;
- the activity does not compromise the relevant principles of ESD; and

• the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as "Low", the consequence does not exceed "C – Significant" and the risk has been reduced to ALARP.		
Environmental performance outcomes	Environmental performance standards	Measurement criteria
Planned emissions and discharges from vessels undertaking the activity are in accordance with MARPOL requirements and industry good practice.	Comply with Marine Order 96 including: • Current International Sewage Pollution Prevention Certificate (ISPPC).	ISPPC
	Comply with Marine Order 95 including: • Garbage that has been ground or comminuted to particles <25 mm: >3 nm from the nearest land. • Garbage disposal record book maintained.	Garbage disposal record book

Deck drainage, bilge and firefighting foam

Table 7-28: Impact and evaluation – Vessels' deck drainage, bilge and firefighting foam discharges

Identify hazards and threats	
Contaminated deck drainage and bilge discharges or failure to treat oily water to suitable OIW concentrations before discharge, have the potential to expose marine fauna to changes in water quality and/or result in impacts through direct toxicity. Contaminated deck drainage and bilge discharges or failure to treat oily water to suitable OIW concentrations before discharge, have the potential to expose marine fauna to changes in water quality and/or result in impacts through direct toxicity. Deck drainage discharge volumes on the vessels will be intermittent and are dependent on weather conditions and frequency of deck washing. Volumes of bilge water from engines and other mechanical sources found throughout the machinery spaces will also vary between vessels. In general, the capacities of oil-water separators (OWS) on vessels range from 100–1000 litres per hour. Therefore, conservatively based on maximum rates, each vessel present in the Operational Area could potentially discharge 1 m^3 per hour. The vessels may be equipped with firefighting foam that is a safety critical requirement. If installed onto the survey vessel, the foam systems supply 3% alcohol resistant aqueous film-forming foam (AR-AFFF) and 3% film forming fluoroprotein foam (FFFP) concentrates which will be used in the event of an incident.	
Potential consequence	**Severity**
The particular values and sensitivities with the potential to be impacted by deck drainage and bilge discharges are: • EPBC-listed species • planktonic communities • fish including commercial species. Discharges of oily water will be treated to <15 ppm (v) in accordance with MARPOL requirements. This could introduce hazardous substances (mixture of water, oily fluids, lubricants, cleaning fluids (rig wash), etc.) into the water column, albeit in low concentrations. These discharges could result in a reduction in water quality, and impacts to EPBC-listed species, plankton and other pelagic organisms such as fish species including those targeted by commercial fisheries. The only marine fauna BIA that overlaps the Operational Area relates to a green turtle and olive ridley turtle foraging (Figure 4-5). Flatback turtles and loggerhead turtles are also known to forage in an area approximately 10 km west of the Operational Area at the closest point. Satellite tracking data reviewed in recent studies (Ferreira et al. 2020; Thums et al. 2021) concluded that although the spatial extent of marine turtle internesting areas was adequately covered by the defined internesting buffers and therefore afforded an appropriate level of protection, it was not the same for foraging areas. The spatial extents of foraging BIAs are considered to potentially underestimate the distribution of foraging turtles. Therefore, it is considered possible that green, olive ridley, flatback and loggerhead turtles may be present in the Operational Area during the survey. Given the mobile and transient nature of foraging turtles, the large size of available foraging grounds, the short survey duration and small volumes expected, the potential exposure is likely to be limited to individuals close to the discharge point at the time of the discharge.	Insignificant (F)

Worst-case impacts to exposed marine fauna may include direct toxic effects, such as damage to lungs and airways, and eye and skin lesions from exposure to oil at the sea surface (Gubbay & Earll 2000). Considering the low concentrations of oil, small volumes and the location in the dispersive open ocean environment, a surface expression is not anticipated; therefore, impacts are considered to be of inconsequential ecological significance to EPBC-listed species and are therefore considered Insignificant (F). Planktonic communities in close proximity to the discharge point may be affected if exposed to oily water. Such exposure may result in lethal effects to plankton. The potential consequence on planktonic communities is a localised impact on plankton abundance in the vicinity of the point of discharge with inconsequential ecological significance (Insignificant F). The NPF and four NT-managed fisheries are potentially active in the Operational Area (Section 4.9.6) and a number of commercially significant fish stocks, considered as key indicator species, may be present in the waters of the Operational Area. There is the potential for individual fishes to be exposed to the discharge; however, this would be limited to those fish present at the sea surface/upper water column where the discharge occurs. Such exposure is not expected to result in any significant impacts to fishes based on the low toxicity, low volume and high dilution levels; in addition, the highly mobile nature and ability of fishes to move away from the intermittent discharge. The potential consequence on fish species will be short-term and highly localised with inconsequential ecological significance (Insignificant F). Firefighting foams generally contain organic and fluorinated surfactants, which can deplete DO in water (Schaefer 2013; IFSEC Global 2014). However, in their diluted form (as applied in the event of a fire), these foams are generally considered to have a relatively low toxicity to aquatic species (Schaefer 2013; IFSEC Global 2014) and further dilution of the foam mixtures in dispersive aquatic environments may then occur before there is any substantial demand for DO (Schaefer 2013; IFSEC Global 2014). To date, limited research regarding the potential impacts of firefighting foam to the marine environment has been undertaken with respect to bioaccumulation and persistence (Suhring et al. 2017). Toxicological effects from these types of foams are typically only associated with prolonged or frequent exposures, such as on land and in watercourses near firefighting training areas (McDonald et al. 1996; Moody and Field 2000). As toxicological effects from foams are associated with frequent or prolonged exposures, and any discharges during the activity will be as a result of an incident and are expected to rapidly disperse. Subsequently, it is not expected that any impacts will occur to EPBC-listed species or fish. It is also expected that effects on planktonic communities, if any, would be localised and of a short-term nature (Insignificant F). Additionally, the potential consequences are also considered to be countered by the net environmental benefit that would be achieved through mitigating the potential for a fire resulting in harm to people and the environment.	
Identify existing design and safeguards/controls measures	
Vessels are equipped with OWS, which remove traces of oil from the bilge and drainage water prior to discharge to sea. Vessels will have equipment to ensure OIW discharges meet <15 ppm in accordance with Marine Order 91. Bilge water and wastewater that does not meet the discharge requirements will be retained onboard for controlled disposal at a port reception facility. Spill kits will be available on-board vessels. Vessel crew will receive an induction/training to inform them of deck spill response requirements in accordance with Section 9.3.3 and Table 9-3	

Propose additional safeguards/control measures (ALARP Evaluation)			
Hierarchy of control	Control measure	Used?	Justification
Elimination	No discharges of contaminated deck drainage or bilge to sea.	No	Discharge of deck drainage, stormwater runoff, or bilge discharges cannot be eliminated from the vessels. There is not sufficient space on board for storage, and onshore disposal would result in additional emissions and discharges associated with frequent transfers resulting in a negative impact.
	No planned discharge of firefighting foams to sea.	Yes	Firefighting foams are safety critical and are required in the event of a fire to prevent potential loss of human life or the occurrence of a significant environmental incident. However, the vessel will not conduct any planned foam system testing while conducting the activity.
Substitution	None identified	N/A	N/A
Engineering	None identified	N/A	N/A
Procedures & administration	None identified	N/A	N/A

Identify the likelihood
Deck drainage and bilge discharges are treated to a maximum concentration of 15 ppm (v) OIW prior to discharge as specified in MARPOL, Annex 1; Marine Order 91: Marine Pollution Prevention - Oil. Impacts to the abundance of plankton in the vicinity of the discharge (oily water) are not expected and are considered Unlikely (4) and will be ecologically insignificant based on the naturally high spatial and temporal variability of plankton distribution in Australian tropical waters. Given the mobile nature of EPBC-listed species and fish potentially in the Operational Area, the likelihood of impacts from the discharge after treatment and subsequent dilution and dispersion is considered Unlikely (4) and is not expected to result in a threat to population viability of protected species or to affect commercial fisheries.

Residual risk summary		
Based on a consequence of Insignificant (F) and a worst-case likelihood of Unlikely (4) the residual risk is Low (9).		
Consequence	Likelihood	Residual risk
Insignificant (F)	Highly Unlikely (4)	Low (10)

Assess residual risk acceptability		
Legislative requirements Vessel OWS meet relevant international, state and territory regulatory requirements, including MARPOL; Marine Order 91: Marine Pollution Prevention - Oil. For vessel bilge the discharge of oil in water of <15 ppm (v) is permitted under MARPOL. **Stakeholder consultation** During consultation with relevant stakeholders, the Director of National Parks requested further detail regarding the identification and management of risks (including cumulative impacts) to natural values of the Oceanic Shoals MP and the Joseph Bonaparte Gulf MP, including, but not limited to, the flatback, loggerhead and olive ridley turtles which are present and display behaviours including foraging and migration. **Australian Marine Park management objectives and values** The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Discharges are expected to disperse rapidly and no impacts to Australian Marine Parks or marine park values are expected. **Conservation management plans / threat abatement plans** Several conservation management plans have been considered in the development of this EP. Although some Conservation Management Plans list discharges as a threatening processes, conservation advice or associated recovery plans specify actions relating to deck drainage/bilge discharges. Managing oily water discharges in accordance with legislative requirements is consistent with the intent of the conservation management documents. **ALARP summary** Although the level of environmental risk is assessed as Low, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact. **Acceptability summary** Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because: • the activity demonstrates compliance with legislative requirements/industry standards; • the activity takes into account stakeholder feedback; • the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values; • the activity is managed in a manner that is consistent with the intent of conservation management documents; • the activity does not compromise the relevant principles of ESD; and • the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as "Low", the consequence does not exceed "C – Significant" and the risk has been reduced to ALARP.		
Environmental performance outcomes	Environmental performance standards	Measurement criteria

Planned emissions and discharges from vessels undertaking the activity are in accordance with MARPOL requirements and industry good practice.	Vessel contractors will comply with the *Navigation Act 2012* – Marine Order 91 including: • vessels (of appropriate class) to have International Oil Pollution Prevention (IOPP) certificate to show they have passed structural, equipment, systems, fittings, and arrangement and material conditions. • OWS tested and approved as per IMO resolutions MARPOL (Annex I).	Record of current IOPP certificate. Calibration and maintenance records of the OWS.
	Vessel liquids from drains will only be discharged if the oil in water content does not exceed 15 ppm.	Documented use of oil record book to record all oil disposal.
	Spill kits will be located on vessels to allow clean-up of any spills to the deck.	Inspection records confirm spill kits are available and stocked.
	Firefighting foams will only be deployed in the event of an emergency.	Incident records and/or incident report

Cooling water

Table 7-29: Impact and evaluation – Vessel cooling water discharges

<table>
<tr><th colspan="2">Identify hazards and threats</th></tr>
<tr><td colspan="2">Sea water is used as a heat exchange medium for the cooling of machinery engines on the vessels. It is pumped aboard and may be treated with biocide (e.g. hypochlorite) before circulation through heat exchangers. It is subsequently discharged from the vessels to the sea surface. Cooling water (CW) discharges to the marine environment will result in a localised and temporary increase in the ambient water temperature surrounding the discharge point. Elevated discharge temperatures may cause a variety of effects, including marine fauna behavioural changes and reduced ecosystem productivity or diversity through impacts to planktonic communities.

CW discharge rates vary largely depending on the vessel type. Maximum discharge rates based on equipment capacities and specifications are approximately 20,000 m^3 per day for a platform supply vessel on a continuous basis. The survey vessels are expected to be similar in size or smaller than a platform supply vessel. The temperature of the CW discharge will be approximately 40 °C, in contrast to ambient surface-water temperatures of approximately 27 °C to 30 °C recorded in the Joseph Bonaparte Gulf (Section 4.6.4).</td></tr>
<tr><th>Potential consequence</th><th>Severity</th></tr>
<tr><td>The particular values and sensitivities with the potential to be impacted by cooling water discharges are:
• EPBC-listed species
• planktonic communities.

Effects of elevation in seawater temperature may include a range of behavioural responses in EPBC-listed species including attraction and avoidance behaviour.

The only marine fauna BIA that overlaps the Operational Area relates to green turtle and olive ridley turtle foraging (Figure 4-5). Flatback turtles and loggerhead turtles are also known to forage in an area approximately 10 km west of the Operational Area at the closest point. Satellite tracking data reviewed in recent studies (Ferreira et al. 2020; Thums et al. 2021) concluded that although the spatial extent of marine turtle internesting areas was adequately covered by the defined internesting buffers and, therefore, afforded an appropriate level of protection, it was not the same for foraging areas. The spatial extents of foraging BIAs are considered to potentially underestimate the distribution of foraging turtles. Therefore, it is considered possible that green, olive ridley, flatback and loggerhead turtles may be present in the Operational Area on a year-round basis. Given the mobile and transient nature of foraging turtles and the large size of available foraging grounds, potential exposure of individuals close to the discharge point at the time of the discharge is unlikely to occur given that the seismic survey vessel and support vessels will also generally be moving throughout the survey. The activity will occur in water depths of 65 m to 106 m in a dispersive, open ocean environment. Therefore, potential consequences to EPBC-listed species are potentially localised avoidance of thermally elevated water temperatures, with an inconsequential ecological significance to protected species (Insignificant F).</td><td>Insignificant (F)</td></tr>
</table>

Elevated seawater temperatures are known to cause alterations to the physiological (especially enzyme-mediated) processes of exposed biota (Wolanski 1994). These alterations may cause a variety of effects and potentially even mortality of plankton in cases of prolonged exposure. In view of the high level of natural mortality and the rapid replacement rate of many plankton species, UNEP (1985) indicates that there is no evidence to suggest that lethal effects to plankton from thermal discharges are ecologically significant. The potential consequence on planktonic communities is a localised impact on plankton abundance in the vicinity of the point of discharge with inconsequential ecological significance (Insignificant F).

The use of biocide (hypochlorite) for the control of biofouling is considered an established and efficient technology for use in offshore environments and is used throughout the world (Khalanski 2002). The effects of chlorination on the marine environment have been summarised by Taylor (2006) who, based on a review of applications using hypochlorite as an antifoulant for the seawater cooling circuits, concluded that:

- the chlorination procedure itself does cause the mortality of a proportion of planktonic organisms and the smaller organisms entrained through a cooling water system; however, only in very rare instances, where dilution and dispersion were constrained, were there any impacts beyond the point of discharge
- long term exposure to chlorination residues on fish species did not impose any apparent ecotoxicological stress
- studies of the impact of chlorination by-products on marine communities, population, physiological, metabolic and genetic levels, indicate that the practice of low-level chlorination on coastal receiving water is minor in ecotoxicological terms.

These findings indicate that the toxicity of the CW discharge is negligible at the point of discharge, therefore, impacts are limited to thermal effects.

Identify existing design and safeguards/controls measures

None identified

Propose additional safeguards/control measures (ALARP Evaluation)

Hierarchy of control	Control measure	Used?	Justification
Elimination	No discharges of CW to sea	No	Engines and machinery require cooling to operate safely and efficiently, therefore CW cannot be eliminated. Storage and containment of CW to allow cooling on board the vessels prior to discharge is not considered practicable given the size/space requirements (i.e. large surface areas are required to sufficiently cool the water). Onshore disposal was also not considered practicable given the distance to the mainland (transit time of approximately 15 hours to Darwin), frequency of trips required, and the associated emissions and discharges generated by such transfers.

Substitution	Substitute hypochlorite with an alternative biofouling control/mechanism.	No	Hypochlorite is an established and efficient technology for use in offshore environments and is a recommended technique in the application of best available techniques to industrial cooling systems (European Commission 2001). The retrofitting of alternative biofouling control mechanisms to all vessels is not considered to be practicable given the low environmental impact from vessel cooling water discharges.
Engineering	None identified	N/A	N/A
Procedures & administration	None identified	N/A	N/A

Identify the likelihood
CW discharges are expected to rapidly disperse in the open-ocean environment of the Operational Area. Vessel CW discharges may result in temporary, localised and ecologically insignificant avoidance behaviour in EPBC-listed species in response to elevated water temperatures. However, any avoidance or behavioural changes are not expected to result in a threat to the population viability of protected species and is considered to be Unlikely (4). Localised impacts to the abundance of plankton within the vicinity of the CW discharges are considered to be Unlikely (4) based on the naturally high spatial and temporal variability of plankton distribution in Australian tropical waters.

Residual risk summary
Based on a consequence of Insignificant (F) and a likelihood of Unlikely (4) the residual risk is Low (9).

Consequence	Likelihood	Residual risk
Insignificant (F)	Unlikely (4)	Low (9)

Assess residual risk acceptability
Legislative requirements The discharge of return seawater from cooling water systems to the marine environment is considered to be standard practice in industry and there are no relevant Australian environmental legislative requirements that relate specifically to the discharge of cooling water. **Stakeholder consultation** No stakeholder concerns have been raised regarding potential impacts and risks from CW discharges. Australian Marine Park management objectives and values

The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Vessel cooling water discharges are expected to rapidly disperse and no risk of impacts to species or communities in Australian Marine Parks or impacts to marine park values are expected.

Conservation management plans / threat abatement plans

Several conservation management plans have been considered in the development of this EP (refer Appendix A), none of the recovery plans or conservation advice documents have specific threats or actions relating to discharges of cooling water in remote offshore waters.

ALARP summary

Although the level of environmental risk is assessed as Low, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls have been identified that can reasonably be implemented to further reduce the risk of impact.

Acceptability summary

Based on the above assessment, the risk of impacts is managed to acceptable levels because:

- the activity demonstrates compliance with legislative requirements/industry standards
- the activity takes into account stakeholder feedback
- the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
- the activity is managed in a manner that is consistent with the intent of conservation management documents
- the activity does not compromise the relevant principles of ESD
- the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as "low", the consequence does not exceed "C – significant" and the risk has been reduced to ALARP.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
N/A - No controls identified		

7.6 Waste management

Table 7-30: Impact and evaluation – Waste management

<table>
<tr><th colspan="2">Identify hazards and threats</th></tr>
<tr><td colspan="2">Vessels associated with the activity may generate a variety of non-hazardous and hazardous wastes, which will not be intentionally discharged to the marine environment. Unsecured or incorrectly stored waste may be windblown or displaced into the ocean where it has the potential to negatively affect marine ecosystems. Wastes can cause contamination of the ocean resulting in changes to water quality e.g. through the leaching of chemicals from wastes, such as ash from incinerators, which can cause changes to ecosystem productivity and diversity. Additionally, certain types of waste can cause injury to marine fauna through entanglement or may affect the health of marine species that ingest waste materials.

Other forms of solid waste that could be lost during the survey include dropped objects/lost equipment. A number of seismic streamers (up to approximately 10 km in length) will be used during the survey. The streamers are solid gel-filled, which will not flow into the marine environment if the streamer skin is punctured. Streamers are also considered to be too large and inflexible to pose an entanglement risk to marine fauna. However, if a streamer is lost, it will remain buoyant (due to floatation devices) and potentially be a floating obstacle for other vessels. Other potential dropped objects could include the fenders that are on vessels or a crate of supplies being transferred from a support vessel to the seismic survey vessel. Should fenders detach, these would remain buoyant and result in a floating obstacle on the surface. Crates of supplies may float or sink to the seabed.</td></tr>
<tr><th>Potential consequence</th><th>Severity</th></tr>
<tr><td>The particular values and sensitivities with the potential to be impacted by improper waste management are:
• EPBC-listed species
• planktonic communities
• benthic communities
• commercial, recreational and traditional fishing, and other marine users.

Improper management of wastes may result in pollution and contamination of the environment. There is also the potential for secondary impacts on marine fauna that may interact with wastes, such as packaging and binding, should these enter the ocean. These include physical injury or death of marine biota (as a result of ingestion, or entanglement of wastes).

A change to water quality has the potential to impact planktonic communities found at the sea surface. Impacts associated with the accidental loss of hazardous waste materials to the ocean as a result of leaching from waste would be localised and limited to the immediate area. These are further likely to be reduced due to the dispersive open ocean offshore environment. While plankton abundance in close proximity to the accidental loss location, or leaching waste items may be reduced, this is expected to be of insignificant ecological consequence (Insignificant F).</td><td>Insignificant (F)</td></tr>
</table>

Marine fauna can become entangled in waste plastics, which can also be ingested when mistaken as prey (Ryan et al. 1988), potentially leading to injury or death. For example, due to indiscriminate foraging behaviour, marine turtles have been known to mistake plastic for jellyfish (Mrosovsky et al. 2009). Seabirds foraging on planktonic organisms, generally at, or near, the surface of the water column may eat floating plastic (DEE 2018). Other items (e.g. discarded rope) have also been found to entangle fauna, such as birds and marine mammals. The accidental loss of waste to the ocean may result in injury or even death to individual transient EPBC Act listed species, but this is not expected to result in a threat to population viability of a protected species (Insignificant F).

The accidental loss of equipment or objects that sink may result in seabed disturbance. The area of potential disturbance would be restricted the size of the dropped object and would be within the Operational Area. The seabed within the Operational Area is understood to comprise soft sediments with sparse coverage of filter feeders (Section 4.6.3). Epifauna and infauna communities are widely occurring throughout the region. Therefore, impacts to substrates and associated benthic communities will be negligible.

In the unlikely event that a seismic streamer becomes detached from the survey vessel, the streamers are fitted with floatation devices (pressure-activated, self-inflating buoys) that are designed to bring the equipment to the surface where it can be retrieved by the seismic or support vessel. Buoyant objects may cause interference with commercial fisheries and other marine users depending on the size of the object(s). Loss of a streamer or other object such as a lost fender or dropped supplies could create a floating obstacle, potentially interfering with other marine users. Should disruption occur, it is only expected to affect individual users and cause temporary disruption through avoidance of a highly localised area. The potential for such interactions will typically be limited to a short period of time while the equipment is in the water, until the object is retrieved (if possible). Given the water depths of the Operational Area (greater than 65 m) and the use of floatation devices on streamers, seabed disturbance impacts from the loss of a streamer are not considered credible.

Dropped objects or towed survey equipment that becomes temporarily detached from the survey vessel are expected to have negligible impact on EPBC-Act listed species and localised disruption to commercial fisheries and other marine users (Insignificant F).

Identify existing design and safeguards/controls measures

Spill containment and recovery equipment.

Vessels manage waste in accordance with MARPOL Annex V, specifically maintain and implement a garbage management plan.

Floatation devices are an inherent design feature of towed streamers.

Propose additional safeguards/control measures (ALARP Evaluation)

Hierarchy of control	Control measure	Used?	Justification
Elimination	None identified	N/A	N/A
Substitution	None identified	N/A	N/A

Engineering	None identified	N/A	N/A
Procedures & administration	Premobilisation HSE inspection of vessel and waste contractors.	Yes	HSE inspection conducted pre-mobilisation and ongoing during the activity will confirm correct storage, labelling and handling of wastes including presence of netting to prevent windblown waste.
	Reporting of equipment lost to sea.	Yes	Any equipment, materials or waste lost to the marine environment will be reported and records maintained in the garbage management plan.

Identify the likelihood		
Separation of towed equipment from a seismic survey vessel, such as all or part of a streamer, has occurred previously in the industry, but is an infrequent event and is unlikely to occur. Seismic survey vessels, as well as vessels associated with previous INPEX activities, have accidentally lost waste or equipment overboard, often as a result of incorrect storage and handling. Therefore, impacts to EPBC-listed species, planktonic communities, benthic communities and other marine users from the unplanned release of waste or loss of equipment to the ocean are considered Possible (3).		
Residual risk summary		
Based on a consequence of Insignificant (F) and a worst-case likelihood of Possible (3) the residual risk is Low (8).		
Consequence	Likelihood	Residual risk
Insignificant (F)	Possible (3)	Low (8)
Assess residual risk acceptability		
Legislative requirements The existing preventative and mitigation measures outlined to prevent accidental release of hazardous and non-hazardous wastes are consistent with, and typical of, good industry practice. Procedures for managing waste (i.e. handling, storage, transfer and disposal) will be outlined in the vessel garbage management plan, in accordance with MARPOL Annex V requirements. **Stakeholder consultation** No stakeholder concerns have been raised regarding potential impacts and risks from improper waste handling and disposal. **Australian Marine Park management objectives and values** The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Proposed control measures reduce the risk of waste materials released or lost to the marine environment and no significant impacts to fauna in Australian Marine Parks or impacts to marine park values are expected.		

Conservation management plans / threat abatement plans

Several conservation management plans have been considered in the development of this EP. Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris was listed in August 2003 as a key threatening process under the EPBC Act as detailed in the 'Threat abatement plan for impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans' (DEE 2018). The entanglement and ingestion of marine debris is also identified as a threat in the 'Recovery Plan for Marine Turtles in Australia" (DEE 2017a). Specific actions which contribute to the long-term prevention of marine debris (Objective 1 of the 'Threat abatement plan for marine debris on vertebrate marine life' (DEE 2018)) have been adopted including compliance with applicable legislation in relation to the improvement of waste management practices, such as MARPOL 73/78, Annex V.

ALARP summary

Although the level of environmental risk is assessed as Low, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact.

Acceptability summary

Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because:

- the activity demonstrates compliance with legislative requirements/industry standards;
- the activity takes into account stakeholder feedback;
- the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
- the activity is managed in a manner that is consistent with the intent of conservation management documents;
- the activity does not compromise the relevant principles of ESD; and
- the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as "Low", the consequence does not exceed "C – Significant" and the risk has been reduced to ALARP.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
No unplanned loss of equipment, materials or wastes to the marine environment during the activity.	Loss of equipment or materials lost to sea will be reported.	Incident report of equipment or material lost overboard.
	Spill kits will be available on board the vessels.	Inspection records confirm spill kits are available and stocked.

	Premobilisation HSE inspection of vessel and waste contractors confirm capability for the correct storage, labelling and handling of wastes.	Premobilisation HSE inspection records.
	Solid-filled seismic streamer contains buoyancy devices and is fitted with marker buoys or locating devices.	HSE inspection records confirm streamer design with buoyancy or locating device
	Garbage management plan will be provided on vessels in accordance with Marine Order 95; Annex V of MARPOL (garbage), and specifically include: • procedures for collecting, storing, processing and disposing of all waste types (including segregation and labelling) • the use of waste storage and transfer equipment • the use of waste incinerators (if present on vessels) • the use of food waste macerators/comminuters • garbage record keeping requirements, including discharges, incinerations and disposals of waste in a Garbage Record Book • communication of waste management practices and awareness materials for crew.	HSE inspection records confirm garbage management plans are implemented on vessels. Incident report of waste lost overboard.

7.7 Loss of containment

The activity will require the handling, use and storage of chemicals and hydrocarbon materials which may include, but are not limited to:

- MGO/diesel
- hydraulic oil
- grease
- paint/solvents/detergents.
- Undertaking the activity introduces the potential for loss of containment events. These events may be classified as Level 1, Level 2 or Level 3 incidents, in accordance with the INPEX *Browse Regional OPEP* described in Table 8-6 of this EP.

INPEX defines an emergency condition as:

"an unplanned or uncontrolled situation that harms or has the potential to harm people, the environment, assets, Company reputation or Company sustainability and which cannot, through the implementation of Company standard operating procedures, be contained or controlled."

An evaluation of the environmental impacts and risks associated with emergency conditions is included in Section 8 of this EP.

A summary of potential loss of containment events (and emergency conditions) associated with this EP is presented in Table 7-31. Incident levels are indicative only and classifications have been assigned for the purposes of enabling the risk evaluation to be undertaken. In the event of a spill, the incident level will be classified as described in the INPEX *Browse Regional OPEP* (Table 8-6).

Table 7-31: Representative loss of containment events and emergency conditions identified for the activity

Scenario		Basis of volume calculation	Type	Indicative incident level	Section addressed
Source	Threat				
Management of chemicals and hydrocarbons products on board	Inappropriate use /handling/ spills	Failure/partial loss of contents of tote tank estimated to be approximately 1 m^3 Failure of hydraulic hoses estimated to be in the order of <1 m^3	Various	1	Accidental release – Table 7-32
Hydrocarbon transfers	Spill during bunkering	2.5 m^3 – based on 15 minutes of hose failure during transfer	Group II – MGO	1	Accidental release – Table 7-32
Emergency conditions (refer to Section 8)					
Vessels	Collision	500 m^3 –based on DNV (2015) – Clean Design requirements for double-hull / fully	Group II – MGO	2	Vessel collision – Section 8.2

		protected internal tanks, and maximum tank size of 1062 m^3, combined with AMSA (2015a) vessel collision guidance - 50% loss of tank protected by double hull.			

7.7.1 Accidental release

Table 7-32: Impact and evaluation – loss of containment: accidental release

<table>
<tr><th colspan="2">Identify hazards and threats</th></tr>
<tr><td colspan="2">A number of potential loss of containment events were identified (Table 7-31), including minor spills on board (up to 1 m^3) and loss of hydrocarbon fuels during bunkering of vessels (2.5 m^3).
Specific predictive modelling was not undertaken for the potential loss of containment events. This was based on the expected low volumes and that any predicted impacts are likely to be localised to the point of release. Given the properties of the chemicals involved (predominantly Group I/II hydrocarbons), which tend to be more volatile and less persistent in the environment any spills will rapidly disperse at the sea surface.
An accidental release overboard resulting in a spill that reaches the marine environment has the potential to result in localised changes to water quality, resulting in impacts to marine fauna and planktonic communities at the sea surface, but no impact on deeper water communities or benthic habitats would be expected.</td></tr>
<tr><th>Potential consequence</th><th>Severity</th></tr>
<tr><td>The particular values and sensitivities with the potential to be impacted by a loss of containment/accidental release are:
• EPBC-listed species
• planktonic communities.
Potential accidental releases overboard from loss of containment events may result in the exposure of marine fauna and plankton near the sea surface, to a range of chemicals and Group I/II hydrocarbons. Foreseeable loss of chemicals to the marine environment would be of small volumes (<1 m^3), and impacts would generally be of low consequence (Insignificant F).
Given the anticipated volumes (worst-case 2.5 m^3 of diesel), potential exposure is expected to be localised to the point of discharge in the Operational Area and in some instances a portion of the spilled volume is expected to be at least partially captured within the vessel drainage system, therefore further reducing the potential spill volume. Upon release to the marine environment hydrocarbons will disperse through natural physical oceanic processes, such as currents, tides and waves, and photochemical and biological degradation. Therefore, any surface expression is expected to weather and dissipate in a relatively short time with limited potential for exposure to surfacing marine fauna or plankton at the sea surface.</td><td>Insignificant (F)</td></tr>
</table>

A marine turtle foraging BIA overlaps the Operational Area relating to green turtles and olive ridley turtles. Flatback turtles and loggerhead turtles are also known to forage in an area approximately 10 km west of the Operational Area at the closest point. Although overlapping the BIA, it is unlikely that the Operational Area is the predominant foraging area for all marine turtle species given water depths range from 65 m to 106 m, which is deeper than the preferred range for foraging marine turtles which is generally less than 40 m based on NPF bycatch records (Poiner & Harris 1996). Dietary samples of olive ridley turtles from the eastern Joseph Bonaparte Gulf indicate foraging depths of less than 14 m (Conway 1994 reported in Whiting et al. 2007). Most turtle foraging is therefore expected to be associated with shallower waters within the KEFs surrounding the Operational Area (Pinnacles of Bonaparte Basin, Carbonate Bank and Terrace System of the Sahul Shelf and Carbonate Bank and Terrace System of the Van Dieman Rise (DEWHA 2008b). Satellite tracking data reviewed in recent studies (Ferreira et al. 2020; Thums et al. 2021) concluded that the spatial extents of foraging BIAs are considered to potentially underestimate the distribution of foraging turtles. In particular, flatback turtles are reported to forage in areas of the Joseph Bonaparte Gulf with bare substrate and may potentially forage in deeper waters depths (Thums at al. 2021) such as those found in the Operational Area. Therefore, it is considered possible that green, olive ridley, flatback and loggerhead turtles may be present in the Operational Area year-round. Given the mobile and transient nature of foraging turtles and the large size of available foraging grounds, the potential exposure is likely to be limited to individuals close to the discharge point at the time of the release and the activity is unlikely to displace turtles from the foraging grounds year-round. Worst-case impacts to exposed marine fauna may include direct toxic effects, such as damage to lungs and airways, and eye and skin lesions from exposure to oil at the sea surface (Gubbay & Earll 2000). Considering the low volumes (< 2.5 m^3), limited duration of exposure and the location of the discharges in the dispersive open ocean environment, a surface expression is not anticipated; therefore, impacts are considered to be of inconsequential ecological significance to EPBC-listed species and are therefore considered Insignificant (F). As a consequence of their presence close to the water surface, plankton may be exposed to any entrained/dissolved components of any hydrocarbons spilled at the sea surface, particularly in high energy seas where the vertical mixing of oil through the water column would be enhanced. The effects of oil on plankton have been well studied in controlled laboratory and field situations. The different life stages of a species often show widely different tolerances and reactions to oil pollution. Usually, eggs, larval and juvenile stages will be more susceptible than adults (Harrison 1999). Post-spill studies on plankton populations are few, but those that have been conducted, typically show either no effects or temporary minor effects (Kunhold 1978). Given the high temporal and spatial variability in plankton communities, and the small size of the area impacted by an accidental release, the potential consequence in regard to planktonic communities is considered to be Insignificant (F).	
Identify existing design and safeguards/controls measures	
All vessels >400 GT will have a SOPEP (or SMPEP) in accordance with Marine Order 91 Spill kits will be available on-board vessels Personnel will receive an induction/training to inform them of deck spill response requirements in accordance with Section 9.3.3 and Table 9-3.	

Propose additional safeguards/control measures (ALARP Evaluation)			
Hierarchy of control	Control measure	Used?	Justification
Elimination	Eliminate the use of chemicals and hydrocarbons on board.	No	Chemicals and hydrocarbons are required for safe and efficient operations and cannot be eliminated. In the case of diesel, it is required as fuel and cannot be eliminated.
	No bunkering.	No	Bunkering of fuel from supply vessels is required during the activity as space limitations/tank capacities mean that supplies need to be replenished.
	No cargo transfers.	No	Cargo transfers cannot be eliminated, as this is the only practicable option for supplying project vessels in offshore locations.
Substitution	None identified	N/A	N/A
Engineering	Prevent onboard spills through appropriate storage of hydrocarbons and chemicals including their associated waste constituents.	Yes	Through bunding of storage areas and good housekeeping practices, the storage and management of hydrocarbon and chemical products and associated wastes can reduce the potential risk of a loss of containment event occurring.
Procedures & administration	Implement hydrocarbon transfer procedures that specify operational requirements (e.g. minimum lighting conditions, communications, visual monitoring, dry break/break away couplings installed and used).	Yes	The transfer of fuel will occur in accordance with strict conditions for preventing spills to the marine environment. Offshore transfers of fuel will be conducted in accordance with the vessel contractor’s transfer procedures.
	Hydraulic equipment on board vessels has a preventative maintenance system to ensure equipment is maintained and operated within OEM specification.	Yes	Routine servicing and inspection of hydraulic equipment will ensure it is fit for purpose and minimise the potential for leaks and spills to deck as a result of corrosion, and wear and tear of hydraulic hoses.
Identify the likelihood			
Based on the low volumes and expected weathering of spilled chemicals, in conjunction with the controls in place the likelihood of a loss of containment event causing harm to the identified receptors is considered to be Unlikely (4).			

Residual risk summary		
Based on a consequence of Insignificant (F) and a likelihood of Unlikely (4) the residual risk is Low (9).		
Consequence	Likelihood	Residual risk
Insignificant (F)	Unlikely (4)	Low (9)
Assess residual risk acceptability		
Legislative requirements The activities and proposed management measures are compliant with industry standards and relevant Australian legislation, specifically concerning prevention pollution, including Marine Order 91: Marine Pollution Prevention - Oil. **Stakeholder consultation** No stakeholder concerns have been raised regarding potential impacts and risks from accidental release/loss of containment. Spill response activities and notifications to relevant stakeholders have been identified and included in INPEX spill response processes. **Australian Marine Park management objectives and values** The Operational Area is located 32 km from the Oceanic Shoals MP and 60 km from the Joseph Bonaparte Gulf MP. Proposed control measures reduce the risk of loss of containment events and the preventative controls in place, spill response preparedness and distance to the nearest marine parks mean no risk of impacts to fauna in Australian Marine Parks or impacts to marine park values are expected. **Conservation management plans / threat abatement plans** Several conservation management plans (Appendix A) identify oil or chemical spills as key threatening processes, through both direct/acute impacts, as well as indirect impacts through habitat degradation. The prevention of loss of containment events and reducing impacts to the marine environment through the preventative controls in place and spill response preparedness, demonstrates alignment with the various conservation management plans. **ALARP summary** Although the level of environmental risk is assessed as Low, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact. **Acceptability summary** Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because: • the activity demonstrates compliance with legislative requirements/industry standards • the activity takes into account stakeholder feedback		

- the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
- the activity is managed in a manner that is consistent with the intent of conservation management documents
- the activity does not compromise the relevant principles of ESD
- the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as "low", the consequence does not exceed "C – significant" and the risk has been reduced to ALARP.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
No loss of containment of hydrocarbons or chemicals to the marine environment.	Premobilisation HSE inspections confirm that vessels >400 GT have SOPEP (or SMPEP) compliant with Marine Order 91.	Premobilisation HSE inspection documentation.
	Spill kits will be available on board the vessels.	Inspection records confirm spill kits are available and stocked.
	Bunding around stored bulk wet chemicals or hazardous liquid waste storage areas in accordance with Australian standards.	Bunding and drainage routine HSE inspections
	Vessel bunkering procedures for hydrocarbon transfers will include as a minimum: • Dry break couplings/weak link breakaway couplings and flotation collars installed on hydrocarbon bulk transfer hoses to prevent entanglement and enable early leak detection. • Bunkering is undertaken during daylight hours and when weather is good (e.g. suitable sea conditions). • Night time bunkering will only occur in fully lit conditions and in favourable sea states.	Vessel bunkering procedure
	INPEX will verify the vessel contractor implements a preventive maintenance system for hydraulic equipment to ensure equipment is maintained and operated within OEM specification.	Documentation of maintenance recorded in the preventive maintenance system.

8 EMERGENCY CONDITIONS

An evaluation of potential loss of containment spill sources and worst-case spill scenarios (WCSS) identified a potential emergency condition related to the activity as summarised in Table 8-1.

Table 8-1: Potential emergency conditions

Scenario		Hydrocarbon type	Release location
Source	**Threat**		
Vessels	Collision	Group II –MGO	Surface

8.1 PEZ and EMBA based on oil spill modelling

As described in Section 4, the PEZ has been derived to inform the outer boundary of potential exposure for oil spill planning and scientific monitoring purposes using low thresholds described in NOPSEMA bulletin #1 (NOPSEMA 2019). The low thresholds used may not be ecologically significant as hydrocarbon exposure has the potential to result in both acute and chronic impacts to marine flora and fauna, depending on the sensitivity of organisms exposed and the concentration of exposure.

A summary of the range of concentrations of different hydrocarbon exposure thresholds adopted to conservatively identify the PEZ and EMBA (area where potential environmental impact may occur) is described in Table 8-2. These thresholds include surface, entrained, dissolved and shoreline accumulation thresholds.

Table 8-2: Hydrocarbon exposure thresholds

Threshold		Description
Surface hydrocarbon exposure	PEZ 1 g/m^2	To define the outer extent of the PEZ, a low surface exposure threshold of 1 g/m^2 has been used to provide an indication of the furthest extent at which a visible sheen may be observed on the sea surface. It is considered too low for ecological impact assessment purposes and is used to inform oil spill scientific monitoring purposes (water quality) as per NOPSEMA (2019). The low exposure threshold also provides an indication of socioeconomic receptors, such as oil and gas industry, tourism and fishing activities that may be affected by safety concerns associated with a light/visible surface expression.
	EMBA 10 g/m^2	The surface oil threshold of 10 g/m^2 to assess environmental impacts is based on research by French-McCay (2009) who has reviewed the minimum oil thickness (0.01 mm) required to impact on thermoregulation of marine species, predominantly seabirds and furred mammals (furred mammals are not present within the EMBA of this EP). Seabirds are particularly vulnerable to oil spills because their feathers easily become coated, and they feed in the upper water column. Other tropical marine megafauna species are unlikely to suffer from comparable physical oil coating because they have smooth skin. Applying the threshold for

		the scenarios outlined for this EP therefore, represents a conservative measure to define the EMBA. This threshold has been applied to various industry oil spill impact assessments by French-McCay (2002; 2003) and is recommended in the AMSA guidelines (AMSA 2015b).
Entrained hydrocarbon exposure	PEZ 10 ppb	The low exposure threshold of 10 ppb has been used to inform the outer extent of potential exposure to entrained hydrocarbons in the water column. It is considered too low for ecological impact assessment and is used to inform oil spill scientific monitoring purposes (water quality) as per NOPSEMA (2019).
	EMBA 100 ppb	The biological impact of entrained oil cannot be determined directly using available ecotoxicity; however, it can be derived from tests using either water-soluble fraction (WSF) of oil or oil-in-water dispersions (OWD). OWD are prepared by highly turbulent shaking of oil in water, which are allowed to separate before use, so that the test organisms are exposed to the dissolved fractions, as well as any very fine entrained oil droplets that remain in suspension. However, results are conservative because entrained droplets are less biologically available to organisms through tissue absorption than the dissolved fraction (Tsvetnenko 1998). French-McCay (2002) reviewed global ecotoxicology data for numerous species (115 for fish, 129 for crustaceans, and 34 for other invertebrates). The intent was to provide an estimate of the magnitude of toxicity effects from oil exposure to marine biota across a wide taxonomic range. These were based on both WSF and OWD tests. Under low turbulence conditions, the total PAH LC_{50} for species of average sensitivity ranges from about 300–1,000 ppb. Under higher turbulence, such as a subsea release, the total PAH LC_{50} decreased to about 64 ppb (French-McCay 2002). Comparatively, the lowest no observed effect concentration level for unweathered Browse condensate from the north-west region was found to be 20 ppm, based on a fish imbalance and tiger prawn toxicity test (Woodside 2014). In addition to potential toxicity impacts, entrained oil droplets (although less bioavailable) may present smothering impacts to submerged receptors. Physical and chemical effects of the entrained oil droplets have been demonstrated through direct contact with receptors through physical coating of gills and body surfaces, and accidental ingestion (NRC 2005). To be conservative, a 100 ppb entrained threshold is proposed to account for any ecological impacts (toxicity and smothering) in the EMBA.
Dissolved hydrocarbon exposure	PEZ -	As dissolved hydrocarbons are the soluble component of entrained hydrocarbons, the conservative low exposure threshold used for entrained hydrocarbons at 10 ppb encompasses the dissolved component to identify the furthest extent of potential exposure used for oil spill planning and scientific monitoring purposes (water quality) as per NOPSEMA (2019).

	EMBA 50 ppb	The 99% species protection threshold of 50 ppb for PAH (ANZG 2018) has been selected to indicate the zones where acute exposure could potentially occur over shorter durations, following a spill.
Shoreline accumulation	PEZ 10 g/m^2	Certain industries, such as tourism may be affected by visible sheen on sandy beaches, therefore a shoreline accumulation of 10 g/m^2 has been included for information purposes to inform the PEZ, that may indicate potential socioeconomic impact as per NOPSEMA (2019). However, it is considered too low for ecological impact assessment purposes.
	EMBA 100 g/m^2 (where threshold for surface or entrained/dissolved hydrocarbon exposure at that shoreline is also exceeded).	A shoreline accumulation threshold of 100 g/m^2 is recommended from the review by French-McCay (2009) based on exposure to birds and smothering of invertebrates in intertidal habitats. This threshold is also proposed to be an acceptable minimum thickness that does not inhibit recovery and is best remediated by natural coastal processes (AMSA 2015b).

As described in Section 4, the spatial extent of the PEZ, used as the basis for the EPBC Act Protected Matters database search (Appendix A), was determined using stochastic spill modelling by applying the low thresholds. The EMBA, used as the basis for the impact and risk evaluation presented in this section of the EP, was determined by applying the defined impact exposure thresholds detailed in Table 8-2.

The stochastic spill modelling results from the WCSS (s vessel collision scenario) during all seasons (summer (wet), winter (dry) and transitional) and under different hydrodynamic conditions (e.g. currents, winds, tides, etc.) is presented in Figure 8-1.

Stochastic spill modelling results provide a highly conservative representation of the PEZ and EMBA and has been used to ensure that the EPBC Protected Matters database search identifies all potential receptors. As such, the actual area that may be affected from any single spill event would be considerably smaller than that represented by the PEZ and EMBA. Example model outputs from individual spill events are available in the INPEX *Browse Regional OPEP Basis of Design* and *Field Capability Assessment Report* (Table 8-6).

Deterministic modelling is a single spill simulation using one set of wind and weather conditions over time. Deterministic modelling runs are often paired with stochastic modelling to place the large stochastic footprint into perspective. Specific deterministic analysis or the use of a selection of worst-case individual stochastic run(s) (selected from the stochastic analysis) are utilised as the basis for developing the response plans and field capability/equipment needs for a realistic spill response as described in the INPEX *Browse Regional OPEP*.

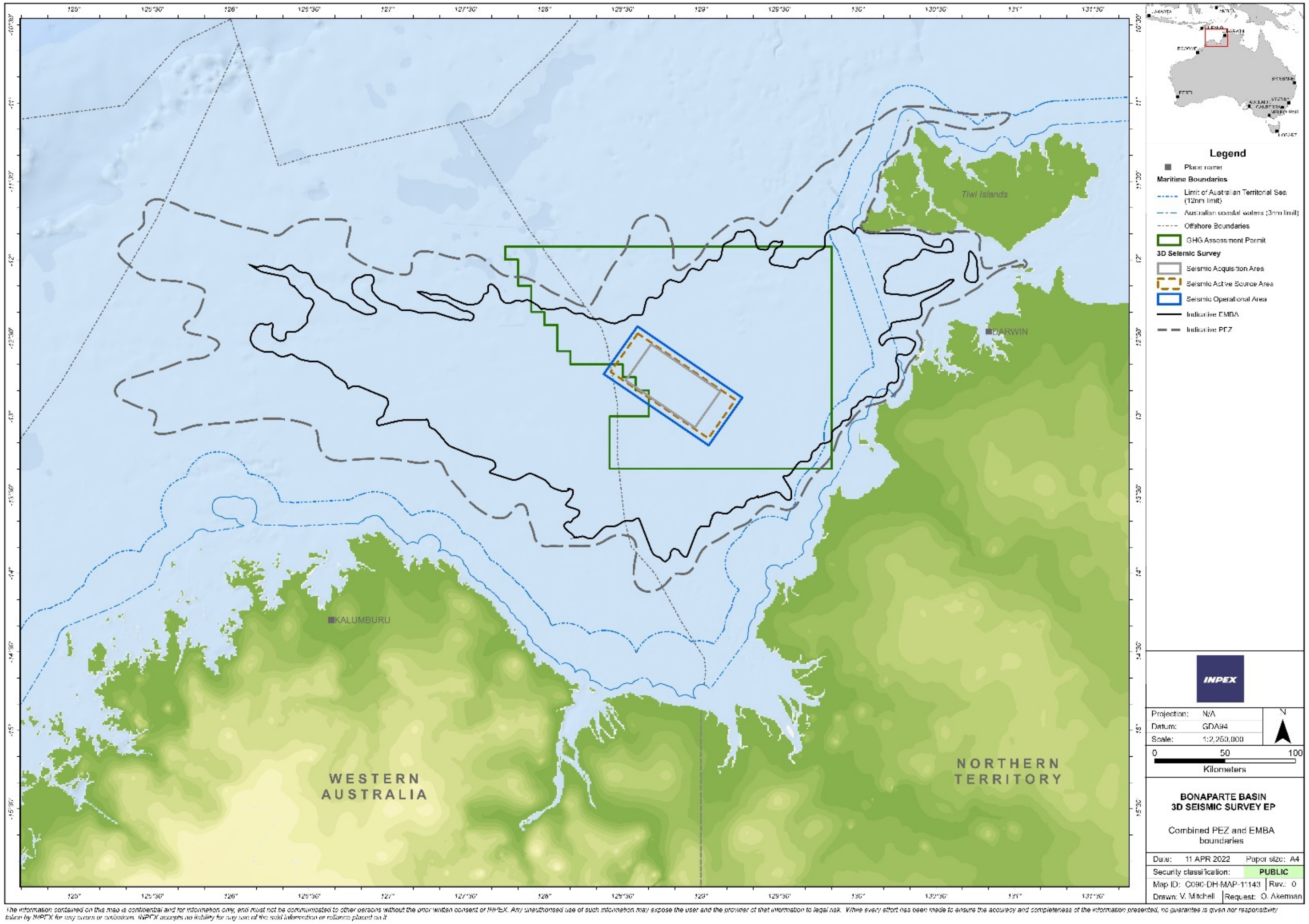


Figure 8-1: PEZ and EMBA from the WCSS

8.2 Vessel collision

8.2.1 Location

Only vessels using MGO will be used during the activities described in this EP. Spill modelling (RPS 2022) was undertaken for a Group II hydrocarbon surface release of MGO in the Operational Area within the Joseph Bonaparte Gulf. The release point provides indicative information only as an exact location for a vessel collision cannot be predicted.

8.2.2 Volume and duration

AMSA guidance (AMSA 2015a) recommends that the maximum credible volume spill for a vessel collision scenario be based on the volume of the largest single fuel tank. The AMSA (2015a) guidance, specifically Table 10, does not take into consideration a new class of "other vessel", which represent vessels that have protected tanks due to a double hull (as is included for 'oil tankers'). The DNV (2015) Environmental Class, specifically "Clean Design", provides an engineering code which specifies the requirements for fully protected internal tanks (double hull), up to a maximum of 1,500 m^3 per tank. A review of the maximum tank sizes associated with the proposed seismic vessels identified the largest tank size to be approximately 1,062 m^3. However, this volume is associated with the largest tank volume, which is of 'clean design' with space between the hull of the vessel and the fuel tanks. Therefore, loss of a full tank volume was not considered to be credible and a 500 m^3 spill has been modelled instead. In most cases the largest tank volume on other seismic survey vessels is significantly less than 500 m^3.

The 500 m^3 spill volume has been used (RPS 2022) with the spill modelled as an instantaneous release, with spill trajectory and fate tracked for 21 days.

8.2.3 Hydrocarbon properties

Hydrocarbon properties associated with the Group II MGO used for the modelling study are presented in Table 8-3.

Table 8-3: Group II MGO properties

Hydrocarbon type	Density at 25 ˚C (g/cm^3)	Viscosity – centipoise (cP) – at 25 ˚C	Characteristic	Volatile (%)	Semi-volatile (%)	Low volatility (%)	Residual (%)
			Boiling point (˚C)	<180	180–265	265–380	>380
MGO	0.829	4.0	% of total	6	34.6	54.4	5

8.2.4 Modelling results

Modelling results are summarised in Table 8-4 and include results taken for three modelled seasons throughout the year: October to March (summer); May to August (winter); and transitional periods April and September. For each season, 100 modelled replicates were run and therefore the results summarised represent 300 possible spill scenarios.

Under weak wind conditions (which do not generate breaking waves) a proportion of the oil mass should evaporate within the first 24 hours after the spill. Remaining oil on the surface is exposed to the atmosphere.

