ENVIRONMENT PLAN - APPENDICES

Beehive-1 Exploration Drilling

WA-488-P

29 April 2022

Rev 0

eog resources

List of appendices

Appendix 1

Commonwealth, State and Territory Legislation

COMMONWEALTH LEGISLATION

Commonwealth Legislation/ Regulation	Scope	Related International Conventions	Administering Authority
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (& Regulations 2000)	Protects matters of national environmental significance (MNES), provides for Commonwealth environmental assessment and approval processes and provides an integrated system for biodiversity conservation and management of protected areas. M NES are: 1. World heritage properties; 2. National heritage places; 3. Wetlands of international importance (Ramsar wetlands); 4. Nationally threatened species and ecological communities; 5. Migratory species; 6. Commonwealth marine environment; 7. The Great Barrier Reef Marine Park; 8. Nuclear actions (including uranium mining); and 9. A water resource, in relation to coal seam gas development and large coal mining development. **Relevance to this activity:** This EP includes a description and assessment of MNES and migratory species (Item 4 and Item 5 in this list) including the Commonwealth marine environment (Item 6), that may be impacted by the activity.	• Republic of Korea Migratory Birds Agreement 2006 (ROKAMBA). • Convention on Biological Diversity and Agenda 21 1992. • Agreement between the Government and Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986 (CAMBA). • Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) 1979. • Agreement between the Government and Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment 1974 (JAMBA). • Convention on International Trade in Endangered Species of Wild Fauna and Flora 1973 (CITES). • Convention on Wetlands of International Importance especially as Waterfowl Habitat 1971 (RAMSAR). • International Convention for the Regulation of Whaling 1946.	DAWE (National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) in the case of this activity)

Commonwealth Legislation/ Regulation	Scope	Related International Conventions	Administering Authority
Offshore Petroleum Greenhouse Gas Storage Act (OPGGSA) 2006 and OPGGS (Environment) Regulations 2009	The Act addresses all licensing and HSE issues for offshore GHG activities extending beyond the 3 nm limit. The Regulations (Part 2) specify that an EP must be prepared for any petroleum activity and that activities are undertaken in an ecologically sustainable manner. **Relevance to this activity:** The submission and acceptance of this EP satisfies the key requirements of this legislation.	Not applicable.	NOPSEMA
Environment Protection (Sea Dumping) Act 1981 (& Regulations 1983)	Aims to prevent the deliberate disposal of wastes (loading, dumping, and incineration) at sea from vessels, aircraft, and platforms. **Relevance to this activity:** There will be no dumping at sea within the meaning of the legislation that would require a sea dumping permit to be obtained.	• Protocol on the Prevention of Marine Pollution by Dumping of Waste and Other Matter 1996 [London Protocol] • Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter 1972 [London Convention]	DAWE
Australian Maritime Safety Authority Act 1990	Facilitates international cooperation and mutual assistance in preparing and responding to a major oil spill incidents, and encourages countries to develop and maintain an adequate capability to deal with oil pollution emergencies. Requirements are effected through the Australian Maritime Safety Authority (AMSA). AMSA is the lead agency for responding to oil spills in the Commonwealth marine environment and is responsible for implementing the Australian National Plan for Maritime Environmental Emergencies (NatPlan). **Relevance to this activity:** In the event of a Level 2 or 3 hydrocarbon spill to sea from a vessel in Commonwealth waters, AMSA is the designated Combat Agency and implements the NatPlan. In the event of a spill from a well blowout, AMSA will assist the Drilling Incident Management Team (DIMT)	• Protocol on Preparedness, Response and Cooperation to Pollution Incidents by Hazardous and Noxious Substances 2000 • International Convention on Oil Pollution Preparedness, Response and Cooperation 1990 (OPRC).	AMSA

Commonwealth Legislation/ Regulation	Scope	Related International Conventions	Administering Authority
Underwater Cultural Heritage Act 2018	Protects the heritage values of shipwrecks, sunken aircraft and relics (older than 75 years) in Australian Territorial waters below the low water mark to the outer edge of the continental shelf (excluding the State's internal waterways. It is an offence to interfere with a shipwreck covered by this Act. This Act replaced the *Historic Shipwrecks Act* 1976 and came into effect on 1 July 2019. **Relevance to this activity:** No historic shipwrecks have been identified within the operations area through desktop research. In the event of discovery of, and damage to, previously unrecorded wrecks, this legislation may be triggered.	• Convention on Protection of the Underwater Cultural Heritage 2001. • Agreement between the Netherlands and Australia concerning old Dutch Shipwrecks 1972.	DAWE
Ozone Protection and Synthetic Greenhouse Gas Management Act 1989	Regulates the manufacture, importation and use of ozone depleting substances. **Relevance to this activity:** The MODU and support vessels will have a register of ozone-depleting substances (ODS).	• United Nations Framework Convention on Climate Change 1992. • Montreal Protocol on Substances that Deplete the Ozone Layer 1987.	DAWE
Navigation Act 2012 (& Regulations 2013)	This Act regulates ship-related activities in Commonwealth waters and invokes certain requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) relating to equipment and construction of ships. Several Marine Orders (MO) are enacted under this Act relating to offshore petroleum activities, including: • MO Part 21: Safety of navigation and emergency procedures • MO Part 30: Prevention of collisions • MO Part 50: Special purpose ships • MO Part 59: Offshore industry vessel operations • MO Part 70: Seafarer certification. **Relevance to this activity:** Support vessels will adhere to the relevant MOs while operating within Commonwealth waters.	• International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) as amended, 1995. • United Nations Convention on the Law of the Sea 1982 (UNCLOS). • International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978 (MARPOL). • International Convention for the Safety of Life at Sea 1974 (SOLAS). • Convention on the International Regulations for Preventing Collisions at Sea 1972 (COLREG).	AMSA

Commonwealth Legislation/ Regulation	Scope	Related International Conventions	Administering Authority
Protection of the Sea (Prevention of Pollution from Ships) Act 1983 Protection of the Sea (Prevention of Pollution from Ships) (Orders) Regulations 1994	Regulates ship-related operational activities and invokes certain requirements of the MARPOL Convention relating to discharge of noxious liquid substances, sewage, garbage, air pollution etc. Requires that ships >400 gross tonnes to have pollution emergency plans. Several MO are enacted under this Act relating to offshore petroleum activities, including: • MO Part 91: Marine Pollution Prevention – Oil • MO Part 93: Marine Pollution Prevention – Noxious Liquid Substances • MO Part 94: Marine Pollution Prevention – Harmful Substances in Packaged Forms • MO Part 95: Marine Pollution Prevention – Garbage • MO Part 96: Marine Pollution Prevention – Sewage • MO Part 97: Marine Pollution Prevention – Air Pollution • MO Part 98: Marine Pollution Prevention – Anti-fouling Systems. **Relevance to this activity:** The MODU and support vessels > 400 gross tonnes will adhere to the relevant MOs by having a SMPEP, Oil Record Book and Garbage Management Plan in place and implemented, along with international pollution prevention certificates verifying compliance with oil, air pollution and sewage measures.	• Various parts of MARPOL.	AMSA

Commonwealth Legislation/ Regulation	Scope	Related International Conventions	Administering Authority
Protection of the Sea (Civil Liability for Bunker Oil Pollution Damage) Act 2008	Sets up a compensation scheme for those who suffer damage caused by spills of oil that is carried as fuel in ships' bunkers. There is an obligation on ships > 1,000 gross tonnes to carry insurance certificates when leaving/entering Australian ports, or leaving/entering an offshore facility within Australian coastal waters. **Relevance to this activity:** Vessels will hold the required insurance certificates.	• International Convention on Civil Liability for Bunker Oil Pollution Damage 2001.	AMSA
Protection of the Sea (Harmful Antifouling Systems) Act 2006	Creates an offence for a person to engage in negligent conduct that results in a harmful anti-fouling compound being applied to a ship. Also provides that Australian ships must hold 'anti-fouling certificates', provided they meet certain criteria. **Relevance to this activity:** The MODU and support vessels will hold the required valid anti-fouling certificates.	• International Convention on the Control of Harmful Anti-fouling Systems on Ships 2001.	AMSA
Protection of the Sea (Shipping Levy) Act 1981	Provides that where, at any time during a quarter when a ship with tonnage length of no less than 24 m was in an Australia port, there was on board the ship a quantity of oil in bulk weighing more than 10 tonnes, a levy is imposed in respect of the ship for the quarter. **Relevance to this activity:** The support vessels will adhere to the shipping levy, as required.	Not applicable.	AMSA
Maritime Legislation Amendment (Prevention of Air Pollution from Ships) Act 2007	This Act implements the requirements of MARPOL 73/78 Annex VI for shipping in Commonwealth waters as per: • MO Part 97: Marine Pollution Prevention – Air Pollution. **Relevance to this activity:** The MODU and support vessels will use low sulfur diesel fuel.	• Various parts of MARPOL.	Department of Infrastructure, Transport, Regional Development and Communications

Commonwealth Legislation/ Regulation	Scope	Related International Conventions	Administering Authority
National Greenhouse and Energy Reporting Act 2007 (NGER) (& Regulations 2008)	Establishes the legislative framework for the NGER Scheme, which is a national framework for reporting GHG emissions, GHG projects and energy consumption and production by corporations in Australia. **Relevance to this activity:** Under the NGER Act, a controlling corporation assesses its reporting obligations by reference to the facilities that are under its 'operational control.' As the MODU and support vessel contractors do not come under EOG's operational control, they will be required to collect and submit their own emissions data under the NGER Act (if triggered).	• United National Framework Convention on Climate Change (UNFCCC), entered into force in 1994. Goals under the framework are updated during the annual convention.	Clean Energy Regulator

Commonwealth Legislation/ Regulation	Scope	Related International Conventions	Administering Authority
Biosecurity Act 2015 (& Regulations 2016)	This Act provides the Commonwealth with powers to take measures of quarantine, and implement related programs as are necessary, to prevent the introduction of any plant, animal, organism or matter that could contain anything that could threaten Australia's native flora and fauna or natural environment. The Commonwealth's powers include powers of entry, seizure, detention and disposal. Offshore petroleum installations outside of 12 nm are located outside of Australian territory for the purposes of the Act. While these installations are not subject to biosecurity control, aircraft and vessels (not subject to biosecurity control) that leave Australian territory and are exposed to the installations are subject to biosecurity control when returning to Australian territory. When a vessel or aircraft leaves Australian territory and interacts with an installation or petroleum industry vessel it becomes an 'exposed conveyance' and is subject to biosecurity control when it returns to Australian territory unless exceptions can be met. The person in charge of an exposed conveyance carries the responsibility for pre-arrival reporting under the Act and must arrive at a first point of entry. This Act includes mandatory controls in the use of seawater as ballast in ships and the declaration of sea vessels voyaging into and out of Commonwealth waters. The regulations stipulate that all information regarding the voyage of the vessel and the ballast water is declared correctly to the quarantine officers. **Relevance to this activity:** The MODU and support vessels sourced from foreign ports will adhere to the DAWE guidelines regarding quarantine clearance to enter Australian waters.	• International Convention for the Control and Management of Ships Ballast Water & Sediments 2004. • World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures (SPS agreement) 1995. • World Organisation for Animal Health and the International Plant Protection Convention 1952.	DAWE

Commonwealth Legislation/ Regulation	Scope	Related International Conventions	Administering Authority
Marine Safety (Domestic Commercial Vessel) National Law Act 2012 (& Regulations 2013)	This Act provides for a national system for Domestic Commercial Vessels (DCV) between states and territories to ensure their safe operation. This system provides for MO and National Standards to be adopted for DCVs of different classes. Current MO include: • MO 501 (Administration – National Law) 2013 • MO 502 (Vessel Identifiers – National Law) 2013 • MO 503 (Certificates of Survey – National Law) 2013 • MO 504 (Certificates of Operation and Operational Requirements – National Law) 2013 • MO 505 (Certificates of Competency – National Law) 2013 • MO 507 (Load Line Certificates – National Law) 2013. This law does not over-ride state legislation with respect to marine environmental management, dangerous goods management, speed limits, navigation aids, rules for prevention of collisions, monitoring of marine communications systems, workplace health and safety or emergency management and response. **Relevance to this activity:** The MODU and support vessels will adhere to the relevant MOs while operating within Commonwealth waters.	Not applicable.	AMSA
Native Title Act 1993	Allows for recognition of native title through a claims and mediation process and also sets up regimes for obtaining interests in lands or waters where native title may exist. **Relevance to this activity:** Native Title Determination area does not cover the operational area, and therefore there is no relevance to this activity.	Not applicable.	National Native Title Tribunal (NNTT)

Commonwealth Legislation/ Regulation	Scope	Related International Conventions	Administering Authority
Fisheries Management Act 1991 (& Regulations 2009)	This Act aims to implement efficient and cost-effective fisheries management on behalf of the Commonwealth, ensure that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of Ecologically Sustainable Development (ESD), maximise the net economic returns to the Australian community from the management of Australian fisheries, ensure accountability to the fishing industry and to the Australian community in in the Australian Fisheries Management Authority's (AFMA's) management of fisheries resources, and achieve government targets in relation to the recovery of the costs of AFMA. **Relevance to this activity:** Provides the regulatory and other mechanisms to support any necessary fisheries management decisions in the event of a hydrocarbon spill in Commonwealth waters.	Not applicable.	AFMA
Aboriginal and Torres Strait Islander Heritage Protection Act 1984	This Act provides for the preservation and protection from injury or desecration areas and objects that are of significance to Aboriginal people, under which the Minister may make a declaration to protect such areas and objects. Under the Act, discovery of Aboriginal remains must be reported to the Environment Minister. **Relevance to this activity:** No known sites of Aboriginal heritage significance occur within the operational area. May be relevant in the event of a hydrocarbon spill requiring shoreline access for clean-up purposes.	Not applicable.	DAWE

WESTERN AUSTRALIAN LEGISLATION

WA Legislation/ Regulation	Scope	Relevance to activity	Administering Authority
Conservation and Land Management Act 1984	This Act makes provision for the use, protection and management of certain public lands and waters and the flora and fauna. It establishes authorities responsible for such protection. This Act covers the management of Nationally Important Wetlands that are present along the coast of the EMBA.	This Act would be triggered in the event of a hydrocarbon spill that threatens coastal marine parks, or that access to respond to a hydrocarbon spill is required through such parks.	Conservation and Parks Commission
Contaminated Sites Act 2003 (& Regulations 2006)	This Act provides for the identification, recording, management and remediation of contaminated sites. Under the Act, a 'site' is an area of land or water in WA, including surface water, groundwater and offshore areas out to 3 nm. A site is 'contaminated' if it has a substance in it at above background concentrations, which presents or has the potential to present a risk of harm to human health or the environment.	This Act would be triggered in the event that a hydrocarbon spill contaminates shorelines and requires remediation.	Department of Water and Environmental Regulation (DWER)
Environmental Protection Act 1986	This is the principal Act relating to environmental protection in WA. It establishes the EPA and gives the EPA overall responsibility for the prevention, control and abatement of environmental pollution and for the conservation, preservation, protection, enhancement and management of the environment. Part 5 of the Act states that a person who causes pollution or environmental harms or allows pollution or environmental harm to be caused commits an offence.	Hydrocarbons are listed in Schedule 1 of the Act as a Listed Waste. The Act would be triggered in the event of a hydrocarbon spill that reaches the coast, particularly with regard to waste treatment, transport and disposal.	Office of the EPA
Environmental Protection (Controlled Waste) Regulations 2004	These regulations detail the appropriate management and handling of controlled wastes in respect to the environment. Schedule 1 of the regulations lists waste oil and water, or hydrocarbons and water, mixtures or emulsions as a controlled waste.	These regulations may be triggered in the event that a hydrocarbon spill enters state waters and reaches shorelines, requiring collection and onshore handling, transport and disposal.	DWER

WA Legislation/ Regulation	Scope	Relevance to activity	Administering Authority
Environmental Protection (Unauthorised Discharges) Regulations 2004	These regulations make it an offence to cause pollution through unauthorised discharges, particularly with regard to dark smoke (anything darker than shade 1 on the Australian Miniature Smoke Chart, AS 3543, 1989). It may be a defence to cause dark smoke to prevent irreversible damage to a significant part of the environment. Schedule 1 of the regulations lists hydrocarbon as a material that must not be discharged to the environment.	This Act would be triggered in the event that a hydrocarbon spill enters state waters and/or in-situ burning is a response consideration.	DWER
Emergency Management Act 2005	This Act provides for prompt and coordinated organisation of emergency management in the State. Hazards captured under the Act include events that result in destruction of or damage to the environment. It establishes the State Emergency Management Committee (SEMC), which is the key plan in responding to emergencies of state significance.	This Act would be triggered in the event that a hydrocarbon spill threatens state waters and shorelines. The SEMC would implement the State Emergency Management Plan on behalf of the state.	SEMC
Aquatic Management Resources Act 2016 (ARMA)	This Act provides for the ecologically sustainable development and management of the State's aquatic resources including management of aquatic biosecurity.	This Act would be triggered in the event that a hydrocarbon spill enters state waters and has the potential to impact commercial fishing activities (e.g., closures).	Department of Primary Industry and Regional Development (DPIRD)
Harbours and Jetties Act 1928	This Act relates to the liability of owners of ships for damage to harbours and jetties, and works connected therewith.	This Act may be triggered in the event that a support vessel used for the project causes loss or damage to a harbor or jetty.	Department of Transport (DoT)
Pollution of Waters by Oil and Noxious Substances Act 1987 (& Regulations 1993)	This Act provides for the protection of the sea and certain waters from pollution by oil and other noxious substances discharged from ships (as defined in the WA Marine Act, see below). This Act prohibits the discharge of oil or noxious substances into State waters and provides for the removal of oil or any mixture containing oil from affected waters.	This Act may be triggered in the event that a hydrocarbon spill enters state waters.	EPA & DoT
Western Australian Marine Act 1982 (& (Infringements) Regulations 1985)	This Act regulates navigation and shipping in WA waters.	Activity vessels traversing WA state waters (e.g., in the event of hydrocarbon spill) must abide by the requirements of the Act with regard to marine safety requirements.	DoT

WA Legislation/ Regulation	Scope	Relevance to activity	Administering Authority
Biodiversity Conservation Act 2016 (& Regulations 2018)	This Act provides for the conservation and protection of wildlife. Licences to take (i.e., for fauna, to kill, capture, disturb, hunt and for flora to gather, pluck, dig up, destroy, etc) protected flora and fauna on Crown land (e.g., coastal parks) are required under this act. The regulations provide for the issuing of licences to take, keep, import and export flora and fauna, and for the caring of sick or injured fauna.	This Act would be triggered in the event that native wildlife rescue and treatment is required in the event of a hydrocarbon spill, or that native habitat on the coast may be damaged in the process of responding to coastal stranding of hydrocarbons.	Department of Biodiversity, Conservation and Attractions (DBCA)
Animal Welfare Act 2002 (& Animal Welfare (General) Regulations 2003)	This Act is established to provide for the welfare, safety and health of animals, to regulate the use of animals for scientific purposes and for related purposes. The Act is focused on prohibiting cruelty to, and other inhumane or improper treatment of, animals.	This Act would be triggered in the event that wildlife rescue and treatment is required in the event of a hydrocarbon spill.	DPIRD

NORTHERN TERRITORY LEGISLATION

NT Legislation/ Regulation	Scope	Relevance to activity	Administering Authority
Environment Protection Act 2019 (& Regulations 2020)	This Act provides the requirement for operators in the Northern Territory to hold an 'environmental approval' for proposed actions that will have a significant impact on the environment or require referral under a 'referral trigger'.	The Act would be triggered in the event of a hydrocarbon spill that reaches the shoreline, particularly with regard to pollution and waste containment, avoidance and abatement.	NT EPA
Waste Management and Pollution Control Act 1998 (& (Administration) Regulations 1998)	Legislation protecting the environment through the encouragement of effective waste management, pollution prevention and control practices (relevant for waste disposal and transfer).	This Act and its regulations may be triggered in the event that a hydrocarbon spill enters state waters.	NT EPA
Dangerous Goods Act 1998 (& Regulations 1985)	This Act provides for the safe storage, handling and transport of certain Dangerous Goods.	This Act and its regulations may be triggered in the event that a hydrocarbon spill enters state waters, with regard to incident reporting requirements.	NT Worksafe
Marine Pollution Act 1999 (& Regulations 2003)	This Act provides protection of the marine and coastal environment by minimising intentional and negligent discharges of ship sourced pollutants to coastal waters. It also enacts Annexures 1, 2, 3 and 5 of MARPOL.	This Act and its regulations may be triggered in the event that a hydrocarbon spill enters state waters.	NT Department of Environment, Parks and Water Security (DEPWS)

Appendix 2
Project Information Flyers

Beehive-1 Exploration Well

Information Flyer #3

28 February 2022

EOG Resources Australia Block WA-488 Pty Ltd, a subsidiary of EOG Resources, Inc. (together 'EOG') is the Titleholder of Exploration Permit WA-488-P in the Joseph Bonaparte Gulf in Western Australia (WA).

EOG is planning to drill the Beehive-1 exploration well ('the project') (Figure 1, over page). The Beehive-1 well is targeting the Sunbird Formation and anticipates the presence of a light crude oil.

Why We're Consulting You

EOG has identified you, your group, organisation or company as a 'relevant person', defined under the Offshore Petroleum and Greenhouse Gas (Environment) Regulations 2009 as someone whose *functions* (power, duty, authority or responsibility), *activities* (things you do or have done) or *interests* (your rights, advantages, duties and liabilities, or concerns) may be affected by the project. Relevant persons typically include Commonwealth, State and Territory government agencies, commercial and recreational fisheries, asset owners and environment groups.

This information flyer aims to introduce you to EOG and provide information about the project and invites you to submit questions or concerns about the project. This process will assist to inform the preparation of the project's drilling Environment Plan (EP), which is currently in preparation for regulatory submission and acceptance.

Who is EOG?

EOG is the one of the largest independent crude oil and natural gas exploration and production companies in the United States of America (USA). EOG acquired the WA-488-P exploration permit from Finniss Offshore Exploration Pty Ltd in November 2021 with the aim of exploring known hydrocarbon prospects in the Bonaparte Basin.

EOG has operated offshore since 1992, a history of 30 years with assets in Trinidad and Tobago, UK North Sea, and the US Gulf of Mexico. In the past 10 years, EOG has drilled nearly 40 offshore wells with an excellent safety and environmental record.

The Project

The Beehive-1 exploration well is situated within Commonwealth marine waters 83 kilometres (km) off the WA coastline and 300 km southwest of Darwin in a water depth of 40 m. Drilling of the Beehive-1 exploration well is the second phase of work following the geophysical and geotechnical (G&G) investigations that are planned to occur over 4-6 weeks between April and August 2022.

This information flyer is focused on the proposed drilling activities. Additional information flyers will be issued as the project progresses.

Drilling Activities

Drilling is planned to occur between Q4 2022 and Q3 2023 (contingent on the receipt of EP acceptance, including drill rig and equipment availability).

Drilling activities are estimated to take approximately 50 to 90 days. The duration of drilling may be subject to change based on geological conditions and potential for operational challenges (e.g., sea state). Operations will be conducted 24 hours per day, seven days per week.

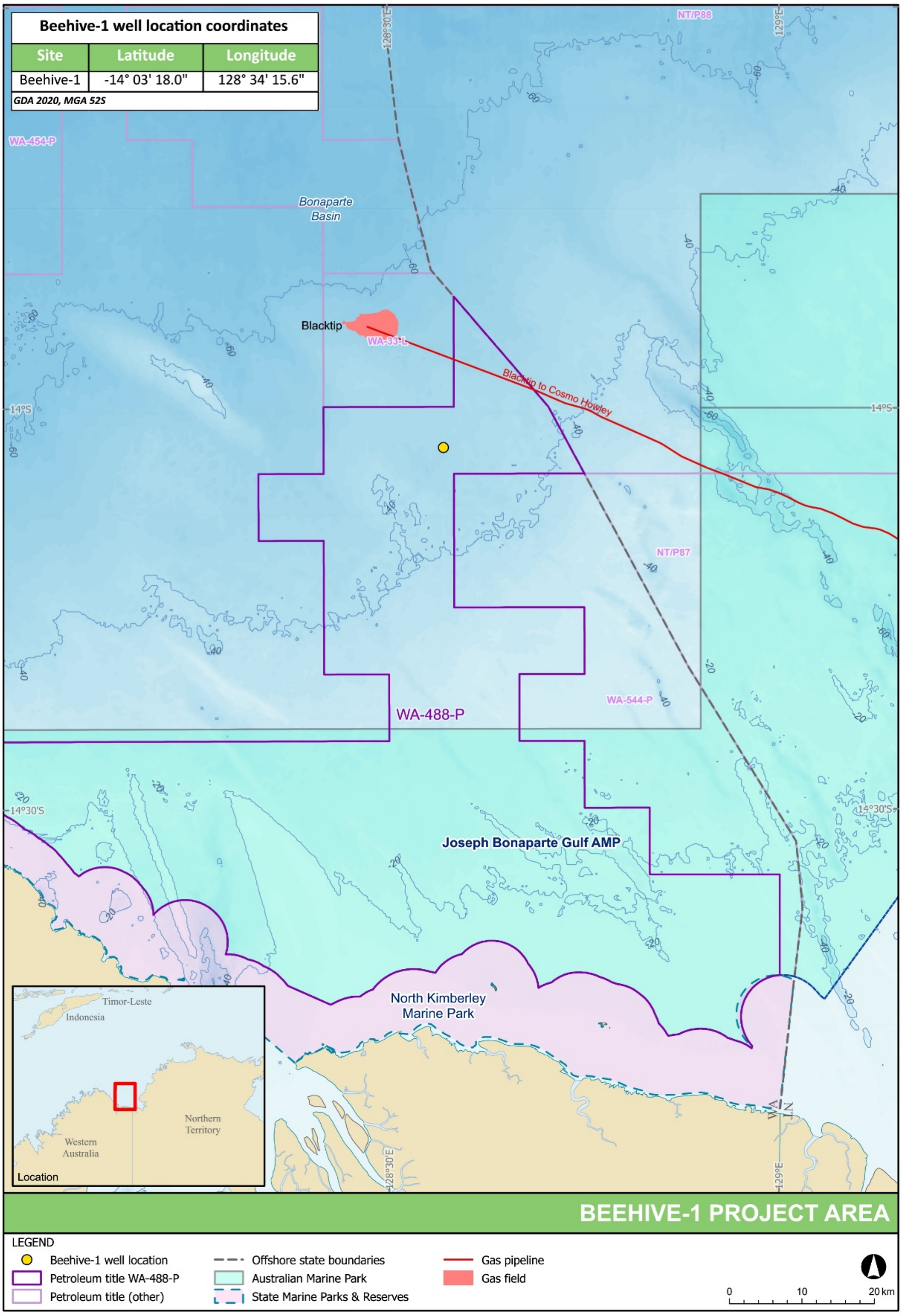


Figure 1. Beehive-1 Location map

Approach and Equipment

EOG proposes to undertake the activity using a jack-up mobile offshore drilling unit (MODU) with a 500 m exclusion zone. There will also be auxiliary activities including the use of support vessels and helicopters.

EOG is currently evaluating the availability of drill rigs for this activity. Further information on the nominated drill rig will be made available as part of EOG's ongoing consultation.

The approach to and setup of the jack-up MODU on location is summarised in Figure 2, over page.

Drilling Program

The following phases describe the planned drilling activity:

- Move the MODU to location, position MODU, pre-load and jack-up to operational elevation.
- Drill conductor hole and run conductor pipe.
- Drill surface hole section.
- Run and cement surface casing.
- Install the surface wellhead and blowout preventor (BOP).
- Perform a pressure test.
- Drill intermediate hole section(s).
- Run and cement intermediate pipe (casing) strings.
- Drill remaining sections to well total depth (TD).
- Run well evaluation program (wireline logging, sidewall cores, vertical seismic profiling [VSP] and possibly a drill stem test).
- Plug and abandon (P&A) or temporarily suspend the well.
- Demobilise the MODU and tow it away.

Environment Plan

Preparation of a Drilling EP is underway. This will be submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for assessment.

The full EP will be made available on NOPSEMA's website for public exhibition prior to formal assessment by NOPSEMA.

The EP is a comprehensive document that describes the project, outlines stakeholder feedback, details the existing marine and socio-economic environment, describes and assesses impacts and risks (see Table 1) and outlines the control measures to avoid, minimise and mitigate environmental impacts and risks to be acceptable and ALARP (As Low as Reasonably Practicable).

The project will be subject to industry best practice standards and undertaken in accordance with all relevant environmental and safety legislation and regulations.

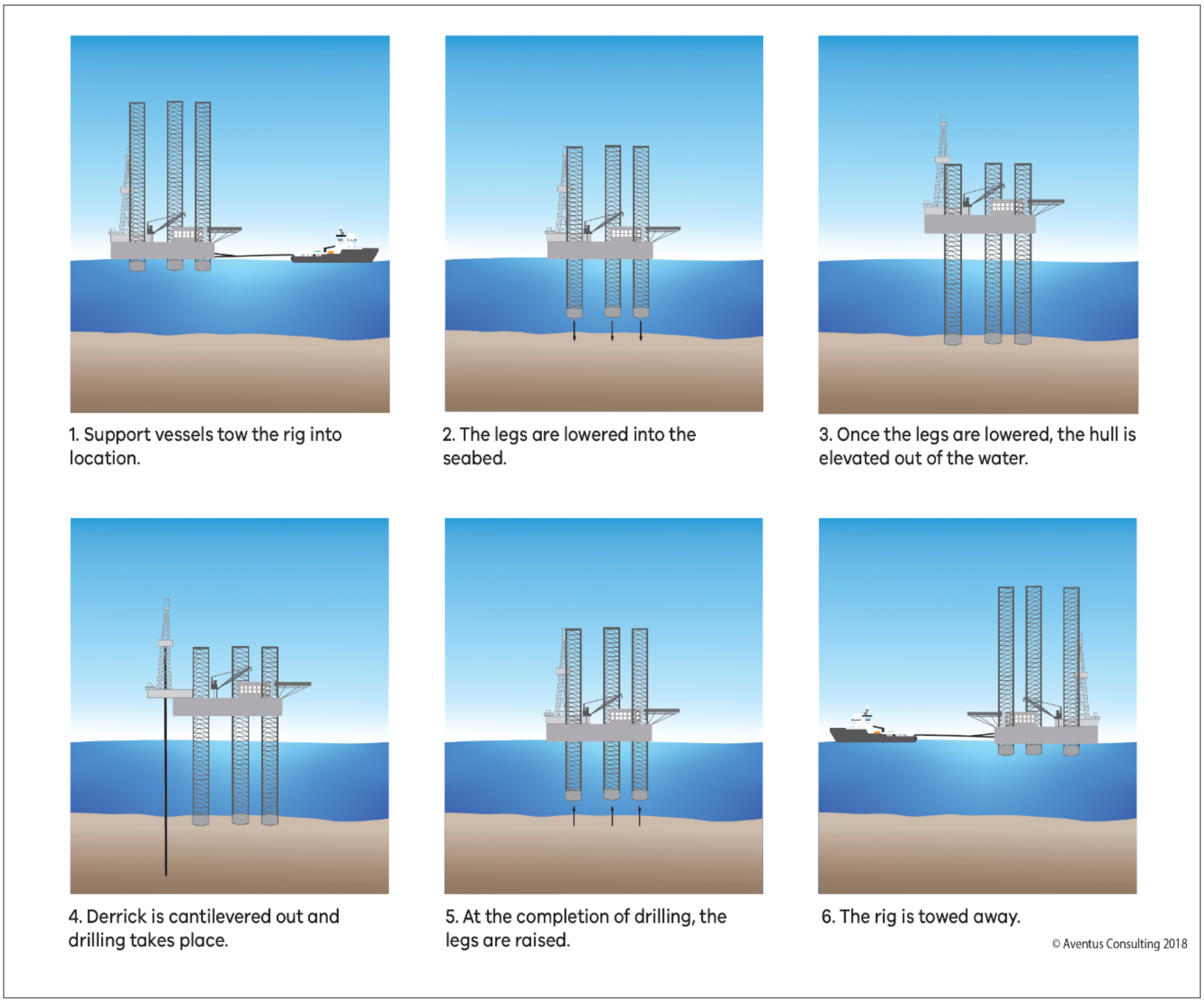


Figure 2. Overview of the jack-up MODU setup

Ongoing Consultation

Consultation with relevant persons will be ongoing throughout the project planning phase, with additional information flyers to be distributed at various milestones.

How to Provide Feedback

EOG encourages you to provide feedback on the project using the following contact details:

Email: australia@eogresources.com

Phone: 0409 772 170

EOG will respond to feedback in a timely fashion.

Additional background project information (and this information flyer) is available on the EOG website at: **https://www.eogresources.com/australia**

Table 1. Preliminary environmental impact and risk assessment for Beehive-1 exploration well drilling

Hazard	Potential impacts & risks	Preliminary avoidance, mitigation & management strategies
Planned Events		
Physical presence		
Seabed disturbance	• Physical removal or disturbance of seabed sediments. • Increase in turbidity of the water column near the seabed.	• Seabed disturbance will be kept to the minimum area necessary for safe operations. • Procedures will be in place to avoid objects being dropped overboard. • If large objects are dropped overboard, they will be retrieved wherever possible.
Displacement of other marine users	• Diversion from a planned travel route and additional time to re-join the planned route. • Increased fuel use (and cost) as a result of this diversion. • Temporary exclusion from fishing grounds.	• The exclusion zone will be reduced to the lowest area possible for safe operations. • The required area of displacement for the duration of the activity will be communicated to commercial fisheries and authorities.
Routine emissions and discharges		
Light	• Light glow may act as an attractant to light-sensitive species, in turn affecting predator-prey dynamics (due to attraction to or disorientation from light). • Continuous lighting may result in localised alterations to normal marine fauna behaviours.	• MODU and support vessel external lighting will be kept to levels required for navigation and safety of deck operations. • Blinds on portholes and windows will be lowered on support vessels at night. • Lighting will be directed to working areas only (i.e., not overboard, unless in an emergency). • The duration of flaring will be kept to the minimum time necessary.
Air	• Localised and temporary decrease in air quality due to emissions from diesel combustion. • Addition of greenhouse gas (GHG) to the atmosphere (influencing climate change).	• Only low sulphur (<0.5% m/m) marine diesel oil will be used. • A planned maintenance system (PMS) will be implemented for combustion equipment. • International Air Pollution Prevention (IAPP) certification will be maintained. • A Ship Energy Efficiency Management Plan (SEEMP) will be in place and implemented. • An Ozone Depleting Substances (ODS) procedure will be in place and implemented. • Waste incineration will be managed in accordance with MARPOL and Marine Orders. • The duration of flaring will be kept to the minimum time necessary. • Fuel use will be monitored for abnormal consumption.

Hazard	Potential impacts & risks	Preliminary avoidance, mitigation & management strategies
Noise	• Behavioural effects to sound-sensitive species (e.g., whales). • Temporary or permanent threshold shift in sound-sensitive species (e.g., whales).	• EPBC Policy Statement 2.1 – Part A (Standard management procedures) will be implemented during VSP activities. • Environmental awareness induction will be provided for all crew. • Vessels and helicopters will comply with EPBC Regulations 2000. • Vessel engines and thrusters will be well maintained.
Drill cuttings and muds	• Localised and temporary increase in total suspended solids in the water column. • Smothering of benthic habitat and fauna. • Alteration of benthic substrate. • Potential toxicity impacts to fauna. • Reduction of visual amenity from turbidity plumes.	• Water-based mud (WBM) will be used for drilling (rather than synthetic- or oil-based muds). • Only low-toxicity additives will be added to the WBM system. • Mud operations will be managed to minimise discharge volumes. For example, shaker screens are used to maximise mud separation prior to overboard discharge.
Cement	• Localised and temporary increased turbidity of the water column. • Smothering of benthic habitat and fauna. • Alteration of benthic substrate. • Potential toxicity impacts to fauna.	• Cement operations will be managed to minimise discharge volumes. For example, once good returns are noted at the seabed, the mixing and pumping of cement will cease and displacement of the string with drilling fluid will begin. • Only low-toxicity additives will be added to the cement system.
Putrescible waste	• Temporary and localised increase in the nutrient content of waters surrounding the discharge point. • An associated increase in scavenging behaviour of marine fauna and seabirds (at the sea surface or within the water column).	• A Garbage Management Plan will be in place and implemented. • Putrescible waste will be treated as per MARPOL Annex V requirements prior to discharge. • Environmental awareness induction will be provided for all crew.
Sewage and grey water	• Increase in the nutrient content of surface waters around the MODU and support vessels. • An associated increase in scavenging behaviour of marine fauna and seabirds (at the sea surface or within the water column).	• Treatment will be via a MARPOL-compliant sewage treatment plant prior to overboard discharge. • The sewage treatment plant will be maintained in accordance with the PMS.
Cooling and brine water	• Increase in sea water temperature, causing thermal stress to marine biota.	• Engines and associated equipment that require cooling by water will be maintained in accordance with the PMS so they are operating within accepted parameters.

Hazard	Potential impacts & risks	Preliminary avoidance, mitigation & management strategies
	• Increase in sea surface salinity, potentially causing harm to fauna unable to tolerate higher salinity. • Potential toxicity impacts to marine fauna from the ingestion of residual biocide and scale inhibitors.	• Only low-toxicity biocide will be used.
Bilge water and deck drainage	• Temporary and localised reduction of surface water quality around the discharge point. • Acute toxicity to marine fauna through ingestion of contaminated water in a small mixing zone.	• All bilge water passes through a MARPOL-compliant oily water system set to limit oily-in-water to <15 ppm prior to overboard discharge. • The oily water system is maintained in accordance with the PMS. • Bunding of hydrocarbons and chemical storage areas. • Shipboard Marine Pollution Emergency Plan (SMPEP) is in place. • Use of non-toxic, biodegradable deck cleaning products. • Spill kits are availability on deck and crew are trained in spill response.
Unplanned Events		
Accidental discharge of waste to the ocean	• Marine pollution. • Acute toxicity to marine fauna through ingestion or absorption. • Injury and entanglement of individual animals (such as seabirds and seals). • Smothering or pollution of benthic habitats.	• Waste is managed in accordance with the Garbage Management Plan. • Recover accidentally discharged wastes or lost equipment. • Chemical lockers are in place and used. • Follow established handling and storage procedures. • All crew are inducted in waste management procedures.
Vessel collision with megafauna	• Injury or death of marine megafauna (e.g., whales, dolphins, turtles).	• Australian National Guidelines for Whale and Dolphin Watching (2017) are implemented by the support vessels. • All vessel crew are inducted in the guidelines. • Incident reporting procedure will be in place.
Introduction and establishment of invasive marine species (IMS)	• Reduction in native marine species diversity and abundance. • Depletion of commercial fish stocks (and associated socio-economic effects). • Changes to conservation values of protected areas.	• A MODU and support vessels already in Australia are likely to be used (reducing the risk of introducing IMS). • An IMS risk assessment will be undertaken. • The International Anti-fouling System (IAFS) Certification will be maintained. • Implement a Biofouling Management Plan and Biofouling Record Book. • Implement a Ballast Water Management Plan. • Incident reporting procedure will be in place.

Hazard	Potential impacts & risks	Preliminary avoidance, mitigation & management strategies
Interference with other marine users	• Damage to third-party vessels in the case of collision. • Damage to or loss of fishing equipment and/or loss of commercial fish catches.	• An Exclusion (Safety) zone will be designated around the MODU. • Navigation equipment and associated procedures will be used, including constant bridge watch. • Crew will be appropriately qualified. • Stakeholder notification process will be in place.

Marine diesel oil spill	• Temporary and localised reduction in water quality.
	• Injury or death of exposed marine fauna and seabirds.
	• Habitat damage where the spill reaches shorelines.
	• Changes to the functions, interests or activities of other users (e.g., commercial fisheries).
		• As per '*Interference with other marine users*.'
		• A bunkering procedure for any at-sea refuelling will be used.
		• Crews will be trained in spill prevention and response.
		• The following plans will be implemented in the event of a spill:
		  ○ SMPEP.
		  ○ Project-specific Oil Pollution Emergency Plan (OPEP).
		  ○ Project-specific Operational and Scientific Monitoring Program (OSMP).

Loss of well containment	• Temporary but potentially widespread reduction in water quality. • Tainting of commercial fisheries species. • Injury and death of species such as seabirds. • Pathological effects on fish larvae and plankton. • Pollution of shoreline habitats such as sandy beaches, mudflats and mangroves.	• Well design (including casing) will be based on geotechnical data and previously drilled wells in the area (i.e., review of offset well data). • Continuous monitoring of mud weight and other mud flow parameters will occur to ensure primary well control barrier is operating as designed. • Blow out preventer (BOP) will be tested and installed before entering the hydrocarbon zone. • Well casing will be pressure tested after drilling prior to drilling ahead. • Well control exercises will be undertaken. • An approved Well Operations Management Plan (WOMP) and Safety Case Revision will be in place. • A blowout contingency plan will be in place. • EOG will be a member of the Australian Marine Oil Spill Centre (AMOSC), who would be called upon to assist in spill response.
Hydrocarbon spill response activities	• Routine and non-routine impacts and risks associated with vessel operations. • Noise disturbance to marine fauna and shoreline species by aircraft and vessels.	• Maintain access to spill response capabilities (including capable personnel and equipment) and implement as required. • An appropriate distance will be maintained from marine fauna during spill response activities.

Beehive-1 Exploration Well

Information Flyer #2

01 December 2021

eog resources

Update on the Pre-Drill Seabed Assessment

EOG Resources, Inc. (EOG) advises that the Beehive Pre-Drill Seabed Assessment (PDSA) Environment Plan (EP) is now available on the National Offshore Petroleum Safety and Environmental Management Authority's (NOPSEMA) website for public exhibition and comment at https://info.nopsema.gov.au/home/open_for_comment

The following updates have occurred since Information Flyer #1 was issued:

- EOG Resources Australia Block WA-488 Pty Ltd, a subsidiary of EOG, is now the sole titleholder of the WA-488-P Exploration Permit;
- The activity window has been amended and is now April to August 2022 (exact timing dependent on the receipt of EP acceptance, weather, and vessel/equipment availability), rather than February to June 2022 as previously stated; and
- The PDSA activity area has been reduced by 100 km^2 from 440 km^2 to an area of 340 km^2.

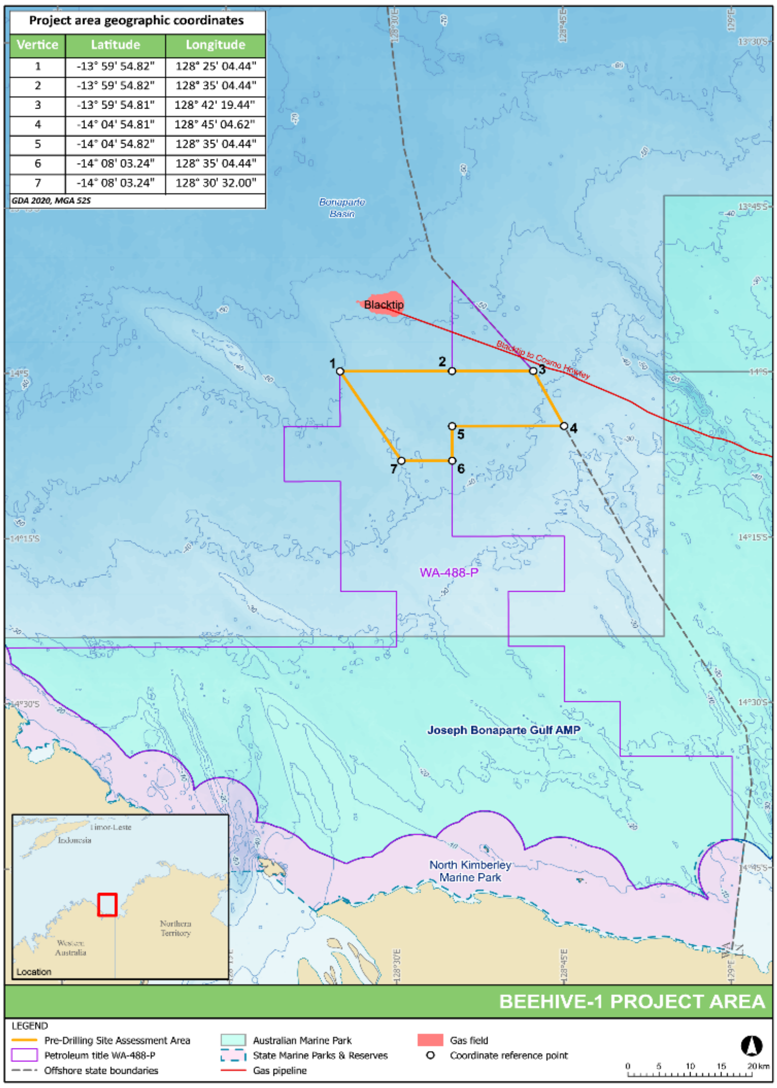


Figure 1. Updated Beehive PDSA location

How to Provide Feedback

EOG encourages you to provide feedback on the activity using the following contact details:

Email: australia@eogresources.com

Phone: 0409 772 170

EOG will respond to feedback in a timely fashion.

Background project information (and this information flyer) is also available on the EOG website at: **https://www.eogresources.com/australia**

Ongoing Consultation

Consultation with relevant persons will be ongoing throughout the project planning and during preparation of the Beehive-1 Drilling EP.

Beehive-1 Exploration Well

Information Flyer #1

17 September 2021

EOG Resources Inc (EOG) is planning to drill the Beehive-1 exploration well ('the project') in Exploration Permit WA-488-P in the Joseph Bonaparte Gulf in Western Australia (WA) (Figure 1, over page).

Why We're Consulting You

EOG has identified you, your group, organisation or company as a 'relevant person', defined under the Offshore Petroleum and Greenhouse Gas (Environment) Regulations 2009 as someone whose *functions* (power, duty, authority or responsibility), *activities* (things you do or have done) or *interests* (your rights, advantages, duties and liabilities, or concerns) may be affected by the project. Relevant persons typically include Commonwealth, State and Territory government agencies, commercial and recreational fisheries, asset owners and environment groups.

This information flyer aims to introduce you to EOG and provide information about the project and invites you to submit questions or concerns about the project. This process will assist to inform the preparation of the project's Environment Plans (EPs), which are currently in preparation for regulatory submission.

Who is EOG?

EOG is one of the largest independent crude oil and natural gas exploration and production companies in the United States of America (USA).

EOG is in the process of acquiring the WA-488-P exploration permit from Finniss Offshore Exploration Pty Ltd, which is expected to complete in September or October 2021. EOG has operated offshore since 1992, with a history of nearly 30 years in Trinidad & Tobago, the UK North Sea and the USA Gulf of Mexico.

In the past 10 years, EOG has drilled nearly 40 offshore wells, with an excellent safety and environment record.

The Project

EOG aims to explore a known hydrocarbon prospect in WA-488-P located in the Bonaparte Basin. The project is divided into two phases; geophysical and geotechnical (G&G) investigations, followed by drilling.

This information flyer is focused on the first phase of work, the G&G investigations. Additional information flyers will be issued as the project progresses.

Geophysical and Geotechnical Investigations

The G&G investigations are planned to commence any time between the start of February and end of June 2022 (contingent on the receipt of EP acceptance, vessel and equipment availability). They will be undertaken within a 440 km^2 envelope, which is located 163 km from the nearest WA shoreline and 73 km from the nearest Northern Territory (NT) shoreline. Water depths in the project area range from 40 m to 50 m.

The G&G investigations (Figure 2) collect seabed and shallow geological information to inform the safe location of a jack-up drilling rig. The G&G investigations are divided into two phases, as outlined here.

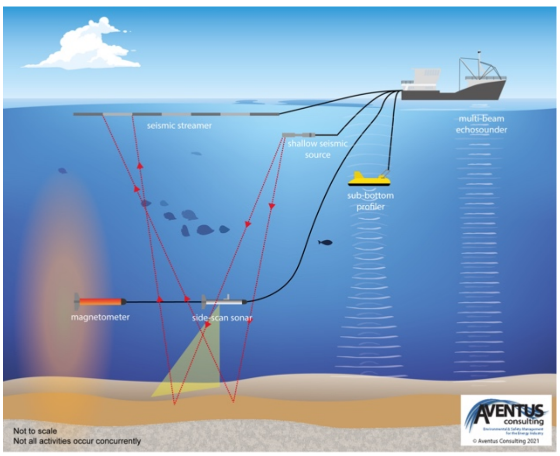
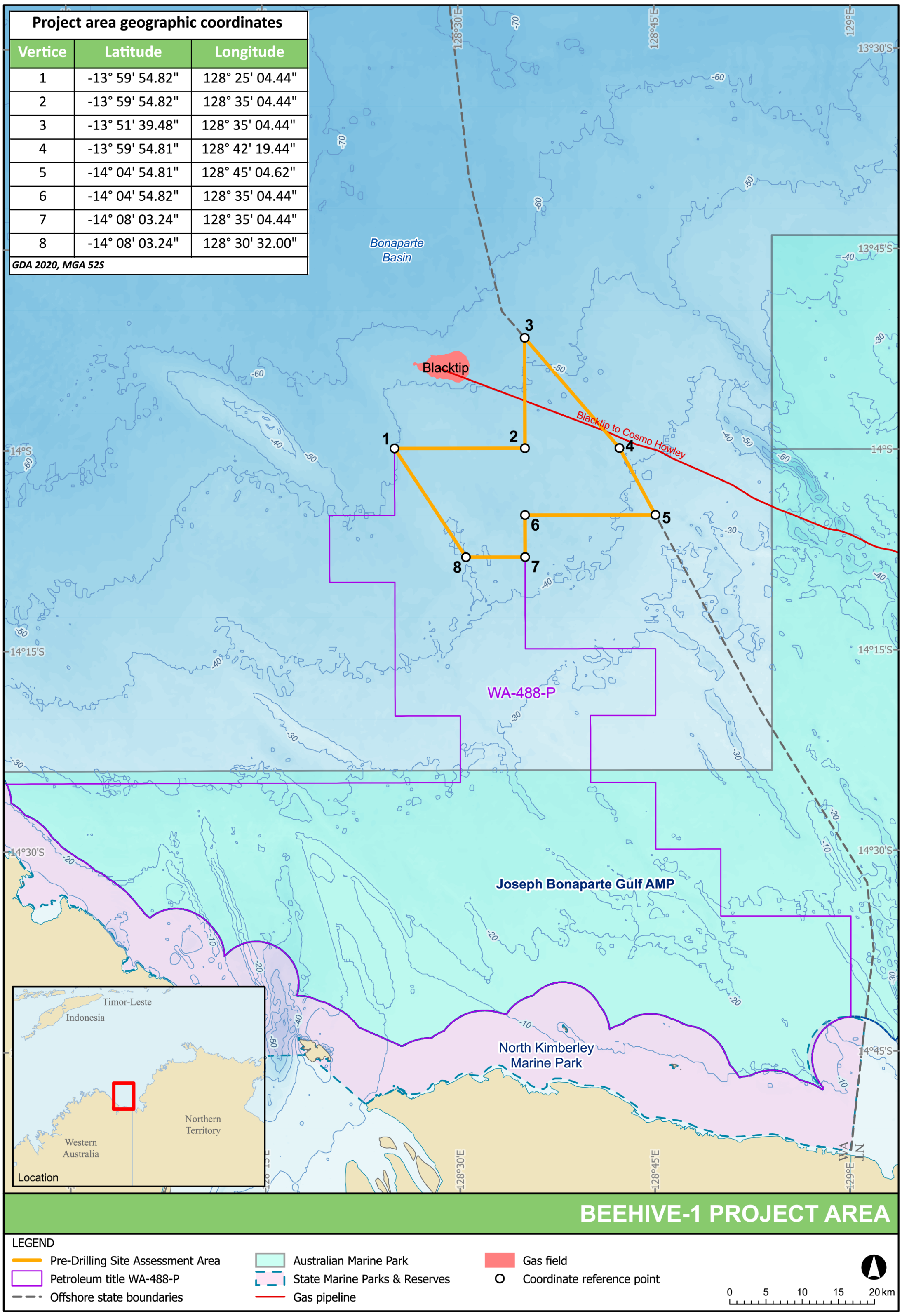


Figure 2. Geophysical investigations



Project area geographic coordinates		
Vertice	Latitude	Longitude
1	-13° 59' 54.82"	128° 25' 04.44"
2	-13° 59' 54.82"	128° 35' 04.44"
3	-13° 51' 39.48"	128° 35' 04.44"
4	-13° 59' 54.81"	128° 42' 19.44"
5	-14° 04' 54.81"	128° 45' 04.62"
6	-14° 04' 54.82"	128° 35' 04.44"
7	-14° 08' 03.24"	128° 35' 04.44"
8	-14° 08' 03.24"	128° 30' 32.00"

GDA 2020, MGA 52S

Figure 1. Beehive-1 project area

Geophysical investigations involve the following suite of tests:

- Assess water depths (bathymetry) – using a multi-beam echo sounder (MBES).
- Detect seabed hazards such as pipelines, shipwrecks, reefs and anchors – using a side scan sonar (SSS).
- Map the structure and thickness of uppermost seabed sediments (shallow geology) – using a sub-bottom profiler (SBP).
- Detect metallic objects on or below the seabed, such as cables, anchors, chains, buried pipelines – using a magnetometer.
- Map the near-surface geological hazards, such as shallow gas pockets – using a mini-airgun or sparker system.

The geophysical activities are likely to be conducted using a small, locally-based vessel (as depicted in Figure 2) and is likely to take up to two weeks to complete.

Geotechnical investigations acquire physical measurements and samples of the local shallow geology at and around the potential drill location, using the following techniques:

- Geological analysis of unconsolidated seabed sediments – using grab sampling.
- Geological analysis of formations below the seabed – using coring.
- Determine seabed strength – using piezo cone penetrometer testing (PCPT) and borehole sampling.

The geotechnical investigations are undertaken using a specialised medium-sized vessel, as depicted in Figure 3, and is likely to take up to two weeks to complete. This may be the same vessel as that used to undertake the geophysical investigations.

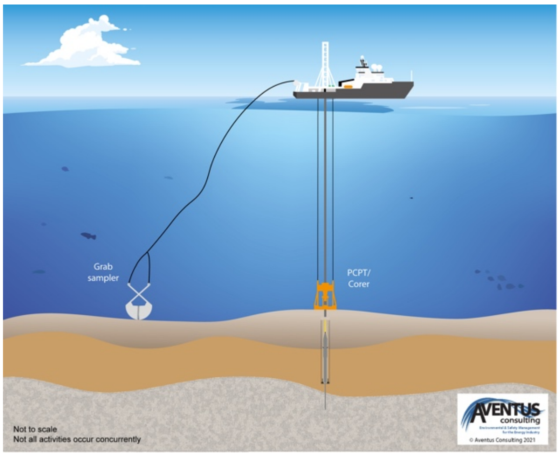


Figure 3. Geotechnical investigations

Drilling

Planning for the drilling campaign is underway. The Beehive-1 well is targeting the Sunbird Formation and anticipates the presence of a light oil or gas condensate.

A jack-up drill rig will drill the well vertically to a depth of about 5,000 m using a water-based mud system, which will take 40-50 days. In the event that hydrocarbons are discovered, well testing (that involves flaring) may take place.

It is anticipated that drilling may commence as early as Q3 2022 (contingent on the receipt of EP acceptance, vessel and equipment availability), but ideally no later than Q2 2023. Further details about the drilling campaign will be provided in future information flyers as planning progresses.

Environment Plans

Preparation of a G&G Investigations EP and a Drilling EP are underway. These will be submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for assessment.

The full EPs will be made available on NOPSEMA's website for public exhibition prior to formal assessment by NOPSEMA.

An EP is a comprehensive document that describes the project, outlines stakeholder feedback, details the existing marine and socio-economic environment, describes and assesses impacts and risks and outlines the control measures to avoid, minimise and mitigate environmental impacts and risks to be acceptable and ALARP (As Low As Reasonably Practicable).

The project will be subject to industry best practice standards and undertaken in accordance with all relevant environmental and safety legislation and regulations.

Features of the Project Area

Features in the project area include:

- Dominated by the Indonesian Throughflow current and strong tides.
- A seabed dominated by flat featureless plains comprising sand and gravel, with localised reefs and outcrops supporting sponge gardens. The G&G investigations will provide more detail about the type of seabed in the project area. The plains contain diverse infaunal communities (e.g., crustaceans and polychaete worms).
- Seasonal presence or likely presence of threatened migratory species including turtles, sharks, sawfish, whales, dolphins and seabirds.
- Low-intensity commercial fishing by the Commonwealth-managed Northern Prawn Fishery (the project area has a 0.06% overlap with the fishery).
- Some commercial fishing by the WA-managed Northern Demersal Scalefish Managed Fishery (mostly goldband snapper and red emperor) and Mackeral Managed Fishery.
- An absence of NT-managed commercial fisheries.
- An absence of known shipwrecks.
- Low commercial shipping traffic.
- An overlap by the Department of Defence North Australian Exercise Area.

Distances from the project area to the following features are:

- The Carbonate bank and terrace system of the Sahul Shelf Key Ecological Feature (KEF) – 13 km.
- The Blacktip unmanned wellhead platform – 13 km.
- Joseph Bonaparte Australian Marine Park (AMP) – 16 km.
- WA North Kimberley Marine Park – 50 km.

A summary of key impacts and risks of the G&G investigations is presented in the following pages.

How to Provide Feedback

EOG encourages you to ask questions or provide feedback on the project using the following contact details:

Email: australia@eogresources.com

Phone: 0409 772 170

EOG will respond to feedback in a timely fashion.

Background project information (and this information flyer) is also available on the EOG website at: **https://www.eogresources.com/australia**

Ongoing Consultation

Consultation with relevant persons will be ongoing throughout the project planning phase, with additional information flyers to be distributed at various milestones.

Preliminary environmental impact and risk assessment for the Beehive-1 geophysical and geotechnical investigations (WA-488-P)

Hazard	Potential impacts & risks	Avoidance, management and mitigation measures
Planned events		
Generation of underwater sound from G&G investigations and vessels	Temporary disruption to migration, feeding or breeding patterns for sound-sensitive fauna, such as cetaceans (whales and dolphins).	• In accordance with the EPBC Act Policy Statement 3.1, a 500-m shutdown zone will be maintained during operation of the geophysical equipment to minimise impacts on cetaceans. • Vessel engines and thrusters will be maintained in accordance with planned maintenance system to ensure they are operating efficiently.
	Damage to the Blacktip gas pipeline from sound pulses.	• Shallow gas investigations, using a mini-airgun or sparker system, will not be undertaken over the pipeline.
Seabed disturbance from geotechnical activities	Temporary and localised seabed turbidity. Smothering of seabed habitat by disturbed sediments.	• The vessel will not anchor during geotechnical investigations (it will remain on location using dynamic positioning). • Very low volumes of cuttings and drilling fluids will be discharged during borehole sampling. • Seabed grab sampling and coring activities are extremely localised. • Cored holes are very narrow and will collapse in on themselves and small surface 'craters' will quickly fill in with sediments and recolonise with benthic fauna. • Large bulky items will be securely fastened or stored on the vessel deck to prevent loss to sea. • Any dropped objects will be recovered (where safe to do so).
Routine vessel discharges and emissions		
Atmospheric emissions	Temporary reduction in air quality in the local air shed.	• Vessels >400 gross tonnes will have in place a current International Air Pollution Prevention (IAPP) certificate and Ship Energy Efficiency Management Plan (SEEMP). • Only marine-grade low sulphur diesel (no greater than 0.5% m/m) will be used. • Waste incineration will not take place. • All fuel-burning equipment will be maintained in accordance with planned maintenance systems.
Light glow	Attractant to fauna, temporary increase in predation rates on fauna attracted to lights.	• Vessel lighting will be kept to the minimum required but in accordance with navigational standards and personnel safety requirements for night-time work.

Hazard	Potential impacts & risks	Avoidance, management and mitigation measures
Discharge of treated sewage and grey water	Temporary and localised reduction in water quality.	• Sewage and grey water will be treated in a MARPOL Annex IV-compliant sewage treatment plant prior to discharge (or taken back to port for disposal). • Vessels >400 gross tonnes will have in place a current International Sewage Pollution Prevention (ISPP) certificate. • In the event of a sewage treatment plant malfunction, untreated sewage will only be discharged when > 12 nm from shore or will be offloaded onshore for treatment.
Discharge of cooling water and reverse osmosis (brine)	Temporary and localised elevation in surface water temperature and salinity levels.	• Low impact biocides (chlorine) are used in optimised concentrations in the cooling system. • Engines and associated equipment that require cooling by water will be maintained in accordance with the planned maintenance system so that they are operating within accepted parameters. • Only low-toxicity chemicals (ONCS 'Gold'/'Silver' (CHARM) or 'D'/'E' (non-CHARM)-rated) chemicals are used in the cooling and brine water systems.
Discharge of putrescible waste	Temporary and localised increase in nutrient content of surface and near-surface water quality. Temporary increase in scavenging behaviour of pelagic fish and seabirds.	• Putrescible waste will be macerated to <25 mm prior to discharge (or taken back to shore for disposal). • In the event of macerator malfunction, un-macerated putrescible waste will take place will be discharged when >12 nm of land or returned to shore. • Non-putrescible galley waste will be returned to shore for disposal.
Discharge of bilge water and deck drainage	Temporary and localised reduction in water quality.	• Vessels >400 gross tonnes will have in place a MARPOL Annex I-compliant oily water separator set to limit oil-in-water content to <15 ppm prior to discharge. • Vessels >400 gross tonnes will have a current International Oil Pollution Prevention (IOPP) certificate. • No whole residual bilge oil is discharged overboard (residual oil from the oily water separator is pumped to tanks and disposed of onshore). • Chemical storage areas will be bunded and drain to the bilge tank. • Portable bunds and/or drip trays are used to collect spills or leaks from equipment that is not contained within a permanently bunded area (non-process areas). • Deck cleaning detergents will be biodegradable. • Spills to decks will be cleaned immediately using Shipboard Marine Pollution Emergency Plan (SMPEP) kits.
Unplanned events		
Accidental overboard release of hazardous	Marine pollution (litter and a temporary and localised reduction in	• Vessels >100 gross tonnes or certified to carry more than 15 people will have in place and implement a vessel-specific Garbage Management Plan. • Vessel crew and visitors will be inducted into the waste

Hazard	Potential impacts & risks	Avoidance, management and mitigation measures
and/or non-hazardous waste from the vessels	water quality). Injury and entanglement of individual animals (such as seabirds and turtles) and smothering or pollution of benthic habitats.	management procedures. • A waste manifest will be maintained. • Only small volumes of chemicals will be kept on board and will be stored in secured drums in bunded areas away from open drains. • Bunded areas will drain through a closed system, processed through the oily water separator. • Safety Data Sheets (SDS) will be available in appropriate locations. • SMPEP kits will be available on board for rapid deck clean-up response.

Introduction of invasive marine species from the vessel hulls and/or ballast water	Reduction in native marine species diversity and abundance.
	Displacement of native marine species.
	Socio-economic impacts on commercial fisheries.
	Reduction of conservation values of protected areas.
		• Vessels will carry a low risk of invasive marine species introduction (as determined through a vessel contractor pre-qualification report).
		• Vessels >400 gross tonnes will carry a current International Anti-fouling System (IAFS) Certificate and comply with Marine Order Part 98 (Anti-fouling Systems).
		• The vessel/s will comply with the:
		  ○ Australian Ballast Water Management Requirements (DAWR, 2020); and
		  ○ National Biofouling Guidance for the Petroleum Production & Exploration Industry (AQIS, 2009).
		• Towed/submersible equipment will be cleaned (e.g., fouling is removed) prior to initial use in the project area.

Damage to Blacktip subsea gas pipeline (e.g., dropped objects, anchoring)	Loss of pipeline integrity and lost field production.	• Vessel anchoring will not be permitted. • EOG will consult with ENI Australia (pipeline operator) to understand the implications of operating over the pipeline. • The geophysical investigations will be undertaken prior to geotechnical investigations in order to accurately locate the pipeline and put in place geotechnical exclusion buffer around it. • EOG will ensure that the geotechnical vessel contractor has the coordinates of the Blacktip pipeline marked in its navigation system (confirmed during the geophysical survey) to ensure that no geotechnical work is conducted within a nominated buffer around the pipeline.
Vessel strike or entanglement with megafauna (e.g., whales, dolphins, turtles)	Injury or death of individual animals.	• The Australian Guidelines for Whale and Dolphin Watching (DEWHA, 2005) for sea-faring activities will be implemented, which includes caution and no-approach zones around whales and dolphins. • Vessel strike causing injury to or death of a cetacean is reported via the online National Ship Strike Database within 72 hours of the incident. • Entanglement of megafauna in towed equipment is reported to the NT Marine Wildwatch on 1800 453 941 (or WA's Wildcare on 08-9474 9055) as soon as possible. No attempts to disentangle megafauna will be made by project personnel unless instructed

Hazard	Potential impacts & risks	Avoidance, management and mitigation measures
		by Wildwatch or Wildcare. • Vessel crew will complete an environmental induction covering the above-listed requirements.
Displacement of or interference with third-party vessels	Temporary loss of fishing grounds around the vessel safety zone. Trawling gear snagging on towed or submerged equipment.	• The project area is located in an area with low levels of shipping traffic and low fishing effort. • A 'Notice to Mariners' will be issued. • Standard maritime safety precautions will be in place, including: ○ Radar and other anti-collision monitoring equipment to detect other vessels. ○ Display of lights and day shapes. ○ The ability to quickly move off location to avoid other vessels. ○ Warnings issued (radio, flares, lights and horns) to avoid collisions. ○ The Vessel Master will be qualified in accordance with AMSA Marine Orders Part 3 (Seagoing qualifications) (e.g., International Convention of Standards of Watchkeeping for Seafarers, STCW95, GMDSS Proficiency). • The tail buoy on the shallow seismic streamer will have flashing lights and radar reflectors so it is visible to other marine users. • The vessel master will sound the general alarm, manoeuvre the vessel to minimise the effects of the collision and implement all other measures as outlined in the vessel collision procedure. • Vessel collisions will be reported to AMSA if that collision has or is likely to affect the safety, operation or seaworthiness of the vessel or involves serious injury to personnel.
Diesel release due to a vessel-to-vessel collision	Temporary and localised reduction in water quality. Tainting of commercial fisheries species. Injury and/or death of marine fauna and seabirds. Pathological effects on fish larvae and plankton.	• *As per 'displacement of or interference with third-party vessels', plus:* • No refuelling will take place on location. • Vessel crew will be trained in spill response techniques in accordance with the SMPEP and vessel training matrix. • Diesel spill trajectory modelling indicates a very small area of ecological impact in the event of the loss of a whole tank of fuel. • An Oil Pollution Emergency Plan (OPEP) will be developed based on the spill modelling results. • Vessel-specific SMPEP and project-specific OPEP will be implemented in the event of a large spill. • EOG will report the spill to regulatory authorities within 2 hours of becoming aware of the spill.

<u>Appendix 3</u>

Stakeholder Communications

(provided to NOPSEMA separately as sensitive information under Regulation 9(8) of the OPGGS(E))

Appendix 4

EPBC Act Protected Matters Search Tool (PMST) Results

Australian Government
Department of Agriculture, Water and the Environment

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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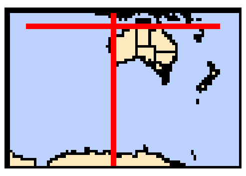

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	1
National Heritage Places:	2
Wetlands of International Importance:	4
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	1
Listed Threatened Species:	73
Listed Migratory Species:	90

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	5
Commonwealth Heritage Places:	4
Listed Marine Species:	154
Whales and Other Cetaceans:	32
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	1
Australian Marine Parks:	22

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	22
Regional Forest Agreements:	None
Invasive Species:	28
Nationally Important Wetlands:	5
Key Ecological Features (Marine)	14

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Status
Kakadu National Park	NT	Declared property

National Heritage Properties [Resource Information]

Name	State	Status
Natural		
Kakadu National Park	NT	Listed place
The West Kimberley	WA	Listed place

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Ashmore reef national nature reserve	Within Ramsar site
Cobourg peninsula	Within Ramsar site
Kakadu national park	Within Ramsar site
Ord river floodplain	Within Ramsar site

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea
Extended Continental Shelf

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North
North-west

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Monsoon vine thickets on the coastal sand dunes of Dampier Peninsula	Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anous tenuirostris melanops		
Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris		
Great Knot [862]	Critically Endangered	Foraging, feeding or

Name	Status	Type of Presence
		related behaviour known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Foraging, feeding or related behaviour known to occur within area
Epthianura crocea tunneyi Alligator Rivers Yellow Chat, Yellow Chat (Alligator Rivers) [67089]	Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat known to occur within area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat known to occur within area
Falcunculus frontatus whitei Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat likely to occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Foraging, feeding or related behaviour known to occur within area
Geophaps smithii blaauwi Partridge Pigeon (western) [66501]	Vulnerable	Species or species habitat likely to occur within area
Geophaps smithii smithii Partridge Pigeon (eastern) [64441]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica baueri Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Russkoye Bar-tailed Godwit [86432]	Critically Endangered	Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Melanodryas cucullata melvillensis Tiwi Islands Hooded Robin, Hooded Robin (Tiwi Islands) [67092]	Critically Endangered	Species or species habitat known to occur within area
Mirafra javanica melvillensis Horsfield's Bushlark (Tiwi Islands) [81011]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within

Name	Status	Type of Presence
		area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area
Polytelis alexandrae Princess Parrot, Alexandra's Parrot [758]	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur within area
Tyto novaehollandiae kimberli Masked Owl (northern) [26048]	Vulnerable	Species or species habitat known to occur within area
Tyto novaehollandiae melvillensis Tiwi Masked Owl, Tiwi Islands Masked Owl [26049]	Endangered	Species or species habitat known to occur within area
Mammals		
Antechinus bellus Fawn Antechinus [344]	Vulnerable	Species or species habitat known to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Conilurus penicillatus Brush-tailed Rabbit-rat, Brush-tailed Tree-rat, Pakooma [132]	Vulnerable	Species or species habitat known to occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat may occur within area
Isoodon auratus auratus Golden Bandicoot (mainland) [66665]	Vulnerable	Species or species habitat likely to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat known to occur within area
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Mesembriomys gouldii gouldii Black-footed Tree-rat (Kimberley and mainland Northern Territory), Djintamoonga, Manbul [87618]	Endangered	Species or species habitat known to occur within area
Mesembriomys gouldii melvillensis Black-footed Tree-rat (Melville Island) [87619]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat known to occur within area
Petrogale concinna canescens Nabarlek (Top End) [87606]	Endangered	Species or species habitat may occur within area
Petrogale concinna monastria Nabarlek (Kimberley) [87607]	Endangered	Species or species habitat known to occur within area
Phascogale pirata Northern Brush-tailed Phascogale [82954]	Vulnerable	Species or species habitat known to occur within area
Phascogale tapoatafa kimberleyensis Kimberley brush-tailed phascogale, Brush-tailed Phascogale (Kimberley) [88453]	Vulnerable	Species or species habitat known to occur within area
Saccolaimus saccolaimus nudicluniatus Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889]	Vulnerable	Species or species habitat likely to occur within area
Sminthopsis butleri Butler's Dunnart [302]	Vulnerable	Species or species habitat known to occur within area
Trichosurus vulpecula arnhemensis Northern Brushtail Possum [83091]	Vulnerable	Species or species habitat known to occur within area
Xeromys myoides Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat known to occur within area
Plants		
Burmannia sp. Bathurst Island (R.Fensham 1021) [82017]	Endangered	Species or species habitat likely to occur within area
Hoya australis subsp. oramicola a vine [55436]	Vulnerable	Species or species habitat known to occur within area
Mitrella tiwiensis a vine [82029]	Vulnerable	Species or species habitat likely to occur within area
Typhonium jonesii a herb [62412]	Endangered	Species or species habitat known to occur within area
Typhonium mirabile a herb [79227]	Endangered	Species or species habitat known to occur within area
Xylopia monosperma a shrub [82030]	Endangered	Species or species habitat known to occur within area
Reptiles		
Acanthophis hawkei Plains Death Adder [83821]	Vulnerable	Species or species habitat likely to occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Cryptoblepharus gurrmul		
Arafura Snake-eyed Skink [83106]	Endangered	Species or species habitat known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Lepidochelys olivacea		
Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Sharks		
Carcharias taurus (west coast population)		
Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat known to occur within area
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	Breeding known to occur within area
Glyphis glyphis		
Speartooth Shark [82453]	Critically Endangered	Species or species habitat known to occur within area
Pristis clavata		
Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding known to occur within area
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus		
Common Noddy [825]		Breeding known to occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna pacifica		
Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Calonectris leucomelas		
Streaked Shearwater [1077]		Species or species

Name	Threatened	Type of Presence
		habitat known to occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Foraging, feeding or related behaviour known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Breeding known to occur within area
Hydroprogne caspia Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Onychoprion anaethetus Bridled Tern [82845]		Breeding known to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding known to occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sternula albifrons Little Tern [82849]		Breeding known to occur within area
Sula dactylatra Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Sula sula Red-footed Booby [1023]		Breeding known to occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat may occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Name	Threatened	Type of Presence
Carcharhinus longimanus Oceanic Whitetip Shark [84108]		Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Cecropis daurica Red-rumped Swallow [80610]		Species or species habitat may occur within area
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Acrocephalus orientalis Oriental Reed-Warbler [59570]		Species or species habitat known to occur within area
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Foraging, feeding or related behaviour known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Foraging, feeding or related behaviour known to occur within area
Calidris alba Sanderling [875]		Foraging, feeding or related behaviour known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Calidris ruficollis		
Red-necked Stint [860]		Foraging, feeding or related behaviour known to occur within area
Calidris subminuta		
Long-toed Stint [861]		Foraging, feeding or related behaviour known to occur within area
Calidris tenuirostris		
Great Knot [862]	Critically Endangered	Foraging, feeding or related behaviour known to occur within area
Charadrius dubius		
Little Ringed Plover [896]		Foraging, feeding or related behaviour known to occur within area
Charadrius leschenaultii		
Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus		
Lesser Sand Plover, Mongolian Plover [879]	Endangered	Foraging, feeding or related behaviour known to occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Foraging, feeding or related behaviour known to occur within area
Gallinago megala		
Swinhoe's Snipe [864]		Foraging, feeding or related behaviour known to occur within area
Gallinago stenura		
Pin-tailed Snipe [841]		Foraging, feeding or related behaviour likely to occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Foraging, feeding or related behaviour known to occur within area
Limicola falcinellus		
Broad-billed Sandpiper [842]		Foraging, feeding or related behaviour known to occur within area
Limnodromus semipalmatus		
Asian Dowitcher [843]		Species or species habitat known to occur within area
Limosa lapponica		
Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa		
Black-tailed Godwit [845]		Foraging, feeding or related behaviour known to occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus		
Little Curlew, Little Whimbrel [848]		Foraging, feeding or related behaviour known to occur within area
Numenius phaeopus		
Whimbrel [849]		Foraging, feeding or related behaviour known to occur within area
Pandion haliaetus		
Osprey [952]		Breeding known to occur within area
Pluvialis fulva		
Pacific Golden Plover [25545]		Foraging, feeding or

Name	Threatened	Type of Presence
		related behaviour known to occur within area
Pluvialis squatarola Grey Plover [865]		Foraging, feeding or related behaviour known to occur within area
Thalasseus bergii Greater Crested Tern [83000]		Breeding known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Foraging, feeding or related behaviour known to occur within area
Tringa glareola Wood Sandpiper [829]		Foraging, feeding or related behaviour known to occur within area
Tringa incana Wandering Tattler [831]		Foraging, feeding or related behaviour known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Foraging, feeding or related behaviour known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Species or species habitat known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Foraging, feeding or related behaviour known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [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.