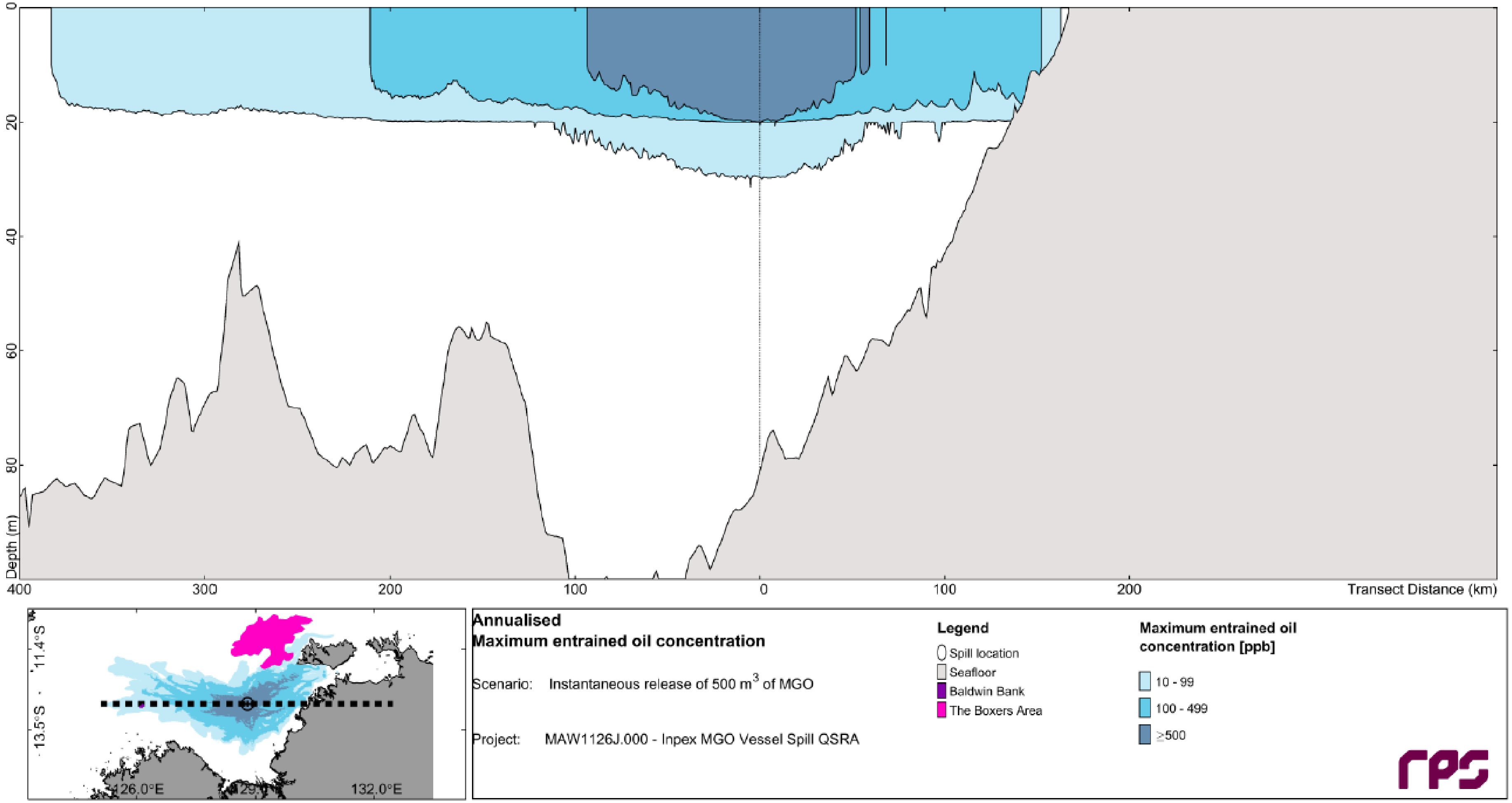
Under stronger wind conditions oil slicks are subject to dispersion into the upper water column, due to the mixing effect of breaking surface waves. Oil is maintained in suspension as entrained droplets if breaking waves persist. Once entrained, the MGO will cease to evaporate, slowing the net evaporation rate. The entrained oil will drift and disperse in the water column, where it undergoes decay.

Table 8-4: Vessel collision stochastic modelling results (RPS 2022)

Hydrocarbon exposure	Surface release of 500 m^3 MGO
Surface	The maximum distance of floating hydrocarbon, at concentrations greater than 1 g/m^2 (visible sheen), travelled by a single spill trajectory (out of 300 simulations) was 88 km from the release location during any of the modelled seasons. The maximum distance travelled by a single spill trajectory (out of 300 simulations) for floating hydrocarbons at concentrations >10 g/m^2 (environmental impact threshold) were predicted to be 78 km from the release location during any of the modelled seasons.
Entrained and dissolved	Entrained oil >100 ppb is predicted to occur at distances up to approximately 300 km from the release location. The worst-case instantaneous entrained oil concentration in the immediate vicinity of the release was calculated as 107,516 ppb. The worst-case instantaneous entrained oil concentration for waters surrounding emergent sensitive receptors is predicted at the Roche Reefs as 218 ppb. These values represent worst single replicates from 300 simulations. When averaged over all replicate simulations, the highest concentrations of entrained oil were predicted as 4,910 ppb in the immediate vicinity of the release. Other notable locations include: 45 ppb at Pinnacles of the Bonaparte Basin KEF (winter), 50 ppb at Flat Top Bank (summer), 44 ppb at Oceanic Shoals MP (winter), 36 ppb at Carbonate Bank and Terrace System of the Sahul Shelf KEF (winter) and 14 ppb at Carbonate Bank and Terrace System of the Van Diemen Rise KEF (summer) which are all below the 100 ppb impact threshold. Cross-sectional transects in the vicinity of the release site indicated that entrained oil concentrations at or greater than the 100 ppb threshold are not predicted to reach depths greater than approximately 20 m (Figure 8-2). Dissolved aromatic hydrocarbons > 50 ppb is predicted to occur at distances up to approximately 100 km from the release location. The worst-case instantaneous dissolved aromatic hydrocarbon concentration in the immediate vicinity of the release was calculated as 1,157 ppb. The worst-case instantaneous dissolved aromatic hydrocarbon concentration for waters surrounding emergent sensitive receptors is predicted at Bathurst Island as 8 ppb. When averaged over all replicate simulations, the highest concentrations of dissolved aromatic hydrocarbons were predicted as 34 ppb in the immediate vicinity of the release. Other notable locations include: 2 ppb at Pinnacles of the Bonaparte Basin KEF (winter), 2 ppb at Flat Top Bank (summer), 2 ppb at Oceanic Shoals MP (winter), <1 ppb at Carbonate Bank and Terrace System of the Sahul Shelf KEF (all seasons) and <1 ppb at Carbonate Bank and Terrace System of the Van Diemen Rise KEF (all seasons) which are all below the 50 ppb impact threshold.

Hydrocarbon exposure	Surface release of 500 m^3 MGO
	Cross-sectional transects in the vicinity of the release site indicated that dissolved aromatic hydrocarbon concentrations at or greater than the 50 ppb threshold are not predicted to reach depths greater than approximately 60 m (Figure 8-3).
Shoreline	No shoreline accumulated > 10 g/m^2 was recorded in any replicate. The highest accumulated concentration on any shoreline, was calculated as 0.6 g/m^2 at Joseph Bonaparte Gulf (NT) (summer) below the 100 g/m^2 impact threshold. Worst case estimates for the total volume of oil on shorelines was calculated at to be <1 m^3 across all seasons.

A)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Transect Distance (km)
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13.5°S
126.0°E
129
132.0°E
Annualised
Maximum entrained oil concentration
Scenario: Instantaneous release of 500 m3 of MGO
Project: MAW1126J.000 - Inpex MGO Vessel Spill QSRA
Legend
Spill location
Seafloor
Baldwin Bank
The Boxers Area
Maximum entrained oil concentration [ppb]
10 - 99
100 - 499
≥500

B)

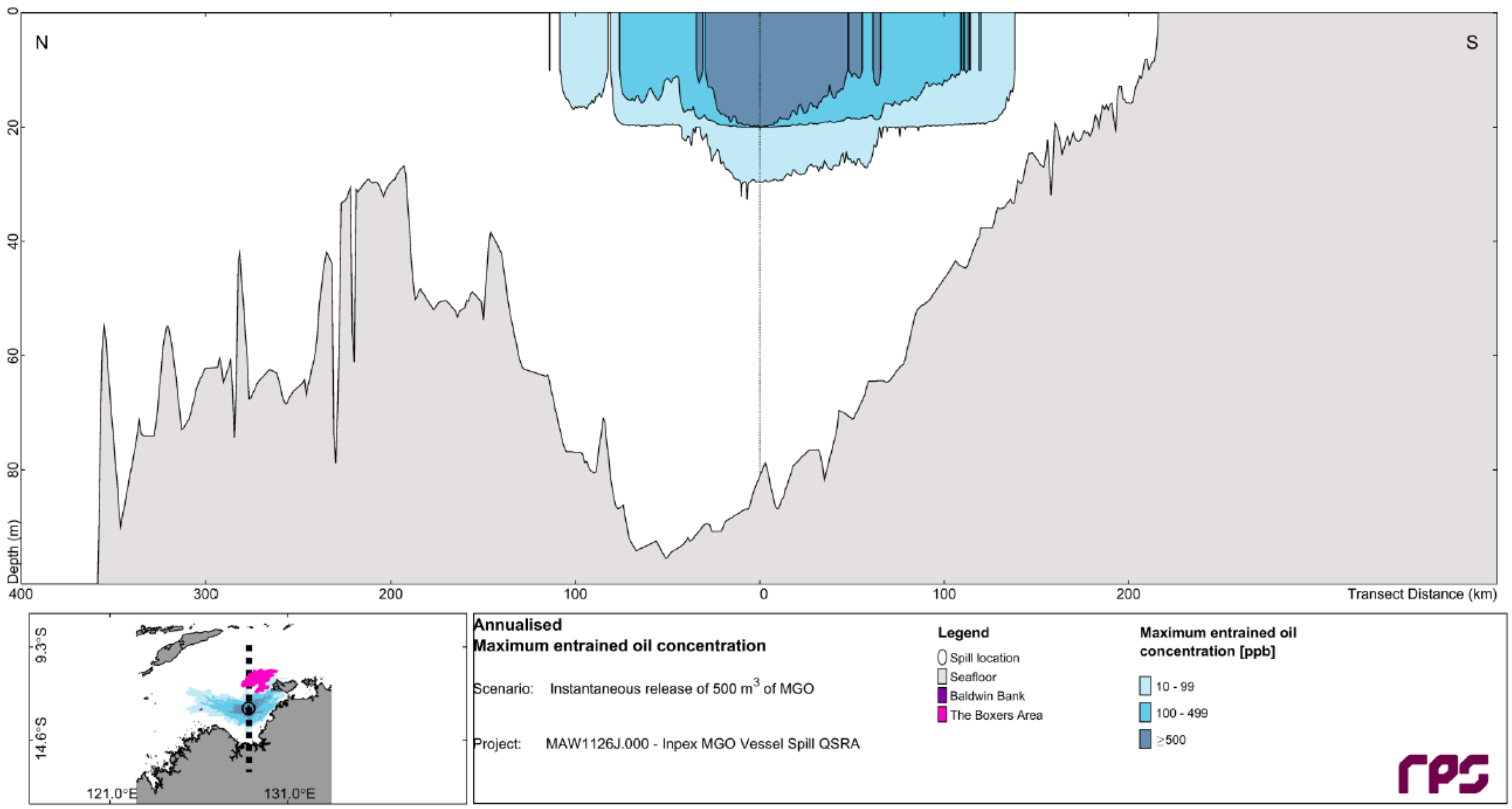
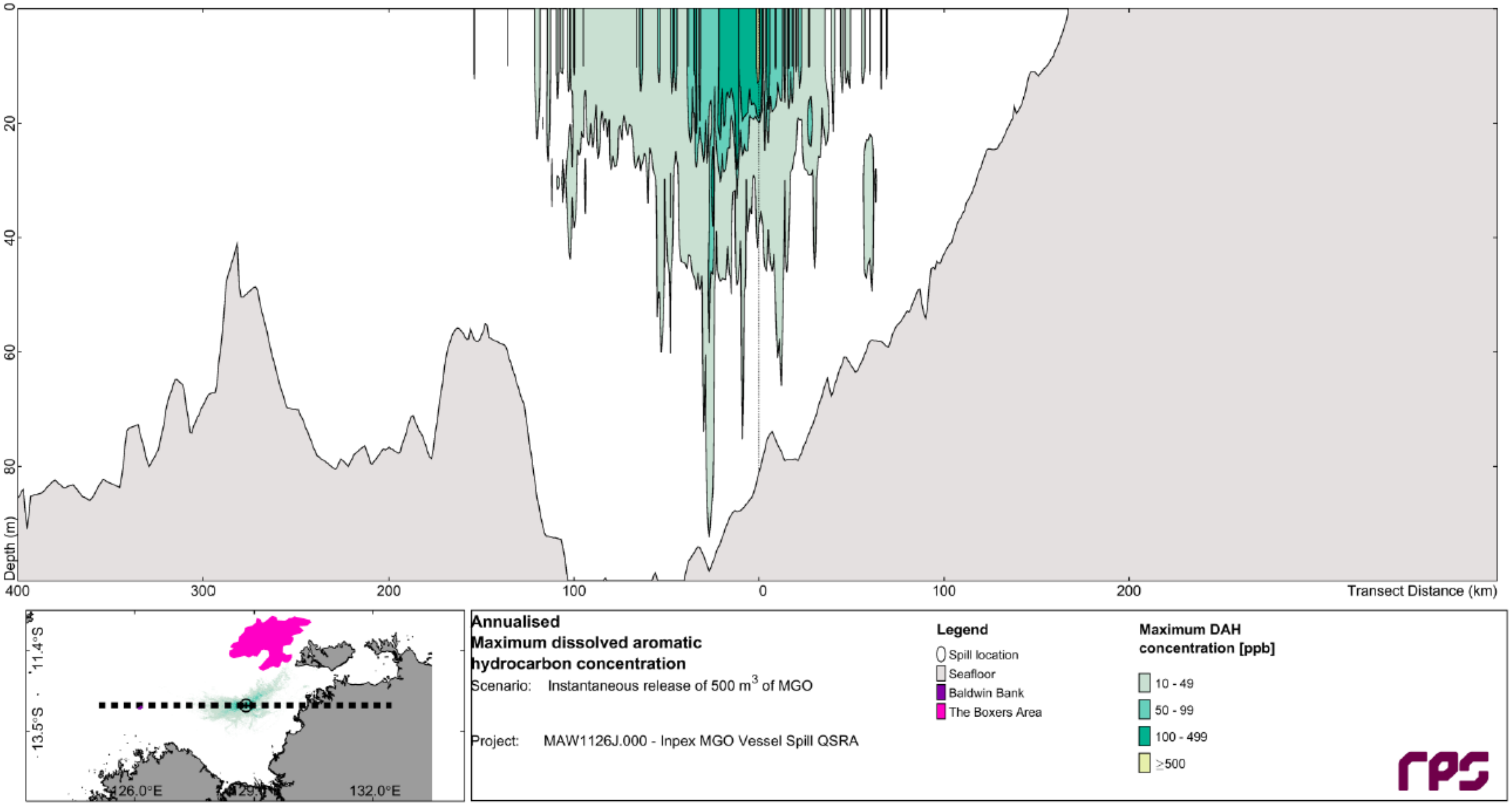


Figure 8-2: A) Annualised east-west cross-section of entrained oil concentrations B) Annualised north-south cross section of entrained oil concentrations (RPS 2022)

A)


Depth (m)
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Transcect Distance (km)
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13.5°S
126.0°E
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Annualised
Maximum dissolved aromatic hydrocarbon concentration
Scenario: Instantaneous release of 500 m3 of MGO
Project: MAW1126J.000 - Inpex MGO Vessel Spill QSRA
Legend
Spill location
Seafloor
Baldwin Bank
The Boxers Area
Maximum DAH concentration [ppb]
10 - 49
50 - 99
100 - 499
≥500

B)

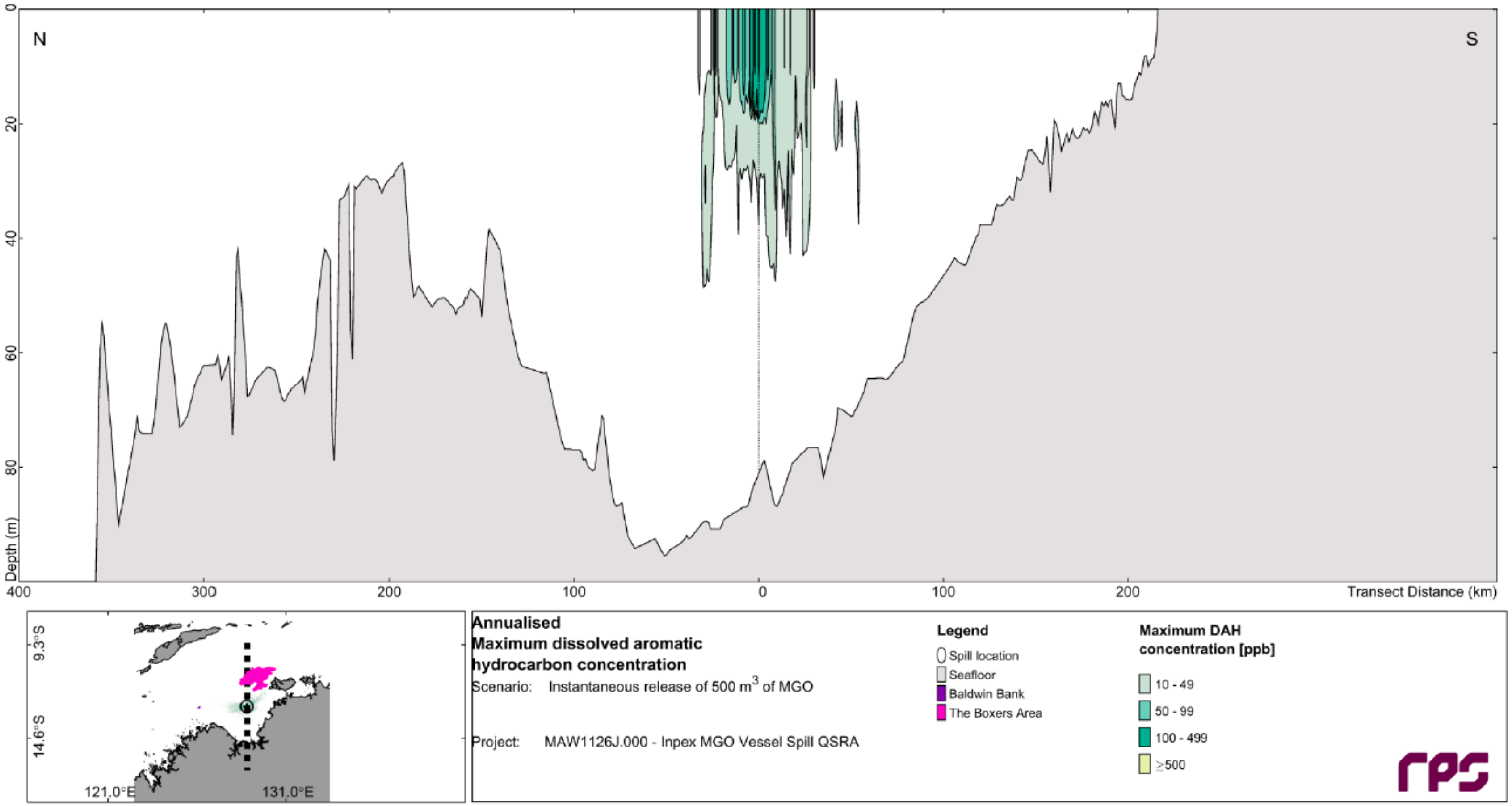

Figure 8-3: A) Annualised east-west cross-section of dissolved aromatic hydrocarbon concentrations B) Annualised north-south cross-section of dissolved aromatic hydrocarbon concentrations (RPS 2022)

8.2.5 Impact and risk evaluation

Table 8-5: Impact and evaluation – Vessel collision resulting in a Group II (MGO) spill

<table>
<tr><th colspan="2">Identify hazards and threats</th></tr>
<tr><td colspan="2">A surface release of Group II hydrocarbons has the potential to result in changes to water quality through exposure to hydrocarbons. The thresholds for impacts associated with surface, entrained/dissolved, and shoreline, hydrocarbon exposures are described in Table 8-2. The results of the predictive modelling for the vessel collision scenario are presented in Table 8-4.</td></tr>
<tr><th>Potential consequence – surface hydrocarbons</th><th>Severity</th></tr>
<tr><td>The values and sensitivities with the potential to be affected by surface hydrocarbon exposure from a surface release due to a vessel collision include:
• commercial, recreational and traditional fisheries (within 88 km from the release location based on 1 g/m^2 visible sheen threshold in worst-case)
• EPBC Act-listed species (within 78 km from the release location based on 10 g/m^2 impact threshold)
• planktonic communities (within 78 km from the release location based on 10 g/m^2 impact threshold).
The values and sensitivities associated with commercial, recreational and traditional fisheries (seafood quality and employment) could be impacted by a visible sheen on the sea surface. A visible sheen is predicted to possibly extend up to 88 km from the release location; however, it would not be a continuous surface expression. Exclusion zones may impede access to fishing areas for a short-to-medium term, and nets and lines could become oiled (ITOPF 2011).
The NPF and several NT-managed fisheries are potentially active in the Operational Area as described in Section 4.9.6. Fisheries whose fishing grounds overlap the Operational Area and EMBA/PEZ may potentially have access limitations in the event of a spill resulting from a vessel collision. Fishing data from the NPF confirmed that most fishing effort in the Joseph Bonaparte Gulf has historically occurred >50 km south-west of the Operational Area. The NT Demersal Fishery confirmed that trawl vessels consistently operate in the Operational Area as well as waters located to the north of the Operational Area throughout the year. A review of historic fishing effort data confirmed the other NT-managed fisheries (NT Offshore Net and Line and NT Aquarium) (Table 4-4) reported low fishing effort in the Operational Area. Other commercial fisheries are active in the EMBA/PEZ.</td><td>Minor (E)</td></tr>
</table>

Recreational fishing occurs in the Joseph Bonaparte Gulf with the majority of fishing occurring in estuaries (e.g. barramundi fishing) or in coastal waters. Recreational day-fishing is typically concentrated around the population centres and readily accessible coastal population settlements which are generally at the edge of, or outside of the PEZ, and therefore unlikely to be impacted by this type of spill. Traditional fishing activities are known to occur within the EMBA/PEZ at the Tiwi Islands and along NT coastlines. Any socioeconomic impacts are expected to be localised to within 88 km of the release location and temporary in nature given the expected evaporation and rapid dispersion of Group II hydrocarbons at the sea surface. Therefore, the consequence is considered to be Insignificant (F).Within the EMBA, several marine turtle BIAs are known to occur (Figure 4-5), and the Operational Area overlaps a foraging BIA for green turtles and olive ridley turtles. Flatback turtles and loggerhead turtles are also known to forage in an area approximately10 km west of the Operational Area at the closest point. Therefore, there is a potential for marine turtles to be exposed to surface hydrocarbons within 78 km of the release location. Turtles may be exposed to hydrocarbons if they surface within the spill, resulting in direct contact with the skin, eyes, and other membranes, as well as the inhalation of vapours or ingestion (Milton et al. 2003). Floating oil is considered to have more of an effect on reptiles than entrained/dissolved oil because reptiles hold their breath underwater and are unlikely to directly ingest dissolved oil (WA DoT 2018). Other aspects of turtle behaviour, including a lack of avoidance behaviour, indiscriminate feeding in convergence zones, and large, pre-dive inhalations, make them vulnerable (Milton et al. 2003; WA DoT 2018). A range of other EPBC-listed marine fauna may also be present within this area albeit on a transient basis (Appendix A). The Indo-pacific humpback dolphin would not be expected to be exposed to surface hydrocarbons as the breeding BIA is located approximately 160 km west of the Operational Area (Figure 4-4) where water depths range from 75 m to 100 m, and the species is mainly found in water less than 20 km from the nearest river mouth, and in water depths of less than 15 m to 20 m (DAWE 2022b). Omura's whale populations may also be present within the Operational Area and EMBA based on vocalisations detected in the Joseph Bonaparte Gulf (McCauley 2009, 2014). BIAs associated with humpback whales and pygmy blue whales are located over 400 km and 300 km respectively from the Operational Area and therefore they are also not expected to be exposed to surface hydrocarbons. Whale sharks do not breach the surface as cetaceans do; however, they are known to swim near to the water surface. The foraging area for whale sharks (BIA) is located approximately 300 km west of the Operational Area at its closest point. Therefore, no exposure to surface hydrocarbons is predicted for whale sharks. Based on the limited extent of the surface hydrocarbons (within 78 km where concentrations are > 10 g/m^2, noting that the spill would not represent a continuous surface expression) and the rapid evaporation of volatile components and expected weathering resulting in reduced levels of toxicity, any impacts to EPBC-listed species are expected to be on a local scale, with short-term impacts on a small portion of the population of a protected species (Minor E). Plankton may potentially be exposed to hydrocarbons on the sea surface. However, the majority of impacts would be toxicity related, associated with entrained/dissolved hydrocarbons exposure. Therefore, the impact evaluation for plankton is provided in the subsection below.	
Potential consequence – entrained/dissolved hydrocarbons	Severity
The values and sensitivities with the potential to be affected by dissolved/entrained hydrocarbon exposures are: • historic shipwrecks (within 300 km from the release location)	Moderate (D)

• commercial, recreational and traditional fisheries (within 300 km from the release location) • KEFs and fish communities (within 300 km from the release location) • planktonic communities (within 300 km from the release location) • benthic communities (within 300 km from the release location) • EPBC-listed species including marine mammals, turtles, marine avifauna BIAs (within 300 km from the release location). Exposure to hydrocarbons above impact thresholds was predicted in the upper water column up to 20 m depth for entrained oil and up to 60 m depth for dissolved aromatic hydrocarbons. Two shipwrecks with protection zones under the *Underwater Cultural Heritage Act 2018* are present within the PEZ/EMBA (Section 4.9.4). They are located approximately 125 km and 205 km from the Operational Area at the closest points. Given any release would be at the sea surface, the location of the shipwrecks on the seabed they will not be exposed to surface or entrained hydrocarbons. They may be exposed to dissolved hydrocarbons; however, there are no reports of damage to shipwrecks on the seabed from exposure to in-water hydrocarbons and therefore the consequence is considered to be Insignificant (F). Fishing grounds that overlap the EMBA may potentially be exposed to entrained/dissolved hydrocarbons above impact thresholds. The impact to fish communities from exposure to entrained and dissolved hydrocarbons above threshold values, is primarily associated with toxicity resulting in impacts to seafood quality. The level of effort in fisheries overlapping the Operational Area is generally reported to be low, however for other fishing activities it is unknown. The commercial fisheries that may be active in the EMBA/PEZ are presented in Table 4-4. The species targeted by these fisheries include demersal, shark and invertebrate species (Table 4-5). Recreational fishing occurs in the Joseph Bonaparte Gulf with the majority of fishing occurring in estuaries (e.g. barramundi fishing) or in coastal waters of shallow depth. Traditional fishing with the EMBA/PEZ occurs at the Tiwi Islands and NT coastlines and could be affected by impacts to fish and benthic habitats from dissolved/entrained oil. A surface release of MGO is expected to entrain predominantly within the upper water column in the top 20 m (RPS 2022); therefore, exposure is considered to be relatively limited within the water column. Pelagic fish, site attached fish and fish associated with KEFs in the top 20 m of the water column have the potential to be exposed to entrained hydrocarbons above the impact threshold (>100 ppb) within 300 km of the release location. The highest concentrations of entrained oil when averaged over 300 modelled scenarios, was at the immediate vicinity of the release location (4,910 ppb) and the highest concentration received in the waters surrounding a sensitive receptor was 218 ppb at Roche Reefs located 120 km east of the Operational Area. Exposure to all other receptors was below the entrained oil impact threshold of 100 ppb. Dissolved aromatic hydrocarbons above the impact threshold were predicted to extend up to 100 km of the release location within the top 60 m of the water column. The highest concentrations of dissolved aromatic hydrocarbons when averaged over 300 modelled scenarios, was at the immediate vicinity of the release location (1,157 ppb) with concentrations at all other receptor locations below the impact threshold of 50 ppb.	

Fish associated with KEFs or deeper benthic habitats are less likely to be exposed above impact thresholds in deeper waters. Chronic impacts to juvenile fish and larvae may occur if exposed to entrained/dissolved hydrocarbon plumes potentially resulting in lethal or sub-lethal effects or impairment of cellular functions (WA DoT 2018). Juvenile fish and larvae may experience increased toxicity upon such exposure to plumes, because of the sensitivity of these life stages, with the worst impacts predicted to occur in smaller species (WA DoT 2018). Adult fish exposed to entrained hydrocarbons are likely to metabolise the hydrocarbons and excrete the derivatives, with studies showing that fish have the ability to metabolise petroleum hydrocarbons. These accumulated hydrocarbons are then released from tissues when fish are returned to hydrocarbon free seawater (Reiersen & Fugelli 1987). Given the highly mobile nature of pelagic fish, they are not expected to remain within entrained/dissolved hydrocarbon plumes for extended periods, and limited acute impacts or risks associated with the exposure are expected. Site attached fish, such as reef fish within the EMBA in the top 60 m of the water column, may be exposed above the hydrocarbon exposure thresholds (entrained and dissolved). Therefore, local to medium scale, with short to medium term impacts could occur. As such, the consequence of entrained/dissolved hydrocarbons on fisheries (commercial, recreational and traditional), KEFs, and fish populations is considered to be Moderate (D). Planktonic communities may be exposed to entrained/dissolved hydrocarbon plumes, especially in high energy seas where the vertical mixing of oil through the water column would be enhanced. The effects of oil on plankton have been well studied in controlled laboratory and field situations. The different life stages of a species often show widely different tolerances and reactions to oil pollution. Usually, eggs, larval and juvenile stages will be more susceptible than adults (Harrison 1999). Post spill studies on plankton populations are few, but those that have been conducted typically show either no effects, or temporary minor effects (Kunhold 1978). The lack of observed effects may be accounted for by the fact that many marine species produce very large numbers of eggs, and therefore larvae, to overcome natural losses (such as through predation by other animals; adverse hydrographical and climatic conditions; or failure to find a suitable habitat and adequate food). A possible exception to this would be if a shallow entrained/dissolved hydrocarbon plume were to intercept a mass, synchronous spawning event. Recently spawned gametes and larvae would be particularly vulnerable to oil spill effects, since they are generally positively buoyant and would also be exposed to surface spills. Hook & Osborn (2012) reported that typically, phytoplankton are not sensitive to the impacts of oil. Although phytoplankton are not sensitive to oil, they do accumulate it rapidly because of their small size and high surface area to volume ratio and can pass oil onto the animals that consume them (Wolfe et al. 1998a, 1998b). This is also applicable to zooplankton, that are reported to accumulate oil via the ingestion of phytoplankton. However, consumption of zooplankton by fish does not appear to be an efficient means of trophic transfer, perhaps because of the metabolism of oil constituents (Wolfe et al. 2001). Under most circumstances, impacts to plankton at the sea surface is expected to be localised, with short term impacts. Therefore, the consequence is considered to be Insignificant (F).	

Benthic communities in the EMBA, including benthic primary producers, such as coral reefs, seagrass and mangroves could be exposed to entrained oil above impact thresholds (down to 20 m depth) and dissolved aromatic hydrocarbons (down to 60 m depth) which could result in a number of lethal or sub-lethal effects on these values and sensitivities. Shallow water communities are generally at greater risk of exposure than deep water communities (NRC 1985; WA DoT 2018). Exposure of shallow subtidal corals to entrained and dissolved hydrocarbons has the potential to result in lethal or sublethal toxic effects, resulting in acute impacts or death at moderate to high exposure thresholds (Loya & Rinkevich 1980; Shigenaka 2001; WA DoT 2018), including increased mucus production, decreased growth rates, changes in feeding behaviours and expulsion of zooxanthellae (Peters et al. 1981; Knap et al. 1985). Adult coral colonies, injured by oil, may also be more susceptible to colonisation and overgrowth by algae or to epidemic diseases (Jackson et al. 1989). A study by Nordborg et al. (2018) reported that the presence of ultraviolet radiation increases the hazard posed by dissolved hydrocarbons to tropical, shallow-water coral reefs due to phototoxicity. PAH phototoxicity occurs through the formation of radical oxygen species and/or transformation of PAHs into more toxic products. Therefore, co-exposure to ultraviolet radiation may considerably enhance negative impacts and the risks to coral larvae may be substantially underestimated in shallow-water tropical reef systems (Nordborg et al. 2018). Lethal and sublethal effects of entrained and dissolved oils have been reported for coral gametes at much lesser concentrations than predicted for adult colonies (Heyward et al. 1994; Harrison 1999; Epstein et al. 2000). Goodbody-Gringley et al. (2013) found that exposure of coral larvae to oil and dispersants negatively impacted coral settlement and survival, thereby affecting reef resilience. Roche Reefs and the southern coastline of the Bathurst Island, within the EMBA, are predicted to be exposed to entrained oil at maximum average concentrations of 218 ppb and 4 ppb respectively. The highest worst-case concentration of dissolved aromatic hydrocarbons for all locations during all seasons was predicted as 8 ppb at Bathurst Island, with the maximum average predicted as <1 ppb. The potential consequence for coral reefs is considered to be a local scale event with short-term impact (Minor E). Within the PEZ seagrasses are reported at the Vernon Islands and on the northern coastlines of Bathurst and Melville islands. The furthest extent of the EMBA does not overlap either of these locations and therefore exposure to entrained/dissolved hydrocarbons is not predicted. Similarly, although extensive mangrove communities are located along the NT coastline and at the Tiwi and Vernon islands, these locations do not overlap the EMBA. Therefore, exposed to entrained/dissolved hydrocarbons is not predicted. EPBC-listed species including marine mammals, marine reptiles and marine avifauna could also be impacted through entrained and dissolved hydrocarbon exposure, primarily through ingestion during foraging activities. The EMBA overlaps several BIAs for marine turtles (foraging and internesting) that may be exposed to dissolved/entrained hydrocarbons above impact thresholds (Section 4.7.4). There are no BIAs that relate to marine mammals or avifauna (including Ramsar or nationally important wetlands) within the EMBA (Appendix A). Any entrained/dissolved plume would be spatially and temporally limited in extent and as such, impacts to EPBC-listed species are expected to be on a local scale, with short-term impacts on a small portion of the population of a protected species, with the consequence considered to be Minor (E). In summary, the potential extent of entrained/dissolved hydrocarbons with concentrations above impact thresholds may result in localised, short-term exposure to the identified values and sensitivities. There would likely also be cumulative impacts as a result of interactions between surface and entrained/dissolved hydrocarbon impacts on the food web and through bioaccumulation up the food chain. On this basis, the potential consequence associated with entrained/dissolved plumes from the vessel collision spill scenario is considered to be Moderate (D).	
Potential consequence – shoreline hydrocarbons	Severity

No hydrocarbons were predicted to contact shorelines >10 g/m^2 and the highest accumulated concentration on any shoreline was calculated as 0.6 g/m^2 at Joseph Bonaparte Gulf (NT). As these concentrations are below the impact threshold (100 g/m^2) and given the worst-case estimates for the total volume of oil on shorelines was calculated at to be <1 m^3 across all seasons, the consequence is considered to be Insignificant (F).			Insignificant (F)
Identify existing design safeguards/controls			
Vessels fitted with lights, signals, AIS transponders and navigation equipment as required by the *Navigation Act 2012*. Ongoing stakeholder consultation and notifications made to relevant stakeholders as per Section 9.8.3 and Table 9-6.			
Propose additional safeguards/control measures (ALARP evaluation)			
Hierarchy of control	Control measure	Used?	Justification
Elimination	Eliminate vessels.	No	Vessels are the only form of transport that can undertake the 3D MSS and maintain ongoing logistical support in a fashion that is practical and cost efficient.
Substitution	Use only Group II (MGO) fuel oils, as opposed to Group IV (IFO 180 / HFO 380) fuel oils.	Yes	Limiting vessel selection to only vessels which use Group II fuel oils may require more detailed planning to avoid delays in sourcing appropriate available vessels. However, in the event of a vessel collision, MGO fuel is less persistent than alternative heavier fuels such as Heavy Fuel Oil (HFO) and Intermediate Fuel Oil (IFO). Therefore, this control has been adopted.
Engineering	None identified.	N/A	N/A
Procedures and administration	Implement INPEX Browse Regional OPEP.	Yes	The INPEX *Browse Regional OPEP* defines the processes that will be used to maintain oil spill preparedness and implement effective response measures, in the event of a spill. For this EP, an assessment of the vessel collision WCSS against the *Browse Regional OPEP* Basis of Design (BOD) has been conducted, as is required under BROPEP BOD/FCA, Figure 8-1 – management of change process. The vessel collision WCSS from this EP have been compared against the *Browse Regional OPEP* BOD response planning thresholds, (BROPEP BOD/FCA Table 4-5). The vessel collision data presented in Table 8-4 of this EP, are lower than the response planning thresholds, as presented in the BROPEP BOD/FCA Table 4-5.

			Therefore, the vessel collision WCSS assessed under this EP is less than the vessel collision WCSS defined in the *Browse Regional OPEP* BOD. As such, no revision to the spill preparedness/response arrangements defined in the *Browse Regional OPEP* are required.
Identify the likelihood			
Likelihood	Reported industry statistics indicate vessel failures are considered rare with 37 collisions reported out of a total of 1200 marine incidents in Australian waters between 2005 and 2012 (most recent data) (ATSB 2013). A ship collision risk assessment was undertaken to support the INPEX Ichthys Project. The study determined collision frequencies and impact energies for passing (third party) vessels, infield vessels and offloading tankers. The annual frequency of a collision with a passing vessel – i.e. one not within the control of INPEX – imparting at least 150 megajoules (sufficient impact energy) is 3.5×10^{-7}, or once every 2.9 million years. On this basis and given the controls that have been identified to minimise the potential for vessel collision and subsequent loss of containment, the likelihood of the consequence occurring is considered Highly Unlikely (5).		
Residual risk	Based on the worst-case consequence for all applicable hydrocarbon exposure mechanisms (surface, entrained and dissolved) Moderate (D) and a likelihood of Highly Unlikely (5) the residual risk is ranked as Moderate (8).		
Residual risk summary			
Consequence	Likelihood	Residual risk	
Moderate (D)	Highly Unlikely (5)	Moderate (8)	
Assess residual risk acceptability			
Legislative requirements The activities and proposed management measures are compliant with industry standards and with relevant Australian legislation, specifically concerning navigational safety requirements, including AMSA *Marine Orders – Part 30: Prevention of Collisions, Issue 8* (Order No. 5 of 2009). **Stakeholder consultation** Stakeholders have been engaged throughout the development of the EP, and on an ongoing basis for the development of the INPEX *Browse Regional OPEP* for a range of spill scenarios. Where relevant, the controls in place have been developed in consultation with relevant stakeholders (e.g. WA DoT and AMSA refer to Appendix B). The controls in place are considered to manage risks associated with a vessel collision to ALARP. During stakeholder consultation AMSA requested that all relevant notifications be adopted as controls in this EP and therefore, these requirements have been adopted. First strike capabilities with respect to a vessel spill scenario has been discussed with AMSA and the INPEX *Browse Regional OPEP* updated to reflect the outcome of the engagement. All vessels are required to comply with the *Navigation Act 2012*, and associated Marine Orders, which are consistent with the COLREGS requirements.			

<table>
<tr><td colspan="3">Australian Marine Park management objectives and values
The prevention of vessel collisions and oil spill response preparedness and response activities (refer INPEX Browse Regional OPEP) reduce the risk of a spill occurring and hydrocarbons reaching Australian marine parks at levels that could impact significantly upon species and communities, with impacts to marine park values expected to be highly unlikely.
Conservation management plans / threat abatement plans
Several conservation management plans (refer Appendix A) identify oil spills as a key threatening process, through both direct/acute impacts of oil, as well as indirect impacts through habitat degradation (which is a potential consequence of an oil spill). The prevention of vessel collisions and reducing impacts to the marine environment through oil spill response preparedness and response (refer INPEX Browse Regional OPEP), demonstrates alignment with the various conservation management plans.
ALARP summary
Given the level of environmental risk is assessed as Moderate, a detailed ALARP evaluation was undertaken to determine what additional control measures could be implemented to reduce the level of impacts and risks. No additional controls, beyond those identified during the detailed ALARP assessment can reasonably be implemented to further reduce the risk of impact.
Acceptability summary
Based on the above assessment, the proposed controls are expected to effectively reduce the risk of impacts to acceptable levels because:
• the activity demonstrates compliance with legislative requirements/industry standards
• the activity takes into account stakeholder feedback
• the activity is managed in a manner that is consistent with Australian Marine Park management objectives for ecologically sustainable use and the protection of marine park values;
• the activity is managed in a manner that is consistent with the intent of conservation management documents
• the activity does not compromise the relevant principles of ESD
• the predicted level of impact does not exceed the defined acceptable level in that the environmental risk has been assessed as “low”, the consequence does not exceed “C – Significant” and the risk has been reduced to ALARP.</td></tr>
<tr><th>Environmental performance outcomes</th><th>Environmental performance standards</th><th>Measurement criteria</th></tr>
<tr><td rowspan="2">No incidents of loss of hydrocarbons to the marine environment as a result of a vessel collision.</td><td>Vessels will be fitted with lights, signals, AIS transponders and navigation and communications equipment, as required by the Navigation Act 2012.</td><td>Records confirm that required navigation equipment is fitted to vessels to ensure compliance with the Navigation Act 2012.</td></tr>
<tr><td>Only vessels using Group II/MGO/marine diesel will undertake activities described in this EP.</td><td>Vessel selection records.</td></tr>
<tr><td colspan="3">Refer to the INPEX Browse Regional OPEP for environmental performance outcomes, standards and measurement criteria related to mitigative controls.</td></tr>
</table>

8.3 Oil spill response and capability

INPEX has developed a regional OPEP for the Browse region which applies to the activity described in this EP. The INPEX *Browse Regional OPEP* (BROPEP) consists of a suite of documents as shown in Figure 8-4 and described in Table 8-6. The BROPEP covers all INPEX Australia's exploration and production activities in the Browse region.

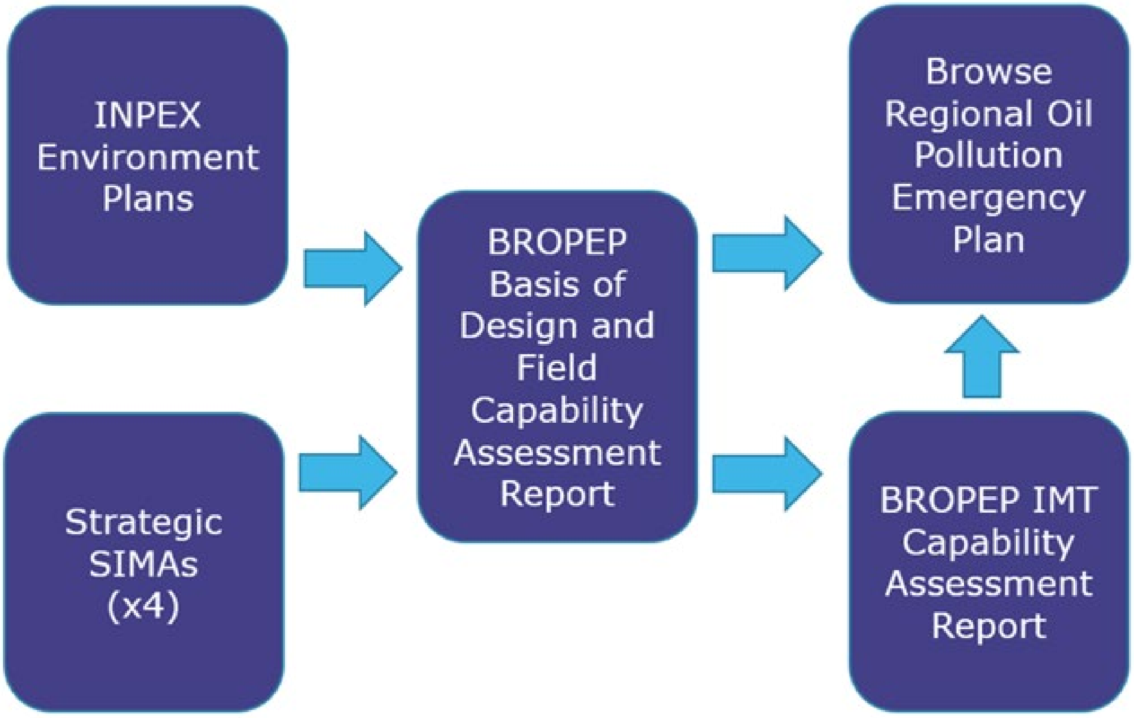

Figure 8-4: Browse Regional OPEP document structure

Table 8-6: Browse Regional OPEP documentation overview

Document title	Document number	Purpose
INPEX Environment Plans	N/A	All INPEX EPs contain a detailed activity description and activity-specific oil spill scenarios. Specifically, INPEX EPs include the following: a description of the activity-specific spill scenarios (including the potential release rates, volumes, locations, hydrocarbon types, etc.) activity-specific oil spill modelling (used to inform environmental risk assessments) an assessment of oil spills risks/impacts on environmental values and sensitivities

Document title	Document number	Purpose
		evaluations of controls to prevent oil pollution from the specific activity. The WCSS from all INPEX EPs are included in the INPEX Australia - Browse Regional Oil Pollution Emergency Plan - Basis of Design and Field Capability Assessment.
Strategic Spill Impact Mitigation Assessments (SIMAs): Condensate spill – instantaneous surface release Marine gas oil/diesel spill – instantaneous surface release Intermediate fuel oil/heavy fuel oil (HFO) spill – instantaneous surface release Condensate/gas well or pipeline blowout – long duration subsea release.	X060-AH-LIS-60031 X060-AH-LIS-60032 X060-AH-LIS-60033 X060-AH-LIS-60034	The four INPEX Strategic SIMA documents are pre-spill planning tools. These are used to facilitate response option selection by identifying and comparing the potential effectiveness and impacts of the various oil spill response strategies on a range of environmental values and sensitivities. The Strategic SIMAs utilise a semi-quantitative process to evaluate the impact mitigation potential of each response strategy. This method provides a transparent decision-making process for determining which response strategies are most likely to be effective at minimising oil spill impacts. The SIMA process includes environmental considerations as well as a range of shared values such as ecological, socio-economic and cultural aspects.
INPEX Australia - Browse Regional Oil Pollution Emergency Plan - Basis of Design and Field Capability Assessment (BROPEP BOD/FCA)	X060-AH-REP-70016	The BROPEP BOD/FCA presents an overview of all of INPEX Australia's offshore activities and associated oil spill risks. It includes an evaluation of modelling outcomes from a series of selected WCSSs and presents an oil spill response field capability analysis. The BROPEP BOD/FCA includes the EPOs and EPSs relevant to the preparedness and environmental risk assessment of field response capability and arrangements and the broader BROPEP implementation strategy (i.e. reviews, management of change process, etc.).
INPEX Australia - Browse Regional Oil Pollution Emergency Plan – Incident Management Team Capability Assessment (BROPEP IMTCA)	X060-AH-REP-70015	The BROPEP IMTCA utilises the field capability assessments as inputs to evaluate the size and structure of the INPEX incident management team (IMT) necessary to mobilise and maintain the field capability. The BROPEP IMTCA outlines the EPOs and EPSs relevant to INPEX IMT capability and arrangements.
INPEX Australia - Browse Regional Oil Pollution Emergency Plan (BROPEP)	X060-AH-PLN-70009	The BROPEP is the tool which will be utilised by the INPEX IMT during any impending/actual oil spill event. This document assists/guides the IMT through the process of notifications, gaining/maintaining situational awareness, response strategy evaluation and incident

Document title	Document number	Purpose
		action plan development, and mobilisation of field response capabilities. The BROPEP outlines the EPOs and EPSs related to the implementation of response strategies.

An assessment of the WCSS defined in this EP has been conducted against the INPEX *Browse Regional OPEP* BOD, within the ALARP evaluations of the WCSS (refer to Table 8-5).

The outcome of this assessment was that no change is required to the spill preparedness/response arrangements defined in the INPEX *Browse Regional OPEP* for the proposed activities covered under this EP.

9 ENVIRONMENTAL MANAGEMENT IMPLEMENTATION STRATEGY

This section provides a description of the INPEX BMS which captures the HSE requirements to manage HSE risks and meet legislative and corporate obligations, as applicable to the implementation of this EP and its associated performance outcomes and standards.

9.1 Overview

The BMS is a comprehensive, integrated system that includes standards and procedures necessary for the management of HSE risks. Activities to manage HSE risks are planned, implemented, verified and reviewed under an iterative "plan, do, check, act" (PDCA) cycle. The PDCA cycle enables INPEX to ensure that processes are adequately resourced and managed and that opportunities for improvement are determined and acted on.

INPEX HSE requirements are designed to meet the in-principle expectation of several standards, international management frameworks, guidelines and legislation. Of particular relevance to this EP are the following:

- Commonwealth of Australia, OPGGS (E) Regulations
- NOPSEMA Environment plan content requirements (NOPSEMA 2020d)
- International Association of Oil and Gas Producers (IOGP) 510 Operating Management System Framework for controlling risk and delivering high performance in the oil and gas industry
- IOGP 511 Operating Management System in practice
- International Standards Organisation (ISO) 9001 Quality Management Systems
- ISO 14001 Environmental Management Systems.

The components of the BMS relevant to HSE are grouped into 13 external elements (Figure 9-1). These elements must be managed and implemented properly in order to achieve the desired HSE performance and reflect a PDCA cycle, which is applied to every aspect of the 13 elements.

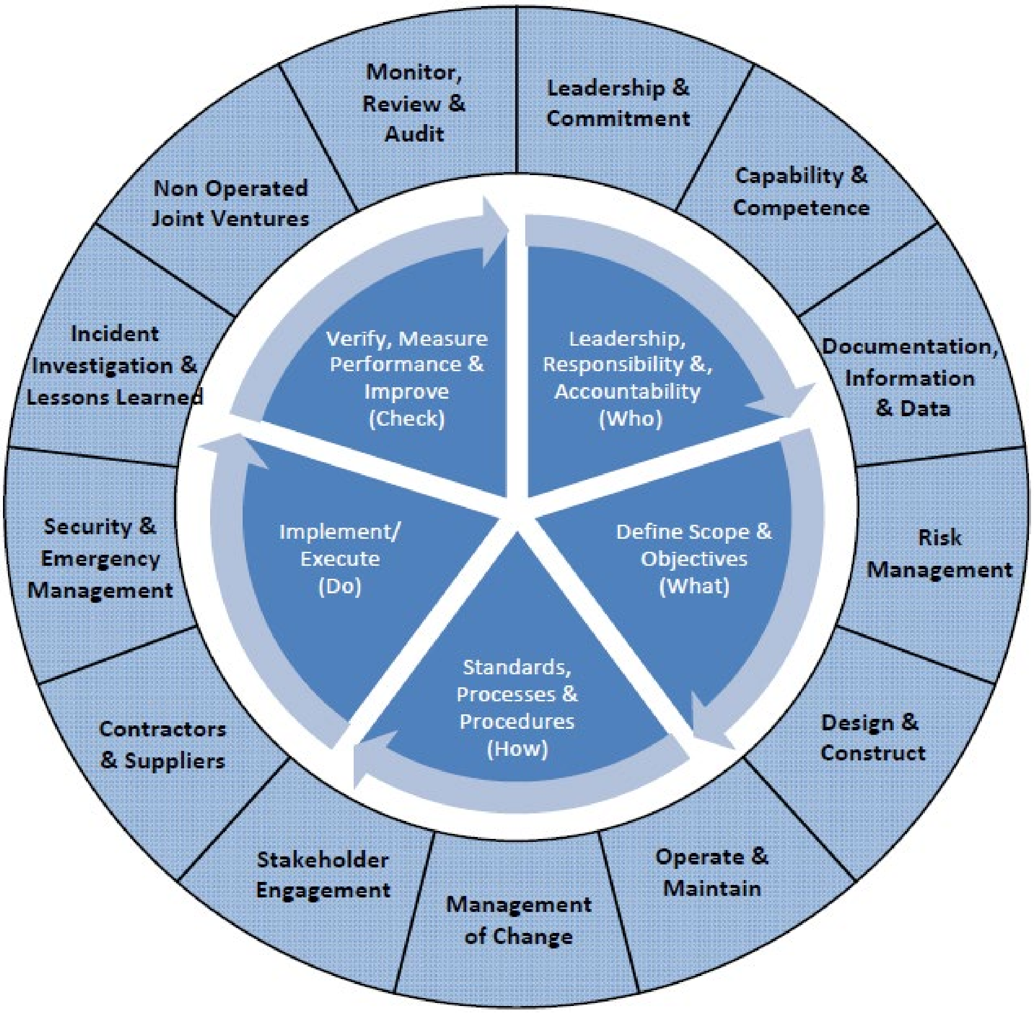

Figure 9-1: INPEX BMS: HSE requirements

9.2 Leadership and commitment

INPEX environmental performance is achieved through strong visible leadership, commitment and accountability at all levels of the organisation. Leadership includes defining performance targets and providing structures and resources to meet them. Achieving high levels of HSE performance is defined within the highest levels of management system documents (policies) and is cascaded through subsidiary documents.

The INPEX Environmental Policy (as amended from time to time) (Figure 9-2) solidifies this commitment and states the minimum expectations for environmental performance. The policy applies to all INPEX controlled activities in Australia. All personnel, including contractors, are required to comply with the policy.

The policy (as amended) is available on the INPEX intranet and displayed at all INPEX workplaces including all contractor vessels in the Operational Area. It is communicated to personnel involved in the activities, including contractors, through inductions.

INPEX

Environmental Policy

Objective

INPEX is a worldwide oil and gas exploration, development and production company committed to conducting each of its activities in a manner that is environmentally responsible.

Our objective is to develop an environment culture that is recognised as amongst "best in industry" that will exceed the performance expectations of our stakeholders.

We recognise our responsibility to adhere to the principles of sustainable development and we acknowledge that we owe a duty of care to both the natural environment and the communities in which we operate.

Strategy

To accomplish this, INPEX will:

- comply with applicable laws and regulations, environmental plans and commitments and apply appropriate INPEX standards
- maintain a culture where people are empowered to intervene to prevent environmental harm
- set, measure and review environmental performance objectives and targets and ensure appropriate management of change processes are followed
- ensure our personnel have the necessary awareness, training, knowledge, resources and support, to meet environmental objectives and targets
- identify, manage and review environmental hazards and risks associated with our current and future business activities and manage these to levels that are 'as low as reasonably practicable' (ALARP)
- implement, maintain and regularly test control measures associated with major environmental events
- maintain and regularly test emergency management processes and procedures, including with industry and government emergency response partners
- engage with and communicate openly on environmental issues with internal and external stakeholders
- provide clearly defined environmental performance expectations for our contractors and suppliers, and work collaboratively with them to attain these
- endeavour to prevent pollution and seek continual improvement with respect to emissions, discharges, wastes, energy efficiency and resource consumption
- actively promote the reduction of greenhouse gas emissions across our operations in a safe, technically and commercially viable manner
- endeavour to protect biodiversity and to contribute to increased understanding of our natural environment
- drive continual improvement in environmental performance through monitoring, auditing and reviews.

Application

This policy applies to all INPEX controlled activities in Australia and related project locations. It will be displayed at all company workplaces and on the company's intranet and it will be reviewed regularly.

Hitoshi Okawa
President Director, Australia

Rev: 3
April 2019

Figure 9-2: INPEX environmental policy

9.3 Capability and competence

INPEX appoints and maintains competent personnel to manage environmental risks and provide assurance that the INPEX Environmental Policy, objectives and performance expectations will be achieved. This applies to individual competencies established in position descriptions and competency plans that set expectations, track progress and monitor results. It also applies to the overall capability of the organisation through well-defined organisational structures and provision of resources.

9.3.1 Organisation

Figure 9-3illustrates the organisational structure for onshore and offshore roles for the 3D MSS. During the survey, the Exploration Project Manager will ensure the implementation of this EP with support from the Environmental Advisor and offshore resources, namely the MFOs, Survey Manager, Vessel Manager and Vessel Masters.

Work activities for the 3D MSS will be conducted by the survey contractor, under the direction of the INPEX Offshore Representative via written work instructions and work programs.

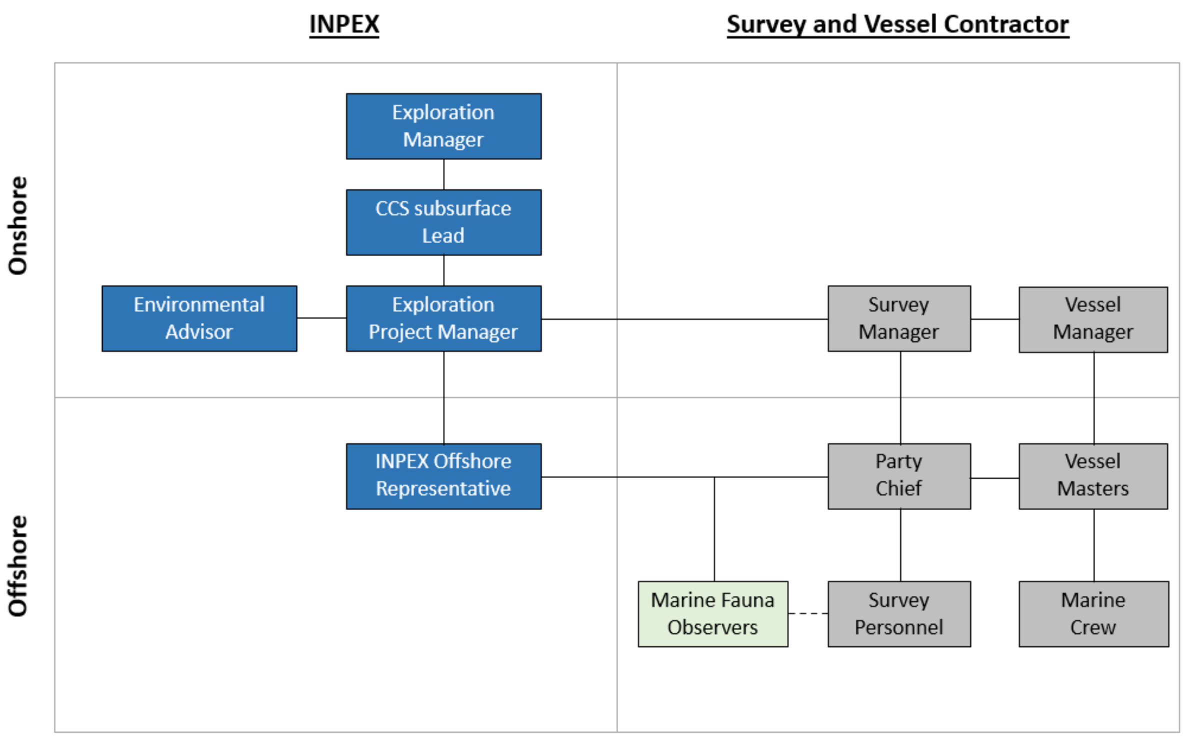

Figure 9-3: Bonaparte Basin 3D MSS organisational structure

9.3.2 Roles and responsibilities

INPEX has established and implements standards, procedures and systems to build and maintain a trained and competent workforce capable of fulfilling its assigned roles and responsibilities, as well as meeting its legislative and regulatory requirements. The selection process for the key INPEX personnel identified in Table 9-1 includes consideration of their previous work experience and recognised qualifications when compared with the INPEX minimum competency standards. Key personnel are provided with a position description to formalise their role and define their responsibilities.

The key roles in Table 9-1 are responsible for collecting and maintaining the required evidence and monitoring data as specified in the environmental performance standards detailed in sections 1197, 8 and 9 of this EP. Additional roles and responsibilities related to the implementation of HSE requirements are also listed in Table 9-1.

Prior to mobilisation of personnel (vessel), those in key roles (Table 9-1) will be informed of their respective responsibilities in relation to this EP. This information will be disseminated by INPEX (e.g. through workshops, one-on-one sessions or by email) to ensure EP/INPEX *Browse Regional OPEP* awareness and that appropriate competencies and training requirements are met.

INPEX conducts training needs analysis for each of the key roles listed in Table 9-1 to define minimum training requirements. The analysis is used to develop training plans which document, schedule and record completion of specific HSE training for individuals.

Table 9-1: Key personnel and support roles and responsibilities

Key role	Responsibilities
Exploration Manager (Onshore)	Provides resources to implement the 3D seismic program
Carbon Capture and Storage (CCS) Subsurface Lead (Onshore)	Ensures relevant INPEX BMS HSE requirements, including environmental performance outcomes and standards are communicated to INPEX contractors.
Exploration Project Manager (INPEX Lead geophysicist) (Onshore)	Ensures activities are undertaken in accordance with this EP. Ensures any changes to the activity that may affect the performance outcomes and environmental management procedures detailed in this EP are communicated to the INPEX Environmental adviser. Ensures the Survey Manager/Vessel Master/Party Chief is provided with the resources required to ensure that the commitments in this EP are undertaken. Ensures the INPEX Offshore Representative is provided with the resources required to ensure that the commitments in this EP are undertaken. Ensures reporting of environmental incidents meets external reporting requirements and INPEX incident reporting requirements. Ensures corrective actions raised from environmental audits are tracked and closed out.

Key role	Responsibilities
INPEX Offshore Representative (Offshore)	Ensures contractors perform operations in a manner consistent with the performance outcomes and environmental management procedures detailed in this EP. Ensures the implementation of the INPEX Environment Policy, through application of this EP. Ensures the Party Chief, Vessel Master and all crews adhere to the requirements of this EP. Ensures that the INPEX Exploration Manager and Environmental Advisor are alerted to any changes in activities that could have a negative impact on environmental performance. Reports incidents to the INPEX Exploration Project Manager.
INPEX Environmental Adviser (Onshore)	Ensures that environmental audits are undertaken. Ensures that waste management and containment equipment audits are undertaken. Ensures that the roles and responsibilities have been communicated. Ensure that any changes to the survey program that may affect EP mitigation and management measures are captured via the management of change process.
Contractor Survey Manager (Onshore)	Ensures contractor activities are undertaken in accordance with this EP. Ensures personnel and vessels mobilised for the survey meet the required standards specified in this EP. Ensures vessel pre-mobilisation inspections are completed and any corrective actions are implemented Ensures the required notifications with Government agencies and stakeholders are completed in accordance with this EP.
Contractor Vessel Manager (Onshore)	Ensures contractor activities are undertaken in accordance with this EP. Ensures vessels mobilised for the survey meet the required standards specified in this EP.
Contractor Party Chief (Offshore)	Ensures the vessel management systems and procedures are implemented. Ensures personnel starting work on the survey vessel and support vessels receive an induction that meets the requirements specified in this EP. Ensures personnel are competent to undertake the work they have been assigned. Ensures emergency drills are conducted as per the vessel schedules. Ensures the vessels' emergency response team has been given sufficient training to implement SOPEP/SMPEP. Ensures any environmental incidents or breaches of performance outcomes, standards or criteria, are reported immediately to the INPEX Offshore Representative.

Key role	Responsibilities
Vessel Masters (Offshore)	Conduct vessel operations in accordance with this EP. Implement the vessel's SOPEP/SMPEP in an emergency. Implements relevant performance standards stated within this EP. Ensure that environmental incidents or breaches of performance outcomes, standards or criteria on vessels, are reported.
Marine Fauna Observers (Offshore)	Maintain watch for cetaceans and other marine fauna during the course of the survey and advise the INPEX Offshore Representative and Party Chief, of the presence of these marine fauna. Implement EPBC Act Policy Statement 2.1, Part A Standard Management Procedures and additional management procedures applicable to the sighting of marine fauna, as identified in this EP. Monitor and record any interactions with cetaceans and other marine fauna. Assist in the preparation of the marine fauna compliance and sightings report to the Department of Environment and Energy upon completion of the survey. Support the INPEX Offshore Representative to ensure contractors perform operations in a manner consistent with the performance outcomes and environmental management procedures detailed in this EP. Monitor and record performance against the environmental performance outcomes, performance standards and environmental management procedures detailed in this EP. Maintain records to demonstrate compliance and meet measurement criteria. Support the INPEX Environmental Advisor and Offshore Representative with inductions and environmental inspections and audits. Provide suitable support (i.e. training and materials) to assist vessel crews understand requirements relating to the identification, distance estimation and reporting of cetaceans, consistent with EPBC Act Policy Statement 2.1, and other marine fauna. Assist in preparation of environmental performance and incident reports. Ensures any environmental incidents or breaches of performance outcomes, standards or criteria, are reported immediately to the INPEX Offshore Representative.
Support roles	**Responsibilities**
All marine crew and survey personnel (Offshore)	Work in accordance with accepted vessel HSE systems and procedures. Comply with EP requirements as applicable to assigned role. Report any hazardous condition, near miss, unsafe act, accident or environmental incident immediately to supervisors. Attend HSE meetings and training when required.

9.3.3 Training and inductions

Inductions are conducted for all personnel (including INPEX representatives, contractors, subcontractors and visitors) before they start work on any of the vessels described in this EP. Inductions cover the HSE requirements under the INPEX BMS, including information about the commitments contained in this EP. A summary of the inductions and training programs in place to ensure relevant personnel are aware of their responsibilities under accepted EPs is presented in Table 9-2. In addition, environmental awareness is communicated to all personnel through a number of different mechanisms including environmental alerts, environmental bulletin posts on INPEX intranet site and posters displayed at work locations.

Table 9-2: Inductions and training course summary

Induction/training course	Target audience	EP relevant content
INPEX Australia HSE Induction	All INPEX Australia employees	Overview of INPEX Environment Policy, OPGGS (E) Regulations and requirement to adhere to EP commitments.
INPEX Australia Offshore EPs Support Vessels Induction	All personnel working onboard project vessels for 3D seismic activities.	Overview of the management controls for emissions, discharges and wastes from project vessels (which are consistent throughout INPEX EPs) including: • environmental values and sensitivities • environmental aspects/risk from offshore activities • controls to manage emissions, discharges and wastes • reporting requirements.
INPEX Australia Browse Regional Oil Pollution Emergency Plan Induction	Vessel masters and any other relevant crew.	Overview of the *Browse Regional OPEP* requirements related to support vessels (which are consistent throughout INPEX EPs).
INPEX Australia Support Vessels Marine Fauna Awareness Training	All vessel bridge personnel.	Overview of the marine fauna management requirements (which are consistent with this EP).

Table 9-3: Environmental performance outcome, standard and measurement criteria for inductions and training

Environmental performance outcome	Environmental performance standard	Measurement criteria
INPEX personnel including staff, contractors and visitors are aware of their responsibilities under this EP.	The training and awareness material described in Table 9-2 is delivered.	Records that inductions, training and awareness material have been provided.

9.4 Documentation, information and data

INPEX implements and maintains document and records management procedures and systems. These are in place to ensure that the information required to support safe and reliable seismic activities, is current, reliable and available to those who need it. It also ensures that organisational knowledge and learning is captured and preserved to enable the effective operations of processes to maintain compliant management of HSE information.

Documents and records are stored electronically in INPEX document management systems and databases. This EP and associated documentation are maintained within a database, with current versions also available via the controlled document repository.

Records to demonstrate implementation of the INPEX BMS HSE requirements and compliance with legislative requirements and other obligations are identified and maintained for at least five years. These records include:

- written reports – including risk assessment reports, hazard and risk registers, monitoring reports, ALARP demonstrations and audit and review reports– about environmental performance or implementation strategies
- records relating to environmental performance or the implementation strategies
- records of environmental emissions and discharges
- management of change records
- incident and/or near miss investigation reports
- lessons learned records
- improvement plans (corrective actions, key performance indicators)
- records relating to training and competency in accordance with this EP.

9.5 Risk management

A robust, structured process is applied by INPEX to identify hazards and ensure that HSE risks arising from assets and operations are systematically identified, assessed, evaluated and controlled to levels as low as reasonably practicable.

The risks and impacts associated with the activity are detailed in Section 7 and Section 8. Additional risk assessments will be undertaken on an ongoing basis when triggered by any of the following circumstances:

- when there is a proposed change to the activity, as identified by an INPEX Management of Change (MoC) request
- when identified as necessary following the investigation of an event
- when additional information about environmental impacts or risks becomes available (e.g. through better knowledge of the receptors present within the EMBA, new scientific information/papers, results of monitoring, other industry events or studies)
- if there is a change in regulations, as necessary
- during scheduled reviews of the documentation associated with this EP.

The risk assessments will be carried out in line with the assessment process described in Section 6 and are aligned to the HSE requirements of the INPEX BMS. This ensures that risks related to the activity are systematically identified, assessed, evaluated and controlled.

An environmental risk register for the activity is reviewed on a monthly basis. The review includes assessment of any new information and other changes that have been recorded throughout the previous quarter. Where this review results in a change, the changes are documented and communicated.

9.6 Operate and maintain

9.6.1 Commercial fisheries adjustment protocol

INPEX proposes to meet the following outcomes, performance objectives and measurement criteria for the activity (Table 9-4).

Table 9-4: Environmental performance outcome, standards and measurement criteria for commercial fisheries adjustment protocol

Environmental Performance Objective	Environmental Performance Standard	Measurement criteria
Proposed activities are carried out in a manner that does not interfere with commercial fishing activities to a greater extent than is necessary for the reasonable exercise of the rights and performance of duties of the Titleholder during seismic acquisition.	Provide the claim process to relevant stakeholders at least three weeks prior to the commencement of survey activities.	Stakeholder consultation records confirm that the claim process was provided to relevant stakeholders at least three weeks prior to the commencement of the seismic survey activity (i.e. at least three weeks prior to Form 29 notification of commencement).
	Implementation of the claim process, in the event that a genuine claim is made by a stakeholder.	Records demonstrate that following the receipt of a claim, the process was applied.

9.6.2 Biofouling risk assessment for domestic movements

The biofouling risk assessment process for domestic vessel movements includes aspects of the vessels history with respect to IMS risk e.g. vessels origin from within Australian waters and previous locations of operation (including whether these Australian locations have reported IMS occurrences), periods out-of-water and inspections/cleaning undertaken, age of anti-fouling coatings, presence and condition of internal treatment systems etc.

While undertaking the INPEX biofouling risk assessment for domestic movements (Figure 9-4) in any instances where potential risks are identified e.g. no anti-fouling coating or extended stays in port, the process requires INPEX to engage an independent IMS expert and if required a further risk assessment may be undertaken.

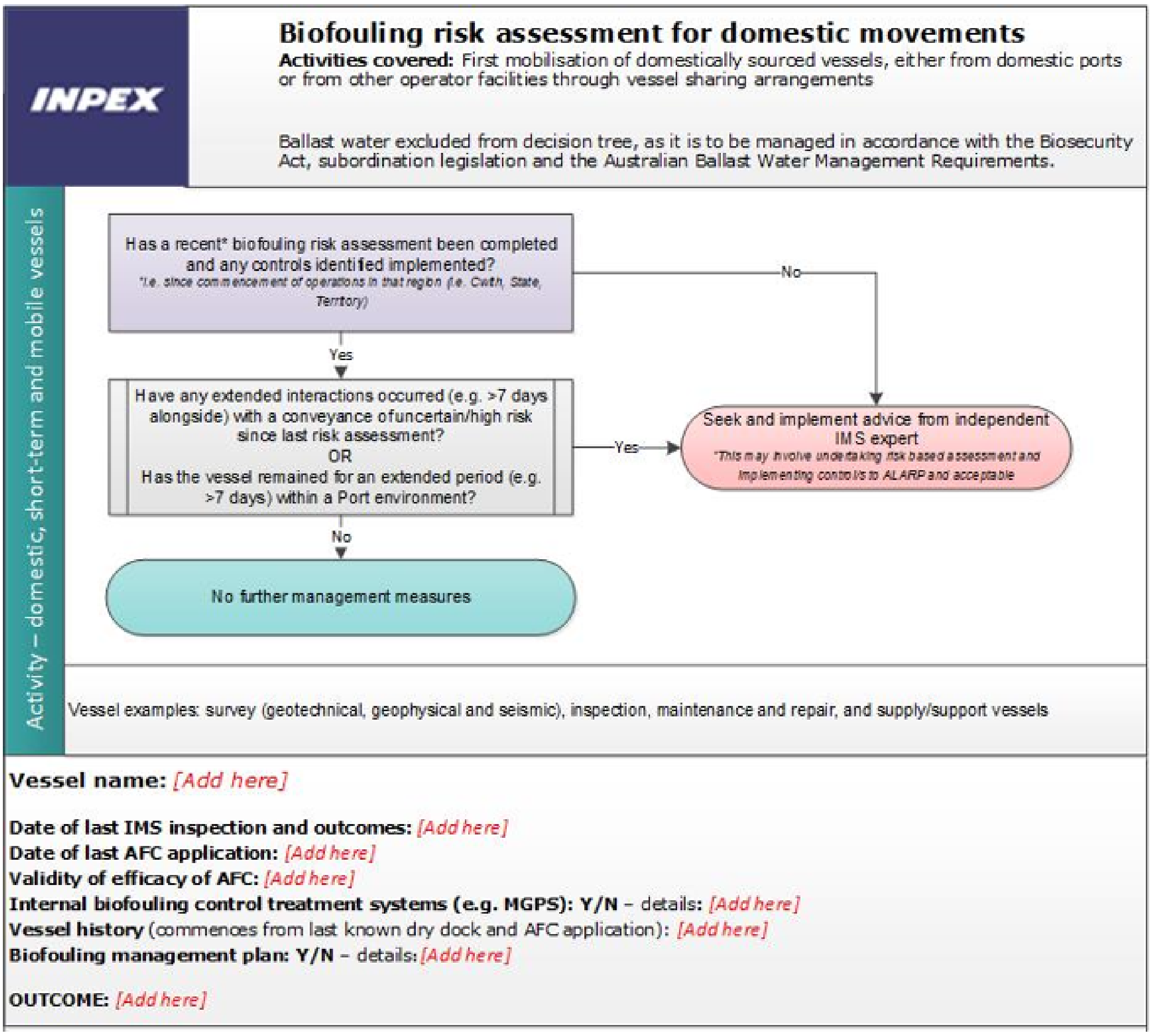

Figure 9-4 : INPEX biofouling risk assessment for domestic movements

9.7 Management of change

Changes to this EP will be managed in accordance with the INPEX Australia MoC standard, and related procedures and guidelines. Where a change to management of an activity is proposed, it will be logged. Internal notification will be communicated via a MoC request. The request will identify the proposed change(s) along with the underlying reasons and highlight potential areas of risk or impact. In accordance with the INPEX business rules, it is mandatory to undertake an environmental risk assessment in every case for changes that could affect the environment. The MoC request will be managed by an environmental adviser who will then determine the necessary approval/endorsement pathway, in consultation with the environmental approvals advisor. Minor changes (such as updating a document or process) that do not invoke a revision trigger are endorsed by the Exploration Manager (or delegate) and the change is implemented.

In accordance with Regulation 17 of the OPGGS (E) Regulations, a revision of this EP will be submitted to NOPSEMA where:

- a change is considered to represent a new activity

- a change is considered to represent a significant modification to, or a new stage of, an existing activity
- a change will create a significant new environmental impact or risk that is not provided for in the current EP; or
- a change will result in a series of new (or increased) environmental impacts or risks that, together, will result in a significant new environmental impact or risk, or a significant increase in an existing environmental impact or risk.

The MoC request process will be periodically checked against NOPSEMA guidance to ensure ongoing compliance and will be undertaken as part of the management review process described in Section 9.13.

9.8 Stakeholder engagement

Communications with stakeholders are designed to be inclusive and effective, and ensure appropriate information is provided to stakeholders. Stakeholders include INPEX Corporation, INPEX employees, contractors, regulators, external industry bodies, shareholders, joint venture participants, suppliers, customers, non-government organisations, indigenous groups, financiers and members of the community.

9.8.1 Legislative and other requirements

INPEX maintains an approvals and compliance tracking system which identifies future approval requirements and when they must be in place, as well as compliance with existing approvals. Through this system, responsible persons are provided with alerts for required actions and time frames to avoid non-compliance and ensure there are no gaps in approvals.

In addition, INPEX personnel participate in industry and regulator forums, as well as maintain current knowledge of industry practices and proposed regulatory changes. Changes to legislative and other requirements are reviewed for potential impacts to business operations and communicated, as required, to personnel managing potentially affected activities.

Updates to matters relating to the EPBC Act, including policy statements and conservation management documentation is achieved through subscription to automated email notifications provided by the DCCEEW. In addition, updates following the Government's independent AMP review, such as AMP management plans will also be reviewed for relevance against this EP. Where required, updates to this EP will be conducted in accordance with the MoC process described in Section 9.7.

9.8.2 Communication

INPEX HSE requirements and matters are communicated throughout the organisation. This facilitates the cascading and implementation of business policies and standards through the business, and on to contractors who work on behalf of INPEX.

INPEX and its contractors adopt a number of methods to ensure that information relating to HSE risks and impacts are communicated to personnel, including:

- daily toolbox meetings
- HSE meetings
- use of noticeboards, intranet, HSE alerts and newsflashes, e.g. environmental aspects and events
- internal and external reporting.

9.8.3 Ongoing stakeholder consultation

In relation to an EP implementation strategy, Regulation 14(9) of the OPPGS (E) Regulations 2009 specifies a requirement for consultation with relevant authorities of the Commonwealth, a state or territory, and other relevant interested persons or organisations. Any objections or claims received from stakeholders while the activity is ongoing will be considered and assessed as detailed in Section 5, using the same process and criteria described for the stakeholder consultation undertaken during the development of this EP. Mechanisms that provide ongoing opportunities for consultation with stakeholders, in relation to the implementation of this EP, are summarised in Table 9-5 and an environmental performance outcome and standard is presented in Table 9-6.

Table 9-5: Ongoing stakeholder consultation

Stakeholder	Information supplied	Frequency
Australian Hydrographic Office (Cwlth)	The AHO will be notified of the activity commencement and cessation via datacentre@hydro.gov.au, for promulgation of fortnightly Notice to Mariners.	4 weeks prior to commencement and upon completion
AMSA JRCC (Cwlth)	INPEX to notify AMSA JRCC for promulgation of radio-navigation warnings 24-48 hours before operations commence and upon completion of the survey (Email: rccaus@amsa.gov.au; Phone: 1800 641 792 or +61 2 6230 6811). AMSA's JRCC require the vessel names, IMO vessel numbers and call signs, and Maritime Mobile Service Identity numbers.	24-48 hours before operations commence and upon completion
DCCEEW (Cwlth; formerly DAWE)	Completion of a 'Questionnaire for Biosecurity Exemptions for Biosecurity Control Determination'.	4 weeks prior to commencement of activities
Defence (Cwlth)	INPEX to provide advance details in relation to the nature and scale of the activities including vessel size and proposed dates for scheduled activities in the Operational Area.	5 to 6 weeks prior to commencement of activities
NOPSEMA (Cwlth)	NOPSEMA will be notified of the activity commencement and cessation, using the Regulation 29 Notification Form available at https://www.nopsema.gov.au/environmental management/notification-and-reporting/	At least 10 days prior to commencement and within 10 days of completion
National Offshore Petroleum Titles Administrator (NOPTA) (Cwlth)	NOPTA will be notified of the activity commencement and cessation via reporting@nopta.gov.au	48 hours prior to commencement and upon completion
DMIRS (WA)	DMIRS will be notified of the activity commencement and cessation.	As required
Commercial fisheries	Relevant commercial fisheries stakeholders, with activities or interests that may be affected by the planned activity (as identified in Table 5-2), will be notified of the activity commencement and cessation.	3 weeks prior to the commencement of activities and

Stakeholder	Information supplied	Frequency
	The notification of commencement to commercial fishers will include details of: the location where the survey will commence expected start date and survey duration IMO vessel numbers and call signs vessel radio and satellite phone communication details how stakeholders can register to receive daily look-ahead reports during the survey The notification of completion will confirm the date of completion and vessel demobilisation from the Operational Area.	within 2 weeks following completion.
	NT Aquarium Fishery and NT Pearl Oyster Fishery stakeholders will be notified 3 weeks prior to commencement of the seismic survey. A joint risk assessment will be undertaken with these operators if diving activities are identified within 30 km of the survey.	3 weeks prior to the commencement of activities
Other titleholders	Titleholders of facilities within 45 km of survey activities will be notified 3 weeks prior to commencement of the seismic survey. If diving operations are planned within 30 km of the survey at the same time as the survey, then potential controls will be included in a simultaneous operations management plan.	3 weeks prior to the commencement of activities

Table 9-6: Environmental performance outcome, standards and measurement criteria for implementation of ongoing stakeholder consultation

Environmental performance outcome	Environmental performance standard	Measurement criteria
Where requested, relevant stakeholders will be kept informed of activities.	Ongoing stakeholder consultation with relevant stakeholders undertaken in accordance with Table 9-5.	Stakeholder consultation records.

9.9 Contractors and suppliers

Selection and management processes are in place to ensure that contractors working for, or on behalf of, INPEX are able and willing to meet the minimum business expectations of INPEX, including those related to HSE and risk management.

Contractors and suppliers are selected based on their capabilities and managed throughout the scope of works to deliver on HSE and process safety performance expectations.

The processes for pre-qualification, selection and management of suppliers and contractors are detailed within the INPEX BMS such that:

- HSE and process safety risks associated with the scope of work are identified and known

- contractors and suppliers are selected based on their organisational capability and personnel competence to execute the scope of work, including effective management of HSE and process safety risks
- roles and responsibilities, and minimum performance expectations are communicated to contractors and suppliers, and form part of contractual obligations
- contractors are partnered to deliver desired HSE and process safety performance targets, and monitored for compliance with contractual requirements
- lessons learned from each scope of work are applied to future activities.

9.10 Security and emergency management

Regulation 14(8) of the OPGGS (E) Regulations requires the implementation strategy to contain an OPEP and the provision for the OPEP to be updated. In accordance with Regulation 14 (8AA)) the OPEP must include arrangements to respond to and monitor oil pollution, including:

- the control measures necessary for a timely response to an oil pollution emergency
- the arrangements and response capability to implement a timely implementation of those controls, including ongoing maintenance of that capability
- the arrangements and capability for monitoring the effectiveness of the controls and ensuring that performance standards for those controls are met
- the arrangements and capability for monitoring oil pollution to inform response activities
- the provision for the OPEP to be updated.

These requirements are addressed through the INPEX *Browse Regional OPEP*, a summary of which is provided in Section 8.3 of this EP.

9.11 Incident investigation and lessons learned

HSE and process safety incidents and high potential hazards must be reported and investigated to identify and address the root causes, and apply lessons learned to improve designs, systems and work practices.

9.11.1 HSE performance measurement and reporting

HSE performance data is monitored in accordance with the INPEX BMS. This enables the status of conformance with HSE obligations and goals to be determined, and also ensures HSE risks are being effectively managed to support continuous improvement. HSE is regularly reviewed by senior management.

9.11.2 Environmental incident reporting – internal

INPEX refers to environmental incidents and hazards as “environmental events”, which all personnel, including contractors, are required to report as soon as is reasonably practicable. Reporting must be in accordance with the INPEX *Incident Reporting and Investigation Standard* and associated procedure.

All events will be documented and reviewed for their actual and potential consequence severity levels and investigated as appropriate. Corrective or preventative actions will be identified and documented, and their completion verified in an action register. These actions may include changes to the risk registers, standards, or procedures, or the need for training, different tools or equipment. Any actions will be recorded and tracked.

9.11.3 Environmental incident reporting – external

For the purposes of regulatory reporting to NOPSEMA, an incident is classified as either "Reportable" or "Recordable" based on the definitions contained in Regulation 4 of the OPGGS (E) Regulations.

A "Reportable" incident is defined as "an incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage." Environmental damage (or the potential to cause damage) includes social, economic and cultural features of the environment. For the purposes of this EP, such an incident is considered to have an environmental consequence level of Moderate (D) to Catastrophic (A) as defined in the INPEX Risk Matrix (Figure 6-1).

Based on the consequence assessments described in sections 7 and 8 of this EP, incidents identified as having the potential to be "Reportable" (i.e. Moderate (D) or above on the INPEX Risk Matrix; Figure 6-1) include:

- the introduction of IMS
- vessel collision.

A "Recordable" incident is defined as "a breach of an environmental performance outcome or environmental performance standard … that is not a reportable incident." In terms of the activities within the scope of this EP, it is a breach of the performance standards and outcomes listed in Section 7, Section 8 or Section 9 of this EP and the INPEX *Browse Regional OPEP*.

For the purposes of regulatory reporting to DCCEEW, any significant impact to MNES, as classified using the INPEX Risk Matrix, will be reported to DCCEEW. The DNP will be notified of any oil/gas pollution incidences within or likely to impact an AMP as soon as possible (refer to INPEX *Browse Regional OPEP*).

Reportable incidents

Initial verbal notification

In the event of a reportable incident, INPEX will give NOPSEMA an initial verbal notification of the occurrence as soon as is practicable; and in any case, not later than two hours after the first occurrence of the reportable incident; or if it is not detected at the time of the first occurrence, within two hours of the time that INPEX becomes aware of the incident.

The initial verbal notification will contain:

- all material facts and circumstances concerning the reportable incident that are known or can, by reasonable search or enquiry, be found out
- any action taken to avoid or mitigate any adverse environmental impacts of the reportable incident
- the corrective action that has been taken, or is proposed to be taken, to stop, control or remedy the reportable incident.

Written notification

- As soon as possible after an initial verbal notification of a reportable incident, INPEX will provide a written record of the notification to:
- NOPSEMA
- NOPTA (Cwlth)
- WA DMIRS or NT DIPL, depending on the jurisdiction.

In the event of a significant impact to MNES, INPEX will provide an initial notification to DCCEEW within 24 hours of becoming aware of the event.

In the event of a reportable incident, INPEX will provide a written report to NOPSEMA as soon as is practicable; and in any case, not later than three days after the first occurrence of the incident. If, within the three day period, NOPSEMA specifies an alternative reporting period, INPEX will report accordingly. The report will contain:

- all material facts and circumstances concerning the reportable incident that are known or can, by reasonable search or enquiry, be found out
- any action taken to avoid or mitigate any adverse environmental impacts of the reportable incident
- the corrective action that has been taken, or is proposed to be taken, to stop, control or remedy the reportable incident
- the action that has been taken, or is proposed to be taken, to prevent a similar incident occurring in the future.

Within seven days of giving a written report of a reportable incident to NOPSEMA, INPEX will provide a copy of the report to:

- NOPTA (Cwlth)
- WA DMIRS or NT DIPL, depending on the jurisdiction.

Following submission of the above, NOPSEMA may, by notice in writing, request INPEX to submit an additional report(s) of the incident. Where this is the case, NOPSEMA will identify the information to be contained in the report(s) or the matters to be addressed and will specify the submission date for the report(s). INPEX will prepare and submit the report(s) in accordance with the notice given.

In the event of a significant impact to MNES, INPEX will provide a written notification to DCCEEW (Cwlth) within three days of becoming aware of the event, and provide additional information as available, if requested by DCCEEW. This includes reporting any vessel strike incidents to the National Ship Strike Database at <https://data.marinemammals.gov.au/report/shipstrike>.

Suspected or confirmed presence of any marine pest or disease will be reported for NT waters by email (aquaticbiosecurity@nt.gov.au). For WA waters, WA DPIRD will be notified within 24 hours by email (biosecurity@fish.wa.gov.au) or telephone. This includes any organism listed in the WA prevention list for introduced marine pests and any other non-indigenous organism that demonstrates invasive characteristics.

Recordable incidents

Reporting

In the event of a recordable incident, INPEX will report the occurrence to NOPSEMA as soon as is practicable after the end of the calendar month in which it occurs; and in any case, not later than 15 days after the end of the calendar month. The report will contain:

- a record of all the recordable incidents that occurred during the calendar month
- all material facts and circumstances concerning the recordable incidents that are known or can, by reasonable search or enquiry, be found out
- any action taken to avoid or mitigate any adverse environmental impacts of the recordable incidents
- the corrective action that has been taken, or is proposed to be taken, to stop, control or remedy the recordable incident

- the action that has been taken, or is proposed to be taken, to prevent a similar incident occurring in the future.

9.11.4 Annual performance reporting – external

In accordance with Regulation 14(2) of the OPGGS (E) Regulations, INPEX will undertake a review of its compliance with the environmental performance outcomes and standards set out in this EP and will provide a written report of its findings for the reporting period 1 January to December 31, to NOPSEMA on an annual basis, as agreed with NOPSEMA. The annual submission date for the environmental performance report will be April 1 of each year.

9.12 Monitor, review and audit

HSE performance must be monitored through audits, reviews, validation, verification and assurance checks, to correct at risk situations and deliver improved performance.

9.12.1 Management system audit

An audit and inspection program will be developed and implemented in accordance with the INPEX business standard for auditing. The program will include:

- self-assessment HSE audits against the INPEX BMS
- regular inspections of workplace equipment and activities
- reviews to evaluate compliance with legislative and other requirements.

Unscheduled audits may be initiated by INPEX in the event of an incident, non-compliance or for other valid reasons.

Audit teams will be appropriately qualified, experienced and competent in auditing techniques. They will include relevant technical expertise, as required, and the audit team structure will be commensurate with the scope of the audit. HSE audit and inspection findings will be summarised in a report. Non-conformances, actions and improvement plans resulting from audits will be managed in an action tracking system.

9.12.2 Vessel inspections

Inspections will be undertaken to ensure that the environmental performance outcomes and standards documented in this EP can be achieved.

Pre-mobilisation inspections will be conducted prior to seismic activities on relevant vessels.

During the activity, operational compliance against relevant EPO/EPSs will be assessed and maintained through the implementation of respective monthly/routine environmental inspection checklists.

Non-conformances and relevant findings during the inspections will be converted into actions that will be tracked within an action tracking database until closed.

9.13 Management review

Through a process of adaptive management, lessons from management outcomes will be used for continual improvement. Formal reviews of the effectiveness and appropriateness of the HSE requirements as per the INPEX BMS are performed by senior management on a periodic basis. Learnings from this process, and iterative decision-making will then be used as feedback to improve future management.

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Appendix A-
EPBC Act Protected Matters Reports
& Species Risk Evaluation

APPENDIX A: EPBC ACT PROTECTED MATTERS REPORT AND SPECIES RISK EVALUATION

A.1 EPBC Act Protected Matters report

Operational Area

PEZ

NB: The EPBC Act Protected Matters Search Tool (https://pmst.awe.gov.au) uses a 32 km grid square for data across marine regions. Where boundaries of an Operational Area, EMBA or PEZ overlap a 32 km^2 grid square, all protected matters that fall within that grid square are captured within the PMST report output, regardless of whether the Operational Area, EMBA or PEZ actually overlap the protected matter or not. This results in protected matters being included in the PMST that may actually be >30 km away from a location.

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. Please see the caveat for interpretation of information provided here.

1. Operational Area

Report created: 29-Apr-2022

Summary

Matters of National Environment 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 (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	19
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

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 Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	67
Whales and Other Cetaceans:	13
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	1
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	None
Regional Forest Agreements:	None
Nationally Important Wetlands:	None
EPBC Act Referrals:	22
Key Ecological Features (Marine):	2
Biologically Important Areas:	4
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

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 a Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area.

Feature Name
EEZ and Territorial Sea

Listed Threatened Species [Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text
BIRD		
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
MAMMAL		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Species or species habitat may occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
REPTILE		

Scientific Name	Threatened Category	Presence Text
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
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
SHARK		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Glyphis garricki Northern River Shark, New Guinea River Shark [82454]	Endangered	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sphyrna lewini Scalloped Hammerhead [85267]	Conservation Dependent	Species or species habitat likely to occur within area

Listed Migratory Species

[Resource Information]

Scientific Name	Threatened Category	Presence Text
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Species or species habitat may occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat may occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
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 likely to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]		Species or species habitat likely to occur within area
Mobula alfredi as Manta alfredi Reef Manta Ray, Coastal Manta Ray [90033]		Species or species habitat likely to occur within area
Mobula birostris as Manta birostris Giant Manta Ray [90034]		Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis 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 may 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 likely to occur within area

Migratory Wetlands Species

Scientific Name	Threatened Category	Presence Text
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Bird		
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

Scientific Name	Threatened Category	Presence Text
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area overfly marine area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		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

Scientific Name	Threatened Category	Presence Text
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
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
Reptile		
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

Scientific Name	Threatened Category	Presence Text
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
Chitulia inornata as Hydrophis inornatus Plain Seasnake [87379]		Species or species habitat may occur within area
Chitulia ornata as Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [87377]		Species or species habitat may occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis macdowelli as Hydrophis mcdowelli Small-headed Seasnake [75601]		Species or species habitat may occur within area
Lapemis curtus as Lapemis hardwickii Spine-bellied Seasnake [83554]		Species or species habitat may occur within area
Leioselasma coggeri as Hydrophis coggeri Black-headed Sea Snake, Slender-necked Seasnake [87373]		Species or species habitat may occur within area
Leioselasma pacifica as Hydrophis pacificus Large-headed Seasnake, Pacific Seasnake [87378]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Parahydrophis mertoni Northern Mangrove Seasnake [1090]		Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and Other Cetaceans [Resource Information]

Current Scientific Name	Status	Type of Presence
Mammal		

Current Scientific Name	Status	Type of Presence
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
Delphinus delphis Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat may occur within area

Current Scientific Name	Status	Type of Presence
Tursiops aduncus (Arafura/Timor Sea populations)		
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat likely to occur within area
Tursiops truncatus s. str.		
Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Australian Marine Parks [Resource Information]

Park Name	Zone & IUCN Categories
Oceanic Shoals	Multiple Use Zone (IUCN VI)

Extra Information

EPBC Act Referrals [Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
Bonaparte Liquified Natural Gas Project	2011/6141	Controlled Action	Post-Approval
Ichthys Gas Field, Offshore and onshore processing facilities and subsea pipeline	2008/4208	Controlled Action	Post-Approval
Not controlled action			
2D Seismic Survey in Permit Areas WA-318-P & WA-319-P, near Cape Londonderry	2004/1687	Not Controlled Action	Completed
Not controlled action (particular manner)			
2D and 3D Seismic Survey	2011/6197	Not Controlled Action (Particular Manner)	Post-Approval
2D and 3D Seismic Survey WA-405-P	2009/5104	Not Controlled Action (Particular Manner)	Post-Approval
2D and 3D Seismic Survey WA-405-P	2008/4133	Not Controlled Action (Particular Manner)	Post-Approval
2D Marine Seismic Survey	2009/4728	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
2D marine seismic survey within permit area WA-318-P	2007/3879	Not Controlled Action (Particular Manner)	Post-Approval
2D Seismic survey	2009/5076	Not Controlled Action (Particular Manner)	Post-Approval
Bonaparte 2D & 3D marine seismic survey	2011/5962	Not Controlled Action (Particular Manner)	Post-Approval
Bonaparte Seismic and Bathymetric Survey	2012/6295	Not Controlled Action (Particular Manner)	Post-Approval
Fishburn2D Marine Seismic Survey	2012/6659	Not Controlled Action (Particular Manner)	Post-Approval
Floyd 3D and Chisel 3D Seismic Surveys	2011/6220	Not Controlled Action (Particular Manner)	Post-Approval
Kingtree & Ironstone-1 Exploration Wells	2011/5935	Not Controlled Action (Particular Manner)	Post-Approval
Marine Environmental Survey 2012	2012/6310	Not Controlled Action (Particular Manner)	Post-Approval
NT/P77 3D Marine Seismic Survey	2009/4683	Not Controlled Action (Particular Manner)	Post-Approval
NT/P80 2010 2D Marine Seismic Survey	2010/5487	Not Controlled Action (Particular Manner)	Post-Approval
Petrel MC2D Marine Seismic Survey	2010/5368	Not Controlled Action (Particular Manner)	Post-Approval
Santos Petrel-7 Offshore Appraisal Drilling Programme (Bonaparte Basin)	2011/5934	Not Controlled Action (Particular	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
		Manner)	
Sonar and Acoustic Trials	2001/345	Not Controlled Action (Particular Manner)	Post-Approval
Westralia SPAN Marine Seismic Survey, WA & NT	2012/6463	Not Controlled Action (Particular Manner)	Post-Approval
Referral decision			
2D Marine Seismic Survey	2008/4623	Referral Decision	Completed

Key Ecological Features [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 Sahul Shelf	North-west
Pinnacles of the Bonaparte Basin	North-west

Biologically Important Areas

Scientific Name	Behaviour	Presence
Marine Turtles		
Caretta caretta Loggerhead Turtle [1763]	Foraging	Known to occur
Chelonia mydas Green Turtle [1765]	Foraging	Known to occur
Lepidochelys olivacea Olive Ridley Turtle [1767]	Foraging	Known to occur
Natator depressus Flatback Turtle [59257]	Foraging	Known to occur

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and 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

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a 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 detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

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. Please see the caveat for interpretation of information provided here.

2. PEZ

Report created: 21-Feb-2022

Summary

Matters of National Environment 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 (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	53
Listed Migratory Species:	63

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

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 Lands:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	105
Whales and Other Cetaceans:	25
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	6
Habitat Critical to the Survival of Marine Turtles:	2

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	None
Regional Forest Agreements:	None
Nationally Important Wetlands:	1
EPBC Act Referrals:	52
Key Ecological Features (Marine):	4
Biologically Important Areas:	14
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

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 a Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area.

Feature Name	Buffer Status
EEZ and Territorial Sea	In feature area
Extended Continental Shelf	In feature area

Listed Threatened Species [Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text	Buffer Status
BIRD			
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Species or species habitat may occur within area	In feature area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area	In feature area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Species or species habitat likely to occur within area	In feature area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area	In feature area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat likely to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat known to occur within area	In feature area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat may occur within area	In feature area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat known to occur within area	In feature area
Geophaps smithii smithii Partridge Pigeon (eastern) [64441]	Vulnerable	Species or species habitat known to occur within area	In feature area
Limosa lapponica baueri Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area	In feature area
Melanodryas cucullata melvillensis Tiwi Islands Hooded Robin, Hooded Robin (Tiwi Islands) [67092]	Critically Endangered	Species or species habitat likely to occur within area	In feature area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area	In feature area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area	In feature area
Tyto novaehollandiae kimberli Masked Owl (northern) [26048]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Tyto novaehollandiae melvillensis Tiwi Masked Owl, Tiwi Islands Masked Owl [26049]	Endangered	Species or species habitat known to occur within area	In feature area
FISH			
Thunnus maccoyii Southern Bluefin Tuna [69402]	Conservation Dependent	Species or species habitat likely to occur within area	In feature area
MAMMAL			

Scientific Name	Threatened Category	Presence Text	Buffer Status
Antechinus bellus Fawn Antechinus [344]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area	In feature area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Conilurus penicillatus Brush-tailed Rabbit-rat, Brush-tailed Tree-rat, Pakooma [132]	Vulnerable	Species or species habitat known to occur within area	In feature area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat likely to occur within area	In feature area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Mesembriomys gouldii melvillensis Black-footed Tree-rat (Melville Island) [87619]	Vulnerable	Species or species habitat known to occur within area	In feature area
Petrogale concinna canescens Nabarlek (Top End) [87606]	Endangered	Species or species habitat may occur within area	In feature area
Phascogale pirata Northern Brush-tailed Phascogale [82954]	Vulnerable	Species or species habitat likely to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Saccolaimus saccolaimus nudicluniatus			
Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Sminthopsis butleri			
Butler's Dunnart [302]	Vulnerable	Species or species habitat known to occur within area	In feature area
Trichosurus vulpecula arnhemensis			
Northern Brushtail Possum [83091]	Vulnerable	Species or species habitat known to occur within area	In feature area
Xeromys myoides			
Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat likely to occur within area	In feature area
PLANT			
Burmannia sp. Bathurst Island (R.Fensham 1021)			
[82017]	Endangered	Species or species habitat likely to occur within area	In feature area
Hoya australis subsp. oramicola			
a vine [55436]	Vulnerable	Species or species habitat known to occur within area	In feature area
Typhonium jonesii			
a herb [62412]	Endangered	Species or species habitat likely to occur within area	In feature area
Typhonium mirabile			
a herb [79227]	Endangered	Species or species habitat likely to occur within area	In feature area
Xylopia monosperma			
a shrub [82030]	Endangered	Species or species habitat likely to occur within area	In feature area
REPTILE			
Acanthophis hawkei			
Plains Death Adder [83821]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Aipysurus foliosquama			
Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area	In feature area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area	In feature area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area	In feature area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area	In feature area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding known to occur within area	In feature area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area	In feature area
SHARK			
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area	In feature area
Glyphis garricki Northern River Shark, New Guinea River Shark [82454]	Endangered	Species or species habitat may occur within area	In feature area
Glyphis glyphis Speartooth Shark [82453]	Critically Endangered	Species or species habitat may occur within area	In feature area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area	In feature area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area	In feature area
Sphyrna lewini Scalloped Hammerhead [85267]	Conservation Dependent	Species or species habitat known to occur within area	In feature area

Listed Migratory Species

[Resource Information]

Scientific Name	Threatened Category	Presence Text	Buffer Status
Migratory Marine Birds			
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area	In feature area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area	In feature area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area	In feature area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area	In feature area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area	In feature area
Sternula albifrons Little Tern [82849]		Breeding known to occur within area	In feature area
Migratory Marine Species			
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area	In feature area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area	In feature area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area	In feature area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Carcharhinus longimanus Oceanic Whitetip Shark [84108]		Species or species habitat may occur within area	In feature area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area	In feature area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area	In feature area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area	In feature area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area	In feature area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area	In feature area
Dugong dugon Dugong [28]		Species or species habitat known to occur within area	In feature area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area	In feature area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area	In feature area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding known to occur within area	In feature area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Mobula alfredi as Manta alfredi Reef Manta Ray, Coastal Manta Ray [90033]		Species or species habitat likely to occur within area	In feature area
Mobula birostris as Manta birostris Giant Manta Ray [90034]		Species or species habitat likely to occur within area	In feature area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area	In feature area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat known to occur within area	In feature area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area	In feature area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area	In feature area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area	In feature area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Rhincodon typus			
Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area	In feature area
Sousa sahulensis as Sousa chinensis			
Australian Humpback Dolphin [87942]		Breeding known to occur within area	In feature area
Tursiops aduncus (Arafura/Timor Sea populations)			
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area	In feature area
Migratory Terrestrial Species			
Cecropis daurica			
Red-rumped Swallow [80610]		Species or species habitat may occur within area	In feature area
Cuculus optatus			
Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area	In feature area
Hirundo rustica			
Barn Swallow [662]		Species or species habitat likely to occur within area	In feature area
Motacilla cinerea			
Grey Wagtail [642]		Species or species habitat may occur within area	In feature area
Motacilla flava			
Yellow Wagtail [644]		Species or species habitat likely to occur within area	In feature area
Rhipidura rufifrons			
Rufous Fantail [592]		Species or species habitat likely to occur within area	In feature area
Migratory Wetlands Species			
Acrocephalus orientalis			
Oriental Reed-Warbler [59570]		Species or species habitat may occur within area	In feature area
Actitis hypoleucos			
Common Sandpiper [59309]		Species or species habitat known to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Arenaria interpres Ruddy Turnstone [872]		Species or species habitat likely to occur within area	In feature area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area	In feature area
Calidris alba Sanderling [875]		Species or species habitat likely to occur within area	In feature area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area	In feature area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area	In feature area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Species or species habitat likely to occur within area	In feature area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area	In feature area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat likely to occur within area	In feature area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area	In feature area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Limnodromus semipalmatus Asian Dowitcher [843]		Species or species habitat may occur within area	In feature area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area	In feature area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat likely to occur within area	In feature area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area	In feature area
Numenius phaeopus Whimbrel [849]		Species or species habitat likely to occur within area	In feature area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area	In feature area
Pluvialis squatarola Grey Plover [865]		Species or species habitat likely to occur within area	In feature area
Thalasseus bergii Greater Crested Tern [83000]		Breeding likely to occur within area	In feature area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area	In feature area

Other Matters Protected by the EPBC Act

Commonwealth Lands [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Commonwealth Land Name	State	Buffer Status
Defence		
Defence - QUAIL ISLAND BOMBING RANGE [70003]	NT	In feature area