Name
Commonwealth Land -
Commonwealth Land - Australian Government Solicitor
Commonwealth Land - Kakadu National Park
Defence - QUAIL ISLAND BOMBING RANGE
Defence - YAMPI SOUND TRAINING AREA

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Natural		
Ashmore Reef National Nature Reserve	EXT	Listed place
Mermaid Reef - Rowley Shoals	WA	Listed place
Scott Reef and Surrounds - Commonwealth Area	EXT	Listed place
Yampi Defence Area	WA	Listed place

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Acrocephalus orientalis Oriental Reed-Warbler [59570]		Species or species habitat known to occur within area
Actitis hypoleucos Common Sandpiper [59309]		Species or species

Name	Threatened	Type of Presence
		habitat known to occur within area
Anous minutus Black Noddy [824]		Breeding known to occur within area
Anous stolidus Common Noddy [825]		Breeding known to occur within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Foraging, feeding or related behaviour known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Foraging, feeding or related behaviour known to occur within area
Calidris alba Sanderling [875]		Foraging, feeding or related behaviour known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Foraging, feeding or related behaviour known to occur within area
Calidris subminuta Long-toed Stint [861]		Foraging, feeding or related behaviour known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Foraging, feeding or related behaviour known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Charadrius dubius Little Ringed Plover [896]		Foraging, feeding or related behaviour known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Foraging, feeding or

Name	Threatened	Type of Presence
		related behaviour known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Foraging, feeding or related behaviour known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Foraging, feeding or related behaviour known to occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat known to occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Foraging, feeding or related behaviour known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Breeding known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Foraging, feeding or related behaviour known to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Foraging, feeding or related behaviour likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Foraging, feeding or related behaviour known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Foraging, feeding or related behaviour known to occur within area
Heteroscelus incanus Wandering Tattler [59547]		Foraging, feeding or related behaviour known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Foraging, feeding or related behaviour known to occur within area
Hirundo daurica Red-rumped Swallow [59480]		Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Foraging, feeding or related behaviour known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species

Name	Threatened	Type of Presence
		habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Foraging, feeding or related behaviour known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Foraging, feeding or related behaviour known to occur within area
Numenius phaeopus Whimbrel [849]		Foraging, feeding or related behaviour known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding known to occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Foraging, feeding or related behaviour known to occur within area
Pluvialis squatarola Grey Plover [865]		Foraging, feeding or related behaviour known to occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Breeding known to occur within area

Name	Threatened	Type of Presence
Sterna anaethetus Bridled Tern [814]		Breeding known to occur within area
Sterna bengalensis Lesser Crested Tern [815]		Breeding known to occur within area
Sterna bergii Crested Tern [816]		Breeding known to occur within area
Sterna caspia Caspian Tern [59467]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sterna fuscata Sooty Tern [794]		Breeding known to occur within area
Sterna nereis Fairy Tern [796]		Breeding known to occur within area
Stiltia isabella Australian Pratincole [818]		Foraging, feeding or related behaviour known to occur within area
Sula dactylatra Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Sula sula Red-footed Booby [1023]		Breeding known to occur within area
Tringa glareola Wood Sandpiper [829]		Foraging, feeding or related behaviour known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Foraging, feeding or related behaviour known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Species or species habitat known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Foraging, feeding or related behaviour known to occur within area
Fish		
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Corythoichthys haematopterus Reef-top Pipefish [66201]		Species or species habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
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
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys parvicarinatus Short-keel Pipefish, Short-keeled Pipefish [66230]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Breeding known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus fuscus Dusky Seasnake [1119]		Species or species habitat known to occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus johnstoni Freshwater Crocodile, Johnston's Crocodile, Johnstone's Crocodile [1773]		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

Name	Threatened	Type of Presence
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis coggeri Slender-necked Seasnake [25925]		Species or species habitat may occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis inornatus Plain Seasnake [1107]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Hydrophis pacificus Large-headed Seasnake, Pacific Seasnake [1112]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area

Name	Threatened	Type of Presence
Parahydrophis mertoni Northern Mangrove Seasnake [1090]		Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans

[Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Delphinus delphis Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat may occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Indopacetus pacificus Longman's Beaked Whale [72]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur

Name	Status	Type of Presence
		within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Mesoplodon ginkgodens Gingko-toothed Beaked Whale, Gingko-toothed Whale, Gingko Beaked Whale [59564]		Species or species habitat may occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Commonwealth ReservesTerrestrial [Resource Information]

Name	State	Type
Kakadu	NT	National Park (Commonwealth)

Australian Marine Parks [Resource Information]

Name	Label
Arafura	Multiple Use Zone (IUCN VI)
Arafura	Special Purpose Zone (IUCN VI)
Arafura	Special Purpose Zone (Trawl) (IUCN VI)
Argo-Rowley Terrace	Multiple Use Zone (IUCN VI)
Argo-Rowley Terrace	National Park Zone (IUCN II)
Argo-Rowley Terrace	Special Purpose Zone (Trawl) (IUCN VI)
Arnhem	Special Purpose Zone (IUCN VI)
Ashmore Reef	Recreational Use Zone (IUCN IV)
Ashmore Reef	Sanctuary Zone (IUCN Ia)
Cartier Island	Sanctuary Zone (IUCN Ia)
Gascoyne	Multiple Use Zone (IUCN VI)
Joseph Bonaparte Gulf	Multiple Use Zone (IUCN VI)
Joseph Bonaparte Gulf	Special Purpose Zone (IUCN VI)
Kimberley	Habitat Protection Zone (IUCN IV)
Kimberley	Multiple Use Zone (IUCN VI)
Kimberley	National Park Zone (IUCN II)
Mermaid Reef	National Park Zone (IUCN II)
Montebello	Multiple Use Zone (IUCN VI)
Oceanic Shoals	Habitat Protection Zone (IUCN IV)
Oceanic Shoals	Multiple Use Zone (IUCN VI)
Oceanic Shoals	National Park Zone (IUCN II)
Oceanic Shoals	Special Purpose Zone (Trawl) (IUCN VI)

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Adele Island	WA
Bardi Jawi	WA
Browse Island	WA
Dambimangari	WA
Djukbinj	NT
Garig Gunak Barlu	NT
Keep River	NT
Lacepede Islands	WA
Lesueur Island	WA
Low Rocks	WA
Mitchell River	WA
Montebello Islands	WA
Niiwalarra Islands	WA
Ord River	WA
Pelican Island	WA
Unnamed WA28968	WA
Unnamed WA41080	WA
Unnamed WA41775	WA
Unnamed WA44673	WA
Unnamed WA44677	WA
Uunguu	WA
Yampi	WA

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia		
Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina		
Cane Toad [83218]		Species or species

Name	Status	Type of Presence
		habitat known to occur within area
Mammals		
Bos javanicus		
Banteng, Bali Cattle [15]		Species or species habitat likely to occur within area
Bos taurus		
Domestic Cattle [16]		Species or species habitat likely to occur within area
Bubalus bubalis		
Water Buffalo, Swamp Buffalo [1]		Species or species habitat likely to occur within area
Camelus dromedarius		
Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris		
Domestic Dog [82654]		Species or species habitat likely to occur within area
Equus asinus		
Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus		
Horse [5]		Species or species habitat likely to occur within area
Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus		
House Mouse [120]		Species or species habitat likely to occur within area
Rattus exulans		
Pacific Rat, Polynesian Rat [79]		Species or species habitat likely to occur within area
Rattus rattus		
Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa		
Pig [6]		Species or species habitat likely to occur within area
Plants		
Andropogon gayanus		
Gamba Grass [66895]		Species or species habitat likely to occur within area
Brachiaria mutica		
Para Grass [5879]		Species or species habitat likely to occur within area
Cabomba caroliniana		
Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Cenchrus ciliaris		
Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Hymenachne amplexicaulis		
Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Mimosa pigra Mimosa, Giant Mimosa, Giant Sensitive Plant, ThornySensitive Plant, Black Mimosa, Catclaw Mimosa, Bashful Plant [11223]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Pennisetum polystachyon Mission Grass, Perennial Mission Grass, Missiongrass, Feathery Pennisetum, Feather Pennisetum, Thin Napier Grass, West Indian Pennisetum, Blue Buffel Grass [21194]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Vachellia nilotica Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat known to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Ashmore Reef	EXT
Cobourg Peninsula System	NT
Kakadu National Park	NT
Mermaid Reef	EXT
Ord Estuary System	WA

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Carbonate bank and terrace system of the Van	North
Pinnacles of the Bonaparte Basin	North
Shelf break and slope of the Arafura Shelf	North
Tributary Canyons of the Arafura Depression	North
Ancient coastline at 125 m depth contour	North-west
Ashmore Reef and Cartier Island and surrounding	North-west
Canyons linking the Argo Abyssal Plain with the	North-west
Carbonate bank and terrace system of the Sahul	North-west
Continental Slope Demersal Fish Communities	North-west
Exmouth Plateau	North-west
Glomar Shoals	North-west
Mermaid Reef and Commonwealth waters	North-west
Pinnacles of the Bonaparte Basin	North-west
Seringapatam Reef and Commonwealth waters in	North-west

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-10.042247 136.244142,-10.042247 136.200197,-10.949647 135.541017,-11.251508 134.750001,-11.337697 133.387697,-11.251508 132.684572,-11.122177 131.937501,-11.423859 131.981447,-11.639151 132.50879,-12.069231 132.4209,-12.198121 131.805665,-12.112201 131.058595,-12.67018 130.267579,-13.184156 129.959962,-13.995732 129.564454,-14.421741 129.256837,-14.676957 129.520509,-14.88941 129.564454,-14.846936 129.125001,-14.761963 128.509767,-15.101654 128.20215,-14.761963 128.377931,-14.591918 128.070314,-13.825106 127.367189,-14.038369 126.576173,-14.506845 125.829103,-14.974333 124.950197,-15.398438 124.422853,-16.454881 124.334962,-15.948483 123.456056,-16.454881 123.543947,-16.749674 123.543947,-17.295932 123.543947,-16.201845 123.236329,-16.581277 122.66504,-17.044011 121.91797,-17.798735 121.346681,-18.758464 119.369142,-19.298534 118.182618,-20.125926 115.897462,-20.989997 114.579103,-20.989997 114.271486,-20.784711 113.436525,-20.784711 112.381837,-19.464353 112.337892,-17.882399 114.271486,-16.875875 114.491212,-16.201845 113.041017,-16.15964 109.613283,-17.001991 107.416017,-17.379829 104.208009,-17.337885 100.472658,-16.875875 98.626954,-16.15964 99.022462,-15.398438 99.505861,-13.953088 102.318361,-13.355244 106.097658,-12.755916 110.66797,-12.069231 114.007814,-11.725221 119.588868,-11.208404 121.742189,-10.906498 122.225587,-10.690663 122.357423,-10.172037 122.401368,-10.647477 122.533204,-11.251508 122.66504,-11.553054 123.236329,-11.079054 124.334962,-10.301774 127.586915,-10.172037 128.465822,-9.869113 129.69629,-9.305805 132.4209,-9.565909 134.969728,-10.042247 136.244142

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- -Office of Environment and Heritage, New South Wales
- -Department of Environment and Primary Industries, Victoria
- -Department of Primary Industries, Parks, Water and Environment, Tasmania
- -Department of Environment, Water and Natural Resources, South Australia
- -Department of Land and Resource Management, Northern Territory
- -Department of Environmental and Heritage Protection, Queensland
- -Department of Parks and Wildlife, Western Australia
- -Environment and Planning Directorate, ACT
- -Birdlife Australia
- -Australian Bird and Bat Banding Scheme
- -Australian National Wildlife Collection
- -Natural history museums of Australia
- -Museum Victoria
- -Australian Museum
- -South Australian Museum
- -Queensland Museum
- -Online Zoological Collections of Australian Museums
- -Queensland Herbarium
- -National Herbarium of NSW
- -Royal Botanic Gardens and National Herbarium of Victoria
- -Tasmanian Herbarium
- -State Herbarium of South Australia
- -Northern Territory Herbarium
- -Western Australian Herbarium
- -Australian National Herbarium, Canberra
- -University of New England
- -Ocean Biogeographic Information System
- -Australian Government, Department of Defence
- Forestry Corporation, NSW
- -Geoscience Australia
- -CSIRO
- -Australian Tropical Herbarium, Cairns
- -eBird Australia
- -Australian Government – Australian Antarctic Data Centre
- -Museum and Art Gallery of the Northern Territory
- -Australian Government National Environmental Science Program
- -Australian Institute of Marine Science
- -Reef Life Survey Australia
- -American Museum of Natural History
- -Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
- -Tasmanian Museum and Art Gallery, Hobart, Tasmania
- -Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Australian Government
Department of 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.

Report created: 04-Mar-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:	20
Listed Migratory Species:	38

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:	60
Whales and Other Cetaceans:	14
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	2
Habitat Critical to the Survival of Marine Turtles:	1

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:	13
Key Ecological Features (Marine):	1
Biologically Important Areas:	3
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 may occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
REPTILE		

Scientific Name	Threatened Category	Presence Text
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	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
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	Congregation or aggregation 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

Scientific Name	Threatened Category	Presence Text
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
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 likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Species or species habitat may occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may 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
Dugong dugon Dugong [28]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
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	Congregation or aggregation 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

Scientific Name	Threatened Category	Presence Text
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa sahulensis as Sousa chinensis Australian Humpback Dolphin [87942]		Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat likely to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Bird		

Scientific Name	Threatened Category	Presence Text
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area 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 likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Fish		
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys 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 schultzi Schultz's Pipefish [66205]		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
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
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
Mammal		
Dugong dugon Dugong [28]		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 foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
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
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
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
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
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		
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 may 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

Current Scientific Name	Status	Type of Presence
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
Sousa sahulensis as Sousa chinensis Australian Humpback Dolphin [87942]		Species or species habitat may occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Australian Marine Parks [Resource Information]

Park Name	Zone & IUCN Categories
Joseph Bonaparte Gulf	Multiple Use Zone (IUCN VI)
Joseph Bonaparte Gulf	Special Purpose Zone (IUCN VI)

Habitat Critical to the Survival of Marine Turtles

Scientific Name	Behaviour	Presence

Scientific Name	Behaviour	Presence
Aug - Sep		
Natator depressus Flatback Turtle [59257]	Nesting	Known to occur

Extra Information

EPBC Act Referrals			[Resource Information]
Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
Development of Blacktip Gas Field	2003/1180	Controlled Action	Post-Approval
Not controlled action			
2D seismic survey, exploration permit NT/P67	2004/1587	Not Controlled Action	Completed
2D Seismic Survey in Permit Areas WA-318-P & WA-319-P, near Cape Londonderry	2004/1687	Not Controlled Action	Completed
Nexus Drilling Program NT-P66	2007/3745	Not Controlled Action	Completed
Not controlled action (particular manner)			
2D and 3D Seismic Survey	2011/6197	Not Controlled Action (Particular Manner)	Post-Approval
2D Marine Seismic Survey	2009/4728	Not Controlled Action (Particular Manner)	Post-Approval
2D Seismic survey	2009/5076	Not Controlled Action (Particular Manner)	Post-Approval
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
Bonaparte 2D & 3D marine seismic survey	2011/5962	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
Nova 3D Seismic Survey	2013/6825	Not Controlled Action (Particular Manner)	Post-Approval
Petrel MC2D Marine Seismic Survey	2010/5368	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			
Nova 3D Seismic Survey, WA 442-NT/P81, Joseph Bonaparte Gulf	2013/6820	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

Biologically Important Areas

Scientific Name	Behaviour	Presence
Marine Turtles		
Chelonia mydas Green Turtle [1765]	Foraging	Known to occur
Lepidochelys olivacea Olive Ridley Turtle [1767]	Foraging	Known to occur
Natator depressus Flatback Turtle [59257]	Internesting buffer	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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Appendix 5

Existing Environment of the Spill EMBA

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5. Description of the Existing Environment

In accordance with OPGGS(E) Regulation 13(2), the 'environment that may be affected' (EMBA) by the activity is described in this section, together with its values and sensitivities. While each hazard associated with the activity has its own unique EMBA, the largest one has been chosen for this chapter so as to describe all possible values and sensitivities, which is a surface release of crude oil from a loss of well control (LoWC). Spill modelling of this event used the NOPSEMA Bulletin #1 Oil Spill Modelling (NOPSEMA, 2019) hydrocarbon contact values of four oil phases (surface, dissolved, entrained and accumulated shoreline) that pose differing environmental risks to define the outer extent of the EMBA (see Table 5.1 in Section 5.1.2 of Chapter 5).

The low contact values used to inform the extent of the EMBA are useful for establishing scientific monitoring parameters and identifying potential socio-economic impacts (the socio-economic EMBA); however, they may not be at concentrations that are ecologically significant (NOPSEMA, 2019). Therefore, in addition to the socio-economic EMBA, an ecological EMBA has also been derived from the stochastic spill modelling using hydrocarbon thresholds that are identified by NOPSEMA Bulletin #1 (NOPSEMA, 2019) (see Table 5.1 in Section 5.1.2 of Chapter 5) as having the potential to cause impacts to ecological receptors. This is simply referred to as the 'spill EMBA' or interchangeably throughout this appendix as the 'EMBA' (Figure 5.1).

This spill EMBA has been established through hydrocarbon spill modelling (see Section 8.6 for MDO and Section 8.7 for crude oil). The EMBA is generated from stochastic modelling and therefore does not represent the possible outcome from a single spill scenario. The EMBA represents the compilation of possible outcomes and encompasses the area predicted to be affected from 100 simulations of the scenario per season (summer, winter, transition). Because of this, the EMBA is very large, covering areas that may not be affected by any single spill event.

The modelling also reports hydrocarbon contact for a given grid cell even if hydrocarbon concentrations reach this very low threshold for only one time step (2 hours) within the entire duration of the model run (6 hours for MDO and 77 days for crude oil). Because of this, the EMBA from a single spill event would be considerably smaller than the EMBA presented for the loss of MDO or a LoWC (which is an amalgamation of 100 simulations). Additionally, the spill EMBA does not consider mitigation measures that would be applied in the event of an MDO spill or LoWC, which would act the reduce the extent of the EMBA.

The 'environment' described in this EP is as per the definition in the OPGGS(E) regulations:

- Ecosystems and their constituent parts, including people and communities;
- Natural and physical resources;
- The qualities and characteristics of locations, places and areas;
- The heritage value of places; and
- The social, economic and cultural features of these matters.

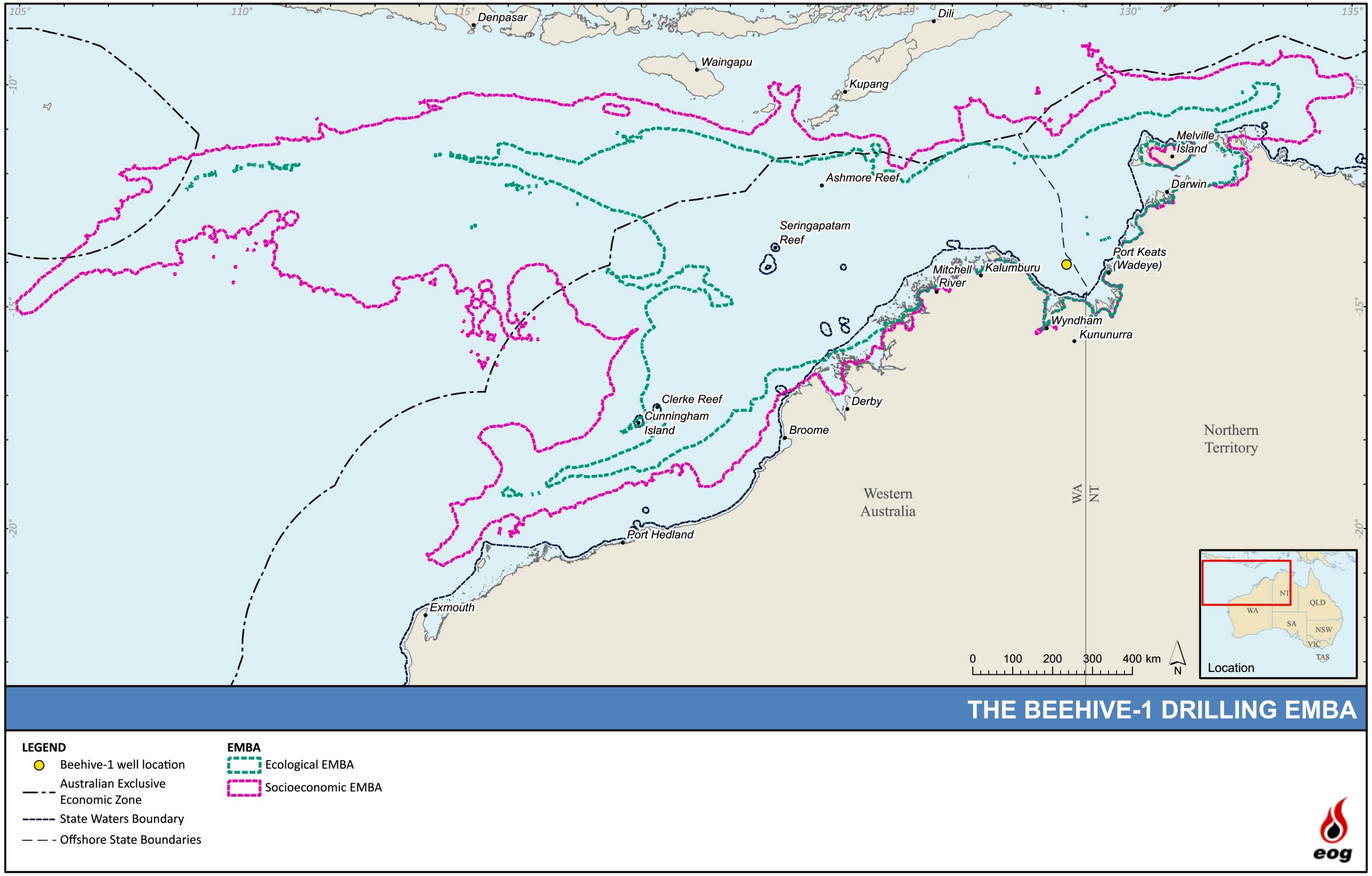


Figure 5.1. The LoWC spill EMBA

The key sources of information used in developing this chapter include the:

- EPBC Act Protected Matters Search Tool (PMST) database (DAWE, 2021a), conducted for the for the socio-economic EMBA on 17th August 2021 and for the ecological EMBA on 7th of September 2021 and repeated on 17th February 2022 (**Appendix 4**);
- Species Profile and Threats (SPRAT) Database (DAWE, 2021b);
- The Northwest Marine Bioregional Plan Bioregional Profile (DEWHA, 2008b);
- Marine bioregional plan for the North Marine Region (DSEWPC, 2012);
- National Conservation Values Atlas (NCVA) (DAWE, 2021c);
- Species recovery plans, conservation advice and scientific publications; and
- Seabed Habitats and Hazards of the JBG and Timor Sea, Northern Australia (Przeslawski *et al.*, 2011).

The relevant values and sensitivities considered in this chapter are inclusive of but not limited to the matters protected under Part 3 of the EPBC Act.

5.1. Regional Context

The spill EMBA occurs within both the NWMR and the NMR. The marine bioregional plans for the NWMR (DSEWPC, 2012a) and NMR (DSEWPC, 2012b) have been used in conjunction with other relevant management plans, reports and published papers to inform the description of the existing environment.

5.1.1. Northwest Marine Region

The NWMR comprises Commonwealth waters from the Western Australia-Northern Territory (WA-NT) border to Kalbarri, south of Shark Bay, WA (DEWHA, 2008a).

The NWMR is characterised by the large area of continental shelf and continental slope, highly variable tidal regions and very high cyclone incidence (DEWHA, 2008a).

The NWMR is characterised by a wide continental shelf with water depths generally less than 70 metres, complex geomorphology with features including shelves, shoals, banks and terraces and valleys, currents driven largely by strong winds and tides and complex weather and a tropical monsoonal climate (DEWHA, 2008b).

5.1.2. North Marine Region

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

5.1.3. Provincial Bioregions

Based on the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) Version 4.0, the ecological EMBA is situated within the Northwest IMCRA Transition bioregion (containing the Northwest Shelf Transition), Northwest IMCRA province (containing the Northwest Shelf Province, Northwest Transition and the Timor Province). The socio-economic EMBA intersects all the above bioregions including the Northwest Province, Christmas Island Province and the Northern IMCRA Province and the Timor Province (CoA, 2006), which is illustrated in Figure 5.2.

The following mesoscale bioregions are intersected by the spill EMBA and are presented in Figure 5.3:

- Anson Beagle;
- Arafura;
- Bonaparte Gulf;
- Cambridge-Bonaparte;
- Canning;
- Cobourg;
- Kimberley;
- King Sound;
- NorthWest Shelf;
- Oceanic Shoals;
- Pilbara (offshore);
- Tiwi; and
- Van Diemens Gulf.

Northwest Shelf Transition

The Northwest Shelf transition is a provincial bioregion situated within the NWMR and NMR extending from the Tiwi Islands in the NT to Cape Leveque in WA, covering an area of 305,463 km^2. The Indonesian Throughflow is the dominant oceanographic feature and dominates the majority of the water column. The strength of the Throughflow and its influence in the bioregion varies seasonally in association with the North-west Monsoon (DEWHA, 2008a).

The vast majority of the bioregion is located on the continental shelf with water depths generally in the range 10 to 100 m. The provincial bioregion has a complex seafloor topography with a diversity of features including submerged terraces, carbonate banks, pinnacles, reefs and sand banks. The carbonate banks and pinnacles of the Joseph Bonaparte Gulf are distinctly different in morphology and character to other parts of the region and are considered to support a high diversity of marine species (DEWHA, 2008a).

The biological communities of the North-west Shelf Transition are typical of Indo-west Pacific tropical flora and fauna and occur across a range of soft-bottom and harder substrate habitats. The inshore waters off the Kimberley are where the Western Australian population of humpback whales mate and calve. The bioregion is important for commercial fisheries and supports both defence activities and the petroleum industry (DEWHA, 2008a).

Northwest Shelf Province

This provincial bioregion is located primarily on the continental shelf between Northwest Cape and Cape Bougainville. It varies in width from about 50 km at Exmouth Gulf to more than 250 km off Cape Leveque. Approximately half of the bioregion has water depths of only 50 to 100 m. The bioregion is a dynamic oceanographic environment, influenced by strong tides, cyclonic storms, long-period swells and internal tides. Its waters derive from the Indonesian Throughflow, are warm and oligotrophic, and circulate throughout the bioregion via branches of the South Equatorial and Eastern Gyral Currents (DEWHA, 2008a).

Fish communities are diverse and both benthic and pelagic fish communities appear to be closely associated with different depth ranges. Humpback whales migrate through the bioregion and Exmouth Gulf is an important resting area, particularly for mothers and calves on their southern migration. A number of important seabird breeding sites are located in the bioregion (but adjacent to Commonwealth waters), including Eighty Mile Beach, the Lacepede Islands, and Montebello and Barrow islands. The bioregion is important for the petroleum industry and the location of commercial fishing operations. The nationally significant ports of Dampier and Port Hedland operate in this bioregion (DEWHA, 2008a).

Northwest Transition

The Northwest Transition is a provincial bioregion located off the shelf between the Dampier Archipelago and Lacepede Islands covering a total area of 184 424 km^2. The area includes shelf break and continental slope and the majority of the Argo Abyssal Plain included in the NWMR. Key topographic features include the Mermaid, Clerke and Imperieuse Reefs, all of which are marine reserves and together constitute the Rowley Shoals.

Surface circulation of Indonesian Throughflow waters occurs both via direct southward movement of the Throughflow itself, and recirculation of Throughflow waters via the South Equatorial Current. Cyclone incidence is high in this bioregion during summer months (DEWHA, 2008a).

Little is known about benthic biological communities in the deeper parts of the provincial bioregion, although high levels of species diversity and endemism have been identified among demersal fish communities on the continental slope. The Rowley Shoals are biodiversity hotspots in the bioregion and the steep change in slope around them attracts a range of pelagic migratory species including billfish, sharks, tuna and cetaceans. Commercial fishers operate within the bioregion and it may increase in importance for the petroleum industry in the future (DEWHA, 2008a).

Northwest Province

The Northwest Province is located on the continental shelf between Northwest Cape and Cape Bougainville, with half the bioregion located in water depths of 50 m to 100 m. It varies in width from approximately 50 km at Exmouth Gulf to more than 250 km off Cape Leveque in the Kimberley. The bioregion is a dynamic oceanographic environment, influenced by strong tides, cyclonic storms, long-period swells and internal tides. Waters derive from the Indonesian Throughflow, are warm and oligotrophic, and circulate throughout the bioregion via branches of the South Equatorial and Eastern Gyral Currents (DEWHA, 2008b).

Fish communities are diverse and both benthic and pelagic fish communities appear to be closely associated with different depth ranges. Humpback whales migrate through the bioregion, with Exmouth Gulf identified as an important resting area, particularly for mothers and calves on their southern migration. A number of important seabird breeding sites are located in the bioregion (adjacent to Commonwealth waters), including Eighty Mile Beach, the Lacepede Islands, and the Montebello and Barrow islands. The bioregion is important for the petroleum industry and the location of commercial fishing operations. The nationally significant ports of Dampier and Port Hedland operate in this bioregion (DEWHA, 2008b)

Christmas Island Province

This provincial bioregion surrounds Christmas Island and covers a total area of 277,180 km^2. It contains the fourth largest abyssal plain/deep ocean floor area and smallest area of slope of all the bioregions (DEH, 2005). Water depths range from 0 m to 6,545 m and support a suite of marine species typical of Indian Ocean tropical reefs. The recorded marine species diversity includes 88 coral species and over 600 fish species, including the whale shark and several other shark species, as well as hybrid fish. Green turtles and hawksbill turtles are found in offshore waters of the bioregion (DNP, 2014).

Northern Shelf Province

The Northern Shelf Province extends over the continental shelf from the eastern shore of Melville Island to West Cape York and is the largest of all the shelf provincial bioregions in the Region. It comprises the Gulf of Carpentaria in the east and the south-western Arafura Sea in the west, a covering a total area of 556,350 km^2. The provincial bioregion is characterised by relatively featureless sandy and muddy continental shelf and basin, turbid coastal waters, and submerged patch or barrier reefs around 30 m to 50 m water depth. Offshore features of the Arafura Shelf include canyons, terraces and the Arafura Sill (DEWHA, 2008c).

Of all the provincial bioregions of the Region, the Northern Shelf Province is the best sampled for demersal fish and invertebrates. Most data are associated with scientific studies and sampling of prawns and fish trawling. Localised upwellings offshore, around islands and offshore reefs, are also known to be hotspots for marine biodiversity in the provincial bioregion (DEWHA, 2008c).

Timor Province

This provincial bioregion covers almost 15% of the NWMR predominantly covering the continental slope and abyss between Broome and Cape Bougainville in WA. Water depth ranges from about 200 m near the shelf break to 5,920 m over the Argo Abyssal Plain. In addition to the Argo Abyssal Plain, the major geomorphic features are the Scott Plateau, the Ashmore Terrace, part of the Rowley Terrace and the Bowers Canyon. Important features of the bioregion include Ashmore Reef, Cartier Island, Seringapatam Reef and Scott Reef (DEWHA, 2008c).

The bioregion is dominated by warm, oligotrophic waters of the Indonesian Throughflow. In this bioregion the thermocline in the water column is pronounced and associated with the generation of internal tides. The variety of geomorphic features in the Timor Province, coupled with the variation in bathymetry, results in several distinct habitats and biological communities. The reefs and islands of the bioregion are regarded as particular hotspots for biodiversity. A high level of endemicity exists in demersal fish communities of the continental slope in the Timor Province and two distinct communities have been identified associated with the upper slope and mid slope (DEWHA, 2008c).

The bioregion supports commercial fisheries, and the petroleum industry (DEWHA, 2008a).

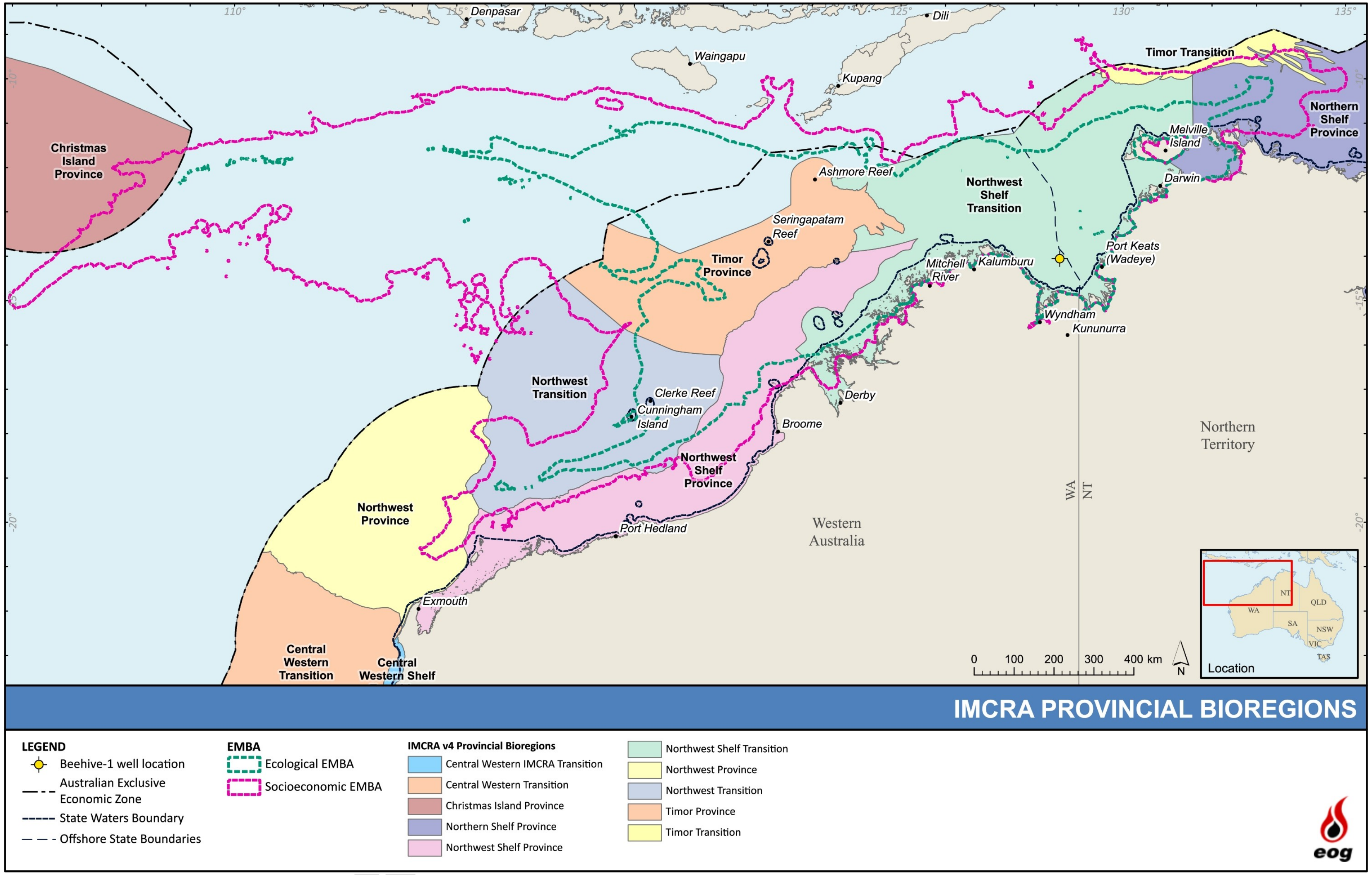


Figure 5.2. Provincial bioregions intersected by the EMBA

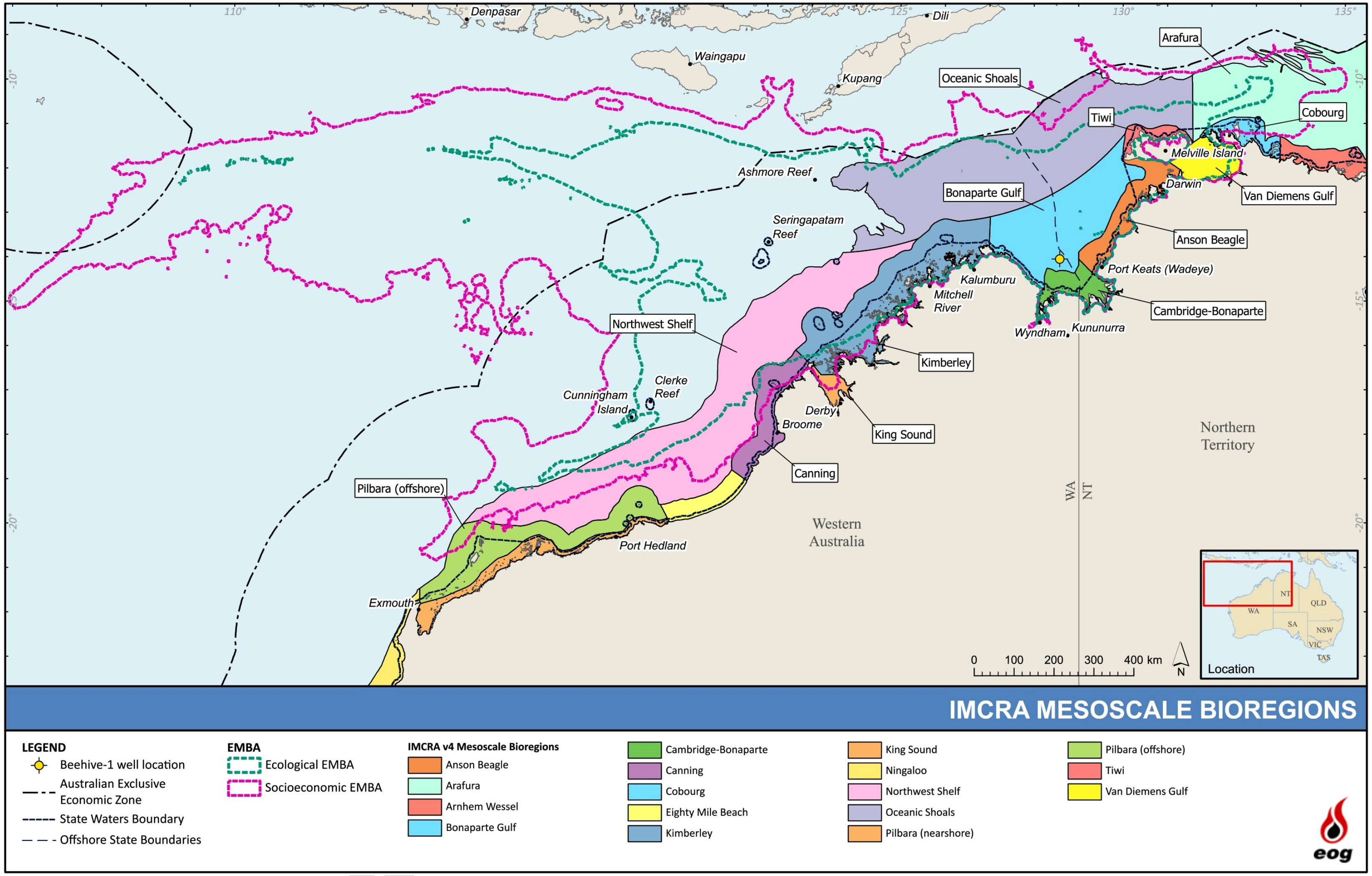


Figure 5.3. Mesoscale bioregions intersected by the EMBA

5.1.4. Climate

The northwest of Australia has a tropical climate with hot and humid summers and warm winters. There are two distinct seasons known as the northwest monsoon, which occurs from late October to mid-March ('wet season'); and the southeast monsoon, which occurs from May to mid-October ('dry season').

Air Temperature

Mean air temperatures range from a minimum of 11°C in winter to a maximum of 36°C in summer (Condie *et al.,* 2006). During summer, hot and dry wind from the north-east, which comes from the desert, can become really intense, with air temperatures reaching above 40°C.

Rainfall

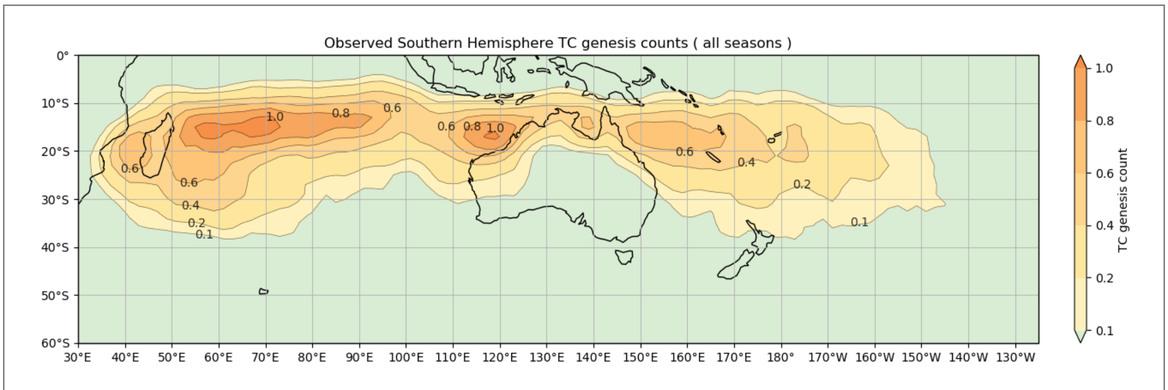
Regular and high rainfall is a characteristic of the northwest monsoon, mainly over coastal areas and during tropical cyclones. This is caused by large amounts of moisture being gathered as the monsoon crosses the sea from the Asian high-pressure belt on its way to the intertropical convergence zone, which drifts southward close to, or over, northern Australia. On the contrary, the southeast monsoon originates from the southern hemisphere high-pressure belt and is relatively dry and cool (DSEWPC, 2012a). Low rainfall and humidity are associated with the southeast monsoon.

Historical rainfall data in the region shows the highest mean monthly rainfall occurs from January to March (BoM, 2022a).

Cyclones

Cyclones are common in the region resulting in severe storms with gale force winds and a rapid rise in water levels. The cyclone season typically occurs between November and April (BoM, 2022b). Cyclones result in severe storms with gale force winds and a rapid rise in water levels. Cyclones in the Australian region are influenced by several factors, and in particular variations in the El Niño –Southern Oscillation, generally more tropical cyclones occur across the coast during La Niña years than during El Niño years. On average about eleven cyclones form in the Australian region (90-160° E) each cyclone season (BoM, 2022b).

The average number of tropical cyclones through the Australian region and surrounding waters in El Niño, La Niña, neutral years and using all years of data is presented in Figure 5.4. The data is based on a 48-year period from the 1969/70 to 2017/18 tropical cyclone season



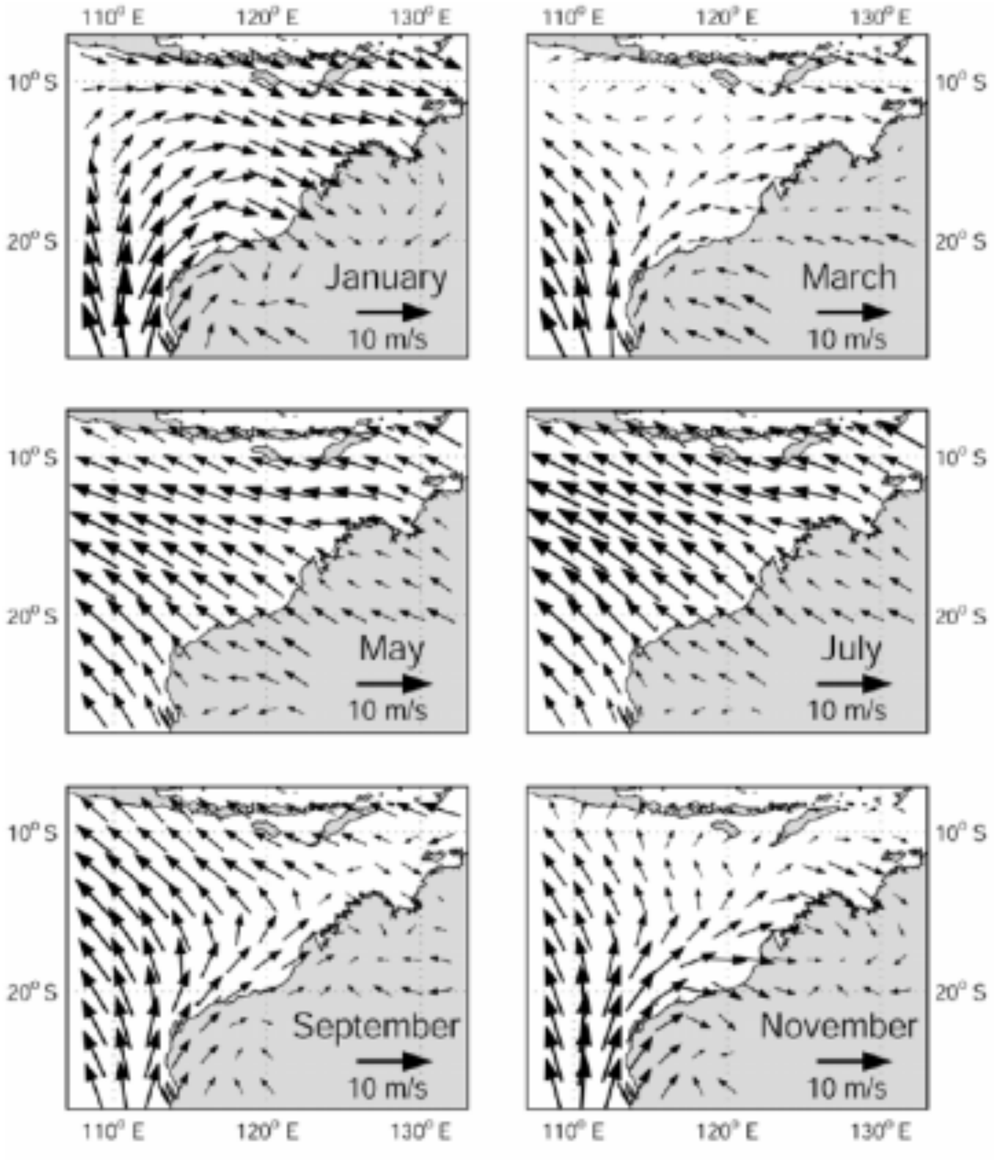
Source: BoM (2022).

Figure 5.4. Average number of tropical cyclones in Australia from 1969 to 2018

Winds

Winds typically vary seasonally, with a tendency for south-westerly winds during September–March and south-easterly from May–July (Condie *et al.,* 2006). Transitional wind periods, during which either pattern may predominate, can be experienced in April–May and September of each year. September–March winds are more variable and are driven by high pressure cells that pass from west to east over the Australian continent. During May–July the relative position of the high-pressure cells moves further north, leading to prevailing easterly winds blowing from the mainland (Pearce *et al.,* 2003).

Seasonally averaged winds in the NWMR at 10 m above sea level during January, March, May, July, September and November are presented in Figure 5.5.



Source: Condie et al.,2006.

Figure 5.5. Seasonally averaged winds in the Northwest Marine Region

5.1.5. Oceanography

Currents

Broad-scale ocean circulation of the North Australian Shelf is dominated by the Indonesian Throughflow current system. The NWMR is influenced by a complex system of ocean currents that vary between seasons and years, which generally result in warm, nutrient-poor and low salinity surface waters (DEWHA, 2008b). Two ocean and coastal surface currents in the WA region are significant in shaping marine environmental conditions and climate. Forming on the NWS, the Leeuwin Current exerts a major influence on the distribution of marine life and WA's weather. The Indonesian Throughflow is a system of currents that carries water westward from the Pacific to the Indian Ocean through the deep passages and straits of the Indonesian Archipelago where warm, equatorial waters flow from one ocean to another, that influence the character of the Leeuwin Current (CSIRO, 2022).

During the wet season (December to March), monsoon winds push some of the waters of the Indonesian Throughflow eastwards, extending as far as the Gulf of Carpentaria. At the end of the Northwest monsoon (March-April), the pressure gradient is released, which releases a south-westerly flow of water across the shelf during autumn and winter, known as the Holloway Current (DEWHA, 2008).

Currents in the NMR are driven largely by strong winds and tides, with only minor influences from oceanographic currents such as the Indonesian Throughflow and the South Equatorial Current. The net tidal flows that occur over time drive longer-term transport patterns through the region. The movement of tidal waters across the northern Australian marine environment is complex due to the barrier of islands and submerged reefs in the Torres Strait that hinder tidal energy entering from the Coral Sea (DSEWPC, 2012).

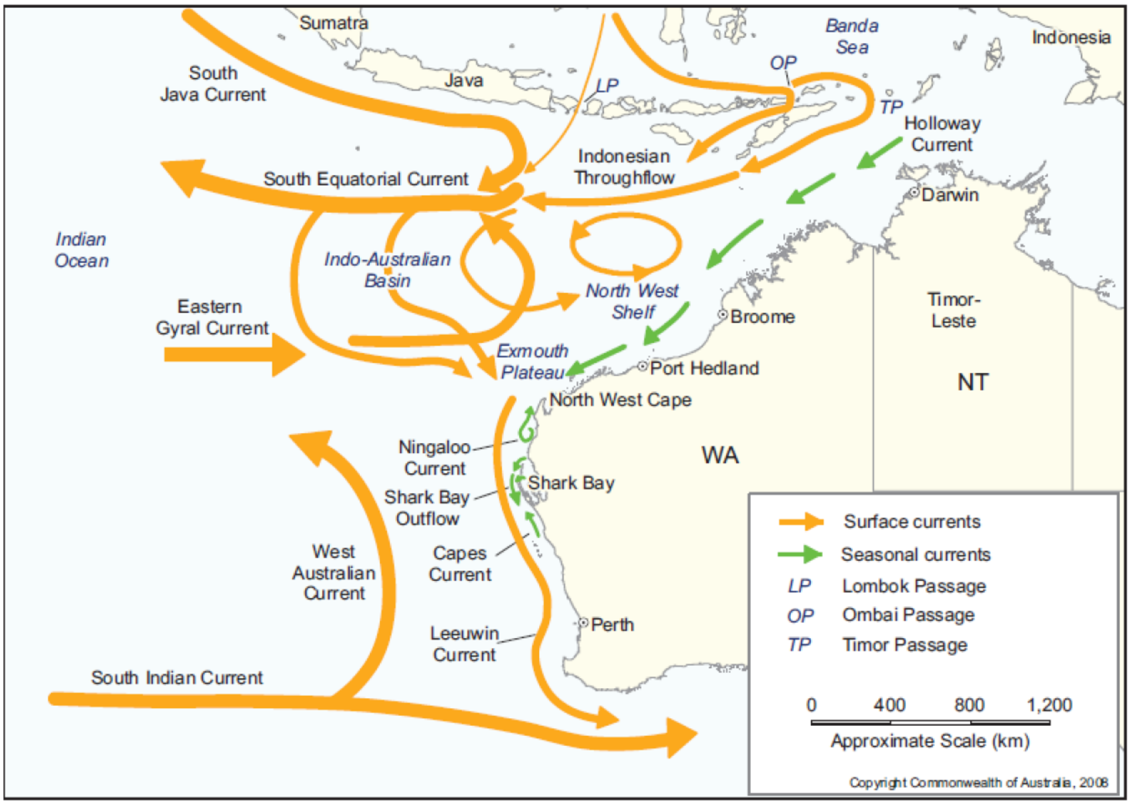
Surface currents that have some minor influence in the NMR include the Indonesian Throughflow and the South Equatorial Current. The Indonesian Throughflow brings warm water of lower salinity from the tropical western Pacific Ocean between the Indonesian islands to the Indo-Australian basin in the north-west of the region. The influence of the South Equatorial Current in the region is marginal, although the strength of its influence varies with the season (DSEWPC, 2012a).

Figure 5.6 represents the major ocean currents in north-western Australian waters.

Sea Temperature and Salinity

Surface water temperatures and salinities in northern WA vary seasonally and are influenced by the Indonesian Throughflow. During the northwest monsoon, a thermocline flow of relatively cool water dominates resulting in the tropical Indian Ocean being cooled rather than warmed. The region typically has average sea surface temperatures of 28-30°C and salinities of 34-35 psu.

Two marine baseline studies in 2010 (wet season) and 2011 (dry season) within the Bonaparte Basin in support of GDF SUEZ Bonaparte LNG Project were undertaken by Environmental Resources Management Australia Pty Ltd (ERM). The studies indicated that temperature gradients throughout the water column did not display a thermocline, however a vertical gradient in seawater temperature was observed in which temperature decreased progressively from the surface to the bottom ranging from 32.1°C to 25.3°C (ERM 2011).



Source: DEWHA, 2008b.

Figure 5.6. Ocean currents along the Northwest Australian continental shelf

Tides

The tides of the region are mixed and predominantly semi-diurnal (two high tides and two low tides per day), with well-developed spring to neap tidal variation (DEWHA, 2008a). The Kimberley region within the NWMR has some of the largest tides in Australia, along a coastline adjoining an open ocean. Tides increase in amplitude from with an increase in amplitude from south to north, which corresponds with the increasing width of the shelf (Holloway, 1983).

Tides and winds strongly influence water flow in the coastal zone and over the inner to mid-shelf, whereas flows over the outer-shelf, slope, rise and deeper waters are influenced by large scale regional circulation (DEWHA, 2008a).

Tides are semi-diurnal (two high tides and two low tides each day) and generally quite large; up to 10 m during spring tide and less than 3 m in the neap tides for the Kimberley region (DEWHA, 2008). Water flows in the deeper waters are influenced more by large scale regional water circulation than tides and winds that influence the coastal regions. Tides contribute to the vertical mixing of surface water layers and sediments, but this is more evident in shallow waters than deep waters (DEWHA, 2008).

The JBG is subject to semi-diurnal tides with two high and low tides per day, and has the largest tidal energy observed anywhere in the world (>7 m) (Rothlisberg *et al.*, 2005). Within the Bonaparte Gulf (situated in the Northwest Shelf Transition provincial bioregion), tides range from 2-3 m offshore (microtidal) rising to 3-4 m inshore (mesotidal).

Waves

In the JBG, the Southern Ocean swell is higher in winter than in summer as a result of northerly migration of swell-generating storms. The wave period and significant wave height generated by this swell is highly dependent on the exact location within the basin. For example, the JBG is protected from the Southern Ocean swell; therefore, swells affecting the area are limited to those generated by cyclones or prolonged storm winds (Maxwell *et al*., 2004). The region is considered a moderate-energy environment except when influenced by tropical cyclones which generate short-term but major fluctuations in sea levels. Swells generated may have periods of 6-18 seconds and wave heights of 0.5-9 m and are dependent on the size, intensity, speed and relative location of the cyclone.

One of the most unique features of the NWMR is the occurrence of internal waves. Internal waves are dynamic, episodic events, which are strongly influenced by topography and generated by internal tides (DEWHA, 2008a). Internal tides occur at the thermocline, where the warm, low salinity waters of the Indonesian Throughflow overlay colder, more saline, deeper ocean waters. Internal tides are large in scale, frequently occurring across an ocean basin and forced by the gravitational pull of the moon and sun. An internal tide can rise and fall at a different rate to the surface tide but are typically occur semi-diurnal (twice daily) (Holloway *et al.,* 1997) and may travel either towards the shore, or away from the shore across the shelf and out into deeper water (DEWHA, 2008a).

Water Quality

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

Major inputs of fine silt sediments from the Ord, Victoria and Keep River systems occur during the wet season, creating vast areas of high turbidity, particularly in the southern part of the Gulf. The sediments are deposited to form sand bars and mud flats which are themselves the source of high turbidity throughout the year as sediments are resuspended by tidal movements. Though there is only limited marine and nearshore water quality data available, as there are no major developments or population centres near the Beehive-1 well location, the potential for existing pollution is limited.

A study conducted by Holloway et al in 1985 into the mechanisms of nitrogen supply in the NWS indicated the NWMR is an oligotrophic (low in nutrients) environment. Nutrient enrichment of the shelf occurs through river runoff, tidal mixing, internal tides, low frequency circulation, upwelling, and tropical cyclones that induce oceanic mixing and further upwelling (Holloway *et al.,* 1985).

Ambient Ocean Sound

Physical and biological processes contribute to natural background sound. Physical processes include that of wind, waves, rain and earthquakes, whilst biological noise sources include vocalisations of marine mammals and other marine species.

Wind is a major contributor to noise between 100 Hz and 30 kHz and can reach 85-95 dB re 1µPa^2/Hz under extreme conditions (WDCS, 2004). Rain may produce short periods of high underwater sound with a flat frequency spectra to levels of 80 dB re 1µPa^2/Hz and magnitude 4 earthquakes have been reported to have spectral levels reaching 119 dB re 1µPa^2/Hz at frequency ranges of 5-15 Hz.

Turnpenny and Nedwell (1994) found that in sensitive species such as the cod, continuous ambient sound alone resulted in auditory masking, and that sound had to be 20 dB above ambient sound to be audible. A comparison of biological and anthropological sounds in the marine environment is provided in Table 5.5 of Section 5.2.2 of Chapter 5.

5.1.6. Physical Environment

Bathymetry

Water depths in the NWMR range from 0 to 5,980 m. The NWMR is relatively shallow, with greater than 40% of the total area in water depths of less than 200 m and greater than 50% in depths of less than 500 m (Baker *et al.,* 2008). Water depths in the spill EMBA range from ~100 m (offshore) to <10 m (inshore).

Bathymetry in parts of the south of the JBG is strongly influenced by the strong tidal movement and channels of the Ord, Keep, Victoria and Fitzmaurice rivers. A series of extensive sandbars, known as the King Shoals and Medusa Banks, have been generated in the southwest by the strong outflows of sediment-laden water from the Cambridge Gulf. Similar sandbars can be found in the southeast of the JBG. Bathymetry of the spill EMBA is presented in Figure 5.7.

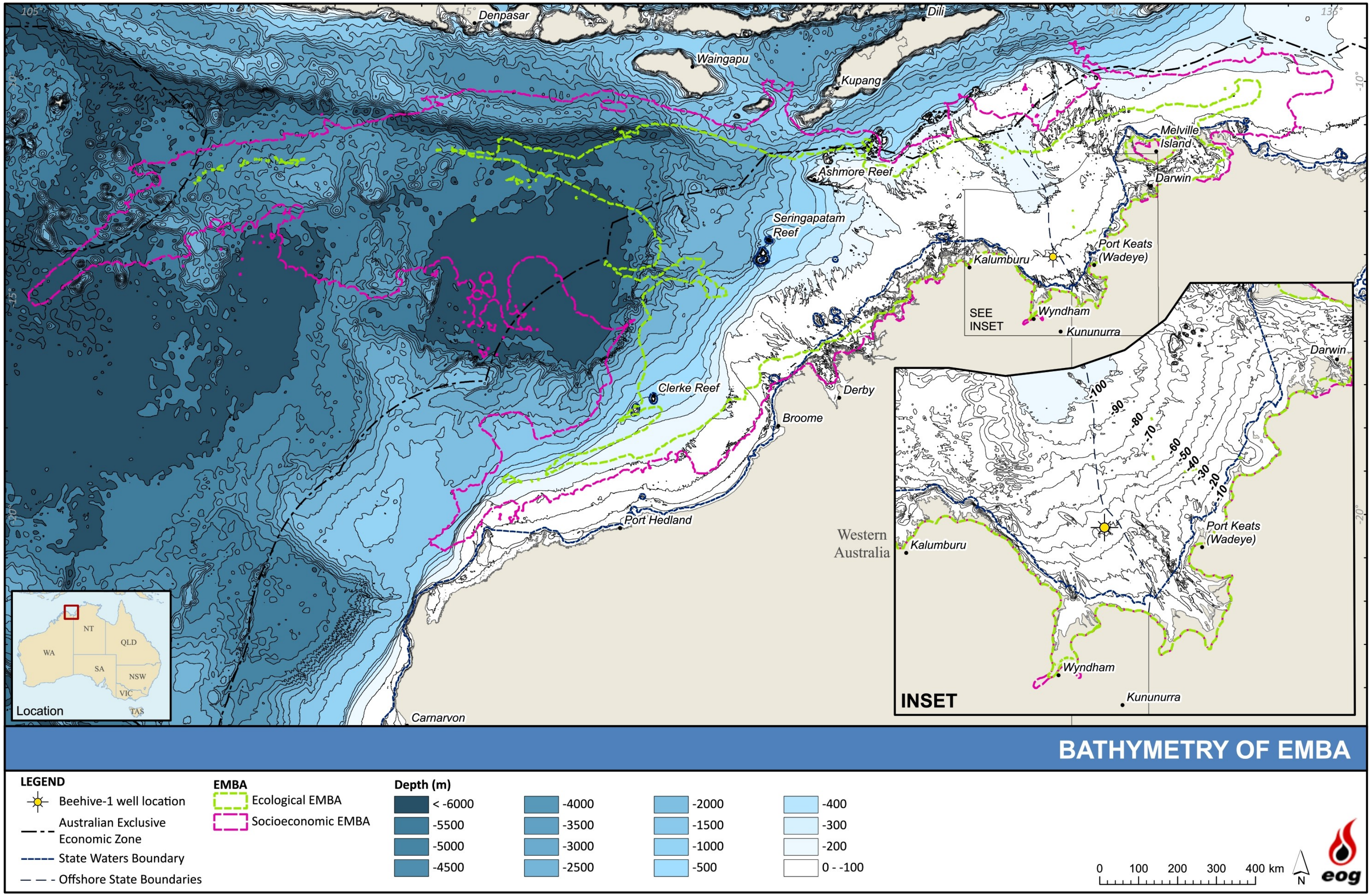


Figure 5.7. Bathymetry of the spill EMBA

Geomorphology

The seafloor of the NWMR comprises an extensive area of continental shelf, slope, rise and abyssal plain/deep ocean floor. The seafloor of the NWMR comprises an extensive area of continental shelf, slope, rise and abyssal plain/deep ocean floor. Most of the region consists of continental slope (61%) or continental shelf (28%) and a range of features such as canyons, plateau, terraces, ridges, reefs, banks and shoals. Over half of the total area of banks and shoals in Australian marine jurisdiction occurs in the NWMR, including 39% of terraces and 56% of deeps, holes and valleys (DSEWPC, 2012a).

Sediment texture and composition displays a zoning with depth, and sand and gravel dominate the shelf area whilst mud dominates the lower slope and abyssal plain/deep ocean floor. Calcium carbonate concentrations throughout the region are generally highest along the shelf to the shelf edge and are associated with reefs (Baker *et al.,* 2008).

Ten key geomorphic features have been identified in the JBG (Przeslawski *et al.,* 2011). The inner gulf comprises mostly shelf with sand banks and valleys. The outer gulf and Timor Sea mostly comprise of basin with banks/shoals, terraces and pinnacles separated by deep hole/valley features and escarpment.

The benthic environment of the JBG is linked to its geomorphic features, with the majority of the area characterised by infaunal plains, with some localised reefs and outcrops supporting sponge gardens. Seabed morphology in parts of the JBG is influenced by the strong tidal movement and channels of the Ord, Keep, Victoria and Fitzmaurice rivers. A series of extensive sandbars, known as the King Shoals and Medusa Banks (approximately 72 km and 66 km south respectively of the Beehive-1 exploration well location), have been generated by the strong outflows of sediment-laden water from Cambridge Gulf. Similar sandbars can be found in the south-east of the JBG. The Beehive-1 exploration well location is located entirely within the ‘shelf’ geomorphic feature, which is typically characterised by extensive sediment plains and high sediment deposition from the coastal rivers to the south (Figure 5.8).

The NMR seafloor comprises a wide continental shelf with water depths generally less than 70 m although water depths range from approximately 10 m to a maximum known depth of 357 m (DSEWPC, 2012b). It contains the Van Diemen Rise, characterised by complex geomorphology with features including shelves, shoals, banks, terraces and valleys like the Malita Shelf Valley, which provides a significant connection between the Joseph Bonaparte Gulf and the Timor Trough. In addition, numerous limestone pinnacles up to tens of kilometres in length and width, lie within the Bonaparte Basin (DSEWPC, 2012b).

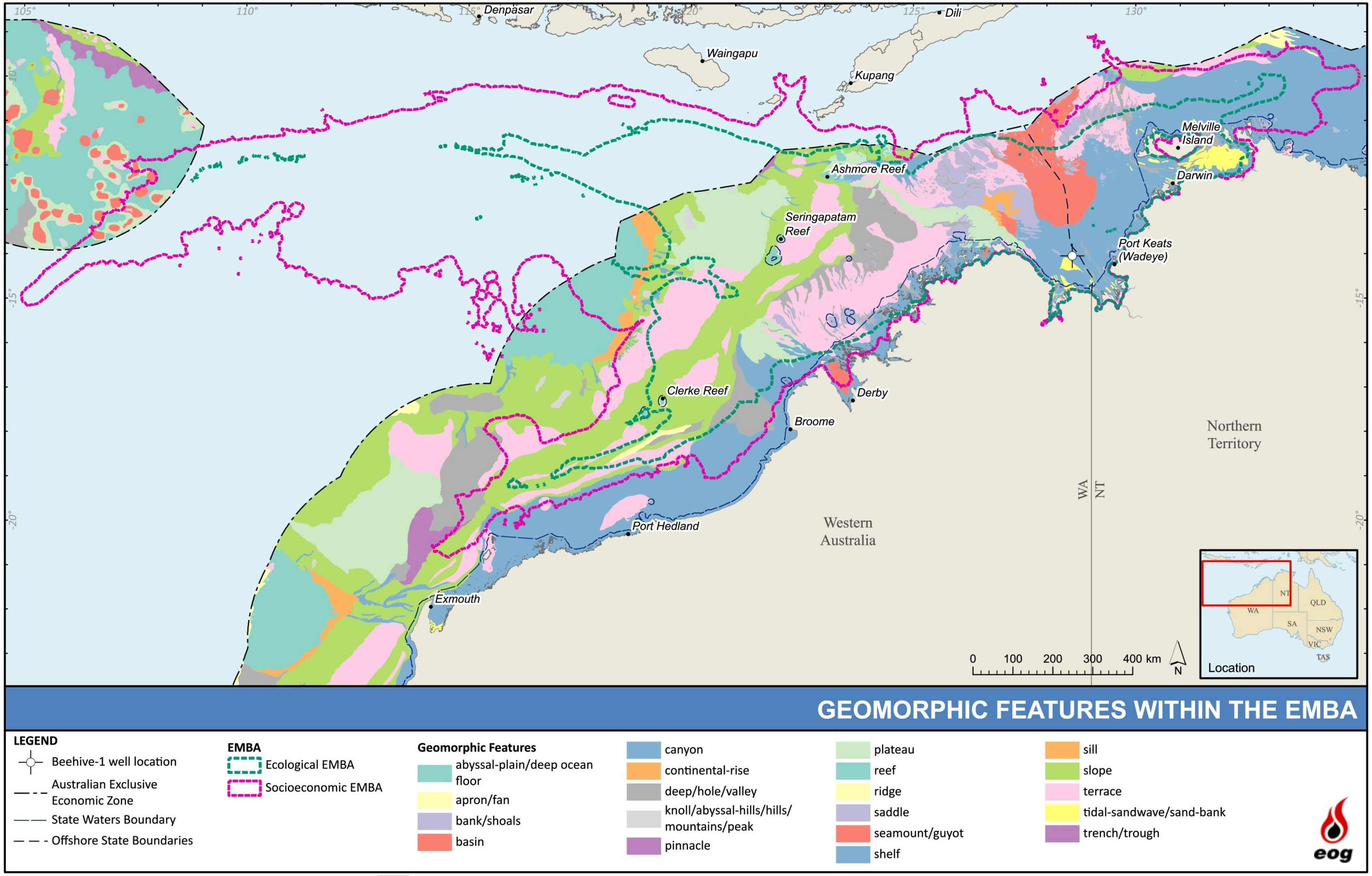


Figure 5.8. Geomorphic features of the EMBA

Sedimentology

The sedimentology of the NWMR is varied due to the diversity of physical features from coral reefs to major canyons that act as conduits for sediment and nutrient transport (DSEWPC, 2012a). The region is made up of a tropical carbonate shelf dominated by sand and gravel to 15° latitude, while the outer shelf/ slope zone is dominated by mud (Baker *et al.,* 2008). It has a relatively homogenous rise and abyssal plain/ deep ocean floor that is dominated by non-carbonate mud because it occurs below the carbonate compensation depth (Baker *et al.,* 2008).

Major contributors to sediment mobilisation in the NWMR include storm events, tropical cyclones; internal tides; and ocean currents, including the Leeuwin current (Baker *et al.,* 2008). Sediments of the middle shelf region are predominantly influenced by tidal processes, including internal tides (Baker *et al.,* 2008).

Sedimentology in the NMR is also varied, with physical features including shallow canyons, which mainly consist of calcium carbonate, based sediments, as well as limestone pinnacles and reefs (DEWHA, 2008b).

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

The distribution of seabed sediments in the JBG, and in particular within the Sahul Shelf, reflects the present-day oceanographic condition and displays a distinct seaward fining pattern (Lees 1992, in Baker *et al*., 2008). Sediment sampling undertaken by Environmental Resource Management Australia Pty Ltd (ERM) in 2010 and 2011 (within WA-6-R and NT/RL1, more than 100 km north of the Beehive-1 exploration well location) confirms that the area is mainly dominated by sand, with similar proportions of smaller gravel, silt and clay (ERM, 2011).The top layer of sediment in the JBG from ~3 km to 35 km offshore is expected to be greater than 1 m in depth and consists of sand and gravel with variable proportions of clay. This material is primarily alluvium, derived from sedimentary sandstones and basal conglomerate. Sonar images indicate some minor paleochannels in this area containing mega-ripple or sand waves. These sediments are generally unconsolidated coarse sand, fine gravel interspersed with areas of flat and featureless seabed containing very soft to firm gravelly clays (Woodside, 2004).

The main drainage channels for the Victoria River System occur from approximately 35 km to 58 km offshore. This area is dynamic as currents and tidal influence are constantly changing the seabed features in the area. Due to the dynamic nature of the channels, the thickness of the top layer of sediment is expected to be variable. A top layer greater than one metre in depth and consisting of sands and gravels with variable proportions of clay is expected from 59 km to 65 km offshore, with some minor paleochannels occurring. The influence of alluvial inputs diminishes from around 60 km offshore to the Blacktip Wellhead Platform (WHP), which is located approximately 20 km northwest of the Beehive-1 exploration well location. This top layer increases to greater than two metres in depth from 66 km offshore and the sediments range from loose silty/clayey sands from 66 km to 75 km and very soft clayey silt and silty clay from 75 km offshore to the Blacktip WHP location (Woodside, 2004). Again, the seabed alternates between flat and featureless seabed containing very soft to firm silty clay and an area of hummocky seabed containing mega-ripple or sand waves, though the seabed is generally flat to gently sloping from about 66 km offshore to the Blacktip WHP location (Woodside, 2004).

5.2. Coastal Environments

The physical coastal environment described in this section is defined by the potential extent of dispersion of low threshold entrained hydrocarbons predicted under the MDO spill scenario (i.e., the socio-economic EMBA), which stretches from the northern Kimberley coast in WA to West Arnhem in the NT including (noting that the ecological EMBA does not intersect the shoreline and there is no accumulation of hydrocarbons on the shoreline at concentrations that may cause ecological harm).

Shoreline habitats are defined as those habitats that are adjacent to the water along the mainland and islands that occur above the Lowest Astronomical Tide (LAT), and most often in the intertidal zone. Table 5.1 provides a description of the shoreline types according to shoreline receptors (areas defined in this EP to inform oil spill response planning purposes and are referred to as 'sectors') that are intersected by the socioeconomic EMBA. Descriptions of the shoreline habitats for each sector are derived from the Australian Coastal Geomorphology Smartline database.

Maps of the coastal habitats of the shoreline sectors intersected by the EMBA is provided in Figure 5.9 to Figure 5.23. These maps note the maximum probability of shoreline loading from a LoWC.

The following section broadly categorises shoreline habitats as the following biological communities that were identified to occur within the socio-economic EMBA: sandy beaches, rocky shorelines, tidal flats, mangroves and islands.

5.2.1. Sandy Beaches

Sandy beaches are the dominant shoreline type on the eastern coast of the JBG with only occasional rocky headlands and river estuaries leading to the ocean. These environments are remote and are unlikely to have any significant anthropogenic presence. The beaches may provide roosting and nesting habitat for sand nesting birds and turtles, such as plovers and flatback turtles, respectively.

For the purposes of this description, sandy beaches include areas of mixed sandy shore/mixed sandy sediments on bedrock, sand beach/alluvium/shore/dune/foredunes (see Table 5.1).

Sandy beaches provide habitat to a variety of burrowing invertebrates and subsequently provide foraging grounds for shorebirds (Garnet and Crowley, 2000). The number of species and densities of benthic macroinvertebrates that occur in the sand are typically inversely correlated with sediment grain-size and exposure to wave action, and positively correlated with sedimentary organic content and the amount of detached and attached macrophytes (Wildsmith *et al.,* 2005). However, the distributions of these fauna among habitats will also reflect differences in the suite of environmental variables that characterize those habitats (Wildsmith *et al.,* 2005).

Sandy beaches are found scattered throughout the coastline of northwest WA and the NT with large areas on the western side of the Dampier Archipelago, north and south of Broome (approximately 140 km in length) (Figure 5.10), Derby-West Kimberley (10.6 km) (Figure 5.11), Mitchell River (23.9 km) (Figure 5.12), Wyndham-East Kimberley sector (150 km) (Figure 5.13), Ashmore Reef/Cartier Island (14.5 km) (Figure 5.14), Scott Reef/Browse Island (~2 km) (Figure 5.15), north of Cox-Finniss (25.8 km) (Figure 5.19) and Litchfield (4.8 km) (Figure 5.20).

5.2.2. Rocky Shorelines

Rocky shores can include pebbles/cobbles, boulders and rocky limestone cliffs (often at the landward edge of reef platforms). Rocky outcrops typically consist of hard bedrock, but some of the coastline has characteristic limestone karsted cliffs with an undercut notch. Rocky shorelines can vary from habitats where there is bedrock protruding from soft sediments to cliff like structures that form headlands. Rocky shorelines are an important foraging area for seabirds and habitat for invertebrates found in the intertidal splash zone (Morton and Britton cited in Jones, 2004). For the purposes of this description, rocky shorelines include areas of hard bedrock/cliff (> 5 m)/hard rocky shore, rocky shore and soft bedrock (Table 5.1).

Rocky shorelines are the dominant shoreline type on the western coast of the JBG that is intersected by the socio-economic EMBA. Hard bedrock shorelines are also found in all of the shoreline sectors except for Ashmore Reef/Cartier Island (Figure 5.14), Scott Reef/Browse Island (Figure 5.15) and Victoria-Daly (Figure 5.16). The longest length of coastline consisting of hard bedrock cliffs and shore are found in the following shoreline sectors: Derby-West Kimberley (2,261 km) (Figure 5.11) and Mitchell River (3,837 km) (Figure 5.12).

While there are some stretches of sandy beaches on the west coast of the JBG, they are confined to the sheltered bays and inlets. The exposed rocky shores would be exposed to wave action from the surrounding gulfs and as such are likely to provide habitat for intertidal algae and shell species.

5.2.3. Tidal Flats

Tidal flats are comprised of layers of fine mud due to the ongoing deposition of estuarine silts, which combines with deposition of fine sands by tidal movements. For the purposes of this description, tidal flats include areas of tidal flats (sand, mud, sediments)/mangroves, marshy sediment flats/marshy saline sediment flats, saline mudflats and muddy sediments /alluvium/sediment flats (Table 5.1).

These areas provide important habitat for mud and sand-dwelling invertebrates such as crabs, prawns, shells and worms and sheltered habitat for larval and juvenile fishes. Due to the diversity of infauna, they are also an important foraging habitat for various shorebird species including egrets, plovers and oystercatchers.

The socio-economic EMBA intersects tidal flats (sand, mud, sediment) are found in all of the shoreline sectors except for Ashmore Reef/Cartier Island (Figure 5.14), Scott Reef/Browse Island (Figure 5.15) and Victoria-Daly (Figure 5.16). The longest length of coastline consisting of tidal flats are found in the following shoreline sectors: Derby-West Kimberley (100 km) (Figure 5.11), Mitchell River (55 km) (Figure 5.12), and Wyndham-East Kimberley (1,062 km) (Figure 5.13).

Tidal sediments flats (inferred from mangroves) are predominantly found in the NT from the Victoria-Daly coastline extending up to and including West Arnhem (Figure 5.16 to Figure 22).

Marshy sediment flats including marshy saline sediment flats are commonly found along the Cox-Finniss sector (Figure 5.19) toward and including the West Arnhem sector (NT) (Figure 5.22).

5.2.4. Mangroves

Mangroves commonly occur in sheltered coastal areas in tropical and sub-tropical latitudes (Kathiresan and Bingham, 2001). Mangroves are found wherever suitable conditions are present including wave-dominated settings of deltas, beach/dune coasts, limestone barrier islands and ria/archipelago shores (Semeniuk, 1993). For the purposes of this description, mangroves include areas of tidal flats (sand, mud, sediments)/mangroves and marshy sediment flats/marshy saline sediment flats (Table 5.1).

Mangroves are important primary producers and have a number of ecological and economic values, including reducing coastal erosion and providing habitat for a variety of epibenthic, infaunal and meiofaunal invertebrates (Kathiresan and Bingham, 2001). Crustaceans known to inhabit the mud in mangrove systems include fiddler crabs, mud crabs, shrimps and barnacles, while water channels of the system support various finfish. Mangroves and their associated invertebrate-rich mudflats are also an important habitat for migratory shorebirds from the northern hemisphere, as well as some avifauna that are restricted to mangroves as their sole habitat (Garnet and Crowley, 2000).

Mangrove habitat intersected by the socio-economic EMBA typically occur along the banks of the major rivers and estuarine environments of the southern JBG including at Quoin Island (138 km southeast of the Beehive-1 exploration well location) and Clump Island (141 km southeast) and along the southern coastline of Dorcherty Island (102 km east), including the Tiwi Islands and Vernon Islands (located 345 km in the most north-easterly extent of the spill EMBA) (see Figure 5.23).

Shoreline ecological aerial and ground surveys were conducted from Darwin in the NT to Broome in WA in response to the Montara oil spill during 2009 (Pearce & Duke, 2013). A distance of 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.

5.2.5. Islands

Several rocky and sandy islands are located within the socio-economic EMBA that provide intertidal and shoreline habitats for a variety of marine fauna and ecological communities, including many small islands along the north Kimberley coast Browse Island, including sand islands at Ashmore Reef and Cartier Island (as described in Section 5.3.1 and Section 5.4.7), the Tiwi Islands (including Melville and Bathurst Islands (Figure 5.23) and Vernon Islands, as described in Section 5.3.1). For the purposes of this description, islands include reef/coral outer with sandy shore (Table 5.1).

Table 5.1 Description of shoreline receptors by type in the EMBA

EMBA shoreline sector	Description of shoreline by type														
	Alluvial sediment/plain	Beach sediment/ridges	Colluvium	Tidal flats (sand, mud, sediment)/Mangroves	Hard bedrock/Cliff (>5 m)/Hard rocky shore	Marshy sediment flats/Marshy saline sediment flats	Mixed sandy shore/Mixed sandy sediments on bedrock	Muddy sediments/alluvium/sediment flats	Reef/Coral outer with sandy shore	Rocky shore	Saltpans/saline mudflats	Sandy beach/alluvium/shore/dune/foredune	Sediment plain/sediment deposits	Soft bedrock	Unclassified
Broome		X		X	X		X		X		X	X			X
Derby-West Kimberley		X		X	X				X		X				X
Mitchell River	X	X		X	X						X	X		X	X
Wyndham-East Kimberley	X	X		X	X						X	X	X	X	X
Victoria-Daly		X		X							X	X	X		X
Thamarrurr		X		X	X							X	X	X	
Daly	X			X	X							X	X	X	
Cox-Finniss	X	X		X	X	X	X	X		X	X	X	X	X	X
Litchfield				X	X	X	X	X		X	X	X		X	X
South Alligator				X	X	X	X	X			X	X	X	X	
West Arnhem	X		X	X	X	X		X			X	X	X	X	X

EMBA shoreline sector	Description of shoreline by type														
	Alluvial sediment/plain	Beach sediment/ridges	Colluvium	Tidal flats (sand, mud, sediment)/Mangroves	Hard bedrock/Cliff (>5 m)/Hard rocky shore	Marshy sediment flats/Marshy saline sediment flats	Mixed sandy shore/Mixed sandy sediments on bedrock	Muddy sediments/alluvium/sediment flats	Reef/Coral outer with sandy shore	Rocky shore	Saltpans/saline mudflats	Sandy beach/alluvium/shore/dune/foredune	Sediment plain/sediment deposits	Soft bedrock	Unclassified
Bathurst and Melville Islands	X		X	X	X	X	X	X			X	X	X	X	
Scott Reef/Browse Island									X			X			
Ashmore Reef/Cartier Island									X			X			

Key:

X = shoreline type present.

Unclassified is defined as the 13,045 km of shoreline of the EMBA that has no known coastal geomorphological classification.

Source: Australian Coastal Geomorphology Smartline. Note GoogleEarth Pro imagery was used in the absence of GIS data for unclassified areas.

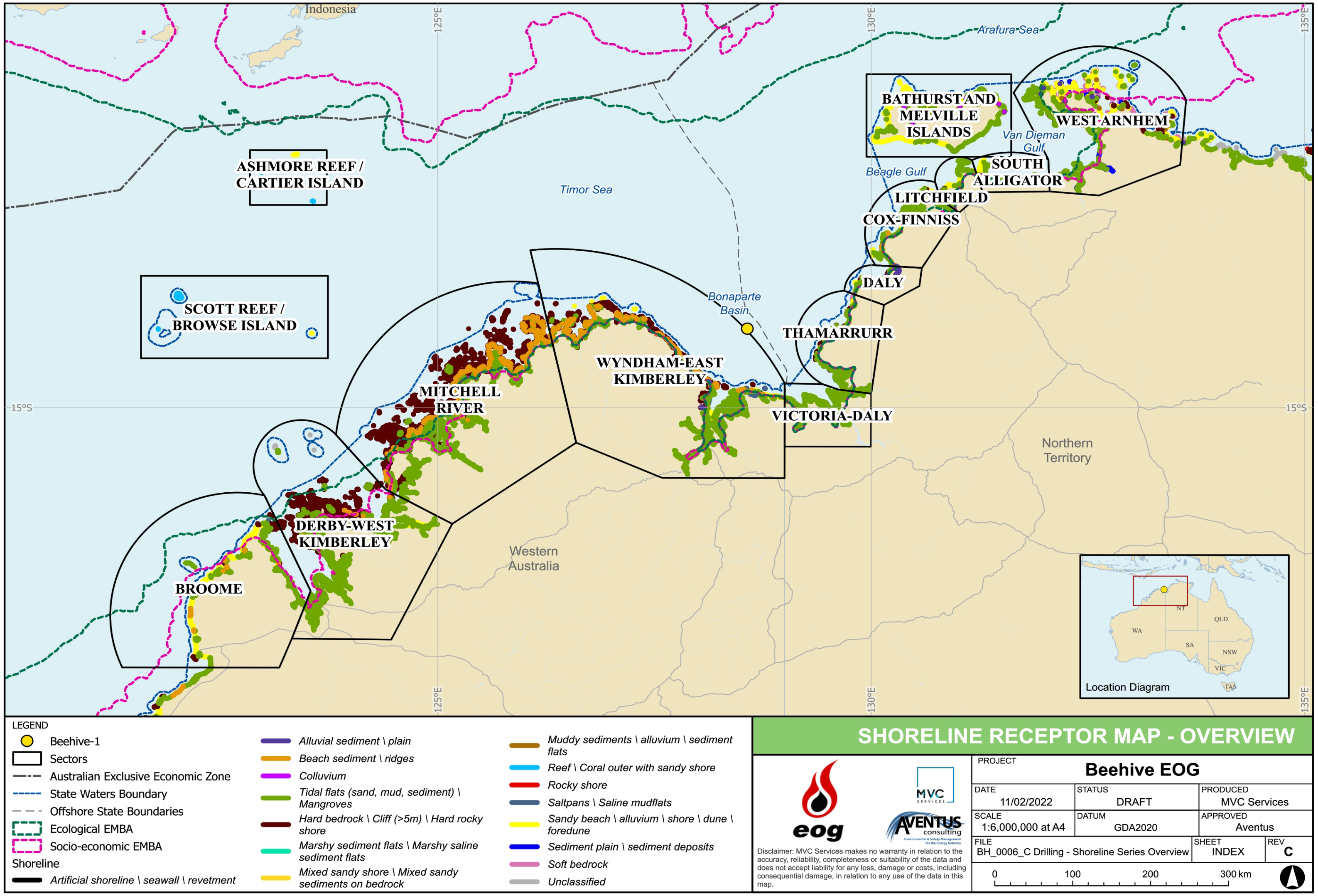
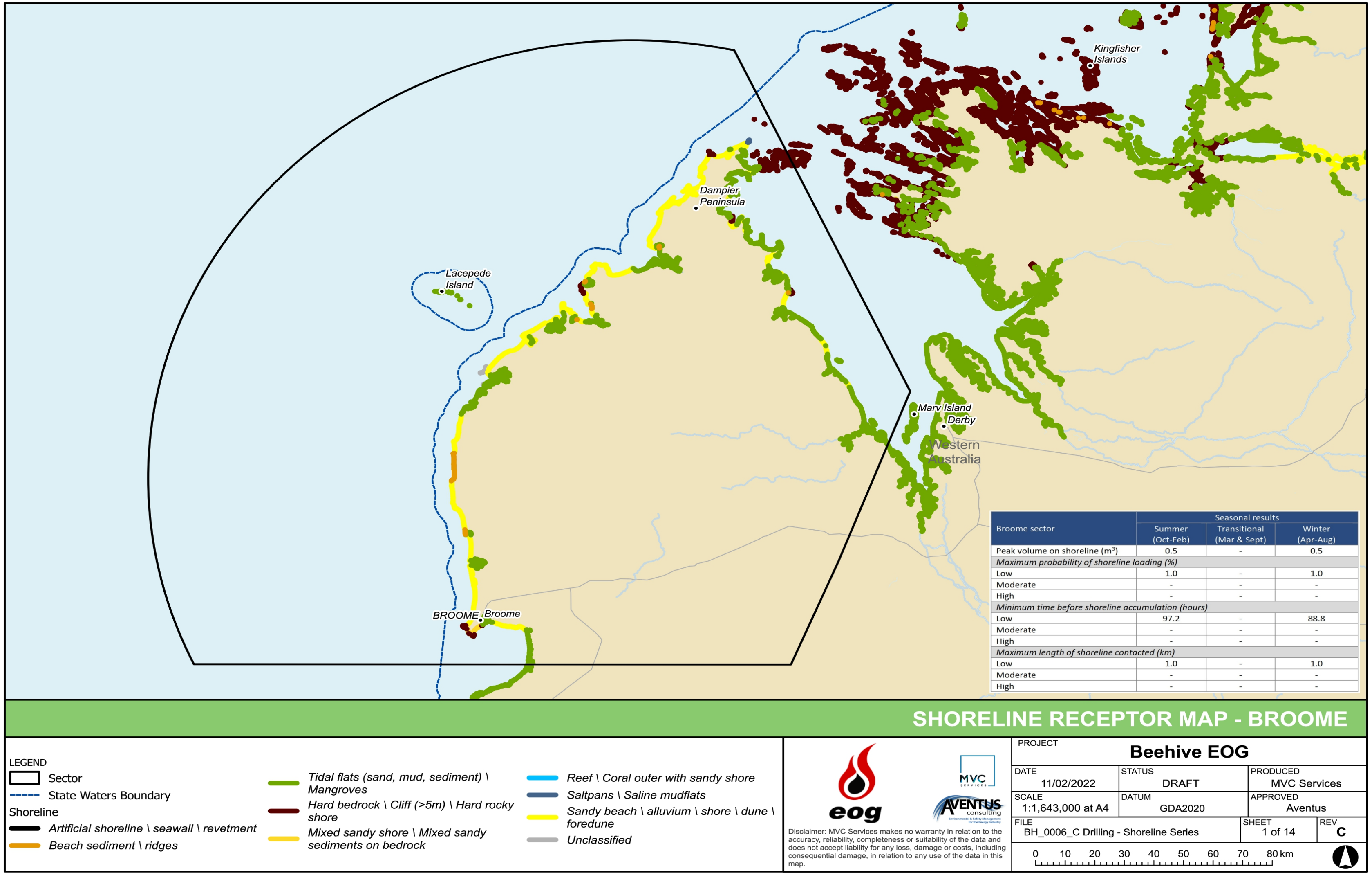
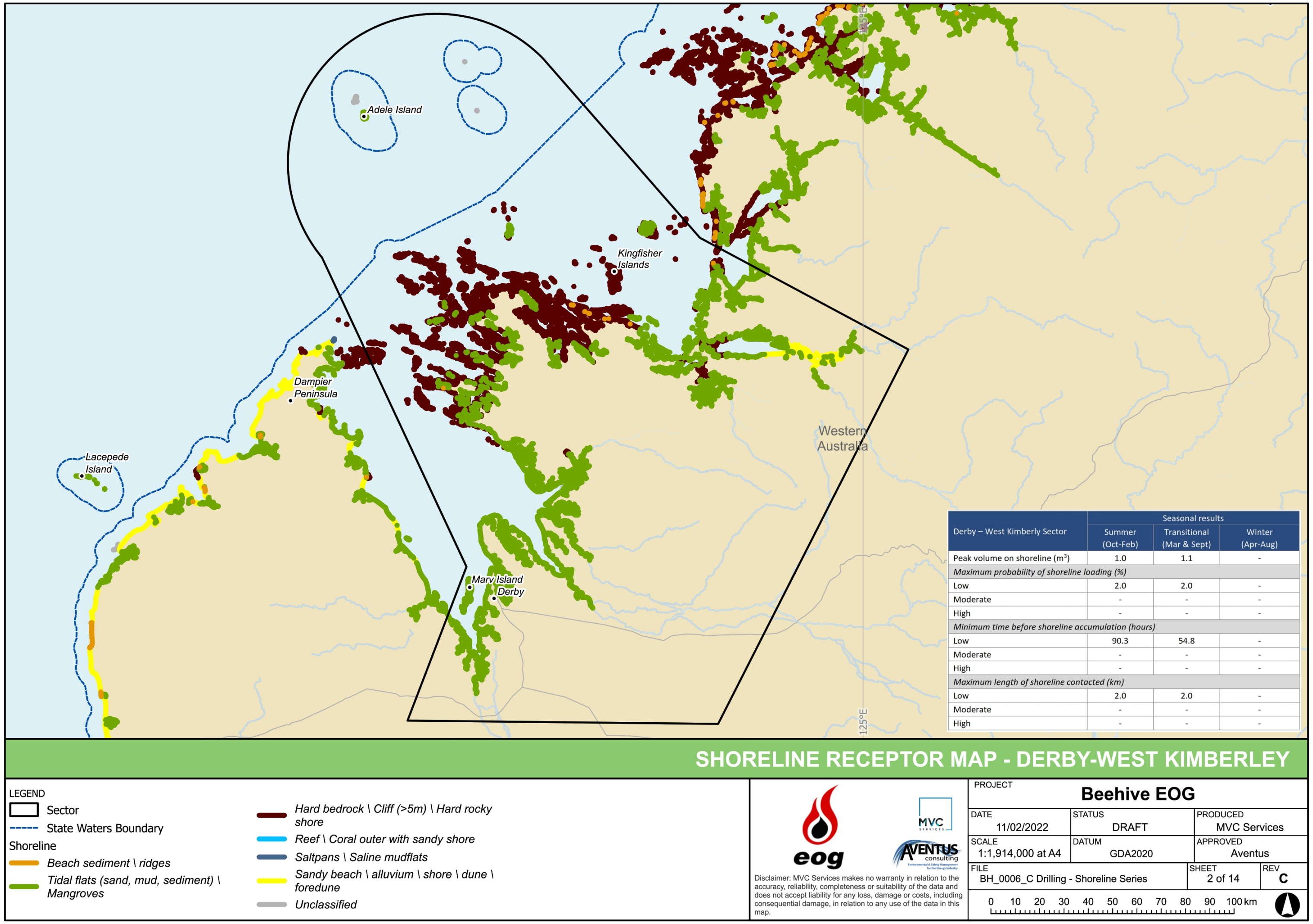


Figure 5.9. Overview of the shoreline receptors intersected by the EMBA



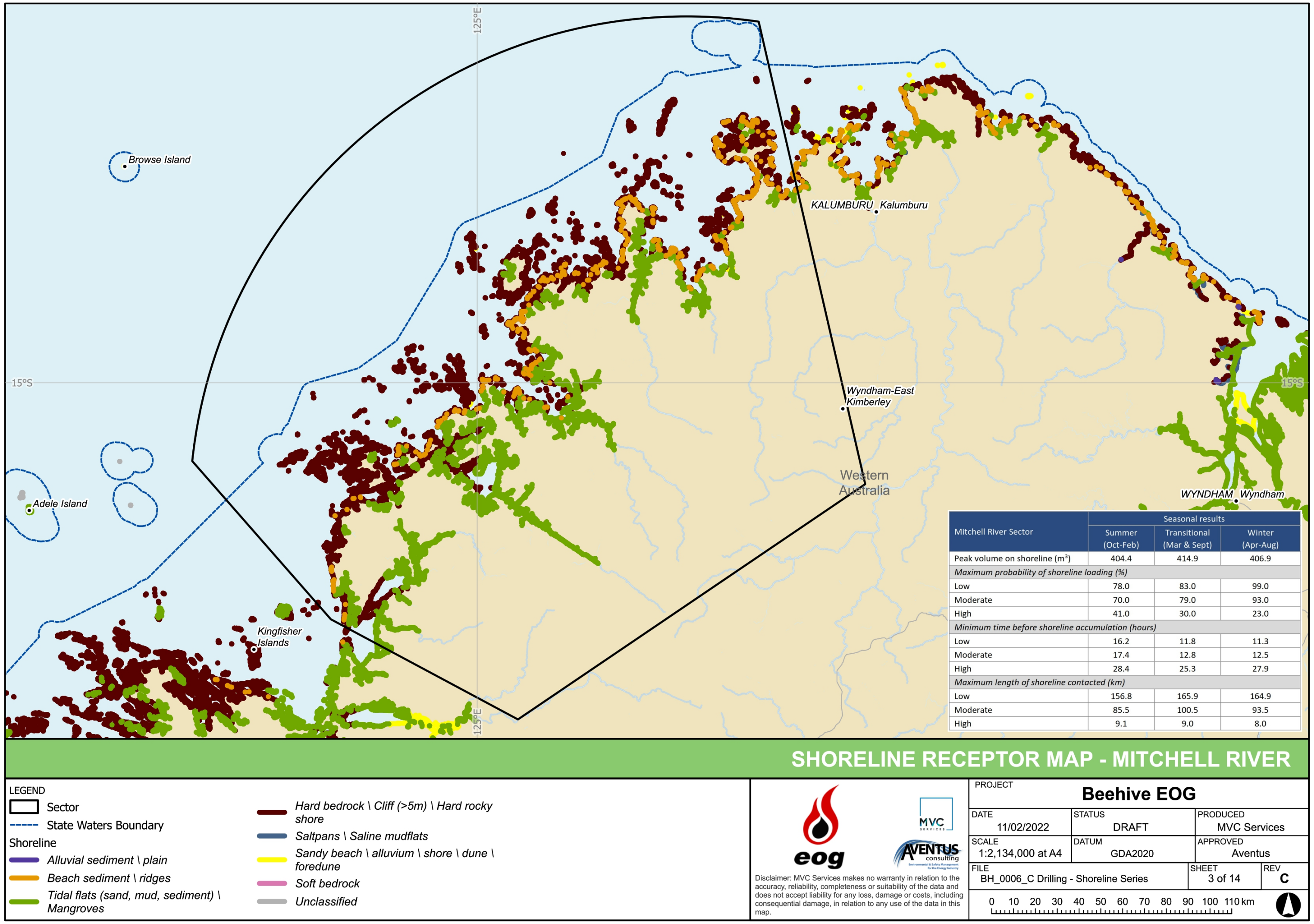
Broome sector	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	0.5	-	0.5
Maximum probability of shoreline loading (%)			
Low	1.0	-	1.0
Moderate	-	-	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	97.2	-	88.8
Moderate	-	-	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	1.0	-	1.0
Moderate	-	-	-
High	-	-	-

Figure 5.10. EMBA shoreline sector - Broome



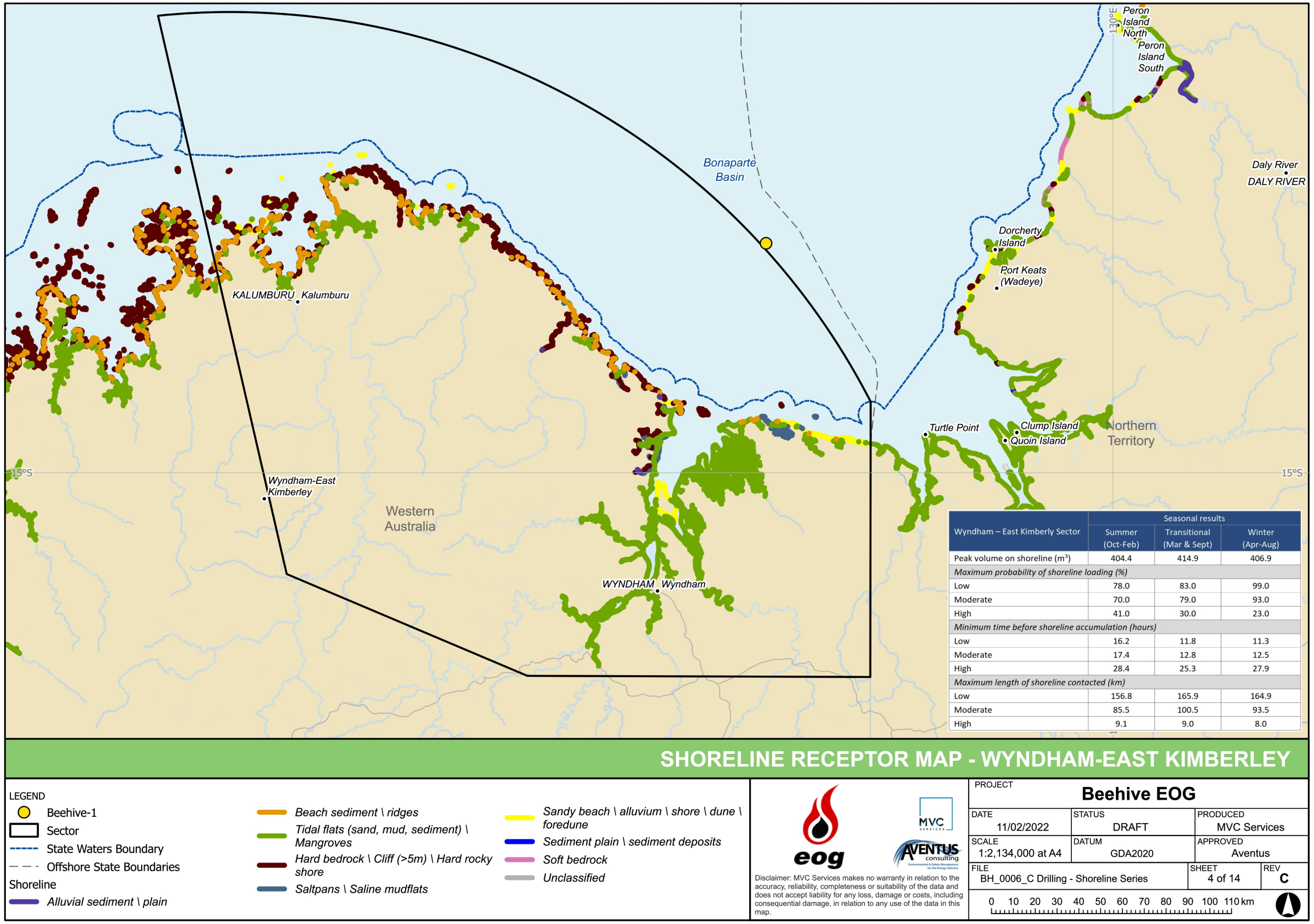
Derby – West Kimberly Sector	Seasonal results: Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	1.0	1.1	-
Maximum probability of shoreline loading (%)			
Low	2.0	2.0	-
Moderate	-	-	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	90.3	54.8	-
Moderate	-	-	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	2.0	2.0	-
Moderate	-	-	-
High	-	-	-

Figure 5.11. EMBA shoreline sector - Derby-West Kimberley



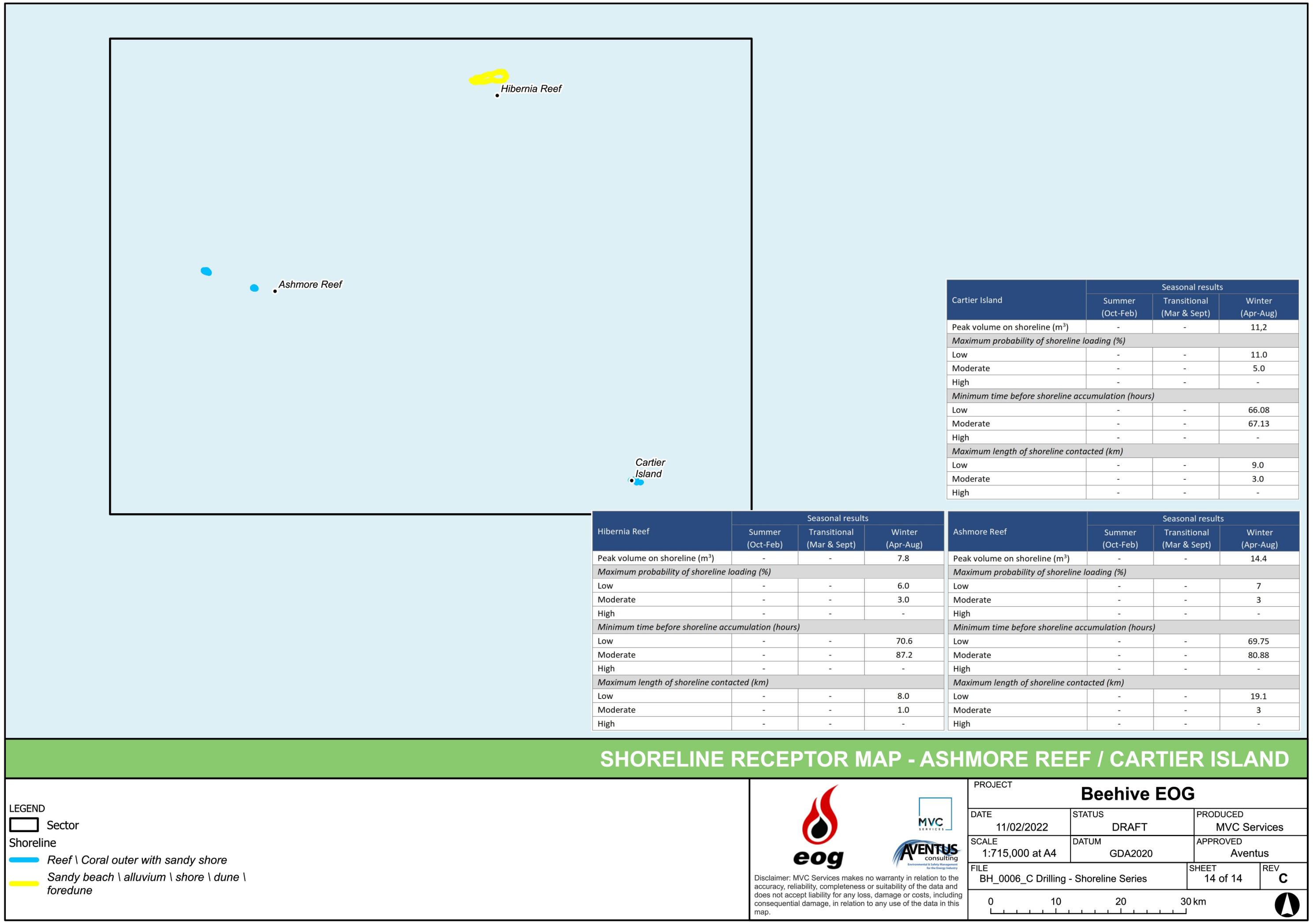
Mitchell River Sector	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	404.4	414.9	406.9
Maximum probability of shoreline loading (%)			
Low	78.0	83.0	99.0
Moderate	70.0	79.0	93.0
High	41.0	30.0	23.0
Minimum time before shoreline accumulation (hours)			
Low	16.2	11.8	11.3
Moderate	17.4	12.8	12.5
High	28.4	25.3	27.9
Maximum length of shoreline contacted (km)			
Low	156.8	165.9	164.9
Moderate	85.5	100.5	93.5
High	9.1	9.0	8.0

Figure 5.12. EMBA shoreline sector - Mitchell River



Wyndham – East Kimberly Sector	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	404.4	414.9	406.9
Maximum probability of shoreline loading (%)			
Low	78.0	83.0	99.0
Moderate	70.0	79.0	93.0
High	41.0	30.0	23.0
Minimum time before shoreline accumulation (hours)			
Low	16.2	11.8	11.3
Moderate	17.4	12.8	12.5
High	28.4	25.3	27.9
Maximum length of shoreline contacted (km)			
Low	156.8	165.9	164.9
Moderate	85.5	100.5	93.5
High	9.1	9.0	8.0

Figure 5.13. EMBA shoreline sector - Wyndham-East Kimberley

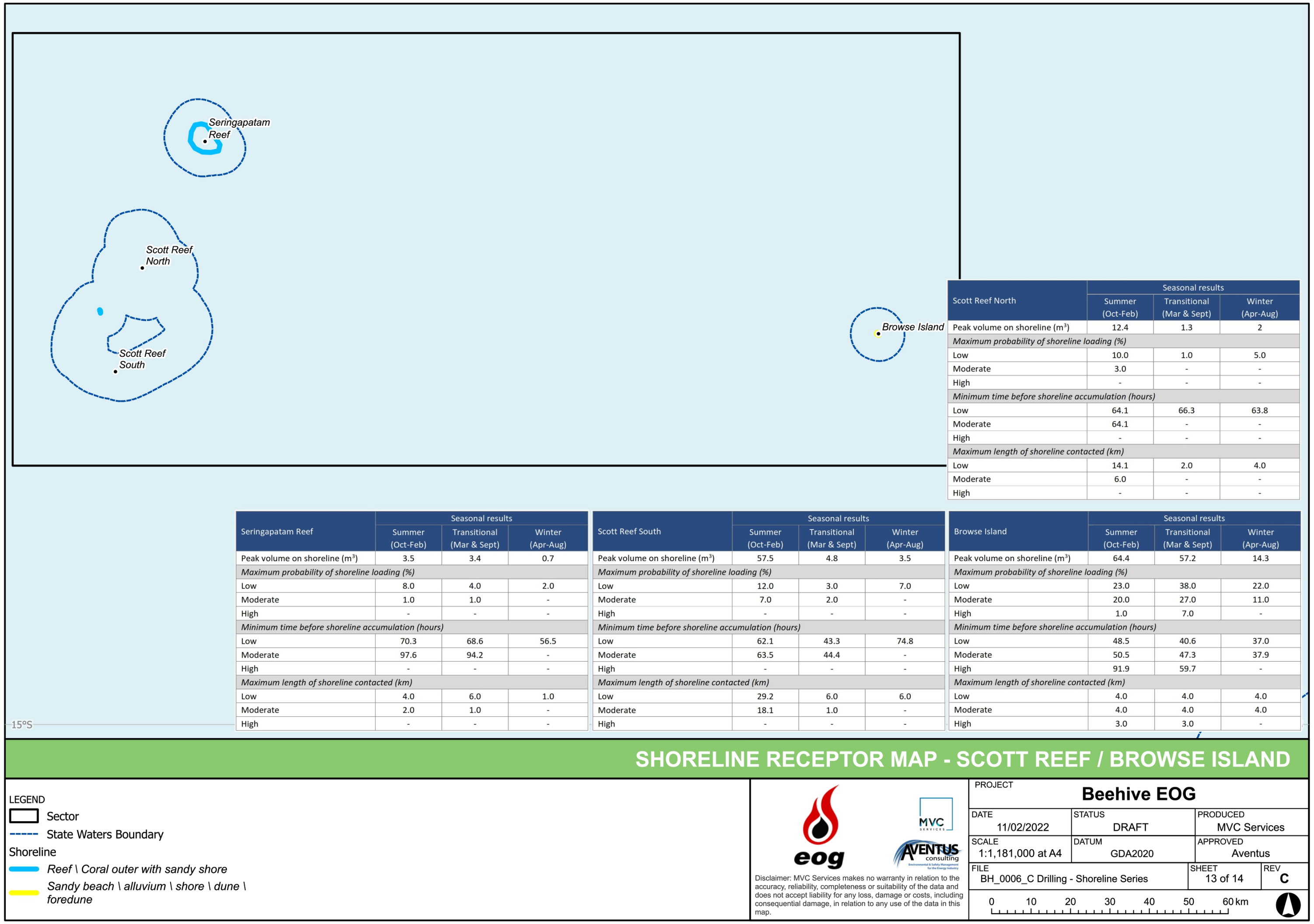


Cartier Island	Seasonal results: Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	-	-	11,2
Maximum probability of shoreline loading (%)			
Low	-	-	11.0
Moderate	-	-	5.0
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	-	-	66.08
Moderate	-	-	67.13
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	-	-	9.0
Moderate	-	-	3.0
High	-	-	-

Hibernia Reef	Seasonal results: Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	-	-	7.8
Maximum probability of shoreline loading (%)			
Low	-	-	6.0
Moderate	-	-	3.0
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	-	-	70.6
Moderate	-	-	87.2
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	-	-	8.0
Moderate	-	-	1.0
High	-	-	-

Ashmore Reef	Seasonal results: Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	-	-	14.4
Maximum probability of shoreline loading (%)			
Low	-	-	7
Moderate	-	-	3
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	-	-	69.75
Moderate	-	-	80.88
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	-	-	19.1
Moderate	-	-	3
High	-	-	-

Figure 5.14. EMBA shoreline sector - Ashmore Reef & Cartier Island



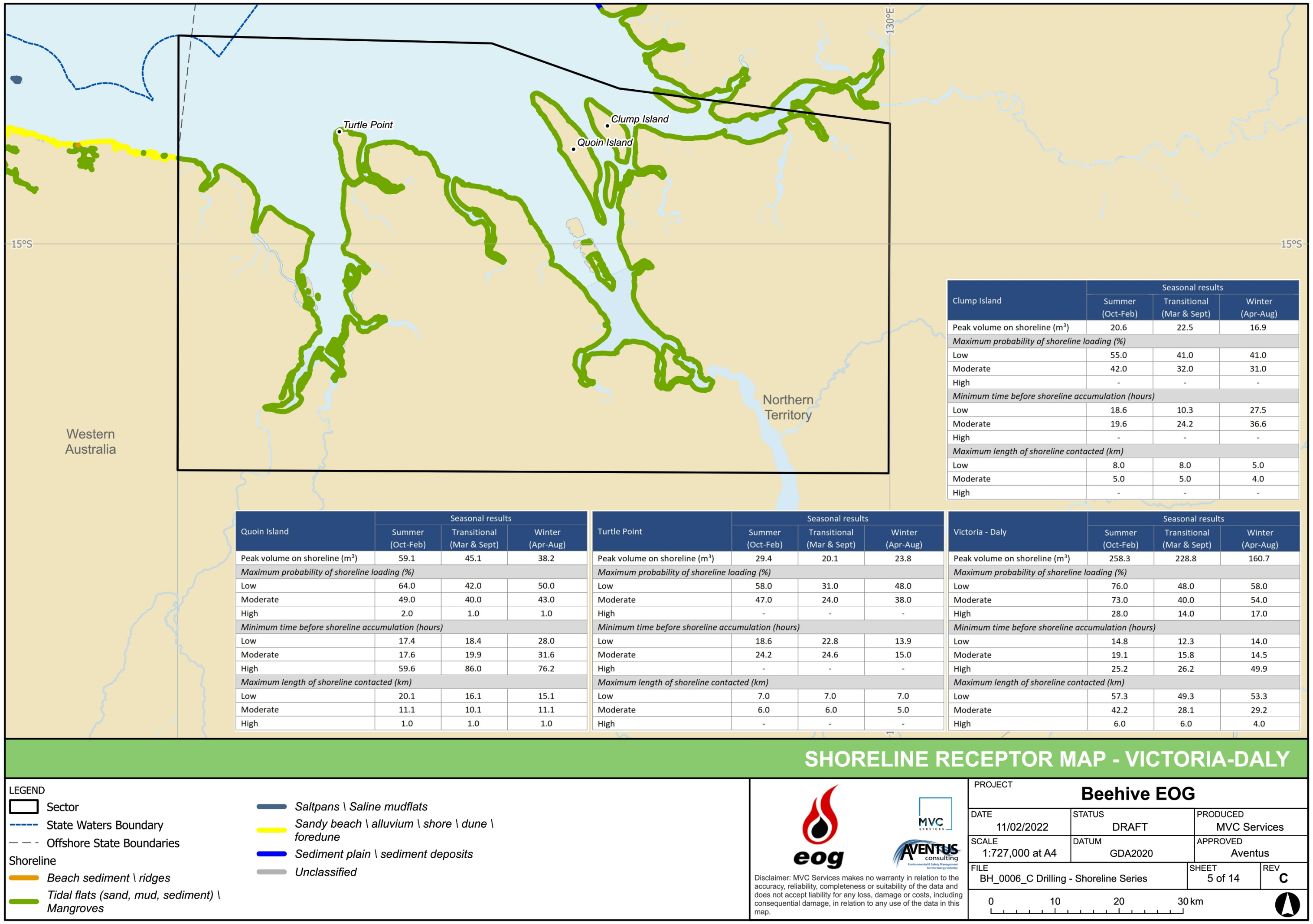
Scott Reef North	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	12.4	1.3	2
Maximum probability of shoreline loading (%)			
Low	10.0	1.0	5.0
Moderate	3.0	-	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	64.1	66.3	63.8
Moderate	64.1	-	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	14.1	2.0	4.0
Moderate	6.0	-	-
High	-	-	-

Seringapatam Reef	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	3.5	3.4	0.7
Maximum probability of shoreline loading (%)			
Low	8.0	4.0	2.0
Moderate	1.0	1.0	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	70.3	68.6	56.5
Moderate	97.6	94.2	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	4.0	6.0	1.0
Moderate	2.0	1.0	-
High	-	-	-

Scott Reef South	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	57.5	4.8	3.5
Maximum probability of shoreline loading (%)			
Low	12.0	3.0	7.0
Moderate	7.0	2.0	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	62.1	43.3	74.8
Moderate	63.5	44.4	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	29.2	6.0	6.0
Moderate	18.1	1.0	-
High	-	-	-

Browse Island	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	64.4	57.2	14.3
Maximum probability of shoreline loading (%)			
Low	23.0	38.0	22.0
Moderate	20.0	27.0	11.0
High	1.0	7.0	-
Minimum time before shoreline accumulation (hours)			
Low	48.5	40.6	37.0
Moderate	50.5	47.3	37.9
High	91.9	59.7	-
Maximum length of shoreline contacted (km)			
Low	4.0	4.0	4.0
Moderate	4.0	4.0	4.0
High	3.0	3.0	-

Figure 5.15. EMBA shoreline sector - Scott Reef & Browse Island



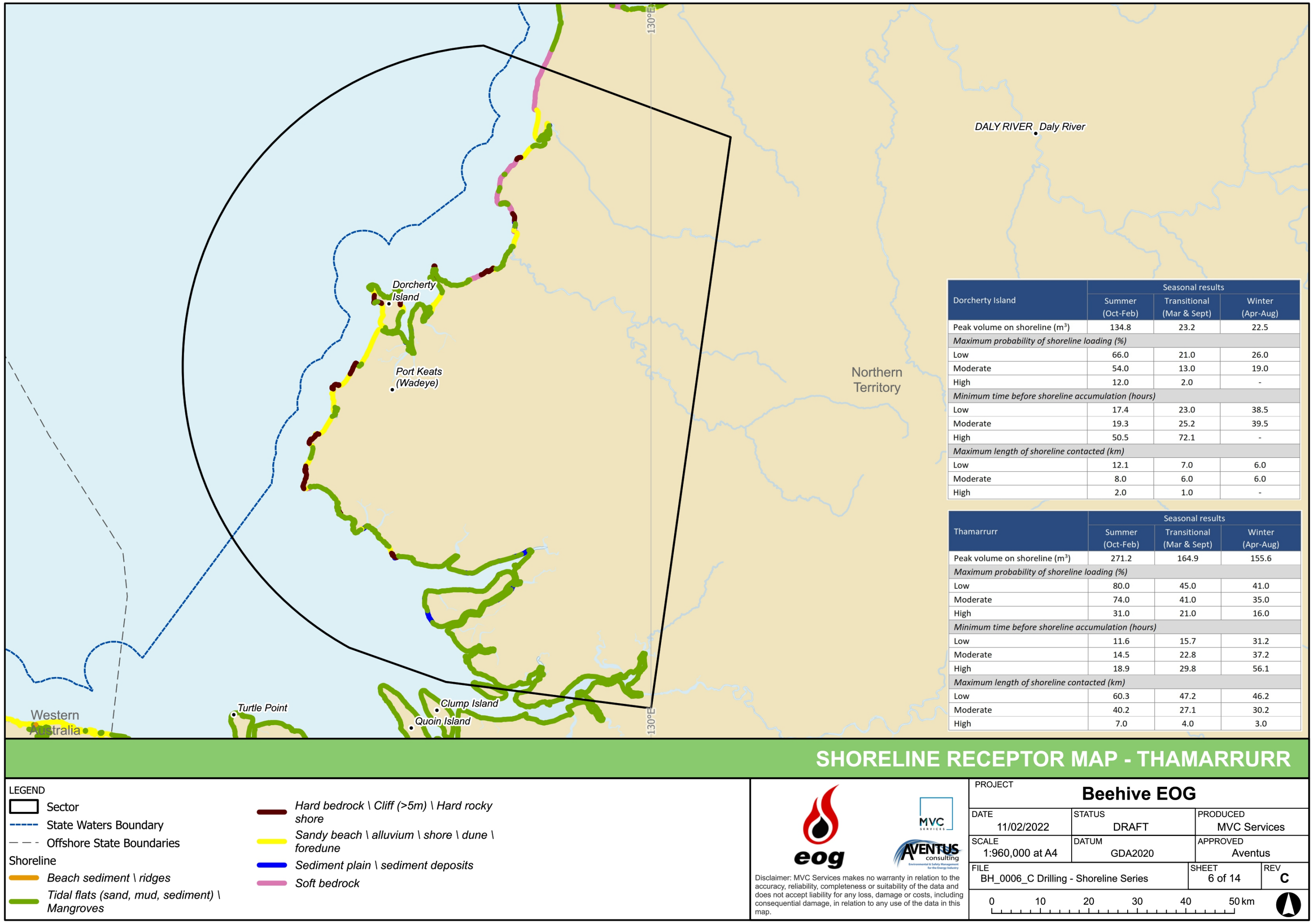
Clump Island	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	20.6	22.5	16.9
Maximum probability of shoreline loading (%)			
Low	55.0	41.0	41.0
Moderate	42.0	32.0	31.0
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	18.6	10.3	27.5
Moderate	19.6	24.2	36.6
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	8.0	8.0	5.0
Moderate	5.0	5.0	4.0
High	-	-	-

Quoin Island	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	59.1	45.1	38.2
Maximum probability of shoreline loading (%)			
Low	64.0	42.0	50.0
Moderate	49.0	40.0	43.0
High	2.0	1.0	1.0
Minimum time before shoreline accumulation (hours)			
Low	17.4	18.4	28.0
Moderate	17.6	19.9	31.6
High	59.6	86.0	76.2
Maximum length of shoreline contacted (km)			
Low	20.1	16.1	15.1
Moderate	11.1	10.1	11.1
High	1.0	1.0	1.0

Turtle Point	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	29.4	20.1	23.8
Maximum probability of shoreline loading (%)			
Low	58.0	31.0	48.0
Moderate	47.0	24.0	38.0
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	18.6	22.8	13.9
Moderate	24.2	24.6	15.0
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	7.0	7.0	7.0
Moderate	6.0	6.0	5.0
High	-	-	-

Victoria - Daly	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	258.3	228.8	160.7
Maximum probability of shoreline loading (%)			
Low	76.0	48.0	58.0
Moderate	73.0	40.0	54.0
High	28.0	14.0	17.0
Minimum time before shoreline accumulation (hours)			
Low	14.8	12.3	14.0
Moderate	19.1	15.8	14.5
High	25.2	26.2	49.9
Maximum length of shoreline contacted (km)			
Low	57.3	49.3	53.3
Moderate	42.2	28.1	29.2
High	6.0	6.0	4.0

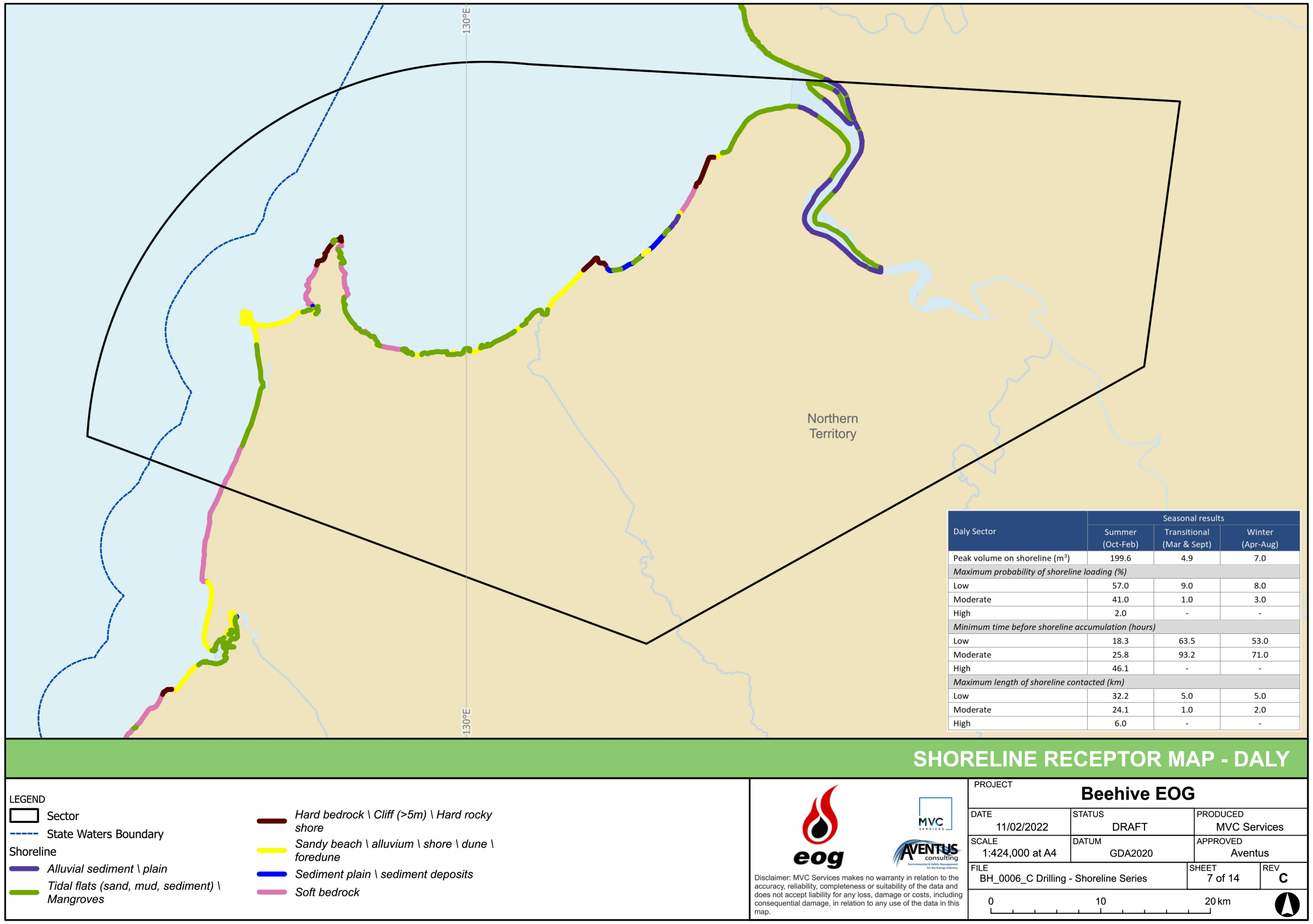
Figure 5.16. EMBA shoreline sector - Victoria-Daly



Dorcherty Island	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	134.8	23.2	22.5
Maximum probability of shoreline loading (%)			
Low	66.0	21.0	26.0
Moderate	54.0	13.0	19.0
High	12.0	2.0	-
Minimum time before shoreline accumulation (hours)			
Low	17.4	23.0	38.5
Moderate	19.3	25.2	39.5
High	50.5	72.1	-
Maximum length of shoreline contacted (km)			
Low	12.1	7.0	6.0
Moderate	8.0	6.0	6.0
High	2.0	1.0	-

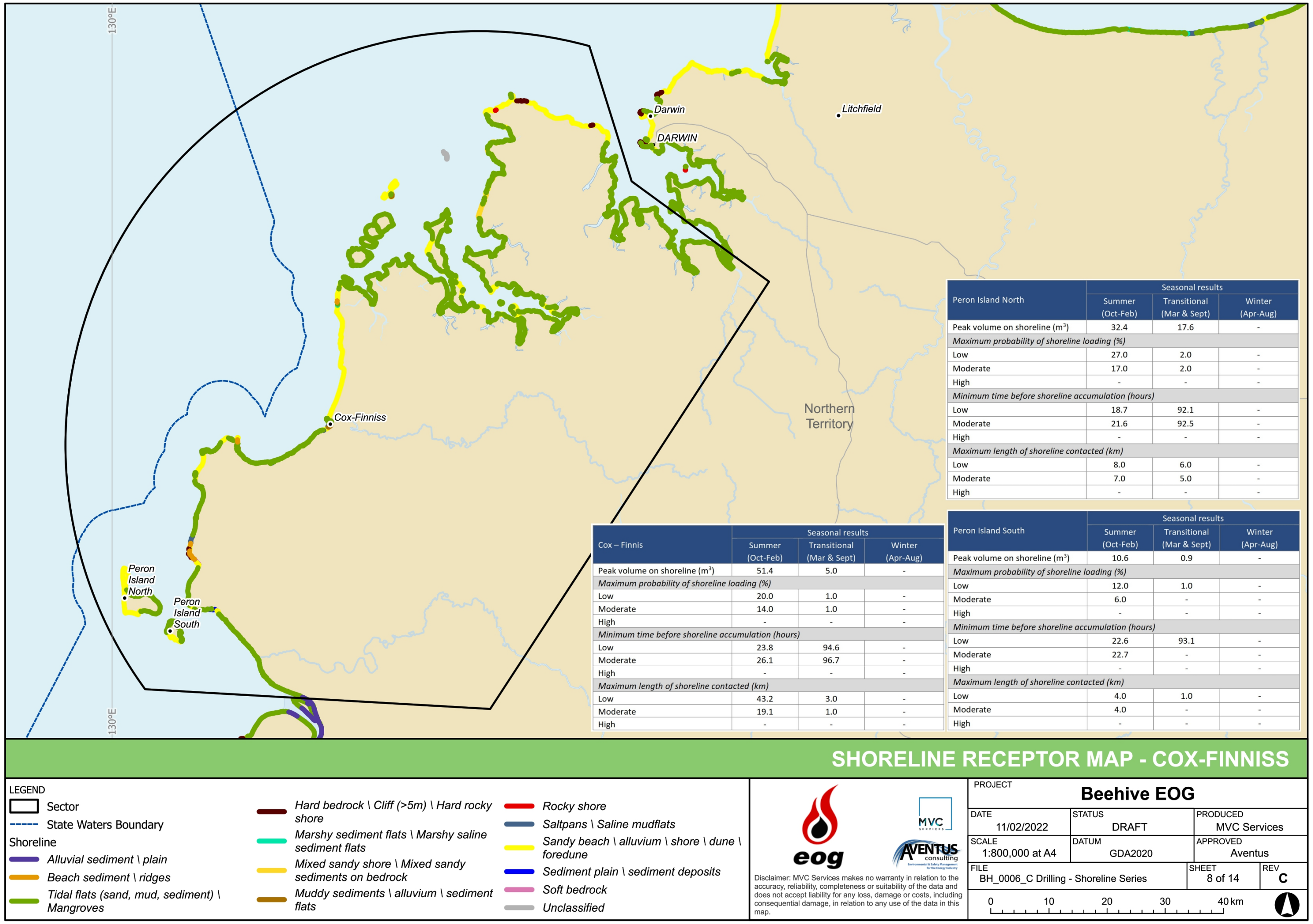
Thamarrurr	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	271.2	164.9	155.6
Maximum probability of shoreline loading (%)			
Low	80.0	45.0	41.0
Moderate	74.0	41.0	35.0
High	31.0	21.0	16.0
Minimum time before shoreline accumulation (hours)			
Low	11.6	15.7	31.2
Moderate	14.5	22.8	37.2
High	18.9	29.8	56.1
Maximum length of shoreline contacted (km)			
Low	60.3	47.2	46.2
Moderate	40.2	27.1	30.2
High	7.0	4.0	3.0

Figure 5.17. EMBA shoreline sector - Thamarrurr



Daly Sector	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	199.6	4.9	7.0
Maximum probability of shoreline loading (%)			
Low	57.0	9.0	8.0
Moderate	41.0	1.0	3.0
High	2.0	-	-
Minimum time before shoreline accumulation (hours)			
Low	18.3	63.5	53.0
Moderate	25.8	93.2	71.0
High	46.1	-	-
Maximum length of shoreline contacted (km)			
Low	32.2	5.0	5.0
Moderate	24.1	1.0	2.0
High	6.0	-	-

Figure 5.18. EMBA shoreline sector - Daly

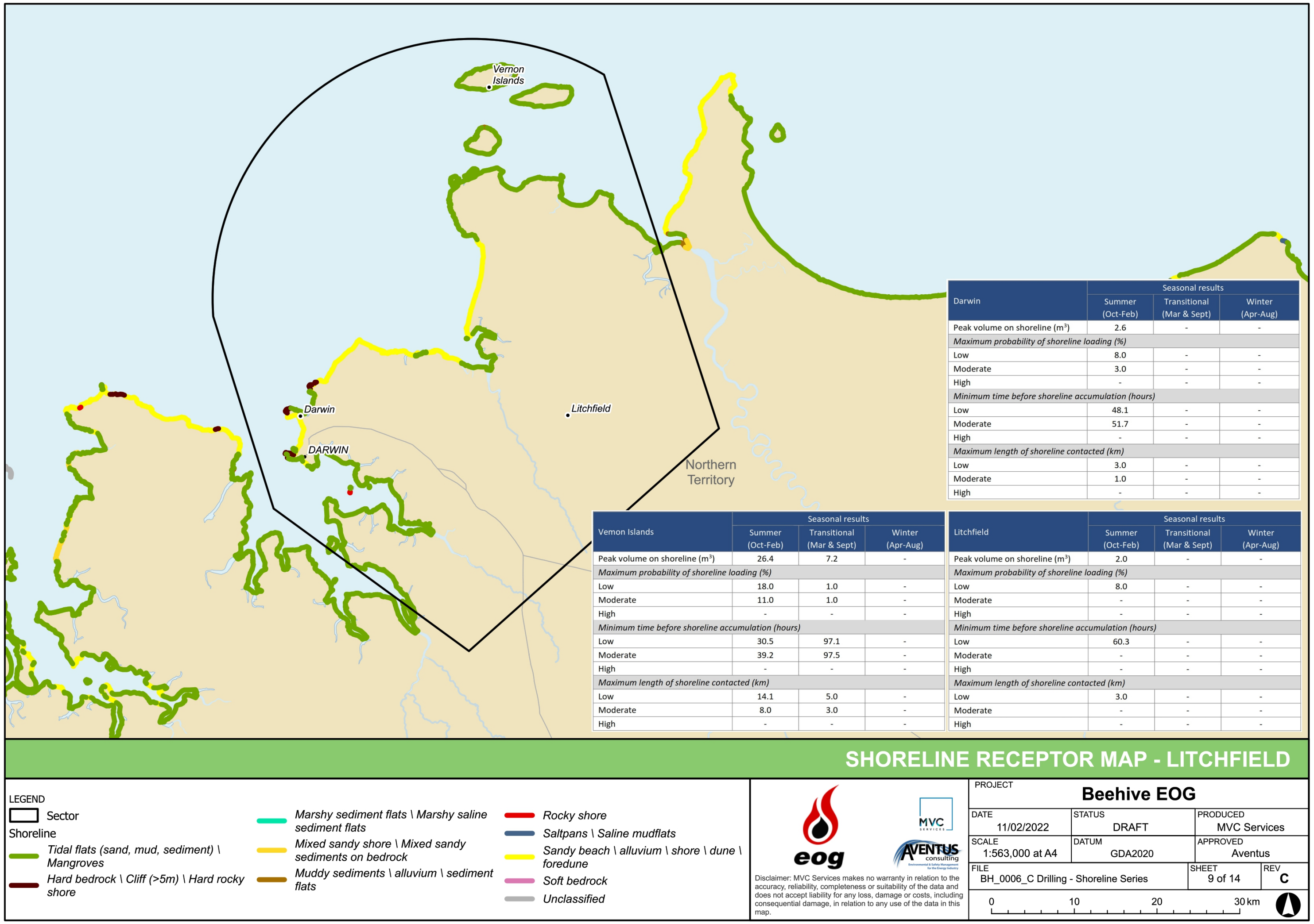


Cox – Finnis	Seasonal results Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	51.4	5.0	-
Maximum probability of shoreline loading (%)			
Low	20.0	1.0	-
Moderate	14.0	1.0	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	23.8	94.6	-
Moderate	26.1	96.7	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	43.2	3.0	-
Moderate	19.1	1.0	-
High	-	-	-

Peron Island North	Seasonal results Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	32.4	17.6	-
Maximum probability of shoreline loading (%)			
Low	27.0	2.0	-
Moderate	17.0	2.0	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	18.7	92.1	-
Moderate	21.6	92.5	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	8.0	6.0	-
Moderate	7.0	5.0	-
High	-	-	-

Peron Island South	Seasonal results Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	10.6	0.9	-
Maximum probability of shoreline loading (%)			
Low	12.0	1.0	-
Moderate	6.0	-	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	22.6	93.1	-
Moderate	22.7	-	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	4.0	1.0	-
Moderate	4.0	-	-
High	-	-	-

Figure 5.19. EMBA shoreline sector - Cox-Finniss

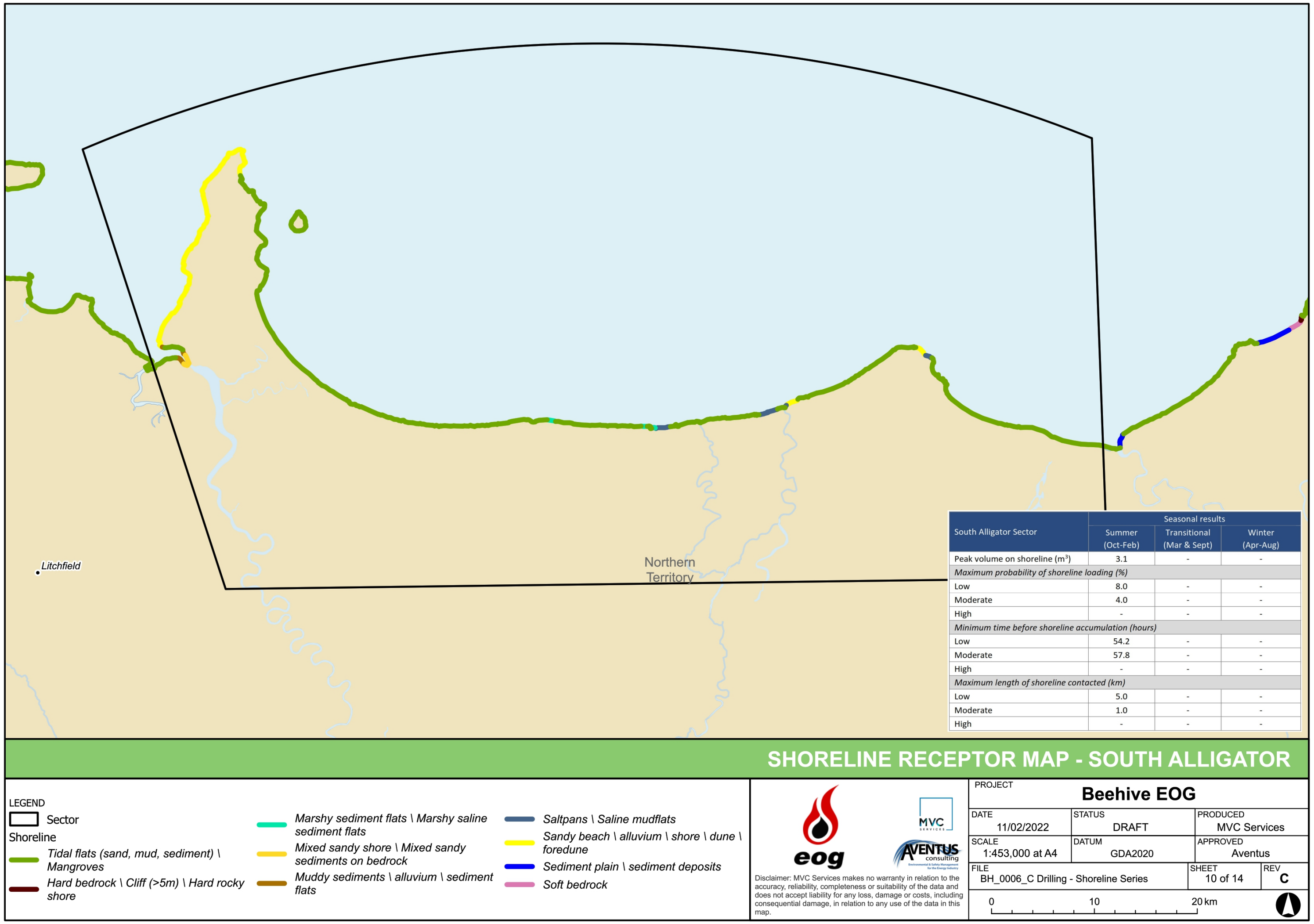


Darwin	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	2.6	-	-
Maximum probability of shoreline loading (%)			
Low	8.0	-	-
Moderate	3.0	-	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	48.1	-	-
Moderate	51.7	-	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	3.0	-	-
Moderate	1.0	-	-
High	-	-	-

Vemon Islands	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	26.4	7.2	-
Maximum probability of shoreline loading (%)			
Low	18.0	1.0	-
Moderate	11.0	1.0	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	30.5	97.1	-
Moderate	39.2	97.5	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	14.1	5.0	-
Moderate	8.0	3.0	-
High	-	-	-

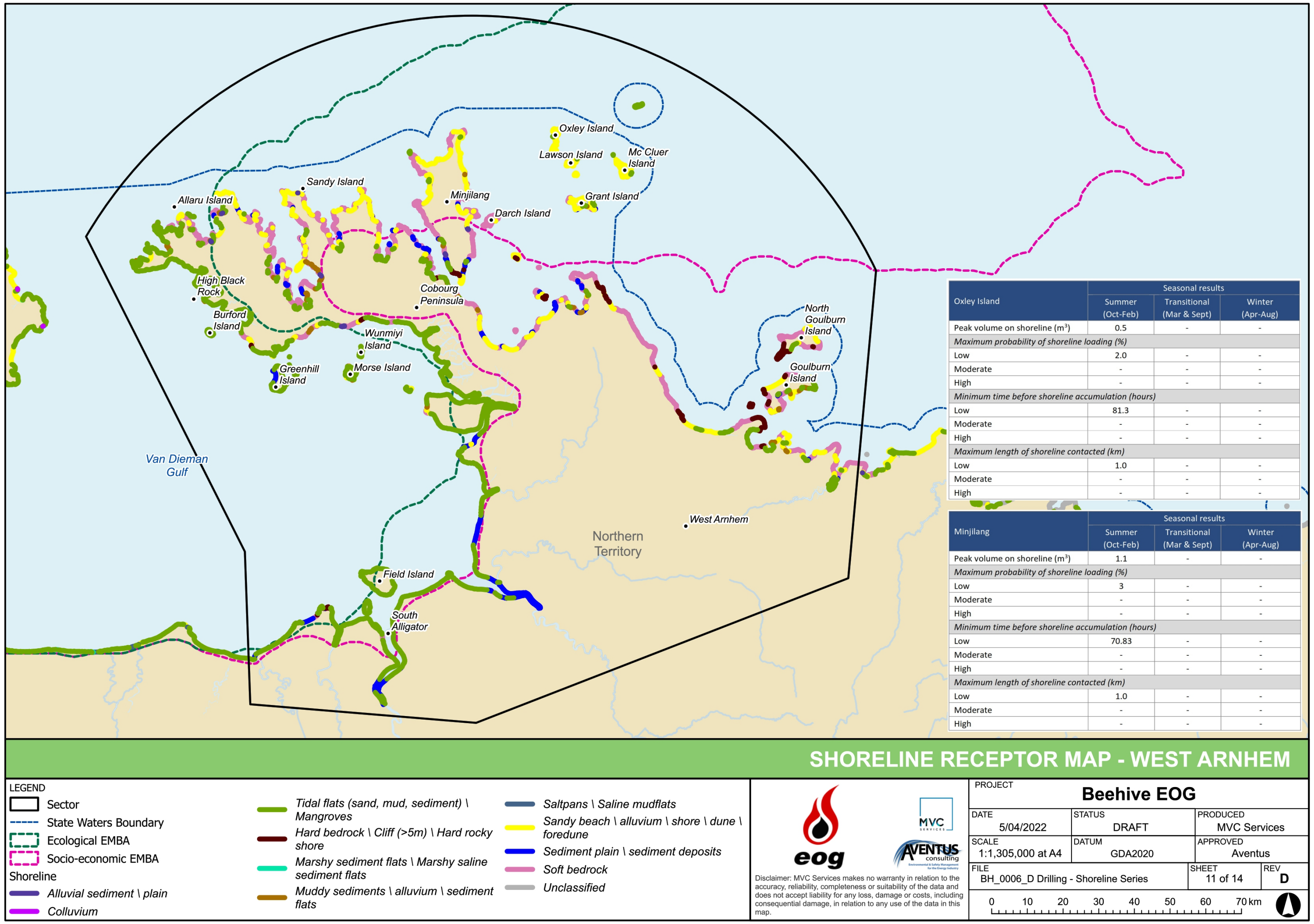
Litchfield	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	2.0	-	-
Maximum probability of shoreline loading (%)			
Low	8.0	-	-
Moderate	-	-	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	60.3	-	-
Moderate	-	-	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	3.0	-	-
Moderate	-	-	-
High	-	-	-

Figure 5.20. EMBA shoreline sector - Litchfield



South Alligator Sector	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	3.1	-	-
Maximum probability of shoreline loading (%)			
Low	8.0	-	-
Moderate	4.0	-	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	54.2	-	-
Moderate	57.8	-	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	5.0	-	-
Moderate	1.0	-	-
High	-	-	-

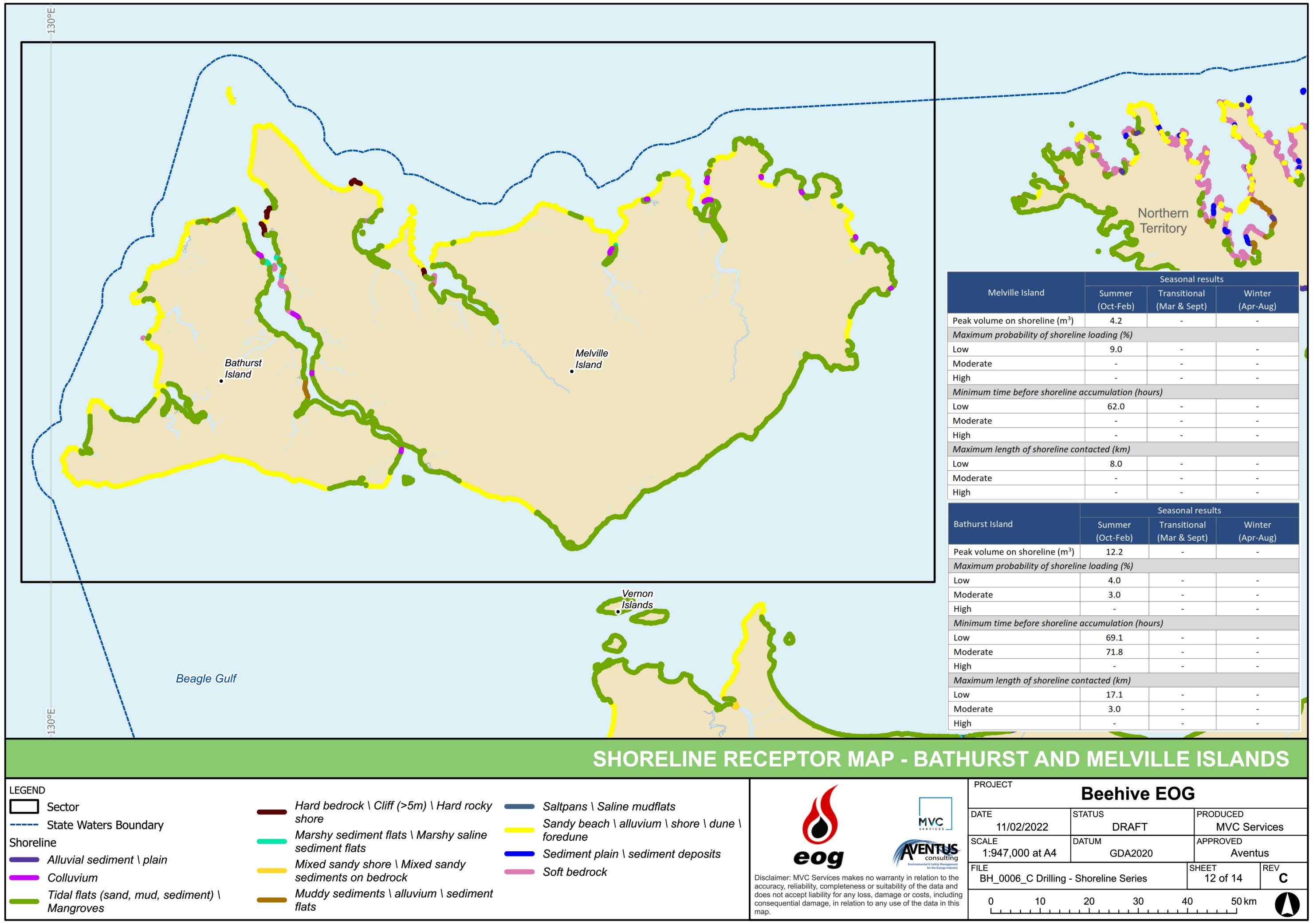
Figure 5.21. EMBA shoreline sector - South Alligator



Oxley Island	Seasonal results Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	0.5	-	-
Maximum probability of shoreline loading (%)			
Low	2.0	-	-
Moderate	-	-	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	81.3	-	-
Moderate	-	-	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	1.0	-	-
Moderate	-	-	-
High	-	-	-

Minjilang	Seasonal results Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	1.1	-	-
Maximum probability of shoreline loading (%)			
Low	3	-	-
Moderate	-	-	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	70.83	-	-
Moderate	-	-	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	1.0	-	-
Moderate	-	-	-
High	-	-	-

Figure 5.22. EMBA shoreline sector - West Arnhem



Melville Island	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	4.2	-	-
Maximum probability of shoreline loading (%)			
Low	9.0	-	-
Moderate	-	-	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	62.0	-	-
Moderate	-	-	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	8.0	-	-
Moderate	-	-	-
High	-	-	-

Bathurst Island	Seasonal results		
	Summer (Oct-Feb)	Transitional (Mar & Sept)	Winter (Apr-Aug)
Peak volume on shoreline (m^3)	12.2	-	-
Maximum probability of shoreline loading (%)			
Low	4.0	-	-
Moderate	3.0	-	-
High	-	-	-
Minimum time before shoreline accumulation (hours)			
Low	69.1	-	-
Moderate	71.8	-	-
High	-	-	-
Maximum length of shoreline contacted (km)			
Low	17.1	-	-
Moderate	3.0	-	-
High	-	-	-

Figure 5.23. EMBA shoreline sector - Melville and Bathurst islands

5.3. Biological Environment

The sources listed at the start of this chapter have been used in the preparation of this section. Additionally, BIAs are identified for those species that may occur in the spill EMBA. BIAs are spatially defined areas, defined by the DAWE based on expert scientific knowledge, where aggregations of individuals of a species are known, or likely, to display biologically important behaviour such as breeding, foraging, resting or migration (DAWE, 2021a). The BIAs do not represent a species' full distribution range.

5.3.1. Benthic Assemblages

The benthic environment of the JBG is linked to its geomorphic features, with the majority of the area characterised by infaunal plains, with some localised reefs and outcrops supporting sponge gardens. Przeslawski et al (2011) provides an overview of the benthic environment associated with the different geomorphic features within the EMBA (see Figure 5.8), which are outlined below.

- Slope – the majority of the Northwest marine bioregion consists of either continental slope or continental shelf. Biological productivity is reliant upon seasonal changes in the strength of surface and subsurface currents.
- Shelf – sediment plains that are swept by strong tidal currents and are subject to large influxes of suspended sediment and freshwater, particularly during the wet season. Support diverse infaunal communities that play a key ecological role by contributing to nutrient cycling and sediment turnover (bioturbation) at the local scale. Low abundance of crustaceans, echinoderms and sessile epifauna are expected.
- Banks/shoals - elevated features with a relatively high proportion of hard substrate that support patches of moderately dense octocoral and sponge gardens which in turn provide habitat for other epifauna and cryptofauna. Banks support high numbers of epifaunal species. Infaunal species richness is moderately high in bank sediments. Very few macroalgae (including *Halimeda*) or reef-forming hard corals were recorded. Carbonate banks and shoals occur predominantly in the JBG (Baker *et al.,* 2008), with the Glomar Shoals and Rowley Shoals situated within the NWS region.
- Basin - low-relief expanses of unconsolidated sediment, and the available biological data suggests that these habitats are dominated by infauna with limited epifauna.
- Canyons – the canyons on the slope of the Argo Abyssal Plain and Scott Plateau and to the north of Scott Reef (in the NWMR) are a unique seafloor feature associated with small periodic upwellings that enhance biological productivity and aggregations of marine life (DEWHA, 2008). The tributary canyons of the Arafura Depression located in the NMR are a key ecological feature (KEF) known to support both benthic and pelagic habitats including a diverse range of invertebrates (e.g., sponges, corals, sea anemones, tunicates, worms, crustaceans, brittle stars and feather stars).
- Cliffs and coral reefs - within the EMBA, offshore coral reefs include Ashmore reef and Hibernia Reef, Cartier Island, Browse Island, the Vernon Islands, with many other islands in coastal waters supporting fringing coral reefs. Submerged cliffs and coral reefs of the Kimberley and atolls and reefs on the edge of the continental shelf support a high diversity of benthic filter-feeders and producers.
- Deep/hole/valley - dominated by flat soft sediment expanses. Support low-moderate numbers of epifaunal species and include many debris-swept channels, which in places expose small patches of underlying rock that support moderate densities of sessile animals.
- Tidal-sandwave/sand bank – high disturbance, soft substrate, limited biota.

- Pinnacles – limestone pinnacles of the of the Bonaparte Depression are thought to be associated with enhance local biological productivity due to the movement of water around these features to facilitate mixing of nutrients and sediments. Associated communities include sessile benthic invertebrates including hard and soft corals and sponges (DEWHA, 2008).

Infaunal communities

The offshore marine environment off WA (from Busselton) to the Northern Territory (NT) border is dominated by soft sediment seabeds; sandy and muddy substrates, occasionally interspersed with hard substrates covered with sand veneers, and rarely, exposed hard substrate. In shallow waters, non-coral benthic invertebrates may form part of the mosaic of benthic organisms found on hard substrates, alongside macrophytes and coral colonies. As light reduces with water depth, non-coral benthic invertebrates are the dominant community, albeit at low densities.

Infauna are animals that inhabit sandy or muddy surface layers of the ocean floor these may include deposit feeders, filter-feeders, grazers and predators. The distribution of infauna and benthic invertebrate species is influenced by many physical parameters (e.g., water temperature, dissolved oxygen, pH, salinity) and biological (e.g., primary productivity, acclimatisation) factors.

Within the EMBA deep offshore areas such as the Northwest Transition support infauna such as sediment burrowing polychaetes and isopods.

Crustaceans

See EP Chapter 5. Crustaceans are found throughout the EMBA primarily in the inner shelf (30 m to 60 m water depth) and the continental slope (between 200 m to 1000 m) of the NWS region, although little is known about the benthic environment in the latter (Commonwealth of Australia, 2007).

Molluscs

See EP Chapter 5. Molluscs are also found in the mid shelf (60 m to 100 m water depth) of the NWS region which includes the Glomar Shoals. Distinct assemblages of molluscs are also found in depths between 100 m to 200 m and 200 m to 500 m with no overlap. Areas of the continental slope, offshore from North West Cape to the southern boundary of the NWMR Region of 200 m to 4,000 m contain molluscs and large isopods that feed on particulate organic matter (Commonwealth of Australia, 2007).

Reefs, Shoals and Banks

Coral reefs are habitats with high diversity of corals, associated fish and other species of both commercial and conservation importance. No reef habitats have been identified within the ecological EMBA; however, the socio-economic EMBA does overlap with areas of coral reef habitats. The closest identified coral reef habitat is located within the Joseph Bonaparte Gulf AMP (JBG AMP). Emu Reefs (located 97 km northeast of Beehive-1) was recently surveyed by traditional owners of the Thamarrur region in partnership with the Australian Institute of Marine Science (AIMS), Eni Australia and Parks Australia. The survey deployed Baited Remote Underwater Video Systems (BRUVS) and captured a diversity of fish, sharks and crabs as well as the protected and culturally significant eyebrow wedgefish (*Rhynchobatus palpebratus*) (Parks Australia, 2021a).

Oceanic shoals and banks are abrupt geological features that rise from the deep continental shelf to within 15-20 m of the sea surface. These unique habitats contain submerged reefs that support a very high diversity of coral reef ecosystems (Heyward *et al*., 2017). It is likely that the open oceanic environment that the northwest banks and shoals are situated in contributes to their high species diversity and abundance as their exposure to oceanic influences may enhance productivity and in turn the diversity of species inhabiting them (Parks Australia, 2021a). There are no identified oceanic shoals or banks located within the ecological EMBA, however, there are several identified shoals and banks in the western extent of the socio-economic EMBA including Holothuria Banks, Tait Bank, Penguin Shoal and Bassett-Smith Shoal (RPS, 2021). Though there is a paucity of information relevant to these specific features, studies of similar nearby shoals not located in the EMBA have found a high diversity of free-living corals, sponges, gorgonian soft corals, hard corals, rhodoliths, tropical fish, rays and sharks (Heyward *et al*., 2017; Moore *et al*., 2017; Heyward *et al*., 2010). It is expected that the shoals and banks located in the western extent of the socio-economic EMBA may include a similar assemblage of species. Identified banks, reefs and shoals in relation to the EMBA are presented in Figure 5.24.

A description of the reefs, shoals and islands within the socio-economic EMBA is provided here.

Scott and Seringapatam Reefs

The Scott and Seringapatam reefs are regionally significant due to its high representation of species not found in coastal waters off WA and unusual nature of its fauna that has affinities with the oceanic reef habitats of the Indo-West Pacific as well as the reefs of the Indonesian region. Scott Reef is important for its contribution to understanding long-term geomorphological and reef formation processes and past environments (DoE, 2016d).

Scott Reef is the largest of the oceanic reef systems off WA and comprises two major formations: North Reef and South Reef, separated by a channel 2 km wide and between 400 and 700 m deep. North Reef is an annular reef enclosing a shallow lagoon (as is Seringapatam) and South Reef is a crescent-shaped reef with a deeper and more extensive lagoon environment.

Scott Reef is the region's best-understood reef from the point of view of resident communities and how they function and change. The most comprehensive datasets come from a long-term monitoring program run by AIMS has provided the most comprehensive dataset of the reef's resident communities. A diverse assemblage of hard coral species has been recorded from the shallow and deep-water environments at Scott Reef, with 306 species from 60 genera and 14 families (Gilmour *et al,* 2012). Two hundred and ninety-five species have been recorded from shallow-water environments (<30 m) and 51 species from deep water habitats (>30 m). Community composition in the deep-water lagoon at South Reef is markedly different to the shallow-water habitats at Scott Reef. The shallow-water coral communities comprise typical reef front, lagoon and reef-flat assemblages, while the deepwater communities are dominated by extensive areas of foliaceous *Agariciidae, Pectinidae, Poritidae and Montipora* species, and fragile branching and plating Acropora species.

Compared with other offshore reefs in the region, Scott Reef appears to have a comparable diversity of hard corals. A shallow-water survey (0 - 20 m) of Ashmore, Scott and Seringapatam reefs and Mermaid Reef (Rowley Shoals) in 2006 recorded 211 species of corals at Mermaid Reef, 159 species at Seringapatam, 255 species at Ashmore Reef, and 201 and 224 species at North and South (Scott) reefs respectively (WAM, 2009). All coral taxa were predominantly widespread Indo-Pacific species that have clear affinities with the coral assemblages of Ashmore Reef and the Indonesian provinces to the north.

Ashmore Reef

Ashmore Reef is a commonwealth marine park (see Section 5.4.1). The marine fauna at Ashmore Reef has the highest diversity of the reefs on the North-West Shelf, with the mollusc fauna being substantially more diverse here (433 species) than either Scott and Seringapatam Reefs (279 species) or Rowley Shoals (DSEWPC, 2013). Ninety-nine species of decapod crustaceans have been recorded at Ashmore Reef compared with 56 for Scott and Seringapatam Reefs) and 178 echinoderms species have been recorded (compared with 119 species for Scott and Seringapatam and 90 species for Rowley Shoals). A total of 560 fish species have also been recorded at the reef, with the most species-rich fish families being the Gobiidae (small to mid-sized gobies, 66 species), Pomacentridae (small and brightly coloured damselfish and anemonefish, 66 species), Labridae (wrasse, 54 species) and Apogonidae (36 species) (DSEWPC, 2013).

Glomar Shoals

The Glomar Shoals are defined as a KEF for their high productivity and aggregations of marine life. Further information on the Glomar Shoals is provided in Section 5.4.7.

Rowley Shoals

The Rowley Shoals is defined as a KEF or its enhanced productivity and high species richness, that apply to both benthic and pelagic habitats within the feature. Further information on the Rowley Shoals is provided in Section 5.4.7.

Cartier Island

Cartier Island is a commonwealth marine park (see Section 4.5.1) consisting of an un-vegetated sand cay surrounded by mature reef flats; it sits at the centre of a reef platform that rises steeply from the seabed. The island is composed of coarse sand and is stabilised by patches of beach rock around its perimeter. The effects of wind, tides and rain periodically expose and remove areas of shifting sandbanks. The island supports large populations of nesting marine turtles.

Cartier Island is located about 55 km southeast of the Ashmore Island complex and in the absence of specific information regarding species assemblages, is likely to host a similar assemblage of fish species to Ashmore Reef given their close proximity.

Browse Island

Browse Island is an isolated sandy cay surrounded by an intertidal reef platform and shallow fringing reef located 540 km northeast from the Beehive-1 exploration well location. This reef rises from a depth of 200 m and is a flat-topped, oval-shaped platform reef with a diameter of 2.2 km at its widest point. The benthic habitats and biotic assemblages are characteristic of coral platform reefs throughout the Indo-West region (Inpex, 2010). Intertidal habitats around Browse Island include a sandy beach (known for green turtle nesting (DAWE, 2021) rocky beach, a lagoon supporting macroalgae and coral such as Acropora species and Porites species, a reef platform supporting sparse algal turf, and the reef crest (supporting hard corals such as *Goniastrae* spp and a high diversity of molluscs). The reef platform is barren in many places, and seagrasses are not present (Inpex, 2010).

Adele Island

Adele Island is a hook shaped island off the central Kimberley coast, located around 97 km north-northwest from Cape Leveque and 605 km from the Beehive-1 exploration well location. The island measures 2.9 km by 1.6 km with an area of 2.17 km². Its surrounding sand banks sit atop a shallow-water limestone platform, surrounded by an extensive reef system.

Adele Island is an important site for breeding seabirds with several Japan-Australia Migratory Birds Agreement (JAMBA), China-Australia Migratory Birds Agreement (CAMBA) and Republic of Korea Migratory Birds Agreement (ROKAMBA) listed species breeding there, with rookeries of cormorants, Australian pelicans, lesser frigate birds (2,000-5,700 breeding pairs), brown booby

(1,500-8,500 breeding pairs), red-footed booby and masked booby (DSEWPC, 2008; Kimberley Coast, 2013).

Cunningham Island

Cunningham Island is an unvegetated sand cay surrounded by a small lagoon which lies near the northern extent of Imperieuse Reef. The island is situated 1,115 km from Beehive-1 and its shoreline is dominated by white sandy shores and low-lying beach rock. There is limited data on the benthic assemblages supported by the island.

Bedwell Island

Bedwell Island a small sandy cay inside Clerke Reef situated 1,060 km from Beehive-1. The island is home to one of only two colonies of red-tailed tropicbirds in WA. The tropicbirds nest on the island, along with wedge-tailed shearwaters, white-bellied sea-eagles, various terns, eastern reef-egrets and even a pair of white-tailed tropicbirds.

Lacepede Islands

The Lacepede Islands situated 756 km from the Beehive-1 well location provide critical nesting and internesting habitat for green turtles and are the site of the largest green turtle rookery in Western Australia. The Commonwealth waters surrounding the islands are important for migrating marine turtles as they move between nesting and feeding sites in this bioregion and beyond. The Lacepede Islands also support some of the largest brown booby colonies in Western Australia. Other seabirds also breed in the area, including lesser frigatebirds, bridled terns, roseate terns and common noddies. The surrounding waters are likely to provide food for seabird species (DEWHA, 2008b).

Tiwi Islands

Located 20 km north of Darwin, the Tiwi Islands are made up of two main islands namely Melville Island (Australia's second largest island) and Bathurst Island (Department of Natural Resources, Environment, the Arts and Sport, 2009) The coasts of the Tiwi Islands support important nesting sites for marine turtles, internationally significant seabird rookeries, and some major aggregations of migratory shorebirds (Department of Natural Resources, Environment, the Arts and Sport, 2009).

Vernon Islands

The Vernon islands are located in the Clarence Strait in the NT, between the Australian mainland at Gunn Point and Melville Island's southernmost point, Cape Gambier (Tiwi Land Council, 2013). There are three major islands making up the Vernon Islands group; north-west Vernon Island, south-west Vernon Island and east Vernon Island, including a large reef and numerous lesser reefs and sand islands (Tiwi Land Council, 2013). The Vernon Islands are rich in mangrove forests, reef systems, rocky shelves and stacks, and seagrass and algal beds (Tiwi Land Council, 2013). The islands are an important coral reef locality, and there is a small number of naturally occurring deep holes (up to 20 m deep) which support coral communities with high species diversity (Tiwi Land Council 2013). The waters surrounding the Vernon Islands support populations of dugong and turtles (Tiwi Land Council, 2013).

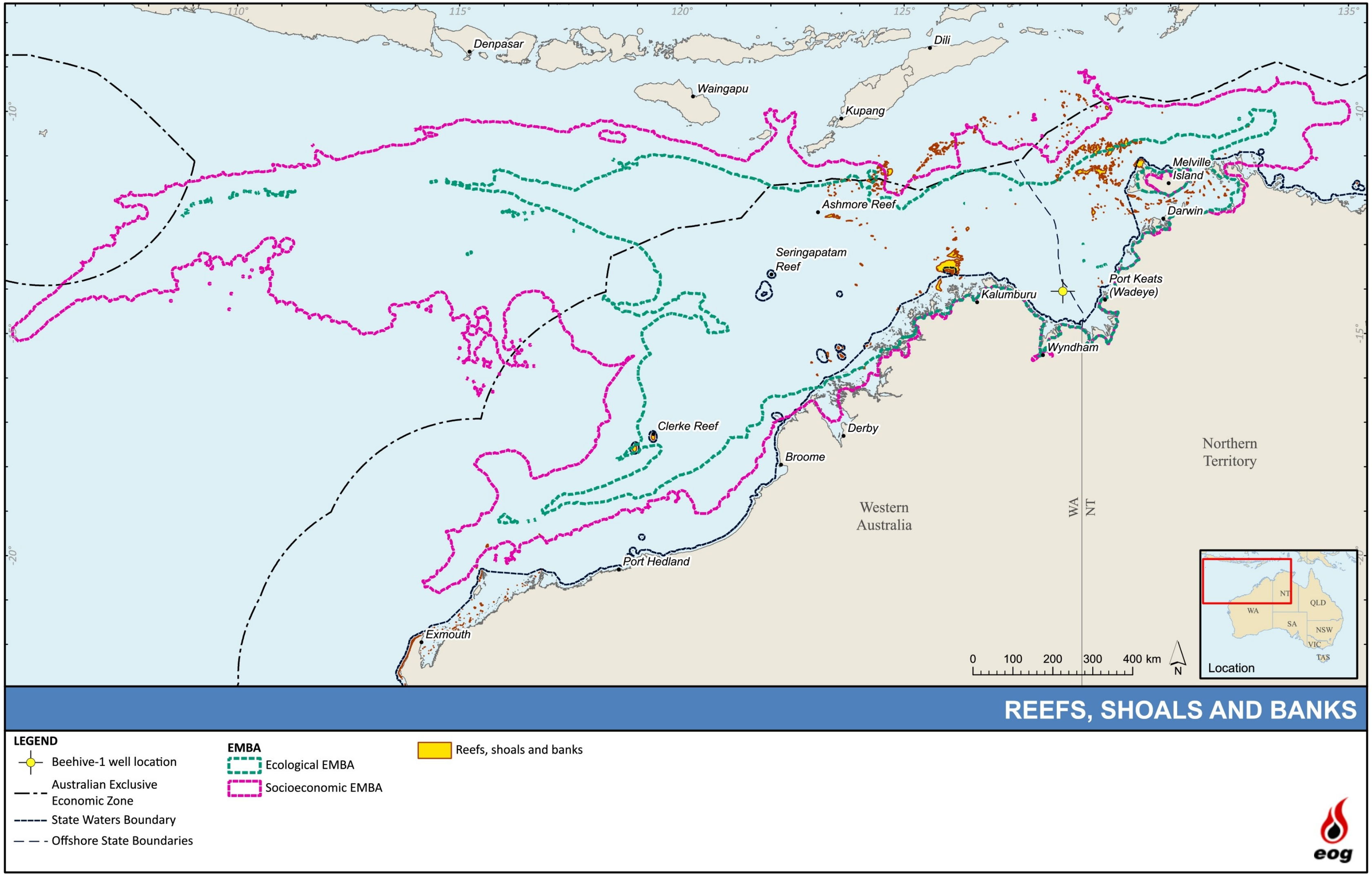


Figure 5.24. Reefs, shoals and banks intercepted by the EMBA

5.3.2. Flora

Marine flora is generally limited to mangroves and seagrass beds and macroalgae, which is generally confined to shallow, nearshore waters.