Listed Marine Species			[Resource Information]
Scientific Name	Threatened Category	Presence Text	Buffer Status
Bird			
Acrocephalus orientalis Oriental Reed-Warbler [59570]		Species or species habitat may occur within area overfly marine area	In feature area
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area	In feature area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area	In feature area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Species or species habitat may occur within area	In feature area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area overfly marine area	In feature area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area	In feature area
Arenaria interpres Ruddy Turnstone [872]		Species or species habitat likely to occur within area	In feature area
Bubulcus ibis as Ardea ibis Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area	In feature area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area	In feature area
Calidris alba Sanderling [875]		Species or species habitat likely to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Calidris canutus			
Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area overfly marine area	In feature area
Calidris ferruginea			
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area overfly marine area	In feature area
Calidris melanotos			
Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area	In feature area
Calidris tenuirostris			
Great Knot [862]	Critically Endangered	Species or species habitat likely to occur within area overfly marine area	In feature area
Calonectris leucomelas			
Streaked Shearwater [1077]		Species or species habitat known to occur within area	In feature area
Cecropis daurica as Hirundo daurica			
Red-rumped Swallow [80610]		Species or species habitat may occur within area overfly marine area	In feature area
Chalcites osculans as Chrysococcyx osculans			
Black-eared Cuckoo [83425]		Species or species habitat likely to occur within area overfly marine area	In feature area
Charadrius leschenaultii			
Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area	In feature area
Charadrius mongolus			
Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat likely to occur within area	In feature area
Charadrius veredus			
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area	In feature area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area	In feature area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area overfly marine area	In feature area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area	In feature area
Hirundo rustica Barn Swallow [662]		Species or species habitat likely to occur within area overfly marine area	In feature area
Limnodromus semipalmatus Asian Dowitcher [843]		Species or species habitat may occur within area overfly marine area	In feature area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area	In feature area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat likely to occur within area overfly marine area	In feature area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area	In feature area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Motacilla flava			
Yellow Wagtail [644]		Species or species habitat likely to occur within area overfly marine area	In feature area
Numenius madagascariensis			
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area	In feature area
Numenius phaeopus			
Whimbrel [849]		Species or species habitat likely to occur within area	In feature area
Pandion haliaetus			
Osprey [952]		Species or species habitat known to occur within area	In feature area
Pluvialis squatarola			
Grey Plover [865]		Species or species habitat likely to occur within area overfly marine area	In feature area
Rhipidura rufifrons			
Rufous Fantail [592]		Species or species habitat likely to occur within area overfly marine area	In feature area
Rostratula australis as Rostratula benghalensis (sensu lato)			
Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area overfly marine area	In feature area
Sternula albifrons as Sterna albifrons			
Little Tern [82849]		Breeding known to occur within area	In feature area
Thalasseus bengalensis as Sterna bengalensis			
Lesser Crested Tern [66546]		Breeding known to occur within area	In feature area
Thalasseus bergii as Sterna bergii			
Greater Crested Tern [83000]		Breeding likely to occur within area	In feature area
Tringa nebularia			
Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area overfly marine area	In feature area
Fish			

Scientific Name	Threatened Category	Presence Text	Buffer Status
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area	In feature area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area	In feature area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area	In feature area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area	In feature area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area	In feature area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area	In feature area
Corythoichthys haematopterus Reef-top Pipefish [66201]		Species or species habitat may occur within area	In feature area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area	In feature area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area	In feature area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area	In feature area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area	In feature area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area	In feature area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area	In feature area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area	In feature area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area	In feature area
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area	In feature area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area	In feature area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area	In feature area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area	In feature area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area	In feature area
Hippichthys parvicarinatus Short-keel Pipefish, Short-keeled Pipefish [66230]		Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area	In feature area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area	In feature area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area	In feature area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area	In feature area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area	In feature area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area	In feature area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area	In feature area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area	In feature area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area	In feature area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area	In feature area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Trachyrhamphus longirostris			
Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area	In feature area
Mammal			
Dugong dugon			
Dugong [28]		Species or species habitat known to occur within area	In feature area
Reptile			
Acalyptophis peronii			
Horned Seasnake [1114]		Species or species habitat may occur within area	In feature area
Aipysurus duboisii			
Dubois' Seasnake [1116]		Species or species habitat may occur within area	In feature area
Aipysurus eydouxii			
Spine-tailed Seasnake [1117]		Species or species habitat may occur within area	In feature area
Aipysurus foliosquama			
Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat may occur within area	In feature area
Aipysurus laevis			
Olive Seasnake [1120]		Species or species habitat may occur within area	In feature area
Astrotia stokesii			
Stokes' Seasnake [1122]		Species or species habitat may occur within area	In feature area
Caretta caretta			
Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area	In feature area
Chelonia mydas			
Green Turtle [1765]	Vulnerable	Breeding known to occur within area	In feature area
Chitulia inornata as Hydrophis inornatus			
Plain Seasnake [87379]		Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Chitulia ornata as Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [87377]		Species or species habitat may occur within area	In feature area
Crocodylus johnstoni Freshwater Crocodile, Johnston's Crocodile, Johnstone's Crocodile [1773]		Species or species habitat may occur within area	In feature area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area	In feature area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area	In feature area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area	In feature area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area	In feature area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area	In feature area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area	In feature area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area	In feature area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area	In feature area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area	In feature area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Hydrophis macdowelli as Hydrophis mcdowelli			
Small-headed Seasnake [75601]		Species or species habitat may occur within area	In feature area
Lapemis curtus as Lapemis hardwickii			
Spine-bellied Seasnake [83554]		Species or species habitat may occur within area	In feature area
Leioselasma coggeri as Hydrophis coggeri			
Black-headed Sea Snake, Slender-necked Seasnake [87373]		Species or species habitat may occur within area	In feature area
Leioselasma pacifica as Hydrophis pacificus			
Large-headed Seasnake, Pacific Seasnake [87378]		Species or species habitat may occur within area	In feature area
Lepidochelys olivacea			
Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding known to occur within area	In feature area
Natator depressus			
Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area	In feature area
Parahydrophis mertoni			
Northern Mangrove Seasnake [1090]		Species or species habitat may occur within area	In feature area
Pelamis platurus			
Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area	In feature area

Whales and Other Cetaceans

[Resource Information]

Current Scientific Name	Status	Type of Presence	Buffer Status
Mammal			
Balaenoptera borealis			
Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Balaenoptera edeni			
Bryde's Whale [35]		Species or species habitat may occur within area	In feature area
Balaenoptera musculus			
Blue Whale [36]	Endangered	Species or species habitat likely to occur within area	In feature area

Current Scientific Name	Status	Type of Presence	Buffer Status
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Delphinus delphis Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area	In feature area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area	In feature area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area	In feature area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area	In feature area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area	In feature area
Kogia sima as Kogia simus Dwarf Sperm Whale [85043]		Species or species habitat may occur within area	In feature area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Orcaella heinsohni as Orcaella brevirostris Australian Snubfin Dolphin [81322]		Species or species habitat known to occur within area	In feature area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area	In feature area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area	In feature area

Current Scientific Name	Status	Type of Presence	Buffer Status
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area	In feature area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area	In feature area
Sousa sahulensis as Sousa chinensis Australian Humpback Dolphin [87942]		Breeding known to occur within area	In feature area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area	In feature area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area	In feature area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area	In feature area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area	In feature area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area	In feature area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area	In feature area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area	In feature area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area	In feature area

Australian Marine Parks

[Resource Information]

Park Name	Zone & IUCN Categories	Buffer Status
Oceanic Shoals	Habitat Protection Zone (IUCN IV)	In feature area
Joseph Bonaparte Gulf	Multiple Use Zone (IUCN VI)	In feature area
Kimberley	Multiple Use Zone (IUCN VI)	In feature area
Oceanic Shoals	Multiple Use Zone (IUCN VI)	In feature area
Joseph Bonaparte Gulf	Special Purpose Zone (IUCN VI)	In feature area
Oceanic Shoals	Special Purpose Zone (Trawl) (IUCN VI)	In feature area

Habitat Critical to the Survival of Marine Turtles

Scientific Name	Behaviour	Presence	Buffer Status
Aug - Sep			
Natator depressus Flatback Turtle [59257]	Nesting	Known to occur	In feature area
May - Jul			
Lepidochelys olivacea Olive Ridley Turtle [1767]	Nesting	Known to occur	In feature area

Extra Information

Nationally Important Wetlands [Resource Information]

Wetland Name	State	Buffer Status
Finniss Floodplain and Fog Bay Systems	NT	In feature area

EPBC Act Referrals [Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Controlled action				
Australia-ASEAN Power Link	2020/8818	Controlled Action	Proposed Decision	In feature area
Bonaparte Liquified Natural Gas Project	2011/6141	Controlled Action	Post-Approval	In feature area
Clarence Strait Offshore Tidal Energy Project	2008/4660	Controlled Action	Assessment Approach	In feature area
Development of Blacktip Gas Field	2003/1180	Controlled Action	Post-Approval	In feature area
Hardwood Plantation	2001/229	Controlled Action	Post-Approval	In feature area

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Controlled action				
Ichthys Gas Field, Offshore and onshore processing facilities and subsea pipeline	2008/4208	Controlled Action	Post-Approval	In feature area
Kilimiraka Mineral Sands and Associated Infrastructure (Bathurst Island), NT	2012/6587	Controlled Action	Assessment Approach	In feature area
PTTEP AA Floating LNG Facility	2011/6025	Controlled Action	Completed	In feature area
Not controlled action				
2D seismic survey, exploration permit NT/P67	2004/1587	Not Controlled Action	Completed	In feature area
2D Seismic Survey in Permit Areas WA-318-P & WA-319-P, near Cape Londonderry	2004/1687	Not Controlled Action	Completed	In feature area
Audacious-3 oil drilling well	2003/1042	Not Controlled Action	Completed	In feature area
Backpacker-1 Offshore Hydrocarbon Exploration Well	2001/300	Not Controlled Action	Completed	In feature area
Construction and operation of Radar Infrastructure	2004/1406	Not Controlled Action	Completed	In feature area
Drilling of Marina-1 Exploration Well	2007/3586	Not Controlled Action	Completed	In feature area
Exploration Drilling in AC/P17, AC/P18 and AC/P24	2001/359	Not Controlled Action	Completed	In feature area
Marine Survey for the Australia-ASEAN Power Link AAPL	2020/8714	Not Controlled Action	Completed	In feature area
Nexus Drilling Program NT-P66	2007/3745	Not Controlled Action	Completed	In feature area
Not controlled action (particular manner)				
2D and 3D Seismic Survey	2011/6197	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
2D and 3D Seismic Survey WA-405-P	2009/5104	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
2D and 3D Seismic Survey WA-405-P	2008/4133	Not Controlled Action (Particular Manner)	Post-Approval	In feature area

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Not controlled action (particular manner)				
2D Marine Seismic Survey	2009/4728	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
2D marine seismic survey of Braveheart,Kurrajong,Sunshine and Crocodile	2006/2917	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
2D marine seismic survey within permit area WA-318-P	2007/3879	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
2D Seismic survey	2009/5076	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
2D Seismic Survey in WA Permit Area TP/22 and Commonwealth Permit Area WA-280-P	2005/2100	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
3D Marine Seismic Survey	2009/4681	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
3D Seismic Survey, petroleum exploration permit AC/P33	2006/2918	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
3D seismic survey of AC/P4, AC/P17 and AC/P24	2006/2857	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Bonaparte 2D & 3D marine seismic survey	2011/5962	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Bonaparte Basin Seabed Mapping Survey	2009/4951	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Bonaparte Seismic and Bathymetric Survey	2012/6295	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Drilling of Audacious-5 appraisal well	2008/4327	Not Controlled Action (Particular	Post-Approval	In feature area

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Not controlled action (particular manner)				
		Manner)		
Exploration Drilling in Permit Areas WA-402-P & WA-403-P	2010/5297	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Fishburn2D Marine Seismic Survey	2012/6659	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Floyd 3D and Chisel 3D Seismic Surveys	2011/6220	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Gold 2D Marine Seismic Survey Permit Areas WA375P and WA376P	2009/4698	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Joseph Bonaparte Gulf Seabed mapping survey	2010/5517	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Kingtree & Ironstone-1 Exploration Wells	2011/5935	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Malita West 3D Seismic Survey WA-402-P and WA-403-P	2007/3936	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Marine Environmental Survey 2012	2012/6310	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Nova 3D Seismic Survey	2013/6825	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
NT/P77 3D Marine Seismic Survey	2009/4683	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
NT/P80 2010 2D Marine Seismic Survey	2010/5487	Not Controlled Action (Particular Manner)	Post-Approval	In feature area

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Not controlled action (particular manner)				
Offshore Fibre Optic Cable Network Construction & Operation, Port Hedland WA to Darwin NT	2014/7223	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Petrel MC2D Marine Seismic Survey	2010/5368	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Removal of Potential Unexploded Ordnance within NAXA	2012/6503	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Santos Petrel-7 Offshore Appraisal Drilling Programme (Bonaparte Basin)	2011/5934	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Sonar and Acoustic Trials	2001/345	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Vampire 2D Non Exclusive Seismic Survey, WA	2010/5543	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Westralia SPAN Marine Seismic Survey, WA & NT	2012/6463	Not Controlled Action (Particular Manner)	Post-Approval	In feature area
Referral decision				
2D Marine Seismic Survey	2008/4623	Referral Decision	Completed	In feature area
Nova 3D Seismic Survey, WA 442-NT/P81, Joseph Bonaparte Gulf	2013/6820	Referral Decision	Completed	In feature area

Key Ecological Features

[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	Buffer Status
Carbonate bank and terrace system of the Sahul Shelf	North-west	In feature area
Carbonate bank and terrace system of the Van Diemen Rise	North	In feature area
Pinnacles of the Bonaparte Basin	North-west	In feature area

Name	Region	Buffer Status
Pinnacles of the Bonaparte Basin	North	In feature area

Biologically Important Areas

Scientific Name	Behaviour	Presence	Buffer Status
Dolphins			
Sousa chinensis Indo-Pacific Humpback Dolphin [50]	Breeding	Known to occur	In feature area
Marine Turtles			
Caretta caretta Loggerhead Turtle [1763]	Foraging	Known to occur	In feature area
Chelonia mydas Green Turtle [1765]	Foraging	Known to occur	In feature area
Chelonia mydas Green Turtle [1765]	Internesting	Likely to occur	In feature area
Lepidochelys olivacea Olive Ridley Turtle [1767]	Foraging	Known to occur	In feature area
Lepidochelys olivacea Olive Ridley Turtle [1767]	Foraging	Likely to occur	In feature area
Lepidochelys olivacea Olive Ridley Turtle [1767]	Internesting	Likely to occur	In feature area
Natator depressus Flatback Turtle [59257]	Foraging	Known to occur	In feature area
Natator depressus Flatback Turtle [59257]	Internesting	Likely to occur	In feature area
Natator depressus Flatback Turtle [59257]	Internesting buffer	Known to occur	In feature area
Seabirds			
Fregata ariel Lesser Frigatebird [1012]	Breeding	Known to occur	In feature area
Thalasseus bengalensis Lesser Crested Tern [66546]	Breeding	Known to occur	In feature area
Thalasseus bergii Crested Tern [83000]	Breeding (high numbers)	Known to occur	In feature area

Scientific Name	Behaviour	Presence	Buffer Status
Sharks			
Rhincodon typus Whale Shark [66680]	Foraging	Known to occur	In feature area

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and 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

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a 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 detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

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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A.2 EPBC-listed species risk evaluation table

This table was developed by:

Searching the Species Profile and Threats database (SPRAT) (http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl) for every species identified in the EPBC search related to this EP.

Through the SPRAT database, identifying the relevant conservation management documents.

Determining the relevant aspects / threats from the conservation management documents related to the activity

Listing where the aspect / threat has been addressed in the EP.

Fauna Type	**Conservation management documents**	**Summary of relevant aspects/threats identified from conservation management documents**	**Summary of relevant actions from conservation management documents**	**Relevant exposure / risk evaluation section of EP**
EPBC-listed fishes and sharks	Whale shark management. 2013. Wildlife management program no. 57. Department of Parks and Wildlife. State of Western Australia. Threatened Species Scientific Committee. 2015. Approved Conservation Advice for Rhincodon typus (whale shark). Commonwealth of Australia. Department of Sustainability, Environment, Water, Population and Communities. 2013. Recovery Plan for the White Shark (Carcharodon carcharias). Commonwealth of Australia. Threatened Species Scientific Committee. 2014. Approved Conservation Advice for *Glyphis garricki* (northern river shark). Commonwealth of Australia. Threatened Species Scientific Committee. 2009. Commonwealth Conservation Advice on *Pristis clavata* (Dwarf Sawfish). Commonwealth of Australia. Threatened Species Scientific Committee. 2008. Approved Conservation Advice for *Pristis zijsron* (Green Sawfish). Commonwealth of Australia. Department of the Environment. 2015. Sawfish and River Sharks - Multispecies Recovery Plan. Commonwealth of Australia. Department of Environment and Energy. 2018. Threat abatement plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans. Commonwealth of Australia. Department of Sustainability, Environment, Water, Population and Communities (DSEWPac). 2012. Marine bioregional plan for the North-west Marine Region. DSEWPac, Canberra, ACT. Department of Sustainability, Environment, Water, Population and Communities (DSEWPac). 2012. Marine bioregional plan for the North Marine Region. DSEWPac, Canberra, ACT. Threatened Species Scientific Committee. 2014. Approved Conservation Advice for *Glyphis glyphis* (speartooth shark). Commonwealth of Australia. Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*) (2014)	• Waste / marine debris • Noise and vibration • Introduced Marine Species • Vessel strike • Benthic habitat degradation / seabed disturbance • Emissions and discharges • Oil spill	• Identify populations and areas of high conservation priority (sawfishes). • Ensure there is no anthropogenic disturbance / implement measures to reduce adverse impacts of habitat degradation and/or modification (northern river shark). • Ensure all future developments will not significantly impact upon sawfish and river shark habitats critical to the survival of the species or impede upon the migration of individual sawfish or river sharks. Implement measures to reduce adverse impacts of habitat degradation and/or modification. • Review and assess the potential threat of introduced species, pathogens and pollutants. • Minimise offshore developments and transit time of large vessels in areas close to marine features likely to correlate with whale shark aggregations (Ningaloo Reef,) and along the northward migration route that follows the northern WA coastline along the 200 m isobath. • Contribute to the long-term prevention of the incidence of harmful marine debris.	• EP Section 7.1 - Noise and vibration • EP Section 7.4.1 - Introduction of invasive marine species • EP Section 7.4.2 - Interaction with marine fauna • EP Section 7.5.3 - Routine discharges • EP Section 7.6 - Waste management • EP Section 8 - Emergency conditions (oil spills).

Fauna Type	Conservation management documents	Summary of relevant aspects/threats identified from conservation management documents	Summary of relevant actions from conservation management documents	Relevant exposure / risk evaluation section of EP
EPBC-listed marine reptiles	Department of the Environment and Energy 2017. Recovery Plan for Marine Turtles in Australia, Commonwealth of Australia 2017. Threatened Species Scientific Committee. 2011. Commonwealth Conservation Advice on *Aipysurus apraefrontalis* (Short-nosed Seasnake). Commonwealth of Australia. Threatened Species Scientific Committee. 2011. Commonwealth Conservation Advice on *Aipysurus foliosquama* (Leaf-scaled Seasnake). Commonwealth of Australia. Department of Environment and Energy. 2018. Threat abatement plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans. Commonwealth of Australia. Department of Sustainability, Environment, Water, Population and Communities (DSEWPac). 2012. Marine bioregional plan for the North-west Marine Region. DSEWPac, Canberra, ACT. Department of Sustainability, Environment, Water, Population and Communities (DSEWPac). 2012. Marine bioregional plan for the North Marine Region. DSEWPac, Canberra, ACT. Department of the Environment and Energy. 2020. Light pollution guidelines – National light pollution guidelines for wildlife: Including marine turtles, seabirds and migratory shorebirds. Commonwealth of Australia, Canberra, ACT. Department of the Environment and Energy. 2017. National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Fauna. Commonwealth of Australia, Canberra, ACT.	• Waste / marine debris • Noise and vibration • Introduced Marine Species • Vessel strike • Benthic habitat degradation / seabed disturbance • Emissions and discharges • Oil spill • Light emissions	• A precautionary approach should be applied to seismic surveys, such that surveys should not occur inside important internesting habitat during the nesting season. • All seismic survey vessels operating in Australian waters must undertake a soft start during surveys irrespective of location and time of year of the survey. • Manage artificial light from onshore and offshore sources to ensure biologically important behaviours of nesting adults and dispersing hatchlings can continue. • 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 and implementation of best practice light management guidelines for developments adjacent to marine turtle nesting beaches. • Identify the cumulative impact on turtles from multiple sources of onshore and offshore light pollution. • Support retrofitting of lighting at coastal communities and industrial developments, including imposing restrictions around nesting seasons. • Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical for survival. • Manage anthropogenic activities in Biologically Important Areas to ensure that biologically important behaviour can continue (i.e. do not change important behaviours such that the recovery of the stock is compromised). • Contribute to the reduction in the source of marine debris. • 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. • Implement best practices to minimise impacts to turtle health and habitats from chemical discharges. • Identify populations and areas of high conservation priority (sea snakes).	• EP Section 7.1 - Noise and vibration • EP Section 7.4.1 - Introduction of invasive marine species • EP Section 7.4.2 - Interaction with marine fauna • EP Section 7.5.1 - Light emissions • EP Section 7.5.3 - Routine discharges • EP Section 7.6 - Waste management • EP Section 8 - Emergency conditions (oil spills).

Fauna Type	Conservation management documents	Summary of relevant aspects/threats identified from conservation management documents	Summary of relevant actions from conservation management documents	Relevant exposure / risk evaluation section of EP
			• Ensure there is no anthropogenic disturbance / implement measures to reduce adverse impacts of habitat degradation and/or modification (sea snakes). • Increased reporting of vessel collision (a requirement of the EPBC Act). • Reduce risk of collision with cetaceans (and turtles) such as maintaining look out, consider reducing vessel speed and course alterations away from sightings.	
EPBC-listed seabirds and shorebirds	Department of the Environment. 2015. EPBC Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing and mitigating impacts on EPBC listed migratory shorebird species. Department of the Environment. 2015. Wildlife conservation plan for migratory shorebirds. Commonwealth of Australia. Department of the Environment. 2015. Draft referral guideline for 14 birds listed as migratory under the EPBC Act. Commonwealth of Australia. Department of Sustainability, Environment, Water, Population and Communities. 2012. Species group report card - seabirds and migratory shorebirds. Supporting the marine bioregional plan for the North-west Marine Region. Prepared under the Environment Protection and Biodiversity Conservation Act 1999. Commonwealth of Australia. Department of the Environment, Water, Heritage and the Arts. 2009. Threat abatement plan to reduce the impacts of exotic rodents on biodiversity on Australian offshore islands of less than 100 000 hectares. Commonwealth of Australia. Department of Environment and Energy. 2018. Threat abatement plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans. Commonwealth of Australia. Department of Sustainability, Environment, Water, Population and Communities (DSEWPac). 2012. Marine bioregional plan for the North-west Marine Region. DSEWPac, Canberra, ACT. Department of Sustainability, Environment, Water, Population and Communities (DSEWPac).	• Waste / marine debris • Noise and vibration • Introduced Marine Species • Introduced Terrestrial Pests (rodents) • Benthic habitat degradation / seabed disturbance • Emissions and discharges • Oil spill • Light emissions	• Reduce risk of rodents gaining access to key vessels at key ports • Contribute to the long-term prevention of the incidence of harmful marine debris • Identify threats to important (migratory shorebird) habitat and develop conservation measures for managing them. • Avoid degradation of migratory shorebird habitat that may occur through the introduction of exotic species, changes to hydrology or water quality (including toxic inflows), fragmentation of habitat or exposure to litter, pollutants and acid sulphate soils. Minimise human disturbance, a major threat to migratory shorebirds • Best practice waste management should be implemented.	• EP Section 7.1 - Noise and vibration • EP Section 7.4.1 - Introduction of invasive marine species • EP Section 7.5.1 - Light emissions • EP Section 7.5.2 - Atmospheric emissions • EP Section 7.5.3 - Routine discharges • EP Section 7.6 - Waste management • EP Section 8 - Emergency conditions (oil spills).

Fauna Type	Conservation management documents	Summary of relevant aspects/threats identified from conservation management documents	Summary of relevant actions from conservation management documents	Relevant exposure / risk evaluation section of EP
	2012. Marine bioregional plan for the North Marine Region. DSEWPac, Canberra, ACT. Threatened Species Scientific Committee. 2016. *Calidris tenuirostris* (Great Knot) Approved Conservation Advice. Commonwealth of Australia. Threatened Species Scientific Committee. 2016. *Calidris canutus* (Red Knot) Approved Conservation Advice. Commonwealth of Australia. Threatened Species Scientific Committee. 2016. *Charadrius leschenaultii* (Greater Sand Plover) Approved Conservation Advice. Commonwealth of Australia. Threatened Species Scientific Committee. 2016. *Charadrius mongolus* (Lesser Sand Plover) Approved Conservation Advice. Commonwealth of Australia. Threatened Species Scientific Committee. 2016. *Fregata andrewsi* (Christmas Island Frigatebird) Approved Conservation Advice. Commonwealth of Australia. Threatened Species Scientific Committee. 2016. *Hypotaenidia philippensis andrewsi* (Buff-banded Rail) Approved Conservation Advice. Commonwealth of Australia. Threatened Species Scientific Committee. 2016. *Limosa lapponica menzbieri* — Northern Siberian Bar-tailed Godwit. Approved Conservation Advice. Commonwealth of Australia. Threatened Species Scientific Committee. 2015. *Calidris ferruginea* (Curlew Sandpiper) Approved Conservation Advice. Commonwealth of Australia. Threatened Species Scientific Committee. 2001. Commonwealth listing advice on *Macronectes giganteus.* Commonwealth of Australia. Threatened Species Scientific Committee. 2015. *Papasula abbotti* — Abbott's Booby. Approved Conservation Advice. Commonwealth of Australia. Department of the Environment. 2015. Conservation advice *Numenius madagascariensis* (eastern curlew). Commonwealth of Australia.			

Fauna Type	Conservation management documents	Summary of relevant aspects/threats identified from conservation management documents	Summary of relevant actions from conservation management documents	Relevant exposure / risk evaluation section of EP
	Department of the Environment. 2014. Conservation Advice *Phaethon lepturus fulvus* white-tailed tropicbird (Christmas Island) Commonwealth of Australia. Threatened Species Scientific Committee. 2015. *Pterodroma arminjoniana* — Round IslandPetrel. Approved Conservation Advice. Commonwealth of Australia. Threatened Species Scientific Committee. 2015. *Pterodroma mollis* — Soft-plumaged petrel. Approved Conservation Advice. Commonwealth of Australia. Threatened Species Scientific Committee. 2015. Approved Conservation Advice for *Anous tenuirostris melanops* (Australian lesser noddy). Commonwealth of Australia. Threatened Species Scientific Committee. 2002. Commonwealth Listing Advice on *Sterna albifrons sinensis* (Little Tern (western Pacific)). Commonwealth of Australia. Department of Sustainability, Environment, Water, Population and Communities. 2013. Approved Conservation Advice for *Rostratula australis* (Australian painted snipe). Canberra, ACT. Department of Sustainability, Environment, Water, Population and Communities. 2011. Approved Conservation Advice for *Sternula nereis nereis* (Fairy Tern). Canberra, ACT. Department of the Environment and Energy. 2020. Light pollution guidelines – National light pollution guidelines for wildlife: Including marine turtles, seabirds and migratory shorebirds. Commonwealth of Australia, Canberra, ACT. Draft National Recovery Plan for albatrosses and petrels. 2021. Commonwealth of Australia.			
EPBC-listed cetaceans	Department of the Environment. 2015. Conservation Management Plan for the Blue Whales - A Recovery Plan under the Environment Protection and Biodiversity Conservation Act 1999 (2015-2025). Commonwealth of Australia.	• Waste / marine debris • Noise and vibration • Introduced Marine Species • Vessel strike • Benthic habitat degradation / seabed disturbance	• 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. • All seismic surveys must be undertaken consistently with the EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales.	• EP Section 7.1 - Noise and vibration • EP Section 7.4.1 - Introduction of invasive marine species • EP Section 7.4.2 - Interaction with marine fauna • EP Section 7.5.3 - Routine discharges • EP Section 7.6 - Waste management

Fauna Type	Conservation management documents	Summary of relevant aspects/threats identified from conservation management documents	Summary of relevant actions from conservation management documents	Relevant exposure / risk evaluation section of EP
	Threatened Species Scientific Committee. 2015. *Balaenoptera borealis* (Sei Whale) Conservation Advice. Commonwealth of Australia. Threatened Species Scientific Committee. 2022. Listing Advice for *Megaptera novaeangliae* (humpback whale). Commonwealth of Australia. Threatened Species Scientific Committee. 2015. Approved Conservation Advice for *Balaenoptera physalus* — Fin Whale. Commonwealth of Australia. EPBC Act Regulations 2000. Part 8 Interacting with cetaceans and whale watching. Division 8.1 Interacting with cetaceans. Commonwealth of Australia. Department of the Environment and Heritage, 2005. Australian National Guidelines for Whale and Dolphin Watching - Information Sheet. Commonwealth of Australia. Department of Environment and Energy. 2018. Threat abatement plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans. Commonwealth of Australia. Department of Sustainability, Environment, Water, Population and Communities (DSEWPac). 2012. Marine bioregional plan for the North-west Marine Region. DSEWPac, Canberra, ACT. Department of Sustainability, Environment, Water, Population and Communities (DSEWPac). 2012. Marine bioregional plan for the North Marine Region. DSEWPac, Canberra, ACT. Department of the Environment and Energy. 2017. National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Fauna. Commonwealth of Australia, Canberra, ACT.	• Emissions and discharges • Oil spill	• Ensure all vessel strike incidents are reported in the National Ship Strike Database. • Ensure the risk of vessel strikes on blue whales is considered when assessing actions that increase vessel traffic in areas where blue whales occur and, if required, appropriate mitigation measures are implemented. • Protect habitat important to the survival of the species (humpback whales); assess and manage physical disturbance and development activities (such as ship-strike and pollution). • Ensure the risk of vessel strike on humpback whales is considered when assessing actions that increase vessel traffic in areas where humpback whales occur and, if required appropriate mitigation measures are implemented to reduce the risk of vessel strike. • Environmental assessment processes must ensure that existing information about coastal habitat requirements of humpback whales, environmental suitability of coastal locations, historic high use and emerging areas are taken into consideration. • Contribute to the long-term prevention of the incidence of harmful marine debris . • if a whale or dolphin surfaces in the vicinity of a vessel travelling for a purpose other than whale and dolphin watching, take all care necessary to avoid collisions. This may include stopping, slowing down and/or steering away from the animal. • Increased reporting of vessel collision (a requirement of the EPBC Act). • Reduce risk of collision with cetaceans (and turtles) such as maintaining look out, consider reducing vessel speed and course alterations away from sightings.	• EP Section 8 - Emergency conditions (oil spills).

Appendix B-
Stakeholder Consultation Log

STAKEHOLDER	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit	INPEX response or actions
Authorities						
Australian Fisheries Management Authority (AFMA) (Cwth)	17/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Australian Hydrographic Office (AHO)- Department of Defence	6/04/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	7/04/2022	Email/ Letter from Stakeholder	Confirmation of receipt. The data supplied will now be registered, assessed, prioritised and validated in preparation for updating AHO's navigational Charting products.	N/A	No objection/claim raised - general correspondence only	No objection/claim raised - general correspondence only
Australian Maritime Safety Authority (AMSA) - Nautical Advice (Cwth)	21/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	1/04/2022	Email/ Letter from Stakeholder	AMSA thanked INPEX for notification. Stated that INPEX's proposed Offshore Greenhouse Gas Storage Exploration snd Assessment Activities have been reviewed, and as apart of this review process AMSA has analysed the shipping traffic in the area. AMSA noted there is considerable traffic in the proposed area. Conventional cargo ships, tankers and support do pass consistently through the northern section. Fishing, passenger, and some cargo and tanker vessels are recorded passing through the rest of the proposed areas. Much of this traffic is entering Darwin from WA coast and the offshore oil and gas activities in NW WA. AMSA advised that due to this traffic in the proposed area it is important that INPEX's activities are communicated effectively and in a timely manner to mariners. Requested INPEX notify AMSA's Joint Rescue Coordination Centre (JRCC) and provided contact details (Phone and Email) for promulgation of radio-navigation warnings 24-48 hours before operations commence. Outlined that AMSA's JRCC will require the rig details (including name, callsign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone), area of operation, requested clearance from other vessels and need to be advised when operations start and end. Reminded INPEX that the Australian Hydrographic Office should also be contacted and provided contact details (Email) no less than four working weeks before operations commence for the promulgation of related notices to mariners.	N/A	Relevant matters raised	INPEX has noted there is considerable traffic in proposed area. INPEX will provide notice to mariners in a timely manner, and notify AMSA's JRCC and provide contact details, rig details, satellite communication details, area of operation, requested clearance from other vessels and advise when operations start and end. INPEX will contact AHO and provide contact details no less than four working weeks before activities commence.
Australian Maritime Safety Authority (AMSA)	14/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the national proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	3/06/2022	Email/Letter to Stakeholder from INPEX	Email sent to stakeholder as a written record of conversation earlier in the week regarding Petroleum Titleholder (TH) activation of 'first strike' capabilities under a TH OPEP, in relation to a 'vessel spill', where AMSA is the Control Agency. The key points we discussed were: -Vessel spill scenario – AMSA is Control Agency – however AMSA position is that TH should activate all TH OPEP 'first strike' capabilities, where there is no 'risk' of additional environmental harm, associated with the mobilisation/activation of that capability. -TH mobilised capabilities can be 'turned-off' at any time, as directed by AMSA. -Whilst initially mobilised by the TH, operational control of these capabilities will be taken over by AMSA as the Control Agency, as the scenario evolves and IMT's become established. Transfer of control of THs capabilities to AMSA will occur via consultation between the TH IMT and the AMSA IMT. -Therefore, in the case of a Group IV vessel spill in the Ichthys field, INPEX will: -TH Field – Deploy satellite tracker buoys -TH Field – proactively mobilise vessel based dispersant capability -Move dispersant onto vessels -Set-up spray equipment -Complete JHAs/ review SOPs etc -NO test-spray or operational dispersant spray until given the direction from AMSA -TH IMT – activate oil spill trajectory modelling -TH IMT – identify/mobilise/activate aerial surveillance capability (TH helicopters, third-party fixed wing aircraft, AMOSC trained aerial observers) -TH IMT – proactively mobilise Containment and Recovery capability including: -equipment from AMOSC Broome Stockpile -identify/mobilise suitable C&R vessels to Broome wharf -identify/mobilise AMOSC Core-Group personnel to Broome -TH IMT – proactively commence mobilisation for FWAD capability (via AMOSC) -commence mobilisation of dispersant stockpile to a nominated airfield -commence process for mobilisation of crop-dusters -commence other such planning processes, under the AMOSC Northern Australia Air Operations Plan -NO test-spray or operational dispersant spray until given the direction from AMSA Whist this is a written record of the conversation, INPEX requested stakeholder reply that the AMSA agree with the above statements.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	3/06/2022	Email/Letter from stakeholder	AMSA agreed with the following amendment: 1. INPEX will advise AMSA of the commencement and completion of each step as listed in previous email. 2. INPEX will note that cost recovery will be against the polluters insurance (i.e. ship). 3. FWAD will be activated through AMSA contract and control for ship-sourced incident.	N/A	Relevant matter raised	INPEX will advise AMSA of the commencement and completion of each step as outlined in previous email. INPEX noted that cost recovery will be against the polluters insurance (i.e. ship). FWAD will be activated through AMSA contract and control for ship-sourced incident.
	3/06/2022	Email/ Letter to Stakeholder from INPEX	INPEX thanked stakeholder for feedback. INPEX accepted the amendments	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	8/06/2022	Email/ Letter to Stakeholder from INPEX	To finalise correspondence, INPEX sent attachment of INPEX's Browse Regional OPEP, covering all of INPEX's activities in northern WA/ NT waters, replacing all previous INPEX OPEPs submitted to AMSA.	Yes- INPEX's Browse Regional OPEP	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX

STAKEHOLDER	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit	INPEX response or actions
Director of National Parks / Marine Parks (Parks Australia)	15/03/2022	Email/ Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway. -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2. The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. Name of the Company and titleholder EP: INPEX Browse E&P Pty Ltd, as Operator of the Bonaparte CCS Assessment Joint Venture. There are potentially three EPs that will be submitted: Exploration Drilling Bonaparte Basin Environment Plan 3D Seismic Bonaparte Basin Environment Plan Geophysical/Geotechnical Site Survey Bonaparte Basin Environment Plan. Note, the names of EPs may change. INPEX provided contact details for titleholder representative As noted above the permit/title is yet to be awarded; however, it will be the extent of the GHG21-1 release area. The location of GHG21-1 release area is shown in Figure 1 of the attached fact sheet. INPEX will update relevant stakeholders with the permit/title details once awarded. The activity overview for 3D seismic and exploration drilling activities is provided in the attached fact sheet. INPEX provided the following description of the operational area including a map showing location of the activity relative to marine park boundaries: The GHG21-1 release area overlaps the Oceanic Shoals Marine Park (Multiple Use Zone; IUCN VI) in the north-west extent of the release area boundary. Further, the Joseph Bonaparte Gulf Marine Park is located to the south and south-west of the release area boundary (~71 km at its closest point). The actual proposed operational/project areas for the 3D seismic and exploration drilling/site survey activities (refer to figures 2 and 3 in the attached fact sheet) do not overlap any marine park: The seismic operational area is located ~32km (at its closest point) from the Oceanic Shoals Marine Park boundary, and ~60km (at its closest point) from the Joseph Bonaparte Gulf Marine Park boundary. The drilling project area is located ~43km (at its closest point) from the Oceanic Shoals Marine Park boundary, and ~87km (at its closets point) from the Joseph Bonaparte Gulf Marine Park boundary. A brief description of any planned aspects of the activity within or that may impact on the values of an Australian Marine Park No planned aspects of the activities are expected to impact on values of any Australian Marine Park. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	20/06/2022	Email/ Letter from Stakeholder	Stakeholder thanked INPEX for providing the opportunity to comment on the summary of proposed actions for relating to proposed Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin GHG21-1, which may consist of the following three environment plans: Exploration Drilling Bonaparte Basin Environment Plan 3D Seismic Bonaparte Basin Environment Plan Geophysical/Geotechnical Site Survey Bonaparte Basin Environment Plan. Based on the information provided, stakeholder noted that part of the proposed acreage is located in Oceanic Shoals and near the Joseph Bonaparte marine parks, which form part of the North Marine Park Network. Further information provided has identified the proposed operational areas within GHG21-1 are: 32km (at its closest point) from the Oceanic Shoals Marine Park boundary and 60km (at its closest point) from the Joseph Bonaparte Gulf Marine Park boundary for the seismic activity. 43km (at its closest point) from the Oceanic Shoals Marine Park boundary and 87km (at its closets point) from the Joseph Bonaparte Gulf Marine Park boundary for the drilling activity. In accordance with the Management Plan, mining operations (excluding the construction and operation of pipelines) are not allowed in Habitat Protection Zones, Recreational Use Zones, National Park Zones or Sanctuary Zones. Mining operations are defined in the Management Plan (aligning with Section 355 [2] of the EPBC Act), being: a) operations or activities connected with, or incidental to, the mining or recovery of minerals or the production of materials from minerals, including: - prospecting and exploring for minerals; and -milling, refining, treatment and processing of minerals; and - storage and disposal of minerals and materials produced from minerals; b) the construction and use of towns, camps, dams, pipelines power lines or other structures for the purposes of operations or activities described in paragraph a); c) the performance of any other work for the purposes of operations or activities described in paragraph a). The North-west Marine Park Network Management Plan (management plan) came into effect in 2018 and provides further information on values for Montebello Marine Park. The management plan allows for mining authorisation to be given through a class approval for the Multiple Use Zone of the Oceanic Shoals Marine Park. The class approval requires an accepted Environment Plan (EP) under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009. You need to be aware of your obligations under the class approval (including conditions). Please note, NOPSEMA is the assessor of environmental management arrangements for activities authorised by the class approval. To assist in the preparation of an EP for petroleum activities in an Australian marine park, NOPSEMA has worked closely with Parks Australia to develop and publish a guidance note that outlines what titleholders need to consider and evaluate. In preparing the EP, you should consider all activities associated with the operation of the program. To take into account Australian marine parks, titleholders are expected to consider the impacts and risks of activities in the context of the management plan objectives and values. This includes the representativeness of the relevant values and the activity footprint on the representative area of the Australian marine park. INPEX should ensure that the EP: Identifies and manages all impacts and risks on Australian marine park values (including ecosystem values) to an acceptable level and has considered 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. Australian marine park values are broadly defined into four categories: natural, cultural, heritage and socio-economic. Specific values for the Ocean Shoals and Joseph Bonaparte marine parks that occur within the proposed operational area include (but are not limited to): Pinnacles of the Bonaparte Basin key ecological feature. Biologically important areas such as foraging areas and migration pathways for the Flatback, Loggerhead (vulnerable) and Olive Ridley (vulnerable) turtles. Noting the values present within and adjacent to the proposed operational area, we make the following claims and objections, that INPEX provide DNP: Further detail regarding the identification and management of risks to natural values, including, but not limited to, the Flatback, Loggerhead and Olive Ridley turtles which are present and display behaviours including foraging and migration within the acreage and proposed operational areas. Matters addressed should include activity timing, cumulative impacts with other known activities within the region, noise interference, vessel disturbance and light pollution. Confirm that equipment would be stowed (such as seismic streamers) when entering and exiting the operational area within the Oceanic Shoals Marine Park to minimise potential impact. Providing this information will enable DNP to finalise any claims and objections and ensure adequate consultation has occurred with the DNP as a 'relevant person' under the OPGGS Act. Emergency responses: The DNP should be made aware of oil/gas pollution incidences which occur within a marine park or are likely to impact on a marine park as soon as possible. Notification should be provided to the 24 hour Marine Compliance Duty Officer on 0419 293 465. The notification should include: titleholder details time and location of the incident (including name of marine park likely to be effected) proposed response arrangements as per the Oil Pollution Emergency Plan (e.g. dispersant, containment, etc.) confirmation of providing access to relevant monitoring and evaluation reports when available; and contact details for the response coordinator. Note that the DNP may request daily or weekly Situation Reports, depending on the scale and severity of the pollution incident.	N/A	Relevant matter raised	INPEX provided all requested information to DNP INPEX will ensure the EP Identifies and manages all impacts and risks on Australian marine park values (including ecosystem values) to an acceptable level and has considered all options to avoid or reduce them to as low as reasonably practicable. INPEX will clearly demonstrates that the activity will not be inconsistent with the management plan. The DNP will be made aware of oil/gas pollution incidences which occur within a marine park or are likely to impact on a marine park as soon as possible. Notification will be provided to the 24 hour Marine Compliance Duty Officer.

	STAKEHOLDER	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit	INPEX response or actions
		23/06/2022	Email/Letter to Stakeholder from INPEX	INPEX thanked stakeholder for below email. INPEX notes that you have requested further information on the following: Further detail regarding the identification and management of risks to natural values, including, but not limited to, the Flatback, Loggerhead and Olive Ridley turtles which are present and display behaviours including foraging and migration within the acreage and proposed operational areas. Matters addressed should include activity timing, cumulative impacts with other known activities within the region, noise interference, vessel disturbance and light pollution. Confirm that equipment would be stowed (such as seismic streamers) when entering and exiting the operational area within the Oceanic Shoals Marine Park to minimise potential impact. Please see below responses as applicable to each of the activities/environment plans (EPs). Drilling and Pre-drill Geophysical/Geotechnical survey activities Please find attached Draft EPs for the Exploration Drilling and Pre-drill Geophysical/Geotechnical Survey, which include the information requested in item 1 above for these activities. A summary of where relevant information can be found in each of the EPs is provided in a table below. INPEX understands that item 2 of the request is specific to the proposed 3D marine seismic survey. Note, the Drilling and Pre-drill Survey EPs are in the process of being finalised and will be submitted once the permit is formally awarded. To facilitate the process and close consultation on these two EPs, INPEX kindly requests that any feedback on the supplied information is provided by 8 July 2022. INPEX included a table which details relevant EP sections to find the following information: - Key ecological features including the Pinnacles of the Bonaparte Basin (EP Section 4.2) -Australian marine park values (Section 4.3) Marine fauna including marine turtles: covering biologically important areas/critical habitats, nesting, migratory and foraging behaviours and the timing/locations of such behaviours are described for each individual turtle species. (Section 4.7.4) - Impact and risk assessment including noise, light pollution and vessel disturbance (interaction with marine fauna) for the identified values and sensitivities defined in Section 6.2 of the EP. These receptors include benthic primary producer habitat, regionally important areas of high diversity, EPBC listed threatened and migratory species and BIAs, which align with AMP values including ecosystem values. (Section 7) - Emergency conditions risk assessment for an unplanned vessel collision spill with respect to the identified values and sensitivities (Section 6.2) which align with AMP values including ecosystem values. (Section 8). <u>Proposed 3D Marine Seismic survey</u> The 3D Marine Seismic Survey EP is currently under development and is not available to send at this time. As with the Drilling and Pre-Drill Survey EPs, INPEX will provide the EP and summary table to the DNP once drafted. INPEX anticipates this will be possible in early-July. INPEX can confirm that all equipment will be stowed if transiting through the Oceanic Shoals Marine Park is required and that this will be noted in the EP. INPEX acknowledges that consultation with the DNP for this activity/EP remains open, until the requested information has been provided. <u>Emergency response</u> INPEX has developed a single oil pollution emergency plan (the INPEX Browse Regional Oil Pollution Emergency Plan) to cover its activities in the Canning (offshore), Browse and Bonaparte basins. The requirement to notify the DNP (including information requirements, contacts and timing) in the event of spill impacting on a marine park is incorporated in the INPEX Browse Regional Oil Pollution Emergency Plan.	Yes - Draft EPs for the Exploration Drilling and Pre-drill Geophysical/Geotechnical Survey	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
		22/07/2022	Email/Letter to Stakeholder from INPEX	INPEX followed up on previous email to confirm whether the additional information provided by INPEX addresses the matters raised by DNP with respect to the proposed drilling and pre drill geophysical/geotechnical survey activities.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
		27/07/2022	Email/ Letter from Stakeholder	DNP thanked INPEX for the response to the claims and objections raised. DNP notes that further information has been provided as requested below, particularly those that may impact upon marine fauna. DNP advised INPEX note that DNP cannot see cumulative impacts having been addressed in respect to other GHG and petroleum activities that may be occurring within the proposed activity timeframes. Where applicable, this may include identifying any concurrent activities and mitigating impacts upon values that are present in the nearby marine parks. This request is consistent with the Director of National Parks' consultation response to the 2021 GHG release – that activities within this acreage would need to address cumulative impacts, noting the proximity of petroleum and GHG acreages and actives adjacent / near this acreage.	N/A	Relevant matter raised	DNP's comment regarding missing information on cumulative impacts relates to the exploration drilling and pre-drill geophysical/geotechnical survey response, not to the seismic survey for which a response has not yet been provided. The 3D MSS EP will address cumulative impacts and a response relating to the 3D MSS will be provided to DNP.
		28/07/2022	Email/Letter to Stakeholder from INPEX	INPEX thanked DNP for email on 27/07/2022. INPEX provided information by way of an update and confirmed the necessary amendments will be made to the draft EPs to consider the potential or cumulative impacts. INPEX outlined which permits overlap or are adjacent to the project area. INPEX provided a table summarising indicative activities for the periods covered by the draft INPEX EPs (2023-2028) in respect to petroleum or GHG activities that may occur or have the potential to occur within the listed permits. INPEX advised there are no current operating petroleum assets in proximity to the project area with the closest production facility located approximately 100 km south (ENI Blacktip). Based on this distance and the oceanic currents, discharge plumes associated with the production facility and INPEX's exploration drilling activities in the project area will not overlap. Similarly, potential disruption associated with vessel and MODU presence (light, noise and potential for vessel strike) is not expected given the distance. Other known exploration activities that are expected to occur within the same timeframe include exploration drilling in WA-488-P approximately 100 km south of the project area at its closest point. As described in the Beehive-1 exploration drilling EP, the duration of this activity is currently anticipated to last between 55 and 90 days and based on the title workplan is expected to be completed by mid-2023 (NOPTA NEATS database). If the timing of the Beehive-1 exploration drilling were to overlap with INPEXs exploration drilling activities in the project area, as per the above description of the Blacktip facility, given the distance between WA-488-P from the project area, no cumulative impacts are expected to occur. The draft Exploration Drilling EP will be amended to include an assessment of potential cumulative impacts associated with any proposed petroleum/GHG activities with a particular focus on those permits that either overlap or are adjacent to the project area. This will include but not be limited to the potential for discharge plumes to overlap, physical presence and light and noise impacts. Consideration will be given to the potential for both spatial and temporal cumulative impacts to sensitive receptors. With respect to the Pre-drill Geophysical/Geotechnical Survey EP, given the short duration of the survey and lack of significant sources of discharges, above that of any other standard vessel operating offshore such as fishing vessels, It is not considered there would be any potential for cumulative impacts to occur. INPEX trusts this information will satisfy DNPs request and INPEX is happy to discuss any matters further. Separately, INPEX is intending to provide the Seismic EP to the DNP shortly. INPEX apologised for the delay.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
		28/07/2022	Email/ Letter from Stakeholder	DNP notes the information provided below regarding activities in the vicinity to the proposed activity and that the risk of cumulative impacts will be addressed in the environment plan. The Director of National Parks has no further claims and objections at this time.	N/A	No relevant matters raised	No relevant matters raised
		5/08/2022	Email/Letter to Stakeholder from INPEX	INPEX followed up to last email sent to stakeholder and provided more information on the following in relation to the proposed 3D marine seismic survey EP: 1. Further detail regarding the identification and management of risks to natural values, including, but not limited to, the Flatback, Loggerhead and Olive Ridley turtles which are present and display behaviours including foraging and migration within the acreage and proposed operational areas. Matters addressed should include activity timing, cumulative impacts with other known activities within the region, noise interference, vessel disturbance and light pollution. 2. Confirm that equipment would be stowed (such as seismic streamers) when entering and exiting the operational area within the Oceanic Shoals Marine Park to minimise potential impact. Inpex attached the Draft EP for the 3D marine seismic survey. INPEX provided a table summarising where relevant information can be found in each of the EPs. In addition, please note that cumulative seismic impacts (relating to underwater noise produced by other seismic surveys) have been assessed in Section 7.3 of the EP. For other aspects of the activity (e.g. light, vessel disturbance) there are no other activities in proximity to the seismic survey that will result in cumulative impacts. No activities are planned within the Oceanic Shoals Marine Park and INPEX can confirm that all equipment will be stowed if transiting through the Oceanic Shoals Marine Park is required. <u>Emergency response</u> INPEX has developed a single oil pollution emergency plan (the INPEX Browse Regional Oil Pollution Emergency Plan) to cover its activities in the Canning (offshore), Browse and Bonaparte basins. The requirement to notify the DNP (including information requirements, contacts and timing) in the event of spill impacting on a marine park is incorporated in the INPEX Browse Regional Oil Pollution Emergency Plan. To facilitate the process and close consultation on this EP, INPEX requested that any feedback on the supplied information is provided by 19 August 2022.	Yes - Draft EP for the 3D marine seismic survey	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
		16/08/2022		INPEX advised the DNP they had been granted the greenhouse assessment permit (G-7-AP) and followed up on when			
		17/08/2022	Email/ Letter from Stakeholder	The DNP noted the information further information provided and commitments to address the envrionmental receptors in the environment plan, and confirmed that DNP had no further claims and objections.	N/A	No relevant matters raised	No relevant matters raised
	Department of Agriculture, Water and Environment (DAWE)	17/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX

STAKEHOLDER	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit	INPEX response or actions
	21/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	10/04/2022	Email/ Letter from Stakeholder	Email response from stakeholder requesting INPEX provide information on what interactions the project vessels/installations will have with domestic vessels during the proposed activities and how they will be managed.	N/A	Request for information (no objection	Request for information (no objection of claim raised)
	11/04/2022	Email/ Letter from Stakeholder	In addition to previous email, stakeholder requested INPEX populate the attached assessment questions.	Yes - assessment questions document	Request for information (no objection	Request for information (no objection of claim raised)
	10/06/2022	Email/Letter to Stakeholder from INPEX	INPEX thanked stakeholder for response to notice issued in March. INPEX outlines that with the Environmental Plan yet to be finalised and accepted by the regulator, INPEX is yet to award a contract for this program. As a consequence, the details the stakeholder has requested cannot be provided at this time, however INPEX commits to providing all requested information at least 4 weeks prior to the commencement of activities.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Department of Biodiversity Conservation and Attractions (DBCA) - Environmental Management Branch (WA)	23/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS). INPEX advised they will refer to the Commonwealth Department of Agriculture, Water and the Environment's National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds for managing potential impacts of light pollution on marine fauna and will refer to the guideline when developing the risk assessment and controls adopted. INPEX inquired whether the current DBCA Kimberley office phone number on the INPEX Australia Emergency contacts list can continue to be used. INPEX advised they will include this notification requirement within the Notifications section of INPEX's OPEP for this activity Advised that within INPEX's OPEPs, it is acknowledged that any spill/impact to WA/NT waters/shorelines is managed in accordance with relevant state/territory management plans and INPEX acknowledges that any DBCA involvement in oiled wildlife response within State waters will only be under the direction of the relevant Control Agency. Advised that as required under the OPGGS Act and associated regulations, INPEX maintains financial assurance against oil spill events, ensuring adequate cost-recovery associated with oil spill response. Outlined that INPEX includes monitoring of impacts, and determination of secondary response actions including shoreline clean-up and oiled wildlife response, and ongoing scientific monitoring post response termination, as part of all INPEX OPEPs. This includes all potentially impacted WA/NT waters/shorelines, including all DBCA interests.	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	12/04/2022	Email/ Letter from Stakeholder	Stakeholder thanked INPEX for providing information in relation to INPEX's upcoming activities in exploration permit GHG21-1 within Commonwealth waters. Based on the documentation provided for review and other readily available information, DBCA has no comments in relation to its Conservation and Land Management Act 1984 and Biodiversity Conservation Act 2016 related responsibilities, beyond that previously provided to INPEX in relation to other petroleum related activities as acknowledged below. Stakeholder confirmed the phone number for the DBCA Kimberley office and requested INPEX continue to use this number for regional communication with DBCA. Provided email address for INPEX to continue to provide all future notifications.	N/A	No objection/claim raised	No objection/claim raised
Department of Defence (DoD)	6/04/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS). INPEX advised they will refer to the Commonwealth Department of Agriculture, Water and the Environment's National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds for managing potential impacts of light pollution on marine fauna and will refer to the guideline when developing the risk assessment and controls adopted. INPEX inquired whether the current DBCA Kimberley office phone number on the INPEX Australia Emergency contacts list can continue to be used. INPEX advised they will include this notification requirement within the Notifications section of INPEX's OPEP for this activity Advised that within INPEX's OPEPs, it is acknowledged that any spill/impact to WA/NT waters/shorelines is managed in accordance with relevant state/territory management plans and INPEX acknowledges that any DBCA involvement in oiled wildlife response within State waters will only be under the direction of the relevant Control Agency. Advised that as required under the OPGGS Act and associated regulations, INPEX maintains financial assurance against oil spill events, ensuring adequate cost-recovery associated with oil spill response. Outlined that INPEX includes monitoring of impacts, and determination of secondary response actions including shoreline clean-up and oiled wildlife response, and ongoing scientific monitoring post response termination, as part of all INPEX OPEPs. This includes all potentially impacted WA/NT waters/shorelines, including all DBCA interests.	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	17/05/2022	Email/Letter to Stakeholder from INPEX	INPEX thanked stakeholder for taking time to meet with INPEX. Followed up on a point made in meeting, outlining that the overall project schedule has been revised very recently to reflect the potential for a marine seismic campaign in Q2 2023. Attached high level schedule to email.	Yes- High level schedule	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	27/05/2022	Email/Letter to Stakeholder from INPEX	INPEX thanked stakeholder for their time on the 17th May to discuss INPEX's proposed assessment program in the NAXA as described in the fact sheet provided to Defence on 6th April 2022. INPEX acknowledged from the meeting that current plans for military exercises include: - Operation Kakadu - September 2022, and - Operation Talisman-Sabre - mid 2023 (major international activity over a much roader spatial area). Both are likely to include patrol boats and live firing exercises. INPEX acknowledged stakeholders request to provide as much advance notice as possible for any planned activities by INPEX or contractors in the NAXA (i.e. five to six weeks' notice was suggested). To help manage the water space, INPEX will also provide advance details in relation to the nature and scale of the activities including vessel size, Mobile Offshore Drilling Unit (MODU) location, and for the proposed seismic survey, also include the length of the seismic vessel streamers, approximate water depth, noise levels (frequencies) and proposed dates for scheduled activity. INPEX recognises these activities are contingent upon a successful bid for acreage GHG 21-1, which is due for determination in the coming weeks.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	31/05/2022	Email/ Letter from Stakeholder	Stakeholder thanked INPEX for email. In addition to the two listed major activities below will Exercise Singaroo conducted immediately following Kakadu in the same areas and will also include live firings. For the Patrol Boats, they regularly conduct training in the NAXA area that includes live firings however these are not usually programed until six to eight weeks prior and will be included in the NOTAMs that were mentioned during the meeting and recommend these are checked regularly (they are a weekly document).	N/A	Relevant matter raised	INPEX notes major defence activities, and will check NOTAMS regularly

STAKEHOLDER	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit	INPEX response or actions
Department of Infrastructure, Planning and Logistics - Transport - Marine Safety Branch (DIPL) (NT)	14/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Department of Mines, Industry Regulation and Safety (DMIRS) (WA)	21/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	29/04/2022	Email/Letter from stakeholder	Acknowledgement of receipt. DMIRS notes that the proposed activity will be assessed under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 and regulated by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA). DMIRS has reviewed the notification and does not require any further information at this stage. DMIRS requested INPEX provide pre-start notification confirming the start date of the proposed activity and a cessation notification to inform DMIRS upon completion of the activity. DMIRS provided contact details (email address) for notification to be sent to. DMIRS advised INPEX see the Consultation Guidance Note for information pertaining to the reporting of incidents that could potentially impact on any land or water under State jurisdiction.	N/A	Relevant matter raised	INPEX will provide pre start notification to DMIRS confirming the start date and end date of proposed activity. INPEX has made note of the consultation guidance note.
Department of Primary Industries and Regional Development (DPIRD) - Aquatic Environment section (WA)	17/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Department of Primary Industries and Regional Development (DPIRD)	14/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	14/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet resent to stakeholder as stakeholder was on leave, asking for best contact details to re-direct to.	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Department of Primary Industries and Regional Development (DPIRD) - Fisheries data	16/02/2022	Email/Letter to Stakeholder from INPEX	Email sent to DPIRD with attached fisheries data request. INPEX requested DPIRD confirm that the request and licence agreement include all of the details needed and INPEX will sign and send through as a PDF final.	Yes - Fisheries data request	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	25/02/2022	Email/Letter to Stakeholder from INPEX	Email sent to DPIRD requesting to confirm that the data request sent on February 16th has been received. Requested that if the details of the request are sufficient, DPIRD advise, and INPEX can sign the licence agreement.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	31/03/2022	Email/ Letter from Stakeholder	Response received. DPIRD apologised for delay in response and explained that DPIRD has been working on refreshing FishCube data as a priority and it has delayed the process of data requests. DPIRD queried if INPEX still require the data for this data request.	N/A	No objection/claim raised	No objection/claim raised
	31/03/2022	Email/Letter to Stakeholder from INPEX	Response from INPEX informing DPIRD that the data is still needed. INPEX queries when they will receive the data and whether DPIRD require any agreements signed off.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	1/04/2022	Email/ Letter from Stakeholder	Stakeholder responded stating the data should be provided early next week. Advised that once DPIRD has the data they will let INPEX know if the agreement needs to be revised or not.	N/A	No objection/claim raised	No objection/claim raised
	1/04/2022	Email/ Letter from INPEXEmail/Letter to Stakeholder from INPEX	INPEX thanked stakeholder for response	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	8/04/2022	Email/ Letter from Stakeholder	Stakeholder advised that a signature is needed on the data licence agreement and requested INPEX to organise for it to be signed.	N/A	No objection/claim raised	No objection/claim raised
	10/04/2022	Email/Letter to Stakeholder from INPEX	INPEX responded advising they amended dates and signed as requested	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	12/04/2022	Email/ Letter from Stakeholder	Stakeholder sent email with attached fisheries data and data licence agreement. Advised that there are aquaculture sites active within the North Coast Bioregion but DPIRD cannot disclose more specific details of their locations or production due to privacy concerns.	Yes - Fisheries data	No objection/claim raised. Provision c	No objection/claim raised. Provision of data.
	14/04/2022	Email/Letter to Stakeholder from INPEX	INPEX thanked DPIRD for providing data and queried the following: Requested DPIRD clarify what 'Open Access' and FBL Condition 74' are? Do these relate to specific fisheries, or are they a standalone type of fishery/licence? The 5 year aggregate spreadsheets have the suffixes 'Daily' and 'Monthly'. INPEX is unsure what this means if it is a 5 year aggregate. Also, the monthly spreadsheet has the fishery set out by 60 NM blocks; Asked if it is possible to get this broken down to 10 NM scale, but advised will wait for your answer about the differences between these two spreadsheets in case I have misunderstood. Pilbara trap, Pilbara line, Pilbara crab, Open Access, Kimberley Gillnet and FBL Condition 74 data are all at the 60 NM scale. Queried if any of these are available in a smaller block size. If not, is this because the fisheries only report at the 60 NM level or is there some other confidentiality/restriction that prevents this? Regarding aquaculture, INPEX appreciates that some of this data cannot be shared. We INPEX is aware of the following two DPIRD datasets: Aquaculture sites (provided links); and Pearling leases and holding sites (provided links). Requested DPIRD confirm if these datasets include all existing sites? Or if this isn't possible, requested INPEX confirm that all sites are in State coastal waters (within the 3 NM limit)? As long as none are in Commonwealth waters in the Joseph Bonaparte Gulf, then INPEX shouldn't need any further information.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	14/04/2022	Email/ Letter from Stakeholder	DPIRD provided the following response to INPEX's queries: Open Access indicates catch that is not attributed to any particular managed fishery licence. FBL Condition 74 is a condition on some Fishing Boat Licences. In this case FBL Condition 74 is a Fish Trapping condition. The datasets were too large to fit in one spreadsheet so they had to be broken up. The 5 year aggregate ones were divided up by the fisheries that report monthly and those that report with Daily returns. Fisheries that report via monthly returns report via 60x60NM blocks. They do not report at the 10x10NM block scale only fisheries that submit daily returns do. See above Advised they can't view the links provided but when checked the aquaculture and pearling lease sites in our Corporate Map Portal (which are provided by our GIS section) confirm that there are no aquaculture sites or pearl leases in the Joseph Bonaparte Gulf and that aquaculture/pearling sites will only be seen beyond the 3NM boundary from Broome westwards.	N/A	No objection/claim raised. Provision c	No objection/claim raised. Provision of information.
Department of Transport (WA)	8/06/2022	Email/Letter to Stakeholder from INPEX	As part of consultation requirements under INPEX's EP, INPEX sent attachment of INPEX's Browse Regional OPEP, which is now accepted by NOPSEMA, and replaces all previous INPEX OPEPs for petroleum activities in commonwealth waters.	Yes - INPEX's Regional Browse OPEP	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX

	STAKEHOLDER	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit	INPEX response or actions
		17/06/2022	Email/ Letter from Stakeholder	Stakeholder thanked INPEX for sending through the Browse Regional OPEP (BROPEP). Stakeholder noted they appreciate that while consultation was done with the Department of Transport during the development of this, they don't believe that they have yet had the chance to review the BROPEP in full. Given the significance of this BROPEP the stakeholder would like to take the opportunity to conduct a review of this document and will let INPEX know if they have any queries on it	N/A	No objection/claim raised	No objection/claim raised
		20/06/2022	Email/Letter to Stakeholder from INPEX	INPEX informed stakeholder they are ok with them undertaking a review of the BROPEP. INPEX informed stakeholder that the BROPEP is now INPEX's single OPEP, replacing all the other OPEPs INPEX currently has. Any comments/items raised by WA DoT can/will now be readily addressed through revisions to the single document – so this process will be much more efficient. Also, as a matter of courtesy, any feedback on the BROPEP from WA DoT (as relevant), will be provided to Shell, as Shell are adopting the BROPEP for their offshore northern WA activities as well. INPEX has been updating Shell with INPEX's recent correspondence with AMSA etc – in INPEX's effort to standardise INPEX's plans and reduce the external stakeholder consultation burden. As discussed, INPEX also looks forward to working on some Tactical Response Plans for the region, including INPEX's initial list of the following key offshore locations: Scott Reef / Seringapatam Reef Rowley Shoals (Clerke and Imperious being WA DoT jurisdiction) Adele Island Lacapede Islands	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
		22/07/2022	Email/ Letter from Stakeholder	Stakeholder thanked INPEX for providing DoT WA with the INPEX Browse Regional OPEP (X060-AH-PLN-70009), Rev 2 (BROPEP) which has been accepted by NOPSEMA. The stakeholder has undertaken a review and attached a document with comments generated from this. Stakeholder outlined that a number of these comments are most likely around the fact that the detail that we would normally look at has not been presented to us in the usual format (and is not in this document). Given that this BROPEP is in a different format, if INPEX would like to have a discussion on how this can be addressed going forward, Stakeholder requested INPEX let them know. Stakeholder outlined it is important that we are informed so that we can ensure that risk to the State is managed accordingly.	Yes - DoT review of Browse regional OPEP	Relevant matter raised	INPEX will update Browse regional OPEP to take into consideration DoT's comments.
		28/07/2022	Email/Letter to Stakeholder from INPEX	INPEX thanked Stakeholder for taking the time to review the BROPEP document. INPEX appreciates the external review and Stakeholders comments will certainly help to improve the document. Before responding formally, INPEX would appreciate an opportunity to have a discussion to clarify some of the DoT's comments. INPEX proposed a time to meet with Stakeholder. A few key things: As Stakeholder identified, a good chunk of Stakeholders comments can be addressed by simply sharing the rest of the BROPEP supporting documentation. INPEX can talk Stakeholder through where all of that is addressed. All the various comments regarding updating to latest WA DoT OSCP etc, easily addressed, especially now INPEX has one plan (not 8+). As a general matter of principle, given the 'collaborative' approach APPEA is driving, INPEX would like to have the session with Stakeholder, agree the updates to be made, and then share that feedback with Shell, such that their version of the BROPEP can be appropriately revised to also addressed your feedback (save WA DoT from having to do this twice).	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
		3/08/2022	Email/ Letter from Stakeholder	Stakeholder thanked INPEX for response and agreed to meet. Stakeholder requested to hold off post-exercise.	N/A	No relevant matter raised	No relevant matter raised
	National Offshore Petroleum Titles Holder	21/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
		22/03/2022	Email/ Letter from Stakeholder	Confirmation of receipt.	N/A	N/A - General Correspondence only	N/A - General Correspondence only
	NT Pollution	16/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	Northern Territory Government - Chief of Staff to the Deputy Chief Minister	22/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	NT Gov	16/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	NT Minister	16/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX

STAKEHOLDER	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit	INPEX response or actions
NT Environmental Protection Authority (EPA)	14/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	14/03/2022	Email / letter from Stakeholder	Confirmation of receipt. Stakeholder referred email for consideration by the Environment Division of the Department of Environment Parks and Water Security acting on behalf of the NT EPA.	N/A	No objection/claim raised - general correspondence only	No objection/claim raised - general correspondence only
NT Department of Industry, Tourism and Trade (DITT) - Fisheries	14/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	29/03/2022	Email/ Letter from Stakeholder	Stakeholder thanked INPEX for the opportunity to provide comment on the proposed Offshore Greenhouse Gas Storage Exploration and Assessment activities in the Bonaparte Basin. Noted that the permit area is contained primarily within NT waters and consequently there are Northern Territory commercial fisheries operating within the area. Advised it should be noted that the stock structure of many commercially and recreationally important fish species is not well understood and any potential impact on aquatic life within the permit area, as a result of this work, could potentially negatively impact on fish stocks across the NT or those shared stocks that straddle the WA/NT border. Outlined that the NT Fisheries is particularly concerned about potential impacts from any seismic exploration conducted as part of the assessment. To date, valuable research work conducted into this matter has resulted in a greater understanding of the range of potential impacts to fish from seismic, including impacts to audio organs, larval survival and other varying spatial and temporal impacts. Whilst our understanding of the impacts of seismic testing on fisheries is improved, several areas of concern remain. Stated that the NT Fisheries understands and acknowledges that seismic surveying is a key component of oil and gas exploration and is often fundamental to this development in the marine environment. However, requested that any seismic work necessary to be undertaken through this assessment, does not occur within the warmer months of the year which generally coincide with many tropical fish species spawning seasons. Provided contact details (Phone number) to contact Fisheries division within Department of Primary Industry and Fisheries, for further information.	N/A	Relevant matter raised	INPEX notes that NT commercial fisheries operate within proposed area. INPEX has sought clarification regarding fish spawning periods.
	29/03/2022	Email/Letter to Stakeholder from INPEX	INPEX thanked stakeholder for providing feedback. Outlined that INPEX is seeking to better understand potential impacts and would like to further discuss Stakeholders concern. INPEX requested stakeholder provide more specific detail and what they mean by warmer months, and whether this indicated a period of 6 months or potentially only one to two months. INPEX inquired whether data request previously lodged with DITT will be made available soon in preparation for the potential impact assessment within the EP, and to investigate optimal timeframes for the survey (referring to attached email which includes a copy of the fact sheet and fisheries data request). INPEX noted that the NT Seafood council advised that Development Fishery licence holder may be active in the area, and requested DITT advise whether the licences are still active or if the NT fisheries are looking to transition the development licence holders into a fishery. Included table outlining fisheries data request.	Yes - Email sent to DITT on 14/03/2022	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	30/03/2022	Email/ Letter from Stakeholder	Stakeholder thanked INPEX for email Advised that the warmer months referred to is the period from about September until the end of March. Given there are a range of tropical species that spawn during this period the actual spawning window is quite protracted (6 months). Advised that the best option from NT Fisheries point of view would be to conduct the 6-10 week seismic survey soon after the wet season ends (and spawning ceases) i.e. from March/April onwards. Advised that conducting the survey later in the year (September onwards) would potentially lead to negative impacts on fish stocks just prior to a spawning event and therefore should be avoided where possible. In relation to the requested data, DITT stated they have forwarded it to the Licensing area who will add the licence holder contact details and then on-forward all the data to INPEX. As for Development Fishery licences, DITT advised that the only current one is the small pelagic. Outlined that Specific information on this licence has been provided within the data request. Requested INPEX note, there is a strong likelihood that this development licence will transition to a stand-alone fishery in the future. No other development licences are current, although NT Fisheries do periodically receive applications for a development permit/licence that we consider on a case-by case basis. Stakeholder outlined they were not copied into your email of 14 March.	N/A	Relevant matter raised	Potential impacts to commercial fish stocks, including spawning and recruitment, have been assessed in the EP. The potential risk has been assessed as low given the small proportion of the stock area and spawning period when disturbance may occur, and given natural variability in spawning and recruitment. The 3D MSS is provisionally expected to be conducted in Q2 2023, which will avoid the peak spawning period; however, an exact start date is subject to vessel availability, operational efficiencies, and weather, other site survey and drilling activities that INPEX plan to undertake within the permit area, as well as potential Department of Defence exercises that may occur. Given the low risk to commercial fish stocks, and the above mentioned scheduling uncertainties, INPEX does not consider it practicable to commit to undertaking the 3D MSS outside of the September to March peak spawning period.
	30/03/2022	Email/Letter to Stakeholder from INPEX	INPEX thanked stakeholder for the feedback. Thanked stakeholder for forwarding on the info to the Licensing area. INPEX apologised for not copying in stakeholder, outlined which email address INPEX had been using for the request and stated INPEX will update my contact register for future engagement so stakeholder is not missed.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	31/03/2022	Email/ Letter from Stakeholder	DITT attached fisheries data as requested. Outlined that due to low licence numbers operating in some of these fisheries, much of the catch information is confidential. Effort data has been provided to give an indication of the relative importance of a grid to the fishery. Requested INPEX let DITT know if they would like to revisit this data and amalgamate catch across years in an effort to remove some of the confidentiality issues. DITT provided attached an update on potential merger of TRF and NT Demersal and how this will affect management areas and access. Refer to attached update DITT provided details of the small pelagic gear type, target species, number of licence holders and location. DITT outlined that the Pearl Oyster Fishery is still operating as well as the jigging fishery with one active licence in the Jigging Fishery.	Yes - Fisheries data request, licence holder contact details, data sharing agreement, update on potential merger of TRF and NT Demersal.	No objection/claim raised. Provision c	N/A - General Correspondence only
	31/03/2022	Email/ Letter from Stakeholder	Stakeholder re-sent email without final data agreement which will be sent separately.	Yes - Fisheries data request, licence holder contact details, update on potential merger of TRF and NT Demersal.	N/A - General Correspondence only	N/A - General Correspondence only
	12/04/2022	Email/Letter to Stakeholder from INPEX	INPEX thanked DITT for sending through the data and information. INPEX reviewed data and asked the following questions: 1)INPEX notes that the Jigging Fishery has reported effort in 60 nautical mile block 1229, overlapping INPEX's proposed activities. There does not appear to be information on this fishery on the department's website. INPEX requested DITT confirm the following information so that INPEX has an understanding of theses fishing activities: Fishing licence area Key target/indicator species Gear type – presumably just jigs 2)INPEX queried how the A14 small pelagic development fishery and the A17 jigging fishery differ from the A19 Small Pelagic Fish & Squid Fishery Licence? 3)There are a great many other fisheries and licence types listed in the 'Licence type description.csv' file that DITT provided that are not on the department's website and some that INPEX were not previously aware of. INPEX requested DITT confirm if any of the other licence types (additional to those DITT have already provided data for) have 2016 – 2020 fishing effort that overlaps the location of our proposed activities? (this includes parts of 60 nm blocks 1228, 1229, 1328 and 1329.) 4)INPEX queried If the data is available in a better resolution than the 60 nm blocks? For example, 10 nm blocks. INPEX appreciates that this scale will return more confidential results, but it is fishing effort that INPEX are primarily interested in, not catch. INPEX queried If it is available, how long would DITT need to be able to provide the data?	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX

STAKEHOLDER	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit	INPEX response or actions
	12/04/2022	Email/ Letter from Stakeholder	DITT provided answers and comments to INPEX questions as below: 1) Jigging Fishery Fishing licence area – all of AFZ Key target/indicator species - squid Gear type – presumably just jigs – squid jigs 2) The A19 is not yet a recognized fishery – therefore no effort. 3) The other licenses or permit types are either no longer active or are not active in the area of your proposed activities. 4) Data is available at 10 nm blocks for some fisheries (not all). It is worth noting however that reporting to 10nm blocks is not a standard reporting function from our database and the extraction therefore requires a level of GIS capability to extract via GPS coordinates. With current staff absences DITT would need until end of April before they could accommodate this request.	N/A	No objection/claim raised. Provision c	INPEX noted information provided
	14/04/2022	Email/ Letter to Stakeholder from INPEX	INPEX thanked stakeholder for response. INPEX responded that INPEX would like to go ahead with the request for the 10 NM block size data as this may make a significant difference to our assessments. If available at this scale, INPEX requested data for • Demersal Fishery • Timor Reef Fishery • Spanish Mackerel • Offshore Net & Line • Aquarium • Development - Small Pelagic • Pearl Oyster • Jigging fishery • Fishing Tour Operators In addition, if C2 pearl oyster culture industry licence is referring to pearl farm leases and holding sites in coastal waters, INPEX requested to get the locations of these sites, if possible.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	5/05/2022	Email/ Letter from Stakeholder	Stakeholder provided Subgrid data attached as requested. Stakeholder informed INPEX that catch data has been removed from the dataset (and replaced with 'NA') where less than 5 licences are operating within a Subgrid in a given year. Effort data is provided in its entirety. Additionally, Stakeholder attached a map of the fishery Subgrids and within each dataset provided the lat and long of each Subgrid centroid to assist in mapping of the data. To assist in INPEX's understanding of the C2 Pearl Oyster Culture Industry Licence, stakeholder included four maps depicting where known pearl leases occur within the NT. Stakeholder advised it should be noted that records pertaining to aquaculture leases and holding areas are not maintained by the Fisheries Division. Leases overlying the sub-tidal sea floor are issued and controlled by the Crown Lands Department and it may be better to contact them to ensure you get a comprehensive understanding of all leased areas in NT waters.	Yes – Subgrid data, map of fishery subgrids, maps of pearl leases in NT.	No objection/claim raised. Provision c	INPEX noted provided information.
NT Department of Industry, Tourism and Trade (DITT) - Agricbusiness and Aquaculture	22/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
NT Department of Industry, Tourism and Trade (DITT) - Mining and Energy	22/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Minister for Primary Industry and Resources	22/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Minister for Resources	22/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Business						
Australian Marine Oil Spill Centre (AMOSC)	14/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	8/06/2022	Email/Letter to Stakeholder from INPEX	As part of consultation requirements under INPEX's EP, INPEX sent attachment of INPEX's Browse Regional OPEP, which is now accepted by NOPSEMA, and replaces all previous INPEX OPEPs for petroleum activities in commonwealth waters.	Yes - INPEX's Regional Browse OPEP	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Australia Bay Seafoods Darwin	31/03/2022	Email / letter from Stakeholder	Stakeholder outlined that their sister company Westmore had received a letter from INPEX notifying them of the proposed activity. Stakeholder outlined that the proposed area of INPEXs exploration survey overlaps one of the stakeholders main fishing grounds that they work at all year. Stakeholder attached an overlay of the proposed area over their fishing grounds. Advised they have major concerns with this proposal area as they work in the area 52 weeks of the year. Requested INPEX get in contact to discuss their concerns.	Yes - Letter & Activity Fact Sheet	Stakeholder's concerns are in relation to the seismic survey, not exploration drilling.	INPEX noted stakeholder concerns

STAKEHOLDER	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit	INPEX response or actions
	31/03/2022	Email/ Letter to Stakeholder from INPEX	INPEX thanked stakeholder for reaching out and highlighting concerns INPEX inquired if the stakeholder could set up a meeting or phone call to discuss further.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	31/03/2022	Email / letter from Stakeholder	Stakeholder requested to talk over the phone on Monday.	N/A	No relevant matters raised	No relevant matters raised
	31/03/2022	Email/ Letter to Stakeholder from INPEX	INPEX confirmed phone call time, and requested a teams meeting to share more information.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	4/04/2022	Email/ Letter to Stakeholder from INPEX	INPEX thanked stakeholder for phone call. Stated INPEX understands there are limitations with scientific data on the impacts of Seismic surveys on fish. INPEX noted the following from the phone call conversation based on INPEX's questions. INPEX requested if these are accurate, would the stakeholder acknowledge, or provide feedback/comment if INPEX has misinterpreted anything. Overview INPEX has provided an overview that explained INPEX are currently in a competitive bid for the permit area and have no guarantee the proposed project will proceed. The permit is for carbon capture and storage assessment only and at this stage INPEX is only looking at preliminary studies. These consist of Exploration Drilling and a 3D Seismic survey. INPEX is working to prepare Environment Plans, inclusive of engagement, with the intent to submit for assessment shortly after permit award (assumed to be around July -August 2022). Best case planning currently estimates INPEX might be ready to complete the 3D Seismic survey in the period April-June 2023. How many vessels work the area? Australia Bay Seafoods has three main vessels that operate in the Fishery. Two of these are the larger trawlers (Ocean Harvest, NT Leader) and a smaller vessel the Australia Bay 2 (AB2). The Ocean Harvest and NT Leader tend to work in other areas that don't overlap the Proposed Operational area but the AB2 regularly fishes (i.e. 52 weeks per year doing 3 trips per month approx. 10 days each). To your knowledge there are no other licence holders using the area. Another Company lease a licence and have 4 other trawlers and a handful of trap fishing vessels but these usually fish to the North or East of the Proposed Operational area. There is some overlap of the Proposed Operational Area and the grounds targeted by the AB2. INPEX attached an image below indicating the overlap of the AB2 and the proposed area (Note INPEX would like to obtain further data from stakeholder to better understand this overlap given this image is only based on 4 months of vessel movement). What species do you target? The main species are Crimson Snapper and Saddletail snapper which make up Approx 85% of the annual catch. The areas targeted are based on bottom profile (as opposed to a certain depth profile). The AB2 does not use traps in the area. There are options to fish/trawl in alternative areas to avoid contact between vessels if they are on water at the same time. You have up to 5 years of data you can share that has breakdown of catch to 1km2 What communication is best? VSat is best for the Vessel masters when on water. Meetings/phone calls with yourself in the near term to discuss potential impacts, overlaps and a claim process for loss of catch, damaged equipment etc. INPEX attached a shapefile of proposed areas which may assist.	N/A	Relevant matters raised	INPEX has captured the information provided by the stakeholder in the impact assessment in the EP. Stakeholder and INPEX agreed to a further meeting/phone call to discuss potential impacts, overlaps and a claim process (adjustment protocol).
	27/04/2022	Email/Letter from INPEX to Stakeholder	Follow up email sent to stakeholder. Notified stakeholder that INPEX personnel will be in Darwin during May and requested to meet to discuss INPEX's proposed controls and provide an update on INPEX's risk assessments within the EP being drafted.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	27/04/2022	Email / letter from Stakeholder	Stakeholder advised they are refitting a vessel in Cairns, and will be in Cairns on 2nd May until 1st June.	N/A	No relevant matters raised	No relevant matters raised
	13/05/2022	Email/Letter from INPEX to Stakeholder	INPEX followed up on previous emails. INPEX advised they plan to develop a first draft Environmental Plan towards the end of the month. INPEX advised it will be in a position to share a draft Claims process with stakeholder at the end of the month as well. INPEX inquire whether stakeholder would like INPEX to set up a teams meeting, or potentially catch up in Darwin in July.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	13/05/2022	Email / letter from Stakeholder	Stakeholder responded that July suits for a catch up.	N/A	No relevant matters raised	No relevant matters raised
	1/07/2022	Email/Letter from INPEX to Stakeholder	INPEX replied they will be available to meet in Darwin Sunday 10th to 14th of July. INPEX attached first draft of proposed adjustment protocol for stakeholders consideration. INPEX outlined they would like to work through this document with stakeholder if they have time. INPEX queries (for budgeting purposes) what the approximate value in $ terms of the fishery or a range of recent annual catch in kg. This would be helpful for INPEX to understand the potential dollar value of any claim that may be raised, and the information would be kept confidential.	Yes - Draft adjustment protocol	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	7/07/2022	Email/Letter from INPEX to Stakeholder	INPEX called and left a message to follow up if stakeholder received previous emails regarding the Claim process. No response.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	13/07/2022	Email/Letter from INPEX to Stakeholder	INPEX thanked stakeholder for returning call. Meeting confirmed with Australia Bay seafoods to run through proposed amendments to claim protocol.	Yes - Draft adjustment protocol	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	25/07/2022	Meeting Between INPEX and Stakeholder	During the meeting Stakeholder advised that 95% of catch is obtained from a single vessel (Australia Bay 2) Average catch is 22-25 tonnes per 10 day trip. Usually does three trips per month to the North of the "Adjustment area". Stakeholder and INPEX discussed avoidance of each other as the primary control. Stakeholder requested that we give notice of proposed start location and timing 2 weeks prior to commencement and that on water location updates could be provided daily via VSAT to Stakeholder and to Australia Bay 2.	N/A	Relevant matter raised	Relevant matter raised - INPEX will provide notice of proposed start location and timing two weeks prior to commencement of activity. INPEX will provide on water location updates daily via VSAT to stakeholder and Australia Bay 2.
Arrow Pearls	18/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requested the following information: - Does the organisation have any pearl oyster fishing, holding or farming activities in Joseph Bonaparte Gulf overlapping or in proximity to the GHG21-1 permit area; - Does the stakeholder have any feedback or concerns about either of the proposed activities. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS). INPEX requested feedback and enquiries to be provided by 15 April 2022.	Yes - Activity fact sheet & Letter	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Chamber of Commerce NT (CCNT) (CEO)	22/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Clipper Pearls	18/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requested the following information: - Does the organisation have any pearl oyster fishing, holding or farming activities in Joseph Bonaparte Gulf overlapping or in proximity to the GHG21-1 permit area; - Does the stakeholder have any feedback or concerns about either of the proposed activities. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS). INPEX requested feedback and enquiries to be provided by 15 April 2022.	Yes - Activity fact sheet & Letter	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX

STAKEHOLDER	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit	INPEX response or actions
Cygnet Bay Pearls	18/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requested the following information: - Does the organisation have any pearl oyster fishing, holding or farming activities in Joseph Bonaparte Gulf overlapping or in proximity to the GHG21-1 permit area; - Does the stakeholder have any feedback or concerns about either of the proposed activities. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS). INPEX requested feedback and enquiries to be provided by 15 April 2022.	Yes - Activity fact sheet & Letter	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Willie Creek Pearls	18/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requested the following information: - Does the organisation have any pearl oyster fishing, holding or farming activities in Joseph Bonaparte Gulf overlapping or in proximity to the GHG21-1 permit area; - Does the stakeholder have any feedback or concerns about either of the proposed activities. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS). INPEX requested feedback and enquiries to be provided by 15 April 2022.	Yes - Activity fact sheet & Letter	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Maxima Pearls	18/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requested the following information: - Does the organisation have any pearl oyster fishing, holding or farming activities in Joseph Bonaparte Gulf overlapping or in proximity to the GHG21-1 permit area; - Does the stakeholder have any feedback or concerns about either of the proposed activities. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS). INPEX requested feedback and enquiries to be provided by 15 April 2022.	Yes - Activity fact sheet & Letter	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	18/03/2022	Email/ Letter from Stakeholder	Email from stakeholder stating for INPEX to go ahead with activities.	N/A	No relevant matters raised	No relevant matters raised
Darwin Port Operations Pty Ltd (a Landbridge company)	14/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	15/03/2022	Email/ Letter from Stakeholder	Stakeholder thanked INPEX for email. Stakeholder shared INPEX's email with leadership team and advised they will get back to INPEX with any questions.	N/A	No relevant matters raised	No relevant matters raised
Kimberley Land Council	17/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Neptune Energy	16/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Paspaley	18/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requested the following information: - Does the organisation have any pearl oyster fishing, holding or farming activities in Joseph Bonaparte Gulf overlapping or in proximity to the GHG21-1 permit area; - Does the stakeholder have any feedback or concerns about either of the proposed activities. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS). INPEX requested feedback and enquiries to be provided by 15 April 2022.	Yes - Activity fact sheet & Letter	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX

STAKEHOLDER	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit	INPEX response or actions
Pearl Producers Association of WA (PPAWA)	15/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities by 15th April 2022 and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Northern Land Council	1/04/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities by 15th April 2022 and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Northern Prawn Fishery Industry (NPFI)	8/03/2022	Email/Letter to Stakeholder from INPEX	Email sent to stakeholder advising INPEX will soon be preparing stakeholder engagement material for an area that may be of interest to the NPF. INPEX requested a phone call/ teams meeting with stakeholder during the week to understand any preferences NPF may have for meaningful consultation.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	14/03/2022	Email/Letter from INPEX to Stakeholder	Email sent to Stakeholder ahead of meeting. INPEX attached fact sheet and map showing potential overlap with NPF and sent through the following background information prior to the meeting: Overlap between the INPEX West Peron 3D MSS Operational Area and NPF activities in the JBG The INPEX West Peron 3D MSS Operational Area is located in water depths of approximately 65 m – 106 m. The INPEX West Peron 3D MSS Operational Area overlaps the boundary of the closure area, but does extend north into waters where fishing is permitted (see attached map). The INPEX West Peron 3D MSS Operational Area does not overlap any waters where low – high fishing intensity has occurred between 2010 and 2020. The Operational Area only overlaps waters where <5 vessels have fished during any year. Most fishing effort in the JBG has historically occurred >50 km south west of the Operational Area. INPEX would like to understand: Is there likely to be any NPF fishing effort at all near the Operational Area during the 1 April – 15 June banana prawn fishing season (to the north of the closure area) or are vessel unlikely to bother travelling to the JBG now given the closure over the main fishing grounds? If there is likely to be any fishing effort may occur there during the tiger prawn fishing season. Is there a map and/or breakdown of fishing catch and effort in the JBG (banana prawn and tiger prawn separated)? 2021 season catch and effort data might provide an indication of what effort may take place in the Operational Area in the coming years (if any). This data isn't yet available from ABARES.	Yes - Fact sheet & Map showing potential overlap with the NPF	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	15/03/2022	Email/Letter from Stakeholder	Email from stakeholder thanking INPEX for email and requesting to reschedule meeting.	N/A	No relevant matters raised	No relevant matters raised
	15/03/2022	Email/Letter from INPEX to Stakeholder	INPEX agreed and rescheduled meeting time.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	15/03/2022	Email/Letter from INPEX to Stakeholder	INPEX emailed stakeholder stating they have included the Seismic Shape file, permit area and Drilling Area.	Yes - seismic shapefile, permit area and Drilling area	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	15/03/2022	Email/Letter from Stakeholder	Stakeholder thanked INPEX for providing information	N/A	No relevant matters raised	No relevant matters raised
	28/03/2022	Email/Letter from INPEX to Stakeholder	INPEX thanked stakeholder for phone call to discuss fact sheet and questions. Requested stakeholder let INPEX know if they need any further information. Stated that if the catch data is available and INPEX has a resource spare to provide they will arrange for payment ASAP.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	5/04/2022	Email/ Letter from Stakeholder	Stakeholder provided response to INPEX's specific questions below: Is there likely to be any NPF fishing effort at all near the Operational Area during the 1 April – 15 June banana prawn fishing season (to the north of the closure area) or are vessel unlikely to bother travelling to the JBG now given the closure over the main fishing grounds? *There is now closure in place in the JBG sub-fishery for sustainability reasons from 1 December to 1 August the following year. This is the NPF's preferred time for any seismic activity in the JBG .* If there is likely to be any fishing effort may occur there during the tiger prawn fishing season. *Yes, given the above closure, there will be activity in the area during the tiger prawn fishery. Previous patterns of fishing activity in the proposed of activity area may well change/ expand during future tiger prawn seasons given the first season closure now in place.* Is there a map and/or breakdown of fishing catch and effort in the JBG (banana prawn and tiger prawn separated)? *I have attached the Shape files showing the shot data over 10 years. This is highly confidential and not for publication.* 2021 season catch and effort data might provide an indication of what effort may take place in the Operational Area in the coming years (if any). This data isn't yet available from ABARES. *The 2021 data is still being analysed by NPFI – this won't be available until toward the end of May.* Stakeholder reiterated the advice given in earlier conversation that NPFI does not support any activities by oil and gas companies being undertaken in the JBG during the period from 1 August and 1 December each year given this is the only time period in which NPF fishers can access the JBG fishery. Stakeholder stated they will be on leave and will arrange for invoice to be sent on return.	Yes – shapefiles showing shot data 2012-2021 for banana and tiger prawns	Relevant objection/claim raised	INPEX notes NPFI's request for activities to be undertaken in the JBG outside the period from 1 August and 1 December each year given this is the only time period in which NPF fishers can access the JBG fishery. However, based on historical fishing effort data and fishery publications, INPEX understands that exploration drilling will not be taking place in a location that is of particular significance for prawns (in terms of biology, recruitment) or for fishing activities. Fishing effort in this location has historically been very low or non-existent in some years. INPEX notes that there is a new closure in place for the banana prawn fishing season, but there is no apparent reason why this would affect tiger prawn fishing activities during the tiger prawn season. Given the limited potential for impact and low risk to the NPF, INPEX does not consider undertaking activities outside the period from 1 August and 1 December to be practicable.
	5/04/2022	Email/Letter from INPEX to Stakeholder	INPEX thanked stakeholder for response.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	12/04/2022	Email/Letter from INPEX to Stakeholder	INPEX acknowledged that the data provided is confidential and informed stakeholder that it will not be included in the EP. However, the maps will be included with records of correspondence, which gets submitted to NOPSEMA with the EP in a 'Sensitive Information Report'. INPEX informed the stakeholder that this is viewed only be NOPSEMA, not published, so the content remains confidential. INPEX also noted stakeholders comments about the closure in place in the JBG sub-fishery and the NPF's preferred timing for seismic activity. INPEX is currently reviewing timing of all receptors in the region with respect to the timing of the survey. Regarding the tiger prawn fishing season, INPEX understands that the new closure in the JBG applies only during the banana prawn fishing season. Therefore, INPEX requested the stakeholder help INPEX understand the stakeholders comment about how the closure could change patterns of fishing activity during future tiger prawn seasons?	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX

STAKEHOLDER	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit	INPEX response or actions
	3/06/2022	Email/Letter from INPEX to Stakeholder	INPEX followed up on previous emails as no response received from stakeholder. INPEX requested stakeholder provide a response to query in previous email. INPEX queried if there has been any progress on the 2021 season catch and effort data that was expected towards the end of May. INPEX acknowledged that the stakeholder does not support any activities by oil and gas companies being undertaken in the JGB during the period from 1 August and 1 December in any year. INPEX is endeavouring to meet this request in our pre-planning. INPEX's intention is to conduct activities from December (Drilling) and the Seismic survey in Q2 2023 (April/May) however INPEX may not be able to avoid the period in its entirety if there are unforeseen delays and are hesitant to do so given that: • INPEX understands the survey is not in an area were a significant amount of prawn trawling normally occurs (based on historical effort for both banana prawn and tiger prawn seasons) • INPEX understands that the water depths of the active source area are largely greater than that of banana prawns and that banana prawn spawning, nursery grounds and juvenile migration for recruitment to adult stock are further inshore from where the survey is located. • Although tiger prawns may occur in deeper water depths, historical fishing effort again indicates that the survey area is not an area where the species typically occurs in abundance or is of any unique significance for their spawning and recruitment. Potential impacts would be negligible in the context of the broader JBG stock and natural variation in recruitment. In order to address INPEX's inability to commit to avoidance INPEX is preparing a claim process that mimics the process developed by the NERA and the Collaborative Seismic EP project that INPEX was a member of.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	20/06/2022	Email/ Letter from Stakeholder	Stakeholder apologised for the late email response and thanks for the assurances below. Stakeholder informed they tried to call INPEX last week to cover off but missed them. Re question below: Stakeholder is anticipating that 20 – 25 boats will fish in or around the JBG in the August/Sep this year – and maybe into October, subject to catch rates. This is a considerable increase (compared to before 2021)and is largely due to the fishery being closed in the first season now. Stakeholder advised they can't give INPEX more definitive info than that as it's predictive, and the actual effort/activity level will be subject to weather and catch rates. The 2021 NPF data summary has been published (Stakeholder provided link). Previous year summaries are also on the AFMA website so INPEX can compare JBG catch/effort from other years. Stakeholder notes the comments about possibly needing to carry out at least some of this work during the open fishing season, and again reiterate NPFI's strong preference/recommendation for the work to NOT be undertaken during the fishing season for all the reasons previously cited. Noted also re 'claims' process.	N/A	Relevant objection/claim raised	INPEX notes the potential for an increase in the number of vessels fishing during the tiger prawn season, which could result in increased fishing effort in the JBG. However, on the basis that key target areas for prawns have consistently been outside of the Operational Area in previous years, there is no apparent reason why the relative distribution of tiger prawns and associated fishing effort in the JBG would change significantly. While an increase in fishing effort is possible, effort in the Operational Area is expected to remain low relative to other areas of the JBG. The 3D MSS is provisionally expected to be conducted in Q2 2023, which is consistent with the timing requested by NPFI; however, an exact start date is subject to vessel availability, operational efficiencies, and weather, other site survey and drilling activities that INPEX plan to undertake within the permit area, as well as potential Department of Defence exercises that may occur. Given the limited potential for impact and low risk to the NPF, INPEX does not consider committing to activities outside the period from 1 August and 1 December to be practicable. Commercial fishers will be notified of the commencement and completion of survey activities, and daily lookaheads will be available. In the event that fishers are impacted and experience a loss of catch, INPEX has developed a commercial fisheries adjustment protocol.
	1/07/2022	Email/Letter to Stakeholder from INPEX	INPEX thanked stakeholder for response. INPEX shared draft claim process in relation to the proposed seismic work (INPEX assumed the seismic work was the focus of the email below due to the greater potential for impact than the drilling activity). INPEX advised they would like this to be a consultative process and would appreciate stakeholders feedback. In addition INPEX queried (for budgeting purposes) what the approximate value in $ terms of the Fishery or a range of recent annual catch in kg. This would be helpful to understand the potential dollar value for any claim that may be raised and INPEX will keep the information confidential. INPEX requested a teams meeting or in person catch up in Darwin in July.	Yes - draft adjustment protocol	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	7/07/2022	Email/Letter to Stakeholder from INPEX	INPEX called and left a message to follow up if stakeholder received previous emails regarding the Claim process. No response.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	13/07/2022	Email/ Letter from Stakeholder	Stakeholder apologised for the delayed response. Stakeholder explained they are not available until early next week.	N/A	No relevant matters raised	No relevant matters raised
	13/07/2022	Email/ Letter from Stakeholder	Stakeholder added to previous email, explaining where they are currently based.	N/A	No relevant matters raised	No relevant matters raised
	13/07/2022	Email/Letter to Stakeholder from INPEX	INPEX thanked stakeholder, and agreed to meet early next week. INPEX informed stakeholder that the award of the GHG Permit has still not occurred so INPEX remains uncertain as to whether INPEX has won the Competitive bid.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	28/07/2022	Email/Letter to Stakeholder from INPEX	INPEX followed up, asking if Stakeholder would still like the opportunity to discuss the Draft claim process wIth INPEX.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	2/08/2022	Email/ Letter from Stakeholder	INPEX accepted a zoom meeting invitation from stakeholder.	N/A	No relevant matters raised	No relevant matters raised
Northern Territory Seafood Council (NTSC), represents: -NT Offshore Net and Line -NT Spanish Mackerel -NT Demersal (Pot and Trawl) -Aquarium Fishery	14/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX thanked Stakeholder for previous phone call and advised they appreciate any early communication NTSC can provide to the licence holders through NTSC's regular updates. INPEX advised they understand the potentially effected fisheries may be: -NT Offshore Net and Line -NT Spanish Mackerel -NT Demersal (Pot and Trawl) INPEX outline they are intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX provided the following key information to support generic fact sheet: -Water depth : 65m-106m -Duration of 3D Seismic Survey ~6-10 weeks -Streamers up 1.5km wide and ~8-11km behind the survey vessel -Acquisition lines approx. 375-675m apart -Vessel speed approx-4-5 knots	Yes - Fact Sheet & NTSC Engagement PowerPoint	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
			Seismic source in the order of 3050- 3090 cubic inch INPEX is part of the Collaborative Seismic EP (CSEP) group and is committed to offering a process to assess any potential claims in a similar manner to that developed as part of the CSEP group. INPEX also recently developed a claim process for a 2D Seismic survey in consultation with WAFIC. This process can be accessed directly via this link 2D Claim Process | INPEX. -There are two Operational Areas; -The Drilling Operational Area is entirely within NT waters however abuts the WA NT border (Provided coordinates and figure showing location - The 3D Seismic Operational Area extends very slightly into WA offshore waters, see point D The full-fold Acquisition Area is entirely on the NT side of the line, the corner of the Active Source Zone is right on the boundary (0.5 km2 overlap with the WA side). (Provided coordinates and figure showing location) INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).			
	15/03/2022	Email/Letter from Stakeholder	Stakeholder thanked INPEX for email. Stakeholder Advised the other NT Fishery in the area is the Aquarium Fishery.	N/A	Relevant matter raised	INPEX has included Aquarium Managed Fishery in consultation.
	16/03/2022	Email/ Letter from Stakeholder	Stakeholder requested INPEX include Development Fishery Licences, as there has been activity by a development licence holder in the activity area. Stakeholder advised it is not clear whether these licences are still active or if NT is looking to transition to a fishery. Stakeholder advised it is best to ask NT Fisheries for contact details for them as well.	N/A	Relevant matter raised	INPEX has included Development Fishery License holders in consultation.
	17/03/2022	Email/Letter from INPEX to Stakeholder	INPEX thanked Stakeholder for feedback. Advised INPEX have included the NT Aquaculture Fishery in the stakeholder mailout. Stated that INPEX has been in touch with NT Fisheries but are yet to receive a response. INPEX advised they will follow up with NT Fisheries on the Development licence holder.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX

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	29/03/2022	Email/Letter from INPEX to Stakeholder	INPEX advised they have lodged a request with DITT to obtain data including the Development fishery licences but nothing has come back yet. Notified that INPEX have sent mailed copies of the fact sheet and letters to licence holders in mid March. INPEX noted that stakeholder previously mentioned that the Demersal fisheries were planning some meetings in April. INPEX have not had a response from letters yet, and advised stakeholder may provide them INPEX's contact details if appropriate and INPEX would attend /present if appropriate.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	4/04/2022	Email/ Letter to Stakeholder from INPEX	INPEX notified stakeholder that they have heard back from Australia Bay Seafoods and they are having a meeting today.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	1/07/2022	Email/Letter from INPEX to Stakeholder	INPEX thanked stakeholder for chat a few weeks back and noted they appreciate stakeholders guidance. INPEX attached draft adjustment protocol that INPEX will be sharing with potentially affected stakeholders to seek feedback. INPEX advised if the stakeholder has any comments of suggestions INPEX would be happy to discuss with stakeholder.	Yes- Draft adjustment protocol	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	4/07/2022	Email/Letter from INPEX to Stakeholder	Further to INPEXs last email, INPEX advise that whilst INPEX did undertake stakeholder engagement with key potentially affected NT fisheries (e.g. Demersal, Spanish Mackerel and Offshore Net and Line). INPEX have only received feedback from Australia Bay seafoods (Demersal) and Norther Prawn Fishery. As such INPEX was wondering if INPEX may seek stakeholders support to further communicate the Draft adjustment protocol to ensure other potentially affected parties have had a chance to review it and provide feedback?	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	11/07/2022	Email/Letter from INPEX to Stakeholder	INPEX requested to catch up with Stakeholder to give an update on INPEX's engagement with NT licence holders around the proposed EP's.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	15/07/2022	Email/ Letter from Stakeholder	Stakeholder apologised for missing opportunity. Stakeholder noted the comment period is closed, but if INPEX welcomes a reminder for any comment on the draft protocol in Stakeholders weekly email, stakeholder can include.	N/A	No relevant matter raised	No relevant matter raised
	15/07/2022	Email/Letter from INPEX to Stakeholder	INPEX replied letting stakeholder know that there is no problem and INPEX has time.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	26/07/2022	Email/Letter from INPEX to Stakeholder	INPEX apologised for missing stakeholder the other week. INPEX informed stakeholder that INPEX has set up a meeting with Australia Bay Seafoods. INPEX informed stakeholder that Australia Bay Seafoods seemed appreciative of the claim process and they discussed the intent and how it may be applied. Only minor amendments will be made before INPEX issues the final version. INPEX queried if Stakeholder has heard from other licence holders regarding the process. INPEX suggested they would be happy to discuss with licence holders before making a final copy. INPEX requested stakeholder let INPEX know if there is anyone INPEX should follow up with, or pass on INPEXs details for them to reach out to.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Western Australian Fishing Industry Council (WAFIC) Represents stakeholders in: WA fisheries • Mackerel Managed Fishery • Northern Demersal Scalefish Fishery • West Coast Deep Sea Crustacean Managed Fishery • Northern Shark Fishery • Pearl Oyster Managed Fishery • Kimberley Prawn Managed Fishery Cwth fisheries • North West Slope Trawl Fishery • Western Tuna and Billfish Fisheries	11/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Carbon Capture Storage (CCS) Drilling and 3D Seismic survey activities within exploration title GHG-21. Drilling is proposed between 2023 and 2024. The 3D Seismic survey could commence as early as January 2023 and be completed as late as December 2023. Inpex provided the following additional information: -The Water depth in both proposed Operational Areas is approx. 75-100m. -The WA/NT Border sits immediately to the West of the Proposed INPEX Operational areas (Inpex provided figures showing location) -The Size of the Seismic source is expected to be either 3050 or 3090 cubic inch. -No Fishing is permitted from INPEX vessel or Drill rigs -The Drilling Operational Area does not extend into WA offshore waters. There is no possibility of interaction with WA fisheries. -The 3D Seismic Operational Area extends very slightly into WA offshore waters (~25 km2). The full-fold Acquisition Area is entirely on the NT side of the line, the corner of the Active Source Zone is right on the boundary (0.5 km2 overlap with the WA side). -The two WA fisheries active in the general area are the Mackerel Managed Fishery (MMF) and the Northern Demersal Scalefish Managed Fishery (NDSMF). -Nearest MMF fishing effort (2010-2020) is a block approximately 75 km south-west from the seismic Operational Area, where less than 3 vessels have fished during the entire 11 year period. -Nearest NDSMF fishing effort (2010-2020) is a block approximately 7.5 km north-west from the seismic Operational Area, where less than 10 days of fishing effort has occurred during the entire 11 year period. -The Santos survey is occurring in Feb/ March 2022 and the INPEX Survey at its earliest is not expected to occur until Q1 2023 which reduces the potential for cumulative impacts. -Overall, there is very limited / no potential for interaction between the drill rig or seismic vessel and towed equipment, and fishing vessel, pots, so INPEX proposed to not engage with MMF or NDSMF unless WAFIC advises otherwise. INPEX noted they consider WAFIC's feedback and appreciate the time for engagement.	Yes - Fact Sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	18/03/2022	Email/ Letter from Stakeholder	Stakeholder thanked INPEX for information regarding proposed activities. Stakeholder advised that given the proposed activities are not occurring in WA waters, with the exception of a small proportion and the nearest fishing effort was approximately 75 km and 7.5 km respectively from the seismic operational area and the full-fold acquisition area is entirely on the NT side of the line, INPEX's activities may not be relevant to WA stakeholders. WAFIC advised if consultation material is already prepared, it might be worth sending it out to the small number of commercial fishers in the MMF and NDSMF, to ensure that if any recent fishing effort has occurred in the operational area, potentially relevant persons have been notified.	N/A	Relevant matter raised	INPEX has consulted with the MMF and NDSMF. Note that the Operational Area has limited overlap with waters managed for WA fisheries, and no historic fishing effort has taken place in the Operational Area in the last 10 years.
	21/03/2022	Email/ Letter to Stakeholder from INPEX	INPEX thanked WAFIC for response. Advised that INPEX has posted letters to the commercial fishers in the MMF and NDSMF.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	10/08/2022	Email/ Letter to Stakeholder from INPEX	INPEX advised that advice in previous email in March was incorrect. INPEX had prepared letters in March but the MMF and NDSF letters were not sent at that time as INPEX were waiting on addresses to be provided. INPEX confirmed letters had now been posted to MMF (25 letters), and NDSF (9 letters).	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	12/08/2022	Email/ Letter from Stakeholder	Stakeholder thanked INPEX for clarification and correction.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
RPS Asia-Pacific Applied Science Associates (APASA)	14/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX

STAKEHOLDER	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit	INPEX response or actions
Suncable Energy	16/03/2022	Email/ Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Tiwi Land Council	1/04/2022	Email/ Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities by 15th April 2022 and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	2/04/2022	Email/ Letter from Stakeholder	Stakeholder thanked INPEX for email. Provided CEO contact details (Email) for consultation to be sent to.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	4/04/2022	Email/ Letter to Stakeholder from INPEX	INPEX thanked stakeholder for sending CEO's contact details and notified that INPEX will send consultation e-mail to the CEO e-mail address.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	4/04/2022	Email/ Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder CEO e-mail address with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities by 15th April 2022 and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	8/07/2022	Email/ Letter to Stakeholder from INPEX	INPEX thanked stakeholder for phone call. INPEX reminded stakeholder that an activity fact sheet was sent on the 4th of April. INPEX requested to meet with some representatives from the Tiwi Land Council with the offer of a briefing and further discussion with INPEX's environmental and NT team members. INPEX requested stakeholder provide some available dates.	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Vocus Group	16/03/2022	Email/ Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	16/03/2022	Email/ Letter from Stakeholder	Stakeholder thanked INPEX for sharing and advised they will review and report back	N/A	No relevant matters raised	No relevant matters raised
	23/03/2022	Email/ Letter to Stakeholder from INPEX	INPEX thanked stakeholder for response.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Industry Capability Network NT (CEO/Director	22/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Amateur Fisherman's Association of the Northern Territory (AFANT)	22/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Northern Territory Guided Fishing Association	22/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Energy Club NT	22/03/2022	Email/Letter to Stakeholder from INPEX	Email and fact sheet sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO_2 injection site and along the expected CO_2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO_2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. INPEX requests feedback on proposed activities and notes a 30-day public comment period applies to all Environmental Plans submitted for seismic or exploratory drilling activities. INPEX advised that all communications will be logged, assessed and acknowledged with a response and provided a link to more information on carbon capture storage (CCS).	Yes - Activity fact sheet	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Commercial Fisheries						

STAKEHOLDER	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit	INPEX response or actions
NT Offshore Net & Line Fishery licence holder	16/03/2022	Letter/Email from INPEX to stakeholder	Letter sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. Provided information on location of the Drilling Project Area and 3D Operational Area, and maps. Provided further details of 3D seismic Survey as may be of particular interest to fishing stakeholder including: -Water depth : 65m-106m -Duration of 3D Seismic Survey ~6-10 weeks -Streamers up 1.5km wide and ~8-11 kilometres behind the seismic vessel -Acquisition lines approx. 375-675 metres apart -Vessel speed approx-4-5 knots -Seismic source in the order of 3050- 3090 cubic inch -INPEX is committed to offering a process to assess any potential claims for loss of catch, damage or displacement as a result of the 3D seismic activity. INPEX has previously developed a claim process for a 2D Seismic survey in consultation with WAFIC. Provided a link to access claim. INPEX provided a map overlaying recent fishing effort and the operational/project areas to assist in understanding potential impacts. INPEX requested feedback and outlines that a 30-day public comment period apples to all Environmental Plans Outlined that all communications will be logged, assessed and acknowledged with a response.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
Northern Prawn Fishery licence holders	16/03/2022	Letter/Email from INPEX to stakeholder	Letter sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. Provided information on location of the Drilling Project Area and 3D Operational Area, and maps. Provided further details of 3D seismic Survey as may be of particular interest to fishing stakeholder including: -Water depth : 65m-106m -Duration of 3D Seismic Survey ~6-10 weeks -Streamers up 1.5km wide and ~8-11 kilometres behind the seismic vessel -Acquisition lines approx. 375-675 metres apart -Vessel speed approx-4-5 knots -Seismic source in the order of 3050- 3090 cubic inch -INPEX is committed to offering a process to assess any potential claims for loss of catch, damage or displacement as a result of the 3D seismic activity. INPEX has previously developed a claim process for a 2D Seismic survey in consultation with WAFIC. Provided a link to access claim. INPEX provided a map overlaying recent fishing effort and the operational/project areas to assist in understanding potential impacts. INPEX requested feedback and outlines that a 30-day public comment period apples to all Environmental Plans Outlined that all communications will be logged, assessed and acknowledged with a response.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
NT Demersal Fishery licence holders	16/03/2022	Letter/Email from INPEX to stakeholder	Letter sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. Provided information on location of the Drilling Project Area and 3D Operational Area, and maps. Provided further details of 3D seismic Survey as may be of particular interest to fishing stakeholder including: -Water depth : 65m-106m -Duration of 3D Seismic Survey ~6-10 weeks -Streamers up 1.5km wide and ~8-11 kilometres behind the seismic vessel -Acquisition lines approx. 375-675 metres apart -Vessel speed approx-4-5 knots -Seismic source in the order of 3050- 3090 cubic inch -INPEX is committed to offering a process to assess any potential claims for loss of catch, damage or displacement as a result of the 3D seismic activity. INPEX has previously developed a claim process for a 2D Seismic survey in consultation with WAFIC. Provided a link to access claim. INPEX provided a map overlaying recent fishing effort and the operational/project areas to assist in understanding potential impacts. INPEX requested feedback and outlines that a 30-day public comment period apples to all Environmental Plans Outlined that all communications will be logged, assessed and acknowledged with a response.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
NT Spanish Mackerel Fishery licence holders	16/03/2022	Letter/Email from INPEX to stakeholder	Letter sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. Provided information on location of the Drilling Project Area and 3D Operational Area, and maps. Provided further details of 3D seismic Survey as may be of particular interest to fishing stakeholder including: -Water depth : 65m-106m -Duration of 3D Seismic Survey ~6-10 weeks -Streamers up 1.5km wide and ~8-11 kilometres behind the seismic vessel -Acquisition lines approx. 375-675 metres apart -Vessel speed approx-4-5 knots -Seismic source in the order of 3050- 3090 cubic inch -INPEX is committed to offering a process to assess any potential claims for loss of catch, damage or displacement as a result of the 3D seismic activity. INPEX has previously developed a claim process for a 2D Seismic survey in consultation with WAFIC. Provided a link to access claim. INPEX provided a map overlaying recent fishing effort and the operational/project areas to assist in understanding potential impacts. INPEX requested feedback and outlines that a 30-day public comment period apples to all Environmental Plans Outlined that all communications will be logged, assessed and acknowledged with a response.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
WA Mackerel Managed Fishery	16/03/2022	Letter/Email from INPEX to stakeholder	Letter sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. Provided information on location of the Drilling Project Area and 3D Operational Area, and maps. Provided further details of 3D seismic Survey as may be of particular interest to fishing stakeholder including: -Water depth : 65m-106m -Duration of 3D Seismic Survey ~6-10 weeks -Streamers up 1.5km wide and ~8-11 kilometres behind the seismic vessel -Acquisition lines approx. 375-675 metres apart -Vessel speed approx-4-5 knots -Seismic source in the order of 3050- 3090 cubic inch -INPEX is committed to offering a process to assess any potential claims for loss of catch, damage or displacement as a result of the 3D seismic activity. INPEX has previously developed a claim process for a 2D Seismic survey in consultation with WAFIC. Provided a link to access claim. INPEX provided a map overlaying recent fishing effort and the operational/project areas to assist in understanding potential impacts. INPEX requested feedback and outlines that a 30-day public comment period apples to all Environmental Plans Outlined that all communications will be logged, assessed and acknowledged with a response.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX

	STAKEHOLDER	Date of Correspondence	Type of Correspondence	Summary of Correspondence / Objection / Claim / Query	Attachments	Assessment of Merit	INPEX response or actions
	WA Northern Demersal Scalefish Managed Fishery	16/03/2022	Letter/Email from INPEX to stakeholder	Letter sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. Provided information on location of the Drilling Project Area and 3D Operational Area, and maps. Provided further details of 3D seismic Survey as may be of particular interest to fishing stakeholder including: -Water depth : 65m-106m -Duration of 3D Seismic Survey ~6-10 weeks -Streamers up 1.5km wide and ~8-11 kilometres behind the seismic vessel -Acquisition lines approx. 375-675 metres apart -Vessel speed approx-4-5 knots -Seismic source in the order of 3050- 3090 cubic inch -INPEX is committed to offering a process to assess any potential claims for loss of catch, damage or displacement as a result of the 3D seismic activity. INPEX has previously developed a claim process for a 2D Seismic survey in consultation with WAFIC. Provided a link to access claim. INPEX provided a map overlaying recent fishing effort and the operational/project areas to assist in understanding potential impacts. INPEX requested feedback and outlines that a 30-day public comment period apples to all Environmental Plans Outlined that all communications will be logged, assessed and acknowledged with a response.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX
	Other Fisheries licence holders	16/03/2022	Letter/Email from INPEX to stakeholder	Letter sent to stakeholder with details of proposed Offshore Greenhouse Gas Storage Exploration and Assessment Activities in the Bonaparte Basin, offshore Northern Australia. INPEX is intending to undertake the following activities: -Exploration drilling within GHG21-1 – including wells close to the notional proposed CO2 injection site and along the expected CO2 migration pathway -A three-dimensional (3D) seismic survey to further assess the storage complex to confirm suitability for injection and storage of CO2 The site survey required to support drilling activities may be undertaken as early as Quarter 4, 2022. Provided information on location of the Drilling Project Area and 3D Operational Area, and maps. Provided further details of 3D seismic Survey as may be of particular interest to fishing stakeholder including: -Water depth : 65m-106m -Duration of 3D Seismic Survey ~6-10 weeks -Streamers up 1.5km wide and ~8-11 kilometres behind the seismic vessel -Acquisition lines approx. 375-675 metres apart -Vessel speed approx-4-5 knots -Seismic source in the order of 3050- 3090 cubic inch -INPEX is committed to offering a process to assess any potential claims for loss of catch, damage or displacement as a result of the 3D seismic activity. INPEX has previously developed a claim process for a 2D Seismic survey in consultation with WAFIC. Provided a link to access claim. INPEX provided a map overlaying recent fishing effort and the operational/project areas to assist in understanding potential impacts. INPEX requested feedback and outlines that a 30-day public comment period apples to all Environmental Plans Outlined that all communications will be logged, assessed and acknowledged with a response.	N/A	N/A - Correspondence sent by INPEX	N/A - Correspondence sent by INPEX

Appendix C-
Acoustic Modelling Report

Bonaparte Basin 3D Marine Seismic Survey

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

JASCO Applied Sciences (Australia) Pty Ltd

3 August 2022

Submitted to:

Jake Prout
INPEX OPERATIONS AUSTRALIA PTY LTD

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Contents

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Executive Summary

JASCO Applied Sciences (JASCO) performed a numerical mdoelling study of underwater sound levels from the planned Bonaparte Basin 3D Marine Seismic Survey (MSS) to assist in understanding the potential acoustic impact on key regional receptors including marine mammals, fish, turtles, benthic invertebrates, sponges, coral, and plankton. The modelling considered an airgun array with a total volume 3050 in^3, towed at 8 m depth, in a triple source configuration, behind a single vessel.

A specialised airgun array source model was used to predict the acoustic signature of the seismic source, and complementary underwater acoustic propagation models were used in conjunction with the modelled array signature to estimate sound levels over a large area around the source. Single-impulse sound fields were predicted at five sites within the Active Source Zone, with water depths between 65 and 100 m. An accumulated sound exposure field was predicted for a representative scenario for likely survey operations over 24 hours.

The modelling methodology considered source directivity and range-dependent environmental properties likely to be encountered within the survey area. 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 (ms^{-2}), and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria. A conservative sound speed profile that would be most supportive of sound propagation conditions for the period of the survey was defined and applied to all modelling.

The analysis considered the distances away from the seismic source at which several effects criteria or relevant sound levels were reached. The results are summarised below for the representative single-impulse sites and accumulated SEL scenarios.

Marine mammal injury and behaviour

- The maximum distance where the NOAA (2019) marine mammal behavioural response criterion of 160 dB re 1 µPa (SPL) for impulsive noise could be exceeded varied between 9.7 and 10 km.
- The results for marine mammal injury considered the criteria from Southall et al. allows for two metrics in the criteria (PK and SEL_{24h}) for the assessment of marine mammal Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS). The longest distance associated with either metric is required to be applied for assessment. Table 1 summarises the maximum distances for PTS, along with the relevant metric associated with the maximum PTS distance.
- The SEL_{24h} is a cumulative metric that reflects the dosimetric impact of noise levels within 24 hours based on the assumption that an animal is consistently exposed to such noise levels at a fixed position. The corresponding SEL_{24h} radii for low-frequency cetaceans were larger than those for peak pressure criteria, but they represent an unlikely worst-case scenario. More realistically, marine mammals (and fish) would not stay in the same location for 24 hours. Therefore, a reported radius for SEL_{24h} criteria does not mean that marine fauna travelling within this radius of the source will be injured, but rather that an animal could be exposed to the sound level associated with injury (either PTS or TTS) if it remained in that location for 24 hours.
- The distance to PTS and TTS was always furthest in the broadside direction with distances shown in Table 1.

Table 1. Summary of maximum (R_{max}) horizontal distances (in km) from modelled sites or scenarios to behavioural response thresholds and temporary threshold shift (TTS) and permanent threshold shift (PTS) for marine mammals. Maximum extents are in the broadside direction.

Hearing group	Modelled distance to effect threshold (R_{max})		
	Behavioural response[1]	Impairment: TTS[2]	Impairment: PTS[2]
LF cetaceans	10.0	78.9	9.22
HF cetaceans		0.06	–

Noise exposure criteria: [1] NOAA (2019) and [2] Southall et al. (2018)
A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).

Table 2. Maximum (R_{max}) horizontal distances (in km) from the seismic source to modelled weighted maximum-over-depth sound pressure level (SPL) threshold based on Southall et al. (2019) for marine mammals, at the modelled single impulse sites, with water depth indicated.

Hearing group	Weighted SPL Threshold	Site 1 (77 m)		Site 2 (97 m)	
		R_{max} (km)	$R_{95\%}$ (km)	$R_{95\%}$ (km)	R_{max} (km)
LF cetaceans	160 ($L_{p,\,LF}$; dB re 1 µPa)	7.42	6.12	7.12	6.21
HF cetaceans	160 ($L_{p,\,HF}$; dB re 1 µPa)	–	–	–	–

A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

Turtles

- The PK turtle injury criteria of 232 dB re 1 µPa for PTS and 226 dB re 1 µPa for TTS from Finneran et al. (2017) was not exceeded at a distance longer than 20 m from the acoustic centre of the source.
- The maximum distance to the SEL_{24h} metric was 70 m for PTS onset and 4.85 km for TTS onset (Finneran et al. 2017). As is the case with marine mammals, a reported radius for SEL_{24h} criteria does not mean that turtles travelling within this radius of the source will be injured, but rather that an animal could be exposed to the sound level associated with either PTS or TTS if it remained in that location for 24 hours.
- Table 3 summarises the distances to where the NMFS criterion (NSF 2011) for behavioural response of turtles to the 166 dB re 1 µPa (SPL) and the 175 dB re 1 µPa (SPL) threshold for behavioural disturbance (McCauley et al. 2000) could be exceeded.

Table 3. Summary of distances to turtle behavioural response criteria, temporary threshold shift (TTS), and permanent threshold shift (PTS).

Hearing group	Modelled distance to effect threshold (R_{max})(km)			
	Behavioural response[1]	Behavioural disturbance[2]	Impairment: TTS[3]	Impairment: PTS[3]
Turtles	5.58	1.93	4.85	0.07

Noise exposure criteria: [1] NSF (2011), [2] McCauley et al. (2000), and [3] 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 4 summarises distances to effect criteria for fish, fish eggs, and fish larvae along with the relevant metric. Seafloor sound levels were assessed for three different water depths within the Active Source Zone (65, 85 and 100 m).

Table 4. Summary of maximum fish, fish eggs, and larvae injury and temporary threshold shift (TTS) onset distances for single impulse and 24 hour sound exposure level (SEL_{24h}) modelled scenarios.

Relevant hearing group	Effect criteria	Water column		Seafloor	
		Metric associated with longest distance to criteria	R_{max} (km)	Metric associated with longest distance to criteria	R_{max} (km)
Fish: No swim bladder	Recoverable injury	PK	0.07	PK	0.09 (65 m depth) 0.07 (100 m depth)
	TTS	SEL_{24h}	10.6	SEL_{24h}	8.29
Fish: Swim bladder not involved in hearing and Swim bladder involved in hearing	Recoverable injury	PK	0.19	PK	0.21 (65 m depth) 0.19 (100 m depth
	TTS	SEL_{24h}	10.6	SEL_{24h}	8.29
Fish eggs, and larvae	Injury	PK	0.19	PK	0.21 (65 m depth) 0.19 (100 m depth

Benthic invertebrates, Sponges, Coral, and Plankton

To assist with assessing the potential effects on these receptors, the following results were determined:

- Crustaceans: The sound level of 202 dB re 1 µPa PK-PK from Payne et al. (2008) which is representative of no effects, was considered for seafloor sound levels; the sound level was reached at ranges between 514 and 684 m depending on the modelled site.
- Bivalves: The distance where a particle acceleration of 37.57 ms^{-2} at the seafloor could occur was determined for comparing to results presented in Day et al. (2016a). The maximum distance to this particle acceleration level was between 8.0 and 5.0 m (water depths of 65 m and 85 m 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); the threshold was not reached.

Divers

An SPL human health assessment of 145 dB re 1 µPa (SPL; L_p) derived from Parvin (2005) was considered for people swimming and diving and the sound level was reached at ranges between 38.9 and 40.7 km in the broadside direction depending on the modelled site.

1. Introduction

JASCO Applied Sciences (JASCO) performed a numerical modelling study of underwater sound levels associated with the planned INPEX Bonaparte Basin 3D Marine Seismic Survey (MSS) to assist in understanding the potential acoustic effect on receptors including marine mammals, fish, sea turtles, benthic invertebrates, plankton, sponges, and corals.

This study considered the worst-case seismic source out of four potential options for the survey. JASCO's specialised Airgun Array Source Model (AASM) was used to predict acoustic signatures and spectra for a 2480, 3050, 3090 and 3280 in^3 seismic source under initial consideration for the Bonaparte Basin 3D MSS (see Section 4.2). AASM accounts for individual airgun volumes, airgun bubble interactions, and array geometry to yield accurate source predictions. Based on the AASM results, the worst-case seismic source decision had to be made between the 3050, 3090 and 3280 in^3 seismic source. For these three arrays, a single nominal source location within the survey area was used to compare single impulse received levels when environmental effects were considered. This allowed the worst-case seismic source to be determined based upon both the source signature and the survey specific environment.

Complementary underwater acoustic propagation models were used in conjunction with the array signature and spectra to estimate sound levels considering site specific environmental influences. Single-impulse sound fields were predicted at two defined locations within the Operational Area, and an accumulated sound exposure field was predicted for a representative scenario considering survey acquisition over 24 h (Section 2) for both arrays.

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 (ms^{-2}), and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL, LE) as appropriate for different noise effect criteria.

Section 3 explains the metrics used to represent underwater acoustic fields and the effect 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

Two single impulse sites and one acquisition scenario were modelled considering a 3050 in^3 seismic source. The locations of the modelled sites are provided in Table 5 with all sites and acquisition lines shown in Figure 1. The modelling assumed that a survey vessel sailed along survey lines at ~4.5 knots, towed three 3050 in^2 arrays in a in a triple source configuration, with an impulse interval (inter-pulse interval) of 12.5 m and a array separation of 37.5 m.

The single impulse sites and accumulated SEL scenario were selected based on a proposed survey line plan where the survey lines run at 125/305°. The locations of the two selected impulse sites and the scenario lines are considered representative of the range of water depths that will be covered during the Bonaparte Basin 3D MSS and the potential sound propagation characteristics that may arise at various locations within the Operational Area. The orientations of the single impulse sites and line scenarios were selected to provide the greatest sound propagation radii broadside from the seismic source towards both shallow water receptors and deep-water receptors relevant to the survey. These receptors include but are not limited to internesting and foraging marine turtles in nearshore waters. Seafloor sound levels were assessed at three different representative depths within the Active Source Zone (65, 85 and 100 m).

The scenario accounted for 12550 impulses during the 18.82 h period of acquisition (excluding turns), henceforth referred to as 24 h. During line turns, the seismic source was not operating for modelling purposes.

Table 5. Location details for the single impulse modelled sites.

Site	Latitude (S)	Longitude (E)	MGA[1] Zone 52		Water depth (m)
			X (m)	Y (m)	
1	13° 02' 58.43	128° 56' 18.79"	493338	8557383	77
2	12° 44' 24.35"	128° 36' 38.76"	4577470	8591574	97

[1] Map Grid of Australia (MGA)

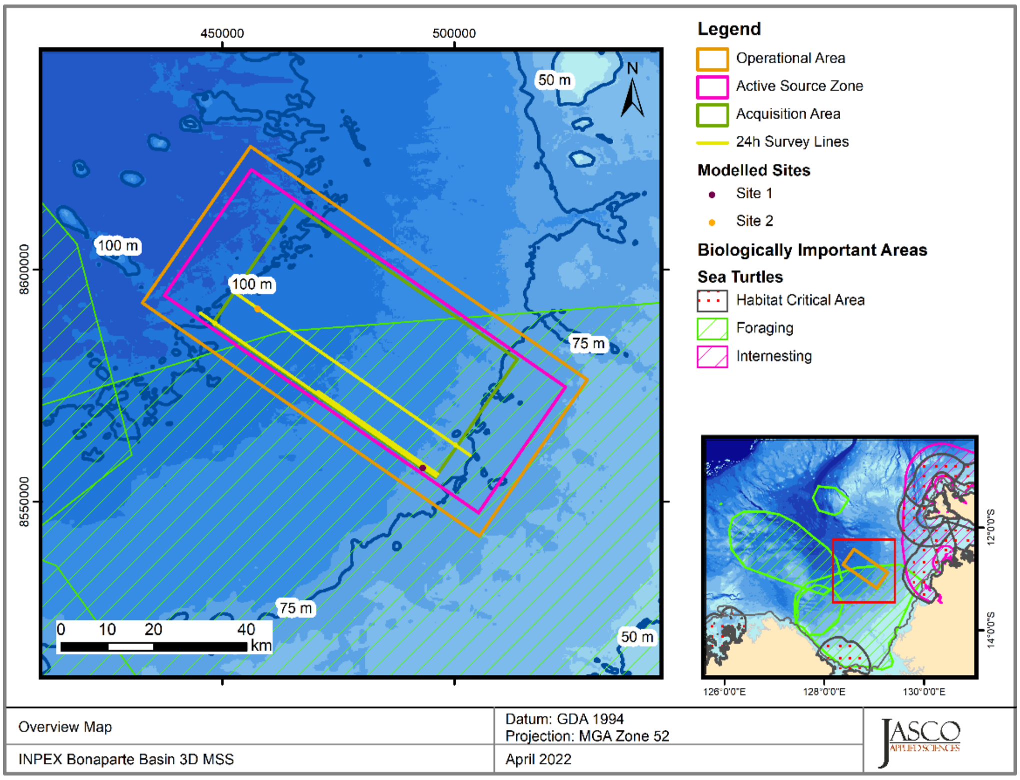

Figure 1. Overview of the modelled sites, acquisition lines, and features for the INPEX Bonaparte Basin 3D MSS.

3. Noise Effect Criteria

The perceived loudness of sound, especially impulsive noise such as from seismic airguns, is not generally proportional to the instantaneous acoustic pressure. Rather, perceived loudness depends on the pulse rise-time and duration, and the frequency content. Several sound level metrics, such as PK, SPL, and SEL, are commonly used to evaluate noise and its effects on marine life (Appendix A). The period of accumulation associated with SEL is defined, with this report referencing either a "per pulse" assessment or over 24 h. Appropriate subscripts indicate any applied frequency weighting; unweighted SEL is defined as required. The acoustic metrics in this report reflect the updated ISO standard for acoustic terminology, ISO/DIS 18405:2017 (2017).

Whether acoustic exposure levels might injure or disturb marine mammals is an active research topic. Since 2007, several expert groups have developed SEL-based assessment approaches for evaluating auditory injury, with key works including Southall et al. (2007), Finneran and Jenkins (2012), Popper et al. (2014), 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 noise criteria and sound levels for this study were chosen because they include standard thresholds, thresholds suggested by the best available science, and sound levels presented in literature for species with no suggested thresholds (Sections 3.1-3.4 and Appendix A):

1. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Southall et al. (2019) 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 US National Oceanic and Atmospheric Administration (NOAA 2019) criterion for marine mammals of 160 dB re 1 µPa (SPL; L_p) for impulsive sound sources including frequency weighted SPLs.
3. Sound exposure guidelines for fish, fish eggs and larvae (used as a surrogate for plankton), and turtles (Popper et al. 2014).
4. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Finneran et al. (2017) for the onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) in turtles.
5. 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. 2000).
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. A sound level of 226 dB re 1 µPa (PK; L_{pk}) reported for comparing to Heyward et al. (2018) for sponges and corals.
8. An SPL human health assessment threshold of 145 dB re 1 µPa (SPL; L_p) for sound exposure to people swimming and diving derived from Parvin (2005), and considering Ainslie (2008).

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 (L_E) is reported.

The following subsections expand on the thresholds and sound levels for marine mammals, fish, sea turtles, fish eggs, fish larvae, and 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 Southall et al. (2019), 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. Of particular note, whilst the newly published Southall et al. (2021) provides recommendations and discusses nuances of assessing behavioural response, the authors do not recommend new numerical thresholds for onset of behavioural responses for marine mammals.

Table 6. Unweighted sound pressure level (SPL), 24 h sound exposure level (SEL_{24h}), and peak pressure (PK) thresholds for acoustic effects on marine mammals.

Hearing group	NOAA (2019)	Southall et al. (2019)			
	Behaviour	PTS onset thresholds[1] (received level)		TTS onset thresholds[1] (received level)	
	SPL (L_p; dB re 1 µPa)	Weighted SEL (L_E; dB re 1 µPa² s)	PK (L_{pk}; dB re 1 µPa)	Weighted SEL (L_E; dB re 1 µPa² s)	PK (L_{pk}; dB re 1 µPa)
Low-frequency cetaceans	160	183	219	168	213
High-frequency cetaceans		185	230	170	224

[1] 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 h 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) and Southall et al. (2019).

Additional information is provided in Appendix A.2.

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

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. (2000) 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 response by NMFS and applied in the Arctic Programmatic Environment Impact Statement (PEIS) (NSF 2011). In addition the 175 dB re 1 µPa level from McCauley et al. (2000) 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. (2000) 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 sound pressure level (SPL), 24 hour sound exposure level (SEL_{24h}), and peak pressure (PK) thresholds

Effect type	Criterion	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)	PK (L_{pk}; dB re 1 µPa)
Behavioural response	McCauley et al. (2000), NSF (2011)	166	NA	
Behavioural disturbance	McCauley et al. (2000)	175		
PTS onset thresholds[1] (received level)	Finneran et al. (2017)	NA	204	232
TTS onset thresholds[1] (received level)			189	226

[1] 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 µPa^{2}s.

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.

The pressure and acceleration examples provided in Day et al. (2016a)(Figures 11 and 12) indicate that the acceleration and pressure signals occurred simultaneously, which was interpreted as an indication that the waterborne sounds were responsible for the accelerations measured by the geophones. For clarity, it is important to distinguish that the acceleration from waterborne sound energy is *not* ground roll, which Day et al. (2016a) correctly define as the sound that propagates along the interface at a speed lower than the shear wave speed of the sediment. However, the report subsequently uses ground roll for all further discussions of particle acceleration. While Day et al. (2016a) discuss that they chose the simplest measure of ground roll, it should have been referring to as ‘the acceleration from waterborne sound energy’, or ‘waterborne acceleration’ for short.

For crustaceans, a PK-PK sound level of 202 dB re 1 µPa (Payne et al. 2008) is considered to be associated with no effect, 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.

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. (2016a). The maximum particle acceleration assessed for scallops was 37.57 ms^{-2}.

3.4.2. Plankton

To assess effects on 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 and at levels of 178 dB PK-PK, 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. Parameter Overview

The specifications of the seismic source and the environmental parameters used in the propagation models are described in detail in Appendix D. A single sound speed profile for June was considered in this modelling study; this was identified as the seasonal period that was likely to result in the farthest propagation (Appendix D.3.2) due to the presence of a slightly upward refracting sound speed profile.

Seabed sediments in the operational area were modelled as a single seabed type. The seabed was modelled as unconsolidated sediment transitioning to more compact and cemented sediments deeper below the seafloor, see Table D-1.

4.2. Acoustic Source Model

The pressure signature of the individual airguns and the composite decidecade bands point-source equivalent directional levels (i.e., source levels) of the four 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, 5 Hz to 25 kHz).
- Full Waveform Range-dependent Acoustic Model (FWRAM, 5 to 1024 Hz).
- Wavenumber integration model (VSTACK, 5 to 1024 Hz).

The models were used in combination to characterise the acoustic fields at short and long ranges in terms of SEL, SPL, PK, and PK-PK. Appendix C provides further detailed information about each model.

MONM-BELLHOP was used to calculate SEL of a 360° area around each source location. FWRAM was used to model synthetic seismic pulses and to calculate water column PK and PK-PK levels. FWRAM was also used to generate a generalised range-dependent SEL to SPL conversion function for the considered modelled sites. The range-dependent conversion function was applied to predicted per-pulse SEL results from MONM-BELLHOP to estimate SPL values.

VSTACK was used to calculate close range PK, PK-PK, and particle motion levels along transects at the seafloor along the endire and broadside directions of the seismic source at three water depths, 65, 85 and 100 m.

4.4. Geometry and Modelled Regions

To assess sound levels with MONM-BELLHOP, the sound field modelling calculated propagation losses up to distances of 100 km from the source in each cardinal direction, with a horizontal separation of 20 m between receiver points along the modelled radials. The sound fields were modelled with a horizontal angular resolution of $\Delta\theta$ = 2.5° for a total of N = 144 radial planes. The single-impulse sound fields were modelled within a 100 × 100 km box area. Receiver depths were chosen to span the entire water column, from 2 m to a maximum of 150 m, with step sizes that increased with depth. To supplement the MONM results, high-frequency propagation loss was modelled using BELLHOP for frequencies from 1.25 to 25 kHz. The MONM and BELLHOP results were combined to produce results for the full frequency range of interest.

FWRAM was run to 100 km with a 10 m receiver range step which increases with distance from the source along four radials (fore and aft endfire, and port and starboard broadside) for computational efficiency. This was done to compute SEL-to-SPL conversions (Appendix D.2) but also to quantify water column PK and PK-PK.

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 levels were computed for receiver depthsat 5 and 50 cm above the seafloor.

4.5. Accumulated SEL

During a seismic survey, new sound energy is introduced into an environment with each pulse from the seismic source. While some impact criteria are based on the per-pulse energy released, others, such as the marine mammal and fish SEL criteria used in this report (Section 3), account for the total acoustic energy marine fauna is subjected to over a specified duration, defined in this report as 24 h. An accurate assessment of the accumulated sound energy depends not only on the parameters of each seismic impulse but also on the number of impulses delivered in a duration and the relative positions of the impulses.

When there are many seismic impulses, it becomes computationally prohibitive to perform sound propagation modelling for every single event. The distance between the consecutive seismic impulses is small enough, such 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 and seafloor levels were 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 (see 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 unweighted (fish) and frequency-weighted SEL_{24h} results were rendered as contour maps, including contours that focus on the relevant criteria-based thresholds. Only contours at ranges larger than the nearfield of the seismic source were rendered.

5. Results

5.1. Acoustic Source Levels and Directivity

AASM (Section B.1) was used to predict the horizontal and vertical overpressure signatures and corresponding power spectrum levels for the seismic source, with results provided in Appendix B.2 along with the horizontal directivity plots for the selected source.

Preliminary source modelling was conducted to determine the source with the highest equivalent far-field acoustic output of four comparable source arrays, which were defined as being between 2480-3280 in^3 as required to meet the technical specification and objectives of the Bonaparte Basin 3D MSS. Three arrays were coupled with single impulse propagation modelling (Appendix B.4.3) to determine the array most likely to produce the largest ranges to thresholds. This was determined to be a 3050 in^3 seismic source with a 8 m tow depth (see Appendix B.2 for details on this source).

Table 9 shows the PK and per-pulse SEL source levels in the horizontal-plane broadside (perpendicular to the tow direction), endfire (along the tow direction), and vertical directions for the modelled array signature (a 3050 in^3 seismic source). The vertical source level that accounts for the "surface ghost" (the out of phase reflected pulse from the water surface) is also presented to make it easier to compare the output of other seismic source models.

Figure B-2 in Appendix B.2 shows the broadside, endfire, and vertical overpressure signature and corresponding power spectrum levels for the source. The signature consists of a strong primary peak, related to the initial release of high-pressure air, followed by a series of pulses associated with bubble oscillations. Most energy was produced at frequencies below 500 Hz. Frequency-dependent peaks and nulls in the spectrum result from interference among airguns in the source and correspond with the volumes and relative locations of the airguns to each other.

Table 9. Far-field source level specifications for 3050 in^3 sources, for an 8 m tow depth. Source levels are for a point-like acoustic source with equivalent far-field acoustic output in the specified direction. Sound level metrics are per-pulse and unweighted.

Direction	Peak source pressure level ($L_{S,pk}$; dB re 1 µPa m)	Per-pulse source SEL ($L_{S,E}$; dB 1 µPa^{2}m^{2}s)	
		10-2000 Hz	2000-25000 Hz
Broadside	248.3	224.4	185.7
Endfire	247.7	224.8	188.3
Vertical	258.2	230.7	196.6
Vertical (surface affected source level)	258.2	233.0	199.7

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 and PK-PK. 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 scenario and to provide 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 3.1-3.3).
- 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 effect on benthic invertebrates (Section 3.4.1).

The maximum and 95% distances to per-pulse SEL and SPL metrics are presented in Table 10 and Table 11. Table 12 presents the maximum and 95% distances to the 160 dB re 1 µPa SPL threshold for marine mammals. The SPL sound fields, and distances to relevant isopleths can be visualised on the contour maps presented in Figures 2 and 3. The SPL sound fields are also presented as vertical slices for selected sites along the endfire and broadside directions out to 50 km, with the airgun array in the centre (Figures 4 and 5).

Maximum distances to maximum-over-depth water column PK thresholds were calculated for both modelled single impulse sites, Sites 1 and 2, and presented in Table 13. Seafloor sound levels were assessed at three different representative depths within the Active Source Zone (65, 85, and 100 m) and Tables 14 and 15 present the PK and PK-PK results.

5.2.1. Tabulated Results

5.2.1.1. Entire Water Column

Table 10. *3050 in³ source*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the seismic source to modelled maximum-over-depth and maximum-over-azimuth unweighted per-pulse sound exposure level (SEL) isopleths from the modelled single impulse sites, with the water depth indicated.

Per-pulse SEL (L_E; dB re 1 µPa²·s)	Site 1 (77 m)		Site 2 (97m)	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
190	0.05	0.05	0.05	0.05
180	0.26	0.24	0.26	0.23
170	1.08	0.97	0.93	0.85
160[1]	4.13	3.46	4.20	3.38
150	11.9	9.66	11.6	9.50
140	29.5	24.0	28.9	23.4
130	79.3	61.2	78.1	56.4

1 Low power zone assessment criteria DEWHA (2008).

Table 11. *3050 in³ source*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the seismic source to modelled maximum-over-depth and maximum-over-azimuth per-pulse sound pressure level (SPL) isopleths from the modelled single impulse sites, with the water depth indicated.

SPL (L_p; dB re 1 µPa)	Site 1 (77 m)		Site 2 (97 m)	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
200	0.05	0.05	0.05	0.05
190	0.23	0.21	0.22	0.20
180	0.85	0.77	0.85	0.78
175[1]	1.93	1.67	1.84	1.64
170	3.67	2.94	3.55	2.84
166[2]	5.21	4.29	5.58	4.42
160[3]	9.84	7.81	9.96	7.76
150	24.6	20.3	24.9	20.3
145[4]	40.7	32.8	38.9	31.0
140	69.8	53.2	65.4	48.6

1 Threshold for turtle behavioural disturbance from impulsive noise (McCauley et al. 2000).
2 Threshold for turtle behavioural response to impulsive noise (McCauley et al. 2000, NSF 2011).
3 Marine mammal behavioural threshold for impulsive sound sources (NOAA 2019).
4 Human health assessment threshold derived from Parvin (2005).

Table 12. *3050 in³ source* - Maximum (R_{max}) horizontal distances (in km) from the seismic source to modelled weighted maximum-over-depth sound pressure level (SPL) threshold based on Southall et al. (2019) for marine mammals, from the modelled single impulse sites, with the water depth indicated.

Hearing group	Weighted SPL Threshold (L_p; dB re 1 µPa)	Site 1 (77 m)		Site 2 (97 m)	
		R_{max} (km)	$R_{95\%}$ (km)	$R_{95\%}$ (km)	R_{max} (km)
Low-frequency cetaceans	160	7.42	6.12	7.12	6.21
High-frequency cetaceans	160	–	–	–	–

A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

Table 13. *3050 in³ source*: Maximum (R_{max}) horizontal distances (in km) from the seismic source to modelled maximum-over-depth peak pressure level (PK) thresholds based on Southall et al. (2019) for marine mammals, and Popper et al. (2014) for fish and Finneran et al. (2017) for sea turtles, at the modelled single impulse sites, with the water depth indicated.

Hearing group	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (km)	
		Site 1 (77 m)	Site 2 (97 m)
Low-frequency cetaceans (PTS)	219	0.04	0.04
Low-frequency cetaceans (TTS)	213	0.07	0.07
High-frequency cetaceans (PTS)	230	–	–
High-frequency cetaceans (TTS)	224	–	–
Sea Turtles (PTS)	232	–	–
Sea Turtles (TTS)	226	–	–
Fish: No swim bladder (also applied to sharks)	213	0.07	0.07
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	0.18	0.19

A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

5.2.1.2. Seafloor

Ranges presented at the seafloor (50 cm above the interface) provided in Tables 14 and 15 are different to those for the maximum-over-depth modelling results presented in Table 13. This is because the model used for the water column results, calculated using FWRAM (Appendix C.2) do not represent the maximum sound levels at the seafloor close to the array. This is because FWRAM is based on a wide-angle parabolic equation (PE) algorithm which is valid to only approximately 70° down angle from the horizontal, and while it provides accurate predictions in the horizontal direction, it cannot predict sound levels directly under the array. The VSTACK model (Appendix C.3) is used to determine the levels at the seafloor directly under the array, and due to seafloor interactions, these can be greater than those elsewhere in the water column.

Table 14. *3050 in³ source*: Maximum (R_{max}) horizontal distances (in m) from the seimsic source to modelled seafloor (receiver located 50 cm above seafloor) peak pressure level thresholds (PK) at three water depths (65 m, 85 m and 100 m) within the Active Source Zone.

Hearing group/animal type	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (m)		
		65 m	85 m	100 m
Sound levels for sponges and corals[1]	226	*	*	*
Fish: No swim bladder (also applied to sharks)	213	86	74	70
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	209	198	188

[1] Heyward et al. (2018)
An asterisk indicates that the sound level was not reached.

Table 15. *3050 in³ source*: Maximum (R_{max}) horizontal distances (in m) from the seismic source to modelled seafloor (receiver located 5 cm above seafloor) peak-peak pressure levels (PK-PK) at three water depths (65 m, 85 m and 100 m) within the Active Source Zone. Results included in relation to benthic invertebrates (Section 3.4).

PK-PK ($L_{pk\text{-}pk}$; dB re 1 µPa)	Distance R_{max} (m)		
	65 m	85 m	100 m
213[1,2,3]	168	160	161
212[2,3]	189	189	186
210[1,2]	264	258	253
209[1,2]	282	302	294
202[4]	605	684	514

[1] Day et al. (2019), lobster
[2] Day et al. (2016a), lobster and scallops
[3] Day et al. (2017), scallops.
[4] Payne et al. (2008), lobster

5.2.2. Sound Field Maps and Graphs

5.2.2.1. Sound Level Contour Maps

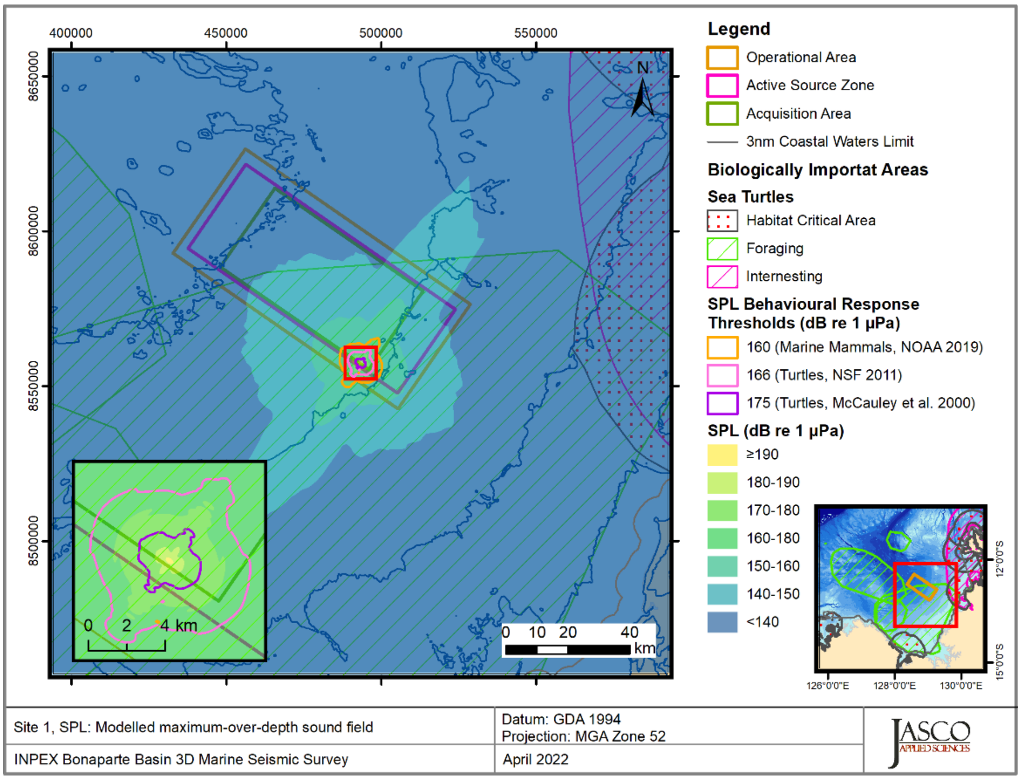

Figure 2. *Site 1, tow azimuth 125°, SPL*: Sound level contour map of unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural response thresholds for marine mammals and turtles.

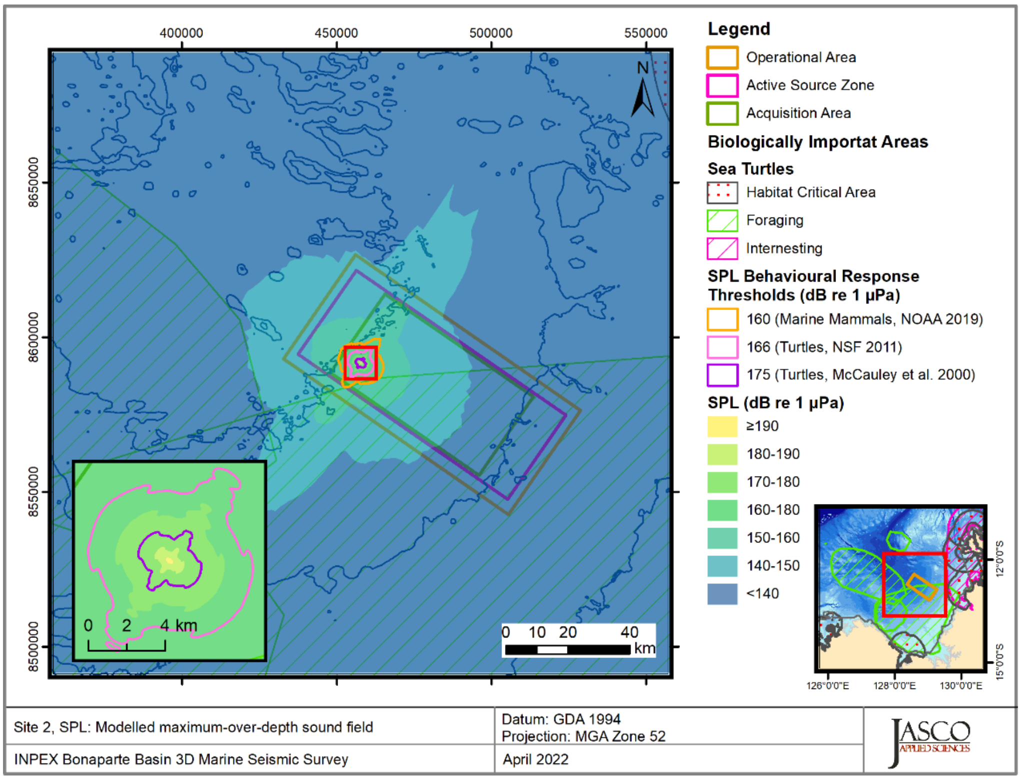

Figure 3. *Site 2, tow azimuth 125°, SPL*: Sound level contour map of unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural response thresholds for marine mammals and turtles.

5.2.2.2. Vertical Slices of Modelled Sound Fields

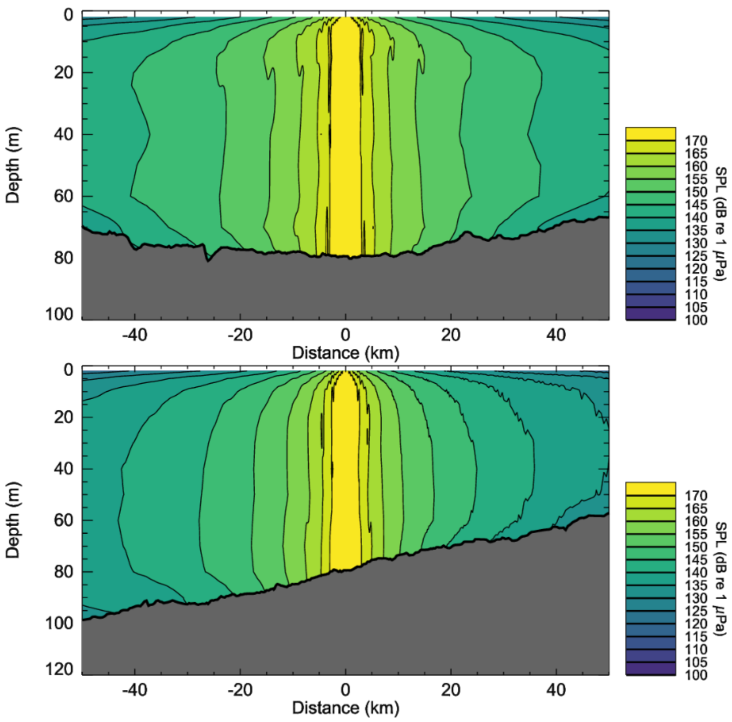

Figure 4. *Site 1, tow azimuth 125°, SPL*: Sound level contours in vertical slice of the sound field , perpendicular to (broadside, top) and along the tow direction (endfire, bottom). The positive distance direction in each slice is 90° clockwise from the tow azimuth for broadside, and the tow azimuth for the endfire slice.

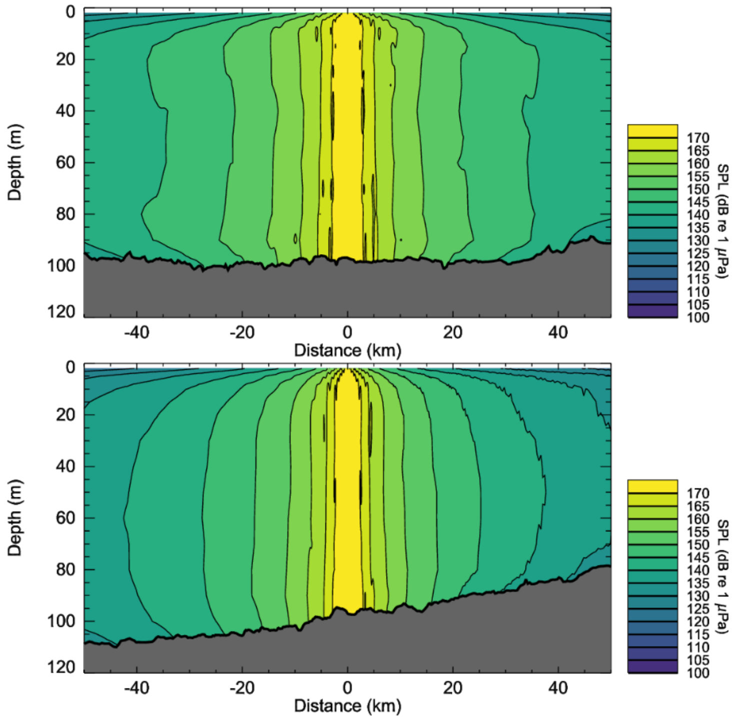

Figure 5. *Site 2, tow azimuth 125°, SPL*: Sound level contours in vertical slice of the sound field , perpendicular to (broadside, top) and along the tow direction (endfire, bottom). The positive distance direction in each slice is 90° clockwise from the tow azimuth for broadside, and the tow azimuth for the endfire slice.

5.2.3. Particle Motion

Figures 6 to 8 show modelled maximum particle acceleration as a function of horizontal range in four perpendicular directions from the centre of the 3050 in^3 seismic source at water depths of 65, 85 and 100 m. The modelling considered a resolution of 10 m, and a receiver positioned 5 cm off the seafloor. The maximum distance to a particle acceleration of 37.57 ms^{-2} (Day et al. (2016a)) is predicted to occur at a range of 8.0, and 5.0 m for a depth of 65 and 85 m, respectively, and is not predicted to occur for a depth of 100 m.

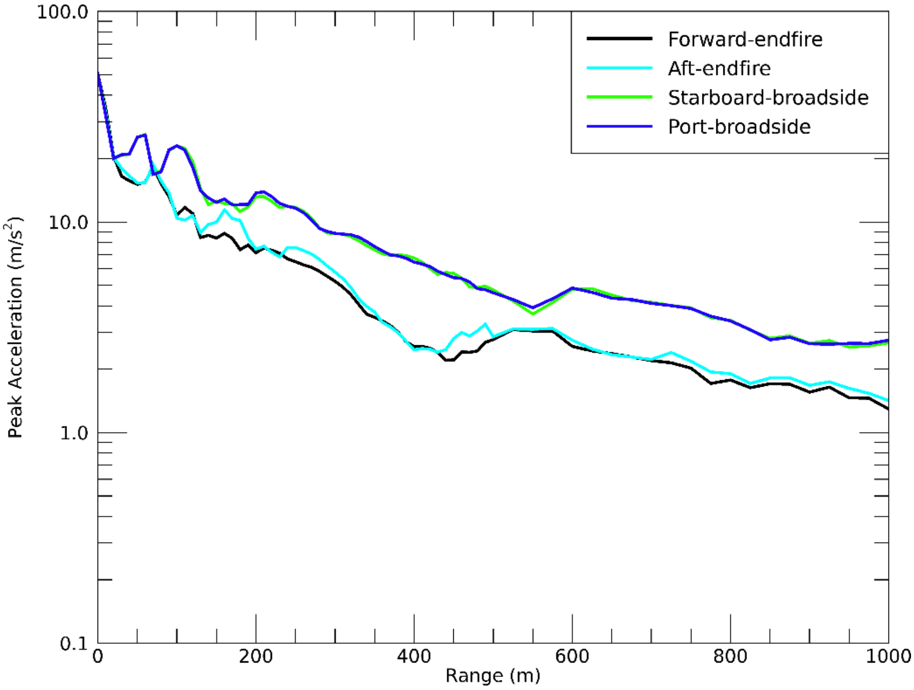

Figure 6. 3050 in^3 seismic source at 65 m water depth: Peak particle acceleration magnitude at the seafloor as a function of horizontal range from the centre of the seismic source along four directions.