Mangroves

Mangroves provide nutrient to surrounding waters and are also important habitat and nursery areas for fish and invertebrates. The north Kimberley region contains some of the most species rich systems of mangroves in the world (DPaW, 2016). The mangroves and estuarine habitats of the north Kimberley support a range of threatened, protected and culturally important species including estuarine crocodiles, turtles, dolphins, sawfish, mud crabs, fish and specialist mangrove birds (DPaW, 2016).

In the JBG, mangroves occur in river estuaries. The mangroves surrounding the Ord River are notable in terms of their structural complexity and diversity. Fourteen species of mangroves have been identified within the Ord River alone (Pedretti & Paling, 2001). This diverse area is known to support significant habitats for saltwater crocodiles, migratory birds and supports populations of the commercially exploited species of red-legged banana prawn (*Penaeus indicus*) (Kenyon *et al*., 2004).

Seagrass Beds and Macroalgae

Seagrass beds and macroalgae communities are the primary food source for many marine species and provide important habitats and nursery grounds (Heck *et al*., 2003; Wilson *et al*., 2010). Within the north Kimberley marine region, seagrass and macroalgae communities are an important source of primary productivity. They provide vital habitat for juvenile fish, turtles and dugongs and can be found around Cape Londonderry (182 km northwest from the Beehive-1 exploration well location), is within the spill EMBA (DPAW, 2016).

5.3.3. Plankton

Plankton is a key component in oceanic food chains and comprises two elements; phytoplankton and zooplankton, as described in Section 5.4.3 of Chapter 5.

5.3.4. Finfish, Sharks and Rays

There are 61 fish species listed under the EPBC Act with potential to occur in the spill EMBA (DAWE, 2022). This includes nine species listed as threatened, eleven species listed as migratory and a further 44 listed marine species, all of which are Sygnathiformes (seahorses, pipefishes and their relatives) (Table 5.2).

The likely temporal presence and absence of these fish species in the EMBA is illustrated in Figure 5.13 in Section 5.4.4 of Chapter 5. Species listed as threatened or migratory are described in this section. BIAs for fish species that overlap the EMBA are presented in Table 5.3.

Table 5.2. EPBC Act-listed finfish, sharks and rays that may occur in the EMBA

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by ecological EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Anoxypristis cuspidate	Narrow sawfish	-	Yes	-	-	Yes	No	-
Carcharias taurus	Grey nurse shark (west coast population)	V	-	-	-	Yes	No	RP
Carcharodon carcharias	Great white shark	V	Yes	-	Yes	Yes	No	RP
Carcharhinus longimanus	Oceanic whitetip shark	-	Yes	-	Yes	Yes	No	-
Glyphis garricki	Northern river shark	E	-	-	Yes	Yes	No	CA, RP
Glyphis glyphis	Speartooth shark	CE	-	-	Yes	Yes	No	CA
Isurus oxyrinchus	Shortfin mako	-	Yes	-	Yes	Yes	No	-
Isurus paucus	Longfin mako	-	Yes	-	Yes	Yes	No	-
Manta alfredi	Reef manta ray	-	Yes	-	Yes	Yes	No	-
Manta birostris	Giant manta ray	-	Yes	-	Yes	Yes	No	-
Milyeringa veritas	Blind gudgeon	V	-	-	-	-	No	-
Pristis clavate	Dwarf sawfish	V	Yes	-	Yes	Yes	Yes	CA, RP
Pristis pristis	Largetooth sawfish	V	Yes	-	Yes	Yes	No	CA, RP
Pristis zijsron	Green sawfish	V	Yes	-	Yes	Yes	Yes	CA, RP
Rhincodon typus	Whale shark	V	Yes	-	Yes	Yes	Yes	CA
Sphyrna lewini	Scalloped Hammerhead	CD	-	-	Yes	Yes	No	-

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by ecological EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Thunnus maccoyii	Southern Bluefin Tuna	CD	-	-	Yes	Yes	No	-
Seahorses, pipefish and pipehorses								
Acentronura larsonae	Helen’s pygmy pipehorse	-	-	Yes	-	Yes	-	-
Bhanotia fasciolata	Corrugated pipefish	-	-	Yes	Yes	Yes	-	-
Bulbonaricus brauni	Braun's pughead pipefish	-	-	Yes	-	Yes	-	-
Campichthys tricarinatus	Three-keel pipefish	-	-	Yes	Yes	Yes	-	-
Choeroichthys brachysoma	Pacific short-bodied pipefish	-	-	Yes	Yes	Yes	-	-
Choeroichthys latispinosus	Murion Island pipefish	-	-	Yes	-	Yes	-	-
Choeroichthys suillus	Pig-snouted pipefish	-	-	Yes	Yes	Yes	-	-
Corythoichthys amplexus	Fijian banded pipefish	-	-	Yes	Yes	Yes	-	-
Corythoichthys flavofasciatus	Reticulate pipefish	-	-	Yes	Yes	Yes	-	-
Corythoichthys haematopterus	Reef-top pipefish	-	-	Yes	Yes	Yes	-	-
Corythoichthys intestinalis	Australian messmate pipefish	-	-	Yes	Yes	Yes	-	-
Corythoichthys schultzi	Schultz’s pipefish	-	-	Yes	Yes	Yes	-	-
Cosmocampus banneri	Roughridge pipefish	-	-	Yes	Yes	Yes	-	-

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by ecological EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Doryrhamphus dactyliophorus	Banded pipefish	-	-	Yes	Yes	Yes	-	-
Doryrhamphus excisus	Bluestripe pipefish	-	-	Yes	Yes	Yes	-	-
Doryrhamphus janssi	Cleaner pipefish	-	-	Yes	Yes	Yes	-	-
Doryrhamphus multiannulatus	Many-banded pipefish	-	-	Yes	-	Yes	-	-
Doryrhamphus negrosensis	Flagtail pipefish	-	-	Yes	-	Yes	-	-
Festucalex cinctus	Girdled pipefish	-	-	Yes	Yes	Yes	-	-
Festucalex scalaris	Ladder pipefish	-	-	Yes	-	Yes	-	-
Filicampus tigris	Tiger pipefish	-	-	Yes	Yes	Yes	-	-
Halicampus brocki	Brock’s pipefish	-	-	Yes	Yes	Yes	-	-
Halicampus dunckeri	Red-hair pipefish	-	-	Yes	Yes	Yes	-	-
Halicampus grayi	Mud pipefish	-	-	Yes	Yes	Yes	-	-
Halicampus nitidus	Glittering pipefish	-	-	Yes	Yes	Yes	-	-
Halicampus spinirostris	Spiny-snout pipefish	-	-	Yes	Yes	Yes	-	-
Haliichthys taeniophorus	Ribboned pipehorse	-	-	Yes	Yes	Yes	-	-
Hippichthys cyanospilos	Blue-speckled pipefish	-	-	Yes	Yes	Yes	-	-
Hippichthys parvicarinatus	Short-keel pipefish	-	-	Yes	Yes	Yes	-	-

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by ecological EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Hippichthys penicillus	Beady pipefish	-	-	Yes	Yes	Yes	-	-
Hippocampus angustus	Western spiny seahorse	-	-	Yes	Yes	Yes	-	-
Hippocampus histrix	Spiny seahorse	-	-	Yes	Yes	Yes	-	-
Hippocampus kuda	Spotted seahorse	-	-	Yes	Yes	Yes	-	-
Hippocampus planifrons	Flat-face seahorse	-	-	Yes	Yes	Yes	-	-
Hippocampus spinosissimus	Hedgehog seahorse	-	-	Yes	Yes	Yes	-	-
Hippocampus trimaculatus	Three-spot seahorse	-	-	Yes	Yes	Yes	-	-
Micrognathus micronotopterus	Tidepool pipefish	-	-	Yes	Yes	Yes	-	-
Phoxocampus belcheri	Black rock pipefish	-	-	Yes	-	Yes	-	-
Solegnathus hardwickii	Pallid pipehorse	-	-	Yes	Yes	Yes	-	-
Solegnathus lettiensis	Gunther's pipehorse	-	-	Yes	Yes	Yes	-	-
Solenostomus cyanopterus	Robust ghost pipefish	-	-	Yes	Yes	Yes	-	-
Syngnathoides biaculeatus	Double-end pipehorse	-	-	Yes	Yes	Yes	-	-
Trachyrhamphus bicoarctatus	Bentstick pipefish	-	-	Yes	Yes	Yes	-	-

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by ecological EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Trachyrhamphus longirostris	Straightstick pipefish	-	-	Yes	Yes	Yes	-	-

Definitions

EPBC Act	Description
Listed threatened species	A native species listed in Section 178 of the *EPBC Act* as either extinct, extinct in the wild, critically endangered, endangered, and vulnerable or conservation dependent.
Listed migratory species	A native species that from time to time is included in the appendices to the Bonn Convention and the annexes of JAMBA, CAMBA and ROKAMBA, as listed in Section 209 of the *EPBC Act*.
Listed marine species	As listed in Section 248 of the *EPBC Act*.

FFG Act	Description
Listed (L)	Listed as threatened
Nominated (N)	Nominated for listing as threatened but has not yet been listed. In some cases, the taxon may have received a preliminary or final recommendation indicating that it is eligible or ineligible for listing. In other cases, the nomination might not yet have been considered.
Invalid or ineligible (I)	Nominated but rejected for listing as threatened on the basis that the taxon was considered to be invalid (either undescribed or not widely accepted) or ineligible (taxon does not satisfy any of the primary listing criteria) by the SAC.
Delisted (D)	Previously listed as threatened but subsequently removed from the Threatened List following nomination for delisting.

Key

EPBC status (@ February 2022)	V	Vulnerable
	E	Endangered
	CE	Critically endangered
BIA	A	Aggregation
	D	Distribution (i.e., presence only)
	F	Foraging
	M	Migration

Recovery plans (under the EPBC Act 1999)	CA	Conservation Advice
	CD	Conservation Dependent
	CMP	Conservation Management Plan
	RP	Recovery Plan

Table 5.3. BIAs of fish species within the EMBA

Species	BIA	Location within the EMBA
Dwarf sawfish	Nursing and pupping	Fitzroy River Mouth, May & Robinson River - tidal tributaries. King Sound (Inshore waters).
	Foraging	Camden Sound - eastern shore.
Largetooth sawfish *(Freshwater sawfish)*	Foraging and nursing	King Sound - tidal tributaries King Sound (Inshore waters).
Green sawfish	Foraging	Camden Sound. Cape Leveque.
	Nursing and pupping	Cape Leveque.
Whale shark	Foraging	Northward from Ningaloo (outside of the EMBA) along 200 m isobath, extending offshore off the Kimberley coastline (within the EMBA).

Note: Biologically important areas have not yet been identified for seahorse or pipefish species in the North-west Marine Region as stated in the Species group report card– bony fishes (Supporting the marine bioregional plan for the North-west Marine Region (Commonwealth of Australia, 2012) accessed via DAWE (February 2022).

Grey nurse shark (west coast population) (EPBC Act: Vulnerable)

The grey nurse shark (*Carcharias taurus*) has a broad inshore distribution, primarily in sub-tropical to cool temperate waters (Last and Stevens, 1994). The west coast population of grey nurse shark are predominantly found in the south-west coastal waters of WA (DAWE, 2021) and has been recorded as far north as the Northwest Shelf (NWS) (Stevens, 1999; *Pogonoski et al*., 2002).

Grey nurse sharks are often observed hovering motionless just above the seabed, in or near deep sandy-bottomed gutters or rocky caves, and in the vicinity of inshore rocky reefs and islands (Pollard *et al*., 1996). The species has been recorded at varying depths but generally found between 15–40 m (Otway and Parker, 2000).

Grey nurse sharks have also been recorded in the surf zone, around coral reefs, and to depths of around 200 m on the continental shelf. They generally occur either alone or in small to medium sized groups, usually of fewer than 20 sharks (Pollard *et al*., 1996). Grey nurse sharks that are observed alone are thought to be moving between aggregation sites (DAWE, 2021). Grey nurse sharks are often observed aggregating around inshore rocky reefs or islands (Department of Environment, 2014). At these locations, grey nurse sharks are typically found near the seabed (at depths of 10 m to 40 m) in deep sandy or gravel filled gutters, or in rocky caves (Otway and Burke, 2004; Dicken, 2006; Last and Stevens, 2009). There are no known aggregation sites critical to the grey nurse shark in WA waters (DoE, 2014).

There are no biologically important aggregation, breeding or foraging areas intersected by the spill EMBA; however, it is likely that individuals may transit through the spill EMBA.

Great white shark (EPBC Act: Vulnerable, Listed migratory)

The great white shark (*Carcharodon carcharias*) is widely distributed and located throughout temperate and sub-tropical waters with their known range in Australian waters including all coastal areas except the NT (DAWE, 2021b). Studies of the great white shark indicates that they appear to be largely transient, with a few longer-term residents; however, individuals are known to return to feeding grounds on a seasonal basis (Klimey and Anderson, 1996). Observations of adult white sharks are more frequent around fur-seal and sea lion colonies whilst juveniles are known to congregate in certain key areas.

There are no biologically important aggregation, breeding or foraging areas intersected by the spill EMBA; however, it is likely that individuals may transit through the spill EMBA.

Shortfin mako shark (EPBC Act: Listed migratory)

The shortfin mako (*Isurus oxyrinchus*) is a pelagic species with a circumglobal, wide ranging oceanic distribution in tropical and temperate seas (Mollet *et al*., 2000). It is widespread in Australian waters, recorded in offshore waters all around the continent's coastline with exception of the Arafura Sea, the Gulf of Carpentaria and Torres Strait (DAWE, 2021b). Shortfin makos are also highly migratory and travel large distances (DAWE, 2021b).

Due to their widespread distribution in Australian waters, their presence in the spill EMBA is likely to be limited to transiting individuals.

Longfin mako shark (EPBC Act: Listed migratory)

The longfin mako is widely distributed; however, it is rarely encountered and can be found along the WA coastline as a far south as Geraldton (Last and Stevens, 2009). There is limited research into the species within Australian waters; however, Sepulveda et al (2004) recorded southern Californian juveniles favoured surface waters, while larger adults were frequently observed at depths of up to 250 m. Whilst assumed to be a deep-dwelling shark, sightings on the ocean surface, and the species' diet, suggest a greater depth range (Reardon *et al*., 2006).

Though there is limited information about the longfin mako, their presence in the spill EMBA is likely to be limited to transiting individuals.

Whale shark (EPBC Act: Vulnerable, listed migratory)

The whale shark (*Rhincodon typus*) is a filter-feeding shark and is the largest known species of fish in the world (DAWE, 2021b). It is considered to be an oceanic and coastal species, commonly seen far offshore but also closer inshore near coral atolls (DAWE, 2021b). Whale sharks generally prefer tropical to warm temperate waters where surface sea temperature ranges from 21° to 25 °C (DAWE, 2021b). In Australian waters the whale shark is commonly seen in waters off northern WA, NT and Queensland with only very occasional sightings off Victoria and South Australia (Last and Stevens, 1994). The movements of whale sharks are not well documented; however, they are known to seasonally aggregate (March and April) in shallow tropical waters off the North West Cape in WA (DAWE, 2021b).

Whale sharks may occur within the spill EMBA. A foraging BIA is intersected by the socio-economic EMBA (see Table 5.3 and Figure 5.25) and hence, individuals may forage in the far western extent of the EMBA.

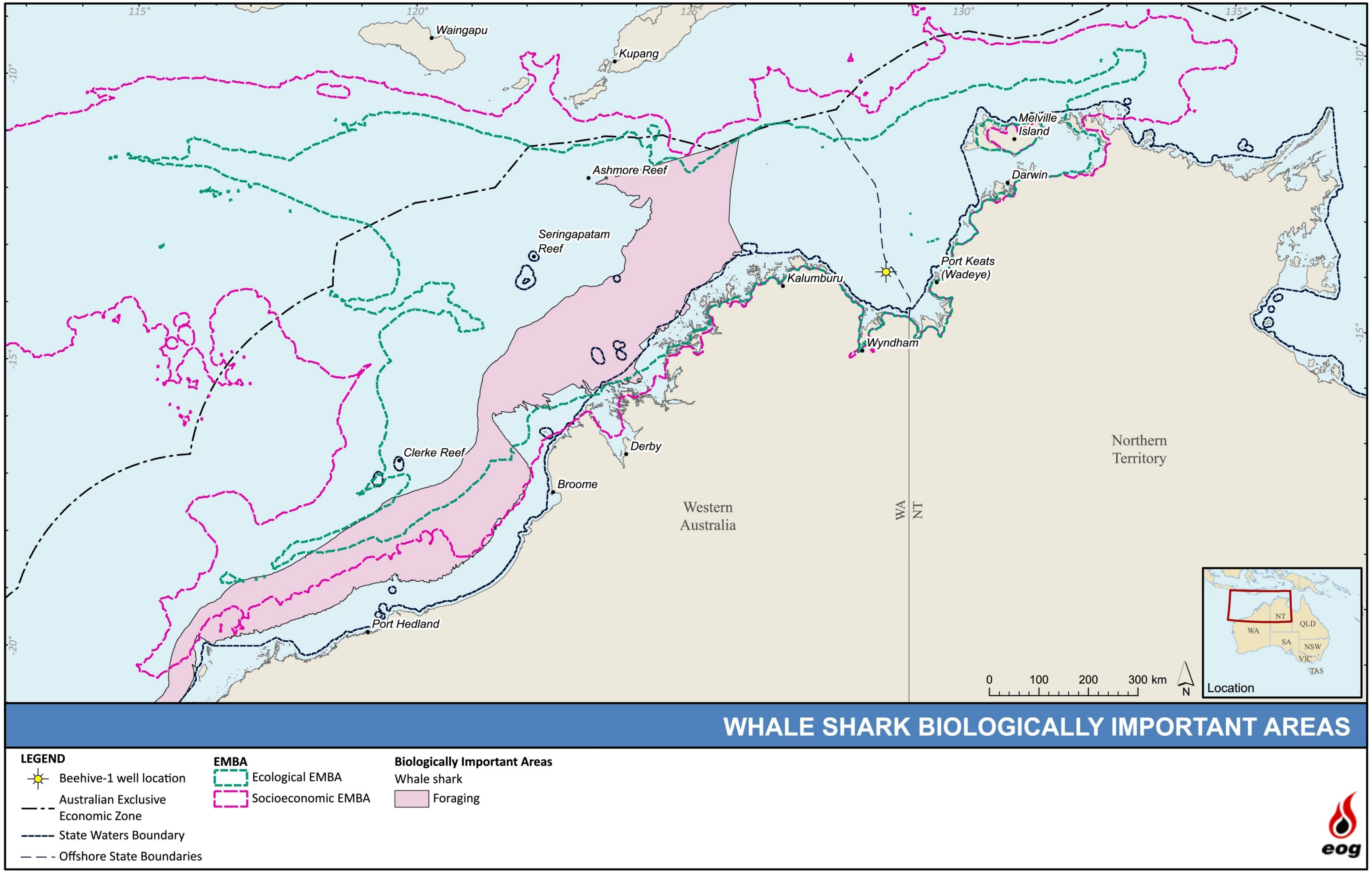


Figure 5.25. Whale shark BIA intersected by the spill EMBA

Northern river shark (EPBC Act: Endangered)

The northern river shark (*Glyphis garricki*) is an elasmobranch capable of living and moving between freshwater and seawater. The species utilises rivers, tidal sections of large tropical estuarine systems, macro tidal embayments, inshore and offshore marine habitats. The species is listed as endangered under the EPBC Act, based partly on its limited geographic distribution (TSSC, 2014a). Within Australia, the northern river shark is known to occur in WA and the NT, occupying both marine and freshwater environments including the JBG, Daly River, Adelaide River and the South and East Alligator Rivers (TSSC, 2014a) (Figure 5.26). Whilst northern river sharks have been observed well offshore, the extent to which this occurs is unknown (TSSC, 2014a). Individuals may be present within the nearshore areas of the spill EMBA.

Speartooth shark (EPBC Act: Listed Critically Endangered)

Speartooth sharks (*Glyphis glyphis*) occur in geographically distinct locations across northern Australia in the NT including Queensland, having been recorded in tidal rivers and estuaries with turbid waters, fine muddy substrates and temperatures ranging from 27 °C to 33°C (DoE, 2014). In the NT, they are found in the Van Diemen Gulf drainage, including the Adelaide River, South, East and West Alligator rivers and Murganella creek (Field *et al.,* 2008; Pillans *et al.,* 2009). Due to their similarity to bull sharks, it is thought that adult speartooth sharks may live outside of rivers in the coastal marine environment (Stevens *et al.,* 2005; Pillans *et al.,* 2008). Given the species preference for estuarine and coastal waters, the speartooth shark may be present in the socioeconomic EMBA along the NT coastline. Given the absence of BIAs for this species, significant numbers are not expected to be impacted.

Blind Gudgeon (EPBC Act: Listed vulnerable)

The blind gudgeon is a small fish known to occur on the Cape Range Peninsula in the arid NW of WA (Humphreys and Feinberg, 1995) and at Barrow Island, to the northeast of the Cape Range Peninsula, off the WA coastline (Humphreys ,1999). The species is known only from the underground waters which lie beneath the narrow coastal plain of the Cape Range Peninsula in WA (Allen, 1982; Humphreys and Blyth, 1994) in water temperatures ranging from 27°C to 30°C in May and Aug (Mees, 1962)

Although the PMST report identifies this species or its habitat may be present within the EMBA, the closest area of presence is 33 km southeast from the southern extent of the socioeconomic EMBA. Therefore given the location preference and there are no BIAs for this species, the blind gudgeon is not expected to occur within the spill EMBA.

Oceanic whitetip shark (EPBC Act: Listed migratory)

Within Australian waters, the oceanic whitetip shark (*Carcharhinus longimanus*) is found from Cape Leeuwin, WA, through parts of the NT and down the east coast of Queensland and NSW to Sydney (Last and Stevens, 2009). It has not been recorded within the Gulf of Carpentaria or the Arafura Sea. The oceanic whitetip shark is a circumglobal deep-water pelagic species inhabiting tropical to warm-temperate waters (Compagno, 1984). Oceanic whitetip sharks prefer water temperatures above 20°C and can reach depths of >180 m (Castro *et al*., 1999).

Given the species distribution in deep offshore waters, the presence of the species within the spill EMBA is expected to be l

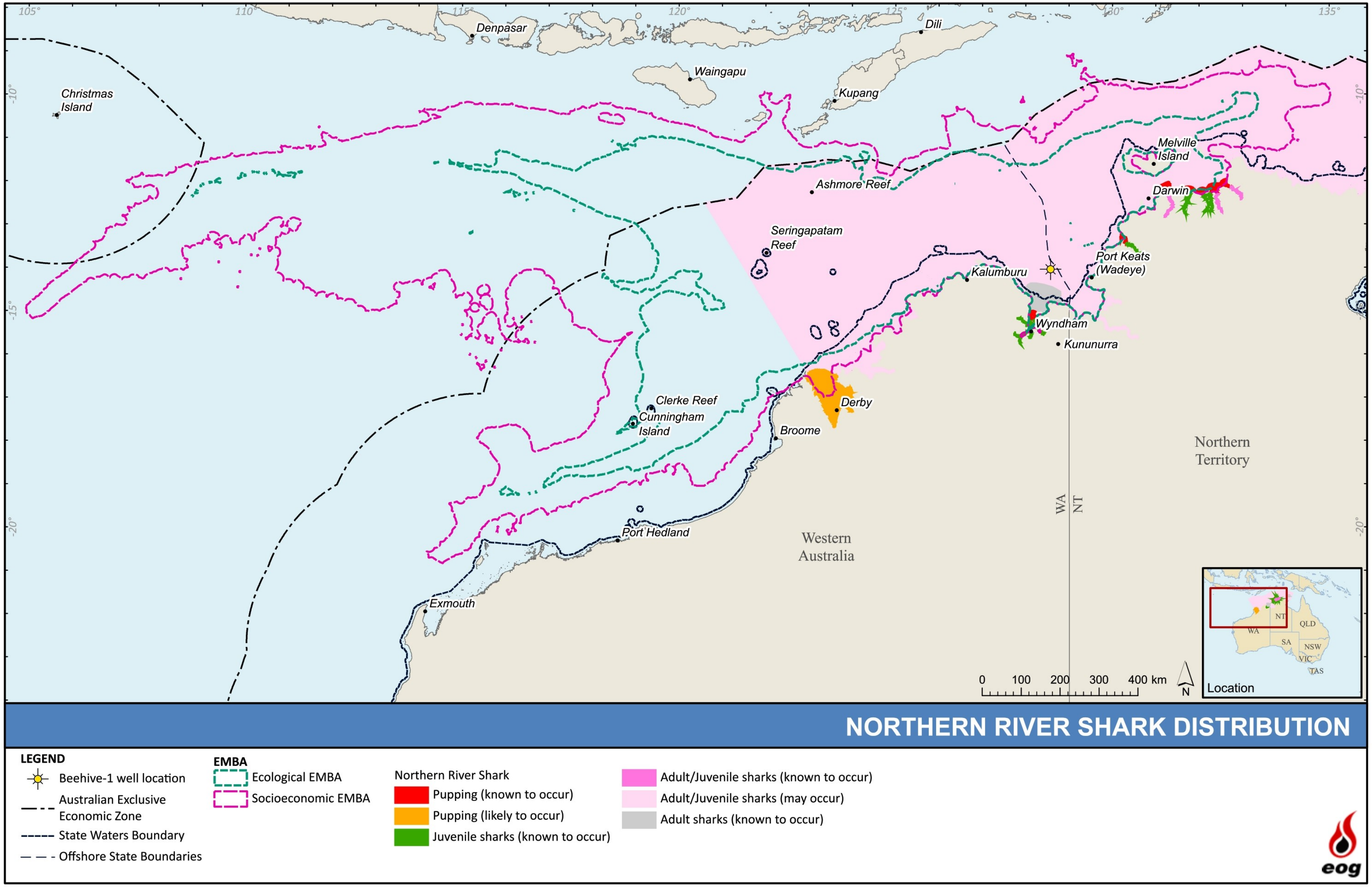


Figure 5.26. Northern river shark presence in the region

Reef manta ray (EPBC Act: Listed migratory)

The reef manta ray (*Manta alfredi*) has a circum-global range in tropical and sub-tropical waters with sightings between waters off Perth, all along the northern coastline of Australia to the waters off the Solitary Islands, NSW (Marshall *et al*., 2011a). While this species tends to inhabit nearshore environments, it is known to occurs in waters as deep as 300 m and has been sighted around offshore coral reefs, rocky reefs and seamounts (Marshall *et al*., 2011a). In addition, it makes seasonal migrations of several hundred kilometres (Marshall *et al*., 2011a).

Despite there being no known aggregation sites within close proximity to the EMBA, reef manta rays may be present in the EMBA as transiting individuals.

Giant manta ray (EPBC Act: Listed migratory)

The giant manta ray (*Manta birostris*) has a widespread distribution along the coast of Australia and is known to seasonally migrate between aggregation sites (Marshall *et al*., 2011b). The giant manta ray is commonly sighted along productive coastlines with regular upwelling, oceanic island groups and particularly offshore pinnacles and seamounts (Marshall *et al*., 2011b).

This species has also been recorded within the Oceanic Shoals Marine Park, which is located within the EMBA (Nichol *et al*., 2013). Despite there being no known aggregation sites within close proximity to the drill site, giant manta rays may be present in the EMBA as transiting individuals.

Narrow sawfish (EPBC Act: Listed migratory)

The narrow sawfish lives in coastal and estuarine habitats across northern Australia and is generally restricted to shallow waters (less than 40 m) (D'Anastasi *et al*., 2013). The species is known to occur in the Gulf of Carpentaria but its distribution and migration is largely unknown. The narrow sawfish has the potential to occur within the spill EMBA because it has been caught as bycatch by the NPF in these areas (Tonks *et al*., 2008).

Dwarf sawfish (EPBC Act: Vulnerable, Listed migratory)

The dwarf sawfish (*Pristis clavata*) usually inhabits shallow (2–3 m deep) coastal waters and estuarine habitats. Its distribution is considered to extend north from Cairns around the Cape York Peninsula in Queensland, across northern Australian waters to the Pilbara coast in WA (DAWE, 2021b). The dwarf sawfish uses its rostrum to stun schooling fish by sideswiping or threshing while swimming through a school. The main prey species is popeye mullet (*Rhinomugil nasutus*). The main threats to dwarf sawfish are habitat loss and entanglement in fishing nets.

Adult dwarf sawfish are known to occur in the nearshore areas of the spill EMBA (Figure 5.27). The EMBA overlaps with foraging, nursing and pupping BIAs in Camden Sound (eastern shore), and some sections of the Fitzroy River Mouth, May & Robinson River tidal tributaries and inshore waters of King Sound respectively (see Table 5.3 and Figure 5.27).

Largetooth sawfish (EPBC Act: Vulnerable, Listed migratory)

Largetooth sawfish (*Pristis pristis*) also known as the freshwater sawfish, utilise both freshwater (juvenile) and marine (adult) environments during the different stages of its lifecycle (TSSC, 2014b). Within Australia, largetooth sawfish have been recorded in numerous drainage systems across northern WA, NT and northern Queensland (TSSC, 2014b). Growing up to 7 m in length, the largetooth sawfish feeds on fishes and benthic invertebrates. The saw is used to stun schooling fish, such as mullet, and for extracting molluscs and small crustaceans from the benthic sediment. Nursing areas for the species include Eighty Mile Beach, Roebuck Bay and King Sound (which is also a known foraging area).

The spill EMBA overlaps areas where adult largetooth sawfish are known to occur. BIAs that overlap the EMBA are shown in Table 5.3 and Figure 5.28.

Green sawfish (EPBC Act: Vulnerable, Listed migratory)

The green sawfish (*Pristis zijsron*) occurs in both inshore and offshore marine coastal waters of northern Australia. Green sawfish have been recorded in very shallow water (less than one metre) to offshore trawl grounds in over 70 m of water (Stevens *et al.,* 2005). Despite being found in deep water, evidence suggests that the range of green sawfish is mostly restricted to the inshore coastal fringe, with a strong association with mangroves and adjacent mudflats (Stevens e*t al.,* 2008). Its current known distribution stretches from Broome, WA around northern Australia and down the east coast as far as Jervis Bay, NSW (DAWE, 2021b).

The main threats to green sawfish are habitat loss and entanglement in fishing nets. The EMBA overlaps areas where both adult and juvenile sawfish are known to occur and is adjacent to the inner waters of the southern JBG where pupping of this species is likely to occur (Figure 5.29). It has also been caught as bycatch from the NPF in the area overlapped by the drill site and spill EMBA and therefore is likely to be present in both (Tonks *et al*., 2008). BIAs for this species that overlap the EMBA are listed in Table 5.3.

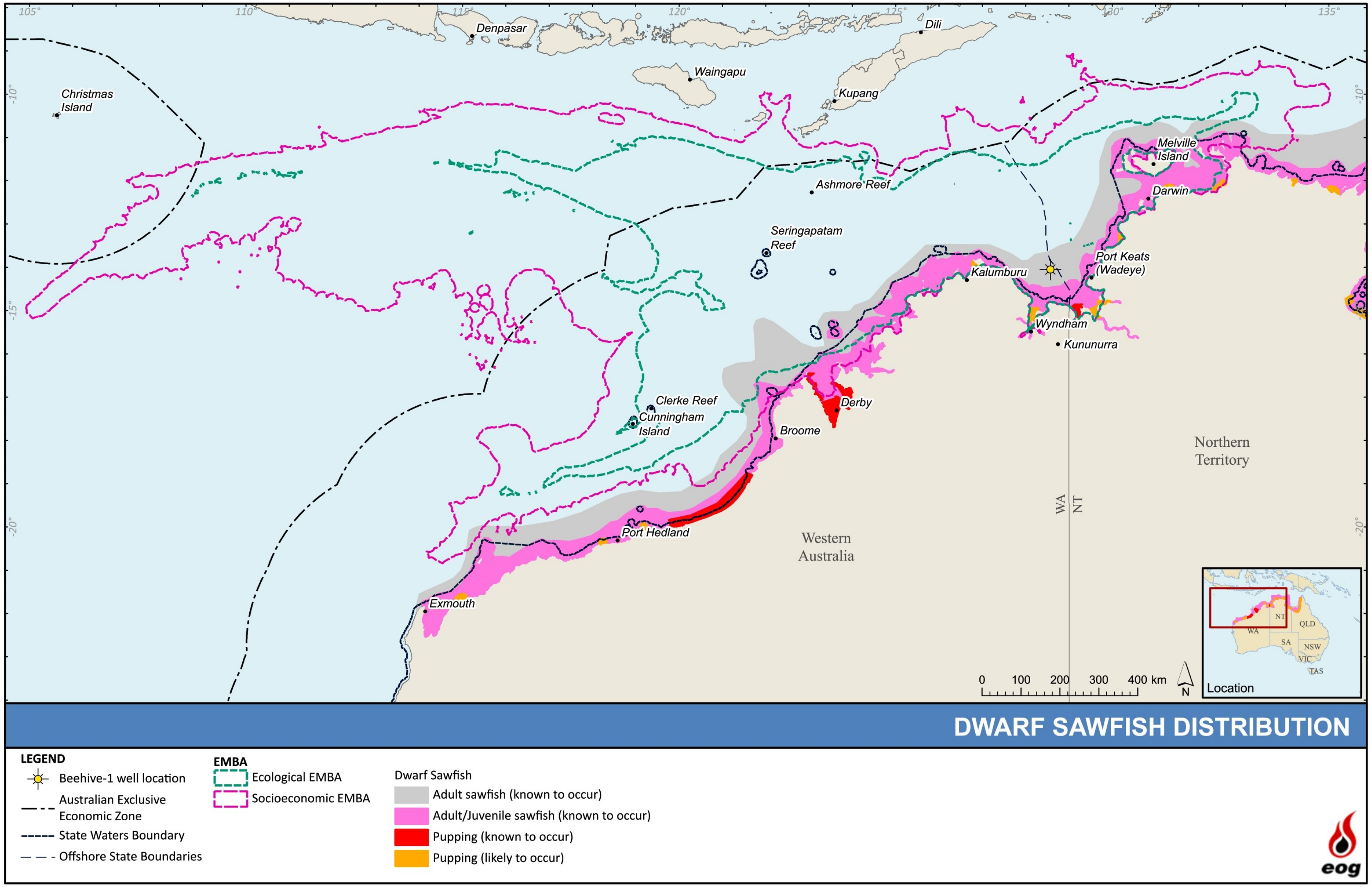


Figure 5.27. Dwarf sawfish presence in the region

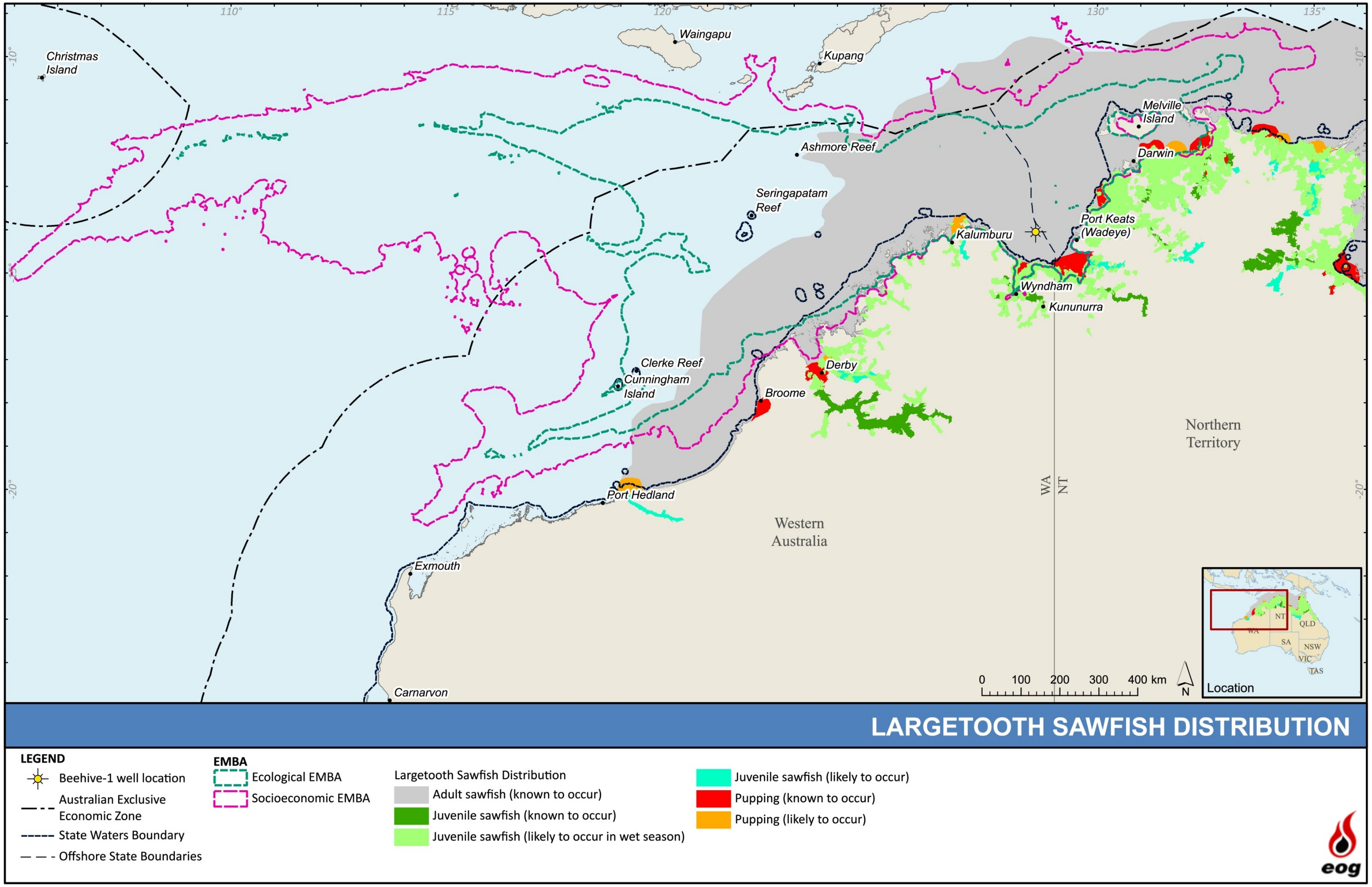


Figure 5.28. Largetooth sawfish presence in the region

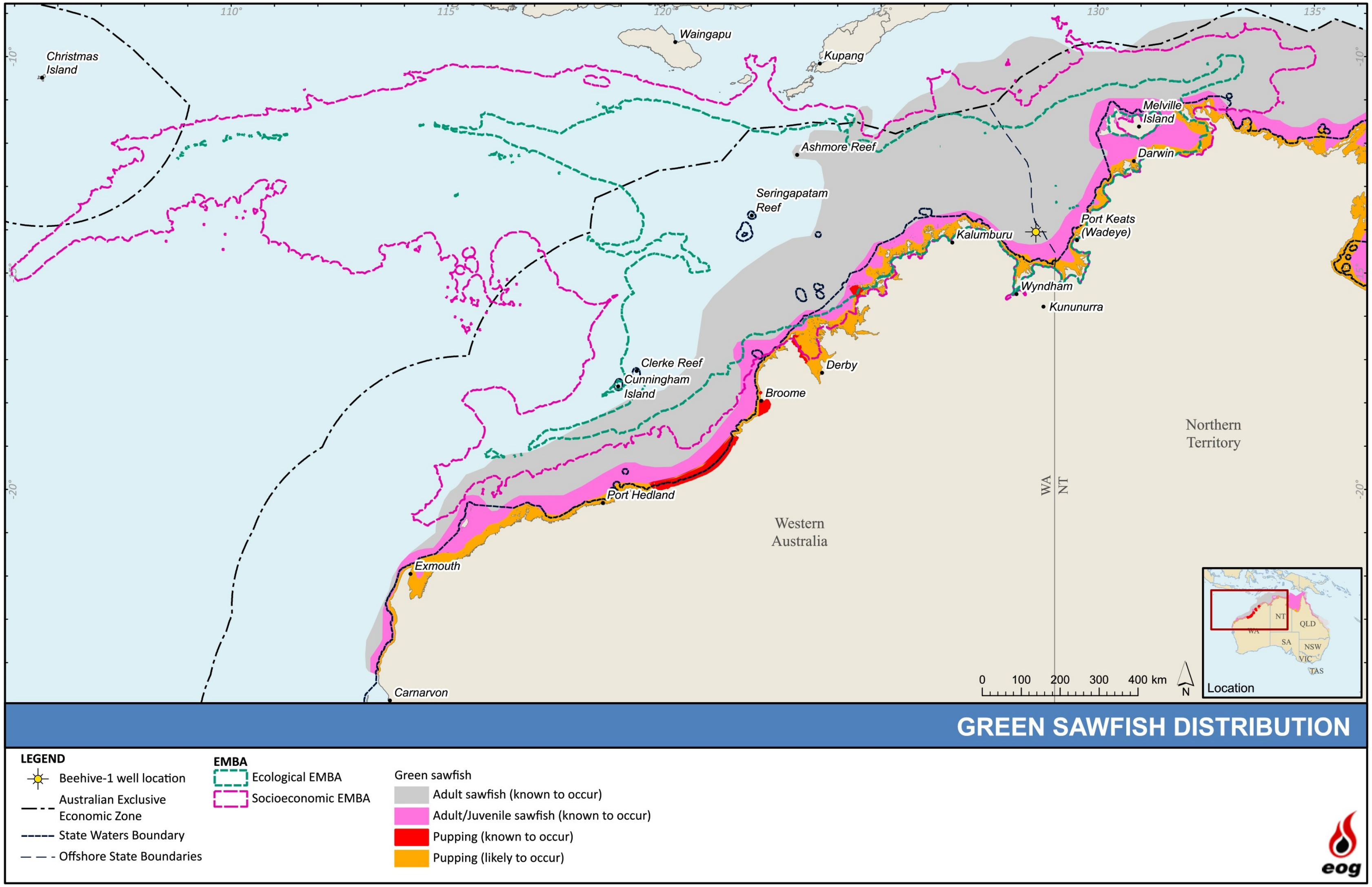


Figure 5.29. Green sawfish presence in the region

Scalloped hammerhead (EPBC Act: Conservation Dependent)

The scalloped hammerhead (*Sphyrna lewini*) is a a relatively large, fusiform-bodied, moderately slender shark. has a circum-global distribution in tropical and sub-tropical waters. This species has a strong genetic population structuring across ocean basins as it rarely ventures into or across deep ocean waters, but ranges quite widely over shallow coastal shelf waters. Within Australian waters the scalloped hammerhead extends from New South Wales (around Wollongong, where it is less abundant), around the north of the continent and then south into Western Australia to approximately y Geographe Bay, though it is rarely recorded south of the Houtman Abrolhos Islands (TSSC, 2018). It is currently under threatened listing assessment (current status is Conservation Dependent) which is due 30 April 2022.

As per the PMST report, breeding of the scallop hammerhead is known to occur in the EMBA.

Southern Bluefin Tuna (EPBC Act: Conservation Dependent)

The Southern Bluefin Tuna (*Thunnus maccoyii*) is highly migratory, occurring globally in waters between 30–50° S, though the species is mainly found in the eastern Indian Ocean and in the south-west Pacific Ocean. There is a single known spawning ground between Java and northern WA (TSSC, 2010). It is currently under threatened listing assessment (current status is Conservation Dependent) which is due 30 October 2023.

As per the PMST report, breeding of the southern bluefin tuna is known to occur in the EMBA.

Sygnathids (EPBC Act: Listed marine species, FFG Act: Not listed)

Thirty-five (35) of the 47 marine ray-finned fish species identified in the EPBC Act PMST (74%) are sygnathiformes, which includes seahorses, seadragon, pipehorse and pipefish. The majority of these fish species are associated with seagrass meadows, macroalgal seabed habitats, reefs and sponge gardens located in shallow, inshore waters (e.g., protected coastal bays, harbours and jetties) less than 50 m deep. They are sometimes recorded in deeper offshore waters, where they depend on the protection of sponges and rafts of floating seaweed such as *Sargassum*. It is likely that sygnathid species will occur in the deeper waters of the spill EMBA.

The PMST species profile and threats profiles indicate that the sygnathiforme species listed for the EMBA are widely distributed throughout northern and north-western Australian waters. The diverse range of ecological niches afforded by reef sites would be expected to provide suitable habitat for these listed species.

5.3.5. Marine Mammals

The PMST indicates that 15 whale species and 16 dolphin species may occur within or migrate through the spill EMBA (DAWE, 2022). These species are presented in Table 5.4 and a description focused on threatened species follows.

The likely temporal presence and absence of cetaceans in the EMBA is illustrated in Figure 5.18 in Section 5.4.5 of Chapter 5.

The species listed as threatened or migratory are described in this section. BIAs for marine mammals that overlap the EMBA are presented in Table 5.5.

Table 5.4. EPBC Act-listed cetaceans that may occur in the spill EMBA

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by ecological EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Whales								
Balaenoptera acutorostrata	Minke whale	-	-	Yes	-	Yes	No	-
B. bonaerensis	Antarctic minke whale	-	Yes	Yes	-	Yes	No	-
B. borealis	Sei whale	V	Yes	Yes	Yes	Yes	No	CA
B. edeni	Bryde’s whale	-	Yes	Yes	Yes	Yes	No	-
B. musculus	Blue whale	E	Yes	Yes	Yes	Yes	Yes	CMP
B. physalus	Fin whale	V	Yes	Yes	Yes	Yes	No	CA
Eubalaena australis	Southern right whale	E	Yes	Yes	-	Yes	No	CMP
Indopacetus pacificus	Longman’s beaked whale	-	-	Yes	Yes	Yes	No	-
Kogia breviceps	Pygmy sperm whale	-	-	Yes	Yes	Yes	No	-
K. simus	Dwarf Sperm Whale	-	-	Yes	Yes	Yes	No	-
Megaptera novaeangliae	Humpback whale	-	Yes	Yes	Yes	Yes	Yes	-
Mesoplodon densirostris	Blainville’s beaked whale	-	-	Yes	Yes	Yes	No	-
Mesoplodon ginkgodens	Ginko-toothed beaked whale	-	-	Yes	Yes	Yes	No	-

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by ecological EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Physeter macrocephalus	Sperm whale	-	Yes	Yes	Yes	Yes	No	-
Ziphius cavirostris	Cuvier's beaked whale	-	-	Yes	Yes	Yes	No	
Dolphins								
Delphinus delphis	Common dolphin	-	-	Yes	Yes	Yes	-	-
Feresa attenuata	Pygmy killer whale	-	-	Yes	-	Yes	-	-
Globicephala macrorhynchus	Short-finned pilot whale	-	-	Yes	Yes	Yes	-	-
Grampus griseus	Risso's dolphin	-	-	Yes	-	Yes	-	-
Lagenodelphis hosei	Fraser's dolphin	-	-	Yes	Yes	Yes	-	-
Orcaella brevirostris	Australian snubfin dolphin	-	Yes	Yes	Yes	Yes	-	-
Orcinus orca	Killer whale	-	Yes	Yes	Yes	Yes	-	-
Peponocephala electra	Melon-headed whale	-	-	Yes	Yes	Yes	-	-
Pseudorca crassidens	False killer whale	-	-	Yes	Yes	Yes	-	-
Sousa sahulensis	Australian humpback dolphin	-	Yes	Yes	Yes	Yes	-	-
Stenella attenuata	Spotted dolphin	-	-	Yes	Yes	Yes	-	-
Stenella coeruleoalba	Striped dolphin	-	-	Yes	Yes	Yes	-	-

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by ecological EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Stenella longirostris	Long-snouted spinner dolphin	-	-	Yes	Yes	Yes	-	-
Steno bredanensis	Rough-toothed dolphin	-	-	Yes	Yes	Yes	-	-
Tursiops aduncus	(Indo-Pacific) spotted bottlenose dolphin	-	-	Yes	Yes	Yes	-	-
Tursiops truncatus	Bottlenose dolphin	-	-	Yes	Yes	Yes	-	-
Dugong								
Dugong dugon	Dugong	-	Yes	Yes	Yes	Yes	-	-

Legend and key is the same as Table 5.2.

Table 5.5. BIAs of marine mammals within the EMBA

Species	BIA	Location within the EMBA
Pygmy blue whale	Foraging	Scott Reef.
	Migration	Augusta to Derby (tend to pass along the shelf edge at depths of 500 m to 1,000 m; appear close to coast in the Exmouth-Montebello Islands area on southern migration). Indonesia - Banda Sea.
Humpback whale	Calving	Kimberley/Coastal North Lacepede Island, Camden Sound.
	Migration (northern and southern)	The migration corridor extends from the coast to out to approximately 100 km offshore in the Kimberley region extending south to Northwest Cape.
	Nursing	Kimberley/Coastal North Lacepede Island, Camden Sound.
	Resting	Camden Sound.
Australian humpback dolphin	Foraging	Port Essington (Cobourg Peninsula). Van Diemen Gulf (East Alligator River). Van Diemen Gulf (South Alligator). Darwin Harbour. King Sound Southern Sector. Pender Bay. Carnot & Beagle Bay.
	Breeding	Port Essington (Cobourg Peninsula). Van Diemen Gulf (East Alligator River). Van Diemen Gulf (South Alligator). Darwin Harbour. Port Nelson, York Sound, Prince Frederick Harbour. Prince Regent River. Camden Sound Area - Walcott Inlet, Doubtful Bay, Deception Bay, Augustus Island (Kuri Bay).
	Calving	Maret and Biggee Island. Willie Creek.
	Significant habitat (unknown behaviour)	Napier Broome Bay/Deep Bay. Vansittart Bay, Anjo Peninsula. Bougainville Peninsula. Admiralty Gulf and Parry Harbour.
Australian snubfin dolphin	Foraging	Ord River (high density prey). Cape Londonderry and King George River (high density prey). Napier Broome Bay/Deep Bay (high density prey). Vansittart Bay (Anjo Peninsula) (high density prey). Bougainville Peninsula (high density prey). Admiralty Gulf & Parry Harbour. Maret and Biggee Island.

Species	BIA	Location within the EMBA
		Port Nelson, York Sound, Prince Frederick Harbour. Prince Regent River (high density prey). Camden Sound Area (Walcott Inlet, Doubtful Bay, Deception Bay, Augustus Island (Kuri Bay)). King Sound North, Yampi Sound and Talbot Bay Fjord area near horizontal falls. King Sound Southern Sector.
	Breeding	Port Essington (Cobourg Peninsula). Van Diemen Gulf (South Alligator River). Darwin Harbour. Ord River. Napier Broome Bay/Deep Bay. Vansittart Bay (Anjo Peninsula). Bougainville Peninsula. Admiralty Gulf & Parry Harbour. Port Nelson, York Sound, Prince Frederick Harbour. Prince Regent River (high density prey). Camden Sound Area (Walcott Inlet, Doubtful Bay, Deception Bay, Augustus Island (Kuri Bay)). King Sound North, Yampi Sound and Talbot Bay Fjord area near horizontal falls. King Sound Southern Sector.
	Calving	Port Essington (Cobourg Peninsula. Van Diemen Gulf (South Alligator River). Darwin Harbour. Ord River. Napier Broome Bay/Deep Bay. Vansittart Bay (Anjo Peninsula). Bougainville Peninsula. Admiralty Gulf & Parry Harbour. Port Nelson, York Sound, Prince Frederick Harbour. Prince Regent River (high density prey). Camden Sound Area (Walcott Inlet, Doubtful Bay, Deception Bay, Augustus Island (Kuri Bay)). King Sound North, Yampi Sound and Talbot Bay Fjord area near horizontal falls. King Sound Southern Sector.
	Resting	Ord River. Napier Broome Bay/Deep Bay. Vansittart Bay (Anjo Peninsula). Bougainville Peninsula. Admiralty Gulf & Parry Harbour. Port Nelson, York Sound, Prince Frederick Harbour. Camden Sound Area (Walcott Inlet, Doubtful Bay, Deception Bay, Augustus Island (Kuri Bay)).
Indo-Pacific spotted	Foraging	Port Essington (Cobourg Peninsula) (provisioning young). Darwin Harbour.

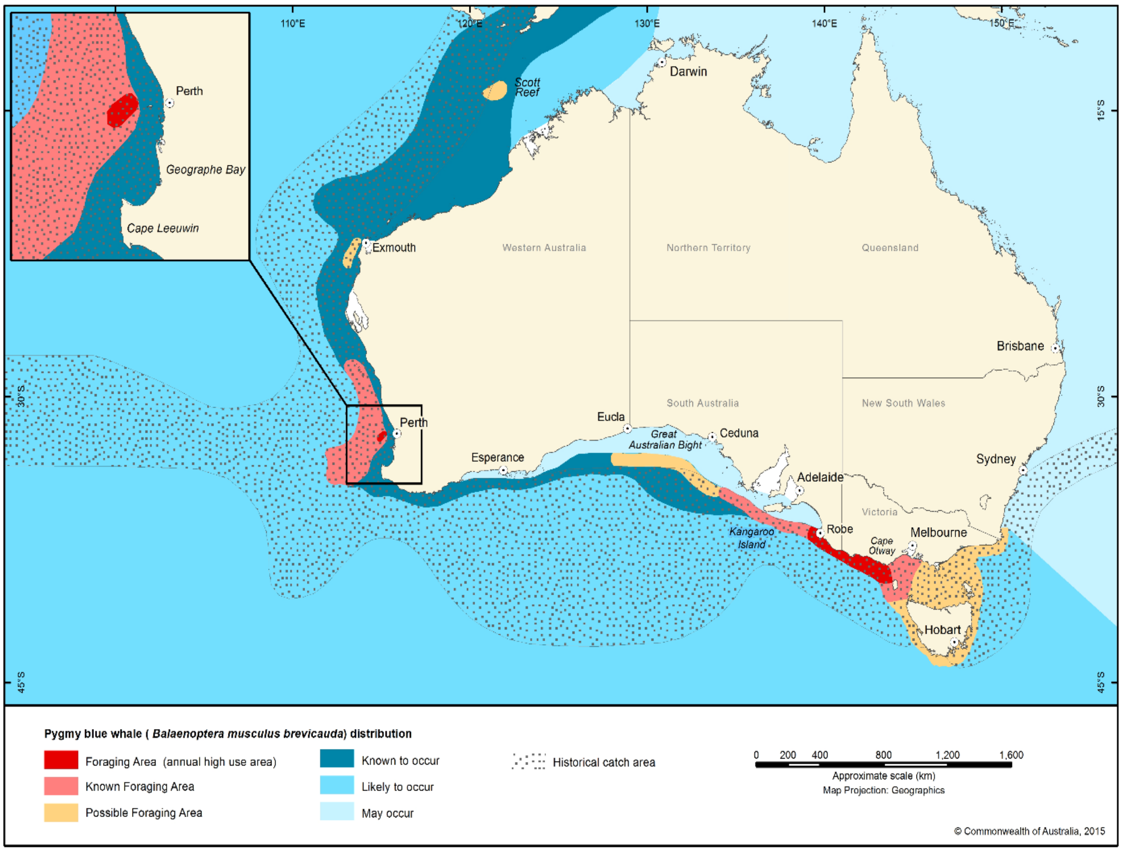
Species	BIA	Location within the EMBA
bottlenose dolphin		Camden Sound Area - Walcott Inlet, Doubtful Bay, Deception Bay, Augustus Island (Kuri Bay). King Sound North and Yampi Sound and Talbot Bay Fjord area near horizontal falls. King Sound Southern Sector.
	Breeding	Port Essington (Cobourg Peninsula) (provisioning young). Darwin Harbour (provisioning young). King Sound North and Yampi Sound and Talbot Bay Fjord area near horizontal falls. King Sound Southern Sector.
	Calving	Camden Sound Area - Walcott Inlet, Doubtful Bay, Deception Bay, Augustus Island (Kuri Bay). King Sound North and Yampi Sound and Talbot Bay Fjord area near horizontal falls. King Sound Southern Sector.
Dugong	Foraging	Kimberley coast (Dampier Peninsula). Ashmore Reef – south (high density). Ashmore Reef – west (high density).
	Breeding	Ashmore Reef – west.
	Calving	Ashmore Reef – west.
	Nursing	Ashmore Reef – west.

Pygmy blue whale (EPBC Act: Endangered, Listed migratory)

Pygmy blue whales are described in Section 5.4.5 of Chapter 5.

The EMBA is considered within the 'likely' distribution of the species and therefore pygmy blue whales may be present in the region during the southern migration period (September to December) (DoE, 2015a).

There is a foraging, migration and distribution BIA located off the Northwest Shelf is and Scott Reef (within the EMBA) is considered to be a 'possible' foraging area (see Table 5.5 and Figure 5.30).



Source: DoE (2015a)

Figure 5.30. Pygmy blue whale BIAs

Southern right whale (EPBC Act: Endangered, Listed migratory)

The southern right whale (*Eubalaena australis*) is present in the southern hemisphere between approximately 30° and 60°S. The species feeds in the Southern Ocean in summer, moving close to the Australian shore in winter.

In Australian waters, the southern right whales distribution range from Perth, along the southern coastline, to Sydney. Sightings have been recorded as far north as Exmouth although these are rare (Bannister *et al.*, 1996). BIAs including calving and aggregation areas are recorded for this species along the southern coastline of Australia (DAWE, 2021).

There are no established or emerging coastal aggregation areas, nor breeding or calving BIAs for the southern right whale in the spill EMBA. Given the preference for the southern coastline of Australia, it is unlikely that southern right whales will be present the spill EMBA.

Humpback whale (EPBC Act: Vulnerable, Listed migratory)

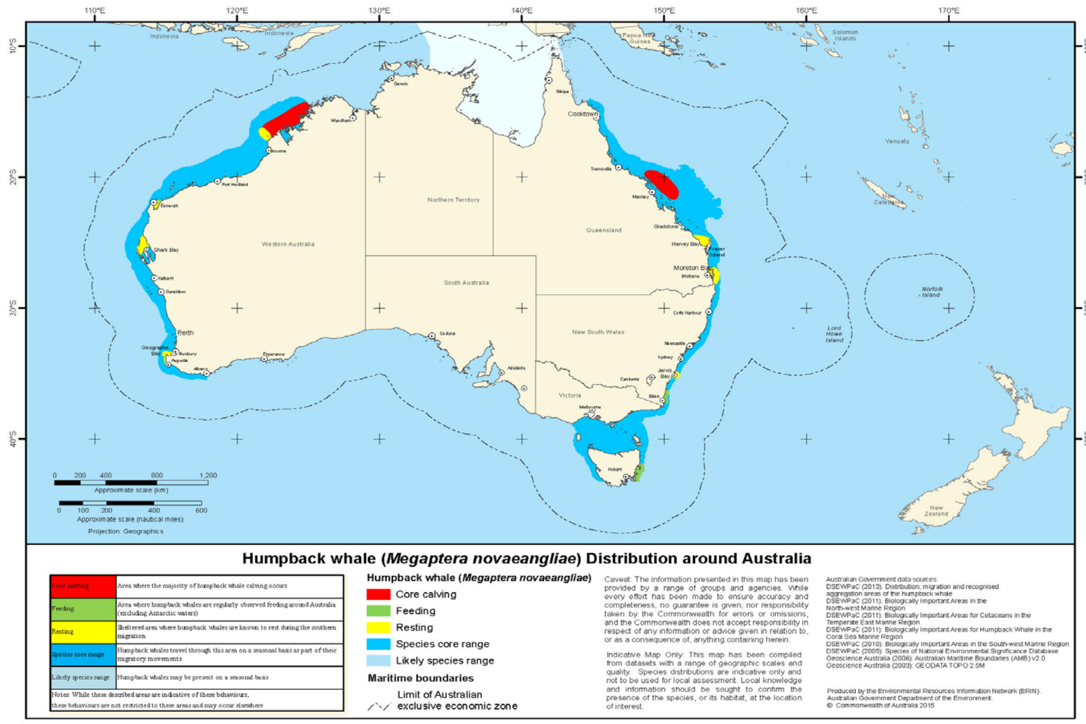
Humpback whales are described in Section 5.4.5 of Chapter 5 and their distribution is illustrated in Figure 5.31.

Humpback whales travel northbound from Northwest Cape, along the continental shelf and pass the west of the Muiron, Barrow and Montebello Islands (within the EMBA), peaking in late July (Jenner et al. 2001). Southbound migrations are more diffuse and irregular with no obvious peak. The southerly migration extends parallel to the coast on the 20 – 30 m depth contour from Lacepede Islands (north of Broome) (Jenner et al. 2001, DEWHA, 2008a). An increase in southerly migrating individuals may be observed between the North West Cape and the Montebello Islands around November (Jenner et al. 2001).

In the NWMR, humpback whales are known to have breeding and foraging grounds between Broome and the northern end of Camden Sound, with the highest concentrations occurring between June and September (DEWHA, 2008b). Camden Sound appears to be the northern most limit for the majority of the west coast whales (Figure 5.32) (Jenner *et al*., 2001). Although, the breeding and calving BIA for humpbacks off the west Kimberley coastline extends as far as Bigge Island (offshore from Mitchell Plateau) located within the spill EMBA.

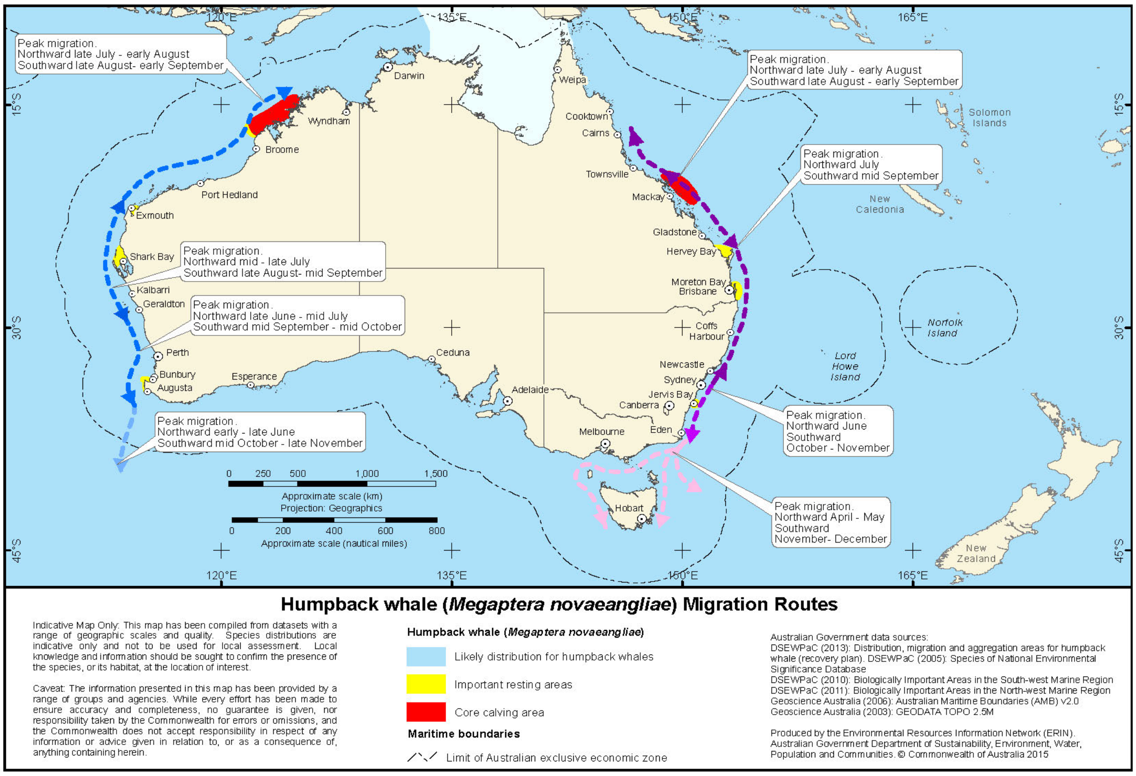
Given the activity timing is outside of the humpback whale period of peak presence in north western Australia (June – September), it is unlikely that the whales are present in significant numbers within the EMBA.

The humpback whale migration (north and south) BIA is located in the EMBA. Other BIAs for this species that overlap the EMBA are presented in Table 5.5 and Figure 5.33.



Source: TSSC (2015a).

Figure 5.31. Distribution of the humpback whale around Australia



Source: TSSC (2015a).

Figure 5.32. Migration routes of humpback whales around Australia

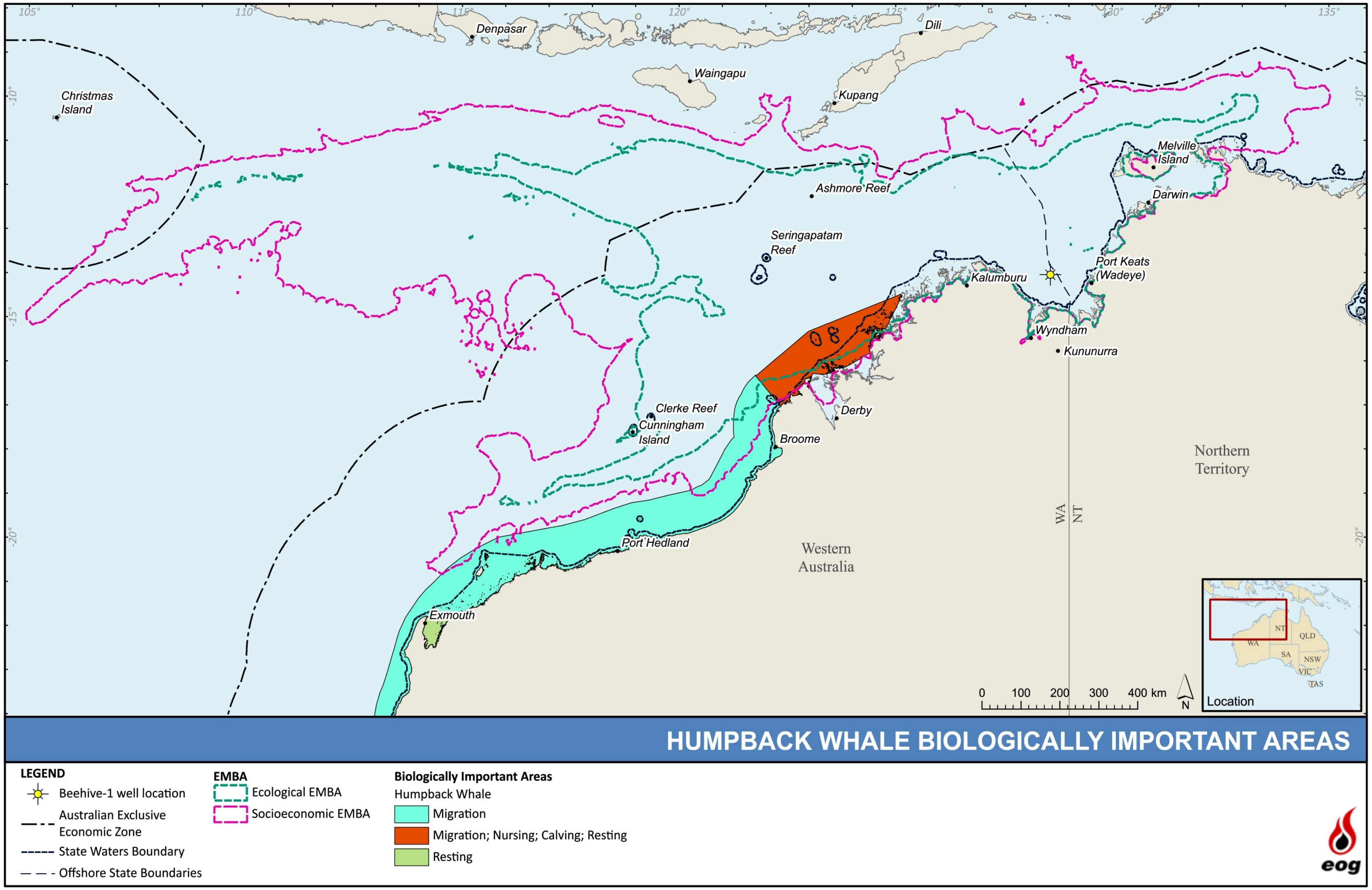


Figure 5.33. Humpback whale BIA intersected by the spill EMBA

Sei whale (EPBC Act: Vulnerable, Listed migratory)

Sei whales are described in Section 5.4.5 of Chapter 5.

Based upon the species preference for deep offshore waters, the wide ranging nature of this species, and the small number of sei whale sightings in Australia, the presence of the species within the EMBA is likely to be low.

Fin whale (EPBC Act: Vulnerable, Listed migratory)

Fin whales are described in Section 5.4.5 of Chapter 5.

Based on the fin whale preference for deep offshore waters and the minimal sightings in the coastal waters of the EMBA, the presence of this species in the spill EMBA is considered to be limited.

Sperm whale (EPBC Act: Vulnerable, listed migratory)

Sperm whales (*Physeter macrocephalus*) are the largest of the toothed whales and are generally found in pods of up to 50 individuals (DAWE, 2021b). Sperm whales have a global distribution. They generally inhabit deeper oceanic waters with a water depth of 600 m or more and are uncommon in waters less than 300 m (DoEE 2019a).

The PMST indicates that the species is known to occur within the EMBA. No BIAs for the species are recorded in the spill EMBA.

It is possible that sperm whales may transit through the spill EMBA, but they are not expected to be present in significant numbers.

Bryde's whale (EPBC Act: Listed migratory)

Fin whales are described in Section 5.4.5 of Chapter 5.

on small crustaceans, such as euphausids, copepods, pelagic red crabs and cephalopods.

The PMST indicates that the species may occur within the EMBA. However, there are no feeding or breeding BIAs within the EMBA.

Killer whale (EPBC Act: Listed migratory)

Killer whales are described in Section 5.4.5 of Chapter 5.

Sightings of killer whale around the Australian coast are typically recorded along the continental slope and shelf, and predominantly in the vicinity of seal colonies, which are not known to exist in the region (DEWHA 2008b). No areas of significance and no determined migration routes have been identified for this species within waters off WA (DoEE, 2019a).

The EMBA is unlikely to represent important habitat for this species. Therefore, killer whales are unlikely to be present in the EMBA.

Australian humpback dolphin (EPBC Act: Listed migratory)

Australian humpback dolphins (*Sousa sahulensis*) are found primarily in coastal waters and feed mainly on fish associated with coastal-estuarine waters (DAWE, 2021b). In Queensland and the NT, Australian humpback dolphins are mainly found in water less than 20 km from the nearest river mouth, and in water less than 15–20 m deep (DAWE, 2021b). They are generally found in river mouths, mangroves, seagrass beds, tidal channels and inshore reefs. They are known to have resident groups that forage, feed, breed and calve in state and territory waters. Calves may be born throughout the year, but peaks in summer and spring have been reported.

Humpback dolphin foraging BIAs are located along the Kimberley coastline, including breeding, and calving. A breeding BIA for the species are also located in Darwin Harbour (approximately 300 km north-east of the drill site). Foraging BIAs are also located in Van Diemen Gulf and Port Essington (Cobourg Peninsula) (see Table 5.5 and Figure 5.34).

The PMST indicates that the species is known to occur within the EMBA. The coastal area of the socio-economic EMBA overlaps the significant habitat BIA for this species located in the north Kimberley coastline and NT coastline are outlined in Table 5.5 and Figure 5.34. Therefore, the species is likely to be present in the spill EMBA.

Australian snubfin dolphin (EPBC Act: Listed migratory)

Australian snubfin dolphins (*Orcaella brevirostris*) occur mostly in protected shallow waters close to the coast, and close to river and creek mouths, including the shallow coastal waters and estuaries along the Kimberley coast and Cambridge Gulf (DAWE, 2021b). Within Australian waters, Australian snubfin dolphins have been recorded almost exclusively in coastal and estuarine waters (DAWE, 2021b). All available data on the distribution and habitat preferences of Australian snubfin dolphins indicate that they mainly occur in one location: shallow coastal and estuarine waters of Queensland, NT and northern WA (DAWE, 2021b). Australian snubfin dolphins share similar habitat preference with Australian humpback dolphins, with these two species potentially occurring in the same area through most of their Australian range (DAWE, 2021b).

Feeding primarily occurs in shallow waters (less than 20 m) close to river mouths and creeks (DAWE, 2021b). This includes a variety of habitats, from mangroves to sandy bottom estuaries and embayments, to rock and/or coral reefs. Prey for this species includes fish of the families Engraulidae, Clupeidae, Chirocentridae, Anguillidae, Hemirhampidae, Leiognathidae, Apogonidae, Pomadasydae, Terapontidae and Sillaginidae, typically associated with shallow coastal waters and estuaries in tropical regions (DAWE, 2021b).

Off the WA Kimberley coast, the development of infrastructure, mostly associated with the petroleum industry and iron ore activities, and seismic surveys and petroleum explorations are of concern and are suspected to have an impact at the local level at all affected sites. This threat to Australian snubfin dolphins is considered likely to continue into the future, with the potential to increase its impact as habitat degradation and loss increase with increased human population requirements (DAWE, 2021b).

The PMST indicates that the species is known to occur within the EMBA. The EMBA overlaps with the resting, calving, breeding and foraging BIA as outlined in Table 5.5 and Figure 5.35.

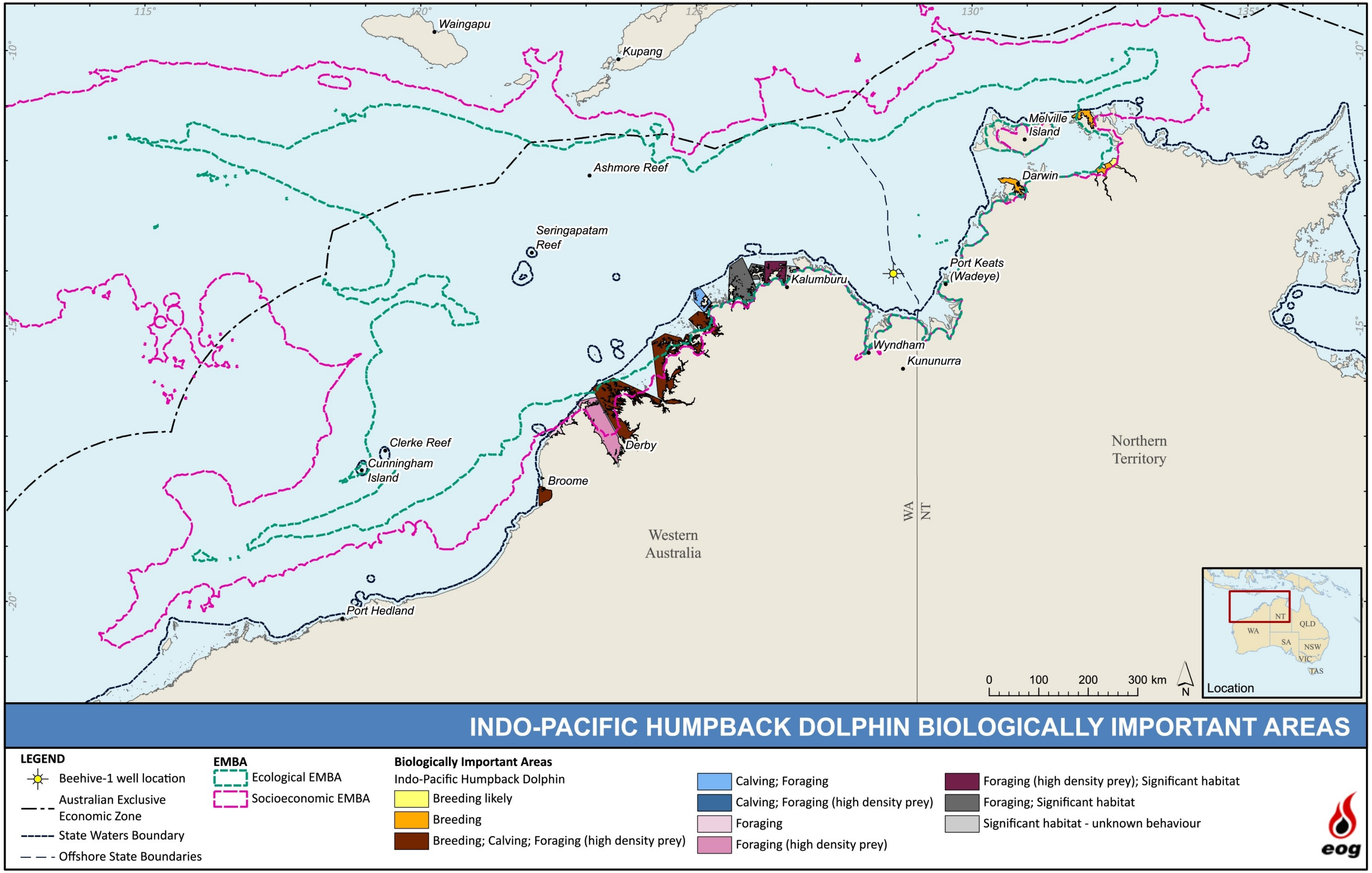


Figure 5.34. Australian humpback dolphin BIA intersected by the spill EMBA

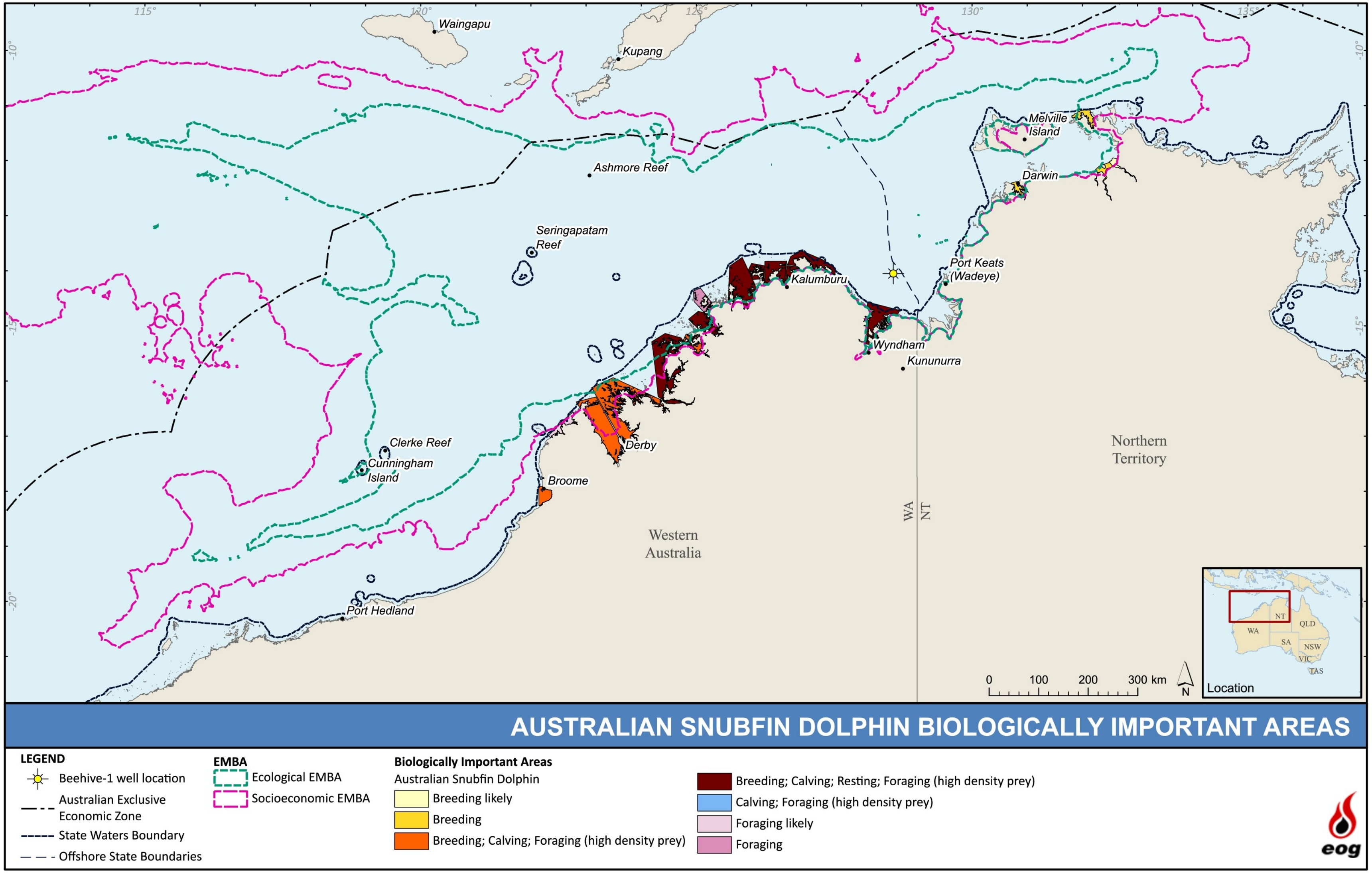


Figure 5.35. Australian snubfin dolphin BIA intersected by the spill EMBA

Dugong (EPBC Act: Listed marine, migratory)

Dugongs are described in Section 5.4.5 of Chapter 5.

Dugongs have been reported to occur along the coastline from Cape Hay to Pearce Point with the main populations concentrated around Dorcherty Island (Woodside, 2004), approximately 102 km east of the drill site. The closest dugong foraging BIA is located south of Ashmore Reef, with additional foraging BIA on the Kimberley coastline off the Dampier Archipelago (within the spill EMBA) (see Table 5.5). Ashmore Reef supports a population of less than 50 individuals that are genetically distinct from other Australian populations. The reef provides breeding and feeding habitats, with seagrass beds of the reef flats and lagoon their preferred food source. Breeding occurs year round at Ashmore Reef (DoEE, 2019a). An additional three BIAs for this species overlaps with the EMBA (see Table 5.5 and Figure 5.36).

Therefore, dugongs are likely to be present in the nearshore areas of the spill EMBA.

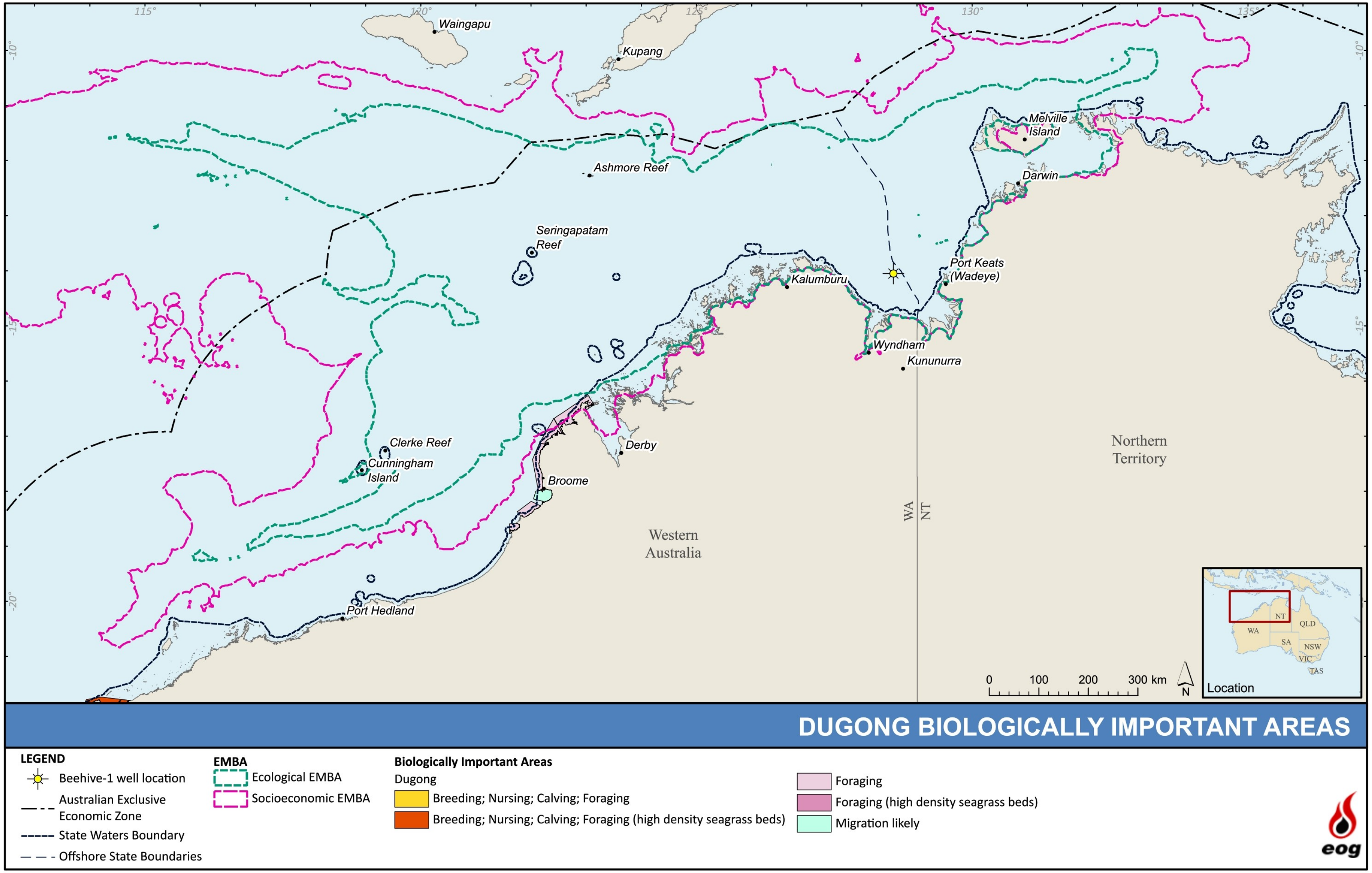


Figure 5.36. Dugong BIA intersected by the spill EMBA

5.3.6. Marine Reptiles

Six species of marine turtle are listed under the EPBC Protected Matters Search Tool (PMST) as potentially occurring in the EMBA, as listed in Table 5.6 (DAWE, 2022). Three of the turtle species are listed as endangered, with the other three listed as vulnerable. Additionally, 26 species of seasnake were identified as potentially occurring in the EMBA (two of which are listed as critically endangered). Two species of crocodile were also identified.

Species of marine turtles listed in Table 5.6 occur in and nest on the sandy beaches of WA, all of which are likely to be present within the spill EMBA. Details on these species are provided in this section. Ecological stages and temporal occupation of the turtle species is presented in Figure 5.20 in Section 5.4.6 of Chapter 5.

BIAs for turtle species that overlap the EMBA are presented in Table 5.7.

Table 5.6 EPBC Act-listed marine reptiles that may occur in the spill EMBA

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by spill EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Turtles								
Caretta caretta	Loggerhead turtle	E	Yes	Yes	Yes	Yes	Yes	F
Chelonia mydas	Green turtle	V	Yes	Yes	Yes	Yes	Yes	I, F
Dermochelys coriacea	Leatherback turtle	E	Yes	Yes	Yes	Yes	Yes	-
Eretmochelys imbricate	Hawksbill turtle	V	Yes	Yes	Yes	Yes	Yes	-
Lepidochelys olivacea	Olive ridley turtle	E	Yes	Yes	Yes	Yes	Yes	I, F
Natator depressus	Flatback turtle	V	Yes	Yes	Yes	Yes	Yes	I, F
Seasnakes								
Acalyptophis peronii	Horned seasnake	-	-	Yes	Yes	-	No	-
Aipysurus apraefrontalis	Short-nosed seasnake	CE	-	Yes	Yes	Yes	No	CA
Aipysurus duboisii	Dubois' seasnake	-	-	Yes	Yes	Yes	No	-
Aipysurus eydouxii	Spine-tailed seasnake	-	-	Yes	Yes	Yes	No	-
Aipysurus foliosquama	Leaf-scaled seasnake	CE	-	Yes	Yes	Yes	No	CA
Aipysurus fuscus	Dusky seasnake	-	-	Yes	Yes	Yes	No	-
Aipysurus laevis	Olive seasnake	-	-	Yes	Yes	Yes	No	-
Aipysurus tenuis	Brown-lined seasnake	-	-	Yes	Yes	Yes	No	-
Astrotia stokesii	Stokes' seasnake	-	-	Yes	Yes	Yes	No	-

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by spill EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Disteira kingii	Spectacled seasnake	-	-	Yes	Yes	Yes	No	-
Disteira major	Olive-headed seasnake	-	-	Yes	Yes	Yes	No	-
Emydocephalus annulatus	Turtle-headed seasnake	-	-	Yes	Yes	Yes	No	-
Enhydrina schistosa	Beaked seasnake	-	-	Yes	Yes	Yes	No	-
Ephalophis greyi	North-western mangrove seasnake	-	-	Yes	Yes	Yes	No	-
Hydrelaps darwiniensis	Black-ringed seasnake	-	-	Yes	Yes	Yes	No	-
Hydrophis atriceps	Black-headed seasnake	-	-	Yes	Yes	Yes	No	-
Hydrophis coggeri	Slender-necked seasnake	-	-	Yes	Yes	Yes	No	-
Hydrophis czeblukovi	Fine-spined seasnake	-	-	Yes	Yes	Yes	No	-
Hydrophis elegans	Elegant seasnake	-	-	Yes	Yes	Yes	No	-
Hydrophis inornatus	Plain seasnake	-	-	Yes	Yes	Yes	No	-
Hydrophis mcdowelli	Small-headed seasnake	-	-	Yes	Yes	Yes	No	-
Hydrophis ornatus	Spotted seasnake	-	-	Yes	Yes	Yes	No	-
Hydrophis pacificus	Large-headed seasnake	-	-	Yes	Yes	Yes	No	-

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by spill EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Lapemis hardwickii	Spine-bellied seasnake	-	-	Yes	Yes	Yes	No	-
Parahydrophis mertoni	Northern mangrove seasnake	-	-	Yes	Yes	Yes	No	-
Pelamis platurus	Yellow-bellied seasnake	-	-	Yes	Yes	Yes	No	-
Crocodiles								
Crocodylus johnstoni	Freshwater crocodile	-	-	Yes	Yes	Yes	No	-
Crocodylus porosus	Salt-water crocodile	-	Yes	Yes	Yes	Yes	No	-

Legend and key is the same as Table 5.2.

Table 5.7. BIAs of marine turtles within the EMBA

Species	BIA	Location within the EMBA
Loggerhead turtle	Foraging	James Price Point. Western Joseph Bonaparte Depression.
Green turtle	Foraging	Field Island (west and east). Joseph Bonaparte Gulf. James Point Price. Montgomery Reef.
	Inter-nesting	Islands north-east of Cobourg Peninsula. Northwest of Melville Island. Lacepede Island. Montebello Islands.
	Inter-nesting buffer	Islands north-east of Cobourg Peninsula (20 km buffer). Northwest of Melville Island (20 km buffer). Cassini Island. Cartier Island. Ashmore Reef. Scott Reef.
	Nesting	Cassini Island (low density nesting site). Ashmore Reef (low density nesting site). Scott Reef (major nesting site).
	Mating	Montebello Islands (very high-density mating aggregations in inner lagoons and sheltered beaches).
Leatherback turtle	Inter-nesting	Cobourg Peninsula.
Hawksbill turtle	Foraging	Ashmore Reef. Cartier Island.
	Inter-nesting	Islands north-east of Cobourg Peninsula. Greenhill Island (off Cobourg Peninsula). Ashmore Reef. Scott Reef. Dampier Archipelago (islands to the west of the Burrup Peninsula). Barrow Island. Thevernard Island.
	Inter-nesting buffer	Ashmore Reef. Scott Reef. Islands north-east of Cobourg Peninsula (20 km buffer). Greenhill Island (off Cobourg Peninsula) (20 km buffer). Dampier Archipelago (islands to the west of the Burrup Peninsula). Barrow Island
	Nesting	Ashmore Reef (low density nesting site). Scott Reef. West of Cape Lambert. Dampier Archipelago (islands to the west of the Burrup Peninsula). Barrow Island. Thevernard Island and south coast.
Olive ridley turtle	Foraging	Fog Bay Northern Joseph Bonaparte Gulf Western Joseph Bonaparte Depression Joseph Bonaparte Gulf Western Joseph Bonaparte Gulf - banks

Species	BIA	Location within the EMBA
	Inter-nesting	Islands north-east of Cobourg Peninsula Greenhill Island (off Cobourg Peninsula) Bathurst Island/Melville Island - North-west Fog Bay and the Cox Peninsula
Flatback turtle	Foraging	Western Joseph Bonaparte Depression James Price Point.
	Inter-nesting	Melville Island, Cobourg Peninsula. Scott Reef. Lacepede Island. Montebello Islands.
	Inter-nesting buffer	Melville Island, Cobourg Peninsula (80 km buffer). Cape Domett. Lacepede Island. Eighty Mile Beach. Delambre Island. Legendre Island, Huay Island. Dampier Archipelago (islands to the west of the Burrup Peninsula). Montebello Islands – Hermite Island, Northwest Island, Trimouille Island. Thevernard Island - South coast.
	Nesting	Dampier Archipelago (islands to the west of the Burrup Peninsula) Delambre Island Legendre Island, Huay Island. Montebello Islands – Hermite Island, Northwest Island, Trimouille Island.

Loggerhead turtle (EPBC Act: Endangered, listed migratory)

Loggerhead turtles are described in Section 5.4.6 of Chapter 5.

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. Two foraging BIAs for the loggerhead turtle overlap with the socio-economic EMBA (see Table 5.7 and Figure 5.37).

Green turtle (EPBC Act: Vulnerable, listed migratory)

Green turtles are described in Section 5.4.6 of Chapter 5.

Nesting on the Scott Reef-Sandy Islet and Browse Island has been observed all year round with peaks between December and January (DoEE, 2017a). Satellite tracking studies have shown that green turtles migrate between breeding beaches and feeding grounds off the northwest coast (Pendoley, 2005). However, during the internesting periods green turtles are known to remain within 10 km of nesting beaches (Waayers *et al.,* 2011). The foraging, nesting and interesting BIAs critical to the survival of green turtles that overlap the EMBA are presented in Table 5.7.

The NCVA identifies that the EMBA overlaps the foraging BIA for this species (Figure 5.38). As such, green turtles are likely to occur in the EMBA. The closest nesting and interesting BIAs are also intersected by the EMBA (Table 5.7 and Figure 5.38).

Leatherback turtle (EPBC Act; Endangered, listed migratory)

Leatherback turtles are described in Section 5.4.6 of Chapter 5.

No major nesting has been recorded in Australia, with isolated nesting recorded in Queensland and the NT (DSEWPaC, 2012). Nesting occurs on tropical beaches and subtropical beaches (Marquez 1990), but no major centres of nesting activity have been recorded in Australia. The species is understood to migrate from Australian waters to breed at larger rookeries in neighbouring countries such as Indonesia, Papua New Guinea and Solomon Islands between December and January (DoE, 2015b). The closest confirmed inter-nesting site for the leatherback turtle is at Cobourg Peninsula (DAWE, 2021b) located in the eastern extent of the EMBA (Table 5.7 and Figure 5.39).

Flatback turtle (EPBC Act: Vulnerable, listed migratory)

The flatback turtle (*Natador depressus*) is only found in Australian waters and some nearby waters in Indonesia and Papua New Guinea. It is commonly found in the NWMR and NMR, nesting in northern Australia and foraging in the region.

Breeding occurs all year round; however, in northern Australia most nesting occurs between June and August (DAWE, 2021b). Flatback turtle nesting is widespread across the islands and mainland beaches east of Dampier Peninsula in winter, with Cape Domett (within the spill EMBA) reported to support the highest density (Whiting *et al*., 2008). Flatback turtles nest at Cape Domett throughout the year. The Recovery Plan for Marine Turtles in Australia 2017 -2027 (DoEE, 2017c) notes that the peak nesting period at Cape Domett is July to September. 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).

The 60 km inter-nesting buffer for flatback turtles in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017) is based primarily on the movements of tagged inter-nesting flatback turtles along the Northwest Shelf reported by Whittock et al (2014), which found that flatback turtles may demonstrate inter-nesting displacement distances up to 62 km from nesting beaches. However, these movements were confined to longshore movements in nearshore coastal waters or travel between island rookeries and the adjacent mainland (Whittock *et al*., 2014). There is no evidence to date to indicate flatback turtles swim out into deep offshore waters during the inter-nesting period. Flatback turtle hatchlings do not have an offshore pelagic phase. Instead, hatchlings grow to maturity in shallow coastal waters thought to be close to their natal beaches (DoEE, 2017c). Flatback turtle hatchlings do not undertake oceanic migrations like the juveniles of other turtle species do, but spend their juvenile life phase within continental shelf waters. The EMBA intersects an inter-nesting BIA, as illustrated in Figure 5.40 and outlined in Table 5.7.

Adult flatback turtles are primarily carnivorous, feeding on soft-bodied invertebrates. Juveniles eat gastropod molluscs, squid, siphonophores, and limited data indicate that cuttlefish, hydroids, soft corals, crinoids, molluscs and jellyfish are also eaten (DAWE, 2021b). The species has been recorded foraging in depths less than 10 m to over 40 m on the carbonate bank and terrace system of the Sahul Shelf KEF and around the pinnacles of the Bonaparte Basin KEF. The EMBA intersects a foraging BIA located in the Bonaparte Basin, as illustrated in Figure 5.40 and outlined in Table 5.7.

The NCVA identifies the area out to 60 km offshore from Cape Domett and Lacrosse Island in the Cambridge Gulf as an inter-nesting BIA for flatback turtles, which is intersected by the EMBA. Hence, it is likely that flatback turtles will be present in the EMBA.

Olive Ridley turtle (EPBC Act: Endangered, listed migratory)

The olive ridley turtle (*Lepidochelys olivacea*) has a worldwide tropical and sub-tropical distribution and is known to occur in both WA and the NT (DSEWPC, 2012c). While nesting has been recorded in WA, it is far more common in the NT (DSEWPC, 2012).

Although olive ridley turtles nest all year round, nesting activity peaks around April to November, with the majority of nesting occurring from the Arnhem Land coast (including Bathurst Island, within the EMBA) to the northwest coast of Cape York Peninsula (Qld) (outside of the EMBA) (DSEWPC, 2012). After nesting, Olive Ridley turtles are known to migrate up to 1,050 km to various foraging areas (DAWE, 2021b), including the pinnacles of the Bonaparte Basin and the carbonate bank and terrace system of the Sahul Shelf KEF (DSEWPC, 2012).

The EMBA overlaps with the inter-nesting BIA of the olive ridley turtle located between Fog Bay and the Cox Peninsula (NT) (see Table 5.7 and Figure 5.41).

The olive ridley turtle is known to primarily forage in soft-bottom habitats ranging in depths from 6 – 35 m, though they are also known to forage in pelagic waters (DEWHA 2008a). Adult turtles forage for crabs, shrimp, tunicates, jellyfish, salps and algae in depths ranging from several metres to over 100 m (DAWE, 2021b). The NCVA identifies that EMBA overlaps with the foraging BIA for this species as outlined in Table 5.7 and Figure 5.41.

Hawksbill turtle (EPBC Act: Vulnerable, listed migratory)

Hawksbill turtles (*Eretmochelys imbricate*) are found in tropical, sub-tropical and temperate waters in all the oceans of the world (DoEE, 2019e). The hawksbill turtle is commonly found in the NWMR and NMR, nesting extensively along the coasts and foraging in the region.

As a juvenile, the hawksbill turtle feeds on plankton in the open ocean and then feeds on sponges, hydroids, cephalopods, gastropods, jellyfish, seagrass and algae as an adult (DAWE, 2021b). The species is also highly migratory, moving up to 2,400 km between foraging and breeding areas (DSEWPC, 2012). Due to genetic variability, Australia's population is considered to comprise of two distinct stocks; one in WA and the other in the northeast of Australia (DSEWPC, 2012). These distinct populations are also known to have significantly different breeding seasons.

Hawksbill turtles forage in waters ranging from 1.5 m to 84 m deep, and Fossette et al (2021) report that 17% of satellite tagged turtles (total n=42) foraged in waters greater than 20 m. Fossette et al (2021) reported less than a quarter of foraging area overlapped with designated foraging BIAs for hawksbill turtles (within the spill EMBA) and/or Commonwealth and State-managed protected areas.

The northeast sub-population breeds throughout the year with a peak nesting period during July to October (DSEWPaC, 2012), while in the WA population breeding peaks around October to January.

The EMBA overlaps with foraging, nesting and inter-nesting BIAs for this species (see Table 5.7 and Figure 5.42.

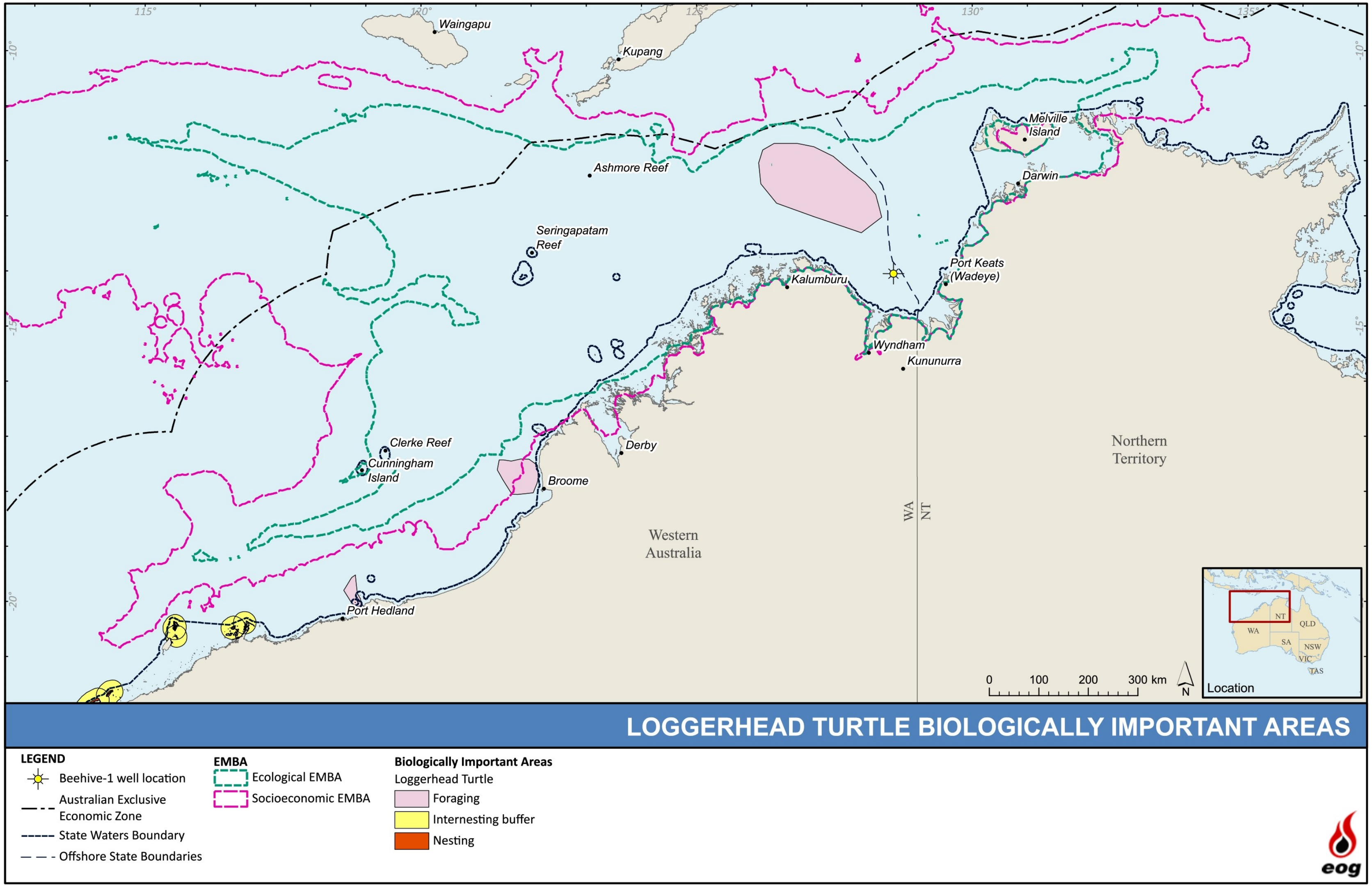


Figure 5.37. Loggerhead turtle BIA intersected by the spill EMBA

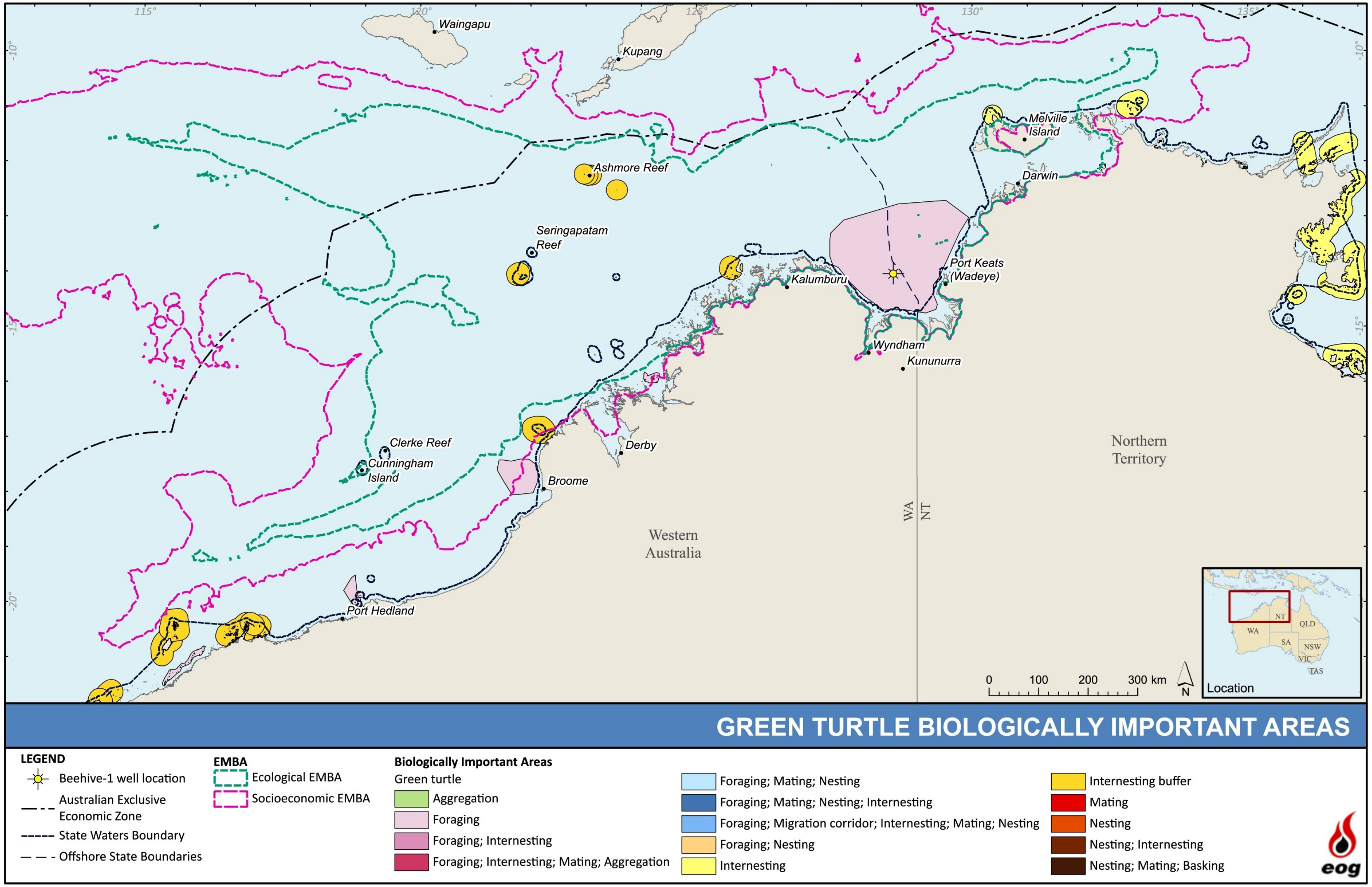


Figure 5.38. Green turtle BIA intersected by the spill EMBA

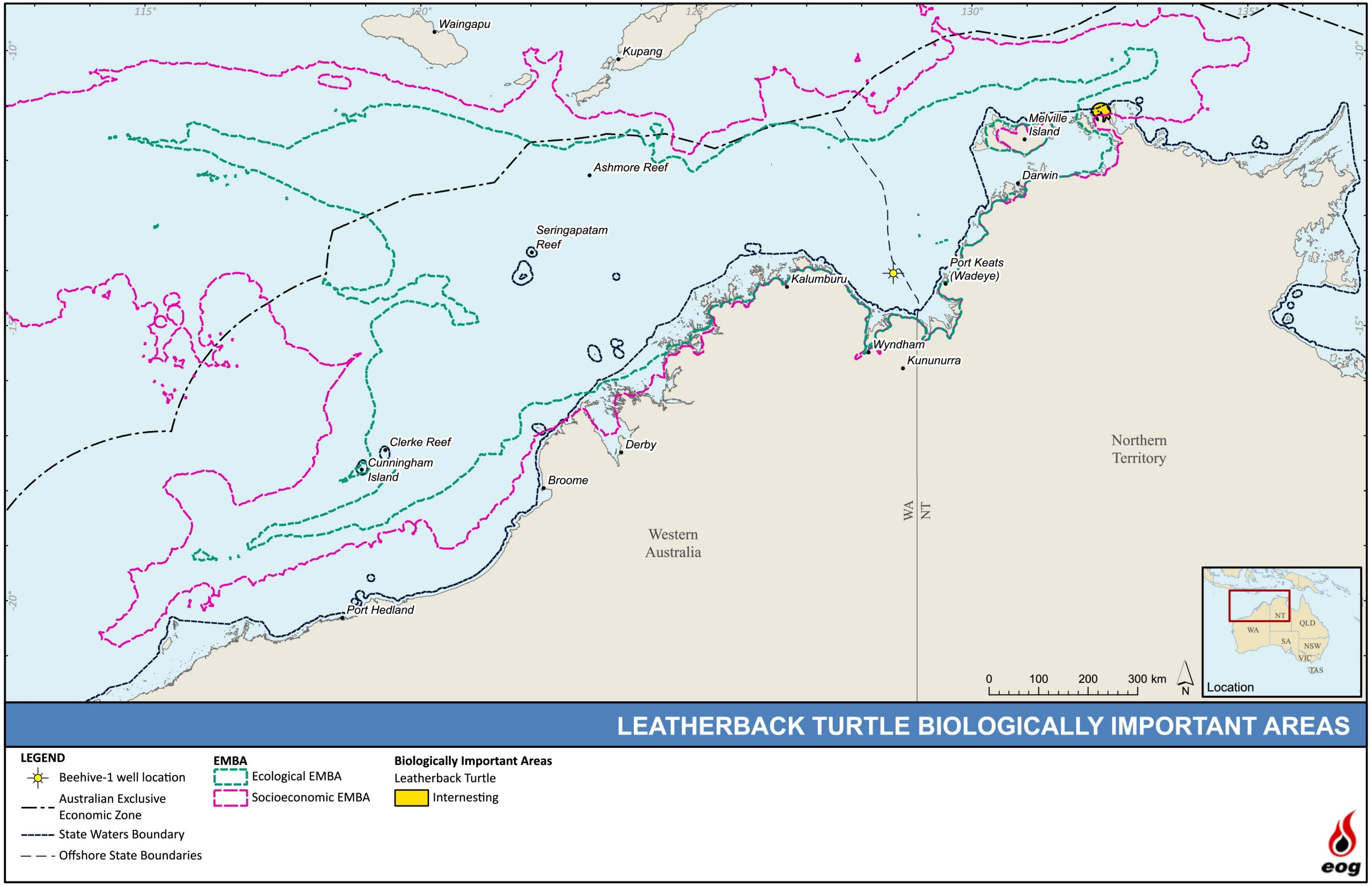


Figure 5.39. Leatherback turtle BIA intersected by the spill EMBA

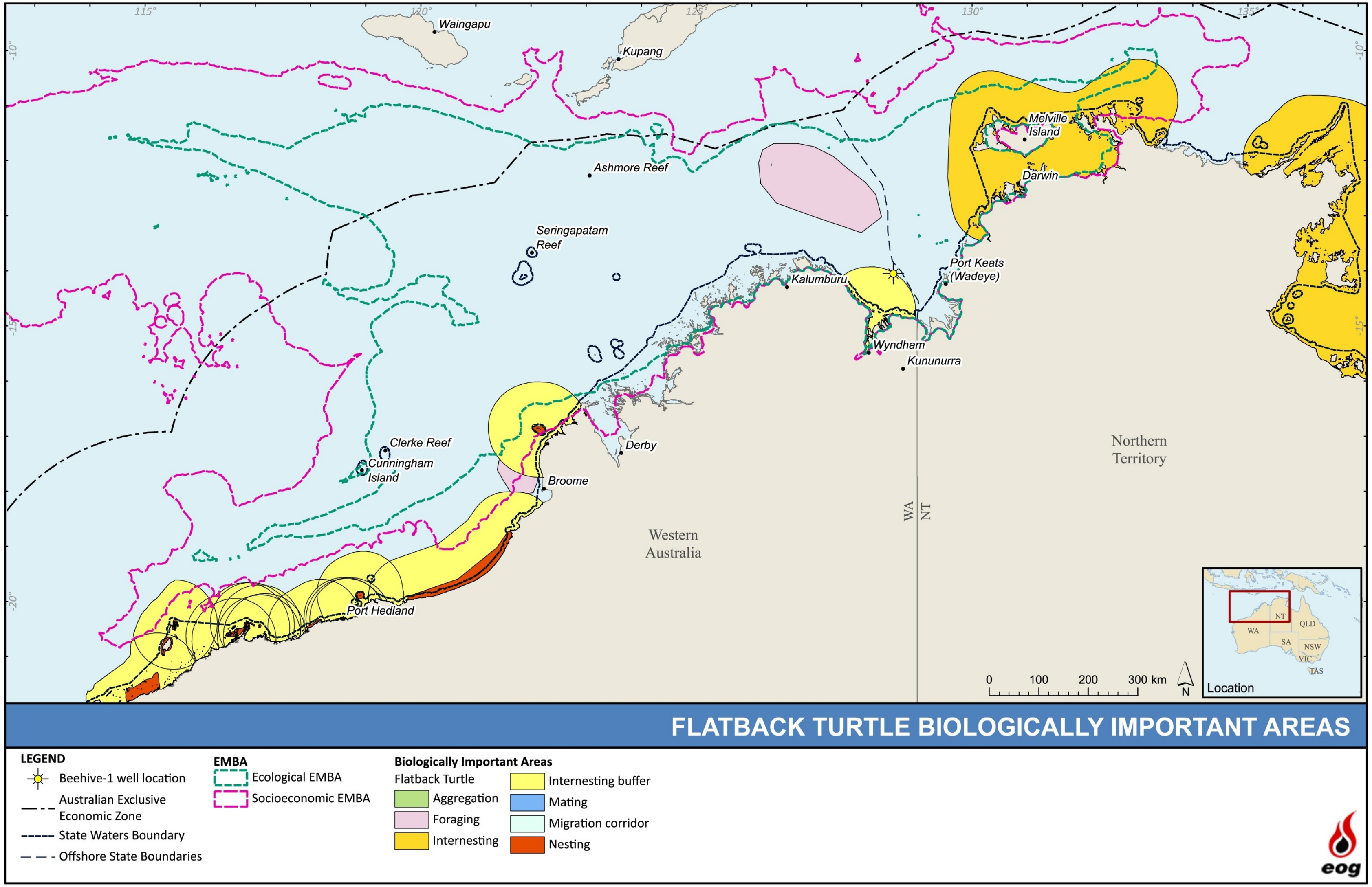


Figure 5.40. Flatback turtle BIA intersected by the spill EMBA

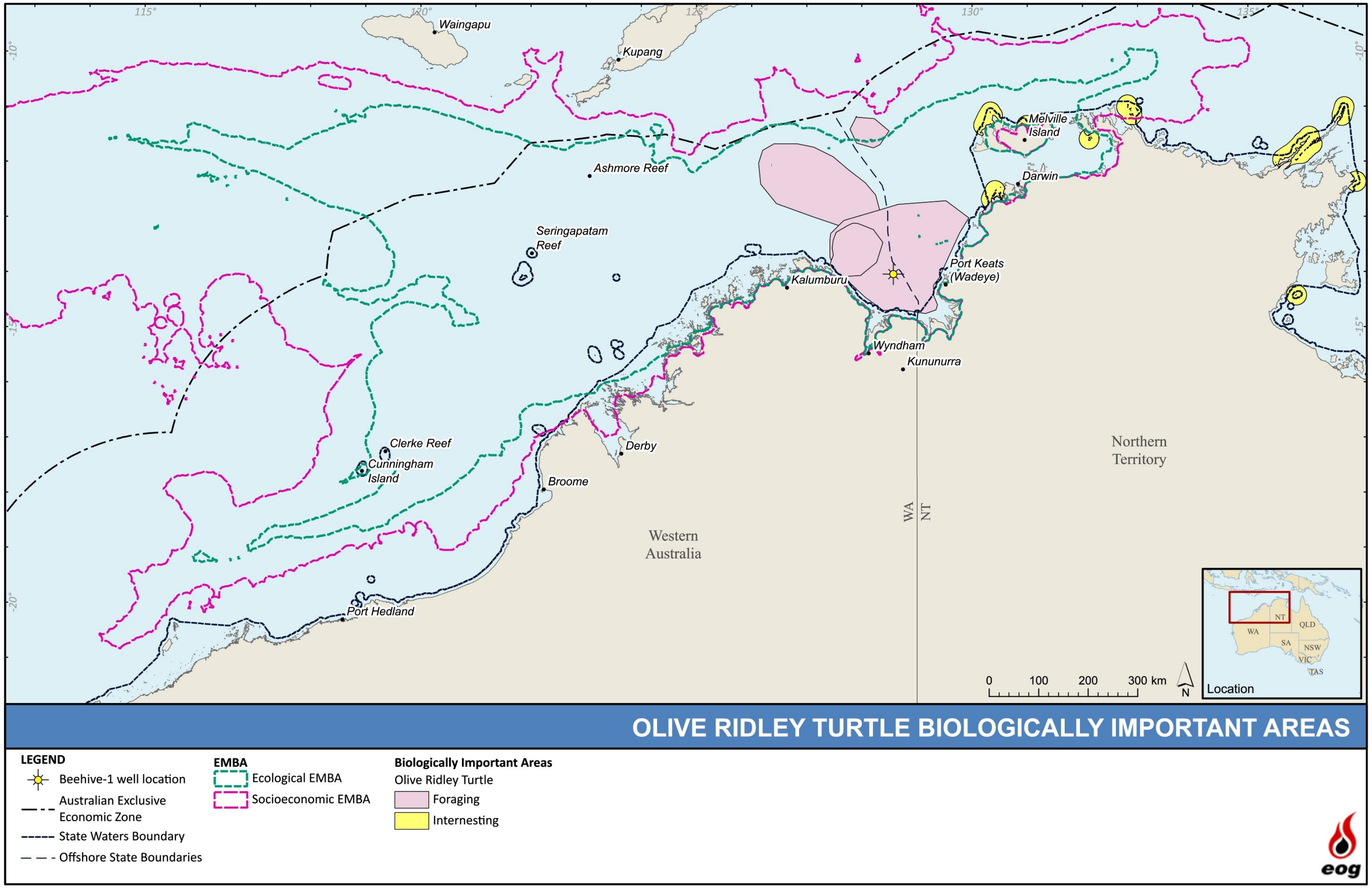


Figure 5.41. Olive Ridley turtle BIA intersected by the spill EMB

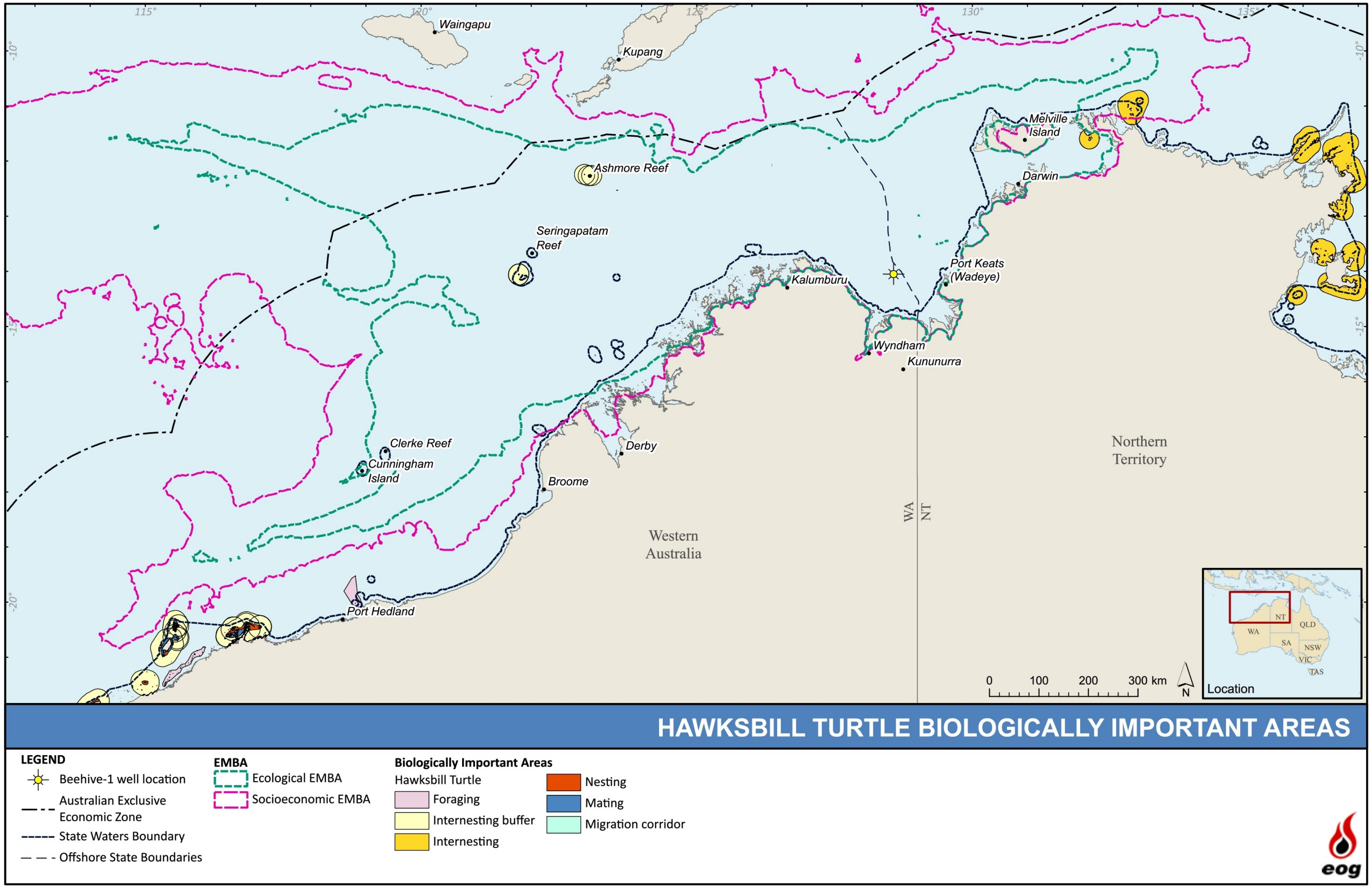


Figure 5.42. Hawksbill turtle BIA intersected by the spill EMBA

Short-nosed seasnake (EPBC Act: Critically Endangered)

The short-nosed seasnake (*Aipysurus apraefrontalis*) is endemic to WA and occurs throughout the Northwest Shelf and eastern Indian Ocean. This fully aquatic species can grow up to 90 cm in length and prefers shallow coastal reef habitats.

Given the shallow water distribution of the species it is unlikely the species will occur within the activity area, however the species and species habitat may occur in the spill EMBA. Cartier Island and Ashmore Reef are internationally significant sites for their abundance and diversity of seasnakes, both of which are located outside the EMBA.

Leaf-scaled seasnake (EPBC Act: Critically Endangered)

The only known populations of the leaf-scaled seasnake (*Aipysurus foliosquama*) species inhabit the shallow reef habitats of the Sahul Shelf and Ashmore Reef (Minton and Heatwole, 1975), which are both located outside the activity area and EMBA.

Given the shallow water distribution, it is unlikely the species will occur within the activity area, but the species and species habitat is known to occur in the EMBA.

Saltwater crocodile (EPBC Act: Listed migratory)

The saltwater crocodile (*Crocodylus porosus*) is distributed from King Sound, WA throughout coastal NT to Rockhampton in Queensland, where it can be found in coastal waters, estuaries, lakes, inland swamps and marshes up to 150 km inland from the coast (DAWE, 2021b).

Preferred nesting habitat of the saltwater crocodile includes elevated, isolated freshwater swamps that do not experience the influence of tidal movements. Floating rafts of vegetation also provide important nesting habitat. In the NT, most nest sites are found on the north-west banks of rivers (DAWE, 2021b). The species nest during the wet season with peak nesting during January and February. Whilst sightings of saltwater crocodiles far out to sea have been recorded, it is more likely to be encountered in the coastal areas of the socio-economic EMBA than in the activity area.

5.3.7. Avifauna

There are 84 bird species (31 seabirds and 52 shorebirds) listed under the EPBC Act with potential to occur in the spill EMBA (DAWE, 2022).

The majority of these are listed as migratory and marine species, with four listed as critically endangered, five as endangered and three as vulnerable. The PMST results includes terrestrial species of birds that are protected under the EPBC Act. Figure 5.25 in Section 5.4.7 of Chapter 5 illustrates the likely temporal presence and absence and ecological stages of these bird species in the activity area and EMBA. The species listed as threatened (Table 5.8) or with a BIA intersected by the EMBA (see Table 5.9) are described in this section.

Many of the birds listed in Table 5.8 are listed in the following international conventions that aim to protect the birds themselves and their habitat:

- Republic of Korea Migratory Birds Agreement 2006 (ROKAMBA);
- Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986 (CAMBA);
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) 1979;
- Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment 1974 (JAMBA); and
- Convention on Wetlands of International Important especially as Waterfowl Habitat 1971 ('Ramsar Convention', see also Section 5.4.4).

Table 5.8. EPBC Act-listed bird species that may occur in the spill EMBA

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by ecological EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Seabirds								
Anous stolidus	Common noddy	-	Yes	Yes	Yes	Yes	No	-
Anous tenuirostris melanops	Australian lesser noddy	V	-	Yes	Yes	Yes	No	CA
Anous minutus	Black noddy	-	-	Yes	Yes	Yes	No	No
Anseranas semipalmata	Magpie goose	-	-	Yes	Yes	Yes	No	No
Ardenna pacifica	Wedge-tailed shearwater	-	Yes	Yes	Yes	Yes	Yes	-
Bubulcus ibis	Cattle egret	-	-	Yes	Yes	Yes	Yes	-
Calonectris leucomelas	Streaked shearwater	-	Yes	Yes	Yes	Yes	No	-
Chalcites osculans	Black-eared cuckoo	-	-	Yes	Yes	Yes	No	No
Fregata andrewsi	Christmas Island Frigatebird	E	Yes	Yes	Yes	Yes	No	-
Fregata ariel	Lesser frigatebird	-	Yes	Yes	Yes	Yes	Yes	-
Fregata minor	Greater frigatebird	-	Yes	Yes	Yes	Yes	Yes	-
Haliaeetus leucogaster	White-bellied sea-eagle	-	-	Yes	Yes	Yes	No	-
Hydroprogne caspia	Caspian tern	-	Yes	Yes	Yes	Yes	No	-
Macronectes giganteus	Southern giant petrel	E	Yes	Yes	-	Yes	No	RP
Onychoprion anaethetus	Bridled tern	-	Yes	Yes	Yes	Yes	Yes	-

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by ecological EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Pandion haliaetus	Osprey	-	Yes	Yes	Yes	Yes	No	-
Papasula abbotti	Abbott's booby	E	-	Yes	Yes	Yes	No	CA
Phaethon lepturus	White-tailed tropicbird	-	Yes	Yes	Yes	Yes	Yes	-
Phaethon lepturus fulvus	Christmas Island white-tailed tropicbird	E	-	Yes	Yes	Yes	No	-
Phaethon rubricauda	Red-tailed tropicbird	-	Yes	Yes	Yes	Yes	No	-
Sterna bengalensis	Lesser crested tern	-	-	Yes	Yes	Yes	Yes	-
Sterna bergii	Crested tern	-	Yes	Yes	Yes	Yes	Yes	-
Sterna caspia	Caspian term	-	Yes	Yes	Yes	Yes	No	-
Sterna dougallii	Roseate tern	-	Yes	Yes	Yes	Yes	Yes	-
Sterna fuscata	Sooty tern	-	-	Yes	Yes	Yes	No	-
Sterna nereis	Fairy tern	-	-	Yes	Yes	Yes	No	-
Sternula albifrons	Little tern	-	Yes	Yes	Yes	Yes	Yes	-
Sula dactylatra	Masked booby	-	Yes	Yes	Yes	Yes	No	-
Sula leucogaster	Brown booby	-	Yes	Yes	Yes	Yes	Yes	-
Sula sula	Red-footed booby	-	Yes	Yes	Yes	Yes	Yes	-
Thalassarche carteri	Indian yellow-nosed albatross	V	Yes	Yes	-	-	No	-
Shorebirds								

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by ecological EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Acrocephalus orientalis	Oriental reed-warbler	-	Yes	Yes	Yes	Yes	No	-
Actitis hypoleucos	Common sandpiper	-	Yes	Yes	Yes	Yes	No	-
Apus pacificus	Fork-tailed swift	-	Yes	Yes	Yes	Yes	No	-
Arenaria interpres	Ruddy turnstone	-	Yes	Yes	Yes	Yes	No	-
Calidris acuminata	Sharp-tailed sandpiper	-	Yes	Yes	Yes	Yes	No	-
Calidris alba	Sanderling	-	Yes	Yes	Yes	Yes	No	-
Calidris canutus	Red knot	E	Yes	Yes	Yes	Yes	No	CA
Calidris ferruginea	Curlew sandpiper	CE	Yes	Yes	Yes	Yes	No	CA
Calidris melanotos	Pectoral sandpiper	-	Yes	Yes	Yes	Yes	No	-
Calidris ruficollis	Red-necked stint	-	Yes	Yes	Yes	Yes	No	-
Calidris subminuta	Long-toed stint	-	Yes	Yes	-	Yes	No	-
Calidris tenuirostris	Great knot	CE	Yes	Yes	Yes	Yes	No	CA
Charadrius dubius	Little ringed plover	-	Yes	Yes	-	Yes	No	-
Charadrius leschenaultia	Greater sand plover	V	Yes	Yes	Yes	Yes	No	CA
Charadrius mongolus	Lesser sand plover	E	Yes	Yes	Yes	Yes	No	CA
Charadrius ruficapillus	Red-capped Plover	-	-	Yes	Yes	Yes	No	-
Charadrius veredus	Oriental plover	-	Yes	Yes	Yes	Yes	No	-
Epthianura crocea tunneyi	Alligator Rivers Yellow Chat	E	-	-	Yes	Yes	No	CA
Erythrotriorchis radiatus	Red Goshawk	V	-	-	Yes	Yes	No	CA

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by ecological EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Erythrura gouldiae	Gouldian Finch	E	-	-	Yes	Yes	No	CA
Falco hypoleucos	Grey Falcon	V	-	-	Yes	Yes	No	CA
Gallinago megala	Swinhoe's snipe	-	Yes	Yes	-	Yes	No	-
Gallinago stenura	Pin-tailed snipe	-	Yes	Yes	-	Yes	No	-
Geophaps smithii blaauwi	Partridge Pigeon (western)	V	-	-	-	Yes	No	CA
Geophaps smithii smithii	Partridge Pigeon (eastern)	V	-	-	Yes	Yes	No	CA
Glareola maldivarum	Oriental pratincole	-	Yes	Yes	Yes	Yes	No	-
Himantopus himantopus	Pied Stilt	-	-	Yes	-	Yes	No	-
Limicola falcinellus	Broad-billed Sandpiper	-	Yes	Yes	Yes	Yes	No	-
Larus novaehollandiae	Silver gull	-	-	Yes	-	Yes	No	-
Limnodromus semipalmatus	Asian dowitcher	-	Yes	Yes	Yes	Yes	No	-
Limosa lapponica	Bar-tailed godwit	-	Yes	Yes	Yes	Yes	No	-
Limosa lapponica baueri	Nunivak bar-tailed godwit	V	-	-	Yes	Yes	No	CA
Limosa lapponica menzbieri	Northern Siberian bar-tailed godwit	CE	-	-	Yes	Yes	No	CA
Limosa limosa	Black-tailed godwit	-	Yes	Yes	-	Yes	No	-
Melanodryas cucullata melvillensis	Tiwi Islands Hooded Robin	CE	-	-	Yes	Yes	No	CA
Merops ornatus	Rainbow bee-eater	-	-	Yes	Yes	Yes	Yes	No

Scientific name	Common name	EPBC Act Status			Presence		BIA intersected by ecological EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine	Ecological EMBA	Socio-economic EMBA		
Numenius madagascariensis	Eastern curlew	CE	Yes	Yes	Yes	Yes	No	CA
Numenius minutus	Little curlew	-	Yes	Yes	Yes	Yes	No	-
Numenius phaeopus	Whimbrel	-	Yes	Yes	Yes	Yes	No	-
Pluvialis fulva	Pacific golden plover	-	Yes	Yes	Yes	Yes	No	-
Pluvialis squatarola	Grey plover	-	Yes	Yes	Yes	Yes	No	-
Rostratula australis	Australian painted snipe	E	-	Yes	Yes	Yes	No	CA
Rostratula benghalensis (sensu lato)	Painted snipe	E	-	Yes	-	Yes	No	CA
Stiltia isabell7a	Australian Pratincole	-	-	Yes	Yes	Yes	No	-
Thalasseus bergii	Greater crested tern	-	Yes	Yes	-	Yes	No	-
Tringa brevipes	Grey-tailed tattler	-	Yes	Yes	Yes	Yes	No	-
Tringa glareola	Wood sandpiper	-	Yes	Yes	Yes	Yes	No	-
Tringa incana	Wandering tattler	-	Yes	Yes	Yes	Yes	No	-
Tringa nebularia	Common greenshank	-	Yes	Yes	Yes	Yes	No	-
Tringa stagnatilis	Marsh sandpiper	-	Yes	Yes	Yes	Yes	No	-
Tringa totanus	Common redshank	-	Yes	Yes	Yes	Yes	No	-
Xenus cinereus	Terek sandpiper	-	Yes	Yes	Yes	Yes	No	-

Table 5.9. BIAs of bird species within the EMBA

Species	BIA	Location within the EMBA
Wedge-tailed shearwater	Breeding	Kimberley coastline and islands including Ashmore Reef.
Lesser frigatebird	Breeding	Kimberley coastline and islands including Ashmore Reef.
Greater frigatebird	Breeding	Kimberley and Ashmore Reef.
White-tailed tropicbird	Breeding	Kimberley coastline and islands including Ashmore Reef.
Roseate tern	Foraging	Northwestern coastline and islands including Ashmore Reef.
	Breeding	Kimberley coastline and islands including Ashmore Reef.
Little tern	Breeding and resting	Kimberley coastline and islands including Ashmore Reef.
Crested tern	Breeding (in high numbers)	No. 2 Sandy Island (Cobourg Peninsula). Seagull Island, off NW of Cape Van Diemen, Melville Island
Lesser crested tern	Breeding	Kimberley coastline and islands including Ashmore Reef.
Bridled tern	Breeding (in high numbers)	No. 2 Sandy Island (Cobourg Peninsula).
Brown booby	Breeding	Kimberley and northern Pilbara coasts and islands also Ashmore Reef.
Red-footed booby	Breeding	Northwest Kimberley and Ashmore reef.

Seabirds

Wedge-tailed shearwater (EPBC Act: Listed Migratory)

The wedge-tailed shearwater (*Ardenna pacifica*) is a medium-sized seabird and inhabits oceanic waters off WA except when roosting in colonies. Foraging at sea, the species feeds mostly on fish, cephalopods, insects, jellyfish and prawns. Ashmore Reef has been identified as an important area for this species (DEWHA, 2008b).

According to the National Conservation Values Atlas (NCVA) (DAWE, 2021) the nearest BIA (Ashmore Reef) is greater than 500 km northwest of the drill site. It is likely that the species will be present in the spill EMBA (see Table 5.9 and Figure 5.43).

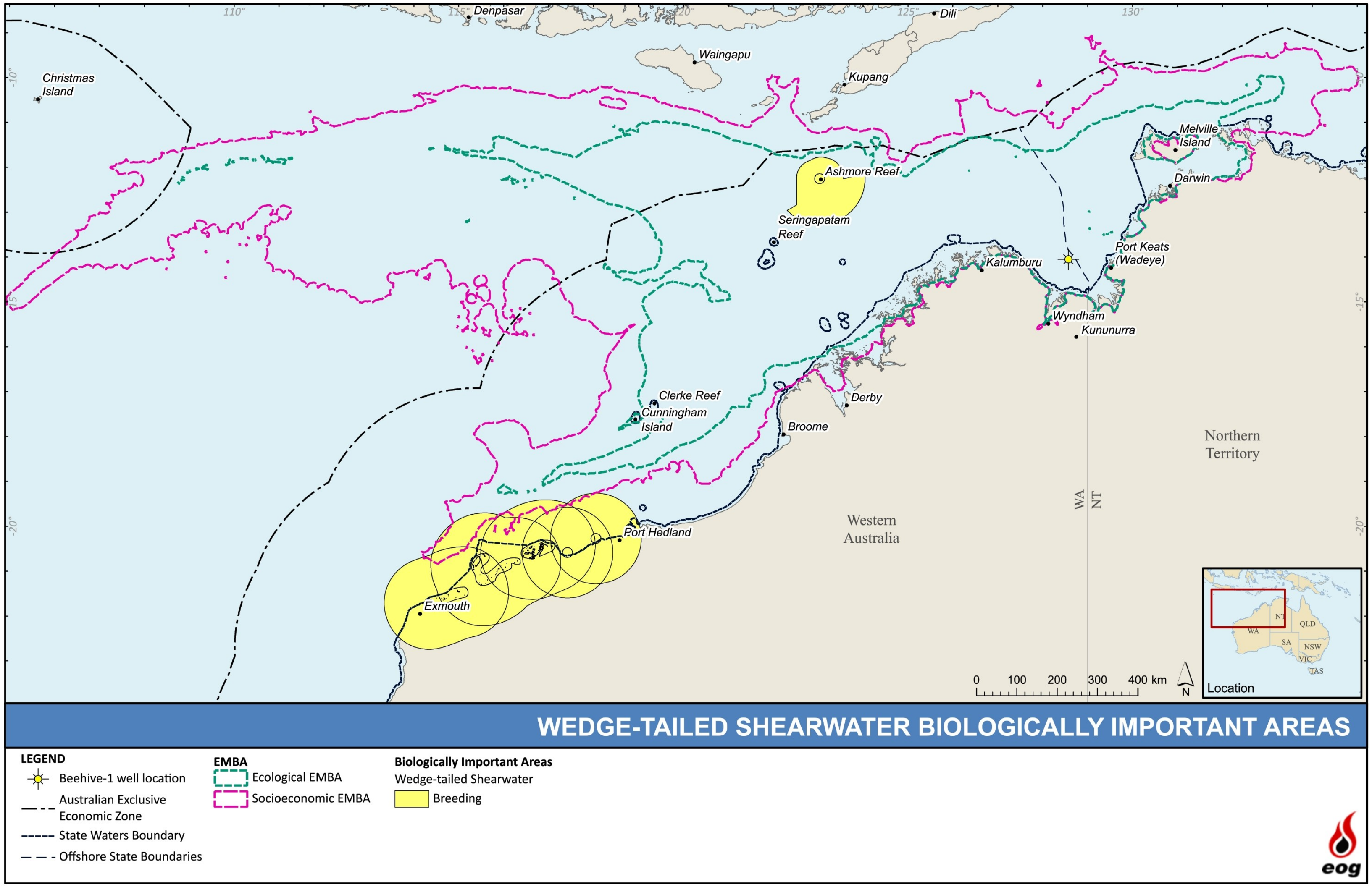


Figure 5.43. Wedge-tailed shearwater BIA intersected by spill EMBA

Christmas Island Frigatebird (EPBC Act: Endangered, Listed Migratory)

The Christmas Island frigatebird (*Fregata andrewsi*) is a very large seabird that primarily forages in the ocean for food, scooping marine organisms such as fish and squid (DAWE, 2021). Christmas Island is the only place in the world where the Christmas Island frigatebird breeds and nests in the forest canopy (DAWE, 2021).

Given the distance to breeding and nesting sites, it is unlikely that this species will be present in the activity or spill EMBA.

Southern giant petrel (EPBC Act: Endangered, Listed Migratory)

The southern giant petrel (*Macronectes giganteus*) is the largest of the petrels. They are a highly migratory bird and widespread throughout the Southern Ocean (DAWE, 2021). This species occurs from Antarctic to subtropical waters and breeds on the Antarctic continent, peninsular and islands and on subantarctic islands and South America. Breeding occurs annually between August and March (DAWE, 2021).

All waters within Australian jurisdiction can be considered foraging habitat, however the most critical foraging habitat is considered to be those waters south of 25 degrees where most species spend the majority of their foraging time. The southern giant petrel is an opportunistic scavenger and predator that scavenge on penguin carcasses and feed on seals and carrions. It also eats a wide variety of seabirds, penguin chicks, crustacean, kelp, fish, jellyfish and rabbits.

Given there are no breeding BIA for this species in the activity area and their preference to forage in southern waters off Australia, it is highly unlikely that the southern giant petrel will be present in the spill EMBA.

Roseate tern (EPBC Act: Listed Migratory)

The roseate tern (*Sterna dougallii*) occurs throughout various coastal habitats including beaches, reefs and sandy/coral islands. It is a specialist forager for small pelagic fish (DAWE, 2021b). The terns prefer nesting sites adjacent to clear shallow hunting areas. Nests are generally a bare scrape in sand, shingle or coral rubble. The species breeds in large mixed-species colonies from April to June, with breeding populations located around Ashmore Reef, Cartier Island and Scott Reef (located in the EMBA) (DEWHA, 2008). Little information is available about migratory movements or timing through the northwest of Australia.

A breeding BIA for the species is intersected by the EMBA at coastal islands off the north Kimberley coast (Table 5.9 and Figure 5.44). Foraging, feeding or related behaviours are likely to occur within the offshore and coastal areas of the EMBA (Table 5.9).

Little tern (EPBC Act: Listed Migratory)

The little tern (*Sternula albifrons*) is a small and slender tern that is found throughout the coast from Broome extending to the NT. Breeding sites are widely distributed across the northwest of WA, with breeding occurring in late April-July and September to early January. There is a lack of information about their migration however however recorded numbers of the species are lowest in the dry season. The EMBA overlaps breeding and resting BIAs for this species along the Kimberley coast and islands including Ashmore Reef (see Table 5.9 and Figure 5.45).

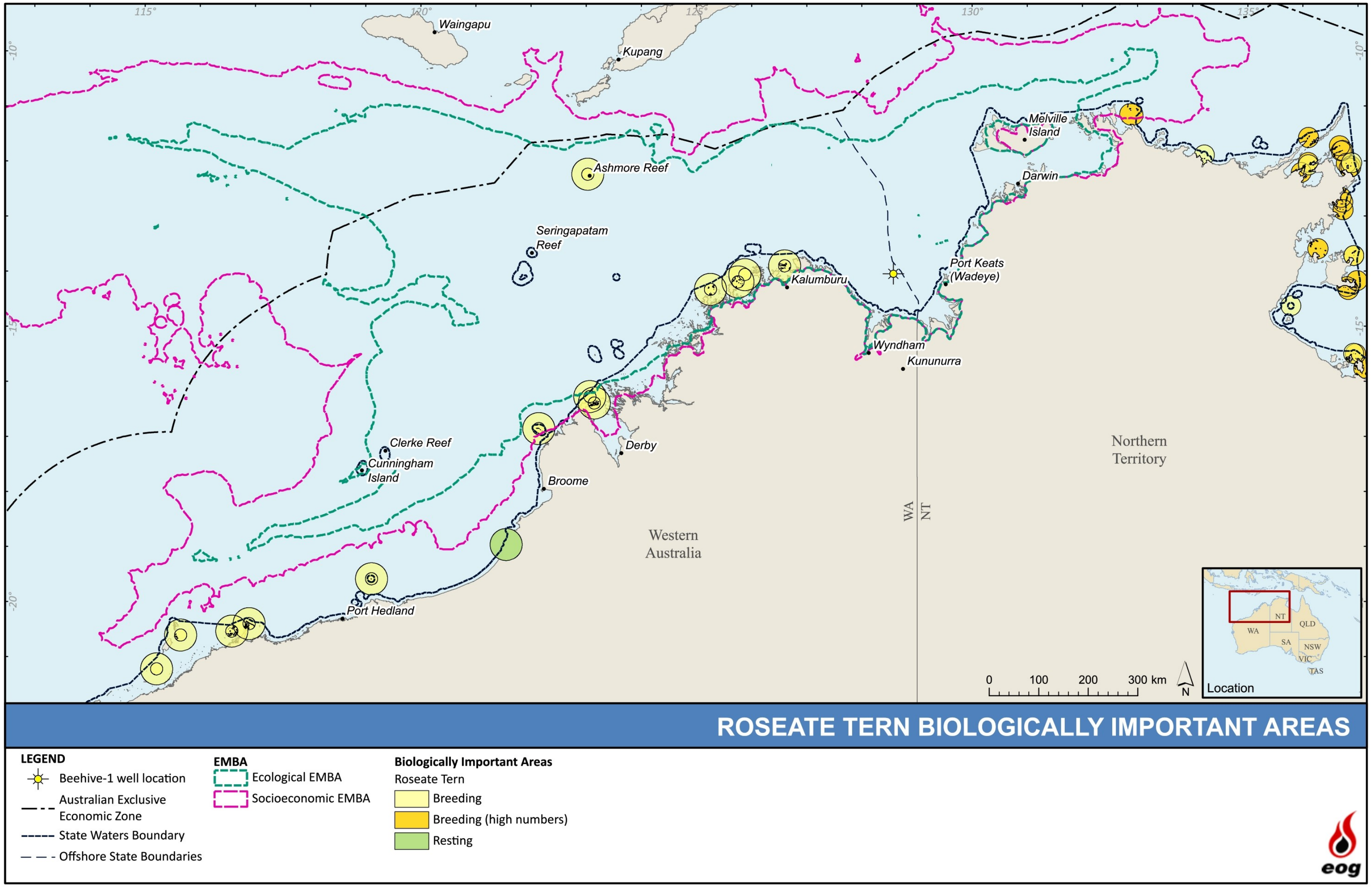


Figure 5.44. Roseate tern BIA intersected by spill EMBA

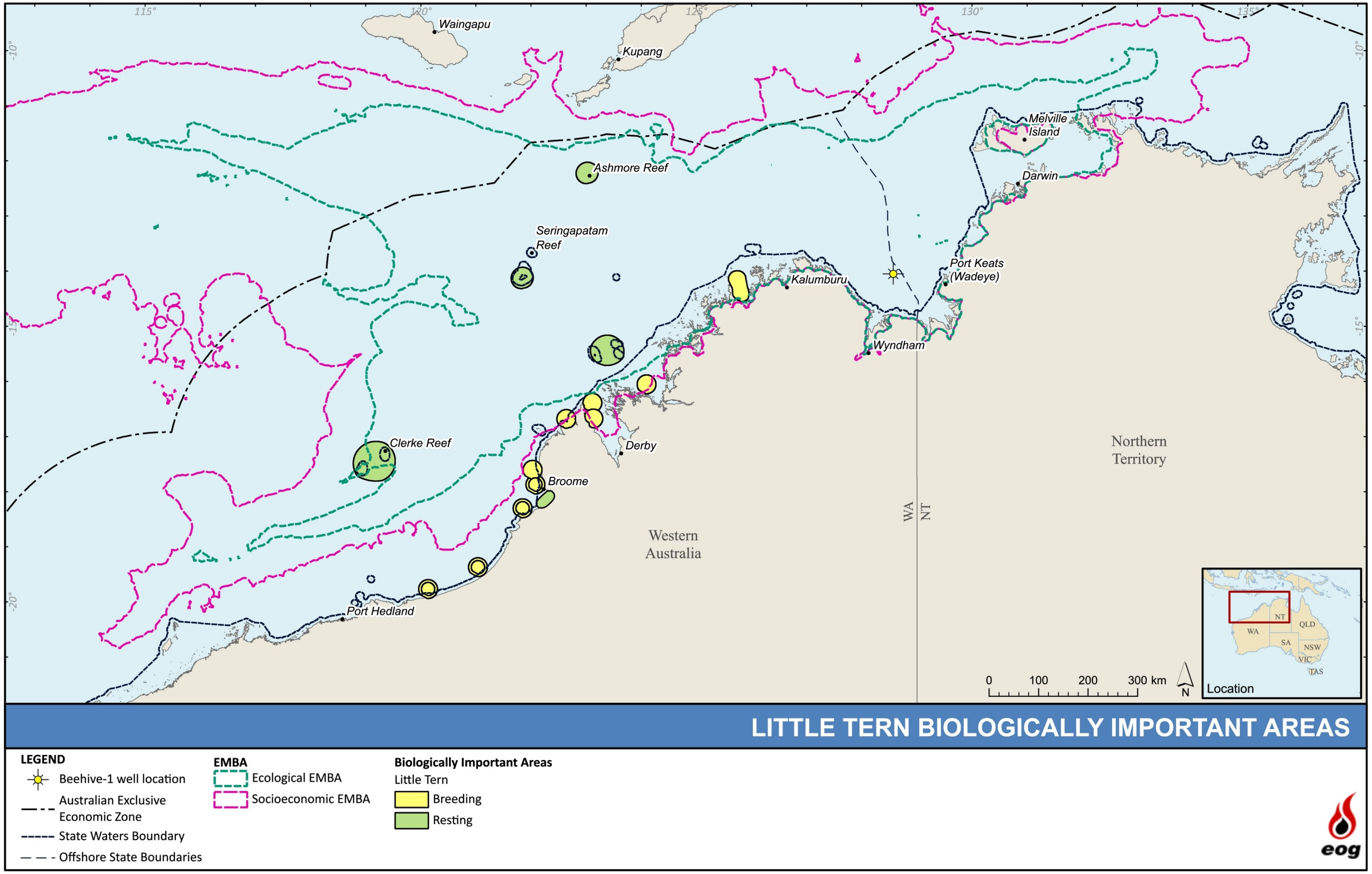


Figure 5.45. Little tern BIA intercepted by the spill EMBA

Lesser frigatebird (EPBC Act: Listed Migratory)

Lesser frigatebirds (*Fregata ariel*) are usually observed in tropical waters around the coast of northern WA, NT, Queensland and NSW (DSEWPC, 2012d). They are often found foraging far offshore, especially during the non-breeding season where some large movements have been recorded (DSEWPC, 2012). During the breeding season (March - September), the lesser frigatebird's range remains close to the breeding colonies (DSEWPC, 2012).

Within the NWMR, the lesser frigatebird is known to breed on Adele, Bedout and West Lacepede islands, Ashmore Reef and Cartier Islands (DSEWPaC, 2012a). Breeding occurs between March and September along the Kimberley and Pilbara coasts and islands (DAWE, 2020b). The EMBA overlaps the Kimberley and Pilbara coasts and islands (including Ashmore Reef) breeding BIA for this species as presented in Table 5.9 and Figure 5.46.

Greater frigatebird (EPBC Act: Listed Migratory)

The great frigatebird (*Fregata minor*) has a global distribution range throughout the world's tropical seas. Great frigatebirds undertake regular migrations across their range. Breeding occurs from May to June and August, with the closest breeding colonies identified on Ashmore Reef and Adele Island (DAWE, 2020b). The great frigatebird forages in pelagic waters within 80 km of the breeding colony or roosting areas (ALA, 2020).

Great frigatebrids commonly eat fish species such as flying fish and squid. Prey is snatched while in flight, either from just below the surface or from the air, in the case of flying fish flushed from the water. The EMBA overlaps with the Kimberley and Ashmore Reef breeding BIAs for this species (Table 5.9 and Figure 5.47).

Lesser crested tern (EPBC Act: Listed Migratory)

The lesser crested tern (*Sterna bengalensis*) inhabits tropical and sub-tropical sandy and coral coasts and estuaries (DSEWPC 2012). In Australia, lesser crested terns are found on coasts and in coastal waters, primarily in northern Australia. The species occurs around most of the NT, with the highest density of confirmed sightings along the coast to the south-west of Darwin (DSEWPC 2012).

The species breeds on low-lying islands, coral flats, sandbanks and flat sandy beaches, and may move nesting sites from one year to the next (DSEWPC 2012). Lesser crested terns forage for small pelagic fish and shrimp in the surf and over offshore waters in areas of reef and deeper shelf waters (DSEWPC 2012). The spill EMBA partially overlaps with a lesser crested tern breeding BIA (Figure 5.48).

The EMBA overlaps with the Kimberley coast and islands including Ashmore Reef breeding BIAs for this species (Table 5.9 and Figure 5.48).

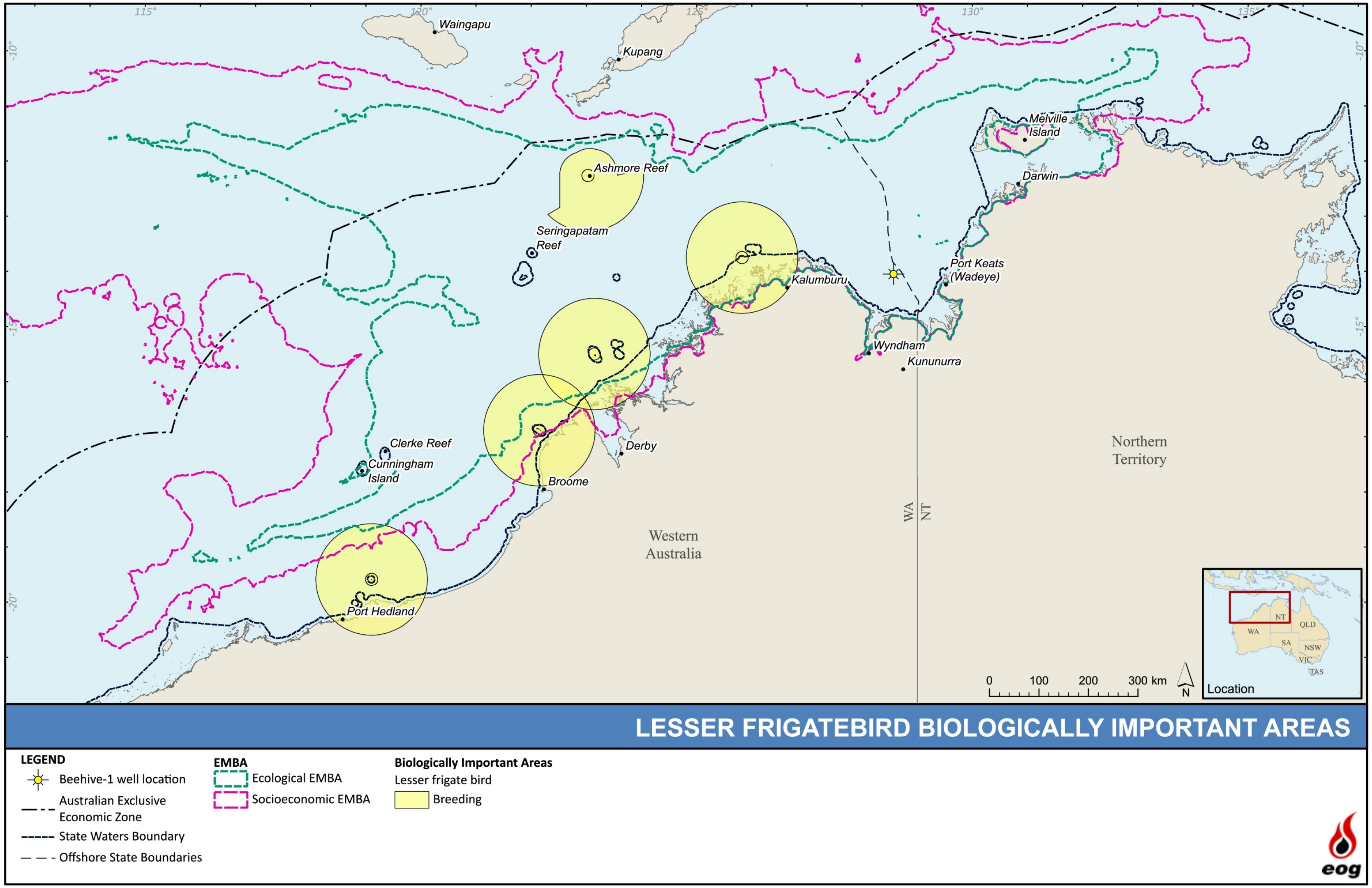


Figure 5.46. Lesser frigatebird BIA intersected by the spill EMBA

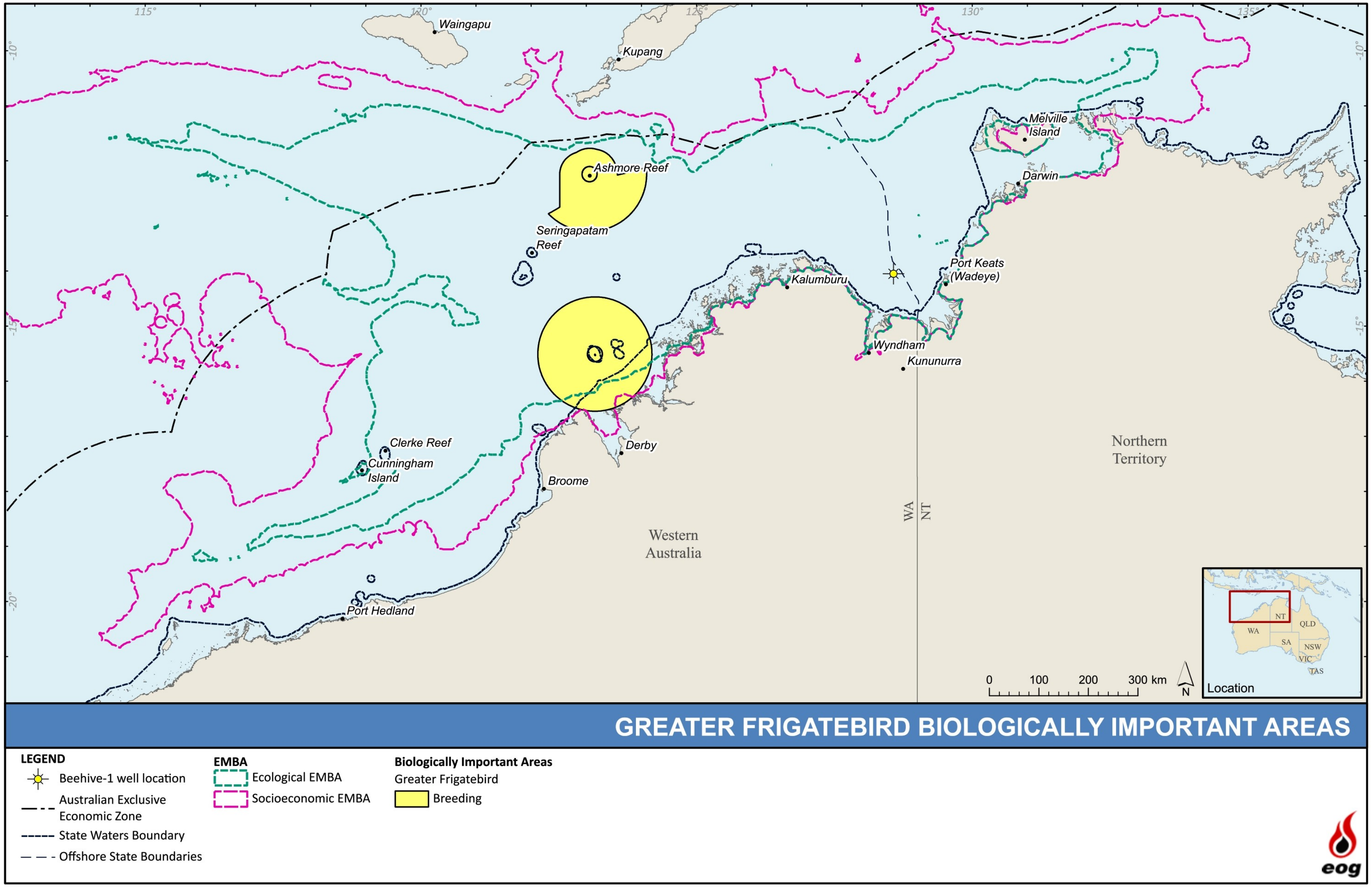


Figure 5.47. Greater frigatebird BIA intercepted by the spill EMBA

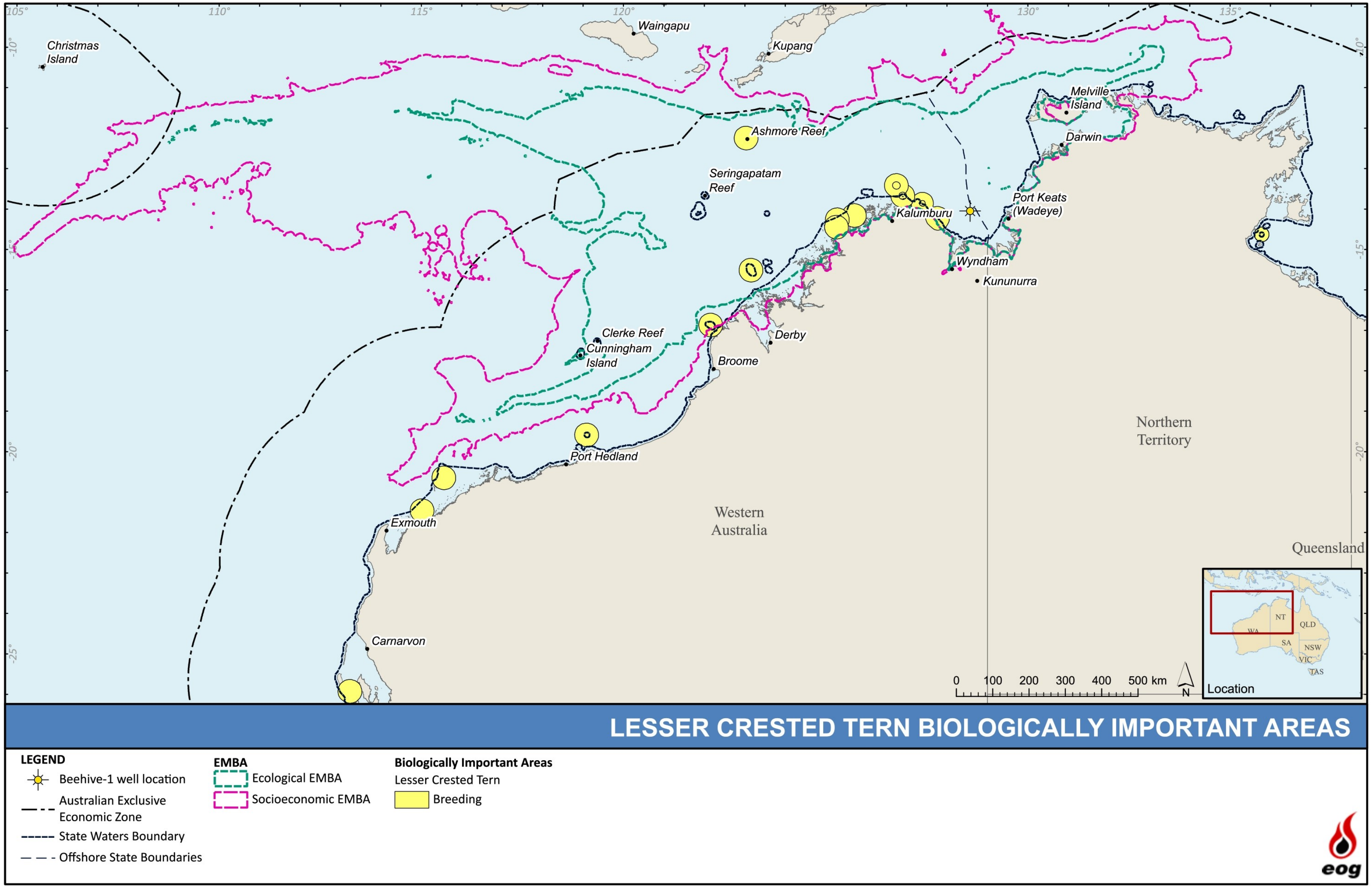


Figure 5.48. Lesser crested tern BIA intersected by the spill EMBA

Crested tern (EPBC Act: Listed Migratory)

The crested tern (*Thalasseus bergii*) inhabits tropical and subtropical coastlines and forages in the shallow waters of lagoons, coral reefs, bay, harbours, inlets and estuaries; along sandy, rocky, coral or muddy shores; on rocky outcrops in open sea; in mangrove swamps; and in offshore and pelagic waters (Higgins and Davies, 1996 <reference>). The crested tern usually feeds from the surface of the sea to less than 1 m water depth. Its diet consists predominantly of pelagic fish, although it will also feed on crustaceans, insects and hatchling turtles, opportunistically (Birdlife, 2020). The crested tern shows a preference for nesting on offshore islands, low-lying coral reefs, low-lying coral reefs, sandy or rocky coastal islets, coastal spits and lagoon mudflats (Birdlife, 2020). According to the NCVA, breeding is known to occur on Seagull Island, off NW of Cape Van Diemen on Melville Island and on the Coburg Peninsula (Table 5.9 and Figure 5.49).