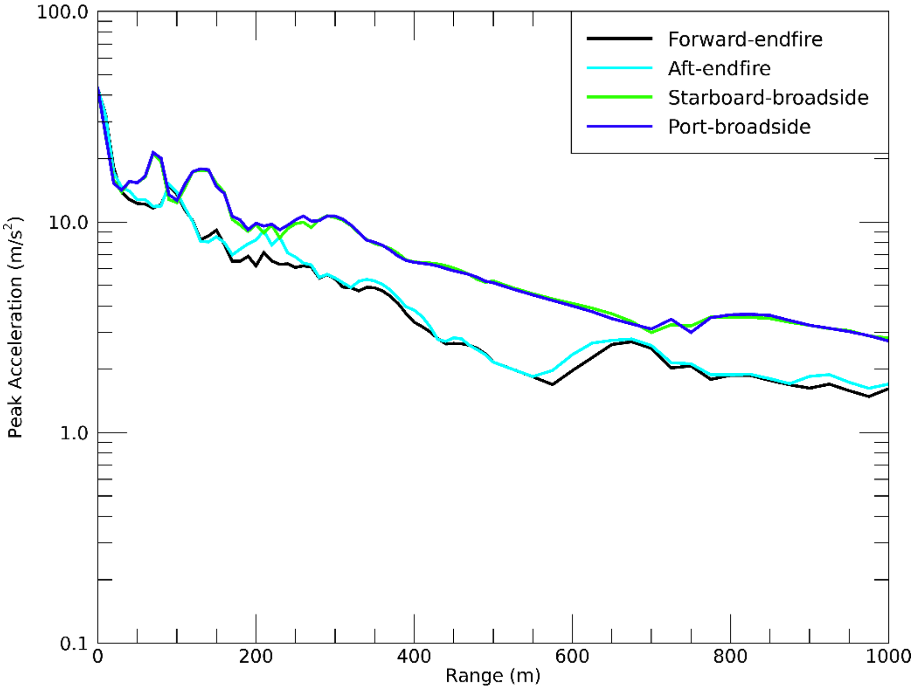

Figure 7. 3050 in^3 seismic source at 85 m water depth: Peak particle acceleration magnitude at the seafloor as a function of horizontal range from the centre of the seismic source along four directions.

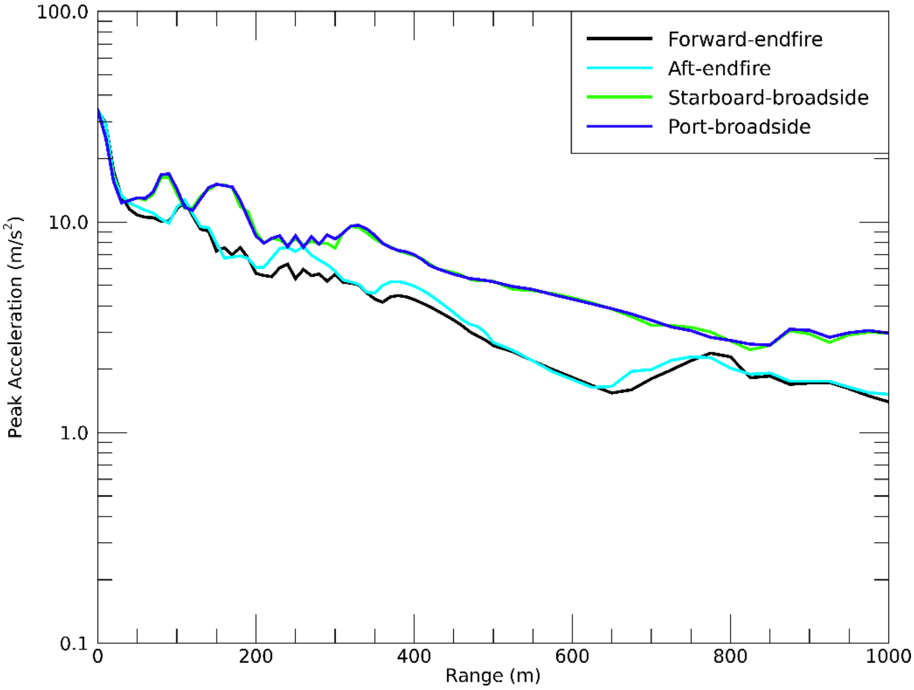

Figure 8. 3050 in³ seismic source at 100 m water depth: Peak particle acceleration magnitude at the seafloor as a function of horizontal range from the centre of the seismic source along four directions.

5.3. Multiple Source Fields

This section presents the sound fields in terms of SEL accumulated over 24 h of survey, for the modelled scenario (Section 2). Frequency-weighted SEL24h sound fields were used to estimate the maximum and 95% distances (R_{max} and $R_{95\%}$; calculated as detailed in Appendix D.1) to marine mammals and turtle PTS and TTS thresholds (listed in Table 16), and to estimate maximum distance and the area to injury and TTS guidelines for fish (Table 17).

The SEL_{24h} sound fields are presented as contour maps in Figures 9 and 10. These figures present the unweighted SEL_{24h} in 10 dB steps, as well as the isopleths corresponding to thresholds or guidelines for which R_{max} is greater than 20 m.

5.3.1. Tabulated Results

Table 16. Maximum-over-depth distances (in km) to frequency-weighted 24 hour sound exposure level (SEL_{24h}) based permanent threshold shift (PTS) and temporary threshold shift (TTS) for marine mammals (Southall et al. 2019) and sea turtles (Finneran et al. 2017) using the 3050 in^3 conventional array. Maximum extents are in the broadside direction.

Hearing group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
PTS			
Low-frequency cetaceans	183	9.22	1397
High-frequency cetaceans	185	–	–
Sea turtles	204	0.07	8.41
TTS			
Low-frequency cetaceans	168	78.9	12097
High-frequency cetaceans	170	0.06	4.26
Sea turtles	189	4.85	896

A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).

Table 17. Distances to 24 hour sound exposure level (SEL_{24h}) based fish criteria in the water column and at the seafloor for the conventional 3050 in^3 seismic source.

Marine fauna group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	Maximum-over-depth		Seafloor	
		R_{max} (km)	Area (km²)	R_{max} (km)	Area (km²)
Mortality and potential mortal injury					
I	219	0.07	5.76	*	*
II, fish eggs and fish larvae	210	0.07	5.79	*	*
III	207	0.07	12.8	0.03	1.05
Fish recoverable injury					
I	216	0.07	5.76	*	*
II, III	203	0.28	48.3	0.28	46.7
Fish temporary threshold shift (TTS)					
I, II, III	186	10.6	1668	8.29	1447

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 threshold was not reached.

5.3.2. Sound Level Contour Maps

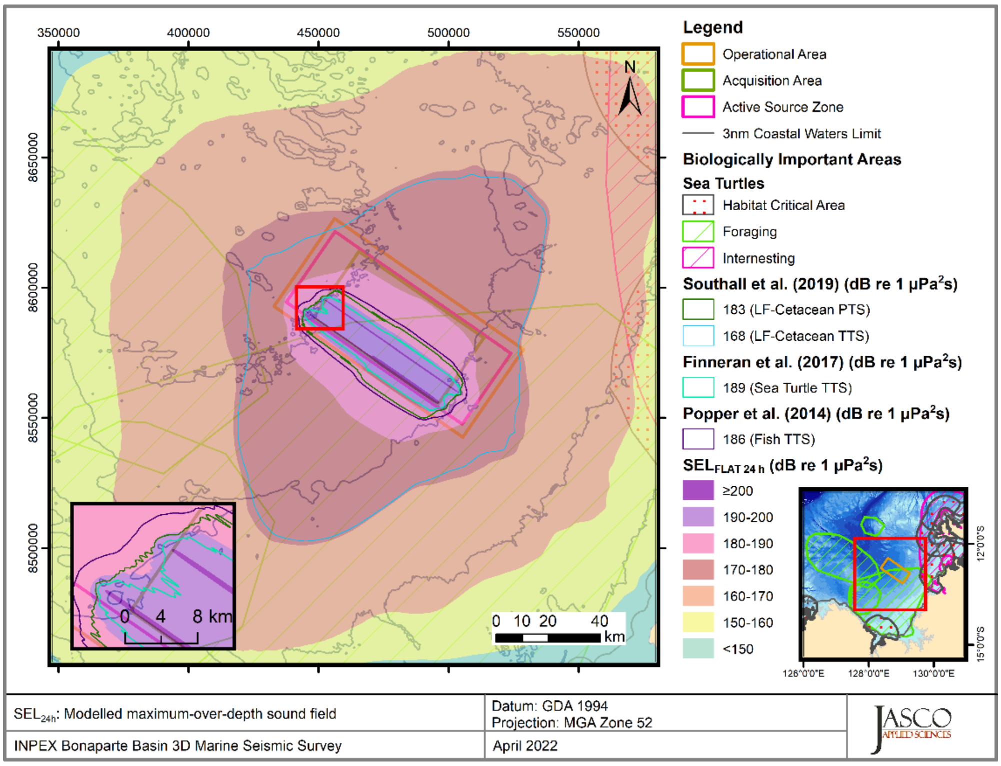

Figure 9. Sound level contour map of unweighted maximum-over-depth SEL_{24h} results, along with isopleths for cetaceans and fish. Thresholds omitted here were not reached or not large enough to display graphically. Refer to Tables 16 and 17 for threshold distances.

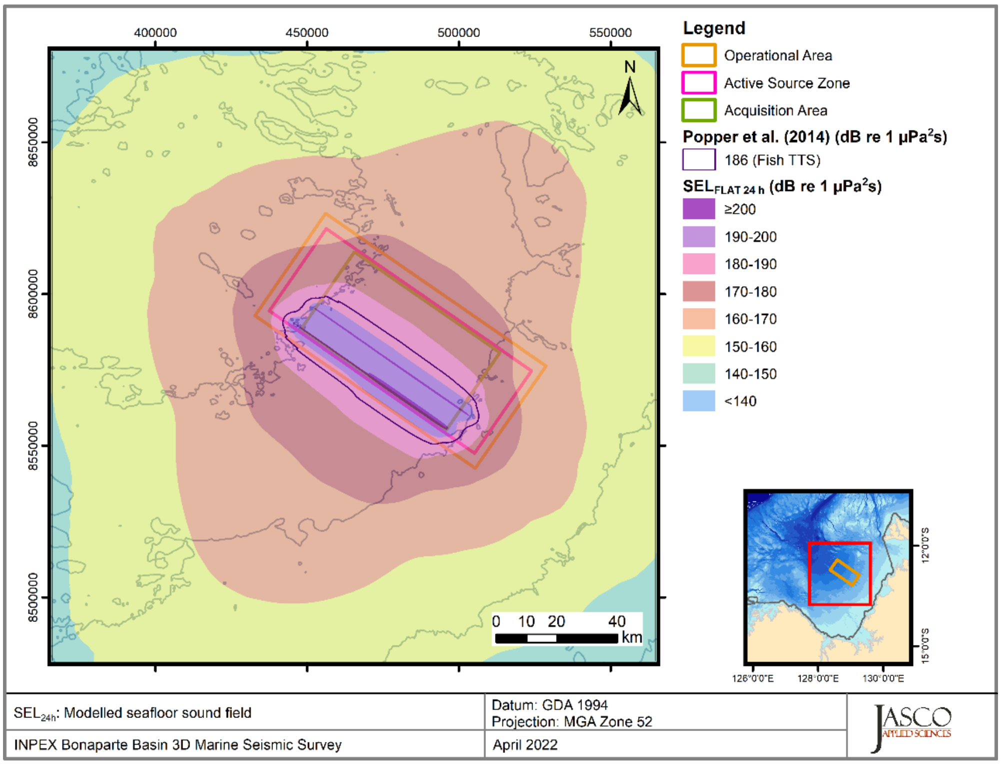

Figure 10. Sound level contour map of unweighted seafloor SEL_{24h} results along with the isopleth for fish temporary threshold shift (TTS). Thresholds omitted here were not reached or not large enough to display graphically. Refer to Table 17 for threshold distances.

6. Discussion and Conclusion

The modelling study predicted underwater sound levels associated with the planned Bonaparte Basin 3D MSS. The underwater sound field was modelled for a 3050 in^3 seismic source (Appendix B.2), selected as a worst-case option based on a comparison of a 2480, 3050, 3090 and 3280 in^3 seismic source for operation within the survey Operational Area (Appendix B.4).

An analysis of seasonal sound speed profiles indicated that June was the month most likely to be the most conducive to sound propagation due to the presence of an upward refracting layer near the sea surface; as such it was selected to as part of a conservative approach to estimating distances to received sound level thresholds (Appendix D.3.2). Modelling also accounted for site-specific bathymetric variations (Appendix D.3.1) and local geoacoustic properties (Appendix D.3.3).

Most acoustic energy from a seismic source is output at lower frequencies, in the tens to hundreds of hertz. The modelled 3050 in^3 array had a pronounced broadside directivity pattern in the source level decidecade bands between ~125 to 250 Hz (Appendix B.2), which caused a noticeable axial bulge in the modelled acoustic footprints.

The overall broadband (10-25000 Hz) unweighted per-pulse SEL source level of the 3050 in^3 seismic source operating at 8 m depth was 224.4 dB 1 μPa^{2}m^{2}s in the broadside direction and 224.8 dB 1 μPa^{2}m^{2}s in the endfire direction. The peak pressure levels were 248.3 and 247.7 dB re 1 μPa m, respectively (Table 9).

6.1. Per-Pulse Sound Fields

The modelled sites encompassed water depths of 77 and 97 m across one defined geological area with a single representative water column profile. At both 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 modelled sites had tow directions of 125° and 305°, meaning the broadside lobes were in the northeast and southwest directions.

The sound speed profile for June (Figure D-5) was primarily downward refracting apart from a slight upward refracting layer, which extended to approximately 70 m from the sea surface. The slight upward refracting layer in the sound speed profile will only effectively trap frequencies above 320 Hz (Jensen et al. 2011). The presence of this layer has the potential to trap levels at higher frequencies which would otherwise dissipate more rapidly in range due to propagation, absorption, and seabed losses.

The array directionality and frequency content coupled with bathymetry, resulted in shallow water propagation phenomena where the water column sound field is significantly influenced by variations and interactions with the seabed. Due to the increasing bathymetry from the southeast to the northwest of the Operational Area, sound footprints extended slightly longer towards deeper water and were shorter towards shallower water. The maximum-over-depth sound footprint maps and vertical slice plots (Sections 5.2.2.1 and 5.2.2.2) assist in demonstrating the influence of the bathymetry, source location and sound speed profile on the sound field.

The distances to PK and PK-PK based criteria (Section 3.2 and 3.4) for fish, benthic crustaceans and bivalves and planktons at the seafloor generally decreased with increasing water depth (Tables Table 14 and 15). However, distances to these criteria did not always consistently change with increasing depth as any correlation between water depth and threshold distance is related to complex patterns of surface and seabed reflections that affect sound propagation in shallow water. Since the threshold distances are relatively small, and the water depths at the two modelled sites span the water depths within the survey area, we expect the threshold distances to be representative of the range of distances for all source locations within the region (Section 5.2.2.1).

6.2. Multiple Pulse Sound Fields

The accumulated SEL over 24 hours of seismic source operation was modelled considering a representative scenario with a realistic acquisition pattern for the Bonaparte Basin 3D MSS. The modelling predicted the accumulation of sound energy, considering the change in location and the azimuth of the 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 3).

The footprints and range maxima for all accumulated SEL thresholds within the survey area are primarily influenced by the high levels in the broadside direction and the gradually variations in bathymetry as discussed above. For the 24 h scenario considered, the maximum ranges to species specific thresholds are associated with the broadside source levels and near constant bathymetry.

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 effect 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 effect of noise levels within 24 h 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 h.

Marine mammals

Table 18 summarises the distances to criteria for marine mammals, note that these distances are associated with the broadside aspect of the array.

Table 18. Maximum (R_{max}) horizontal distances (in km) from modelled sites or scenarios to behavioural response thresholds and temporary threshold shift (TTS) and permanent threshold shift (PTS) for marine mammals (SPL levels from Table 11, PK values from Table 13, and SEL_{24h} values from Table 16).

Hearing group	Modelled distance to effect threshold (R_{max})		
	Behavioural response[1]	Impairment: TTS[2]	Impairment: PTS[2]
LF cetaceans	9.96	78.9	9.22
HF cetaceans		0.06	–

Noise exposure criteria: [1] NOAA (2019) and [2] Southall et al. (2019)
A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).

Table 19. Maximum (R_{max}) horizontal distances (in km) from the seismic source to modelled weighted maximum-over-depth sound pressure level (SPL) threshold based on Southall et al. (2019) for marine mammals, at the modelled single impulse sites, with water depth indicated.

Hearing group	Weighted SPL Threshold	Site 1 (77 m)		Site 2 (97 m)	
		R_{max} (km)	$R_{95\%}$ (km)	$R_{95\%}$ (km)	R_{max} (km)
LF cetaceans	160 ($L_{p,\,LF}$; dB re 1 µPa)	7.42	6.12	7.12	6.21
HF cetaceans	160 ($L_{p,\,HF}$; dB re 1 µPa)	–	–	–	–

A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

Sea turtles

Table 20 summarises the distances to criteria for sea turtles.

Table 20. Maximum (R_{max}) horizontal distances (in km) from modelled sites or scenarios to behavioural response thresholds and temporary threshold shift (TTS) and permanent threshold shift (PTS) for sea turtles (PK values from Table 13 and SEL_{24h} values from Table 16).

Hearing group	Modelled distance to effect threshold (R_{max})			
	Behavioural response[1]	Behavioural disturbance[2]	Impairment: TTS[3]	Impairment: PTS[3]
Sea Turtles	5.58	1.93	4.85	0.07

Noise exposure criteria: [1] NSF (2011), [2] McCauley et al. (2000), and [3] Finneran et al. (2017)

Fish, fish eggs, and fish larvae

This modelling study assessed the ranges at the seafloor and in the water column for quantitative criteria based on Popper et al. (2014) and considered both PK 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 21 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 21. Summary of maximum fish, fish eggs, and larvae injury and temporary threshold shift (TTS) onset distances for single impulse and 24 hour sound level exposure (SEL_{24h}) modelled scenarios (PK values from Tables 13 and 14 and SEL_{24h} values from Table 17).

Relevant hearing group	Effect criteria	Water column		Seafloor	
		Metric associated with longest distance to criteria	R_{max} (km)	Metric associated with longest distance to criteria	R_{max} (km)
Fish: No swim bladder	Recoverable injury	PK	0.07	PK	0.09 (65 m depth) 0.07 (100 m depth)
	TTS	SEL_{24h}	10.6	SEL_{24h}	8.29
Fish: Swim bladder not involved in hearing and Swim bladder involved in hearing	Recoverable injury	PK	0.19	PK	0.21 (65 m depth) 0.19 (100 m depth
	TTS	SEL_{24h}	10.6	SEL_{24h}	8.29
Fish eggs, and larvae	Injury	PK	0.19	PK	0.21 (65 m depth) 0.19 (100 m depth

Benthic invertebrates, Sponges, Coral, and Plankton

To assist with assessing the potential effects on these receptors, the following results were determined:

- Crustaceans: The sound level of 202 dB re 1 μPa PK-PK from Payne et al. (2008) which is representative of no effects, was considered for seafloor sound levels; the sound level was reached at ranges between 514 and 684 m depending on the modelled site.
- Bivalves: The distance where a particle acceleration of 37.57 ms^{-2} at the seafloor could occur was determined for comparing to results presented in Day et al. (2016a). The maximum distance to this particle acceleration level was between 8.0 and 5.0 m (water depths of 65 m and 85 m 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); the threshold was not reached.

Divers

An SPL human health assessment of 145 dB re 1 μPa (SPL; L_p) derived from Parvin (2005) was considered for people swimming and diving and the sound level was reached at ranges between 38.9 and 40.7 km in the broadside direction depending on the modelled site.

Glossary

Unless otherwise stated in an entry, these definitions are consistent with ISO 80000-3 (2017).

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).

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

The process of applying an auditory frequency weighting function. In human audiometry, C-weighting is the most commonly used function, an example for marine mammals are the auditory frequency weighting functions published by Southall et al. (2007).

auditory frequency weighting function

Frequency weighting function describing a compensatory approach accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity. Example hearing groups are low-, mid-, and high-frequency cetaceans, phocid and otariid pinnipeds.

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 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 level

The total level measured over a specified 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 species and include whales, dolphins, and porpoises.

compressional wave

A mechanical vibration wave in which the direction of particle motion is parallel to the direction of propagation. Also called primary wave or P-wave.

conductivity-temperature-depth (CTD)

Measurement data of the ocean’s conductivity, temperature, and depth; used to compute sound speed and salinity.

decade

Logarithmic frequency interval whose upper bound is ten times larger than its lower bound (ISO 80000-3:2006).

decidecade

One tenth of a decade. *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)

Unit of level used to express the ratio of one value of a power quantity to another on a logarithmic scale. Unit: dB.

delphinid

Family of oceanic dolphins, or Delphinidae, composed of approximately thirty extant species, including dolphins, porpoises, and killer whales.

duty cycle

The time when sound is periodically recorded by an acoustic recording system.

endfire direction

Parallel to the travel direction of a source. Also see **broadside direction**.

energy source level

A property of a sound source obtained by adding to the sound exposure level measured in the far field the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: 1 μPa²m²s.

energy spectral density

Ratio of energy (time-integrated square of a specified field variable) to bandwidth in a specified frequency band f_1 to f_2. In equation form, the energy spectral density E_f is given by:

$$E_f = \frac{2\int_{f_1}^{f_2} |X(f)|^2 \, \mathrm{d}f}{f_2 - f_1},$$

where $X(f)$ is the Fourier transform of the field variable $x(t)$

$$X(f) = \int_{-\infty}^{+\infty} x(t) \exp(-2\pi \mathrm{i} f t) \, \mathrm{d}t \, .$$

The field variable $x(t)$ is a scalar quantity, such as sound pressure. It can also be the magnitude or a specified component of a vector quantity such as sound particle displacement, sound particle velocity, or sound particle acceleration. The unit of energy spectral density depends on the nature of x, as follows:

- If x = sound pressure: Pa² s/Hz
- If x = sound particle displacement: m² s/Hz
- If x = sound particle velocity: (m/s)² s/Hz
- If x = sound particle acceleration: (m/s²)² s/Hz

The factor of two on the right-hand side of the equation for E_f is needed to express a spectrum that is symmetric about $f = 0$, in terms of positive frequencies only. See entry 3.1.3.9 of ISO 18405 (2017).

energy spectral density level

The level ($L_{E,f}$) of the **energy spectral density** (E_f). Unit: decibel (dB).

$$L_{E,f} := 10 \log_{10}\left(E_f / E_{f,0}\right) \mathrm{dB} \, .$$

The frequency band and integration time should be specified.

As with **energy spectral density**, energy spectral density level can be expressed in terms of various field variables (e.g., sound pressure, sound particle displacement). The reference value ($E_{f,0}$) for energy spectral density level depends on the nature of field variable.

energy spectral density source level

A property of a sound source obtained by adding to the energy spectral density level of the sound pressure measured in the far field the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: 1 μPa²m²s/Hz.

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.

Fourier transform (or Fourier synthesis)

A mathematical technique which, although it has varied applications, is referenced in the context of this report as a method used in the process of deriving a spectrum estimate from time-series data (or the reverse process, termed the inverse Fourier transform). A computationally efficient numerical algorithm for computing the Fourier transform is known as fast Fourier transform (FFT).

flat weighting

Term indicating that no frequency weighting function is applied. Synonymous with unweighted.

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.

frequency weighting

The process of applying a frequency weighting function.

frequency-weighting function

The squared magnitude of the sound pressure transfer function. For sound of a given frequency, the frequency weighting function is the ratio of output power to input power of a specified filter, sometimes expressed in decibels. Examples include the following:

- *Auditory frequency weighting function*: compensatory frequency weighting function accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity.
- *System frequency weighting function*: frequency weighting function describing the sensitivity of an acoustic acquisition system, typically consisting of a hydrophone, one or more amplifiers, and an analogue to digital converter.

geoacoustic

Relating to the acoustic properties of the seabed.

Global Positioning System (GPS)

A satellite based navigation system providing accurate worldwide location and time information.

harmonic

A sinusoidal sound component that has a frequency that is an integer multiple of the frequency of a sound to which it is related. For example, the second harmonic of a sound has a frequency that is double the fundamental frequency of the sound.

hearing group

Category of animal species when classified according to their hearing sensitivity and to the susceptibility to sound. Examples for marine mammals include very low-frequency (VLF) cetaceans, low-frequency (LF) cetaceans, mid-frequency (MF) cetaceans, high-frequency (HF) cetaceans, very high-frequency (VHF) cetaceans, otariid pinnipeds in water (OPW), phocid pinnipeds in water (PPW), sirenians (SI), other marine carnivores in air (OCA), and other marine carnivores in water (OCW) (NMFS 2018, Southall et al. 2019). See **auditory frequency weighting functions**, which are often applied to these groups. Examples for fish include species for which the swim bladder is involved in hearing, species for which the swim bladder is not involved in hearing, and species without a swim bladder (Popper et al. 2014).

hearing threshold

The sound pressure level for any frequency of the hearing group that is barely audible for a given individual for specified 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

See **hearing group**.

intermittent sound

A sound whose level abruptly drops below the background noise level several times during an observation period.

impulsive sound

Qualitative term meaning sounds that are typically transient, brief (less than 1 second), broadband, with rapid rise time and rapid decay. They can occur in repetition or as a single event. Examples of impulsive sound sources include explosives, seismic airguns, and impact pile drivers.

isopleth

A line drawn on a map through all points having the same value of some quantity.

knot

One nautical mile per hour. Symbol: kn.

level

A measure of a quantity expressed as the logarithm of the ratio of the quantity to a specified reference value of that quantity. Examples include sound pressure level, sound exposure level, and peak sound pressure level. For example, a value of sound exposure level with reference to 1 μPa^2 s can be written in the form *x* dB re 1 μPa^2 s.

low-frequency (LF) cetacean

See **hearing group**.

median

The 50th percentile of a statistical distribution.

mid-frequency (MF) cetacean

See **hearing group**.

monopole source level (MSL)

A source level that has been calculated using an acoustic model that accounts for the effect of the sea-surface and seabed on sound propagation, assuming a point-like (monopole) sound source.

M-weighting

See **auditory frequency weighting function** (as proposed by Southall et al. 2007).

mysticete

A suborder of cetaceans that use baleen plates to filter food from water. Members of this group include rorquals (Balaenopteridae), right whales (Balaenidae), and grey whales (*Eschrichtius robustus*).

non-impulsive sound

Sound that is not an impulsive sound. A non-impulsive sound is not necessarily a continuous sound.

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)

See **hearing group**.

other marine carnivores in air (OCA)

See **hearing group**.

other marine carnivores in water (OCW)

See **hearing group**.

parabolic equation method

A computationally efficient solution to the acoustic wave equation that is used to model propagation loss. The parabolic equation approximation omits effects of back-scattered sound, simplifying the computation of propagation loss. The effect of back-scattered sound is negligible for most ocean-acoustic propagation problems.

peak sound pressure level (zero-to-peak sound pressure level)

The level ($L_{p,pk}$ or L_{pk}) of the squared maximum magnitude of the sound pressure (p_{pk}^2). Unit: decibel (dB). Reference value (p_0^2) for sound in water: 1 µPa^2.

$$L_{p,\mathrm{pk}} := 10\log_{10}\left(p_{\mathrm{pk}}^2/p_0^2\right)\,\mathrm{dB} \;= 20\log_{10}\left(p_{\mathrm{pk}}/p_0\right)\,\mathrm{dB}$$

The frequency band and time window should be specified. Abbreviation: PK or L_{pk}.

peak-to-peak sound pressure

The difference between the maximum and minimum sound pressure over a specified frequency band and time window. Unit: pascal (Pa).

permanent threshold shift (PTS)

An irreversible 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)

See **hearing group**.

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.

power spectral density

Generic term, formally defined as power in a unit frequency band. Unit: watt per hertz (W/Hz). The term is sometimes loosely used to refer to the spectral density of other parameters such as squared sound pressure. ratio of **energy spectral density**, E_f, to time duration, Δt, in a specified temporal observation window. In equation form, the power spectral density P_f is given by:

$$P_f = \frac{E_f}{\Delta t}.$$

Power spectral density can be expressed in terms of various field variables (e.g., sound pressure, sound particle displacement).

power spectral density level

The level ($L_{P,f}$) of the **power spectral density** (P_f). Unit: decibel (dB).

$$L_{P,f} := 10 \log_{10}\left(P_f / P_{f,0}\right) \text{dB}.$$

The frequency band and integration time should be specified.

As with **power spectral density**, power spectral density level can be expressed in terms of various field variables (e.g., sound pressure, sound particle displacement). The reference value ($P_{f,0}$) for power spectral density level depends on the nature of field variable.

power spectral density source level

A property of a sound source obtained by adding to the power spectral density level of the sound pressure measured in the far field the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: 1 μPa^{2}m^2/Hz.

pressure, acoustic

The deviation from the ambient pressure caused by a sound wave. Also called sound pressure. Unit: pascal (Pa).

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).

propagation loss (PL)

Difference between a source level (SL) and the level at a specified location, PL(x) = SL - L(x). Also see **transmission loss**.

received level

The level measured (or that would be measured) at a defined location. The type of level should be specified.

reference values

standard underwater references values used for calculating sound **levels**, e.g., the reference value for expressing sound pressure level in decibels is 1 µPa.

Quantity	Reference value
Sound pressure	1 µPa
Sound exposure	1 μPa^2 s
Sound particle displacement	1 pm
Sound particle velocity	1 nm/s
Sound particle acceleration	1 $\mu m/s^2$

rms

abbreviation for 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 a 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.

sound

A time-varying disturbance in the pressure, stress, or material displacement of a medium propagated by local compression and expansion of the medium.

sound exposure

Time integral of squared sound pressure over a stated time interval. The time interval can be a specified time duration (e.g., 24 hours) or from start to end of a specified event (e.g., a pile strike, an airgun pulse, a construction operation). Unit: Pa^2 s.

sound exposure level

The level (L_E) of the sound exposure (E). Unit: decibel (dB). Reference value (E_0) for sound in water: 1 μPa^2 s.

$$L_E := 10\log_{10}(E/E_0)\,\mathrm{dB} = 20\log_{10}\left(E^{1/2}/E_0^{1/2}\right)\,\mathrm{dB}$$

The frequency band and integration time should be specified. Abbreviation: 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. Unit: Pa^2 s/Hz.

sound field

Region containing sound waves.

sound intensity

Product of the sound pressure and the sound particle velocity. The magnitude of the sound intensity is the sound energy flowing through a unit area perpendicular to the direction of propagation per unit time.

sound particle acceleration

The rate of change of sound particle velocity. Unit: metre per second squared (m/s^2). Symbol: *a*.

sound particle motion

smallest volume of a medium that represents its mean physical properties.

sound particle displacement

Displacement of a material element caused by the action of sound, where a material element is the smallest element of the medium that represents the medium's mean density.

sound particle velocity

The velocity 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*.

sound pressure

The contribution to total pressure caused by the action of sound.

sound pressure level (rms sound pressure level)

The level ($\mathrm{L_{p,rms}}$) of the time-mean-square sound pressure (p^2_{rms}). Unit: decibel (dB). Reference value (p^2_0) for sound in water: 1 μPa^2.

$$L_{p,\mathrm{rms}} := 10\log_{10}(p^2_{\mathrm{rms}}/p^2_0)\ \mathrm{dB}\ = 20\log_{10}(p_{\mathrm{rms}}/p_0)\ \mathrm{dB}$$

The frequency band and averaging time should be specified. Abbreviation: SPL or Lrms.

sound speed profile

The speed of sound in the water column as a function of depth below the water surface.

soundscape

The characterization of the ambient sound in terms of its spatial, temporal, and frequency attributes, and the types of sources contributing to the sound field.

source level (SL)

A property of a sound source obtained by adding to the sound pressure level measured in the far field the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: 1 $\mu Pa^2 m^2$.

spectrum

An acoustic signal represented in terms of its power, energy, mean-square sound pressure, or sound exposure distribution with frequency.

surface duct

The upper portion of a water column within which the sound speed profile gradient causes sound to refract upward and therefore reflect off the surface resulting in relatively long-range sound propagation with little loss.

temporary threshold shift (TTS)

Reversible loss of hearing sensitivity. TTS can be caused by noise exposure.

thermocline

The depth interval near the ocean surface that experiences temperature gradients due to warming or cooling by heat conduction from the atmosphere and by warming from solar heating.

transmission loss (TL)

The difference between a specified level at one location and that at a different location, TL(x1,x2) = L(x1) - L(x2). Also see **propagation loss**.

unweighted

Term indicating that no frequency weighting function is applied. Synonymous with flat weighting.

very high-frequency (VHF) cetacean

See **hearing group**.

very low-frequency (VLF) cetacean

See **hearing group**.

wavelength

Distance over which a wave completes one cycle of oscillation. Unit: metre (m). Symbol: λ.

white noise

An acoustic signal composed of random pressure fluctuations, such that its power spectrum is constant over a specified frequency range. The adjective “white” originates from white light having approximately constant power spectrum over the frequency range visible to humans.

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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, $p(t)$:

$$L_{p,\mathrm{pk}} = 10\log_{10}\frac{\max|p^2(t)|}{p_0^2} = 20\log_{10}\frac{\max|p(t)|}{p_0} \tag{A-1}$$

PK is often included as a criterion for assessing whether a sound is potentially injurious; however, because it does not account for the duration of 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, $p(t)$:

$$L_{p,\mathrm{pk\text{-}pk}} = 10\log_{10}\frac{[\max(p(t)) - \min(p(t))]^2}{p_0^2} \tag{A-2}$$

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:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T g(t)\,p^2(t)\,dt \Big/ p_0^2\right) \tag{A-3}$$

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 are referred to as 90% SPL ($L_{p,90\%}$).

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):

$$L_E = 10\log_{10}\left(\int_T p^2(t)\,dt \Big/ T_0 p_0^2\right) \tag{A-4}$$

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:

$$L_{E,N} = 10\log_{10}\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}} \tag{A-5}$$

If applied, the frequency weighting of an acoustic event should be specified, as in the case of weighted SEL (e.g., $L_{E,LF,24h}$; see Appendix A.5) or auditory-weighted SPL ($L_{p,ht}$). The use of fast, slow, or impulse exponential-time-averaging or other time-related characteristics should also be specified.

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:

$$v = -\int \nabla p(t)dt / \rho_0 \tag{A-6}$$

The particle acceleration (a) is the rate of change of the velocity with respect to time, and it can be obtained from equation A-6 as:

$$a = \frac{dv}{dt} = -\frac{\nabla p(t)}{\rho_0} \tag{A-7}$$

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:

$$|v| = \sqrt{v_x + v_y + v_z} \tag{A-8}$$

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:

$$f_c(i) = 10^{\frac{i}{10}}\,\text{kHz} \tag{A-9}$$

and the low (f_{lo}) and high (f_{hi}) frequency limits of the ith decade band are defined as:

$$f_{\text{lo},i} = 10^{\frac{-1}{20}} f_c(i) \quad \text{and} \quad f_{\text{hi},i} = 10^{\frac{1}{20}} f_c(i) \tag{A-10}$$

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).

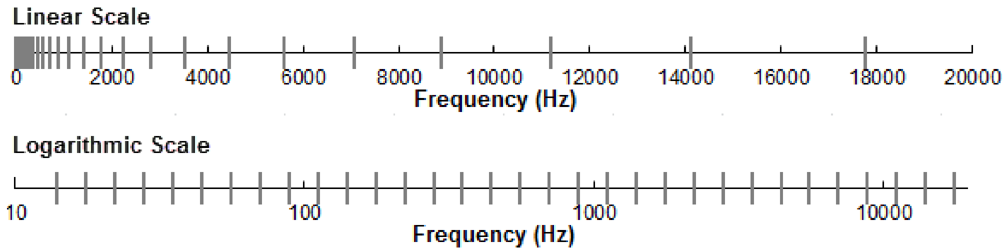

Figure A-1. Decidecade frequency bands (vertical lines) shown on a linear frequency scale and a logarithmic scale.

The sound pressure level in the ith band ($L_{p,i}$) is computed from the spectrum $S(f)$ between $f_{\text{lo},i}$ and $f_{\text{hi},i}$:

$$L_{p,i} = 10\log_{10} \int_{f_{\text{lo},i}}^{f_{\text{hi},i}} S(f)\,df \tag{A-11}$$

Summing the sound pressure level of all the bands yields the broadband sound pressure level:

$$\text{Broadband SPL} = 10\log_{10} \sum_i 10^{\frac{L_{p,i}}{10}} \tag{A-12}$$

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.

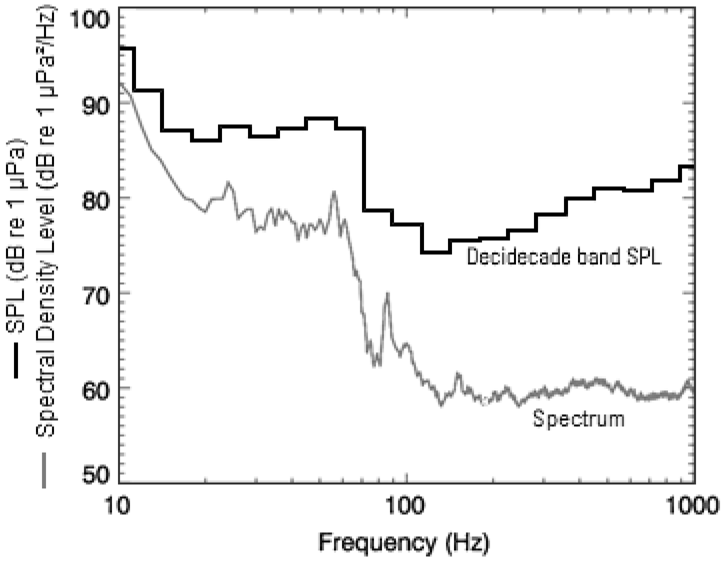

Figure A-2. Sound pressure spectral density levels and the corresponding decidecade band sound pressure levels of example ambient noise shown on a logarithmic frequency scale.

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. Injury

In recognition of shortcomings of the SPL-only based injury criteria, in 2005 NMFS sponsored the Noise Criteria Group to review literature on marine mammal hearing to propose new noise exposure criteria. Some members of this expert group published a landmark paper (Southall et al. 2007) that suggested assessment methods similar to those applied for humans. The resulting recommendations introduced dual acoustic injury criteria for impulsive sounds that included peak pressure level thresholds and SEL_{24h} thresholds, where the subscripted 24h refers to the accumulation period for calculating SEL. The peak pressure level criterion is not frequency weighted whereas the SEL_{24h} is frequency weighted according to one of four marine mammal species hearing groups: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively) and Pinnipeds in Water (PINN). These weighting functions are referred to as M-weighting filters (analogous to the A-weighting filter for human; Appendix A.5). The SEL_{24h} thresholds were obtained by extrapolating measurements of onset levels of Temporary Threshold Shift (TTS) in belugas by the amount of TTS required to produce Permanent Threshold Shift (PTS) in chinchillas. The Southall et al. (2007) recommendations do not specify an exchange rate, which suggests that the thresholds are the same regardless of the duration of exposure (i.e., it implies a 3 dB exchange rate).

Wood et al. (2012) refined Southall et al.'s (2007) thresholds, suggesting lower injury values for LF and HF cetaceans while retaining the filter shapes. Their revised thresholds were based on TTS-onset levels in harbour porpoises from Lucke et al. (2009), which led to a revised impulsive sound PTS threshold for HF cetaceans of 179 dB re 1 µPa^2·s. Because there were no data available for baleen whales, Wood et al. (2012) based their recommendations for LF cetaceans on results obtained from MF cetacean studies. In particular they referenced Finneran and Schlundt (2010) research, which found mid-frequency cetaceans are more sensitive to non-impulsive sound exposure than Southall et al. (2007) assumed. Wood et al. (2012) thus recommended a more conservative TTS-onset level for LF cetaceans of 192 dB re 1 µPa^2·s.

As of present an optimal approach is not apparent. There is consensus in the research community that an SEL-based method is preferable either separately or in addition to an SPL-based approach to assess the potential for injuries. In August 2016, after substantial public and expert input into three draft versions and based largely on the above-mentioned literature (NOAA 2013, 2015, 2016), NMFS finalised technical guidance for assessing the effect of anthropogenic sound on marine mammal hearing (NMFS 2016). The guidance describes injury criteria with new thresholds and frequency weighting functions for the five hearing groups described by Finneran and Jenkins (2012). The latest revision to this work was published in 2018; with the criteria defined in NMFS (2018). The latest criteria are from Southall et al. (2019) which is applied in this report.

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 2018, 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 US 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:

$$G(f) = K + 10\log_{10}\left[\left(\frac{(f/f_{lo})^{2a}}{\left[1+(f/f_{lo})^2\right]^a\left[1+(f/f_{hi})^2\right]^b}\right)\right] \quad \text{(A-13)}$$

Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively), 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 acoustic impacts on marine mammals (NMFS 2018), and in the latest guidance by Southall (2019). The updates did not affect the content related to either the definitions of frequency-weighting functions or the threshold values. 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 Southall et al. (2019).

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
High-frequency cetaceans (dolphins, plus toothed, beaked, and bottlenose whales)	1.6	2	8,800	110,000	1.20

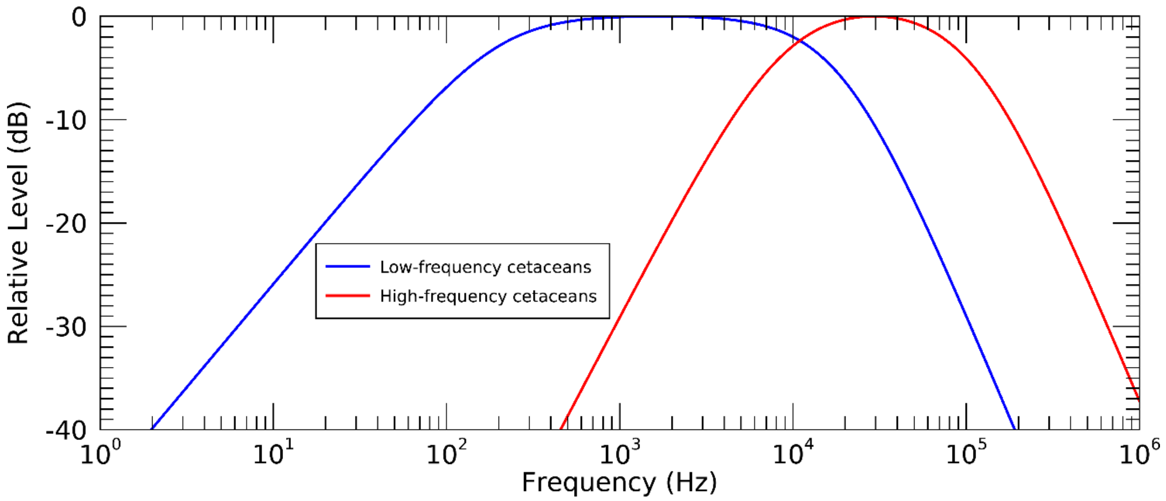

Figure A-3. Auditory weighting functions for functional marine mammal hearing groups used in this project as recommended by Southall et al. (2019).

Appendix B. Acoustic Source Model

B.1. Airgun Array Source Model

The source levels and directivity of the seismic source were predicted with JASCO's Airgun Array Source Model (AASM). AASM includes low- and high-frequency modules for predicting different components of the seismic source spectrum. The low-frequency module is based on the physics of oscillation and radiation of airgun bubbles, as originally described by Ziolkowski (1970), that solves the set of parallel differential equations that govern bubble oscillations. Physical effects accounted for in the simulation include pressure interactions between airguns, port throttling, bubble damping, and generator-injector (GI) gun behaviour discussed by Dragoset (1984), Laws et al. (1990), and Landrø (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-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. Seismic Source

Figure B-1 shows the layout of the 3050 in^3 seismic source used for modelling in this study. Table B-1 provides details of the airgun parameters.

For the modelled array, the layout is presented in a nominal cartesian coordinate system. In this coordinate system the direction of vessel travel determines the relative position of the array elements as plotted and tabulated. The layout used for acoustic modelling was produced by transforming the coordinates of client supplied layouts such that the resultant layouts correspond to a vessel travel direction along the positive X-axis and the array is centred on the X-Y origin. When used with an acoustic model the positive X-axis in this nominal coordinate system aligns with the vessel tow direction or survey line azimuth.

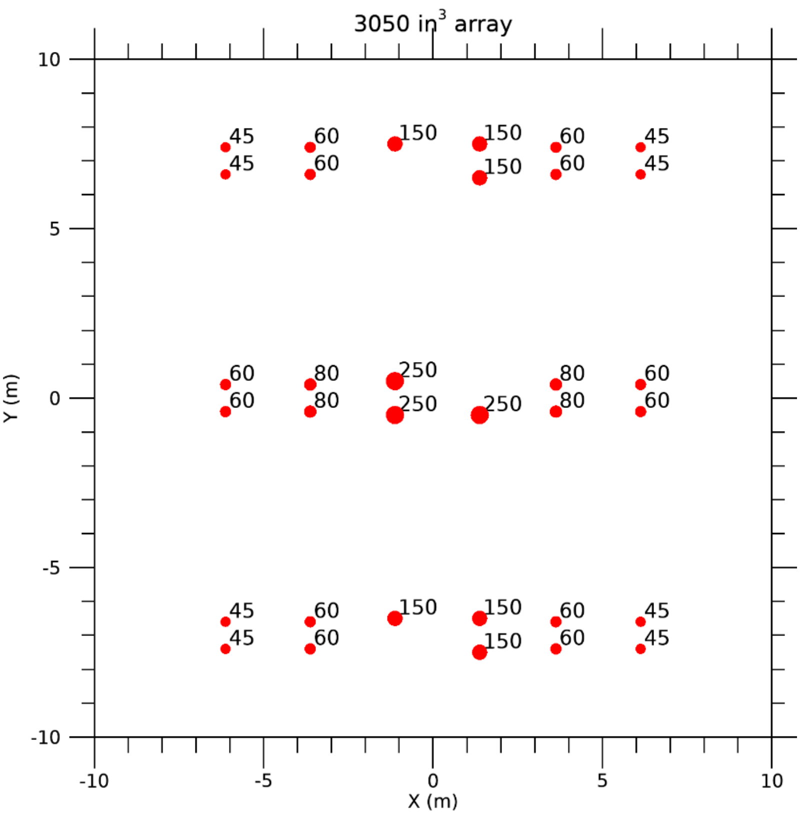

Figure B-1. Layout of the modelled 3050 in^3 seismic source. Tow depth is 8. The labels indicate the firing volume (in cubic inches) for each airgun. Also see Table B-1.

Table B-1. Layout of the modelled 3050 in3 seismic source. Tow depth was 8 m. Firing pressure for all guns was 2000 psi. Also see Figure B-1.

String	Gun	x(m)	y(m)	z(m)	Vol(in3)	String	Gun	x(m)	y(m)	z(m)	Vol(in3)	String	Gun	x(m)	y(m)	z(m)	Vol(in3)
1	1	6.125	-7.4	8	45	2	13	6.125	-0.4	8	60	3	25	6.125	6.6	8	45
	2	6.125	-6.6		45		14	6.125	0.4		60		26	6.125	7.4		45
	3	3.625	-7.4		60		15	3.625	-0.4		80		27	3.625	6.6		60
	4	3.625	-6.6		60		16	3.625	0.4		80		28	3.625	7.4		60
	5	1.375	-7.5		150		17	1.375	-0.5		250		29	1.375	6.5		150
	6	3.375	-6.5		150		19	-1.125	-0.5		250		30	1.375	7.5		150
	8	-1.125	-6.5		150		20	-1.125	0.5		250		32	-1.125	7.5		150
	9	-3.625	-7.4		60		21	-3.625	-0.4		80		33	-3.625	6.6		60
	10	-3.625	-6.6		60		22	-3.625	0.4		80		34	-3.625	7.4		60
	11	-6.125	-7.4		45		23	-6.125	-0.4		60		35	-6.125	6.6		45
	12	-6.125	-6.6		45		24	-6.125	0.4		60		36	-6.125	7.4		45

B.3. Array Source Levels and Directivity

Figure B-2 shows the broadside (perpendicular to the tow direction), endfire (parallel to the tow direction) and vertical overpressure signature and corresponding power spectrum levels for the 3050 in^3 array (Appendix B.2). Horizontal decidecade-band source levels are shown as a function of band centre frequency and azimuth in Figure B-3.

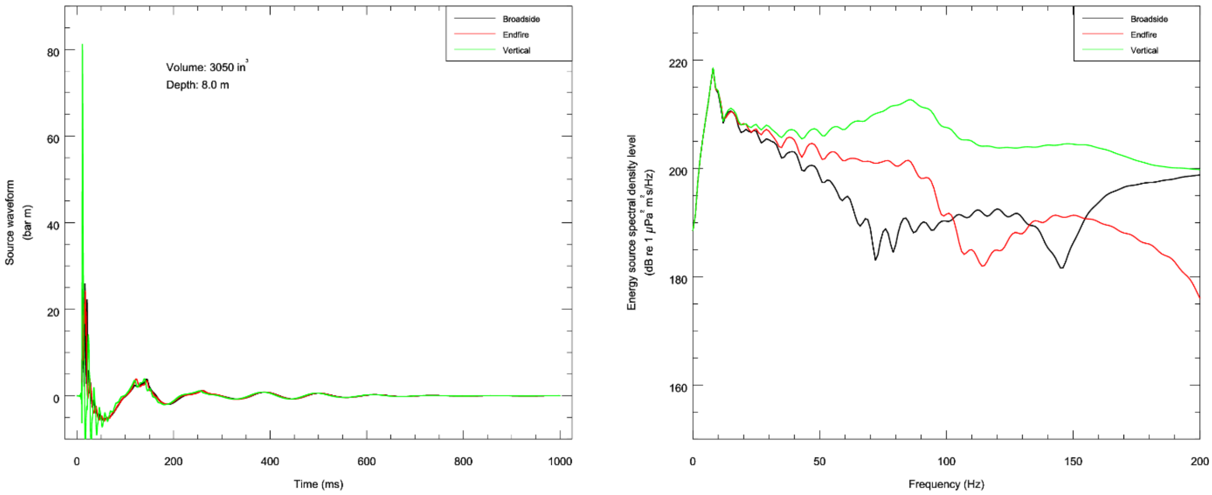

Figure B-2. Predicted source level details for the 3050 in^3 array at 8 m towed depth. (Left) the overpressure signature and (right) the power spectrum for in-plane horizontal (broadside), perpendicular (endfire), and vertical directions (no surface ghost).