Bridled tern (EPBC Act: Listed Migratory)

The bridled tern (*Onychoprion anaethetus*) is found throughout tropical and sub-tropical regions of Australia (DAWE, 2020a). The species is most common on offshore islands as opposed to coastal areas and forages singly or in small flocks, primarily on fish by swooping on schools and dipping only the head in the water (as opposed to plunge diving) (DAWE, 2020a). Breeding populations exist at Ashmore Reef and Cartier Island (DEWHA, 2008a). Birds return to breeding colonies at various island locations throughout northern WA between late September and mid-October and leave from early May to mid-September. The EMBA overlaps with a breeding BIA for this species (see Table 5.9 and Figure 5.50).

Australian lesser noddy (EPBC Act: Vulnerable)

The Australian lesser noddy (*Anous tenuirostris melanops*) is endemic to Australia and nests on the Abrolhos Islands, Ashmore Reef and various other islands throughout tropical and sub-tropical northwest Australia (DAWE, 2021b). They may forage out to sea or close inshore to breeding islands, including outside fringing reefs, feeding on small squid and fish (DoEH, 2005). They roost mainly in mangroves, and sometimes rest on the beaches (DoEH, 2005). The Australian lesser noddy may occur within the coastal areas of the EMBA.

Abbott's booby (EPBC Act: Endangered)

Abbott's booby (*Papasula abbotti*) spend much of their time at sea, but need to come ashore to breed (DAWE, 2021b). It is currently known to only breed on Christmas Island (outside the EMBA) during the months of March to October, with peak nesting May-July (DAWE, 2021b). The species nests in tall rainforest trees, laying a single egg clutch (DAWE, 2021b). Birds are known to travel up to 400 km from nesting locations to forage for fish and squid (DAWE, 2021b). The species may occur in the EMBA.

Brown booby (EPBC Act: Listed Migratory)

The brown booby (*Sula leucogaster*) is the smallest of the booby family. The species feeds either individually or in flocks, around inshore waters and use both marine and terrestrial habitats. They forage by either plunge diving or by snatching prey from the surface. The EMBA overlaps with the Kimberley and northern Pilbara coasts and islands also Ashmore Reef breeding BIAs for this species (see Table 5.9 and Figure 5.51).

Red-footed booby (EPBC Act: Listed Migratory)

The red-footed booby (*Sula sula*) is a slender bird with conspicuous red feet. Its distribution is confined to tropical waters between 30°N and 30°S in the Indian Ocean. In WA a small breeding population has been recorded on Ashmore Reef (DEWHA, 2008a). It mostly feeds on fish, especially flying fish, including cephalopods, by plunge diving in groups to shallow depths

(DAWE, 2020a). The EMBA overlaps with the northwest Kimberley and Ashmore Reef breeding BIAs for this species (see Table 5.9 and Figure 5.52).

White tailed tropicbird (EPBC Act: Listed Migratory)

The white-tailed tropicbird (*Phaethon lepturus*) is a pelagic species that rarely comes ashore, except to breed. The species breeds on islands throughout the tropics of the northern Indian Ocean, including Ashmore Reef and Rowley Shoals off the northern coast of WA (Johnstone and Storr, 1998; Marchant and Higgins, 1993).

The white-tailed tropicbird is a rather scarce breeding species at Ashmore Reef, and it is estimated that up to two pairs nest within the reserve each year (Clarke, 2010). Breeding has been recorded from May through to October, with birds dispersing away from the breeding colonies outside the breeding season.

The species forages in warm waters and over long distances, moving up to 1,500 km from breeding sites when not breeding (DSEWPC, 2012) and up to 89 km from the nest site when breeding. It feeds on fish and cephalopods by plunge-diving (Marchant and Higgins 1990).

The closest breeding BIA for the white-tailed tropicbird within the EMBA is at Ashmore Reef (Table 5.9 and Figure 5.53).

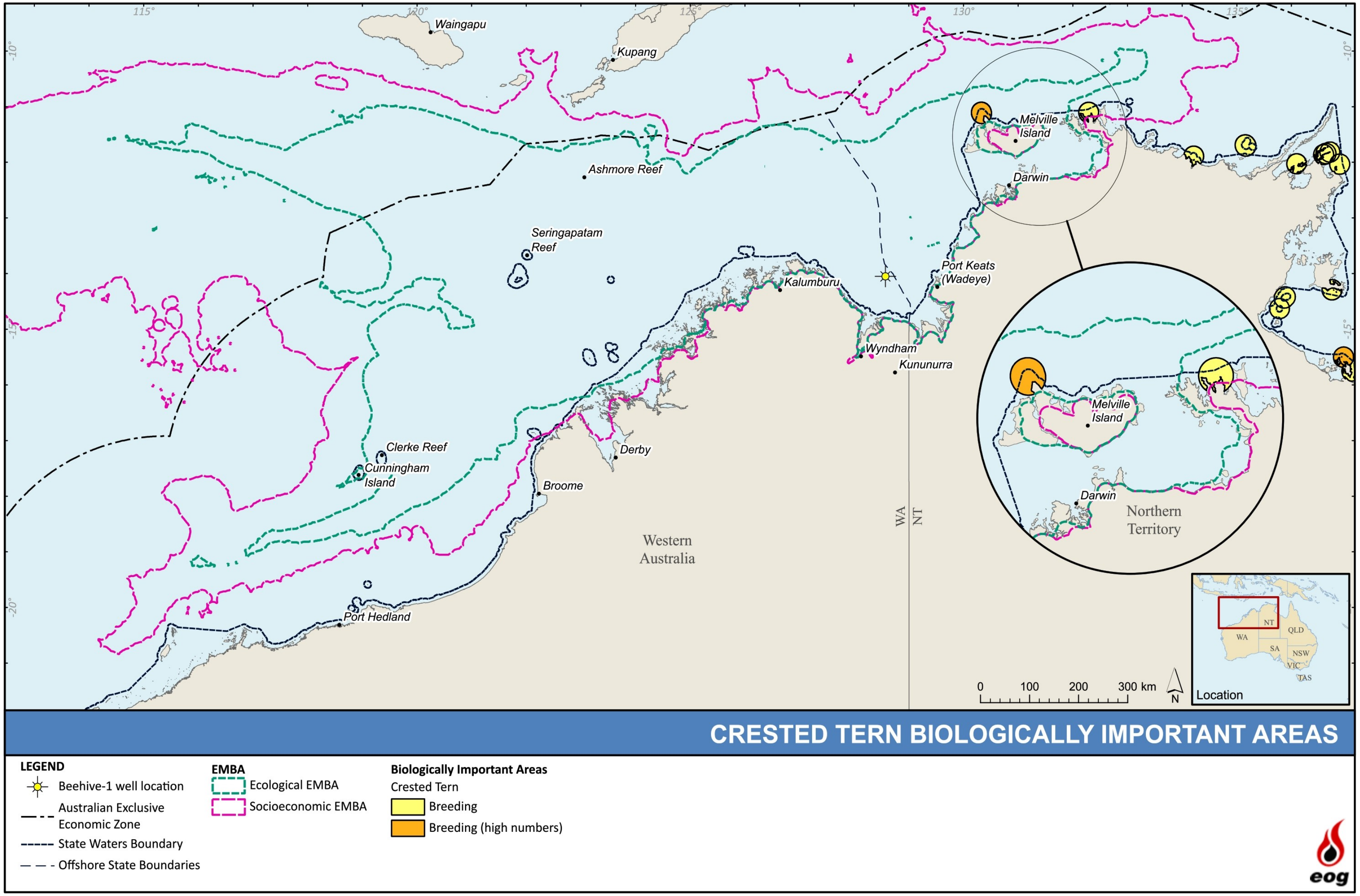


Figure 5.49. Crested tern BIA intercepted by the spill EMBA

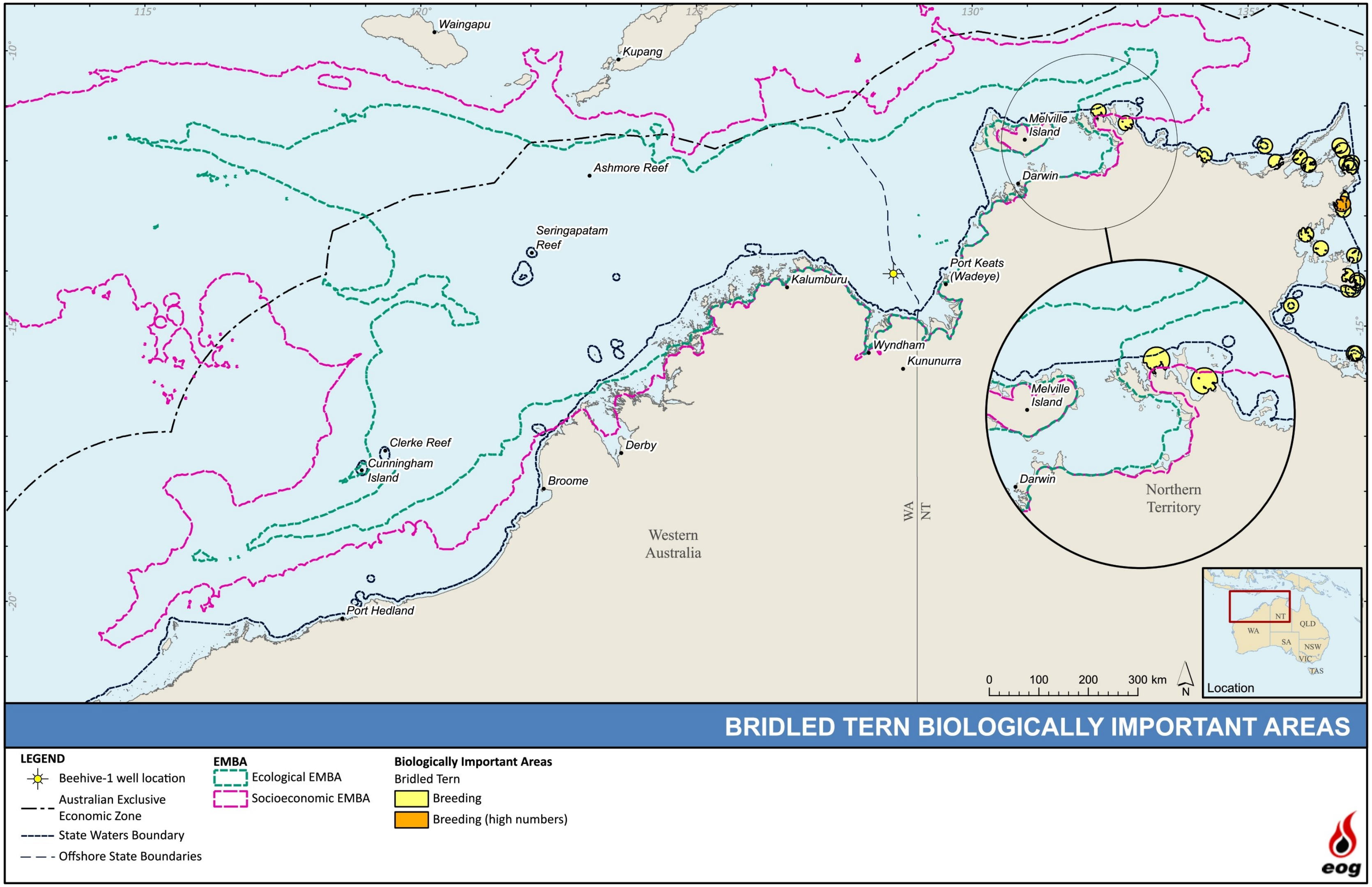


Figure 5.50. Bridled tern BIA intercepted by the spill EMBA

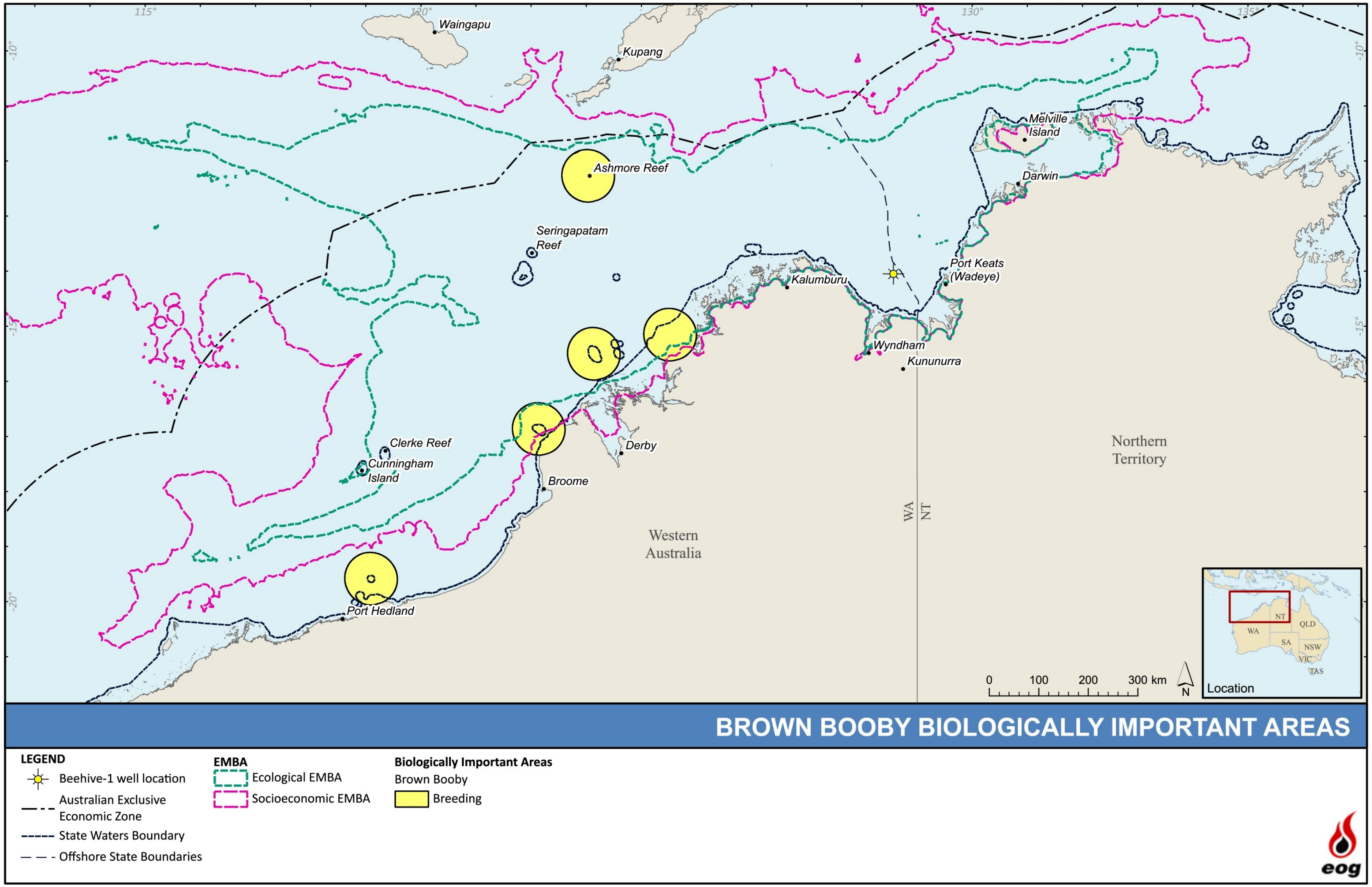


Figure 5.51. Brown booby BIA intercepted by the spill EMBA

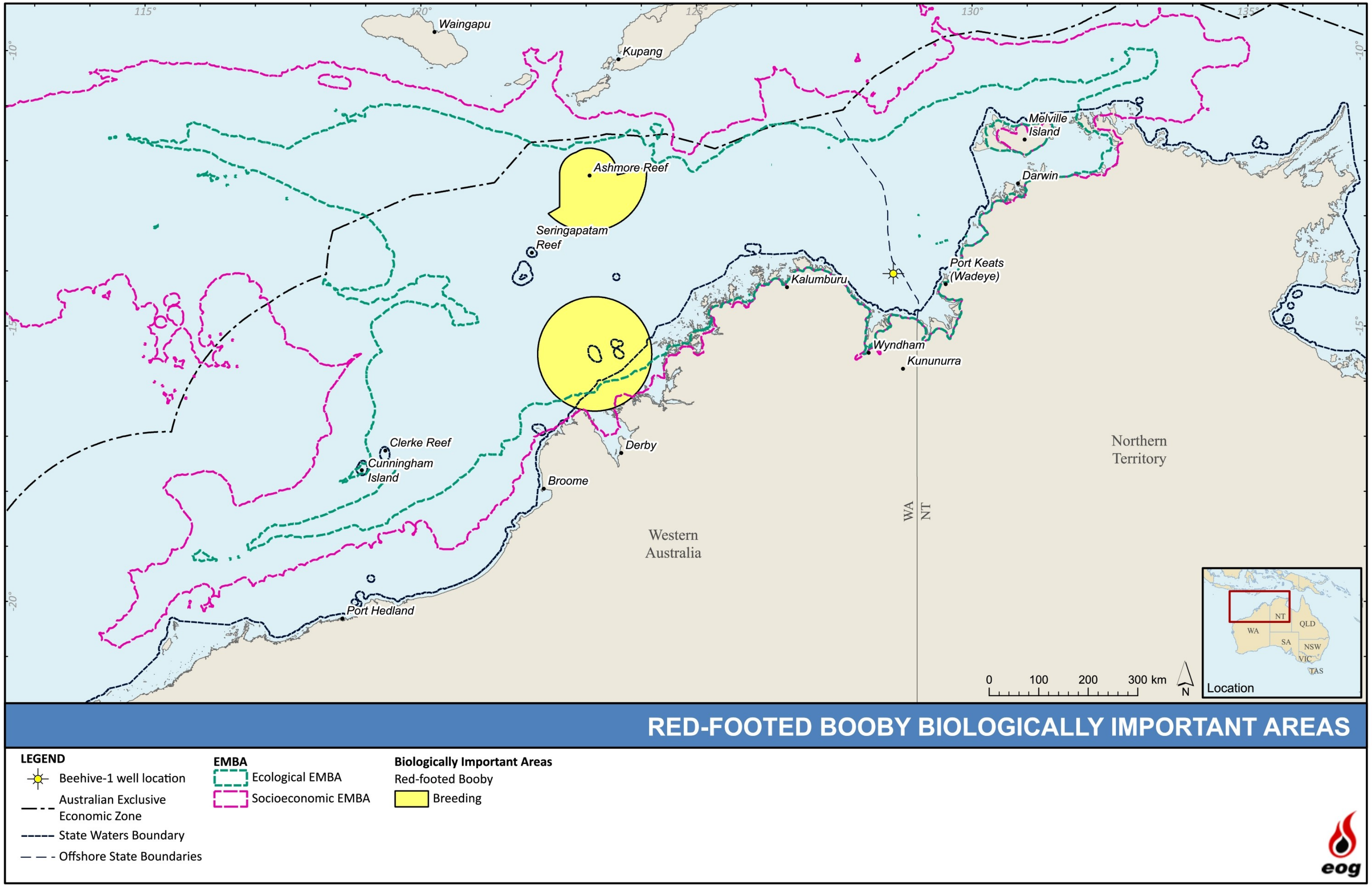


Figure 5.52. Red-footed booby BIA intercepted by the spill EMBA

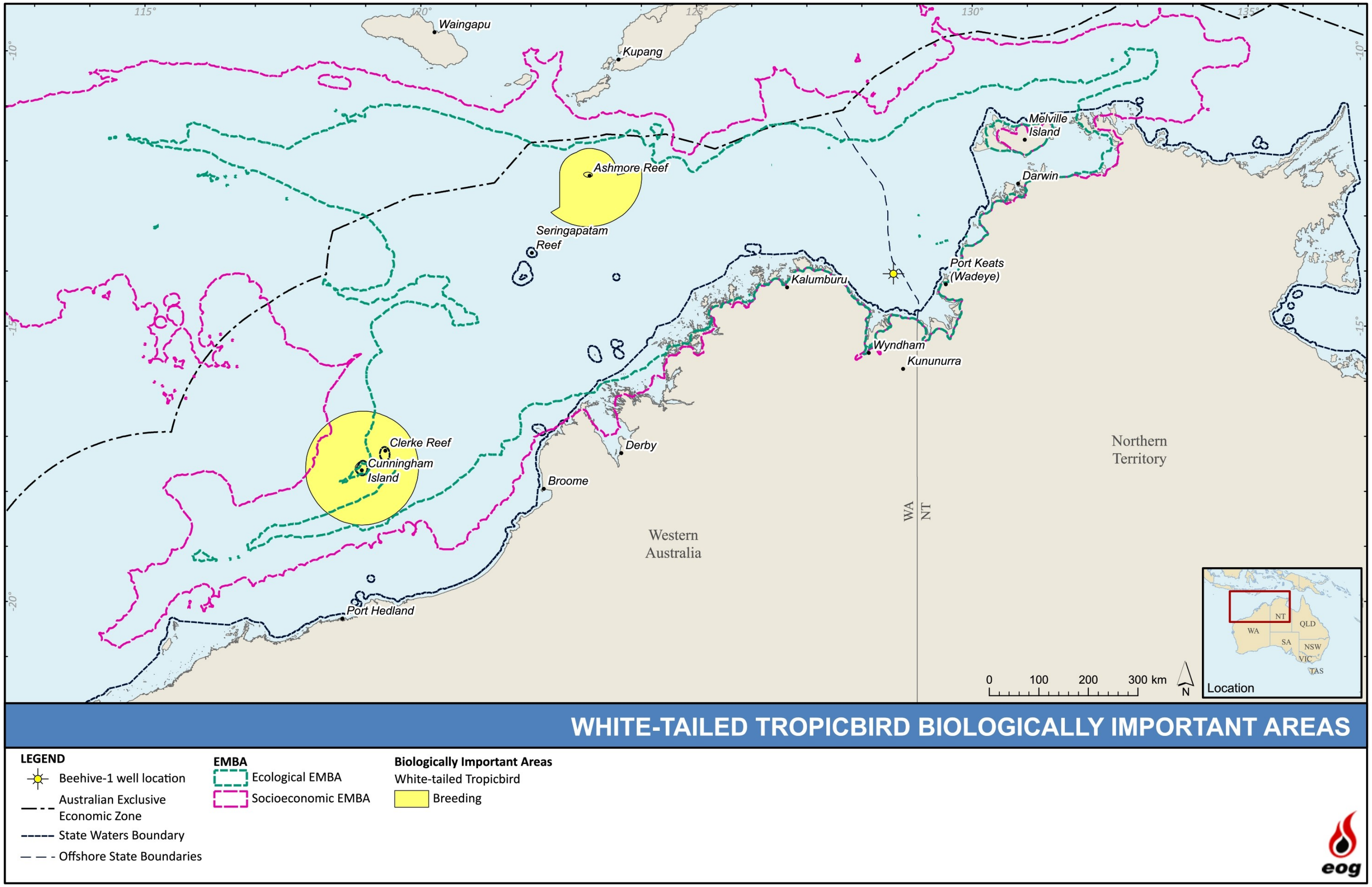


Figure 5.53. White tailed tropicbird BIA intercepted by the spill EMBA

Christmas Island white-tailed tropicbird (EPBC Act: Listed Endangered)

The Christmas Island white-tailed tropicbird (*Phaethon lepturus fulvus*) is endemic to Christmas Island, which is its only known breeding site (DoE, 2014). It leaves the island to forage in the warm waters of the Indian Ocean (Garnett, 2011) mainly feeding on fish and cephlapods. The white-tailed tropicbird roosts at sea; only incubating or brooding adults remain on nests on the island at night (Stokes, 1988).

The National Conservation Values Atlas (DoEE, 2019b) does not identify any BIAs for this species within the activity area nor ecological EMBA.

Indian yellow-nosed albatross (EPBC Act: Listed vulnerable)

The Indian yellow-nosed albatross (*Thalassarche carteri*) is a is a marine bird, located in subtropical and warmer subantarctic waters (Marchant and Higgins, 1990). Foraging BIAs are located throughout the offshore waters of the south-west marine region, north to Shark Bay and extending east into Bass Strait. Although the PMST report identifies this species or its habitat may be present within the EMBA, the closest likely habitat is just south of Barrow Island (outside of the EMBA). There are no BIAs intersected by the spill EMBA; however, it is likely that individuals may transit through the EMBA.

Fairy tern (EPBC Act: Listed marine species)

The Fairy tern (*Sterna nereis*) occurs on the coasts of New South Wales (Dunn & Harris 2009), Victoria, Tasmania, South Australia and on the Western Australia coast as far north as the Dampier Archipelago (Blakers *et al*., 1984; Higgins & Davies 1996).

It breeds on the north-west coast, in Shark Bay, and also on the shores of Lake McLeod, north of Carnarvon, and at Low Point. The fairy tern mostly breeds from July to September and may be present during the non-breeding season. The species nest on sites where the substrate is sandy and the vegetation low and sparse (DSEWPC, 2012).

The fairy tern forages in inshore waters, around island archipelagos and on the mainland. It feeds almost entirely on fish (Higgins and Davies 1996).

Given there is a lack of emergent habitat and the closest breeding BIA is 12 km from the closest edge of the EMBA, fairy terns may be present in the EMBA however not expected in significant numbers.

Shorebirds

Curlew sandpiper (EPBC Act: Critically Endangered, Listed Migratory)

In Australia, the curlew sandpiper (*Calidris ferruginea*) occurs around the coasts and is also quite widespread inland, though in smaller numbers (DAWE, 2021b). They are rarely recorded in the northwest Kimberley, around Wyndham and Lake Argyle (DAWE, 2021b).

This species is unlikely to be present in the activity area due to its location offshore but given that the EMBA is adjacent to (without intersecting) critical habitat for this species (e.g., wetlands), it is possible that this species would be present in the coastal sections of the EMBA during the summer months.

Lesser sand plover (EPBC Act: Endangered, Listed Migratory)

The lesser sand plover (*Charadrius mongolus*) spends non-breeding periods in Australia. The species is widespread in coastal regions and has been recorded in all states within Australia but mainly occurs in northern and eastern Australia (DAWE, 2021b).

The species feeds mostly on extensive, freshly-exposed areas of intertidal sandflats and mudflats in estuaries or beaches, or in shallow ponds in saltworks (DAWE, 2021b). They also occasionally forage on coral reefs and on sandy or muddy river margins (DAWE, 2021b). The lesser sand plover roost near foraging areas, on beaches, banks and spits, banks of sand and shells, and occasionally on rocky spits, isles or reefs (DAWE, 2021b).

This species is not predicted to occur in the activity area due to its distance from shore but may occur within the coastal areas of the EMBA and in the Cambridge Gulf.

Eastern curlew (EPBC Act: Critically Endangered, Listed Migratory)

The eastern curlew (*Numenius madagascariensis*) has a primarily coastal distribution within Australia (DotE, 2015c). It does not breed in Australia and is found foraging on soft sheltered intertidal sandflats or mudflats, open and without vegetation or covered with seagrass, often near mangroves, on saltflats and in saltmarsh, rockpools and among rubble on coral reefs, and on ocean beaches near the tideline (DoE, 2015b).

This species is unlikely to be present in the activity area due to its location offshore but given that the EMBA is adjacent to (without overlapping) critical habitat for this species (e.g., wetlands), it is possible that this species occurs in the EMBA during the summer.

Nunivak bar-tailed godwit (EPBC Act: Vulnerable)

The Nunivak bar-tailed godwit (*Limosa lapponica baueri*) is a large wader recorded in coastal areas of all states and territories of Australia (DAWE, 2021b). The species is found in coastal habitats such as large intertidal sand and mudflats, banks, estuaries, harbours, bays and coastal lagoons where it forages when the tide is out (DAWE, 2021b). Their diet consists of worms, molluscs, crustaceans, insects and some plant material (DAWE, 2021b). This species breeds in the northern hemisphere and migrates south for the winter, arriving in northwest Australia from August and departs before the end of April (DAWE, 2021b).

This species is not predicted to occur in the activity area due to its offshore location but may be present in the coastal sections of the EMBA between August and April.

Northern Siberian bar-tailed godwit (EPBC Act: Critically Endangered)

The northern Siberian bar-tailed godwit (*Limosa lapponica menzbieri*) is a large migratory shorebird (TSSC, 2016). The northern Siberian bar-tailed godwit spends non-breeding periods in Australia and is found in all Australian states and territories (TSSC, 2016). Populations have been recorded in northern Australia, from Darwin east to the Gulf of Carpentaria. The species forages near the edge of water or in shallow water, mainly on muddy coastlines, estuaries, inlets and mangroves feeding on worms, molluscs, crustacean, insects and plant material (TSSC, 2016).

It is unlikely that this species would be present in the activity area due to tis offshore location but this species may be present within the coastal sections of the EMBA.

Great knot (EPBC Act: Critically Endangered, Listed Migratory)

The great knot (*Calidris tenuirostris*) has been recorded around the entire Australian coast and spends non-breeding periods in Australia (DAWE, 2021b). The greatest numbers of this species are found in northern Australia, and most commonly on the coast of the Pilbara and Kimberley, from the Dampier Archipelago to the NT border, and in the NT from Darwin and Melville Island, through Arnhem Land to the southeast Gulf of Carpentaria (DAWE, 2021b). This species typically prefers sheltered coastal habitats with large intertidal mudflats or sandflats (DAWE, 2021b). The great knot feeds on snails, worms and crustaceans, and forages on intertidal mudflats, estuaries, and in mangroves.

This species is not predicted to be encountered in the activity area due to its habitat preferences, although it is expected in parts of the coastal areas of the EMBA where its preferred habitat is available.

Red knot (EPBC Act: Endangered, Listed Migratory)

The red knot (*Calidris canutus*) is common in all the main suitable habitats around the coast of Australia (DAWE, 2021b), and very large numbers are regularly recorded in northwest Australia, with Eighty Mile Beach and Roebuck Bay being particular strongholds (both outside the EMBA). In WA, it is widespread on the coast from Ningaloo Reef and Barrow Island to the southwest Kimberley coastline. In the NT it is mainly recorded in Darwin.

The red knot is not predicted to occur within the activity area due to its habitat preferences but is likely to be present in parts of the coastal areas of the EMBA.

Alligator Rivers tellow chat (EPBC Act: Endangered)

The alligator rivers yellow chat (*Epthianura crocea tunneyi*) is a small that has been recorded from a several sites in the NT on the floodplains of the Adelaide, Mary, Wildman, South Alligator and East Alligator rivers (Garnett *et al.,* 2011). Most records are from within Kakadu National Park. however the relative importance of the different floodplains is unknown (Garnett et al., 2011). Occasional records elsewhere, mostly from between Darwin to Oenpelli, are probably dispersive individuals. The subspecies is presumed to be a single a contiguous population (Garnett et al., 2011).

The species is restricted to alluvial coastal and subcoastal grassy floodplains, primarily near floodplain depressions and channels, typically sparsely vegetated and feed mainly on insects (Armstrong 2004). Given the habitat preference of the alligator rivers yellow chat, the species may be present in the coastal section of the NT. There are no known BIAs intersected by the EMBA.

Australian painted snipe (EPBC Act: Endangered)

The Australian painted snipe (*Rostratula australis*) is a wader and is found in wetlands throughout all Australian states and territories (DAWE, 2021b). The species generally inhabits freshwater wetlands, although can inhabit brackish water, saltmarshes and claypans (DAWE, 2021b). It feeds on vegetation, seeds, insects, worms, molluscs, crustaceans and other invertebrates (DAWE, 2021b). The Australian painted-snipe is not predicted to occur within the activity area, but is likely to be present in the EMBA.

Red goshawk (EPBC Act: Vulnerable)

The red goshawk is a large, swift and powerful rufous-brown hawk found in patchy, but widespread areas across coastal and sub-coastal regions of northern and eastern Australia. Historically it occurred from the north-east tip of New South Wales, across Queensland and the Northern Territory, to the north of WA (Marchant and Higgins, 1993). The species is thought to consist of two subpopulations, one on the Tiwi Islands containing approximately 200 adults, and a mainland population containing approximately 1200 adults (Garnett *et al.,* 2011). The red goshawk may transient through the coastal areas of northern WA and the NT within the EMBA. However, there are no BIAs for this species that overlap the EMBA.

Gouldian finch (EPBC Act: Endangered)

The gouldian finch (*Erythrura gouldiae*) is found in northern Australia from Cape York Peninsula through northwest Qld and the north of the NT to the Kimberley Region of WA (Higgins *et al.,* 2006; O'Malley 2006). They feed almost exclusively on grass seed and depend on a relatively small number of grass species at different times throughout the year (Dostine and Franklin 2002; O'Malley 2006). In the Northern Territory there are recent breeding records at well-known sites in the Yinberrie Hills and Newry, as well as at Wollogorang (Baker-Gabb, cited in Garnett et al., 2011). In the Kimberley, small breeding populations of up to 120 adults each are known from the east (Pryke, cited in Garnett et al., 2011), in the centre of the Kimberley at Mornington Sanctuary (Legge *et al.,* 2015), and west to Dampierland (WWF, 2012). Given the habitat and feeding preferences for this terrestrial species it is unlikely that Gouldian finches would occur in the EMBA. In addition, there are no BIAs for this species that overlap the EMBA.

Grey falcon (EPBC Act: Vulnerable)

The grey falcon (*Falco hypoleucos*) is an elusive species endemic to mainland Australia. The species occurs in arid and semi-arid Australia, including the Murray-Darling Basin, Eyre Basin, central Australia and Western Australia (Marchant and Higgins, 1993). The species is mainly found where annual rainfall is less than 500 mm, although it is essentially confined to the arid and semi-arid zones at all times (Schoenjahn, 2018). Given the grey falcon's preferred habitat, the species is unlikely to occur in the EMBA.

Partridge pigeon (western) and (eastern) (EPBC Act: Vulnerable)

The partridge pigeon (western) (*Geophaps smithii smithii)* occurs in remote locations of the Kimberley region. The subspecies has been recorded from Yampi Peninsula north to Napier Broome Bay and inland to the lower Isdell River, middle Charnley River, Wulumara Creek, Mitchell Plateau and lower Drysdale River. The subspecies is consisting of short, open grasses (Johnstone and Storr, 1998). Given the habitat and distribution of this species, it is unlikely the patridge pigeon (western) would occur in the EMBA.

The partridge pigeon (eastern) is a terrestrial species recorded only in sub-coastal Northern Territory, from Yinberrie Hills (about 50 km north of Katherine) in the south and Litchfield National Park in the west to western Arnhem Land in the east, with a separate subpopulation on Melville and Bathurst Islands in the Tiwi Island group (Garnett *et al.,* 2011). Although there are no BIAs for this species, given they have been recorded in the Tiwi island group the pigeon may be present within the EMBA but restricted to the mainland.

Tiwi Islands hooded robin (EPBC Act: Critically Endangered)

The Tiwi Islands hooded robin (*Melanodryas cucullata melvillensis*) is a small woodland bird endemic to the Tiwi Islands. It inhabits more open forests and woodlands and forages on ground-dwelling invertebrates in areas of thinner ground cover (TSSC, 2018). There is a lack of recent recordings of these species. In 2014 a targeted threatened species survey at 40 sites on Bathurst Island did not detect hooded robins, and none were encountered in a major wildlife survey of the Tiwi Islands from 2000 to 2003 (Woinarski *et al.,* 2003). Therefore, given the preferred habitat and potentially low numbers of this species, it is unlikely that hooded robins would occur in the EMBA.

Greater sand plover (EPBC Act: Vulnerable, Listed Migratory)

The greater sand plover (*Charadrius leschenaultia*) occurs in coastal areas throughout Australia with the greatest populations between the NW Cape and Roebuck Bay (DAWE, 2021b) (both outside the EMBA). The plover spends almost all its time in coastal habitats. Their diet consists mainly of molluscs, worms, crustaceans and insects (DAWE, 2021b). The species breeds in the northern hemisphere and migrates south for the boreal winter (DAWE, 2021b). The greater sand plover is one of the first migratory waders to return to northwest Australia, usually arriving in late July and departing in mid to late April (DAWE, 2021b).

The species is not predicted to occur in the activity area due to its habitat preferences, but may occur within the coastal areas of the EMBA from July to April.

5.3.8. Marine Pests

It is widely recognised that marine pests can become invasive and cause significant impacts on economic, ecological, social and cultural values of marine environments. Impacts can include the introduction of new diseases, altering ecosystem processes and reducing biodiversity, causing major economic loss and disrupting human activities (Brusati and Grosholz, 2007).

The Marine Pests Interactive Map (DAFF, 2021) indicates that the major port likely to be used to support the activity (e.g., Darwin) is not known to harbour any marine pests. However, DAFF (2021) notes that the following species are listed to keep watch for in the Port of Darwin due to their high potential for accidental introduction:

- Asian green mussel (*Perna viridis*) – typically inhabits soft sediment bottoms from the low tide mark to shallow waters up to 42 m deep. Juveniles are bright green than turn brown in adults.
- American slipper limpet (*Crepidula fornicate*) – competes with native species for food and space and may alter sediment characteristics by removing suspended sediments from the water column. Its likely habitat includes mud, rocks and sand within shores and shall waters.
- Black striped false mussel (*Mytilopsis sallei*) – affects the productivity of commercial fisheries and aquaculture by competing with native species for food and space. The species usually inhabits shallow waters up to a few metres deep.
- Charru mussel (*Mytella charruana*) – successful invasive species globally due to its great dispersal ability and tolerance for a wide variety of habitats. Typically found on rocky or hard substrates in shallow waters.

5.4. Conservation Values and Sensitivities

The conservation values and sensitivities within the EMBA are described in this section, with Table 5.10 providing an outline of the conservation categories described.

Table 5.10. Conservation values in the EMBA

Category	Conservation classification	Section
MNES under the EPBC Act	Australian Marine Parks (AMP)	Section 5.4.1
	World Heritage-listed properties	Section 5.4.2
	National Heritage-listed places	Section 5.4.3
	Wetlands of international importance	Section 5.4.4
	Nationally threatened species and threatened ecological communities	Throughout Section 5.3 and Section 5.4.5
	Migratory species	Throughout Section 5.3
	Great Barrier Reef Marine Park	Not applicable.
	Nuclear actions	Not applicable.
	A water resource, in relation to coal seam gas development and large coal mining development	Not applicable.

Category	Conservation classification	Section
Other areas of national importance	Commonwealth heritage-listed places	Section 5.4.6
	Key Ecological Features (KEF)	Section 5.4.7
	Nationally important wetlands (NIW)	Section 5.4.8
State protected areas	State/territory protected areas	Section 5.4.9

5.4.1. Australian Marine Parks

Australian Marine Parks as proclaimed under the EPBC Act (in 2007 and 2013) are located in Commonwealth waters that start at the outer edge of state and territory waters, generally 3 nm (approximately 5.5 km) from the shore, and extend to the outer boundary of Australia's EEZ, 200 nautical miles (approximately 370 km) from the shore (DNP, 2018b).

The AMP Network includes six marine regions being the Coral Sea, South-west, Temperate East, South-east, North and Northwest. The marine park networks applicable to the activity area and spill EMBA are the Northwest Marine Parks Network aligned with the NWMR; and North Parks Marine Network aligned to the NMR. Management plans have been developed and approved for each of these regions including zoning and related rules for managing activities in the marine park to ensure protection of marine habitats and species, while enabling use. A definition of zones in the AMP is provided in Table 5.11.

The nearest AMPs to the Beehive-1 exploration well location is the JBG AMP (located 35 km east of the drill site) and the Kimberley AMP (located 235 km west of the drill site), described herein. AMPs in the EMBA and their zoning (IUCN classification) (as per Table 5.11) are provided in Table 5.12 and illustrated in Figure 5.54.

Table 5.11. Definition of Zones in AMPs

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

Table 5.12. Australian Marine Parks within the EMBA

AMP	Distance and direction to Beehive-1	Zone or IUCN Classification	Presence	
			Ecological EMBA	Socio-economic EMBA
North Marine Region (NMR)				
Oceanic Shoals	152 km north	Multiple Use Zone (IUCN VI)	Yes	Yes
Arafura	548 km north northeast	Multiple Use Zone (IUCN VI)	Yes	Yes
		Special Purpose Zone (Trawl) (IUCN VI)	-	Yes
Arnhem	585 km northeast	Special Purpose Zone (Trawl) (IUCN VI)	-	Yes
Northwest Marine Region (NWMR)				
Argo-Rowley Terrace	890 km west	National Park Zone (IUCN II)	Yes	Yes
		Multiple Use Zone (IUCN VI)	Yes	Yes
		Special Purpose Zone (Trawl) (IUCN VI)	Yes	Yes
Ashmore Reef	601 km northwest	Recreational Use Zone (IUCN IV)	Yes	Yes
		Sanctuary Zone (IUCN 1a)	Yes	Yes
Cartier Island	553 km west	Sanctuary Zone (IUCN 1a)	Yes	Yes
Joseph Bonaparte Gulf	35 km east	Multiple Use Zone (IUCN VI)	Yes	Yes
		Special Purpose Zone (IUCN VI)	Yes	Yes
Kimberley	235 km west	Multiple Use Zone (IUCN VI)	Yes	Yes
		National Park Zone (IUCN II)	Yes	Yes
		Habitat Protection Zone (ICUN IV)	Yes	Yes
Mermaid Reef	1052 km south southwest	National Park Zone (IUCN II)	Yes	Yes
Montebello	1025 km south southwest	Multiple Use Zone (IUCN VI)	-	Yes

Note: Although Oceanic Shoals AMP is part of the North Marine Region, it also overlaps the NWMR, where the EMBA extends.

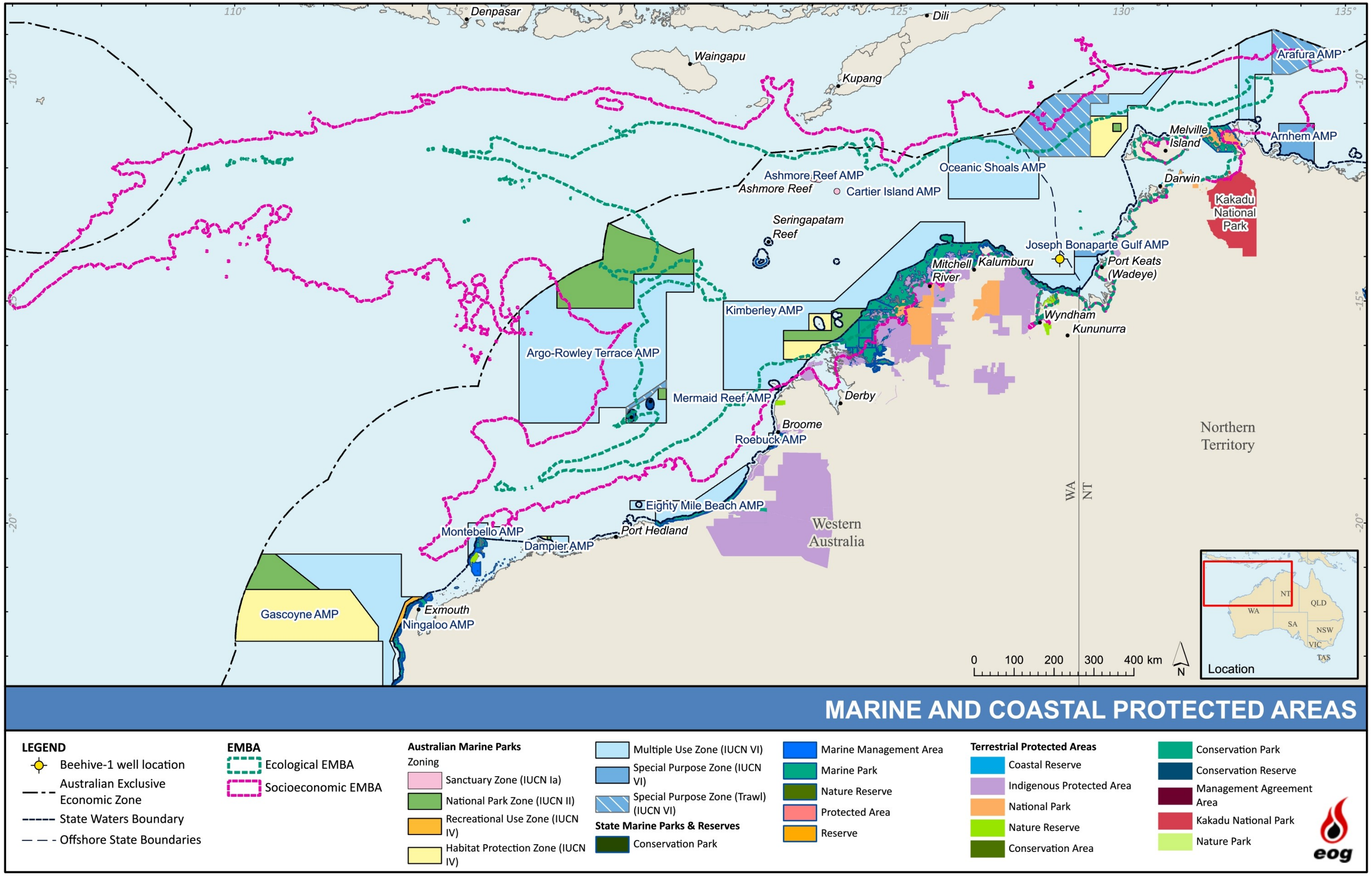


Figure 5.54. Protected areas intersected by the spill EMBA

Oceanic Shoals AMP

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

The Oceanic Shoals AMP is characterised by:

- Examples of ecosystems representative of the Northwest Shelf Transition. The pinnacles, carbonate banks and shoals within the AMP are sites of enhanced biological productivity.
- Four KEFs (refer to Section 5.4.7), namely:
  - Carbonate bank and terrace systems of the Van Diemen Rise;
  - Carbonate bank and terrace system of the Sahul Shelf;
  - Pinnacles of the Bonaparte Basin; and
  - Shelf break and slope of the Arafura Shelf.
- Foraging and internesting BIA for marine turtles (Section 5.3.6).
- Sea country within the marine park is valued for Indigenous cultural identity, health and wellbeing.
- Commercial fishing and mining are important activities in the AMP.

Arafura AMP

The Arafura AMP covers an area of 22,924 km^2 with depths from less than 15 m to 500 m. It is located approximately 256 km northeast of Darwin. The marine park extends from NT waters to the limit of Australia's exclusive economic zone. The Arafura Marine Park is significant because it contains habitats, species and ecological communities associated with the Northern Shelf Province and Timor Transition. It contains one KEF known as the tributary canyons of the Arafura Depression, an area that contains canyons that are approximately 80 to 100 km long and 20 km wide with sediments including sand, mud and rock. The canyons channel deep ocean waters, enhancing productivity and supporting large predatory fish, whale sharks, sawfish and marine turtles, deep sea sponges, and barnacles (DNP, 2018).

In addition, it is in close proximity to important wetland systems including the Cobourg Peninsula Ramsar site, and provides important foraging habitat for seabirds (DNP, 2018). Biologically important areas within the marine park include inter-nesting habitat for marine turtles and important foraging and breeding habitat for seabirds. According to the North Marine Parks Network Management Plan 2018, there are no international, Commonwealth or national heritage listings apply to the marine park No international, Commonwealth or national heritage listings apply to the marine park Commercial fishing, tourism, and recreation, including fishing occur in the marine park (DNP, 2018).

Arnhem AMP

The Arnhem AMP located 60 km southeast of the Arafura Marine Park, is extends from NT waters surrounding the Goulburn Islands, to the waters north of Maningrida. The marine park covers an area of 7,125 km^2 and water depth ranges from less than 15 m to 70 m. The marine park is significant because it contains habitats, species and ecological communities associated with the Northern Shelf Province. It includes dynamic habitats due to gently sloping shelf topped with a number of pinnacles, at depths ranging from 5 m to 30 m. It is nearby important wetland systems including the Blyth-Cadell Floodplain and Boucaut Bay Nationally Important Wetland (outside of the EMBA, 670 km from the drill site) and provides important foraging habitat for seabirds (DNP, 2018).

Internal currents in the region drive a net clockwise movement of nutrient-rich coastal water contributing to high biological diversity. Tidal eddies induce localised upwellings and hotspots of productivity that correspond with aggregations of marine life within the marine park. No international, Commonwealth or national heritage listings apply to the marine park. Commercial fishing, tourism, and recreation, including fishing also occur in the marine park (DNP, 2018).

Argo-Rowley Terrace AMP

The Argo-Rowley AMP covers an area of 146,003 km^2 and water depths between 220 m and 600 m. It is the largest in the Northwest Network, and is adjacent to the Mermaid Reef Marine Park and the WA Rowley Shoals Marine Park. It includes the deeper waters of the region and a range of seafloor features such as canyons on the slope between the Argo Abyssal Plain, Rowley Terrace and Scott Plateau. These are believed to be up to 50 million years old and are associated with small, periodic upwellings that results in localised higher levels of biological productivity (DNP, 2018b).

The Argo–Rowley Marine Park is significant because it contains habitats, species and ecological communities associated with the Northwest Transition and Timor Province. It includes two KEFs:

- Canyons linking the Argo Abyssal Plain with the Scott Plateau and Mermaid Reef; and
- Commonwealth waters surrounding Rowley Shoals.

This AMP supports a range of species including species listed as threatened, migratory, marine or cetacean under the EPBC Act. BIAs within the Marine Park include resting and breeding habitat for seabirds and a migratory pathway for the pygmy blue whale (DNP, 2018b). Commercial fishing and mining are important activities in the marine park (DNP, 2018b).

Ashmore Reef AMP

The Ashmore Reef AMP is in the AET of Ashmore and Cartier Islands, approximately 630 km north of Broome, WA. It covers 583 km^2, with depths less than 15 m to 500 m. The Ashmore Reef AMP is comprised of three small islands, lagoons, sand flats, reef flats with a high diversity of hard and soft corals and sponges, and large seagrass meadows. The AMP is a Sanctuary Zone with a small Recreational Use Zone allowing access to the most westerly island.

The Ashmore Reef AMP is characterised by:

- The presence of around 100,000 seabirds than come to breed each year, including greater crested terns, white-tailed tropicbirds and greater frigatebirds, and 10,000's of migratory shorebirds that forage in the surrounding waters, such as curlew sandpipers, bar-tailed godwits and great knots. It is also a breeding site for green turtles.
- Sea country within the AMP is valued for Indigenous cultural identity, health and wellbeing.
- Tourism, recreation and scientific research are important activities in the Marine Park.
- Two KEFs, namely:
    - The continental slope demersal fish communities KEF; and
    - The Ashmore Reef and Cartier Island and surrounding Commonwealth waters KEF.
- The presence of the Ashmore Reef National Nature Reserve Ramsar site.

Further information on KEFs and Ramsar sites is provided in Section 5.4.7 and Section 5.4.4 respectively.

Cartier Island AMP

The Cartier Island AMP lies in the Timor Sea within the Australian External Territory (AET) of Ashmore and Cartier Islands, approximately 600 km north of Broome, WA. It covers 172 km^2, with water depths from less than 15 m to 500 m. The south-flowing Leeuwin Current originates in this region, and transports marine life southwards.

The entire Carter Island AMP is characterised by:

- Important habitat for seasnakes, turtles, whale sharks, corals, sea fans and sponges. This marine park and the nearby Ashmore Reef AMP are marine biodiversity hotspots, supporting a rich diversity of species and high numbers of individuals.
- Sea country within the marine park is valued for Indigenous cultural identity, health and wellbeing.
- Scientific research is an important activity in the AMP.
- Two KEFs, namely:
    - The continental slope demersal fish communities KEF, characterised by high levels of endemic fish; and
    - The Ashmore Reef and Cartier Island and surrounding Commonwealth waters KEF, characterised by enhanced primarily productivity and aggregations of marine life.

Joseph Bonaparte Gulf AMP

The JBG AMP covers an area of 8,597 km^2 and water depths within the AMP range from less than 15 m to 75 m (Galaiduk *et al*., 2018). The JBG AMP is significant because it contains habitats, species and ecological communities associated with the Northwest Shelf Transition provincial bioregion and the Oceanic Shoals meso-scale bioregion (Galaiduk *et al*., 2018). The AMP contains a number of prominent shallow seafloor features including an emergent reef system, shoals and sand banks (Galaiduk *et al*., 2018). It also includes one key ecological feature, the Carbonate Bank and Terrace System of the Sahul Shelf, which is valued as a unique seafloor feature with ecological properties of regional significance (AMP, 2019a). The Miriuwung, Gajerrong, Doolboong, Wardenybeng and Gija and Balangarra people have responsibilities for sea country in this AMP (DNP, 2018a).

Kimberley AMP

The Kimberley AMP is located approximately 100 km north of Broome, WA and the central part of the Kimberley AMP is adjacent to the WA Camden Sound State Marine Park. It covers 74,469 km^2, with depths from less than 15 m to 800 m.

The Kimberley AMP is characterised by:

- High numbers of marine mammals such as dolphins, whales and dugong. The humpback whale breeds and calves in the Kimberley AMP annually after undertaking an extensive migration from Antarctica. Three dolphin species (Australian snubfin dolphin, Australian humpback dolphin and spotted bottlenose dolphin) use the Kimberley AMP to forage within and travel to coastal waters to calve and raise their young in inshore, protected waters.

- Important foraging rounds for seabirds and shorebirds known to breed on Adele Island (outside of the EMBA), including critically endangered eastern curlews and curlew sandpipers.
- Sea country within the AMP is valued for Indigenous cultural identity, health and wellbeing.
- Tourism, commercial fishing, mining, recreation (including fishing) and traditional use are important activities in the AMP.

There are no KEFs within the Kimberley AMP.

Mermaid Reef AMP

The Mermaid Reef AMP adjacent to the Argo–Rowley Terrace Marine Park, is located 280 km northwest of Broome and approximately 13 km from the Rowley Shoals Marine Park which falls under WA state jurisdiction. The Mermaid Reef Marine Park covers an area of 540 km² and water depths from less than 15 m to 500 m (DNP, 2018).

It is significant because it contains habitats, species and ecological communities associated with the Northwest Transition. It includes one KEF; the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals, and is one of three reefs forming the Rowley Shoals. The other two are Clerke Reef and Imperieuse Reef, to the south-west of the marine park, which are included in the WA Rowley Shoals Marine Park (DNP, 2018).

Ecosystems of the Marine Park are associated with emergent reef flat, deep reef flat, lagoon, and submerged sand habitats. The marine park supports a range of species, including species listed as threatened, migratory, marine or cetacean under the EPBC Act. Biologically important areas within the marine park include breeding habitat for seabirds and a migratory pathway for the pygmy blue whale. Important activities in the marine park include marine tourism, recreation, and scientific research (DNP, 2018).

Montebello AMP

The Montebello AMP covers an area of 3,413 km² and water depths from less than 15 m to 150 m. It is significant because it contains habitats, species and ecological communities associated with the Northwest Shelf Province. It includes one KEF: the ancient coastline at the 125-m depth contour. When tides are low, two coral reefs called Tryal Rocks emerge above the water (DNP, 2018b)

The marine park supports a range of species including species listed as threatened, migratory, marine or cetacean under the EPBC Act. BIAs within the marine park include breeding habitat for seabirds, internesting, foraging, mating, and nesting habitat for four species of marine turtles, a migratory pathway for humpback whales and foraging habitat for whale sharks (DNP, 2018b). Tourism, commercial fishing, mining and recreation are important activities in this AMP (DNP, 2018b).

AMP Pressures

Section 2.4 of the North Marine Parks Network Management Plan 2018 (DNP, 2018a) and Section 2.4 of the North-west Marine Parks Network Management Plan 2018 (DNP, 2018b) identify pressures relevant to the marine park networks. Pressures are defined as human-driven processes, events and activities that may detrimentally affect the values of the reserves network. Table 5.13 summarises the pressures and sources of pressure on the conservation values of the of the NMR and NWMR Reserves Network.

Table 5.13. Summary of environmental pressures in the NWMR and NMR

Pressure	Description
Climate change	Climate change impacts on marine environments are complex and interrelated and may include changes in sea temperature, sea level, ocean acidification, sea currents, increased storm frequency and intensity and species range extension or local extinction. Examples of features and species vulnerable to climate change impacts include submerged coral reefs, sawfish, sharks, dolphins, seabirds and marine turtles.
Changes in hydrology	Coastal developments and agriculture have the potential to discharge increased sediment loads and pollutants to rivers, estuaries and nearshore coastal environments. This can result in increased turbidity and siltation, which in turn impacts species that spawn or inhabit coastal, nearshore or offshore waters. Habitats and species vulnerable to changes in hydrology include seagrass meadows, reefs, sawfish, shark and dugong.
Extraction of living resources	Sustainable fishing as well as illegal or unregulated fishing can modify natural populations and disproportionately target select valuable species. Species vulnerable to extraction include shark, sawfish, turtles, sea snakes, fish and dugong.
Habitat modification	Offshore infrastructure developments can impact habitat within marine parks through physical disturbance and indirectly through the physical presence of infrastructure. Benthic habitats may be impacted by direct discharges to the seabed resulting in smothering or a reduction in the quantity of light reaching the seabed. Habitats and species vulnerable to habitat modification include reefs, shoals and pinnacle habitats, turtles, fish, sea snakes, dolphins and dugong.
Human presence	Wildlife watching, camping, boating, diving and snorkelling are drawcard activities for people to the region and have the potential to impact natural wildlife behaviour or result in damage to fragile marine environments. Habitats and species vulnerable to these impacts include reefs, turtles and seabirds.
Invasive species	Accidental introduction and establishment of invasive species can have potentially debilitating impacts on island, reef or shallow-water marine ecosystems. Direct impacts from predation or damage to important habitat and indirect impacts from competition for food resources can affect native populations. Habitats and species vulnerable to invasive species include reefs, turtles, seabirds and saltwater crocodiles.
Marine pollution	Land-based and marine activities that result in pollution have the potential to impact marine park values. Discharges of emissions including light, marine debris, noise, oil and chemicals can be detrimental to marine life and cause contamination of ecosystems and entanglement of marine fauna. Habitats and species vulnerable to marine pollution include islands, reefs, shallow-water habitats, dolphins, whales, turtles, sawfish, sharks and seabirds.

5.4.2. World Heritage-Listed Properties

World Heritage Listed-properties are examples of sites that represent the best examples of the world’s cultural and heritage values, of which Australia has 19 properties (DAWE, 2021d). In Australia, these properties are protected under Chapter 5, Part 15 of the EPBC Act.

There are no World Heritage Properties within or adjacent to the EMBA. The closest World Heritage Property is Kakadu National Park (onshore), which is located over 400 km northeast of the activity area.

5.4.3. National Heritage-Listed Properties

The National Heritage List is Australia's list of natural, historic and Indigenous places of outstanding significance to the nation (DAWE, 2021e). These places are protected under Chapter 5, Part 15 of the EPBC Act.

The socio-economic EMBA intersects the West Kimberley National Heritage Place. This National Heritage-listed place is described below and presented in Figure 5.55.

West Kimberley National Heritage Place

The West Kimberley was included on the National Heritage List in 2011 and has numerous values which contribute to the significance of the property, including indigenous, historic, aesthetic, cultural and natural heritage values (DAWE, 2021b). The West Kimberley National Heritage place covers a vast area that is characterised by a diversity of landscapes and biological richness found in its cliffs, headlands, sandy beaches, rivers, waterfalls and islands.

The values most relevant to the marine environment is Roebuck Bay as a migratory hub for shorebirds (Roebuck Bay does not fall within the EMBA).

5.4.4. Wetlands of International Importance

Australia has 66 wetlands of international importance ('Ramsar wetlands') that cover more than 8.3 million hectares (as of September 2021) (DAWE, 2021f). Ramsar wetlands are those that are representative, rare or unique wetlands, or are important for conserving biological diversity, and are included on the List of Wetlands of International Importance developed under the Ramsar Convention. These wetlands are protected under Chapter 5, Part 15 of the EPBC Act.

There are four Ramsar-listed wetlands intersected by the EMBA (Figure 5.56), described here.

Ord River Floodplain

The Ord River Floodplain Ramsar site is a floodplain and estuarine wetland system located 88 km south of Beehive-1. North of the lagoons, the site includes the Ord River Estuary leading into the Cambridge Gulf while the northeast end of the site heads around the coast to include a series of extensive intertidal creeks and flats known as the False Mouths of the Ord. The upstream portion of the floodplain and river tends to be freshwater and becomes more saline as the river approaches the Cambridge Gulf and falls under tidal influence (DAWE, 2021b).

Mangroves are the most common vegetation in the site, extending from the False Mouths of the Ord to the upstream sections of the estuary. The mangroves form narrow fringes along the intertidal areas, with saltmarsh on higher ground. The intertidal mangroves support many species of birds and bats and are a breeding area for banana prawns (DAWE, 2021b).

Over 200 species of birds have been recorded within the site including waterfowl, migratory shorebirds, mangrove birds and terrestrial species. The site supports the nationally threatened Australian painted snipe. The wetlands are habitat for many fish species that require migration between marine and more freshwater environments during their life, including the nationally threatened species largetooth sawfish, green sawfish and northern river shark. Reptiles that use the site include the freshwater crocodile and saltwater crocodile (DAWE, 2021b).

The Ord River Floodplain Ramsar site lies within the boundaries of six Indigenous language groups: Miriuwung, Gajerrong, Dulbung, Guluwaring, Djangade and Biambarr. The site contains Indigenous burial sites, artefact scatters, quarries, paintings and ceremonial sites (DAWE, 2021b). The Ord River Nature Reserve is gazetted for the conservation of flora and fauna. The Lower Ord

River and the False Mouths of the Ord are popular destinations for locals and visitors for recreational fishing, crabbing and boating (DAWE, 2021b).

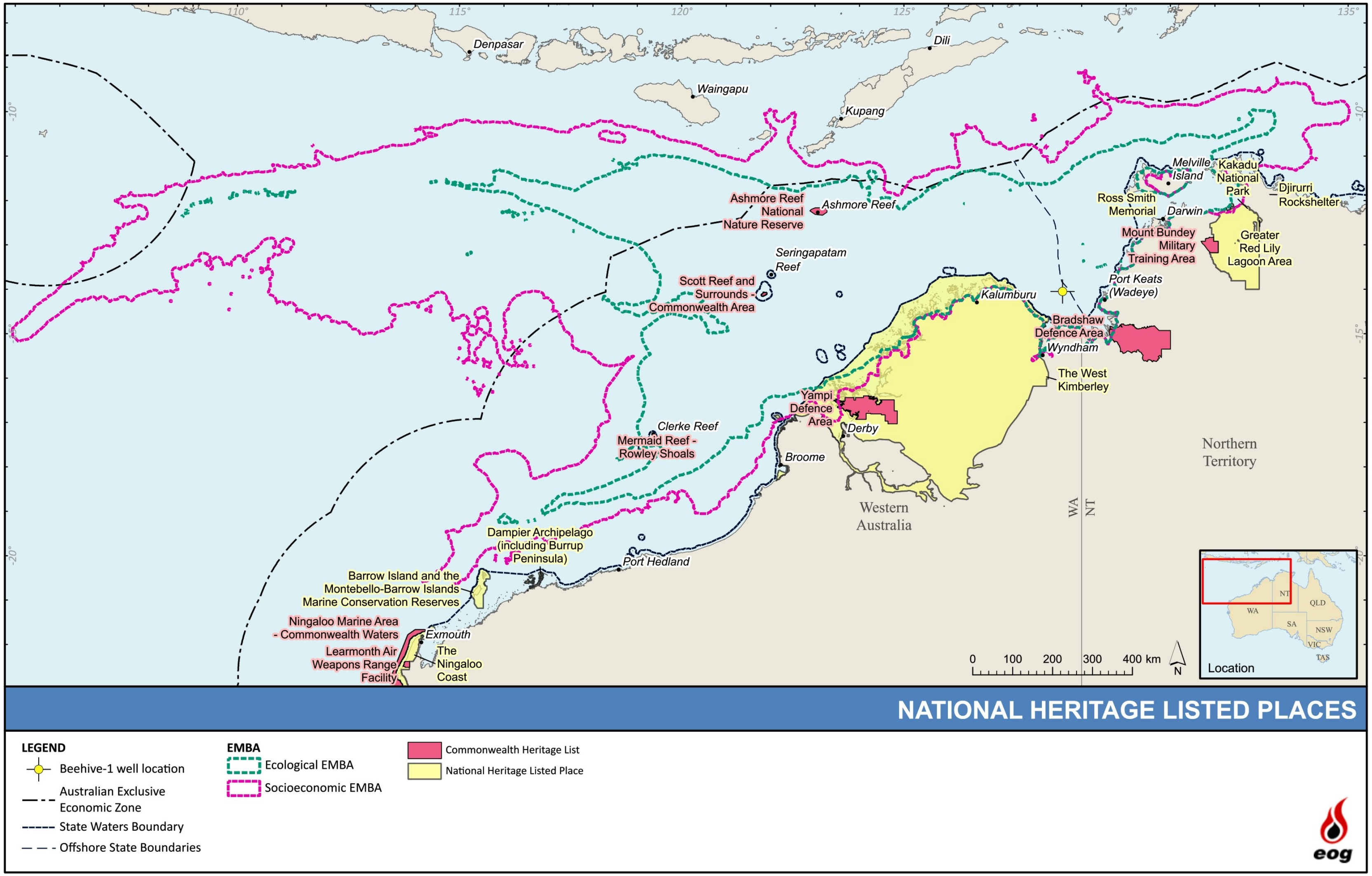


Figure 5.55. National Heritage and Commonwealth Heritage-listed Places intersected by the EMBA

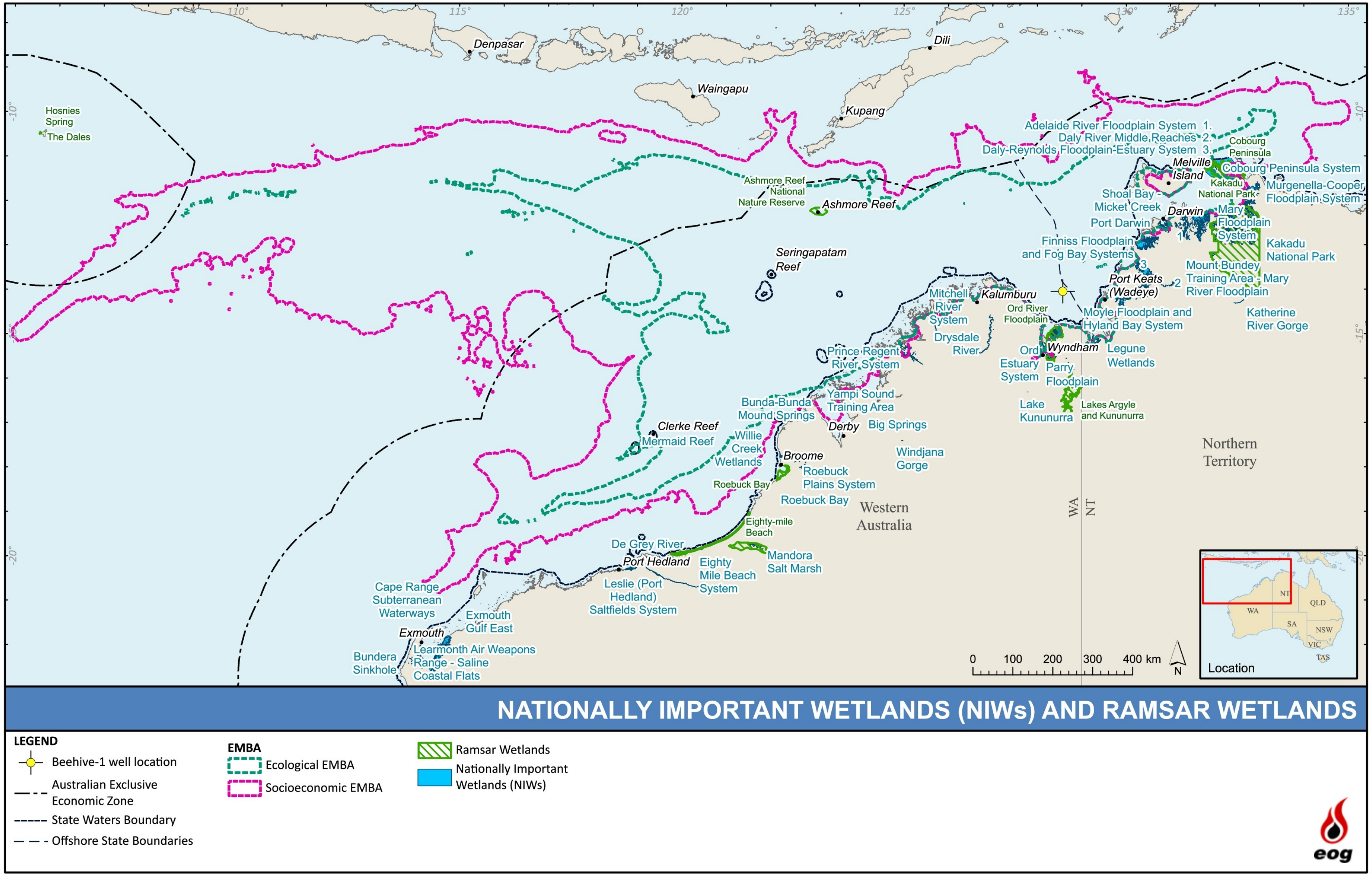


Figure 5.56. Wetlands of international importance and NIWs intersected by the EMBA

Ashmore Reef National Nature Reserve

The Ashmore Reef National Nature Ramsar site (Ashmore Reef Ramsar site) is located in the Indian Ocean approximately 840 km west of Darwin, 610 km north of Broome and 608 km northwest of Beehive-1.

There are a number of other coral atolls and reefs within the Timor Province including Cartier Island, Seringapatam Reef and Scott Reef. These contain some of the same types of wetlands and habitats as Ashmore Reef Ramsar site, notably coral reefs, intertidal sand flats and sub-tidal beds (Hale and Butcher, 2013). However, Ashmore is the largest of the atolls in the region and has been managed for the purposes of conservation for three decades. Each of the wetland types present at Ashmore Reef Ramsar site is in near natural condition, with low densities of coral predators and disease (Richards et al. 2009). The Ashmore Reef Ramsar site also has the highest seagrass cover in the bioregion (Russell et al. 2005). In addition, the three islands at Ashmore Reef Ramsar site (West, Middle and East) represent the only vegetated islands within the Timor Province bioregion (DEWHA 2008a). Thus, by definition the site contains bioregionally unique examples of wetland type E (sand, shingle or pebble shores) (Hale and Butcher, 2013).

Cobourg Peninsula

The Cobourg Peninsula Ramsar site is located approximately 163 km northeast of Darwin and 460 km northeast of Beehive-1.

This Ramsar site occupies the entire peninsula and several nearby islands including the Sir George Hope Islands group, Sandy Island, Allaru Island, High Black Rock and Burford Island (BMT WBM, 2011) with the offshore islands (Figure 5.22). consisting of sandy shores, and the latter consisting of rocky shores; and tidal flats (sand, mud, sediment) and mangroves respectively. The Cobourg Peninsula Ramsar site is composed of a diversity of coastal and inland wetland types. Wetland types present include intertidal forested wetlands and saltflats, seasonal freshwater marshes and permanent freshwater pools. Using the Ramsar typology, there are ten coastal types and ten inland types within the site.

Coburn Peninsula supports populations of threatened species including support for key life-cycle functions such as marine turtle breeding, waterbird breeding fish nursery and spawning habitats. The critical component of the site is the diversity and connectivity of a wide range of wetland habitat types, and is supported by populations of waterbirds, terrestrial ecosystems and freshwater fish and invertebrates (BMT WBM, 2011) <ecological character description>. Recent or continuing threats that are notable in the context of the site that may affect future ecological character include invasive species, climate change, tourism, marine debris and resource extraction.

Kakadu National Park

The Kakadu National Park Ramsar site is located approximately 200 km east of Darwin and 424 km northeast of Beehive-1. This Ramsar site is mainly an inland wetland ranging from intertidal forested wetlands and mudflats, to seasonal freshwater marshes and permanent freshwater pools (BMT WBM, 2010). The socio-economic EMBA only intersects the coastal section of the Kakadu Park Ramsar site. The shoreline in this area consists of tidal flats (sand, mud and sediment) and mangrove habitat.

5.4.5. Threatened Ecological Communities

The Australian Government is responsible for identifying and protecting MNES through the EPBC Act. Threatened Ecological Communities (TECs) are a MNES under the EPBC Act. TECs provide wildlife corridors and/or habitat refuges for many plant and animal species, and listing a TEC provides a form of landscape or systems-level conservation (including threatened species).

One TEC is identified in the EMBA, which is described below.

Monsoon vine thickets on the coastal sand dunes of Dampier Peninsula

The vine thickets of the Dampier Peninsula are a very distinctive type of rainforest in the Kimberley region. This TEC is located about 1,430 km southwest of Beehive-1.

This type of vine thicket is confined to the Peninsula between Broome and Derby, along with the coastal dune formations on which it occurs. Vine thickets occur as discrete areas of dense vegetation and can occur as a stand of a few trees or as larger patches. The 90 known occurrences vary in size from about 0.3 ha up to 507 ha, with a mean size of about 33 ha. They can occur as clumps or narrow linear stands (Black *et al*., 2010). The vine thicket community contains many plants with fleshy fruits that provide important food sources for fauna such as agile wallabies, bats, bower-birds and fruit-doves. They are also an important traditional resource for Indigenous people.

5.4.6. Commonwealth Heritage-listed Places

Commonwealth Heritage-listed places are natural, indigenous and historic heritage places owned or controlled by the Commonwealth (DAWE, 2021g). In Australia, these properties are protected under Chapter 5, Part 15 of the EPBC Act.

One property on the Commonwealth Heritage List occurs within the EMBA, this being the Bradshaw Defence Area, which is described below. The Ashmore Reef National Nature Reserve Commonwealth Place is also within the EMBA, which is described in Section 5.4.4.

Bradshaw Defence Area

The Bradshaw Defence Area is bounded by the Fitzmaurice and Victoria Rivers on the south eastern shores of the JBG. The Bradshaw Defence Field Training Area comprises a vast and rugged habitat endowed with a diverse array of plants and animals. The place demonstrates to a high degree the interplay of erosional terrains associated with coastal and fluvial environments. Coastal mudflats, associated tidal creek networks and mangal stands are prominent along the coastal margins. In places, the mudflats are 'interrupted' by bedrock outcrop, while in other locations, bedrock forms small islands rimmed by mudflats and associated mangrove belts. There is a substantial rainfall gradient within the place, so that species characteristic of both the wetter coastal forests and drier inland woodlands of northwest Australia are represented (DAWE, 2021b).

5.4.7. Key Ecological Features

KEFs are components of the marine ecosystem that are considered to be important for biodiversity or ecosystem function and integrity of the Commonwealth Marine Area.

The EMBA overlaps several KEFs, illustrated in Figure 5.57 and described here.

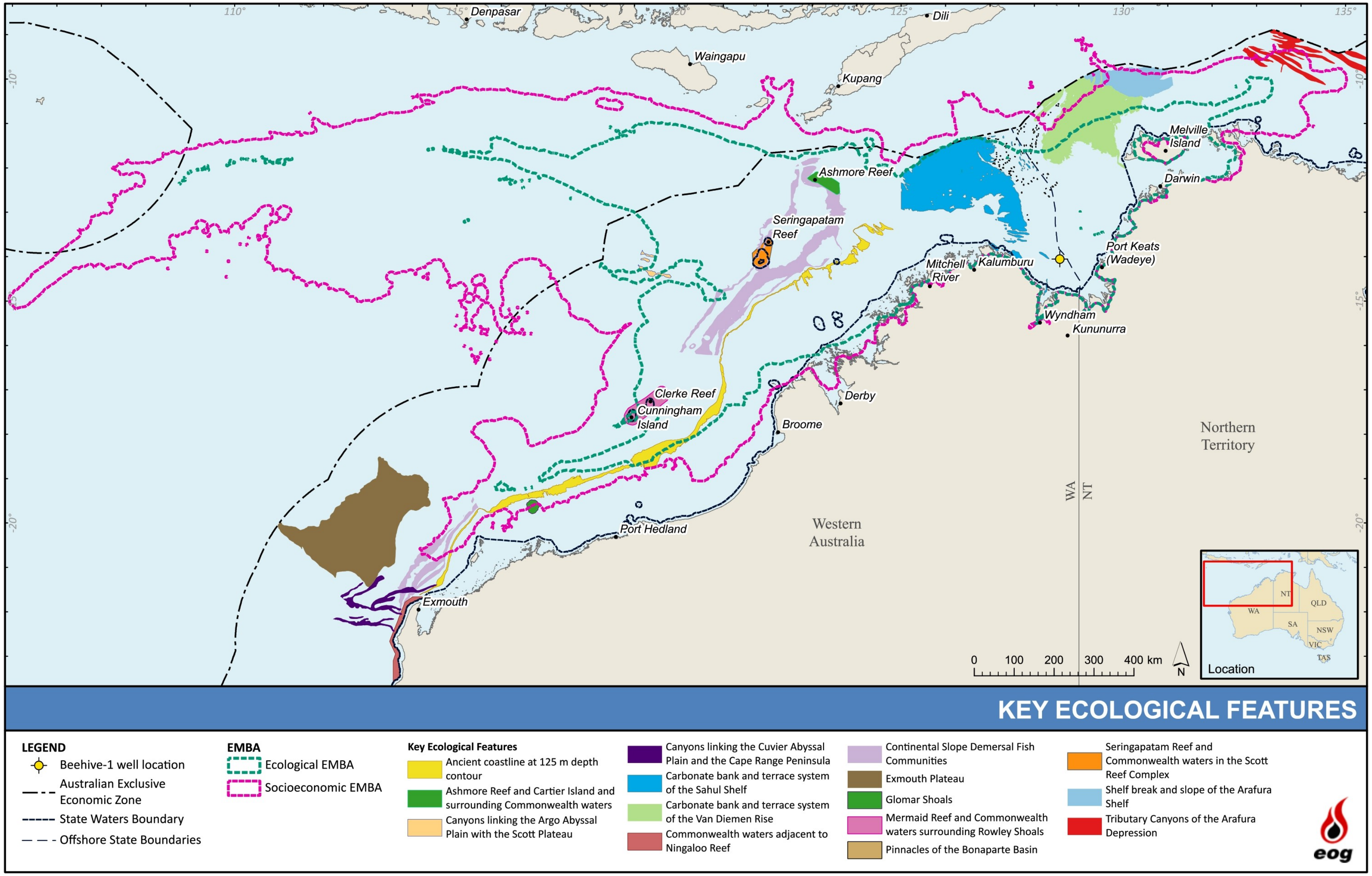


Figure 5.57. KEFs intersected by the spill EMBA

Carbonate bank and terrace system of the Sahul Shelf

The carbonate bank and terrace system of the Sahul Shelf KEF is located in the western JBG and to the north of Cape Bougainville and Cape Londonderry. It is located 26 km west of Beehive-1 at its closest point.

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

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

The banks are recognised as a biodiversity hotspot for sponges with more species and different communities than the surrounding seafloor (NERP MBH, 2014). The KEF is also known as a foraging area for flatback, olive ridley and loggerhead turtles (DSEWPC, 2012).

Threats to the KEF include changes in sea temperature and ocean acidification, both resulting from climate change, as well as extraction of living sources from illegal, unreported and unregulated fishing (Brewer *et al*., 2007; Nichol *et al*., 2013).

Pinnacles of the Bonaparte Basin

The limestone pinnacles of the Bonaparte Basin lie on the mid-outer shelf in the western JBG. It is located 123 km northwest of Beehive-1 at its closest point. The pinnacles are defined as a KEF because they are a unique seafloor feature with ecological properties of regional significance.

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

Carbonate bank and terrace system of Van Diemen Rise

The carbonate bank and terrace system of the Van Diemen Rise KEF is located on the north-eastern side of the JBG and partially overlaps with the north-east of the EMBA. It is located 234 km north of Beehive-1 at its closest point.

The KEF is considered important for its role in enhancing biodiversity and local productivity relative to its surrounds and for supporting relatively high species diversity. The KEF covers an area of 31,278 km^2.

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

A study of the sponge diversity and ecology of the Van Diemen Rise identified the region as a sponge biodiversity hotspot (Przeslawski *et al*., 2014). Sponges were collected with a benthic sled from five geomorphic features (banks, terrace, ridge, plain and valley), resulting in the identification of 283 species. The study found that sponge diversity was generally highest further offshore and on raised geomorphic features, particularly banks. Pelagic fish such as mackerel, red snapper and a distinct gene pool of goldband snapper are found in the Van Diemen Rise (Blaber *et al*., 2005; Salini *et al*., 2006). Olive ridley turtles, seasnakes and sharks have also been reported to occur in the area (DAWE, 2021b).

Ancient Coastline at 125 m depth contour

The ancient coastline at 125 m depth contour KEF comprises a series of several steps and terraces that form an escarpment along north-west WA centred around the 125 m isobath, although this feature is not continuous. It is located 412 km west of Beehive-1 at its closest point.

The KEF is an important divide between carbonate, cemented sands and the fine, less cemented slope materials found offshore. It is valued as a unique seabed feature with ecological properties of regional significance. Hard substrate areas of the ancient coastline are thought to provide biologically important habitat in an area predominantly made up of soft sediment (DAWE, 2021b).

Continental slope demersal fish communities

The continental slope demersal fish communities KEF is considered important due to its high levels of endemism (DEWHA 2008a). It is located 530 km west of Beehive-1 at its closest point.

The diversity of demersal fish assemblages on the continental slope in the Timor Province, the Northwest Transition and the Northwest Province is high compared to elsewhere along the continental slope (DEWHA 2008a). The KEF supports two distinct demersal community types (biomes) associated with the upper slope (water depth of 225–500 m) and the mid-slope (750–1,000 m) (DAWE, 2021b). Although poorly known, demersal-slope communities are thought to rely on bacteria and detritus-based systems comprised of infauna and epifauna, which in turn become prey for a range of teleost fish, molluscs and crustaceans (Brewer *et al*., 2007). Higher-order consumers may include carnivorous fish, deep water sharks, large squid and toothed whales (Brewer *et al*., 2007).

Glomar Shoals

The Glomar Shoals are a submerged littoral feature located approximately 150 km north of Dampier on the Rowley shelf at water depths of 33 m to 77 m (Falkner *et al.,* 2009). The shoals are defined as a KEF primarily due to their high productivity and aggregations of marine life.

The shoals consist of a high percentage of marine-derived sediments with high carbonate content and gravels of weathered coralline algae and shells (McLoughlin and Young, 1985). The area's higher concentrations of coarse material in comparison to surrounding areas are indicative of a high-energy environment subject to strong sea-floor currents (Falkner *et al.,* 2009).

While the biodiversity associated with the Glomar Shoals has not been studied, the shoals are known to be an important area for a number of commercial and recreational fish species such as rankin cod, brown striped snapper, red emperor, crimson snapper, bream and yellow-spotted triggerfish (Falkner *et al.,* 2009; Fletcher and Santoro, 2009). These species have recorded high catch rates associated with the Glomar Shoals, indicating that the shoals are likely to be an area of high productivity.

Mermaid Reef and Commonwealth waters including Rowley Shoals

The Mermaid Reef and Commonwealth waters surrounding Rowley Shoals is defined as a KEF for its enhanced productivity and high species richness and benthic and pelagic habitats within the feature. The Rowley Shoals are a collection of three atoll reefs, Clerke, Imperieuse and Mermaid, which are located about 300 km northwest of Broome. This KEF encompasses Mermaid Reef Commonwealth Marine Reserve as well as waters from 3 nm out to 6 nm surrounding Clerke and Imperieuse reefs (DAWE, 2021a). Mermaid Reef lies 29 km north of Clerke and Imperieuse reefs and is totally submerged at high tide. Mermaid Reef falls under Commonwealth jurisdiction. Clerke and Imperieuse reefs constitute the Rowley Shoals Marine Park, which falls under WA Government jurisdiction (DAWE, 2021a).

Mermaid Reef and Commonwealth waters surrounding Rowley Shoals are regionally important in supporting high species richness, higher productivity and aggregations of marine life associated with the adjoining reefs themselves (Done *et al.,* 1994). The reefs provide a distinctive biophysical environment in the region as there are few offshore reefs in the northwest. They have steep and distinct reef slopes and associated fish communities. In evolutionary terms, the reefs may play a role in supplying coral and fish larvae to reefs further south via the southward flowing Indonesian Throughflow. Both coral communities and fish assemblages differ from similar habitats in eastern Australia (Done *et al.,* 1994).

Ashmore Reef and Cartier Island and surrounding Commonwealth waters

The Ashmore Reef and Cartier Island and surrounding Commonwealth waters KEF is regarded as a biodiversity hotspot which supports a diverse array of pelagic and benthic marine species. It is located 560 km northwest of Beehive-1. The KEF is considered important due to its aggregations of marine life and enhanced primarily productivity in an otherwise low-nutrient environment.

Ashmore Reef and Cartier Island are situated on the shallow upper slope of the Sahul Shelf, north of Scott and Seringapatam reefs. They form part of a series of submerged reef platforms along the outer edge of the continental slope of the NWMR. Localised upwelling and turbulent mixing in the surrounding Commonwealth waters provide nutrients to support the reef structure and ecology (DEWHA 2008b).

Ashmore Reef and Cartier Island and the surrounding Commonwealth waters are regionally important for feeding and breeding aggregations of birds and other marine life, including an unusually high diversity of sea snakes, a genetically distinct breeding population of green turtles and foraging grounds for green, loggerhead and hawksbill turtles (Limpus, 2008). The reef system is an important staging post for seabirds and migratory shorebirds and the area is home to some of the most important seabird colonies in the NWMR (Milton, 2005). Ashmore Reef supports the highest number of coral species of any reef off the WA coast.

Canyons linking the Argo Abyssal Plain with the Scott Plateau

The canyons linking the Argo Abyssal Plain with the Scott Plateau is defined as a KEF for their high productivity and aggregations of marine life (DAWE, 2021a). These values apply to both the benthic and pelagic habitats within the feature.

The spatial boundary of this KEF includes three canyons, adjacent to the south-west corner of Scott Plateau. The canyons cut deeply into the south-west margin of the Scott Plateau at an approximate depth of 2,000 m to 3,000 m, and act as conduits for transport of sediments to depths of more than 5,500 m on the Argo Abyssal Plain. The water masses at these depths are deep Indian Ocean water on the Scott Plateau and Antarctic bottom water on the Argo Abyssal Plain. Both water masses are cold, dense and nutrient-rich (DAWE, 2021a).

Seringapatam Reef and Commonwealth waters in the Scott Reef complex

The Seringapatam reef and Commonwealth waters in the Scott reef complex are defined as a KEF as they support diverse aggregations of marine life, have high primary productivity relative to other parts of the region, are relatively pristine and have high species richness, which apply to both the benthic and pelagic habitats within the feature (DAWE, 2021a).

Scott and Seringapatam reefs are part of a series of submerged reef platforms that rise steeply from the sea floor between the 300–700 m contours on the northwest continental slope and lie in the Timor Province (Falkner *et al.,* 2009). Scott and Seringapatam reefs provide an important biophysical environment in the region as one of few offshore reefs in the northwest. The spatial boundary of this KEF includes both reefs plus the adjacent apron/fan features, and the canyon approximately 10 km to the west of Scott Reef. The southern edge of the KEF is defined by the state water boundary around Scott Reef (DAWE, 2021a).

As two of the few offshore reefs in the north-west, they provide an important biophysical environment in the region (DAWE, 2020a). The coral communities at Scott and Seringapatam reefs play a key role in maintaining the species richness and subsequent aggregations of marine life. Scott and Seringapatam reefs and the waters surrounding them attract aggregations of marine life including humpback whales and other cetacean species, whale sharks and several species of sea snake. Two species of marine turtle nest and forage during the summer months, and this KEF also provides foraging areas for various seabird species (DAWE, 2021a).

Shelf break and slope of the Arafura Shelf

The shelf break and slope of the Arafura Shelf is located north of the Tiwi Islands, near the edge of the Australian EEZ. It is defined as a KEF for its ecological significance associated with productivity emanating from the slope and forms part of a unique biogeographic province (Last *et al.,* 2005). The spatial boundary of this KEF includes the area of slope north of the Van Diemen Rise, an adjacent area of shelf, extending south to the terrace edge of the Van Diemen Rise in the western part and bounded by the 100 m depth contour in the east. At the eastern end, the area of shelf included extends to approximately the eastern extent of the slope. The slope and shelf areas contain pinnacles and reefs (DAWE, 2021a).

Phytoplankton and invertebrates have been sampled in the area (Hallegraeff and Jeffrey 1984; Wilson, 2005), and primary production of phytoplankton is thought to form the basis for offshore food webs (DEWHA, 2007). Fish communities that occur in this key ecological feature represent the break between the Timor Province provincial bioregion and the Timor Transition provincial bioregion (Last *et al*., 2005). Records show at least 284 demersal fish species are found in the area (Last *et al.,* 2005), including commercially fished red snapper species. The area is also likely to support whale sharks, sharks and marine turtles (DEWHA, 2007).

Tributary canyons of the Arafura Depression

The Tributary canyons of the Arafura Depression are defined as a KEF for their high productivity and high levels of biodiversity and endemism, in both the benthic and pelagic habitats within this feature (DAWE, 2021a).

Nearly all the canyons in the NMR are located within this KEF in which endemic benthic species are thought to occur (Wilson, 2005). Primary productivity in this feature is likely to be associated with movements of water through the canyons and surface water circulation driven by seasonal north-west monsoon winds.

Biological diversity and ecosystem processes in the area are influenced by the state of the canyon habitats. The steep topography of the canyons, their diverse current regimes, nutrient enrichment and entrapment, detritus funnelling and diverse substrate types form widely divergent ecosystems (McClain and Barry 2010; Vetter, 1994; Vinogradova, 1959), coupled with the regional setting and geological origins of the area, strongly influence species biodiversity (Kloser *et al.,* 2010).

At least 245 macroscopic species, including a diverse variety of invertebrates (e.g. sponges, corals, sea anemones, tunicates, worms, crustaceans, brittle stars, feather stars) and six small fish species have previously been sampled (Wilson, 2005). It is estimated that a further 500 species could be identified from post-survey analysis of grab and dredge samples (Wilson, 2005). Marine turtles, likely to be olive ridleys, have been reported to feed in the vicinity of the canyons (Whiting *et al.,* 2007).

5.4.8. Nationally Important Wetlands

NIWs are considered significant for a variety of reasons, including their importance for maintaining ecological and hydrological roles in wetland systems, providing important habitat for animals at a vulnerable or particular stage in their life cycle, supporting 1% or more of the national population of any native plant or animal taxa or for its outstanding historical or cultural significance (DAWE, 2021h).

There are 17 NIWs that are intersected by the EMBA, as illustrated in Figure 5.56 and described in Table 5.14. Information provided in Table 5.14 is sourced from DAWE's online Directory of Important Wetlands (DAWE, 2022b). Noting there are NIWs shown in Figure 5.56 that are in close proximity and/or outside of the EMBA, these are not discussed further in this section.

Table 5.14. Nationally important wetlands in the spill EMBA

Name	Distance from Beehive-1	Description
WA		
Ord River Floodplain	91 km south	The Ord River system is a floodplain and estuarine wetland system consisting of broad floodplains known to periodically flood and dry out; and permanent waterholes (known as the Parry Lagoons) (DAWE, 2022b). The wetlands are a habitat for many diadromous fish species (that migrate between salt water and freshwater environments), including nationally threatened species such as freshwater sawfish, green sawfish and the northern river shark. Freshwater and saltwater crocodiles are also known to use the wetland (DAWE, 2022b).
Mitchell River System	323 km southwest	The Mitchell River system consists of a relatively small river system and estuary, with an of escarpment of vertical multi-stage waterfalls (e.g., Mitchell Falls). Tributaries of the system are Camp Creek (off Mitchell Plateau), Youngs Creek and Leichardt Creek. The creeks and upper reaches of Mitchell River are seasonal; the entrenched lower reaches are permanent or near-permanent; twice-daily tides occur in the estuary. At least 10 species of freshwater fish are known to

Name	Distance from Beehive-1	Description
		inhabit the waters of the Mitchell River. Seven waterbird species have been recorded in the system (DAWE, 2022b).
Parry Floodplain	168 km south	The Parry floodplain is a good example of a tropical floodplain with permanent billabongs, seasonal marshes and wooded swamp (one of the few such floodplains of substantial area in WA). The site comprises the lower reaches and floodplain of Parry Creek including Parry Lagoons and numerous other lagoons, billabongs including claypans. The floodplain is 5 km southwest of the Ord River and adjoins tidal wetlands of the Ord estuary system in the north. Surface water flows in the floodplain from upper Parry Creek, originating 25 km south of the site in disturbed (fire and grazing) catchment, and from several short creeks; and occasionally from the Ord River. Seventy-seven waterbird species (including 24 shorebirds and four terns) are recorded in this system (one of the highest totals in the Kimberley); with 22 listed under treaties. Both freshwater crocodile and saltwater crocodile occur in the permanent billabongs (DAWE, 2022b).
Prince Regent River System	411 km southwest	The Prince Regent River System is a tropical estuary and river system incised in a plateau. There are nine major tributaries to this river, originating 11 km to 32 km from their junctions with the river (e.g., Youwanjela Creek from north-east, Cascade Creek from south southwest). The water catchments are relatively undisturbed and the only known habitat of two freshwater fishes; habitat to 15 waterbird species and an important breeding and non-breeding area for saltwater crocodile (DAWE, 2022b).
Yampi Sound Training Area	578 km southwest	The Yampi Sound Training Area contains large areas of coastline. The central and southwestern region is flat, consisting of the low lying flood plains of the Robinson River and its tributaries. The average annual rainfall in the training area is approximately 1,000 mm, which falls almost entirely during the summer wet season from November to April. During this time numerous permanent and semi-permanent pools along both major and minor watercourses are maintained. The Robinson River is tidal, with extensive tidal flats bordering King Sound. Tides are up to 11 m (DAWE, 2022b). Threatened species such as the Little Tern, Gouldian Finch and Western Partridge Pigeon have been recorded in the area (DAWE, 2022b).
Mermaid Reef	1,021 km southwest	Mermaid is the most north-easterly atoll of the Rowley Shoals, which comprises three distinct reef systems arising from depths of between 300 and 700 m along the edge of the continental shelf. The reef experiences a semi-diurnal tidal cycle with a spring range of about 4.5m (DAWE, 2022b). Fauna surveys indicate the reef has a rich and diverse fauna which is regionally important, which includes some endemics and species not occurring elsewhere in Western Australia (Berry ,1986; Done *et. al.,* 1994). In addition to the diverse range of coral species, other benthic groups include sponges, bryozoans, ascidians (sea squirts) polychaetes, molluscs, echinoderms, crustaceans and cnidarians (jellyfish) (DAWE, 2022b).

Name	Distance from Beehive-1	Description
NT		
Legune Wetlands	131 km southeast	The Legune wetlands are floodplain including meso and microscale pools and channels. The Legune Homestead Swamps are regionally significant Eleocharis-dominated wetland supporting significant waterbird numbers in the dry season, and breeding magpie geese in the wet season. The Osmans Lake System is the main area of open shallow wetland in the Keep River drainage. In combination the swamps and lake systems provide a good diversity of wetland habitat in a relatively small area. Forty-seven species of waterbirds have been recorded in the wetlands, 14 of them listed under treaties (JAMBA/CAMBA) (DAWE, 2022b).
Moyle Floodplain and Hyland Bay System	123 km east	Located in the Bonaparte Gulf Basin, the Moyle Floodplain and Hyland Bay System is classed as a megascale irregular floodplain with mesoscale sinuous channel and several mesoscale sumplands. Water supply to the floodplain is from surface inflow from creeks originating 10 km to 22 km southwest and southeast, with surface inflow to the east and north from the Moyle River. Forty-seven bird species known to occur on floodplain and adjacent coast, with 26 listed under treaties (JAMBA, CAMBA, BONN). The floodplain is a significant breeding area for magpie geese, with especially large breeding populations in drier years. The mudflats of Hyland Bay support relatively high numbers of migrant shorebirds. There are at least two significant waterbird breeding rookeries in the area which include darter and cormorant species (Bayliss, 1985; Whitehead *et al.,* 1992). The tidal estuary and creeks support a particularly high density of Saltwater Crocodiles, that also breed on the floodplain channel (DAWE, 2022b).
Daly-Reynolds Floodplain Estuary System	193 km northeast	One of the largest floodplains in the NT with the largest catchment of any major freshwater floodplain system. Water supply to the floodplain esturary is primarily from the Daly River, originating 275-300 km east north-east to south-south-east (catchment area of 49 000 km^2), and the Reynolds River, originating 60 km south-east (catchment area of 10 000 km^2); with substantial inflow from from Hermit-Door Creek system, Kilfoyle, Lookout, Woomeroo and unnamed Creeks. More than 80 fauna species, with at least 30 species listed under treaties (JAMBA/CAMBA), are known to occur within the site. The system supports a large number of magpie geese. Reptiles (frogs, freshwater turtles) are known to occur in areas of the system, which also acts as an important breeding area for saltwater crocodile (in swamps and billabongs) and habitat for freshwater crocodiles (further upstream) (DAWE, 2022b).
Finniss Floodplain and Fog Bay Systems	209 km northeast	A megascale irregular floodplain, with a network of microscale irregular creeks and a series of mesoscale (almost closed loop) irregular channels, also several microscale irregular estuaries and a macroscale embayment (mudflats part, up to 1.5 km wide). Surface water inflow is mainly from the Finniss river originating 50 km southeast (catchment area exceeds 110 000 ha), and several creeks. This system supports a major breeding area for magpie geese, at times a significant dry season refuge area for waterbirds (whistling-

Name	Distance from Beehive-1	Description
		ducks); a major migration stop-over area for shorebirds; and a major breeding area for saltwater crocodile (DAWE, 2022b).
Port Darwin	294 km northeast	A shallow branching embayment supporting one of the largest discrete areas of mangrove swamp in the NT. The wetland acts as a major nursery area for estuarine and offshore fish and crustaceans in the Beagle Gulf area. At least 48 bird species occur, 25 listed under treaties (JAMBA, CAMBA, BONN); including four cormorants, nine herons and allies, three rails, 23 shorebirds and six gulls and terns. Dolphins and turtles are commonly observed (DAWE, 2022b).
Adelaide River Floodplain System	352 km northeast	A major floodplain-tidal wetland system typical of the Top End region, consisting of the largest blocks of mangrove associated with a floodplain, a tightly meandering major tidal river, and several marginal lakes and swamps including the largest floodplain lake (Lake Finniss), and near-permanent marsh (Fogg Dam, Melacca Swamp), considered a rare wetland type in NT. Records indicate there are 88 waterbird species, 43 of them listed under treaties (JAMBA/CAMBA). Saltwater crocodiles, freshwater crocodiles, freshwater turtles, water python, snakes, frogs and numerous fish species are associated with the floodplain, fringing billabongs and swamps. Dolphins and dugongs occur in the lower part of the estuary (DAWE, 2022b).
Shoal Bay - Micket Creek	313 km northeast	The Shoal Bay – Micket creek is a spring fed coastal freshwater floodplain consisting of wetland marshes, mangrove woodlands, beaches, mudflats, creeks and estuaries. The wetland area stretches from Lee Point, which is outside Defence property, around the coast to Gunn Point. Micket Creek is a tidal estuary flowing into Shoal Bay. King creek, other smaller creeks, and water from Noogoo Swamp flow into Shoal Bay. The Micket Creek area is a significant bird habitat with over 200 species of birds recorded. It is also a dry season refuge for waterfowl and birds of prey (AHC 1991). High numbers of migratory shorebirds regularly use the areas' mudflats with counts of more than 15,000 waders. The estuary creeks provide a significant nursery for Barramundi. Twenty-five migratory birds listed on international agreements with Japan and China (JAMBA/CAMBA) have been recorded from intertidal feeding sites, saline flats and local sewage ponds. The most common of these birds are the greenshank, sharp-tailed sandpiper, bar-tailed godwit, black-tailed godwit, great knot, large sand plover and red-necked stint. The area is also notable for the nationally endangered little tern (DAWE, 2022b).
Mary Floodplain System	374 km northeast	A major floodplain-tidal wetland system typical of the Top End region, however unusual due to a lack of coherent river channel or major river estuary. The Mary Floodplain adjoins the Adelaide River Floodplain System located in the northwest. The site includes some of the largest areas of wooded swamp (apart from Arafura Swamp) in the NT and featuring a complex network of channels and billabongs. At least 75 bird species have been recorded, 33 listed under treaties (JAMBA, CAMBA, BONN. The site is one of the two to three most important breeding areas for magpie goose in part due to an abundance of nesting sites and feeding habitat (DAWE, 2022b).

Name	Distance from Beehive-1	Description
Kakadu National Park	420 km northeast	Kakadu National Park is a Ramsar site of contiguous wetlands comprising the catchments of two large river systems, the East and South Alligator rivers, seasonal creeks and the lower reaches of the East Alligator River. It also includes the Magela Creek floodplain, the lower South Alligator floodplain, the entire West Alligator River system and nearly all the Wildman River system. During the dry season water contracts into lagoons and billabongs and up to two million waterbirds frequent the floodplains. At least 53 species of waterbirds use the Ramsar site including large concentrations of magpie geese and wandering whistling-duck. These and many other species breed in the wetlands but most species are dry season migrants (DAWE, 2022b). Both freshwater and saltwater crocodiles are known to breed within the Ramsar site. Fifty-nine fish species are known from the wetland, including eight with narrowly restricted ranges (DAWE, 2022b).
Murgenella-Cooper Floodplain System	498 km northeast	A good example of a floodplain-tidal wetland system of the Top End region, with relatively low volume of freshwater inflow. Surface water flows into the system mainly from Cooper Creek, originating 70 km east south-east (catchment area of 165 000 ha), and several unnamed creeks including minor creeks. At least 71 bird species have been recorded in the area, 26 on treaties (JAMBA, CAMBA, BONN). Magpie geese breed extensively on both Murgenella and Cooper Floodplains. Although, the Murgenella floodplain is not known as a breeding area for saltwater crocodile, Cooper creek swamps are thought to have high numbers (DAWE, 2022b).
Cobourg Peninsula System	460 km northeast	The Coburg Peninsula system is a good example of mangrove swamp occurring around tidal channels and islands not associated with substantial riverine inflow. It is has one of the largest discrete blocks of mangroves in the NT. Most of the site's wetlands are tidal, with numerous creeks flowing into the tidal areas. 58 species of bird species have been recorded, at least 21 listed under treaties (JAMBA/CAMBA); includes four darters and cormorants, 12 herons and allies (e.g., eastern reef egret), 23 shorebirds (e.g., eastern curlew) and six gulls and terns. Saltwater crocodile are present in the tidal areas (e.g., south ends of Port Bremer and Raffles Bay) but densities are relatively low. At least 13 frog species occur on the peninsula. Marine turtles (green and hawksbill turtles) occur at most of the islands and headlands, with all species known to breed in the NT. Dugong occur in the Minimini channels and widely in adjacent shallow seas, with high densities in some northern embayments (DAWE, 2022b).

5.4.9. State/Territory Protected Areas

There is several WA- and NT-managed marine protected areas intersected by the EMBA, previously shown in Figure 5.54 and described in Table 5.15.

Table 5.15. Marine protected areas in the spill EMBA

Name	Distance from Beehive-1	Description
WA		
North Kimberley Marine Park	68 km south	The North Kimberley Marine Park is the largest state marine park in WA, covering an area of approximately 18,450 km^2. The park is located in state waters and extends from York Sound to Cape Londonderry, to the JBG and up to the WA/NT border (DPW, 2016). The park is part of a joint management plan between the Department of Parks and Wildlife and the Uunguu, Balangarra, Miriuwung Gajerrong and Wilinggin traditional owners (DPW, 2016). The North Kimberley Marine Park covers a large variety of marine habitats including coral reefs, seagrass, mangroves and macroalgal communities. More than 1,000 islands and associated intertidal and subtidal habitats are contained within its boundaries. Seagrass beds found around Cape Londonderry (164 km west of the activity area) provide foraging areas for dugong and marine turtles (DPW, 2016). The marine park surrounds thousands of islands with diverse and rich habitats. Marine turtle nesting sites and breeding sites for seabirds and migratory shorebirds have been identified within the marine park, and fringing reefs line the shores of almost all of the islands (DPAW, 2016). The productive deep waters that surround the islands and open sea reefs provide foraging habitat for marine mammals and pelagic fish, such as mackerel (DPW, 2016). The complex coastline of the mainland also creates a variety of habitats and communities, including important areas for dugongs, Australian snubfin dolphins and Australian humpback dolphins (DPW, 2016). The marine park also contains many places of cultural and spiritual importance to traditional owners (DPW, 2016).
North Lalang-garram Marine Park	423 km southwest	The North Lalang-garram Marine Park lies within Dambimangari country between Lalang-garram / Camden Sound Marine Park and the North Kimberley Marine Park and covers about 110,000 hectares.
Lalang-garram/ Camden Sound Marine Park	423 km southwest	The Lalang-garram/Camden Sound Marine Park is a state marine park located 150 km north of Derby. It contains a range of species listed as having special conservation status including marine turtles, snubfin and Indo-Pacific humpback dolphins, dugong, saltwater crocodiles, and several species of sawfish. The park also includes a wide range of marine habitats and associated marine life, such as coral reef communities, rocky shoals, and the extensive mangrove forests and marine life of the St George Basin and Prince Regent River. T The marine park is one is the most important humpback whale nursery in the southern hemisphere. A special purpose zone (whale conservation) with specific management arrangements has been established to enhance protection of humpback cows and calves in the humpback whale calving area of Camden Sound. This zone covers

Name	Distance from Beehive-1	Description
		about 168,000 hectares (approximately 24%) of the marine park ((DPaW, 2013).
Rowley Shoals Marine Park	1,044 km southwest	The Rowley Shoals Marine Park is a WA managed marine park adjacent to Mermaid Reef, Commonwealth managed Marine Park . The Rowley Shoals Marine Park protect a chain of three coral atolls at the edge of Australia's continental shelf. The atolls have shallow lagoons inhabited by diverse corals and abundant marine life. Each cover around 80km-90km, rising with near-vertical sides from very deep water. At low tide the water becomes ponded within the reef walls, and gushes over the edge like waterfalls. At high tide, the reefs disappear beneath the sea, with only the sandy islands of Clerke and Imperieuse visible (DBCA, 2017). Corals form a spectacular chain of reef systems, each covering about 80km2. Shallow lagoons within the reefs provide sheltered waters that are inhabited by diverse and abundant tropical marine life. Further offshore, the seafloor slopes away to the abyssal plain, some 6000m below. Undersea canyons slice the slope: these features are commonly associated with diverse communities of deep-water corals and sponges and create localised upwellings that aggregate pelagic species like tunas and billfish (DBCA, 2017).
Montebello Islands Marine Park	1,544 km southwest	Refer to previous information provided in Section 5.4.1.
NT		
Garig Gunak Barlu National Park	460 km northeast	Garig Gunak Barlu National Park is a protected area on the Cobourg Peninsula and some adjoining waters approximately 216 km northeast of Darwin. It covers an area of 4,500 km^2 and is one of only two areas in the NT which contains adjoining land and marine parks. The national park includes the entire Cobourg Peninsula, the surrounding waters of the Arafura Sea and Van Diemen Gulf, including some of the neighbouring islands (e.g., Burford Island) (NT Government, 2020). The protected area was established by joining the former Gurig National Park and the Cobourg Marine Park. Garig Gunak Barlu is Aboriginal owned land, jointly managed by a Board consisting of Iwaidja speaking peoples of the Cobourg Peninsula and NT Government representatives (NT Government, 2020). The Park consists of sandy beaches, dunes and associated coastal grasslands, mangroves, rainforest patches, swamps, lagoons, coral reefs, sea grass meadows and rich marine life. The park supports rare species such as dugong and marine turtles as listed under the EPBC Act (Table 5.4). In addition, the park is home to the largest wild herd of Banteng (Indonesian cattle) which are an endangered species in their native habitat park (NT Government, 2020).

5.5. Cultural Heritage Values

Cultural heritage can be broadly defined as the legacy of physical science artefacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations. Cultural heritage includes tangible culture (such as buildings, monuments, landscapes, books, works of art, and artefacts), intangible culture (such as folklore, traditions, language, and knowledge) and natural heritage (including culturally significant landscapes).

This section describes the cultural heritage values of the EMBA (which includes the coastline up to the high-water mark), which are broadly categorised as Indigenous and non-Indigenous (maritime archaeology).

5.5.1. Aboriginal Heritage Sites

Indigenous Australian people have a strong continuing connection with the area that extends back some 50,000 years. The existence of any unknown Aboriginal sites or artefacts of significance within the offshore waters of northern Australia is considered highly unlikely.

A search of the WA Department of Aboriginal Affairs' Aboriginal Heritage Inquiry System (AHIS) online was undertaken within the spill EMBA. There are 280 registered Aboriginal sites that within the fall spill EMBA. The majority of the registered sites are located along the coastline between the Derby-West Kimberley, Mitchell River and Wyndham-East Kimberley shoreline sectors which are considered to be remote unpopulated areas in northern WA (see Figure 5.9).

5.5.2. Maritime Archaeological Heritage

Historic shipwrecks are recognised and protected under the *Underwater Cultural Heritage Act* 2018, which aims to protect historic wrecks and associated relics. Under the Act, all wrecks more than 75 years old are protected, together with their associated relics regardless of whether their actual locations are known.

There are 178 shipwrecks identified within the EMBA; 106 located in off the WA coast and 72 located off the NT coast. The locations of these shipwrecks are illustrated in Figure 5.58.

5.5.3. Native Title

A search of the National Native Title Tribunal (NNTT) Register identified the following Native Title registered areas within the spill EMBA:

- Miriuwung Gajerrong (#4 and Western Australia) - represented by the Miriuwung and Gajerrong Aboriginal Corporation (MG Corporation). The determination area extends to intertidal areas and sea country intersected by the EMBA in the Cambridge Gulf and eastern Kimberley region (Figure 5.59).
- Balanggarra (#3) - represented by the Balanggarra Aboriginal Corporation RNTBC. The northern boundary of the area is situated south of Adolphus Island and continues south along the Ord River (within the spill EMBA) (Figure 5.60).
- Balanggarra (#4) - represented by the Balanggarra Aboriginal Corporation RNTBC. The native title covers all land comprising Adolphus Island, above the high water mark (Figure 5.60).
- Balanggarra (Combined) - represented by the Balanggarra Aboriginal Corporation RNTBC. The determination area includes waters at the 3 nautical mile coastal water limit including Lacrosse Island (above the low water mark) and Adolphus Island (above the high water mark) (Figure 5.60).

- Bardi and Jawi Native Title Determination - represented by the Bardi and Jawi Niimidiman Aboriginal Corporation RNTBC. The determination area includes the waters from Pender Bay, Thomas Bay, Curlew Bay, Cygnet Bay and Goodenough Bay.
- Bindunbur – represented by the Gogolanyngor Aboriginal Corporation, Nimanburr Aboriginal Corporation and Nyul Nyul PBC Aboriginal Corporation. Parts of the native title determination area within the spill EMBA include Lacepede Islands and its surrounding waters offshore and Goodenough Bay on the Dampier Peninsula.
- Dambimangari - represented by Wanjina-Wunggurr (Native Title) Aboriginal Corporation RNTBC. The determination area covers the Shire of Derby, West Kimberley and Shire of Wyndham-East Kimberley.
- Mayala #2 - represented by the Mayala Inninalang Aboriginal Corporation. The native title exists in parts of the determination area on two islands (Area 1 and Area 2) east of Arbidej Island and one island (Area 3) northeast of Umida island.
- Mayala People - represented by the Mayala Inninalang Aboriginal Corporation. The native title exists in the determination area that includes parts of King Sound, Cone Bay, Strickland Bay, Yampi Sound and numerous offshore islands off the Derby-West Kimberley sector including Bathurst Island and Sir Frederick Island.
- Uunguu Part A - represented by Wanjina-Wunggurr (Native Title) Aboriginal Corporation RNTBC. The determination area includes the offshore islands and waters of York Sound, Montague Sound, and Admiralty Gulf.
- Uunguu Area B – represented by Wanjina-Wunggurr (Native Title) Aboriginal Corporation RNTBC. The determination area includes the nearshore waters of Port Warrendah and the adjacent Kimberley mainland.
- Spirit Hills Pastoral Lease No.2 – represented by Top End (Default PBC/CLA) Aboriginal Corporation RNTBC. The western boundary of the determination area is on the WA/NT border and includes the land and waters associated with six estates or pastoral leases on the NT mainland.
- Legune Pastoral Lease – represented by Top End (Default PBC/CLA) Aboriginal Corporation RNTBC. The determination area is located in the NT near the Keep River National Park Extension and is held by the Gajerrong-Wadanybang, Gajerrong-Gurrbjim and Gajerrong-Djarrajarrany groups.
- Larrakia (Part A - consolidated proceeding) – represented by the Northern Territory A/TSI body area. The determination area includes waters near and surrounding Darwin Port including the Darwin waterfront and Darwin municipality.
- Croker Island – represented by the Top End (Default PBC/CLA) Aboriginal Corporation RNTBC. The determination area includes Croker Island, Templer Island, Valencia Island, Darch Island, Grant Island, Lawson Island, Oxley Island and Mc Cluer Island.

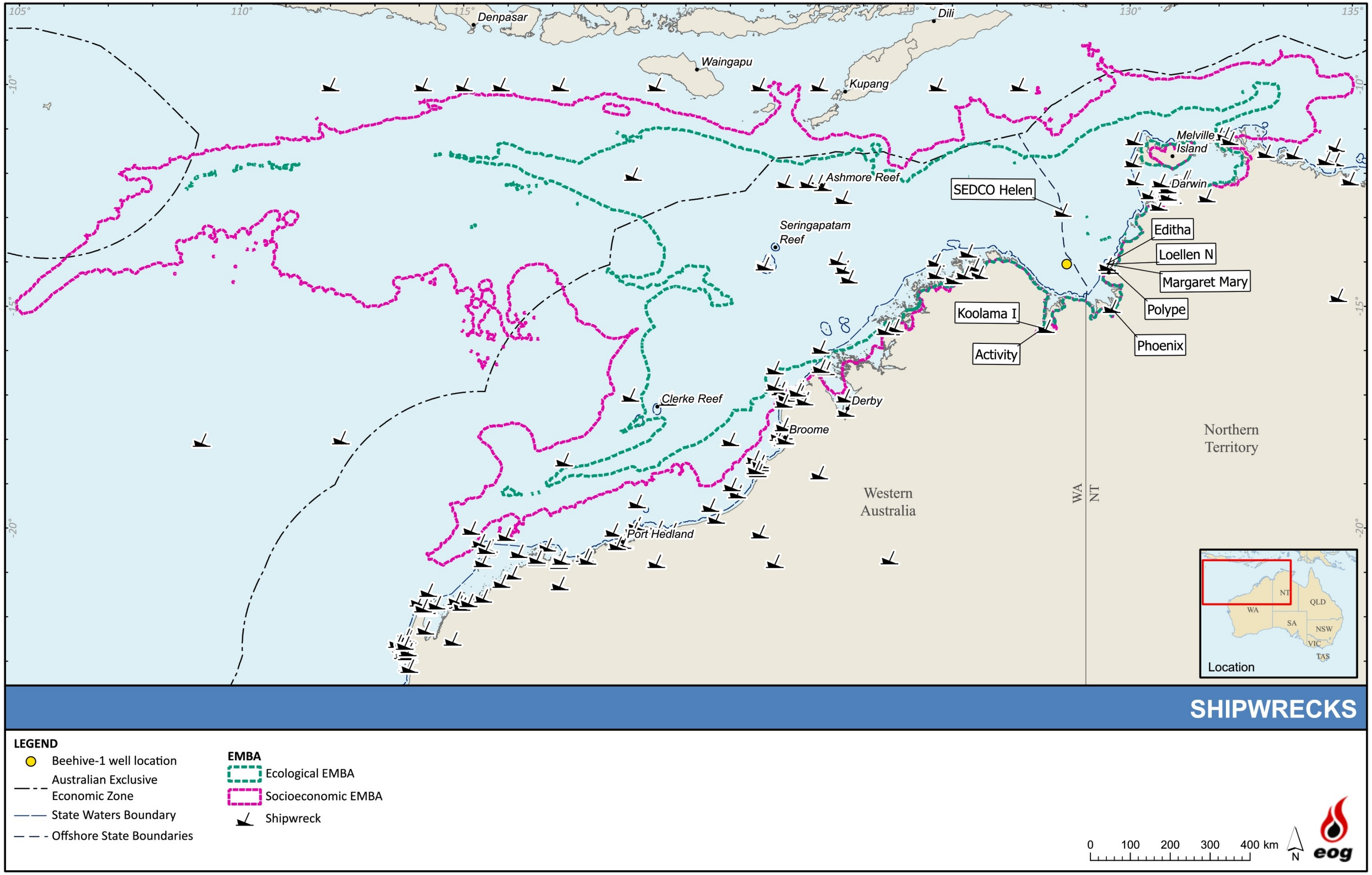


Figure 5.58. Shipwrecks intersected by the EMBA

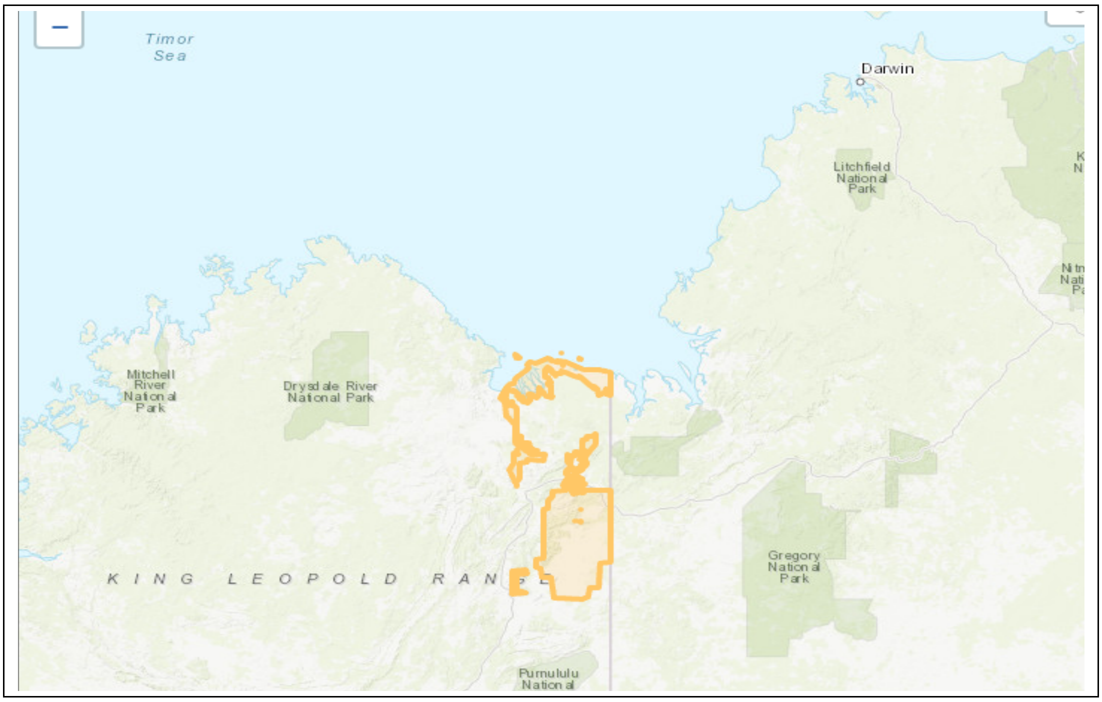


Figure 5.59. Miriuwung Gajerrong Native Title Determination Area

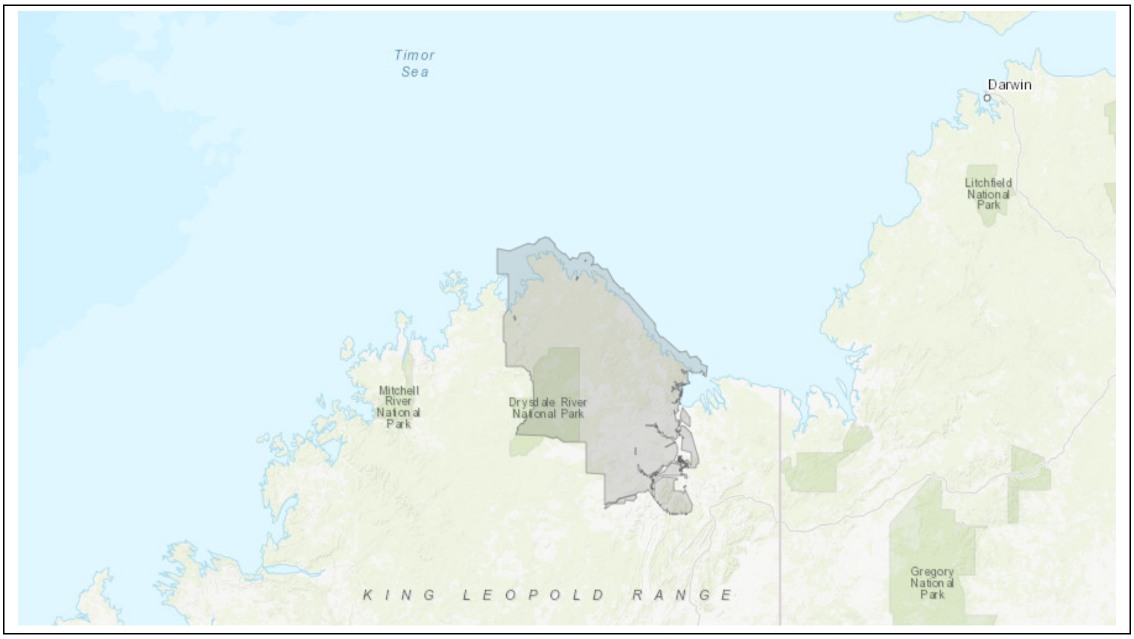


Figure 5.60. Balanggarra Native Title Determination Area

5.6. Socio-economic environment

This section describes the social and economic environment of the EMBA.

5.6.1. Commercial Fishing

Several Commonwealth, WA and NT commercial fisheries are licensed to operate in the EMBA. These are described in the following sections.

Commonwealth-managed Fisheries

Commonwealth fisheries are managed by AFMA under the *Fisheries Management Act 1991* (Cth). Their jurisdiction covers the area of ocean from 3 nm from the coast out to the 200 nm limit (the extent of the Australian Fishing Zone [AFZ]). Commonwealth commercial fisheries with jurisdictions to fish the EMBA are the:

- Northern Prawn Fishery (NPF).
- North West Slope Trawl Fishery;
- Southern Bluefin Tuna (SBT) Fishery;
- Western Tuna and Billfish Fishery;
- Western Deepwater Trawl Fishery; and
- Western Skipjack Fishery.

Of these fisheries, only the NPF and the North West Slope Trawl Fishery have evidence of recent (within the last three years) fishing activity in the EMBA. The NPF is discussed in detail in Section 5.71 of Chapter 5 of the EP.

Although there is no current fishing effort nor previous active fishing for the Southern Bluefin Tuna Fishery off WA, the EMBA does overlap a known spawning ground for this species (see Table 5.16). Table 5.16 summarises the key facts and figures of the relevant fisheries.

Table 5.16. Commonwealth-managed commercial fisheries with jurisdictions to fish in the EMBA

Fishery	Target species	Fishing activity in the EMBA?	Fishing season	Fishing methods, vessels and licences	Catch data and other information
NPF (Figure 5.61)	Redleg banana prawn (*Fenneropenaeus indicus),* white banana prawn (*F. merguiensis*), brown tiger prawn (*Penaeus esculentus*), grooved tiger prawn (*P. semisulcatus*), blue endeavour prawn (*Metapenaeus endeavouri*) and red endeavour prawn (*M. ensis*)	Areas include JBG (low fishing intensity), south-west of Darwin (low to medium intensity), north of Melville Island (low to high intensity) extending to Cobourg Peninsula (low to medium intensity).	The NPF operates in two seasons; • First - beginning in April for a duration of 6-12 weeks during which time banana prawns are mainly caught. • Second (August - November), when tiger prawns are predominately caught.	Otter trawl is the primary fishing method. In 2019, there were 52 active permits and 52 active vessels.	Catch data and economic value available for the last five years: • 2020 – 4,767 tonnes valued at 84.9 million. • 2019 – 8,581 tonnes valued at $117.1 million. • 2018 – 6,778 tonnes valued at $98.2 million. • 2017 – 6,602 tonnes valued at $118.1 million. • 2016 – 5,794 tonnes valued at $126.1 million.
North West Slope Trawl Fishery (Figure 5.62)	Australian scampi (*Metanephrops australiensis*) smaller quantities of velvet scampi (*M. velutinus*) and Boschma's scampi (*M. boschmai*) are also harvested. Mixed deep-water snappers are also a component of the catch.	Low to high intensity fishing area northeast of Clerke Reef; including a small area southwest of Cunningham Island.	All year round.	Deepwater demersal trawling. Fishing occurs on the continental slope in water depths greater than 200 m. The number of vessels involved in the fishery has been one or two vessels each year since 2008/2009.	Catch data available for the following years (economic value confidential): • 2020-21 – not yet available. • 2019-20 – 111.5 tonnes. • 2018-19 – 67.4 tonnes. • 2017-18 – 79.8 tonnes. • 2016-17 – 57.7 tonnes.

Fishery	Target species	Fishing activity in the EMBA?	Fishing season	Fishing methods, vessels and licences	Catch data and other information
Southern Bluefin Tuna Fishery (Figure 5.63)	Southern bluefin tuna (*Thunnus maccoyii*).	There has been no active fishing in WA in recent years as fishing efforts are concentrated off New South Wales and SA (Patterson *et al.,* 2019). However, the EMBA extends to the potential spawning grounds of the target species in the northwest of WA between September and March, and larvae are seasonally abundant in surface waters during these months.	12-month season begins 1st December.	Purse seine catch in the GAB for transfer to aquaculture farms off Port Lincoln in South Australia (five to eight vessels consistently fish this area). Port Lincoln is the primary landing port. On the east coast, pelagic longline fishing is the key fishing method. 27 active vessels in the last year (2018-2019).	There is no recent fishing effort in the EMBA. Catch data and economic value available for the following years: • 2020-21 – not yet available. • 2019-20 – 5,429 tonnes worth $41.27 million. • 2018-19 – 6,074 tonnes worth $43.41 million. • 2017-18 – 6,159 tonnes worth $39.73 million. • 2016-17 – 5,334 tonnes worth $38.57 million.

Sources: Patterson et al (2021; 2020; 2019; 2018; 2017; 2016).

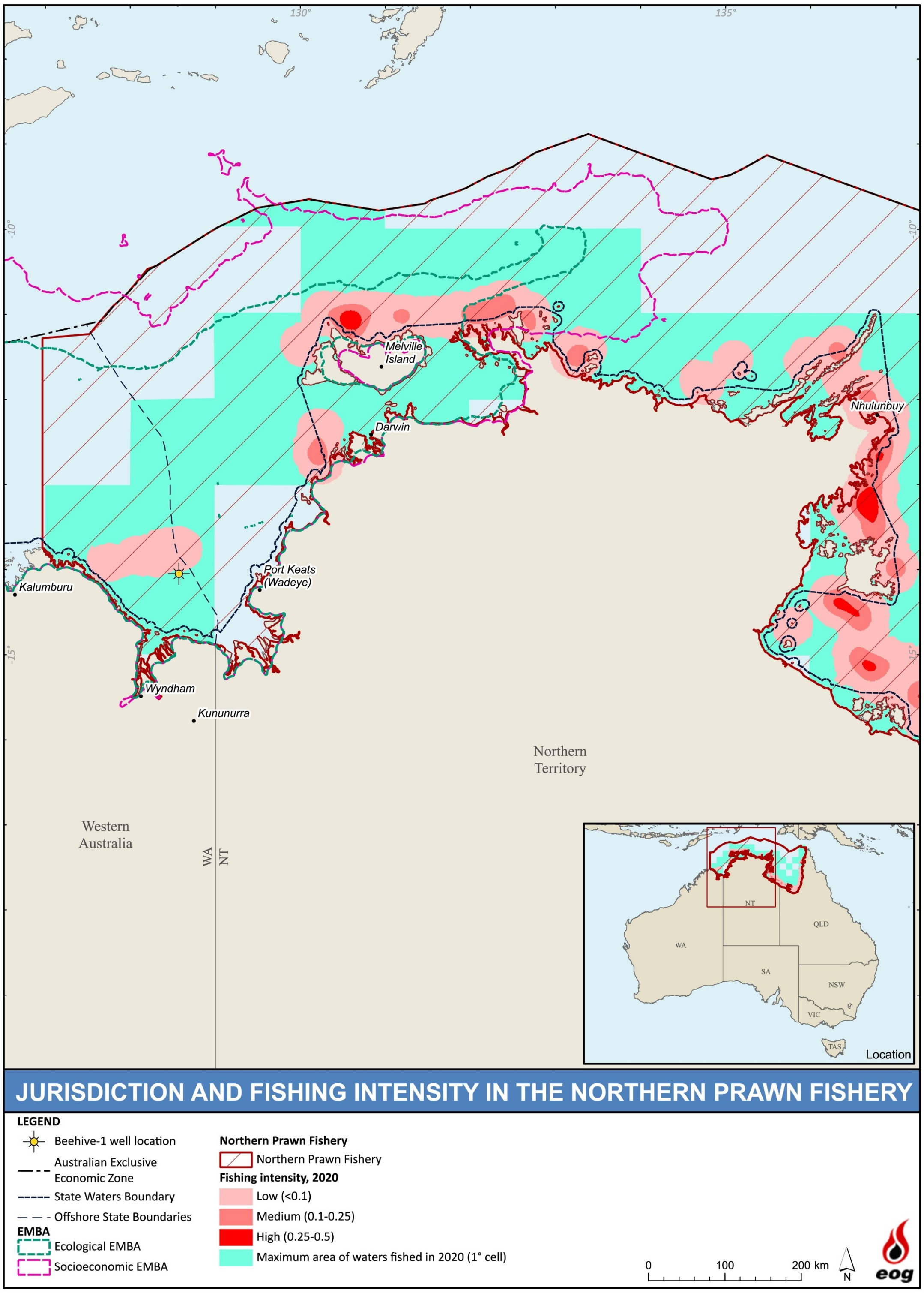


Figure 5.61. Northern Prawn Fishery intersected by the EMBA

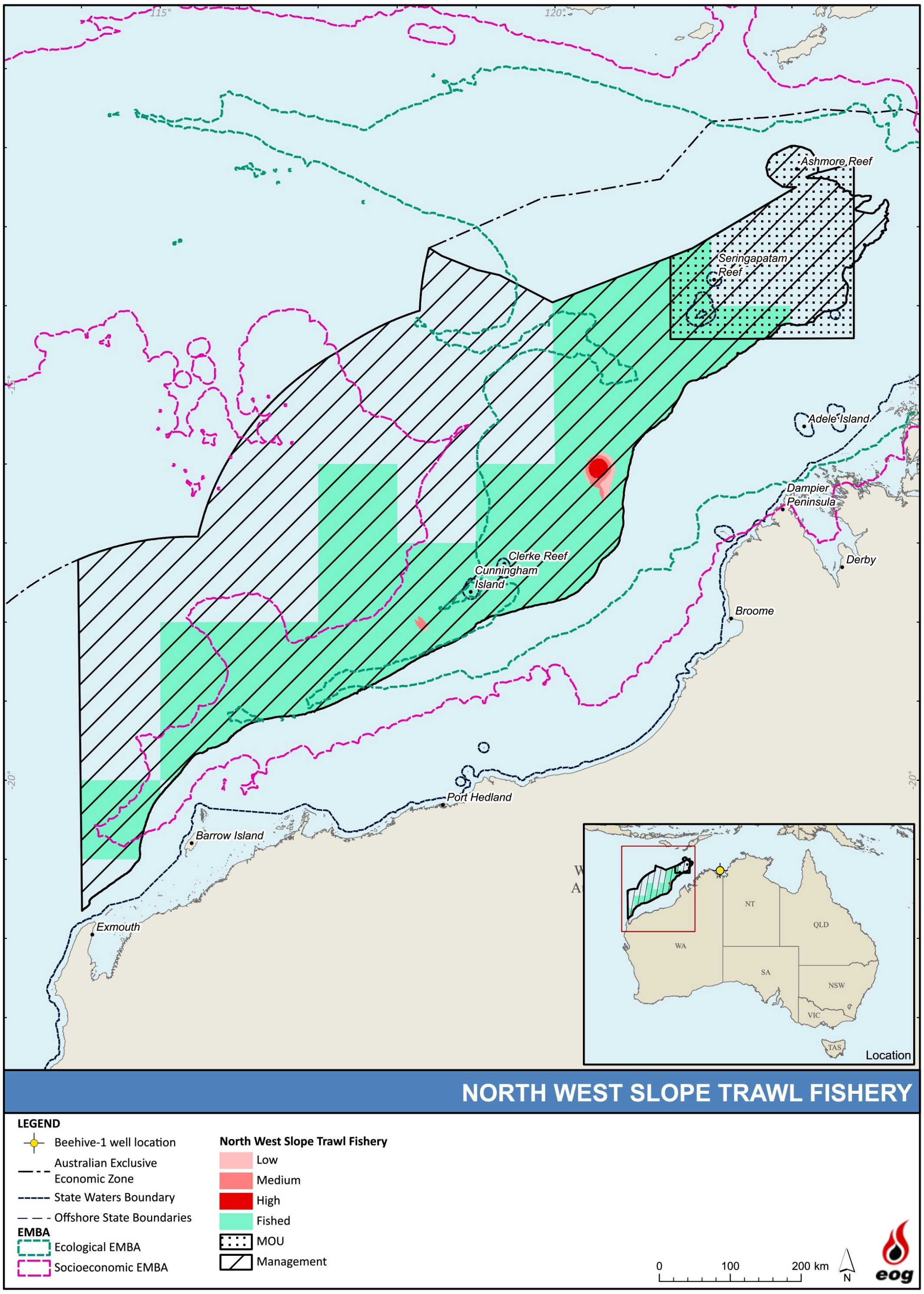


Figure 5.62. North West Slope Trawl Fishery intersected by the EMBA

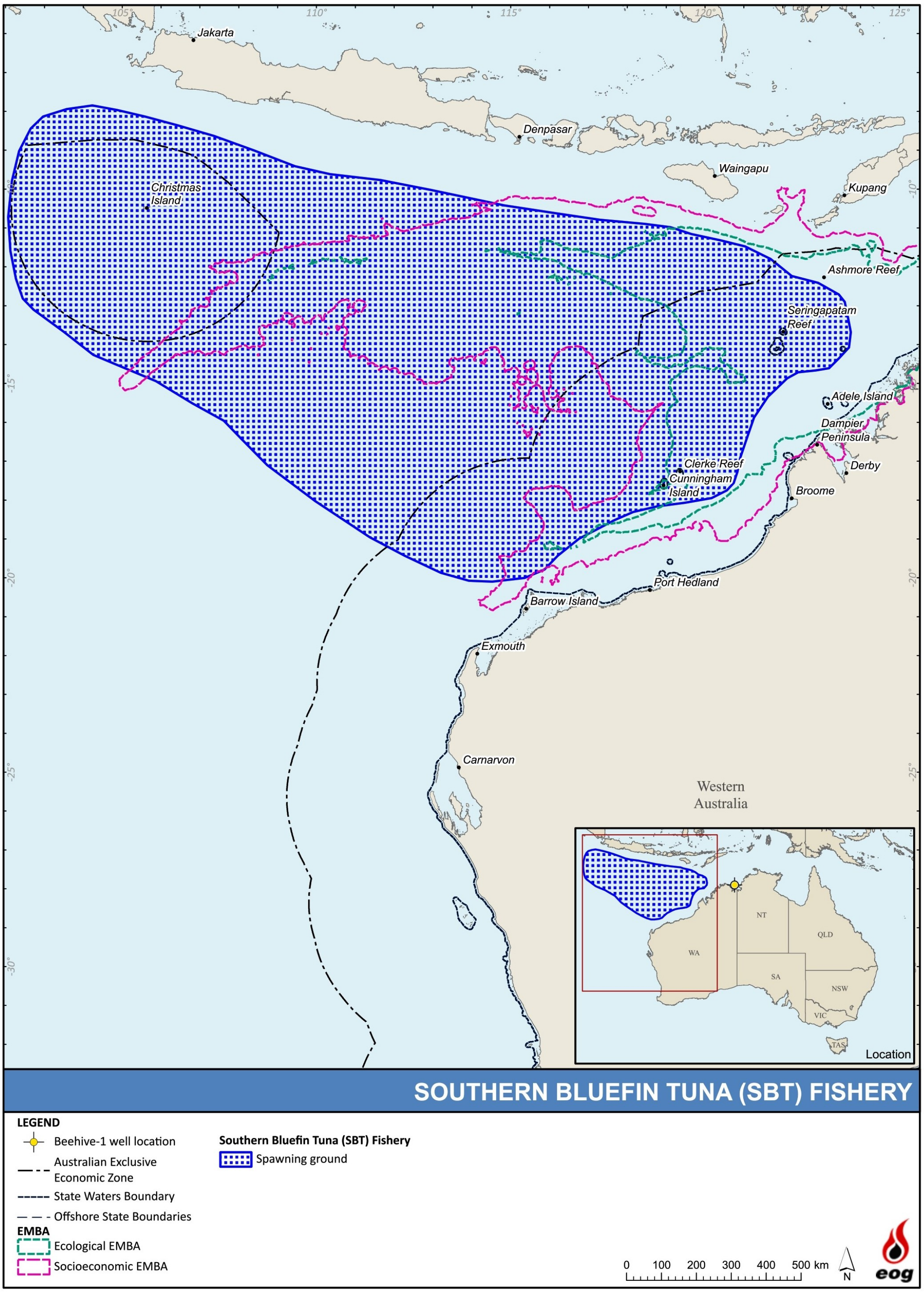


Figure 5.63. Southern Bluefin Tuna spawning grounds intersected by the EMBA

Western Australia-managed Fisheries

Western Australian-managed commercial fisheries that are authorised to harvest in the waters of the activity area and EMBA include the following (noting that not all actively fish):

- Mackerel Managed Fisheries (MMF);
- Northern Demersal Scalefish Managed Fishery;
- Pearl Oyster Managed Fishery;
- Abalone Managed Fishery;
- Kimberley Crab Managed Fishery (North Coast Crab Fishery);
- Kimberly Prawn Managed Fishery;
- Kimberley Gillnet and Barramundi Managed Fishery;
- Broome Prawn Managed Fishery;
- Nickol Bay Prawn Managed Fishery;
- Onslow Prawn Managed Fishery;
- Specimen Shell Fishery;
- Marine Aquarium Fish Managed Fishery (MAFMF);
- Pilbara Demersal Scalefish Fishery;
- Pilbara Crab Managed Fishery (PCMF); and
- West Coast Deep Sea Crustacean Managed Fishery.

Through its consultation process with the WA DPIRD, EOG identified the MMF, the Northern Demersal Scalefish Managed Fishery, Kimberley Crab Managed Fishery, Kimberley Prawn Managed Fishery and the Kimberley Gillnet and Barramundi Fishery as the key fisheries that actively fish in the EMBA. Table 5.17 presents information for these fisheries (noting that catch data for 2020, 2021 or 2020/21 is not yet publicly available).

Table 5.17. WA-managed commercial fisheries with jurisdictions to fish within the EMBA

Fishery	Target species	Fishing activity in the EMBA?	Fishing season	Fishing methods, vessels and licences	Catch data and other information
Northern Demersal Scalefish Managed Fishery (Figure 5.64)	Targets predominately goldband snapper (*Pristipomoides multidens*), crimson snapper, red emperor (*Lutjanus sebae*) bluespotted emperor (*Lethrinus punctulatus*), saddletail snapper (*L. malabaricus*), rankin cod (*Epinephelus multinotatus*), brownstripe snapper (*L. vitta*), rosy threadfin bream (*Nemipterus furcosus*) and spangled emperor (*Lethrinus nebulosus*).	The EMBA intersects fishing Area 1 and Area 2; including the Pilbara offshore closed waters (trawl) and Pilbara trap fishing only (Figure 5.64).	Assumed to be year-round.	Although permitted to use handlines, droplines and traplines, since 2002 the fishery has been essentially trap based. Six vessels actively fished in 2019, which is down from seven vessels operating in 2016.	Catch data available for the last five years: • 2019 – 1,507 t. • 2018 – 1,297 t. • 2017 – 1,317 t. • 2016 – 1,173 t. • 2015 – 1,046 t. Majority of catch (87%) was landed in Zone B in the 2019 season.
Mackerel Managed Fishery (Area 1 and 2) (Figure 5.65)	Spanish mackerel (*Scomberomorus commerson*).	The EMBA intersects fishing Area 1 (Kimberley) and Area 2 (Pilbara) (Figure 5.65)	Fishing is primarily from May – November in 2019. In the Pilbara sector, approximately 65% of effort has historically occurred from July to August.	A total of 15 vessels operated during 2019 across the fishery. In 2014, only three vessels operated in the Kimberley region. Trolling and handline are the only allowable fishing methods.	Catch data available for the last five years: • 2019 – 291 t. • 2018 – 213 t. • 2017 – 283 t. • 2016 – 276 t. • 2015 – 302 t.

Fishery	Target species	Fishing activity in the EMBA?	Fishing season	Fishing methods, vessels and licences	Catch data and other information
Kimberley Crab Managed Fishery (KCMF) (Figure 5.66)	Green mud crabs (*Scylla serrata*) and brown mud crabs (*Scylla olivacea*).	The EMBA intersects fishing Area 1 (permitted areas of fishing) (Figure 5. 66)	Generally March to November, with June to September being the most productive months.	Crab traps are the primary fishing method. In 2019, six people were employed as skippers and crew on vessels fishing for mud crab in the KCMF.	Catch data available for the last five years: • 2019 – 7.4 t. • 2018 – 3.2 t. • 2017 – 9.0 t. • 2016 – 2.5 t. • 2015 – 15.3 t
Kimberley Prawn Managed Fishery (Figure 5.67)	Banana prawns (*Fenneropenaeus indicus* and *F. merguiensis*) are the primary target species though brown tiger prawns (*Penaeus esculentus*) and blue endeavour prawns (*Metapenaeus endeavouri*) are taken as bycatch.	The EMBA intersects the trawled areas and trawl closure areas nearshore and inshore as shown in Figure 5.67. Only the socioeconomic EMBA intersects the size management fish ground (Figure 5.67).	There are two fishing periods for the season (April to mid-June, then from August to the end of November) with around 90% of the total landings taken in the first fishing period.	Otter board trawl system is the primary fishing method.	Catch data available for the last five years: • 2019 – 100 t. • 2018 – 333 t. • 2017 – 269 t. • 2016 – 155 t. • 2015 – 175 t.
Kimberley Gillnet and Barramundi Fishery (Figure 5.68)	Barramundi (*Lates calcarifer*), king threadfin (*Polydactylus macrochir*) and blue threadfin (*Eleutheronema tetradactylum*) are the primary target species.	The EMBA primarily intersects the fishery in areas where the fishery is closed from 1st November to 31st January and 1st December to 31st January inclusive (Figure 5.68).	Year round, though predominantly occurs from April to September.	Fishing is restricted to state waters. There are currently four licences to the fishery.	Catch data available for the last five years: • 2019 – 73.4 t. • 2018 – 91.8 t. • 2017 – 79.9 t. • 2016 – 74.6 t. • 2015 – 82.1 t.

Fishery	Target species	Fishing activity in the EMBA?	Fishing season	Fishing methods, vessels and licences	Catch data and other information
Pearl Oyster Managed Fishery (Figure 5.69)	Silver lipped pearl oyster (*Pinctada maxima*).	The EMBA intersects Zone 1, Zone 2 and Zone 3 including the Kimberley development zone of the fishery (Figure 5.69).	Most vessels operate between March and June each year.	Quota-based diver fishery operating in shallow coastal waters.	Catch data available for the last five years: • 2019 – 611,816 shells. • 2018 – 614,002 shells. • 2017 - 468,573 shells. • 2016 - 541,260 shells. • 2015 - 560,005 shells.
Abalone Managed Fishery (Figure 5.70)	Greenlip abalone (*Haliotis laevigata*) and brownlip abalone (*H. conicopora*).	Yes	Between 1 October to 15 May the following year.	Abalone diving generally occurs close to the shoreline (generally no greater than 30 m depth) using hookah gear (breathing air supplied via hose connected to an air compressor on the vessel). Commercial divers do not use SCUBA gear.	Catch data available for the last five year: • 2019 – 47 t. • 2018 – 48 t. • 2017 – 48 t. • 2016 – 49 t. • 2015 – 51 t.
Marine Aquarium Fish Managed Fishery (Figure 5.71)	Multispecies including Syngnathids, invertebrates, hard coral, soft coral, living rock and sand, sponges and seagrasses.	Likely	Assumed year-round.	10 out of 12 licences were active during the 2019 season.	Catch data available for the last five years: • 2019 – 11,925 individuals • 2018 – 27,327 individuals • 2017 – 26,113 individuals • 2016 – 15,424 individuals • 2015 – 20,993 individuals

Fishery	Target species	Fishing activity in the EMBA?	Fishing season	Fishing methods, vessels and licences	Catch data and other information
Broome Prawn Managed Fishery (Figure 5.72)	Western king prawn (*Melicertus latisulcatus*)	The socio-economic EMBA intersects a known fishing area off Broome.	Assumed to follow that of the Kimberley Prawn Managed Fishery	Demersal trawl.	Between 2015-2019, there was trial fishing only with landings <1 tonne each year.
Nickol Bay Managed Prawn Fishery (Figure 5.73)	Banana prawns (*Fenneropenaeus indicus* and *F. merguiensis*) are the primary target species though brown tiger prawns (*Penaeus esculentus*) and blue endeavour prawns (*Metapenaeus endeavouri*) are taken as bycatch.	Yes –within the fishery extent, however it does not intersect the fishery trawled area nor the size management fish ground (Figure 5.73).	Assumed to follow that of the Kimberley Prawn Managed Fishery.	Demersal trawl.	Catch data available for the last five years: • 2019 – 254 t. • 2018 – 81 t. • 2017 – 227 t. • 2016 – 17 t. • 2015 – 87 t.
Onslow Managed Prawn Fishery (Figure 5.74)	Banana prawns (*Fenneropenaeus indicus* and *F. merguiensis*) are the primary target species though brown tiger prawns (*Penaeus esculentus*) and blue endeavour prawns (*Metapenaeus endeavouri*) are taken as bycatch.	Yes – within the fishery extent, however it does not intersect the fishery trawled area nor the size management fish ground (Figure 5.74).	Assumed to follow that of the Kimberley Prawn Managed Fishery.	Demersal trawl.	Catch data available for the last five years: • 2019 – 50 t. • 2018 – 60 t. • 2017 – Undisclosed (negligible). • 2016 – 3 t. • 2015 – 10 t.
Specimen Shell Fishery (Figure 5.75)	Specimen shells collected across 241 species in 2019.	Low fishing intensity.	Year-round.	Hand collection.	Catch data available for the last five years: • 2019 – 7,232 shells. • 2018 – 7,628 shells. • 2017 – 7,806 shells. • 2016 – 8,531 shells. • 2015 – 18,391 shells.

Fishery	Target species	Fishing activity in the EMBA?	Fishing season	Fishing methods, vessels and licences	Catch data and other information
Pilbara Demersal Scalefish Managed Fishery (Figure 5.76)	Goldband snapper (*Pristipomoides multidens*), blue spotted emperor (*Lethrinus punctulatus*), red emperor (*Lutjanus* sebae), saddletail snapper (*L. malabaricus*), crimson snapper (*L. erythropterus*) and rosy threadfin bream (*Nemipterus furcosus*).	Yes – the southwestern extent of the EMBA intersects the Pilbara offshore closed waters (trawl) (Zone 1 and Area 6) and Pilbara trawl (Zone 1 and Zone 2) and trap fishing (Figure 5.76).	Year-round.	Hand line, drop line and fish traps are permitted.	Catch data available for the last five years: • 2019 – 2,980 t. • 2018 – 2,651 t. • 2017 – 2,529 t. • 2016 – 2,150 t. • 2015 – 1,779 t.
Pilbara Crab Managed Fishery (PCMF) (Figure 5.77)	Blue swimmer crabs (*Portunus pelagicus*)	Yes - the southwestern extent of the EMBA intersects the permitted area of the fishery (Figure 5.77).	Fishers generally operate from March to November with May to September being the most productive months.	Crab trap and drop nets are used to harvest crabs.	Catch data available for the last five years: • 2019 – 19 t. • 2018 – 35 t. • 2017 – 51 t. • 2016 – 37 t. • 2015 – 64 t.
West Coast Deep Sea Crustacean Managed Fishery (Figure 5.78)	Snow crab (*Chaceon albus*), spiny crab (*Hypothalassia acerba*) and giant crab (*Pseudocarcinus gigas*).	Yes –within the fishery extent and closed waters of the fishery, however fishing effort is concentrated in areas south of Exmouth (outside of EMBA) (Figure 5.78)	Typically from January to June, with greater intensity in January/February.	Baited pots or traps in a long line formation in the shelf edge waters (>150 m).	Catch data available for the last five years: • 2019 – 153 t. • 2018 – 154 t. • 2017 – 164 t. • 2016 – 153 t. • 2015 – 154 t.

Gaughan and Santoro (2021; 2020; 2018); Gaughan et al (2019); Fletcher et al (2017); Fletcher and Santoro (2015), How et al (2015).

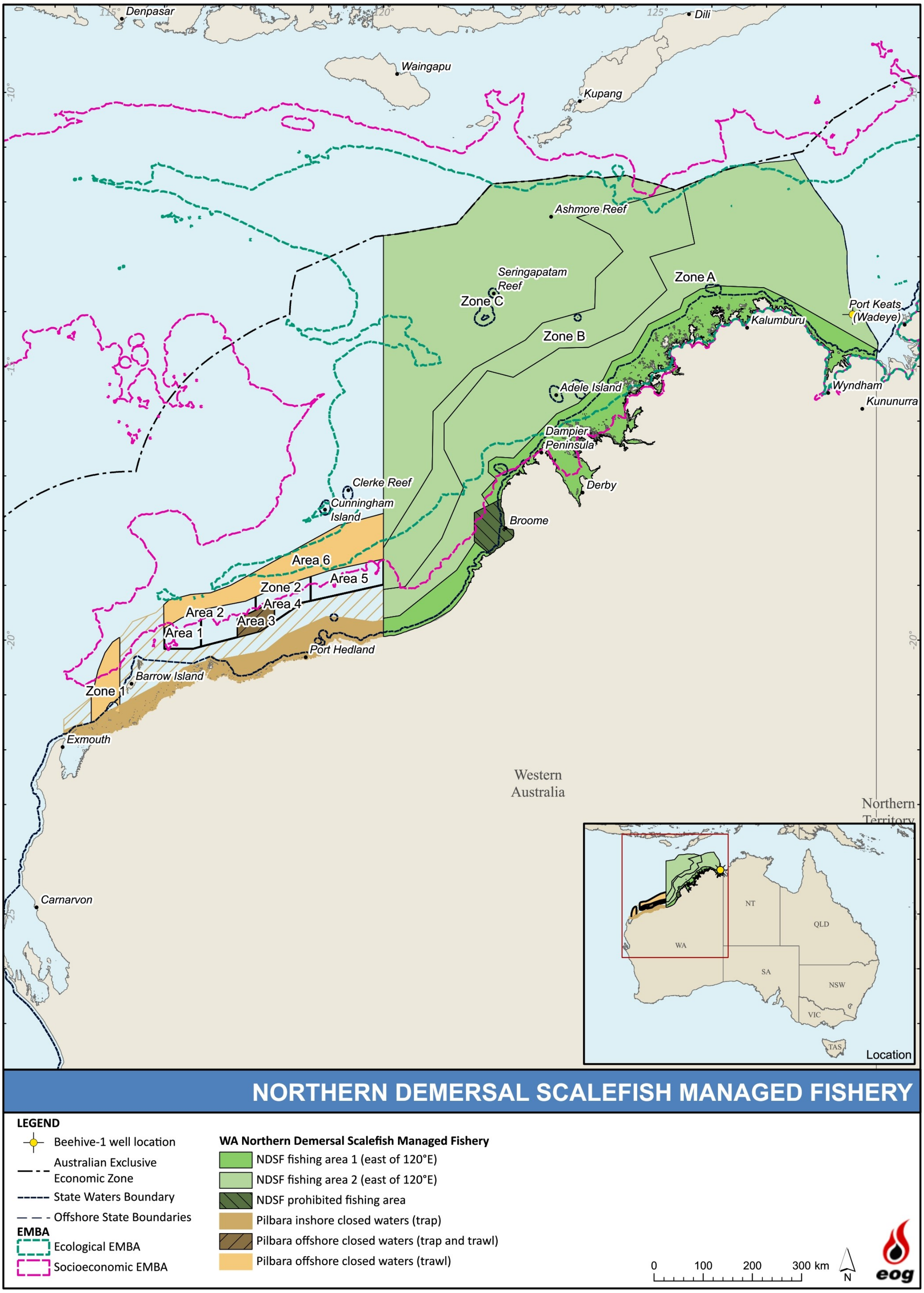


Figure 5.64. WA Northern Demersal Scalefish Fishery intersected by the EMBA

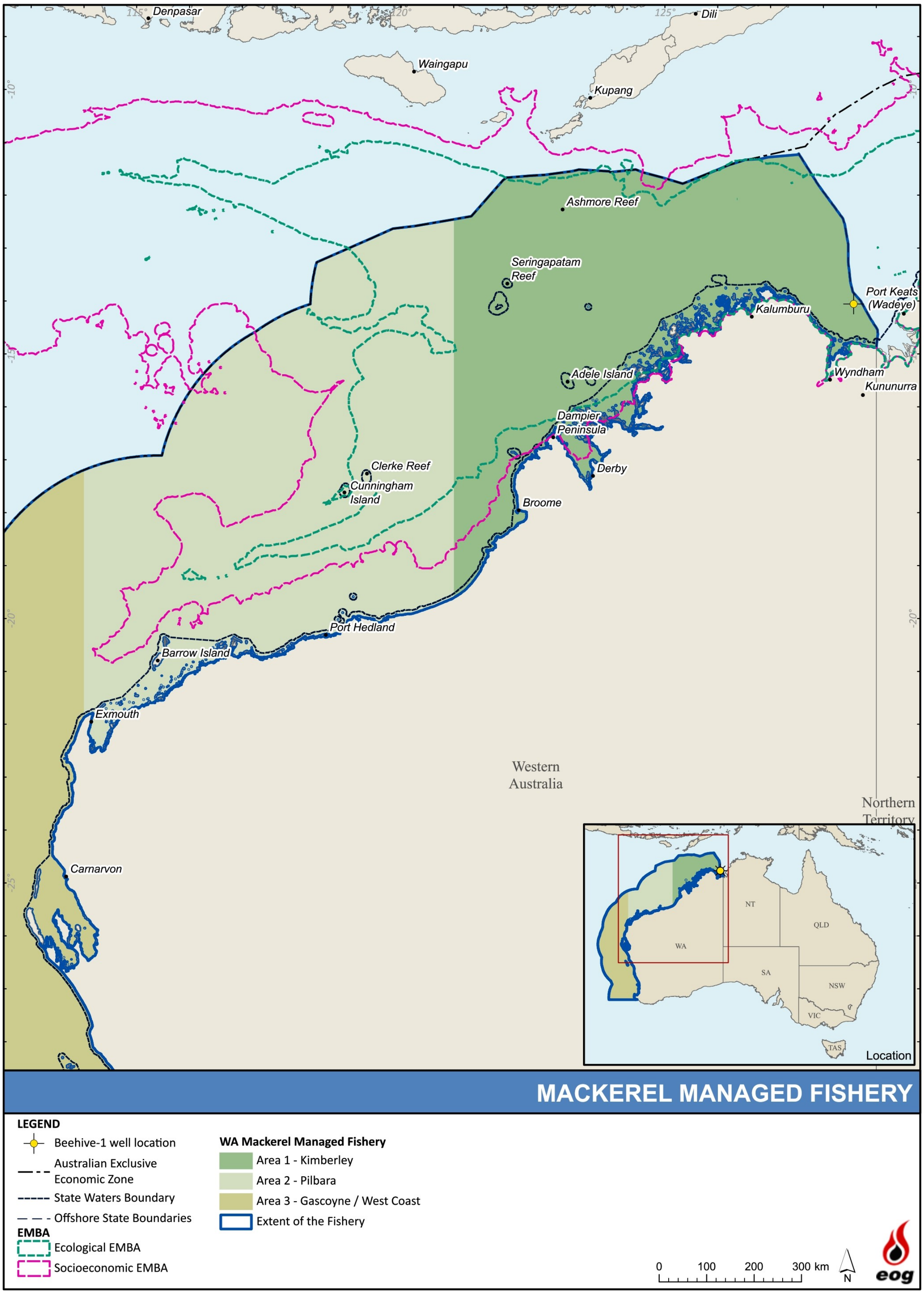


Figure 5.65. WA Mackerel Managed Fishery intersected by the EMBA

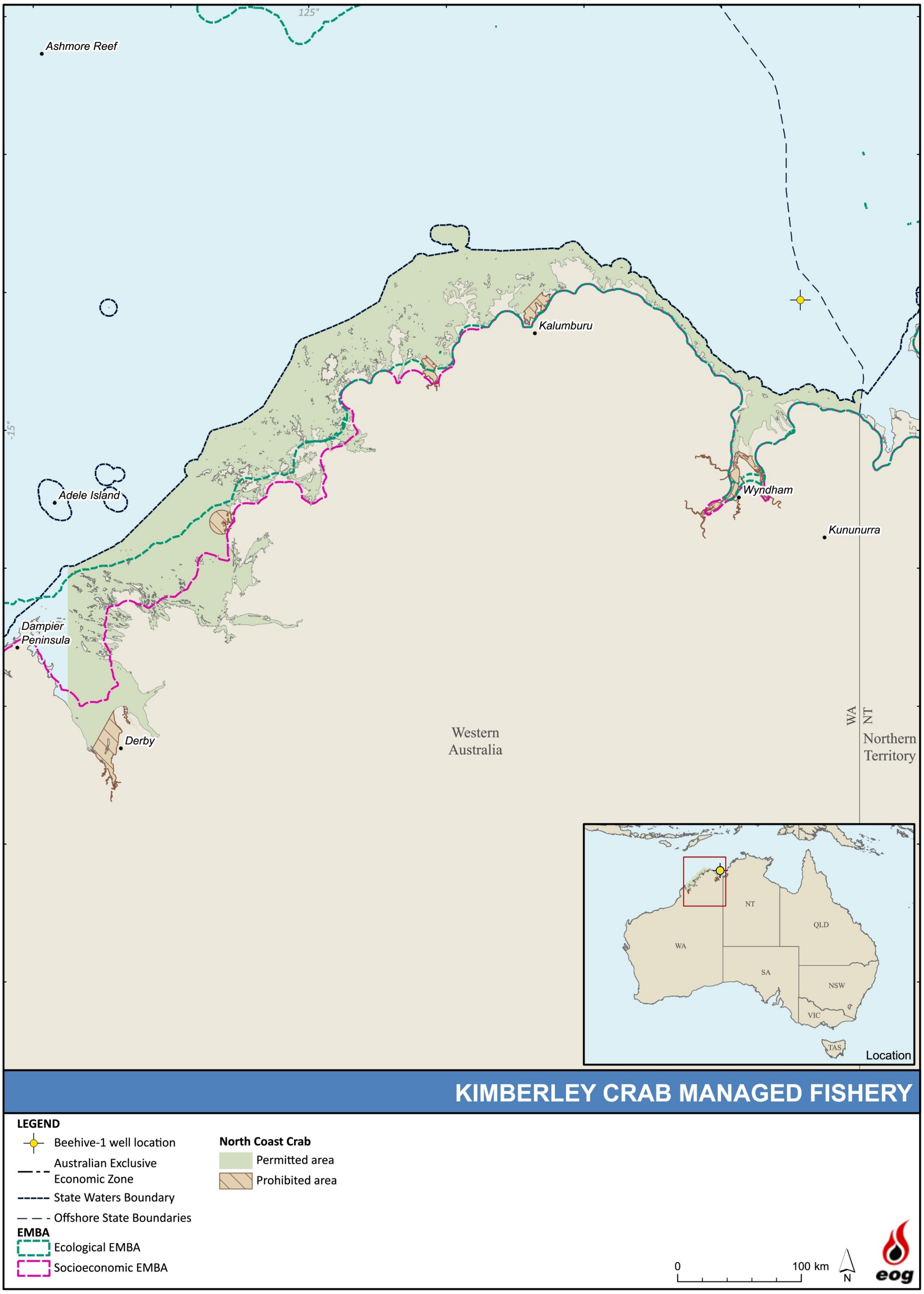


Figure 5.66. WA Kimberley Crab Managed Fishery (North Coast Crab Fishery) intersected by the EMBA

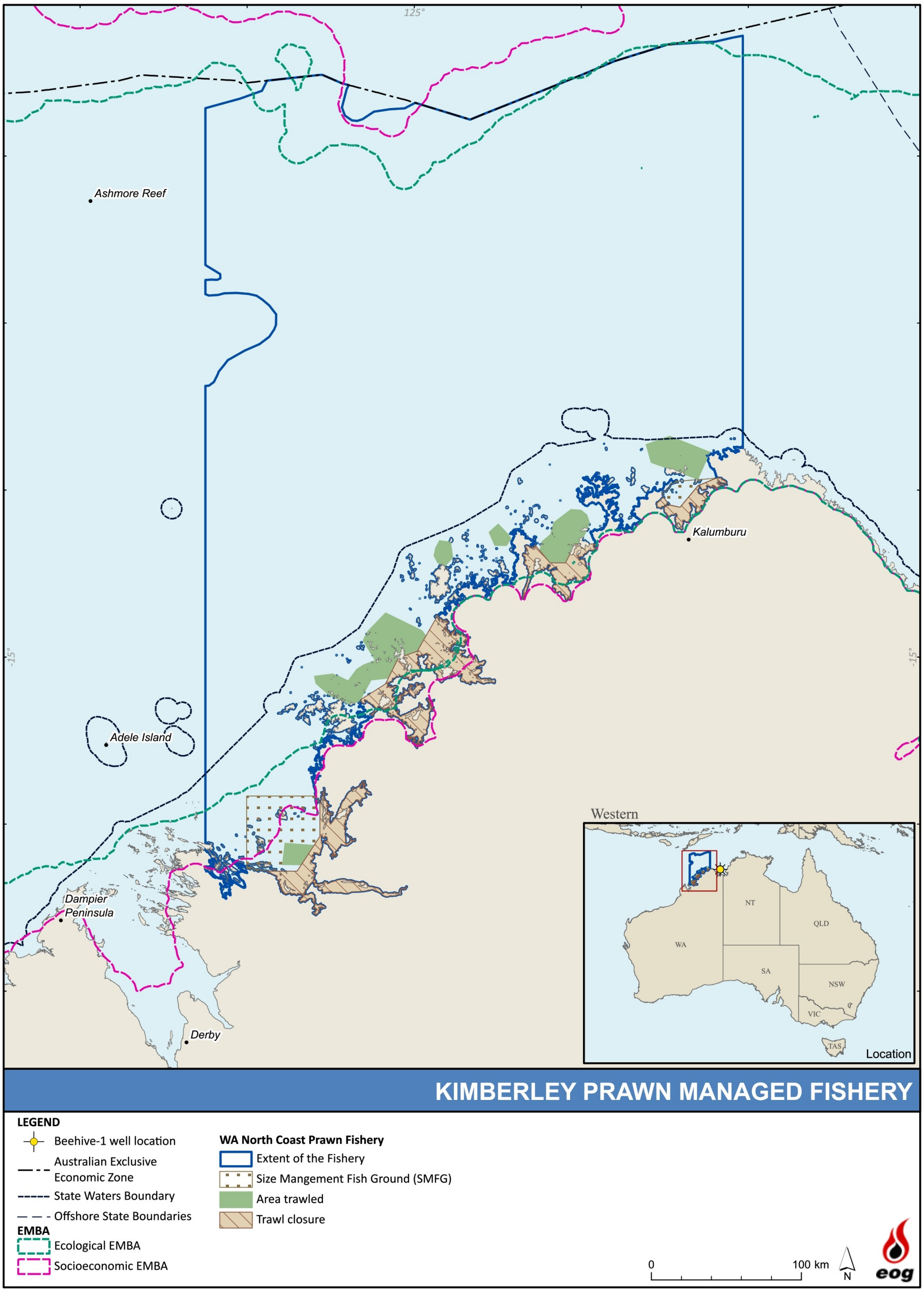


Figure 5.67. WA Kimberley Prawn Managed Fishery intersected by the EMBA

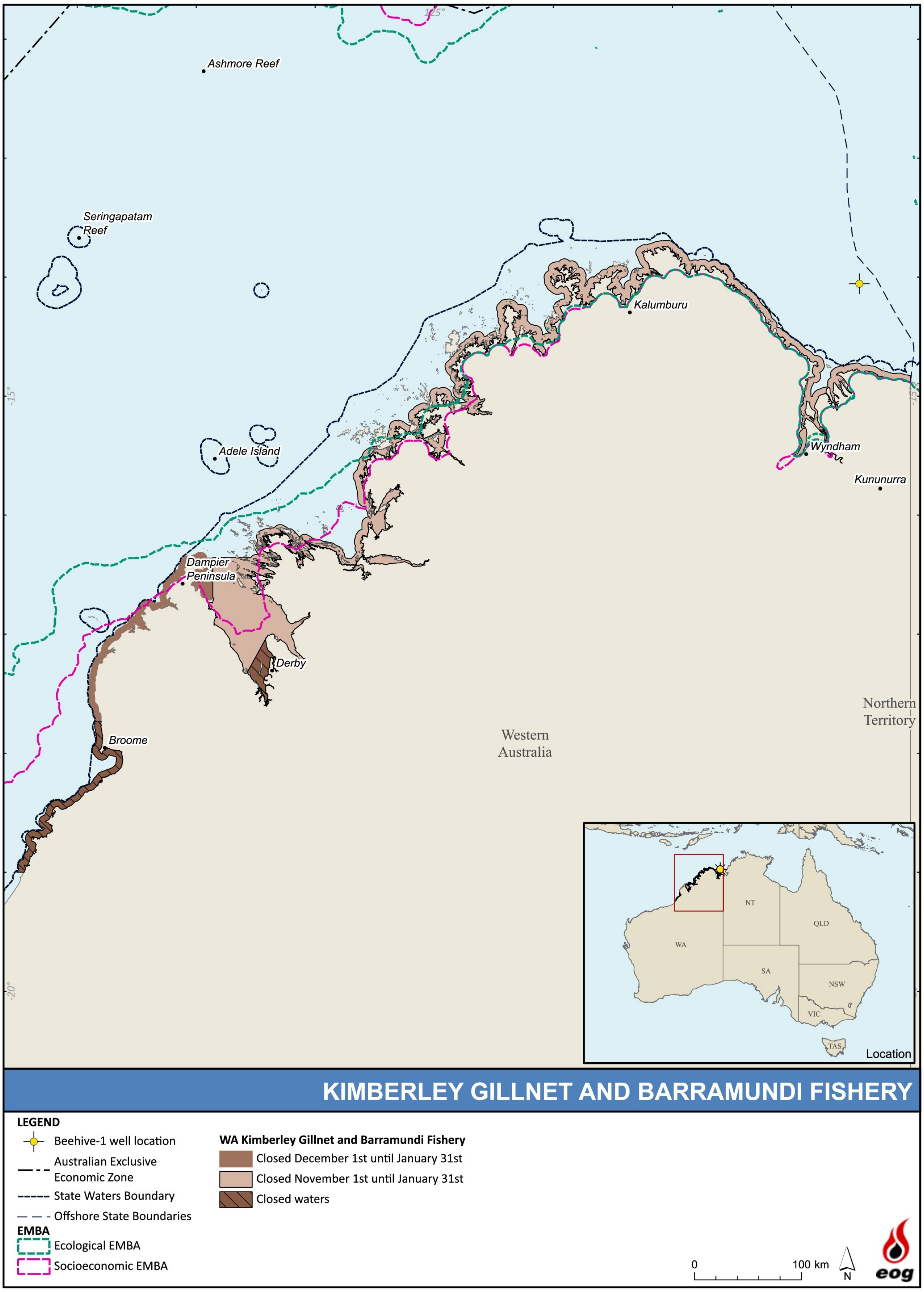


Figure 5.68. WA Kimberley Gillnet and Barramundi Fishery intersected by the EMBA

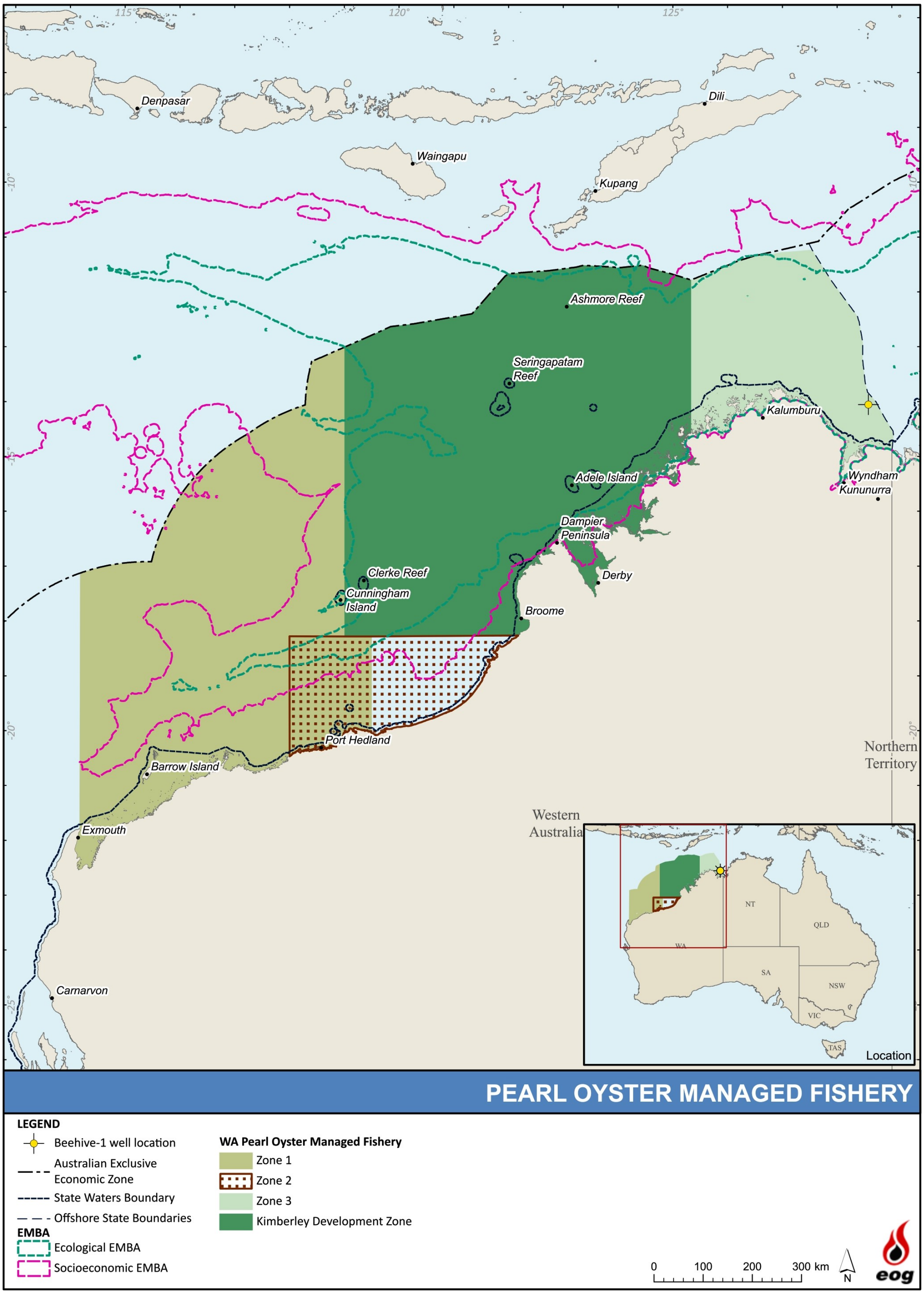


Figure 5.69. WA Pearl Oyster Managed Fishery intersected by the EMBA

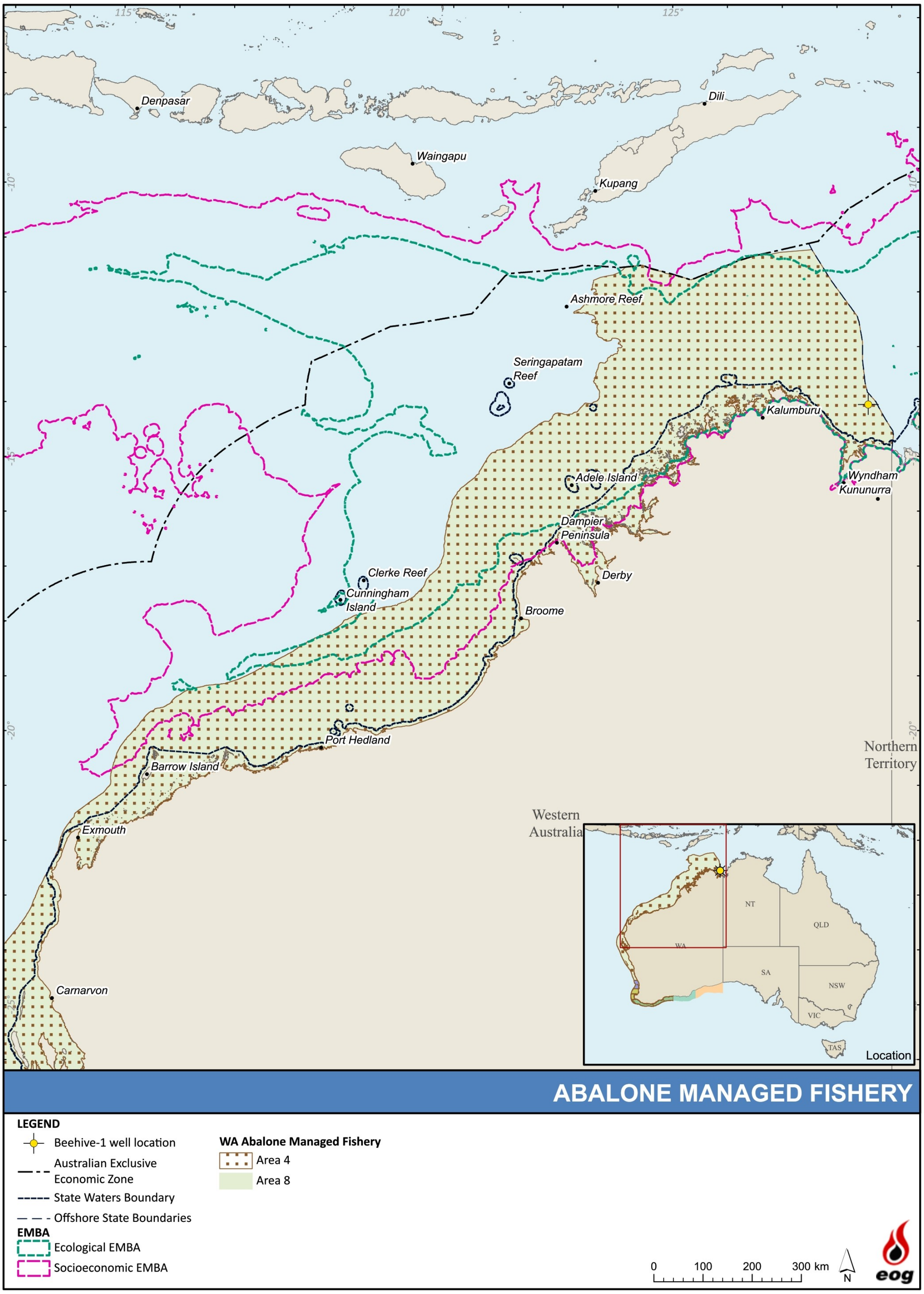


Figure 5.70. WA Abalone Managed Fishery intersected by the EMBA

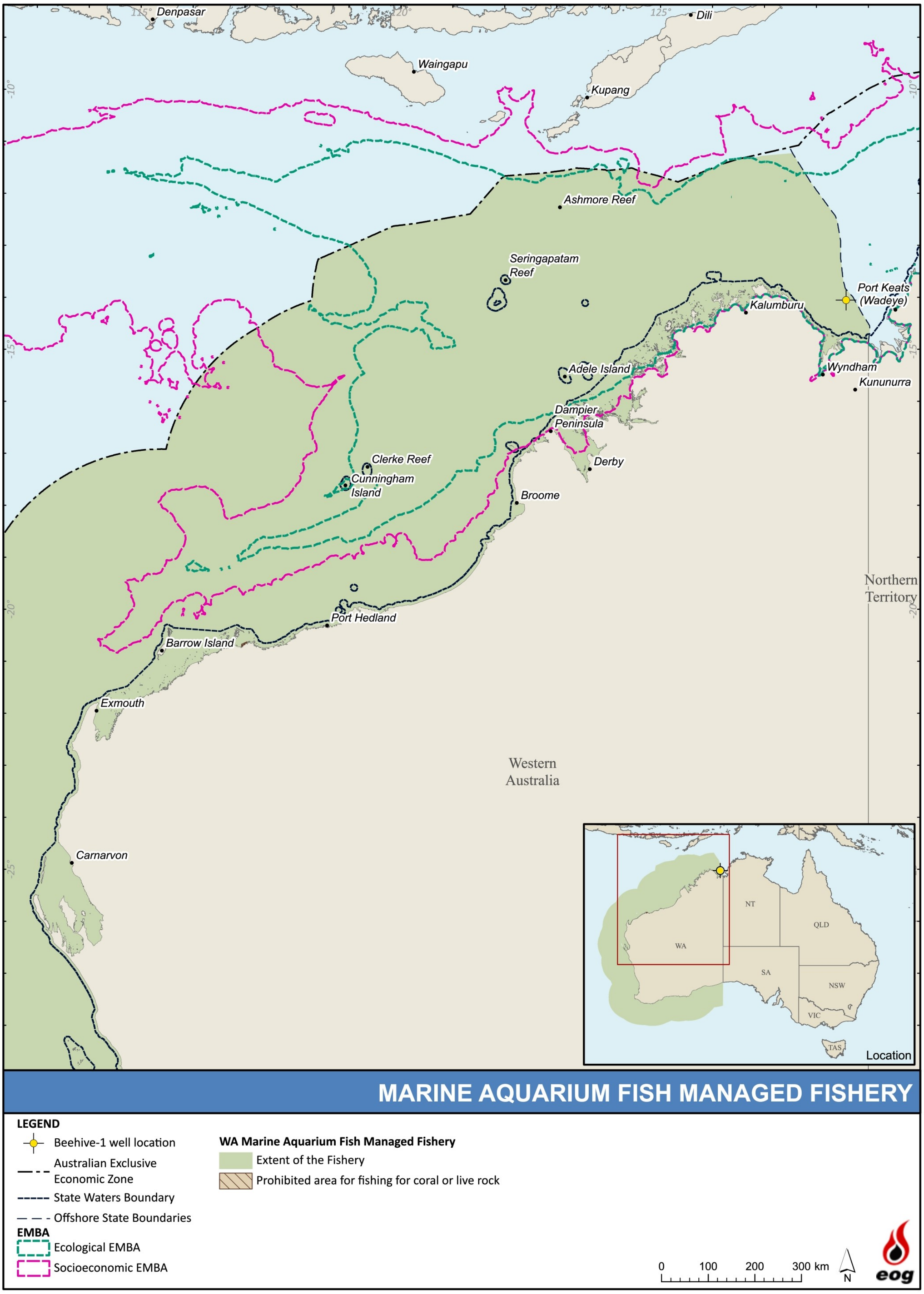


Figure 5.71. WA Marine Aquarium Managed Fishery intersected by the EMBA

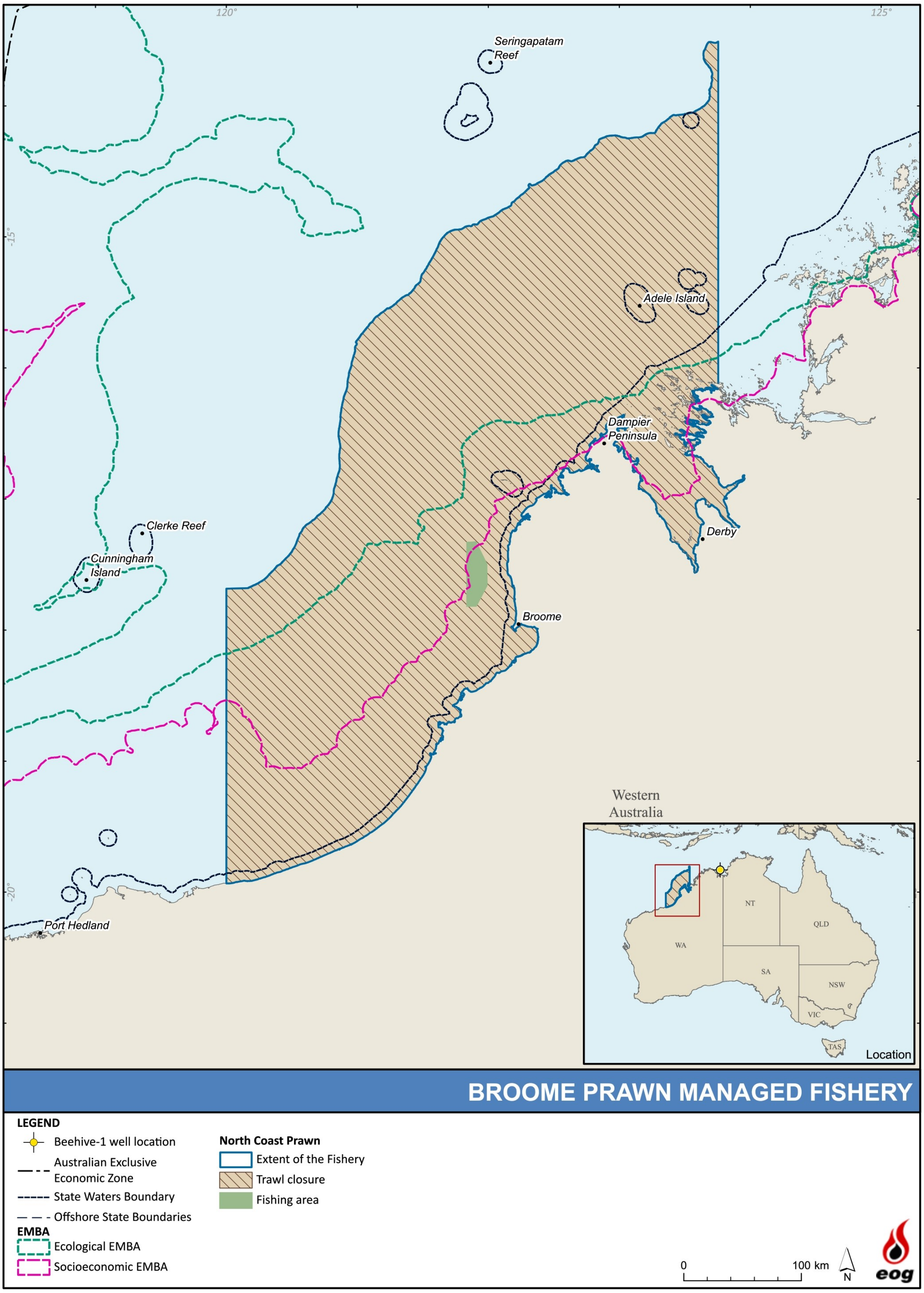


Figure 5.72. WA Broome Prawn Managed Fishery intersected by the EMBA

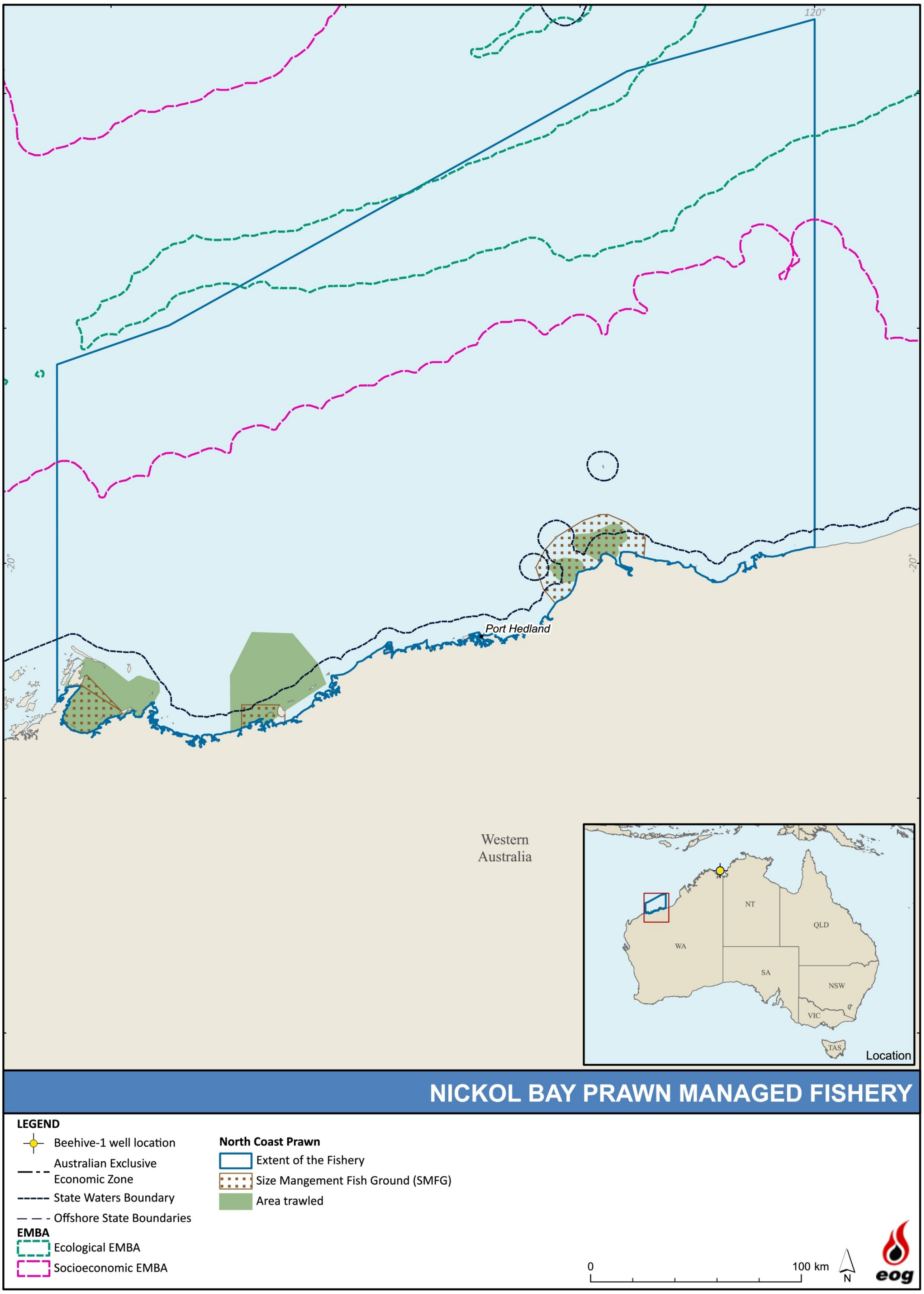


Figure 5.73. WA Nickol Bay Prawn Managed Fishery intersected by the EMBA

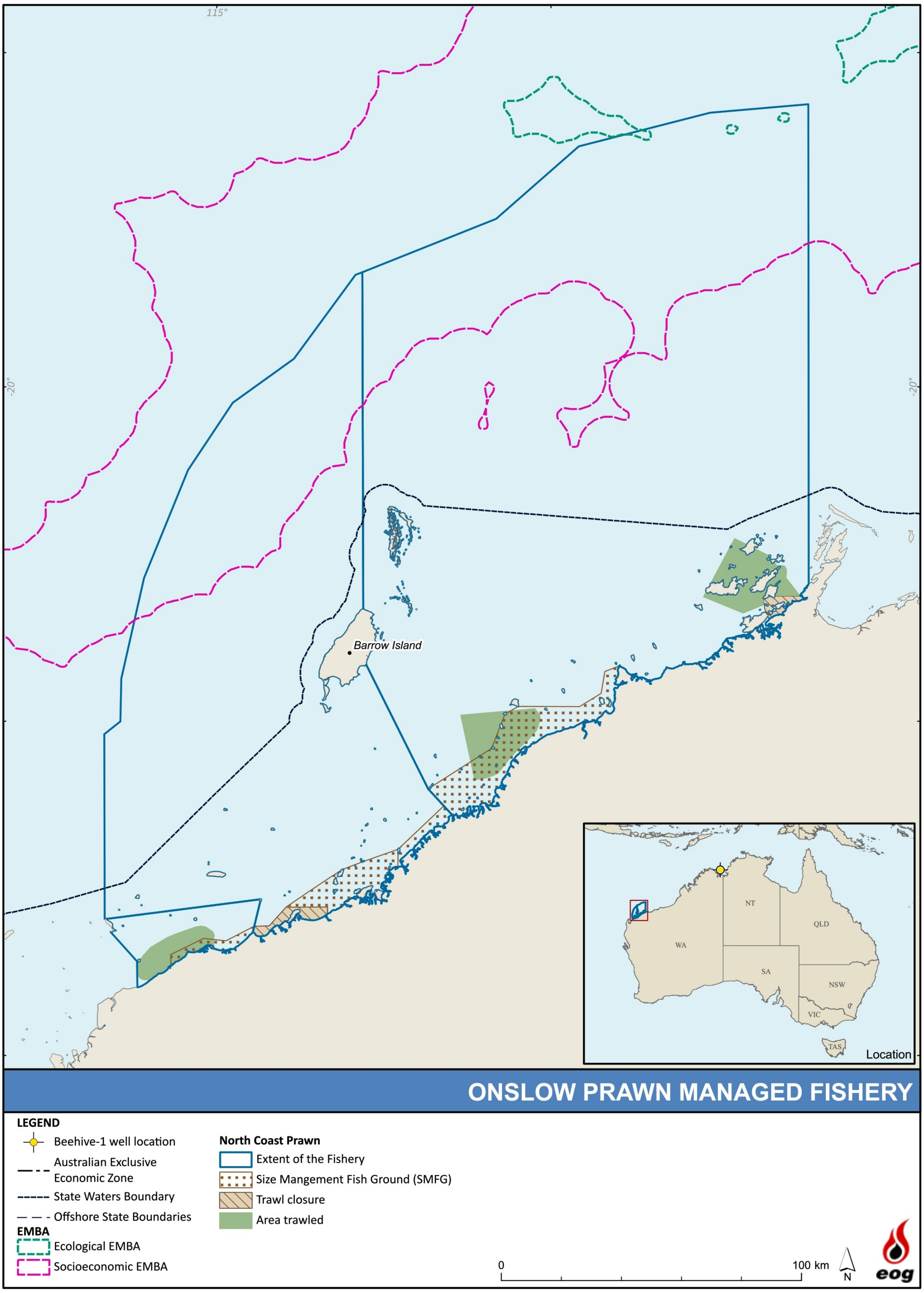


Figure 5.74. WA Onslow Prawn Managed Fishery intersected by the EMBA

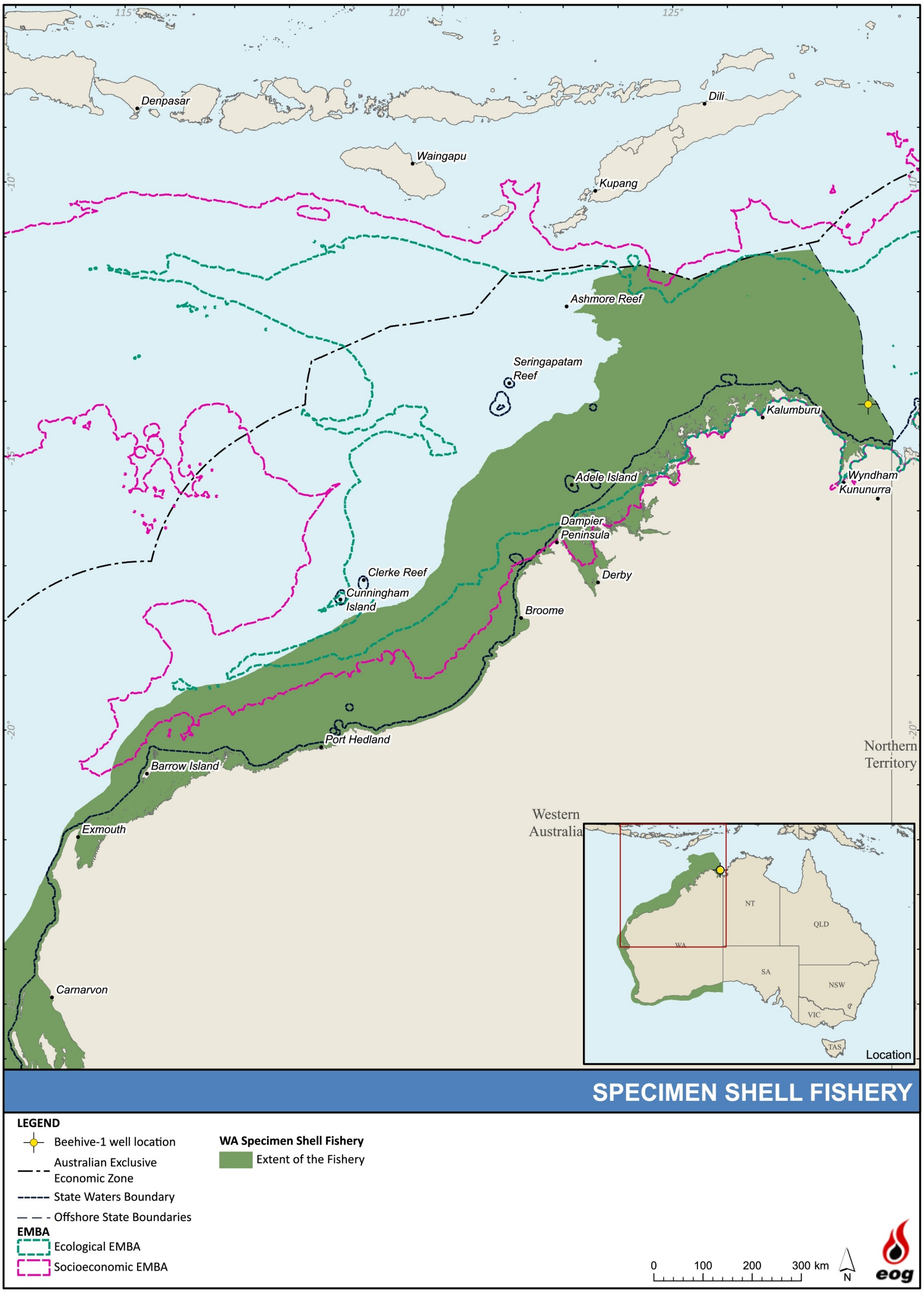


Figure 5.75. WA Specimen Shell Managed Fishery intersected by the EMBA

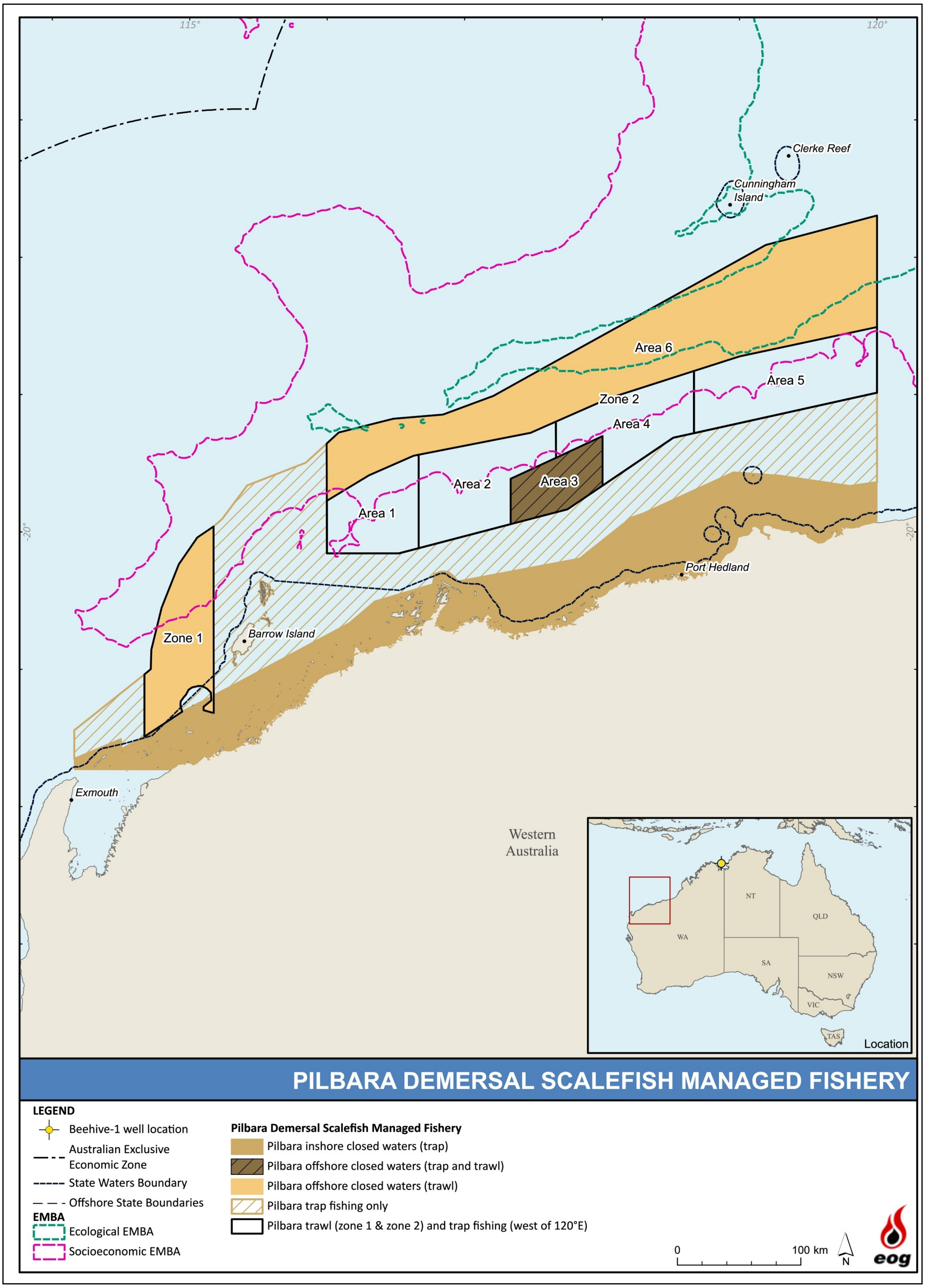


Figure 5.76. Pilbara Demersal Scalefish Fishery intersected by the EMBA

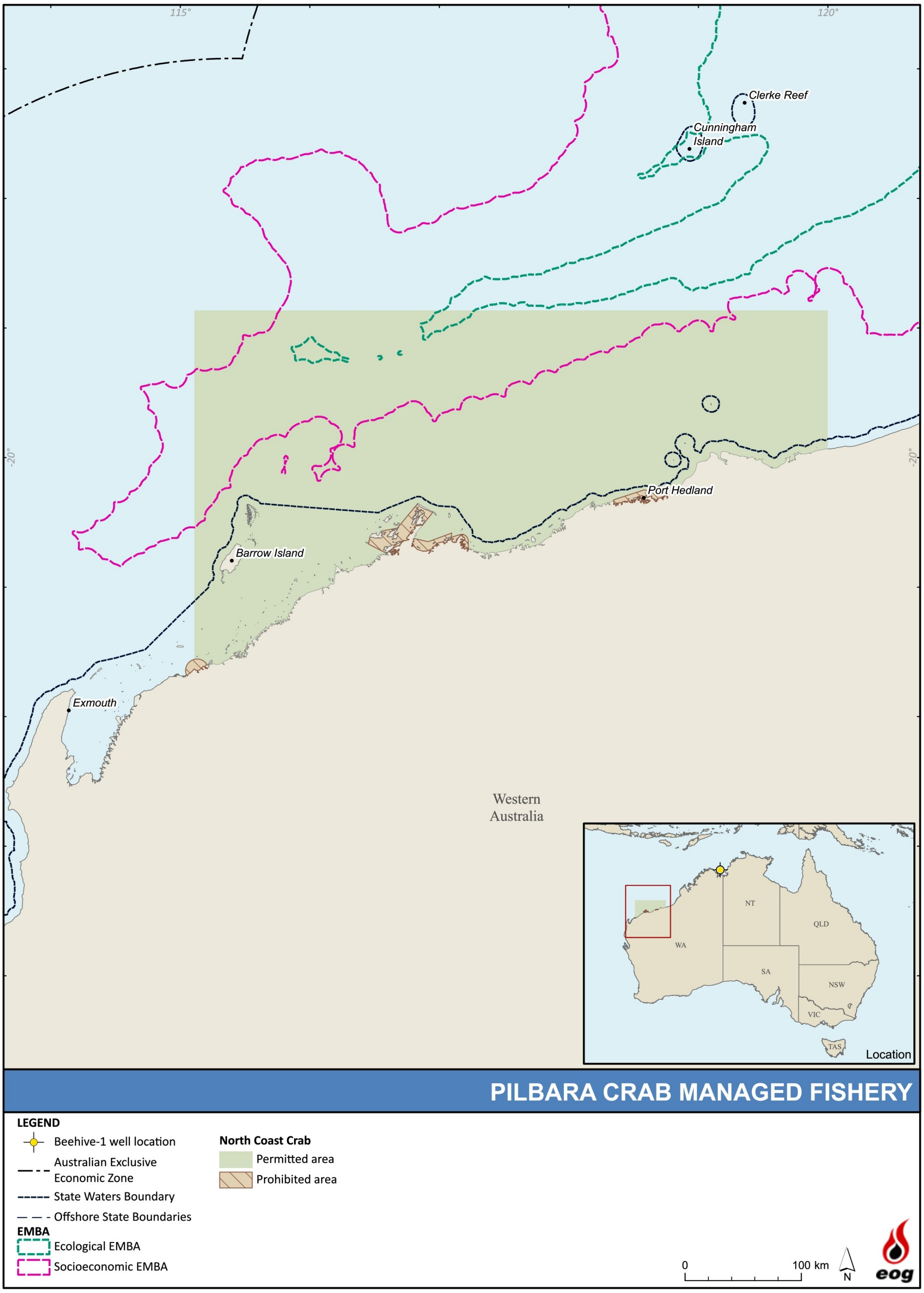


Figure 5.77. Pilbara Managed Crab Fishery intersected by the EMBA

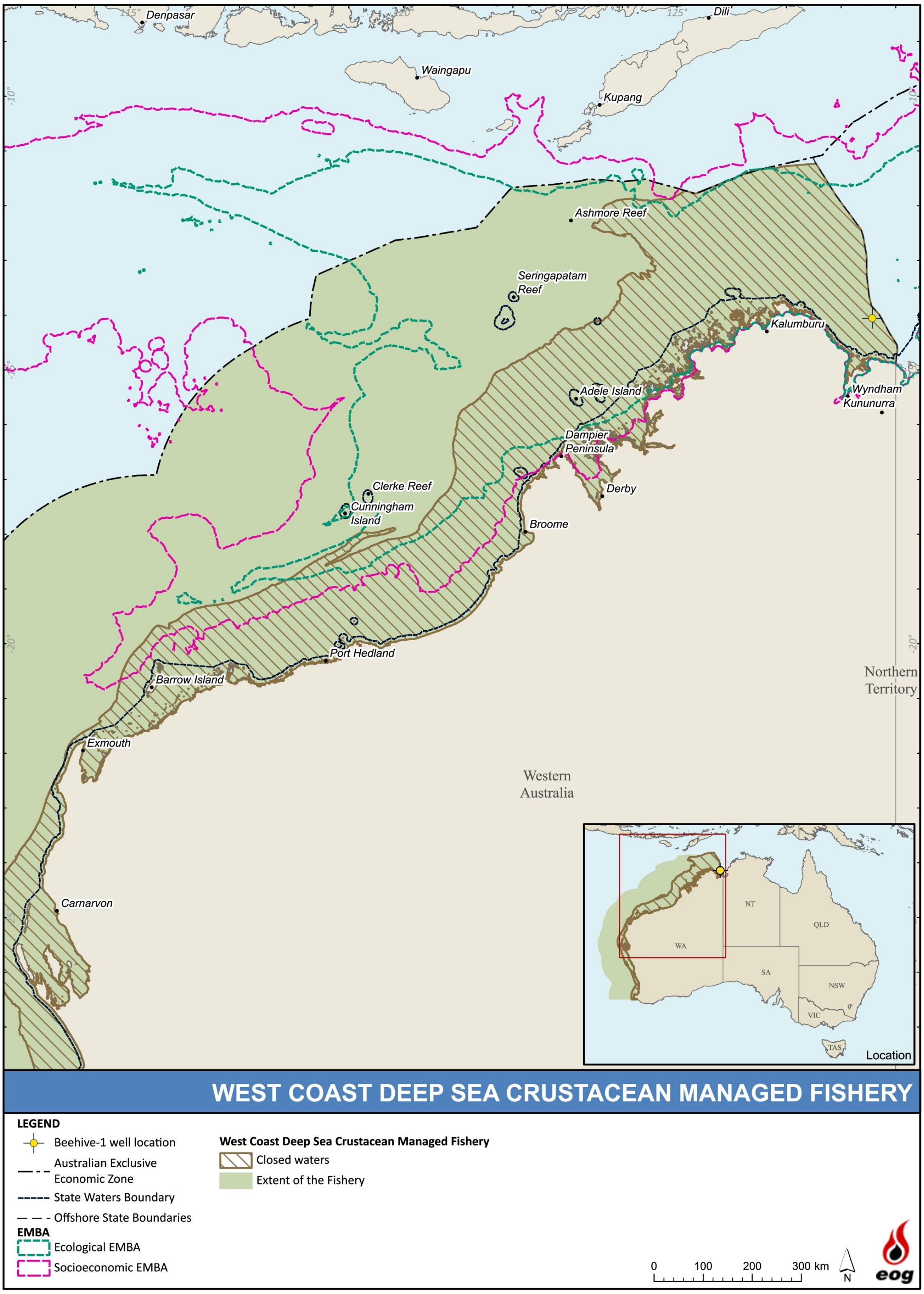


Figure 5.78. West Coast Deep Sea Crustacean Managed Fishery intersected by the EMBA

Northern Territory-managed Fisheries

NT-managed commercial fisheries that are authorised to fish the waters of the EMBA include the following (noting that not all actively fish in the EMBA):

- Spanish Mackerel Fishery;
- Barramundi Fishery;
- Coastal line fishery;
- Timor Reef Fishery;
- Offshore Net and Line Fishery; and
- Demersal Fishery.

A review of data from the NT DITT website and consultation with DITT identifies the Demersal Fishery, Timor Reef Fishery, Spanish Mackerel Fishery and Offshore Net and Line Fishery as have recently fished in the EMBA. Table 5.18 presents the available information for these fisheries.

Table 5.18. NT-managed commercial fisheries with jurisdictions to fish within the EMBA

Fishery	Target species	Fishing activity in the EMBA?	Fishing season	Fishing methods, vessels and licences	Catch data and other information
Demersal Fishery (Figure 5.79)	Primarily targets red snapper (*Lutjanus erythropterus*), goldband snapper (*Pristipomoides multidens*) and saddletail snapper (*L. malabaricus*).	Yes – the EMBA intersects the the line and fish trap permitted areas and Zone A and Zone B (line and fish trap, finfish trawl gear permitted) (Figure 5.79).	Assumed year-round.	Fishing method is through the use of vertical lines, drop lines, finfish long-lines, baited fish traps and semi-demersal trawl nets in two multi-gear areas. Eight vessels operated in 2020. In 2021 there were 18 licences in the fishery.	In 2020, 3,492 t (including 2,522 t of red snapper and 218 t of goldband snapper) was caught. No data found for 2018 and 2019. In 2017, 3,387 t (including 505 t of red snapper and 341 t of goldband snapper) was caught, with an estimated value of $17.9 million. In 2016, 3,463 t (including 2,510 t of red snapper and 318 t of goldband snapper) was caught. In 2015, 3,107 t (including 2,299 t of red snapper and 279 t of goldband snapper) was caught.
Spanish Mackerel Fishery (Figure 5.80)	Primarily targets Spanish mackerel (*Scomberomorus commerson*).	Yes – northeastern extent of EMBA intersects the fishery (Figure 5.80).	Assumed year-round.	The primary fishing method used by all sectors is trolling, where baited hooks or lures are towed behind a boat moving at 3–6 knots near reefs, headlands and shoals. In 2021 there were 15 licences in the fishery, all of which were allocated.	Catch data available for the last five years: • 2019/20 – 357 t. • 2018/19 – 408 t. • 2017/18 – 372 t. • 2016/17 – 411 t. • 2015/16 – 399 t.

Fishery	Target species	Fishing activity in the EMBA?	Fishing season	Fishing methods, vessels and licences	Catch data and other information
Offshore Net and Line Fishery (Figure 5.81)	Blacktip shark (*Carcharhinus limbatus*), spot tail shark (*Carcharhinus sorrah*) and grey mackerel (*Scomberomorus semifasciatus*).	Yes – northeastern extent of EMBA intersects the fishery (Figure 5.81).	Assumed year-round.	Demersal or pelagic longlines or pelagic net gear is permitted.	No data available.
Timor Reef Fishery (see Figure 5.79 *(as per Demersal Fishery)*	Goldband snapper (*Pristipomoides multidens*).	Yes.	There is no closed season for the Timor Reef Fishery, but normally, it is most productive between October and May.	Operates in remote offshore waters in the Timor Sea in a defined area approximately 370 km northwest of Darwin. Methods include vertical lines, drop line, long lines and fish baited traps	Catch data available for the last five years: • 2019 – 246 t. • 2018 – 349 t • 2017 – 329 t • 2016 – 280 t • 2015 – 285 t
Coastal Line Fishery	Black jewfish (*Protonibea diacanthus*).	Possibly.	Possibly all year-round.	Extends 15 nm from the low water mark and covers the entire NT coastline. The majority of fishing effort is focused around rocky reefs within 150 km of Darwin. Mainly hook and line gear is used.	Limited catch data available, however data is available for the last five years for the Darwin region: • 2019 – 141 t. • 2018 – 120 t • 2017 – 173 t • 2016 – 155 t • 2015 – 124 t

Fishery	Target species	Fishing activity in the EMBA?	Fishing season	Fishing methods, vessels and licences	Catch data and other information
Barramundi Fishery	Primarily barramundi (*Lates calcarifer*) and king threadfin (*Polydactylus macrochir*).	Possibly.	Annual commercial fishing runs from 1st February to 30 September.	Operate in tidal mud flats and inside a restricted number of rivers using gillnets.	Catch data available for the last five years: • 2019 – 276 t. • 2018 – 277 t • 2017 – 392 t • 2016 – 305 t • 2015 – 383 t

Sources: NT Government (2020, 2019), DPIR (2021, 2019, 2018). FRDC (2022).

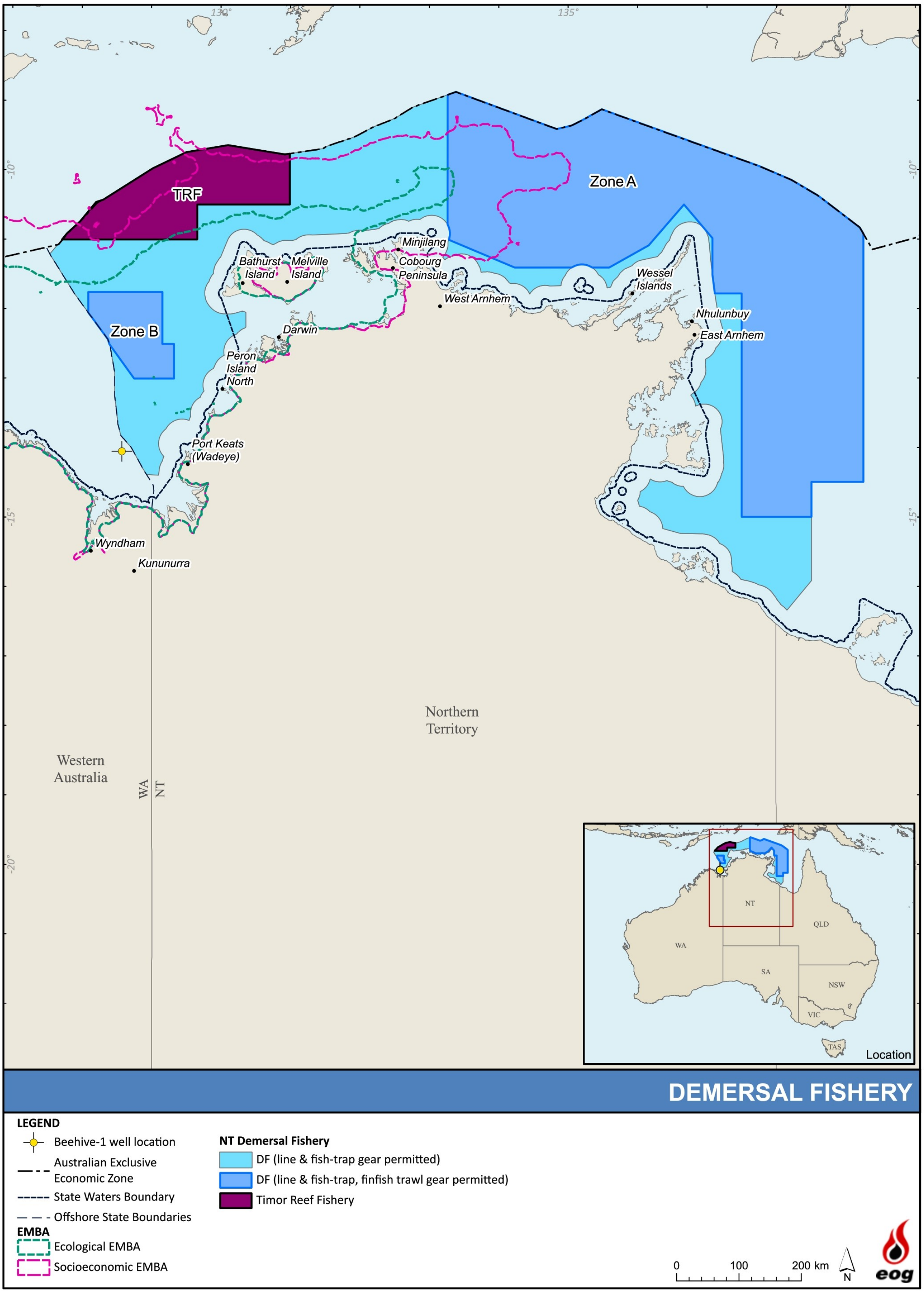


Figure 5.79. NT Demersal Fishery intersected by the EMBA

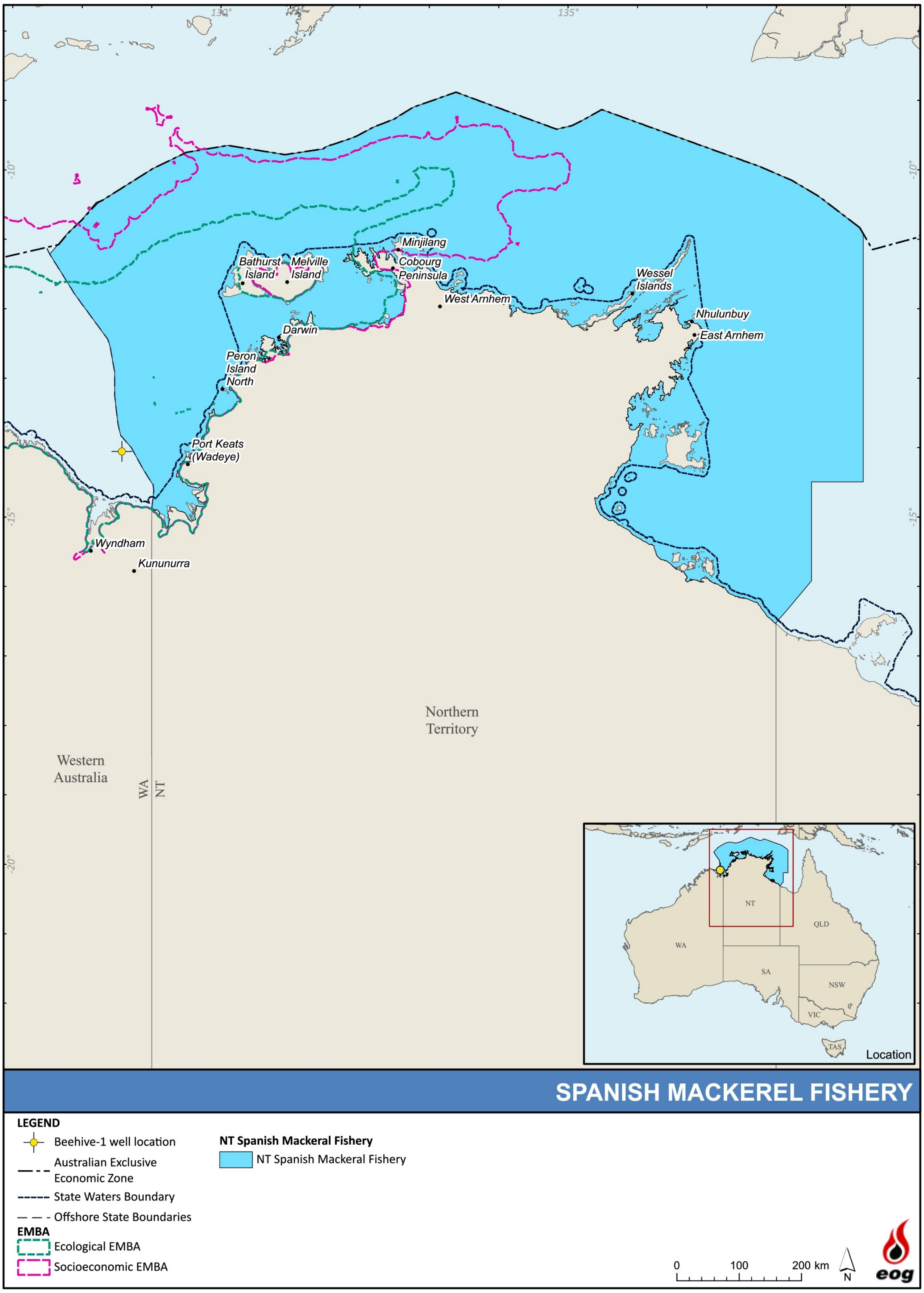


Figure 5.80. NT Spanish Mackerel Fishery intersected by the EMBA

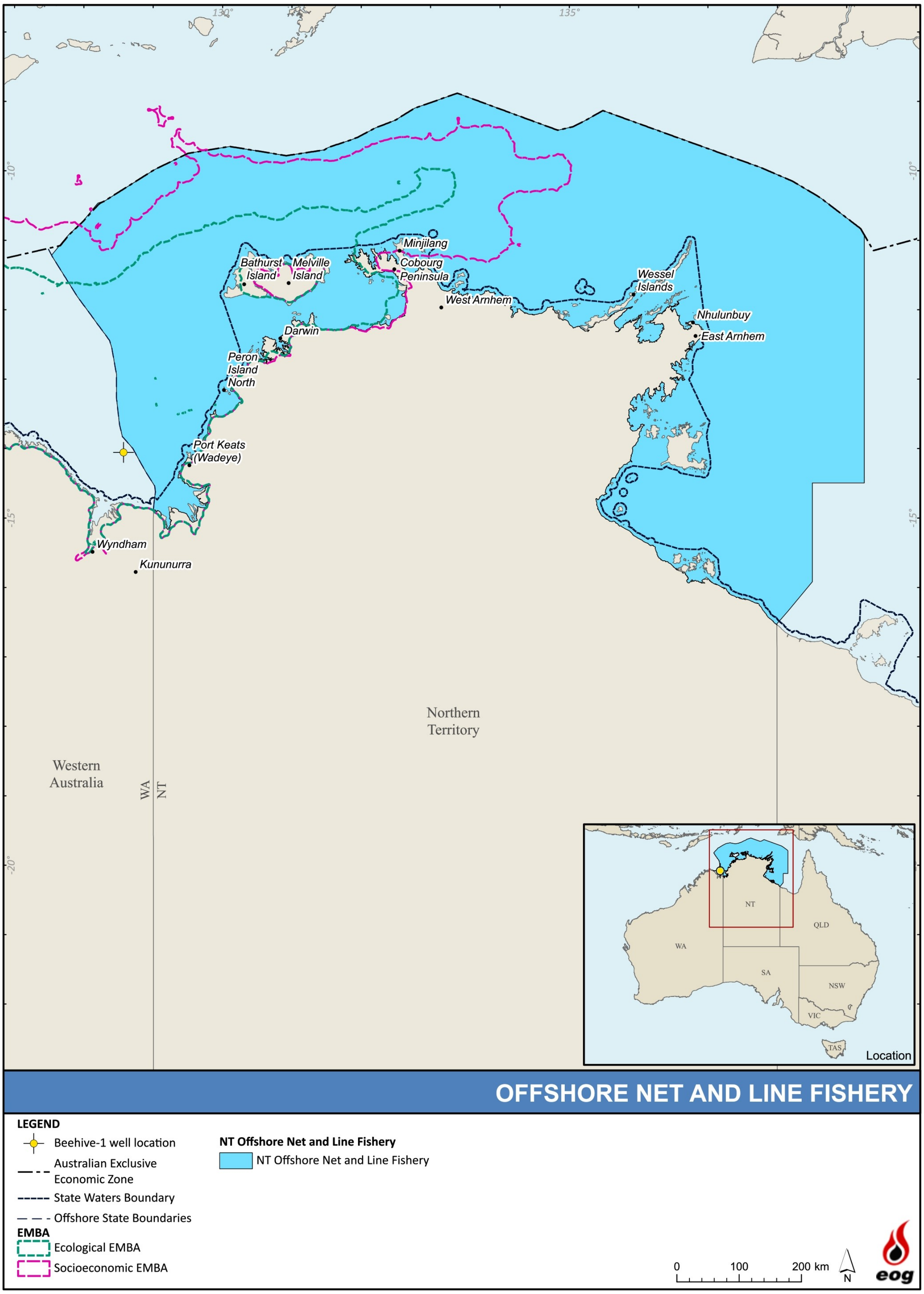


Figure 5.81. NT Offshore Net and Line Fishery intersected by the EMBA

Indonesian Commercial and Subsistence Fishing

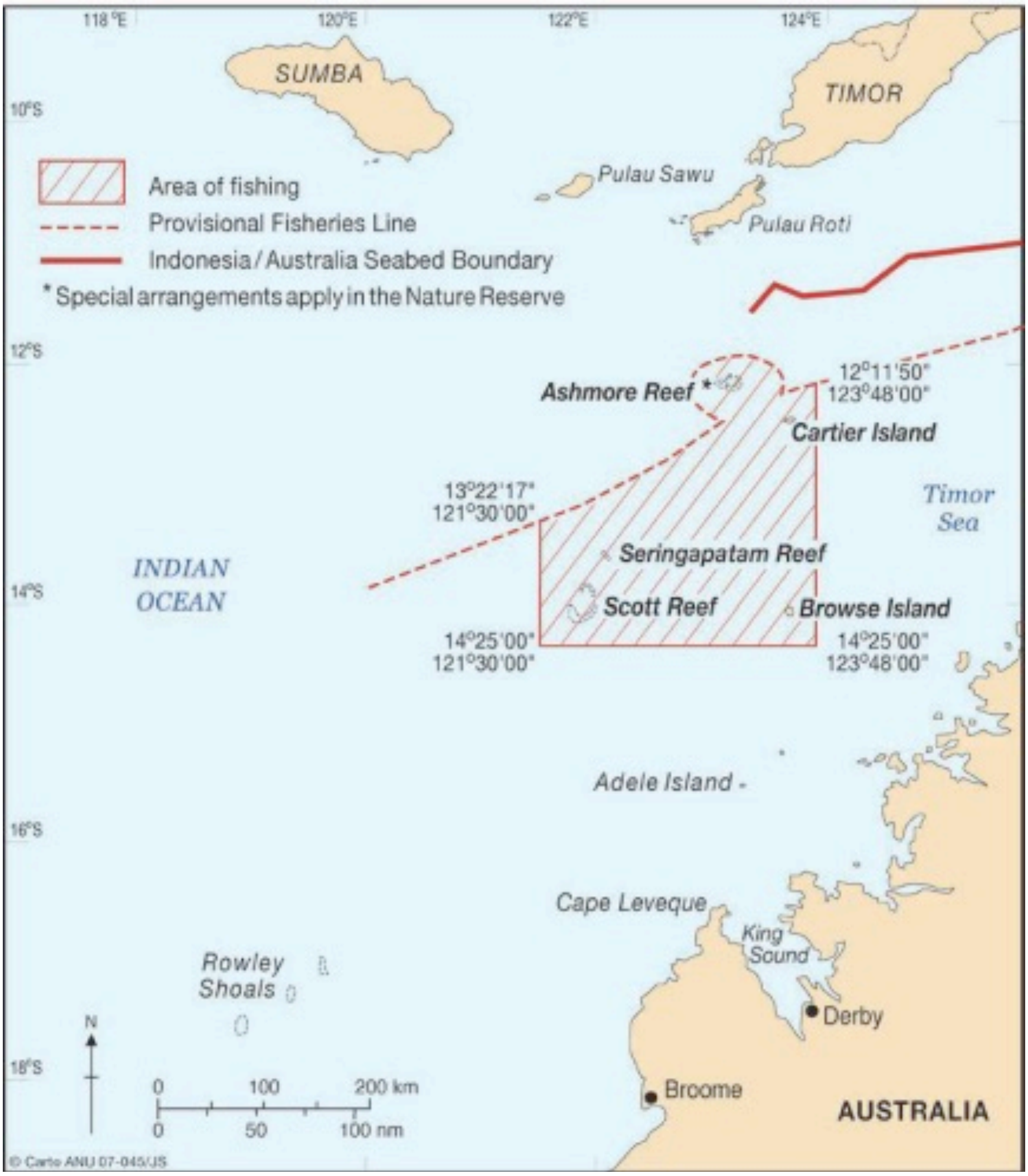
Indonesian fishers have sailed to and actively fished Australia's northern waters, particularly in and around the shallow lagoons of Scott Reef, primarily targeting trepang (sea cucumber), shark fin and other marine resources such as trochus shells. They also catch fish largely for subsistence purposes although the average fish catch per lete-lete (traditional Indonesian fishing vessel) in 2008 increased to commercial volumes. Although deeper waters are more plentiful in trepang, deep diving is generally not undertaken by the fishers due to the MoU stipulation on the exclusive use of traditional equipment only (Woodside, 2011).

Within the northwest extent of the EMBA, there is a defined area where a Memorandum of Understanding (MoU) between the Government of Australian and the Government of the Republic of Indonesia Relating to Cooperating in Fisheries (1992) exists to allow Indonesian fishers (using traditional fishing methods) to operate in the Australian waters of the Timor Sea (Figure 5.82). The MoU is officially known as the Australia-Indonesia Memorandum of Understanding regarding the Operations of Indonesian Traditional Fishermen in Areas of the Australian Fishing Zone and Continental Shelf – 1974 (DAWE, 2020).

The MoU agreement provides the framework for fisheries and marine cooperation between Australia and Indonesia, and facilitates information exchange on research, management and technological developments, complementary management of shared stocks, training and technical exchanges, aquaculture development, trade promotion and cooperation to deter illegal fishing (DAWE, 2020).

Cooperation under the MoU takes place under the auspices of the Working Group on Marine Affairs and Fisheries. Established in 2001, the Working Group on Marine Affairs and Fisheries is the primary bilateral forum to enhance collaboration across the spectrum of marine and fisheries issues relevant to the areas of the Arafura and Timor seas. The Working Group brings together the fisheries, environment and scientific research portfolios and agencies from both countries (DAWE, 2020).

As part of negotiations to delineate seabed boundaries, Australia and Indonesia entered into the MoU which recognises the rights of access for traditional Indonesian fishers in shared waters to the north of Australia. This access was granted in recognition of the long history of traditional Indonesian fishing in the area. The MoU provides Australia with a tool to manage access to its waters while for Indonesia, it enables Indonesian traditional fishers to continue their customary practices and target species such as trepang, trochus, abalone and sponges. Guidelines under the MoU were agreed in 1989 in order to clarify access boundaries for traditional fishers and take into account the declaration of the 200 nm fishing zones (DAWE, 2020).



Source: ResearchGate

Figure 5.82. Australia-Indonesia MoU Box

5.6.2. Recreational Fishing

Within the North Coast Bioregion, there is a distinct seasonal peak of recreational fishing during winter (Gaughan and Santoro, 2018). Offshore islands, coral reefs and the continental shelf provide species of major recreational interest, including tropical snapper, cods, coral and coronation trout, sharks, trevally, tuskfish, tunas, mackerels and billfish (Gaughan and Santoro, 2018).

Recreational fishing activities are primarily based out of Darwin. Given the long distance of the activity area from the mainland and key population areas, recreational fishing activities in much of the EMBA are not predicted. However, given the broad extent of the EMBA across northern Australia, it is likely that some recreational fishing does occur.

RecFish West and the AFANT have not raised any issues regarding recreational fishing for this project.

5.6.3. Traditional Aboriginal Fishing

Traditional Aboriginal fishing in NT waters predominately occurs within inshore tidal waters. Approximately 85% of the NT's intertidal zone is recognised as Aboriginal land under the *Aboriginal Land Rights (Northern Territory) Act*. In the NT, there are three generally recognised Aboriginal fishery zones, which extend to 3, 15, and 200 nm from the coast. Almost all Aboriginal fishing effort is concentrated within the 3 nm coastal waters boundary (93%), with fishing spanning the entire coastline (NT Government, 2017a) and is mostly focused on the Tiwi Islands (in the northeast part of the EMBA). Aboriginal activities within the coastal area of the Tiwi Islands includes fishing, hunting (turtles and dugongs) and gathering (e.g., turtle eggs).

Hunting, subsistence fishing and shell collecting are recognised as occurring in the Kimberley region (DNP 2018a; DPaW 2016b, Smyth 2007). The land and sea country of the Balanggarra people extends from Napier-Broome Bay to Cambridge Gulf and Wyndham in the JBG, inshore from where the Beehive-1 exploration well drilling activity is proposed. 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, 2016b). 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, with fishing and hunting still practiced today (DPaW, 2016b).

5.6.4. Coastal Settlements

The coastline adjacent to the EMBA is sparsely populated, with the townships of Broome (WA) (820 km southwest), Derby (WA) (640 km southwest), Wyndham, WA (173 km south), Wadeye, NT (85 km east) and the city of Darwin (288 km northeast of Beehive-1) being the largest city within the EMBA.

Darwin is the capital of the Northern Territory and had a population of 136,828. Of the people employed in Darwin, 69% worked fulltime. The state government administration, defence and hospitals were the largest employment sectors, which accounted for 15.5% of the workforce.

The population of Wadeye was 2,260 people at the time of the 2016 census, with Aboriginal and/or Torres Strait Islander people making up 89.4% of the population (ABS, 2021). Of the employed people in Wadeye, the education and local government administration sectors were the largest employment sectors, which accounted for 21.7% of the workforce.

The population of Wyndham was 780 people at the time of the 2016 census, with Aboriginal and/or Torres Strait Islander people making up 53.7% of the population (ABS, 2021). Of the employed people in Wyndham, the social services, hospital and secondary education sectors were the largest employment sectors, which accounted for 30.5% of the workforce.

The population of Broome was 13,984 people at the time of the 2016 census, with Aboriginal and/or Torres Strait Islander people making up 21.4% of the population (ABS, 2021). Of the employed people in Broome, accommodation, hospitals and primary education, were the largest employment sectors, which accounted for 72.5% of the workforce.

At the time of the 2016 Census, the population of Derby was 3,511 people, with Aboriginal and/or Torres Strait Islander people making up 49.4% of the population (ABS, 2021). Of the employed people in Derby, hospitals, correctional and detention and secondary education sectors were the largest employment sectors, which accounted for 78.1% of the workforce.

Apart from Kalumbaru (210 km east of Beehive-1, inland of the coast) is located on the western side of Cape Londonberry (181 km northwest of Beehive-1) there are no coastal settlements on the western coast of the JBG until Cambridge Gulf where the Oombulgurri community is located, approximately 140 km south of the activity area. The towns of Wyndham (as described above) and Kununurra (192 km south from Beehive-1) are also located in the Cambridge Gulf.

At the time of the 2016 Census, the population of Kununurra was 4,341 people, with Aboriginal and/or Torres Strait Islander people making up 26.4% of the population (ABS, 2021). Of the employed people in Kununurra, hospitals, accommodation and other non-metallic mineral mining and quarrying were the largest employment sectors, which accounted for 68.1% of the workforce.

In the 2016 Census, the population of the Tiwi Islands were 2,453 people, with Aboriginal and/or Torres Strait Islander people made up 89.0% of the population (ABS, 2021). Of the employed people in the Tiwi Islands, local government administration, primary education followed by supermarket and grocery stores were the largest employment sectors, which accounted for 74.8% of the workforce.

5.6.5. Tourism

The JBG and adjacent lands are remote with very little infrastructure (such as roads, airports, accommodation) and therefore has not been developed for tourism. For up to five months of the year, access to the JBG region is restricted to boat or helicopter due to wet season rains, and road access to areas of Aboriginal freehold land requires prior permission from the Northern Land Council (NLC) (Woodside, 2004).

Expedition cruise boats operate in the North Kimberley Marine Park in the dry season (April to October), between Broome and Wyndham or Darwin, and offer multi-day tours (DPW, 2016). Vessels range from small fishing and sightseeing tour boats to large luxury cruise ships carrying up to 100 passengers (DPW, 2016). Access to the coast is possible although only by using a four-wheel drive. Scenic flights and fishing expeditions operate in connection with coastal accommodation or cruise boats as well as from Broome, Derby and Kununurra (DPW, 2016).

Charter fishing and tourism activities operate from Darwin and the Kimberley and target areas of high scenic value and/or offshore coral reef areas (Woodside, 2004). These attributes are sparse in the JBG, and therefore, given the isolated nature of the area, the likelihood of charter fishing and tourism is also anticipated to be low (Woodside, 2004) though restricted to are located within a few kilometres from the coast, and mainly in estuarine waters. Charter boats operating out of Darwin and Broome/Derby may occasionally visit or pass through the JBG.

Tourism accommodation and 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.

Swimming tends to be limited to guided excursions to freshwater pools and waterfalls on land, given the presence of saltwater crocodiles and other dangerous fauna in northern WA and NT. Known dive sites in the wider Kimberley region are near Broome, the Lacepede Islands and the Rowley Shoals.

5.6.6. Offshore Energy Exploration and Production

The Bonaparte Basin is an established hydrocarbon province with a number of commercial operations. The closest operation is the Blacktip Gas Field, located in adjacent permit WA-33-L and operated by ENI Australia (Figure 5.83). The Blacktip Gas Field consists of an unmanned wellhead platform, two producing wells, flowlines and a subsea gas export pipeline (GEP) that runs from the platform to shore near Wadeye, NT. The Blacktip GEP is located 12 km northeast of Beehive-1. Vessels servicing the Blacktip platform pass through the EMBA (see Section 5.6.7).

The Bonaparte Basin contains several oil and natural gas fields amounting to 18% of Australia's known reserves of natural gas. The basin had produced 11 GL of oil to end-2000 but only 0.11 BCM of gas due mainly to market limitations. Remaining known reserves are 33.42 GL of oil and 668.55 BCM of gas (Geoscience Australia, 2022).

There are numerous petroleum exploration and production permits located within the spill EMBA, operated by companies including ENI Australia, Woodside Energy Limited, Melbana Energy, Neptune Energy Bonaparte Pty Ltd, Santos Ltd, BP Developments Australia Pty Ltd, Chevron Australia Pty Ltd and Kufpec. Petroleum activities include production from platforms, FPSOs, export pipelines and exploration (seismic surveys and drilling) with most concentrated in the southern most extent of the spill EMBA, as shown in Figure 5.83.

5.6.7. Commercial Shipping

Commercial shipping in the activity area is outlined in Section 5.7.7 of Chapter 5. Shipping traffic in the spill EMBA is relatively low given the large extent of the EMBA, with major shipping lanes concentrated in and out of Darwin Port and the NWS as illustrated in Figure 5.84.