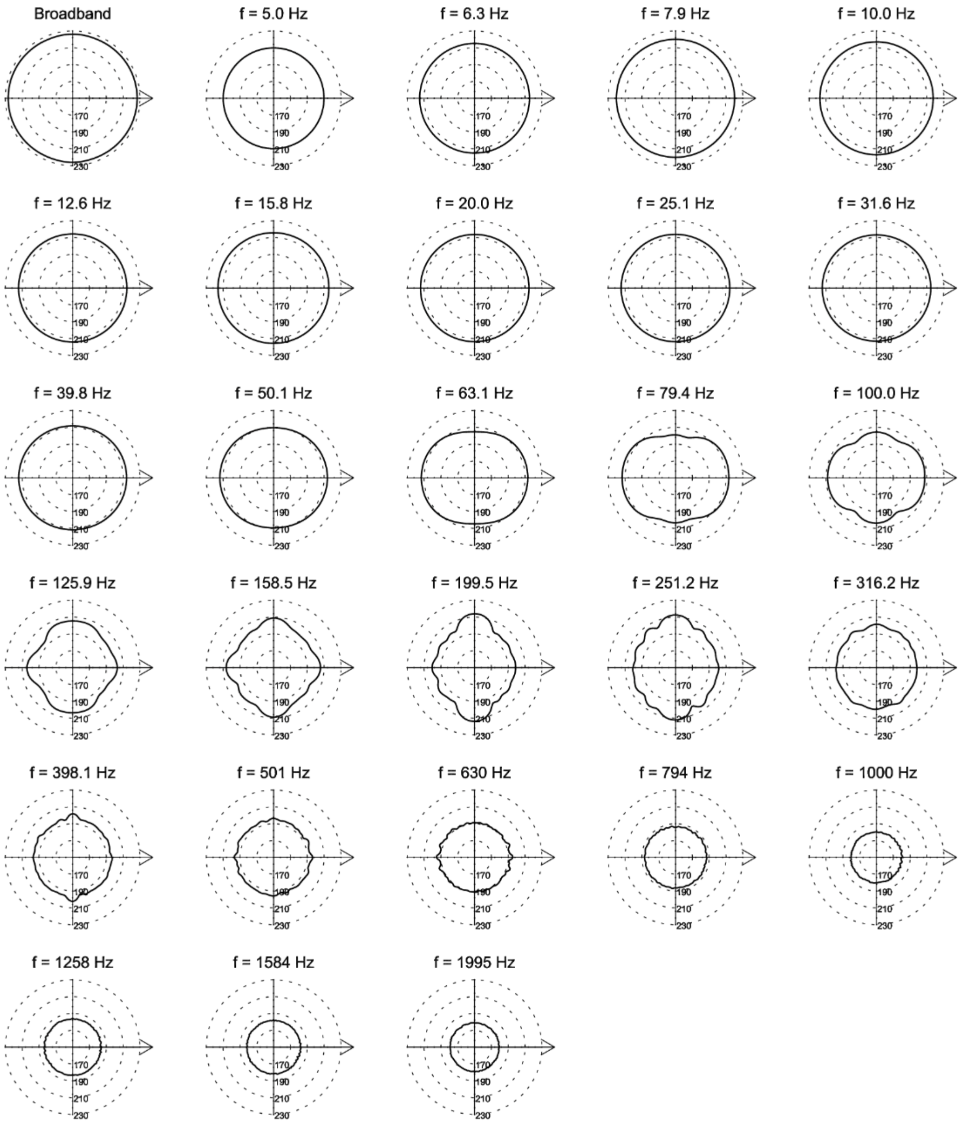

Figure B-3. Directionality of the predicted horizontal source levels for the 3050 in^3 seismic source, 5 Hz to 2 kHz. Source levels (in dB re 1 $\mu Pa^2 \cdot s\ m^2$) are shown as a function of azimuth for the centre frequencies of the decidecade bands modelled; frequencies are shown above the plots. The perpendicular direction to the frame is to the right. Tow depth is 8 m (see Figure B-2).

B.4. Seismic Source Comparison

B.4.1. Array Layouts

The layout and airgun parameters for the remaining 2480, 3090 and 3280 in^3 seismic sources considered in the preliminary source selection analysis are provided in Figures B-4, B-5 and B-6 and Tables B-2, B-3 and B-4, respectively.

For the modelled array, the layout is presented in a nominal cartesian coordinate system. In this coordinate system the direction of vessel travel determines the relative position of the array elements as plotted and tabulated. The layout used for acoustic modelling was produced by transforming the coordinates of client supplied layouts such that the resultant layouts correspond to a vessel travel direction along the positive X-axis and the array is centred on the X-Y origin. When used with an acoustic model the positive X-axis in this nominal coordinate system aligns with the vessel tow direction or survey line azimuth.

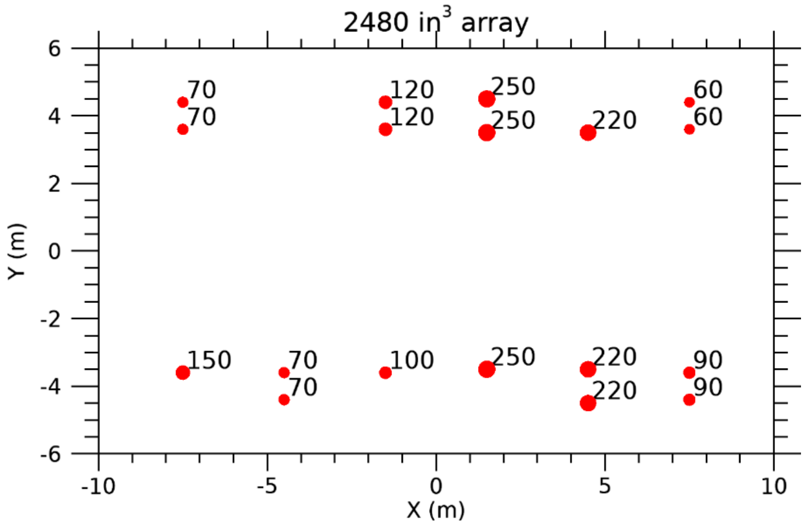

Figure B-4. Layout of the modelled 2480 in^3 seismic source. Tow depth is 8 m. The labels indicate the firing volume (in cubic inches) for each airgun. Also see Table B-2.

Table B-2. Layout of the modelled 2480 in3 seismic source. Tow depth was 8 m. Firing pressure for all guns was 2000 psi. Also see Figure B-4.

String	Gun	*x*(m)	*y*(m)	*z*(m)	Vol (in^3)	String	Gun	*x*(m)	*y*(m)	*z*(m)	Vol (in^3)
	1	7.5	-4.4		90		13	7.5	3.6		60
	2	7.5	-3.6		90		14	7.5	4.4		60
	3	4.5	-4.5		220		15	4.5	3.5		220
	4	4.5	-3.5		220		17	1.5	3.5		250
1	6	1.5	-3.5	8	250	2	18	1.5	4.5	8	250
	8	-1.5	-3.6		100		19	-1.5	3.6		120
	9	-4.5	-4.4		70		20	-1.5	4.4		120
	10	-4.5	-3.6		70		23	-7.5	3.6		70
	12	-7.5	-3.6		150		24	-7.5	4.4		70

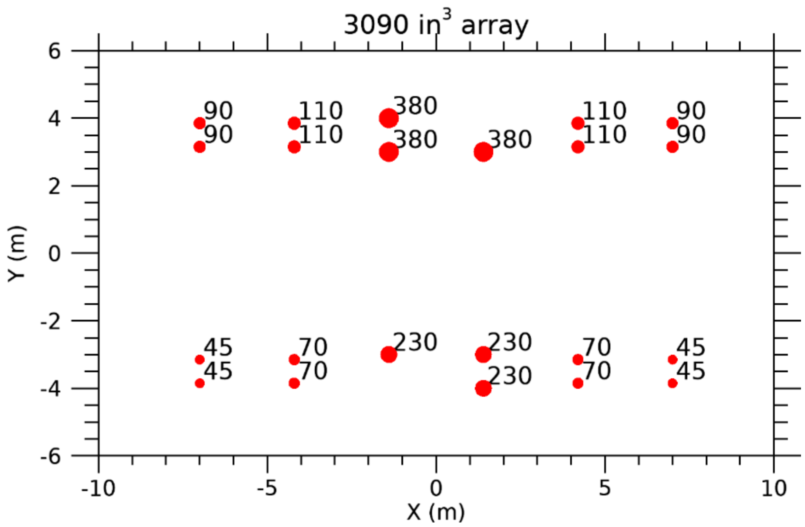

Figure B-5. Layout of the modelled 3090 in^3 seismic source. Tow depth is 8 m. The labels indicate the firing volume (in cubic inches) for each airgun. Also see Table B-3.

Table B-3. Layout of the modelled 3090 in^3 seismic source. Tow depth was 8 m. Firing pressure for all guns was 2000 psi. Also see Figure B-5.

String	Gun	*x*(m)	*y*(m)	*z*(m)	Vol (in^3)	String	Gun	*x*(m)	*y*(m)	*z*(m)	Vol (in^3)
1	1	7.0	-3.85	8	45	2	13	7.0	3.15	8	90
	2	7.0	-3.15		45		14	7.0	3.85		90
	3	4.2	-3.85		70		15	4.2	3.15		110
	4	4.2	-3.15		70		16	4.2	3.85		110
	5	1.4	-4.0		230		17	1.4	3.0		380
	6	1.4	-3.0		230		19	-1.4	3.0		380
	8	-1.4	-3.0		230		20	-1.4	4.0		380
	9	-4.2	-3.85		70		21	-4.2	3.15		110
	10	-4.2	-3.15		70		22	-4.2	3.85		110
	11	-7.0	-3.85		45		23	-7.0	3.15		90
	12	-7.0	-3.15		45		24	-7.0	3.85		90

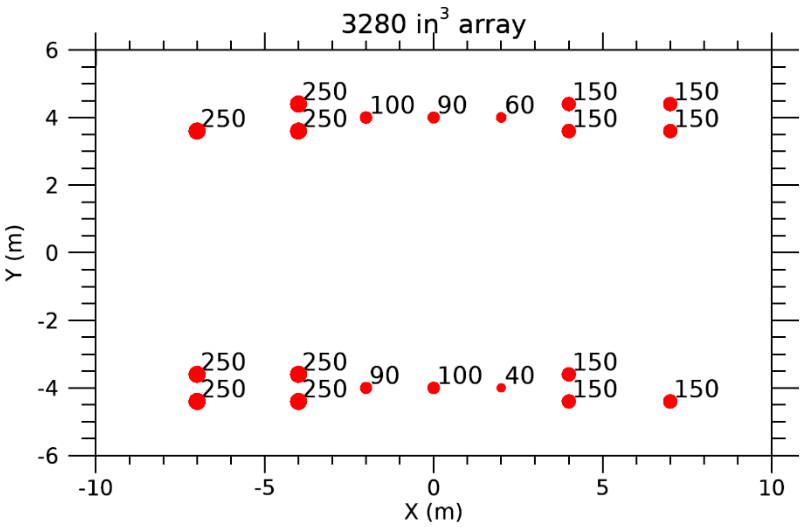

Figure B-6. Layout of the modelled 3280 in^3 seismic source. Tow depth is 8 m. The labels indicate the firing volume (in cubic inches) for each airgun. Also see Table B-4.

Table B-4. Layout of the modelled 3280 in3 seismic source. Tow depth was 8 m. Firing pressure for all guns was 2000 psi. Also see Figure B-6.

String	Gun	*x*(m)	*y*(m)	*z*(m)	Vol (in^3)
	1	7.0	-4.4		150
	3	4.0	-4.4		150
	4	4.0	-3.6		150
	5	2.0	-4.0		40
	7	0.0	-4.0		100
1	9	-2.0	-4.0	8	90
	11	-4.0	-4.4		250
	12	-4.0	-3.6		250
	13	-7.0	-4.4		250
	14	-7.0	-3.6		250

String	Gun	*x*(m)	*y*(m)	*z*(m)	Vol (in^3)
	1	7.0	3.6		150
	2	7.0	4.4		150
	3	4.0	3.6		150
	4	4.0	4.4		150
	5	2.0	4.0		60
2	7	0.0	4.0	8	90
	9	-2.0	4.0		100
	11	-4.0	3.6		250
	12	-4.0	4.4		250
	13	-7.0	3.6		250

B.4.2. Acoustic Source Levels and Directivity

Four different seismic sources were considered for preliminary source analysis and selecting a worst-case seismic source, the total volumes were 2480, 3050, 3090, and 3280 in^3. All arrays were modelled at a tow depth of 8 m.

The results from AASM for these sources are provided in Table B-5.

Table B-5. Far-field source level specifications for 2480, 3050, 3090 and 3280 in^3 sources. 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.

Total volume (in^3)	Direction	Peak source pressure level ($L_{S,pk}$) (dB re 1 µPa m)	Per-pulse source SEL ($L_{S,E}$) (dB 1 µPa²m²s)
			10-25000 Hz
2480	Broadside	248.2	223.5
3050	Broadside	248.3	224.4
3090	Broadside	249.5	224.9
3280	Broadside	249.4	224.8
2480	Endfire	244.6	221.9
3050	Endfire	247.7	224.8
3090	Endfire	245.8	222.5
3280	Endfire	244.5	222.7
2480	Vertical	254.1	227.1
3050	Vertical	258.2	230.7
3090	Vertical	255.2	228.2
3280	Vertical	255.4	228.4

B.4.3. Per-pulse Sound Field Comparison

Considering the zero-to-peak sound pressure levels (PK) as well as the SEL levels presented in Table B-5, there are three potential seismic sources, which require further comparison for the worst case selection, the 3050, 3090, and 3280 in^3 seismic sources. This is due to the fact that the 3090 in^3 source results in the greatest PK and SEL levels in the broadside direction, while the slightly smaller 3050 in^3 source leads to much higher PK and SEL values both in the endfire and vertical direction. Since the 3280 in^3 seismic source PK value in the broadside direction is barely smaller than the one of the 3090 in^3 seismic source, it was also included for further analysis.

FWRAM was used to model synthetic seismic pulses over a frequency range of 5-1024 Hz at Site 2 considering a tow direction of 125º. FWRAM was used to characterise the acoustic fields in terms of SEL, SPL and zero-to-peak sound pressure level (PK) metrics (as per Appendix A.1) for the 3050, 3090 and 3280 in^3 source, which allows for a comparison of the three sources in a representative environment. Modelling was performed along all broadside and endfire radials for the three seismic sources considered above, treating all seismic sources as a triple seismic source.

Figure B-7 to Figure B-9 present the maximum-over-depth for all radials for SEL, SPL and PK metrics as a function of range. The 3050 in^3 array consistently produced the highest SELs and SPLs at the farthest distances away from the source. The difference in SEL and SPL between these arrays will result in larger isopleths for energy based assessments (i.e. the SEL_{24h} assessment) and isopleths to behavioural disturbance for the 3050 in^3 array. The 3050 in^3 array was therefore selected as the worst-case source for modelling in this study.

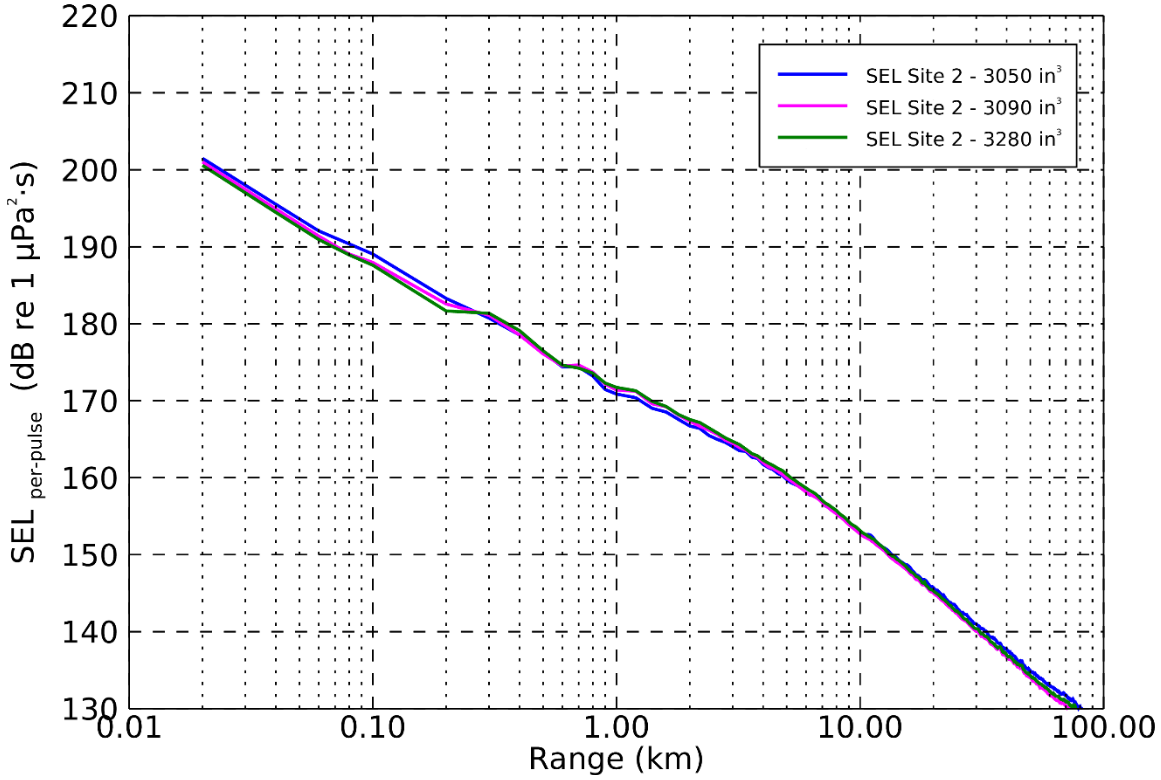

Figure B-7. Maximum-over-depth predicted SEL for 3050,3090 and 3280 in³ sources from FWRAM. Levels are the maximum over all the broadside and endfire directions.

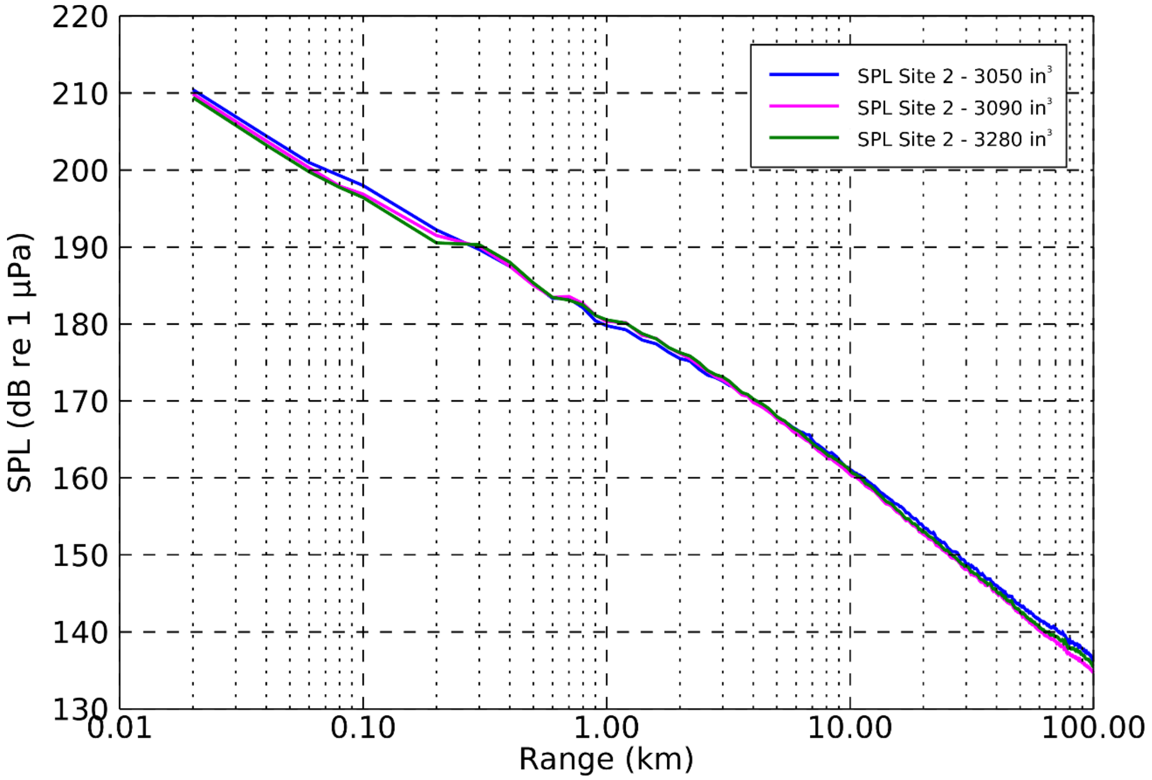

Figure B-8. Maximum-over-depth predicted SPL for 3050, 3090 and 3280 in³ sources from FWRAM. Levels are the maximum over all the broadside and endfire directions.

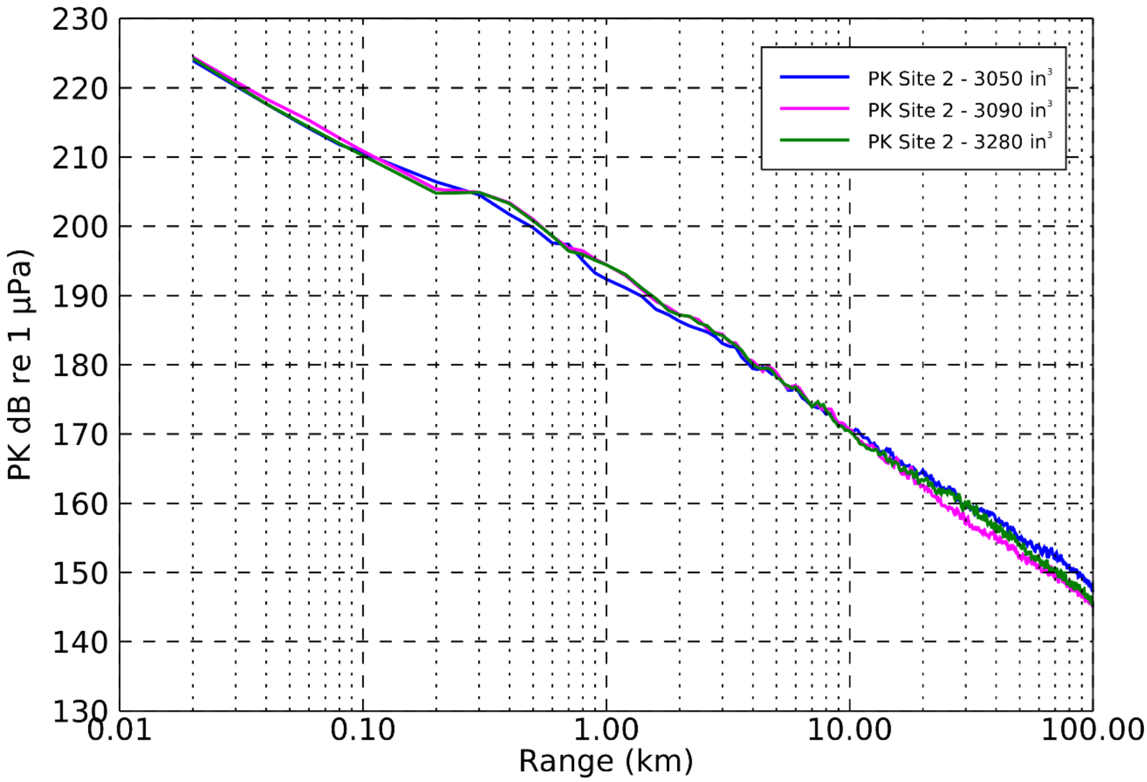

Figure B-9. Maximum-over-depth predicted PK for 3050, 3090 and 3280 in^3 sources from FWRAM. Levels are the maximum over all the broadside and endfire directions.

Appendix C. Sound Propagation Models

C.1. MONM-BELLHOP

Long-range sound fields were computed using JASCO's Marine Operations Noise Model (MONM). Compared to VSTACK, MONM less accurately predicts steep-angle propagation for environments with higher shear speed but is well suited for effective longer-range estimation. This model computes sound propagation at frequencies of 5 Hz to 1 kHz via a wide-angle parabolic equation solution to the acoustic wave equation (Collins 1993) based on a version of the US Naval Research Laboratory's Range-dependent Acoustic Model (RAM), which has been modified to account for a solid seabed (Zhang and Tindle 1995). MONM computes sound propagation at frequencies >1 kHz via the BELLHOP Gaussian beam acoustic ray-trace model (Porter and Liu 1994).

The parabolic equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al. 1996). MONM accounts for the additional reflection loss at the seabed, which results from partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces, and it includes wave attenuations in all layers. MONM incorporates the following site-specific environmental properties: a bathymetric grid of the modelled area, underwater sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor.

This version of MONM accounts for sound attenuation due to energy absorption through ion relaxation and viscosity of water in addition to acoustic attenuation due to reflection at the medium boundaries and internal layers (Fisher and Simmons 1977). The former type of sound attenuation is significant for frequencies higher than 5 kHz and cannot be neglected without noticeably affecting the model results.

MONM computes acoustic fields in three dimensions by modelling transmission loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as N×2-D. These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding N = 360°/$\Delta\theta$ number of planes (Figure C-1).

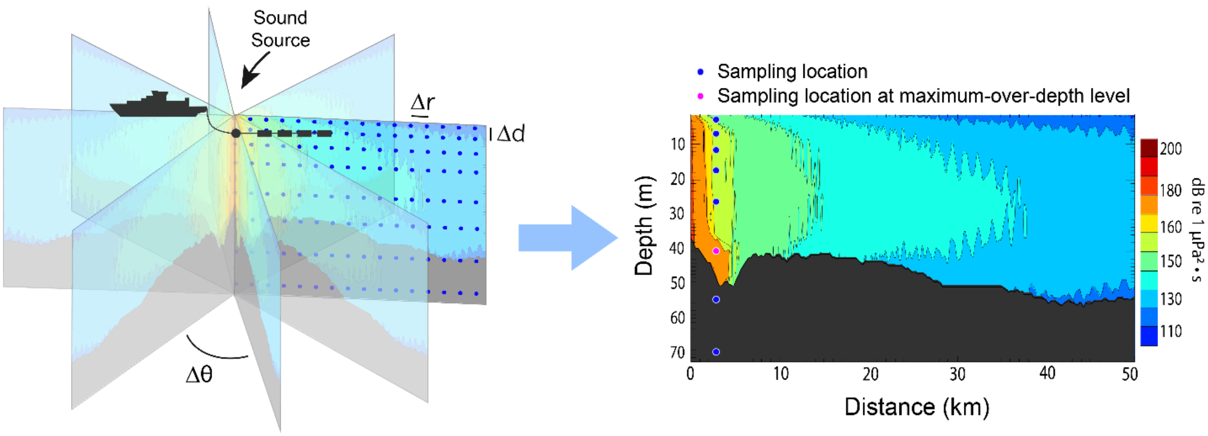

Figure C-1. The N×2-D and maximum-over-depth modelling approach used by MONM.

MONM treats frequency dependence by computing acoustic transmission loss at the centre frequencies of decidecade bands. Sufficiently many decidecade 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. The maximum received per-pulse SEL at a many sampling depths are taken 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 contours around the source.

C.2. Full Waveform Range-dependent Acoustic Model: FWRAM

For impulsive sounds from the seismic source, time-domain representations of the pressure waves generated in the water are required to calculate SPL and PK. Furthermore, the seismic source must be represented as a distributed source to accurately characterise vertical directivity effects in the near-field zone. For this study, synthetic pressure waveforms were computed using FWRAM, which is a time-domain acoustic model based on the same wide-angle parabolic equation (PE) algorithm as MONM. FWRAM computes synthetic pressure waveforms versus range and depth for range-varying marine acoustic environments, and it takes the same environmental inputs as MONM (bathymetry, water sound speed profile, and seafloor geoacoustic profile). Unlike MONM, FWRAM computes pressure waveforms via Fourier synthesis of the modelled acoustic transfer function in closely spaced frequency bands. FWRAM employs the array starter method to accurately model sound propagation from a spatially distributed source (MacGillivray and Chapman 2012).

Besides providing direct calculations of the PK and SPL, the synthetic waveforms from FWRAM can also be used to convert the SEL values from MONM to SPL.

C.3. Wavenumber Integration Model

Sound pressure levels near the seismic source were modelled using JASCO's VSTACK wavenumber integration model. VSTACK computes synthetic pressure waveforms versus depth and range for arbitrarily layered, range-independent acoustic environments using the wavenumber integration approach to solve the exact (range-independent) acoustic wave equation. This model is valid over the full angular range of the wave equation and can fully account for the elasto-acoustic properties of the sub-bottom. Wavenumber integration methods are extensively used in the field of underwater acoustics and seismology where they are often referred to as reflectivity methods or discrete wavenumber methods. VSTACK computes sound propagation in arbitrarily stratified water and seabed layers by decomposing the outgoing field into a continuum of outward-propagating plane cylindrical waves. Seabed reflectivity in the model is dependent on the seabed layer properties: compressional and shear wave speeds, attenuation coefficients, and layer densities. The output of the model can be post-processed to yield estimates of the SEL, SPL, and PK.

VSTACK accurately predicts steep-angle propagation in the proximity of the source, but it is computationally slow at predicting sound pressures at large distances due to the need for smaller wavenumber steps with increasing distance. Additionally, VSTACK assumes range-invariant bathymetry with a horizontally stratified medium (i.e., a range-independent environment) which is azimuthally symmetric about the source. VSTACK is thus best suited to modelling the sound field near the source.

C.3.1. Particle Motion

VSTACK was also used to compute estimates of particle acceleration and velocity for three sites (65, 85 and 100 m water depth) for the 3050 in^3 seismic source. 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 (Section 5.2.1.2) 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 5 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. 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 D. Methods and Parameters

This section details the environmental parameters used in the propagation models.

D.1. Estimating Range to Thresholds Levels

Sound level contours were calculated based on the underwater sound fields predicted by the propagation models, sampled by taking the maximum value over all modelled depths above the sea floor for each location in the modelled region. The predicted distances to specific levels were computed from these contours. Two distances relative to the source are reported for each sound level: 1) R_{max}, the maximum range to the given sound level over all azimuths, and 2) $R_{95\%}$, the range to the given sound level after the 5% farthest points were excluded (see examples in Figure D-1).

The $R_{95\%}$ is used because sound field footprints are often irregular in shape. In some cases, a sound level contour might have small protrusions or anomalous isolated fringes. This is demonstrated in the image in Figure D-1(a). In cases such as this, where relatively few points are excluded in any given direction, R_{max} can misrepresent the area of the region exposed to such effects, and $R_{95\%}$ is considered more representative. In strongly asymmetric cases such as shown in Figure D-1(b), on the other hand, $R_{95\%}$ neglects to account for significant protrusions in the footprint. In such cases R_{max} might better represent the region of effect in specific directions. Cases such as this are usually associated with bathymetric features affecting propagation. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment.

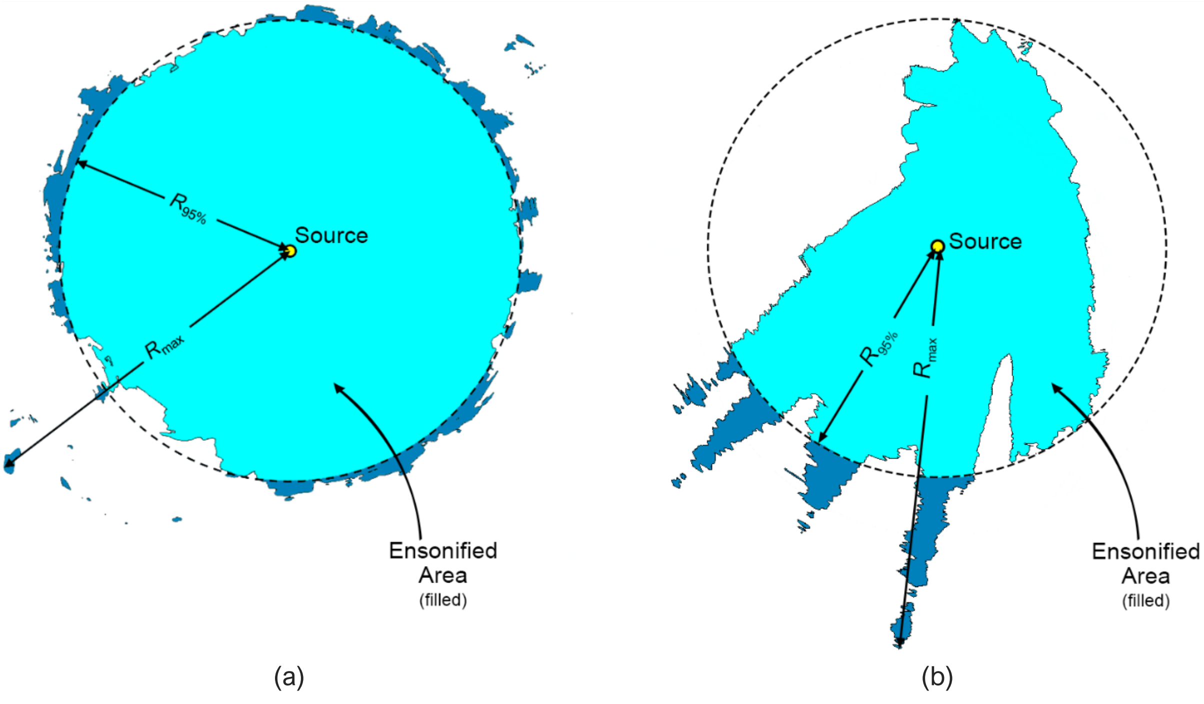

Figure D-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified areas bounded by $R_{95\%}$; darker blue indicates the areas outside this boundary which determine R_{max}.

D.2. Estimating SPL from Modelled SEL Results

The per-pulse SEL of sound pulses is an energy-like metric related to the dose of sound received over a pulse's entire duration. The pulse SPL on the other hand, is related to its intensity over a specified time interval. Seismic pulses typically lengthen in duration as they propagate away from their source, due to seafloor and surface reflections, and other waveguide dispersion effects. The changes in pulse length, and therefore the time window considered, affect the numeric relationship between SPL and SEL. This study has applied a fixed window duration to calculate SPL (T_{fix} = 125 ms; see Appendix A.1), as implemented in Martin et al. (2017). Full-waveform modelling was used to estimate SPL, but this type of modelling is computationally intensive, and can be prohibitively time consuming when run at high spatial resolution over large areas.

For the current study, FWRAM (Appendix C.2) was used to model synthetic seismic pulses over the frequency range 5-1024 Hz. This was performed along all broadside and endfire radials at three sites. FWRAM uses Fourier synthesis to recreate the signal in the time domain so that both the SEL and SPL from the source can be calculated. The differences between the SEL and SPL were extracted for all ranges and depths that corresponded to those generated from the high spatial-resolution results from MONM. A 125 ms fixed time window positioned to maximize the SPL over the pulse duration was applied. The resulting SEL-to-SPL offsets were averaged in 0.02 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 conversion function was applied to predicted per-pulse SEL results from MONM to model SPL values. Figure D-2 and Figure D-3 show the conversion offsets for the two sites for the 3050 in^3 array; the spatial variation is caused by changes in the received airgun pulse as it propagates from the source. The conversion to SPL from SEL was conducted considering the water depth and seabed geology at a given modelled site.

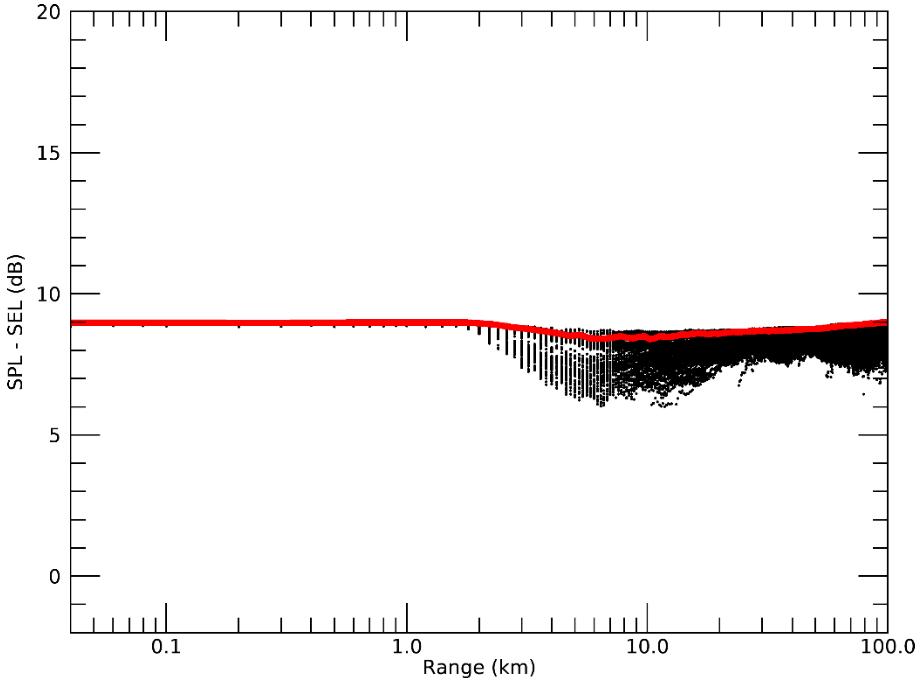

Figure D-2. *Site 1, 3050 in^3 seismic source*: Range-and-depth-dependent conversion offsets for converting sound exposure level (SEL) to sound pressure level (SPL) for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

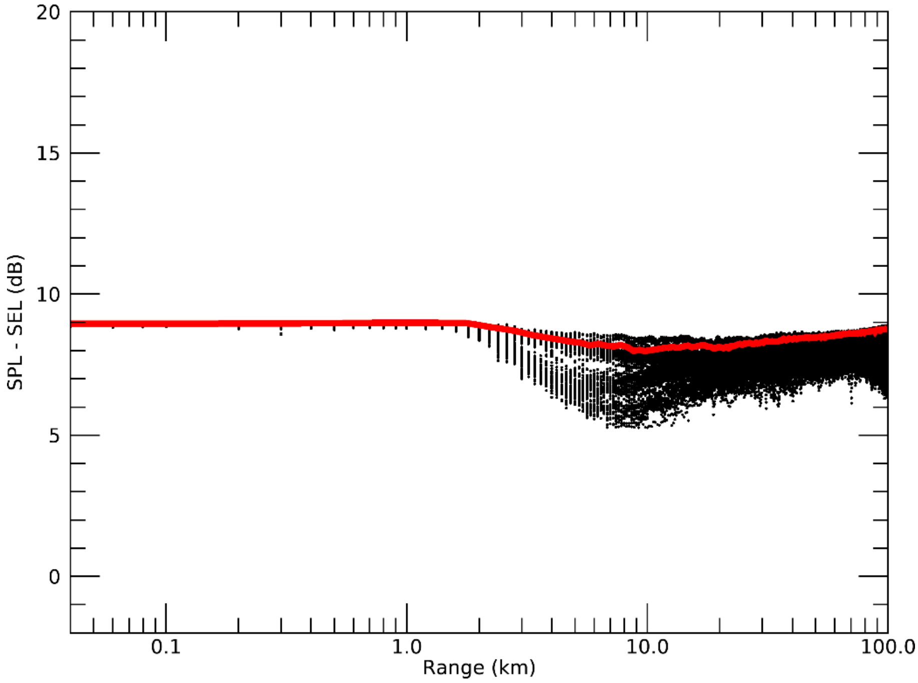

Figure D-3. *Site 2, 3050 in^3 seismic source*: Range-and-depth-dependent conversion offsets for converting sound exposure level (SEL) to sound pressure level (SPL) for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

D.3. Environmental Parameters

D.3.1. Bathymetry

Water depths throughout the modelled area were extracted from the high-resolution depth model for Northern Australia, a ~30 m grid rendered for Northern Australia (Beaman 2018) for the region shown in Figure 1. Bathymetry data was extracted and re-gridded onto a Map Grid of Australia (MGA) coordinate projection (Zone 52) with a regular grid spacing of 250 × 250 m to generate the bathymetry in Figure D-4.

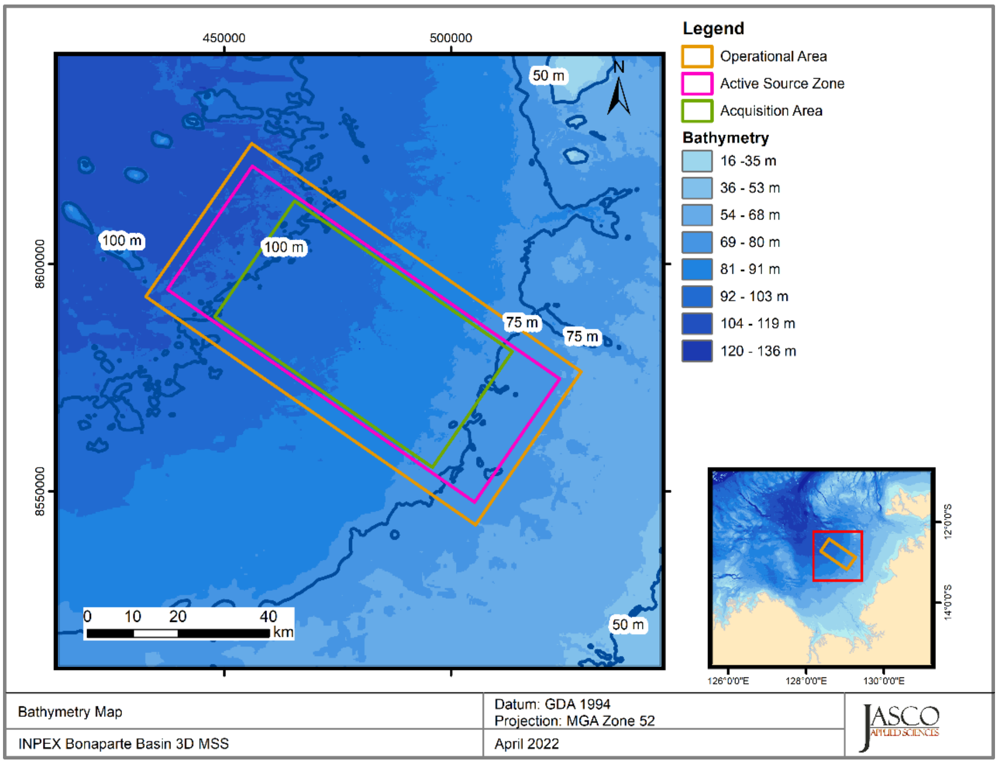

Figure D-4. Bathymetry map of the modelling area for the Bonaparte Basin 3D MSS.

D.3.2. Sound Speed Profile

The sound speed profiles for the modelled sites were derived from temperature and salinity profiles from the US 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 US Navy's Master Oceanographic Observational Data Set (MOODS). The climatology profiles include 78 fixed depth points to a maximum depth of 6800 m (where the ocean is that deep). The GDEM temperature-salinity profiles were converted to sound speed profiles according to Coppens (1981).

Mean monthly sound speed profiles were derived from the GDEM profiles within a 100 km box radius encompassing all modelled sites. The June sound speed profile is expected to be most favourable to longer-range sound propagation during the proposed survey time frame. As such, June was selected for sound propagation modelling to ensure precautionary estimates of distances to received sound level thresholds. Figure D-5 shows the resulting profile used as input to the sound propagation modelling.

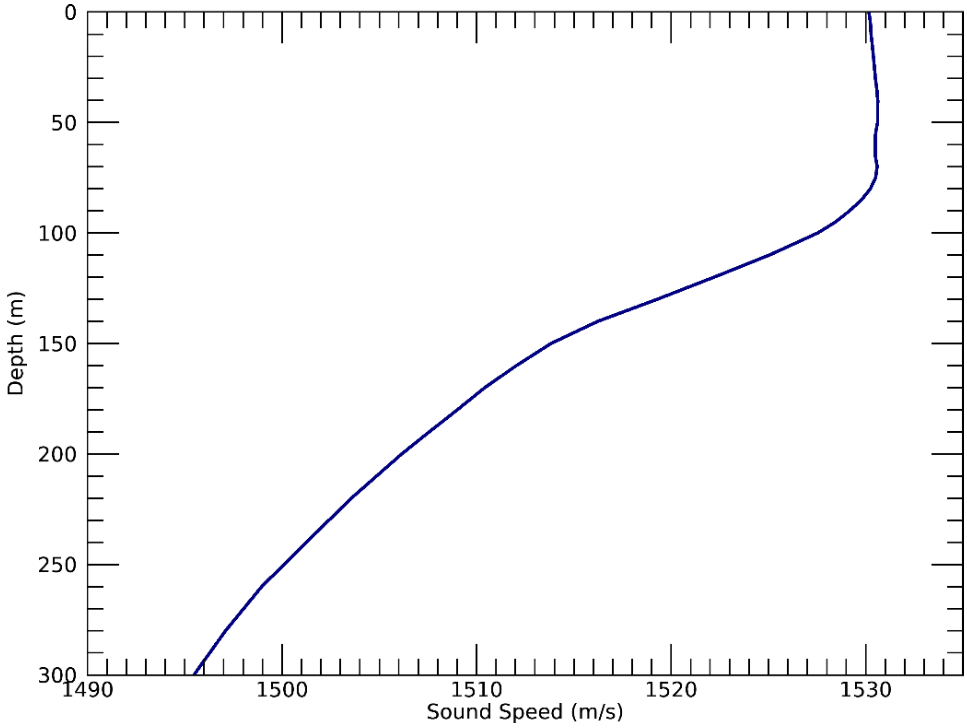

Figure D-5. The sound speed profile (June) used for the modelling showing the entire water column. Throughout the modelling area, the maximum water depth was 148m. The profile is calculated from temperature and salinity profiles from GDEM V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

D.3.3. Geoacoustics

Geoacoustic parameters used for modelling at all sites were derived from sedimentary grain size measurements from the Australian Government's Marine Sediments (MARS) database (Heap 2009). On average, the surficial grain size indicates silty sand is present throughout the modelled area. Representative grain sizes were used in the grain-shearing model proposed by Buckingham (2005) to estimate the geoacoustic parameters required by the sound propagation models. Table D-1 lists the geoacoustic parameters used for modelling for both sites.

Table D-1. Geoacoustic profile for all modelling sites.

Depth below seafloor (m)	Predicted lithology	Density (g/cm^3)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed (m/s)	Attenuation (dB/λ)
0-10	Unconsolidated muddy sand	1.88	1624-1724	0.34-0.71	262	3.65
10-20		1.88	1724-1777	0.71-0.88		
20-50		1.88-1.90	1777-1874	0.88-1.14		
50-100	Compact muddy sand	1.90-1.92	1874-1978	1.14-1.37		
100-200		1.92-1.96	1978-2118	1.37-1.62		
200-500	Consolidated muddy sand/sedimentary rock	1.96-2.06	2118-2392	1.62-1.93		
> 500		2.06	2392	1.93		

Appendix E. Model Validation Information

Predictions from JASCO's Airgun Array Source Model (AASM) and propagation models (MONM, FWRAM and VSTACK) have been validated against experimental data from a number of underwater acoustic measurement programs conducted by JASCO globally, including the United States and Canadian Artic, Canadian and southern United States waters, Greenland, Russia and Australia (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b, Matthews and MacGillivray 2013, Martin et al. 2015, Racca et al. 2015, Martin et al. 2017a, Martin et al. 2017b, Warner et al. 2017, MacGillivray 2018, McPherson et al. 2018, McPherson and Martin 2018).

In addition, JASCO has conducted measurement programs associated with a significant number of anthropogenic activities which have included internal validation of the modelling (including McCrodan et al. 2011, Austin and Warner 2012, McPherson and Warner 2012, Austin and Bailey 2013, Austin et al. 2013, Zykov and MacDonnell 2013, Austin 2014, Austin et al. 2015, Austin and Li 2016, Martin and Popper 2016).

Appendix F. Additional Results

F.1. SEL Contour Maps

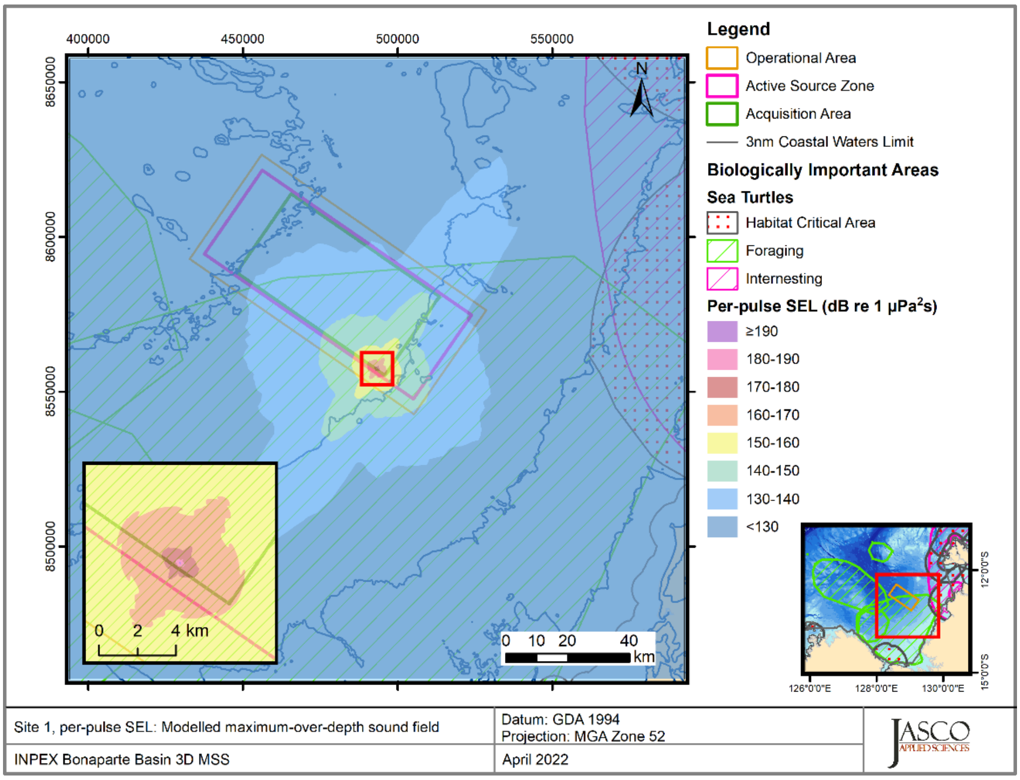

Figure F-1. *Site 1, tow azimuth 125º, SEL:* Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps.

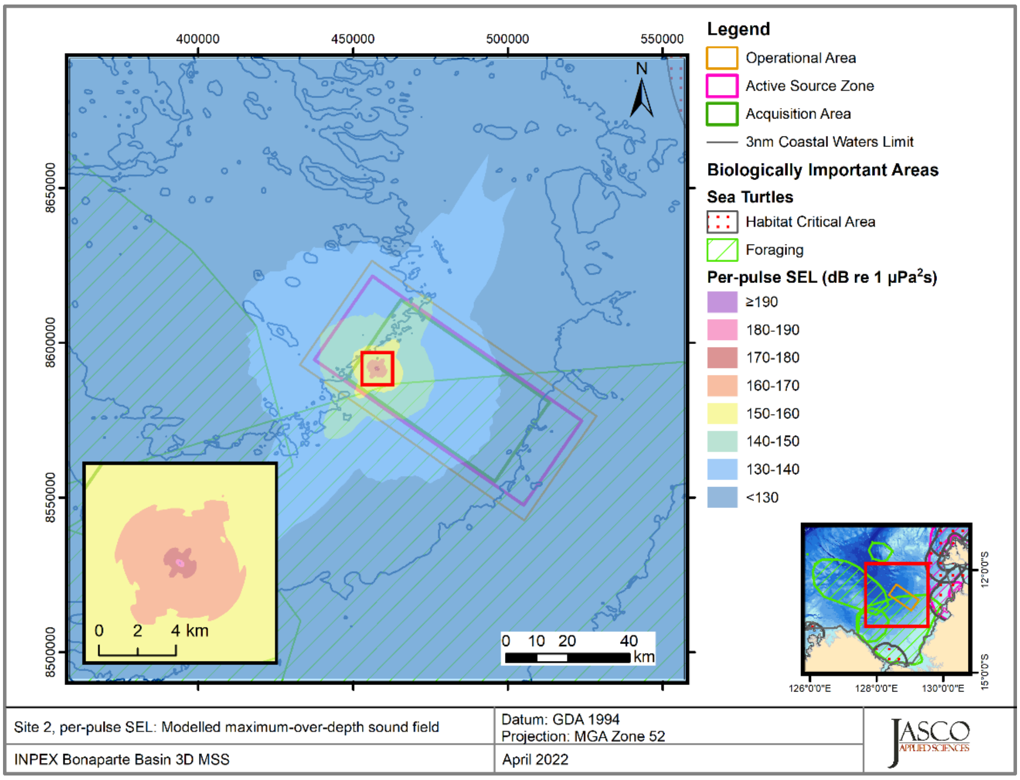

Figure F-2. *Site 2, tow azimuth 125º, SEL:* Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps.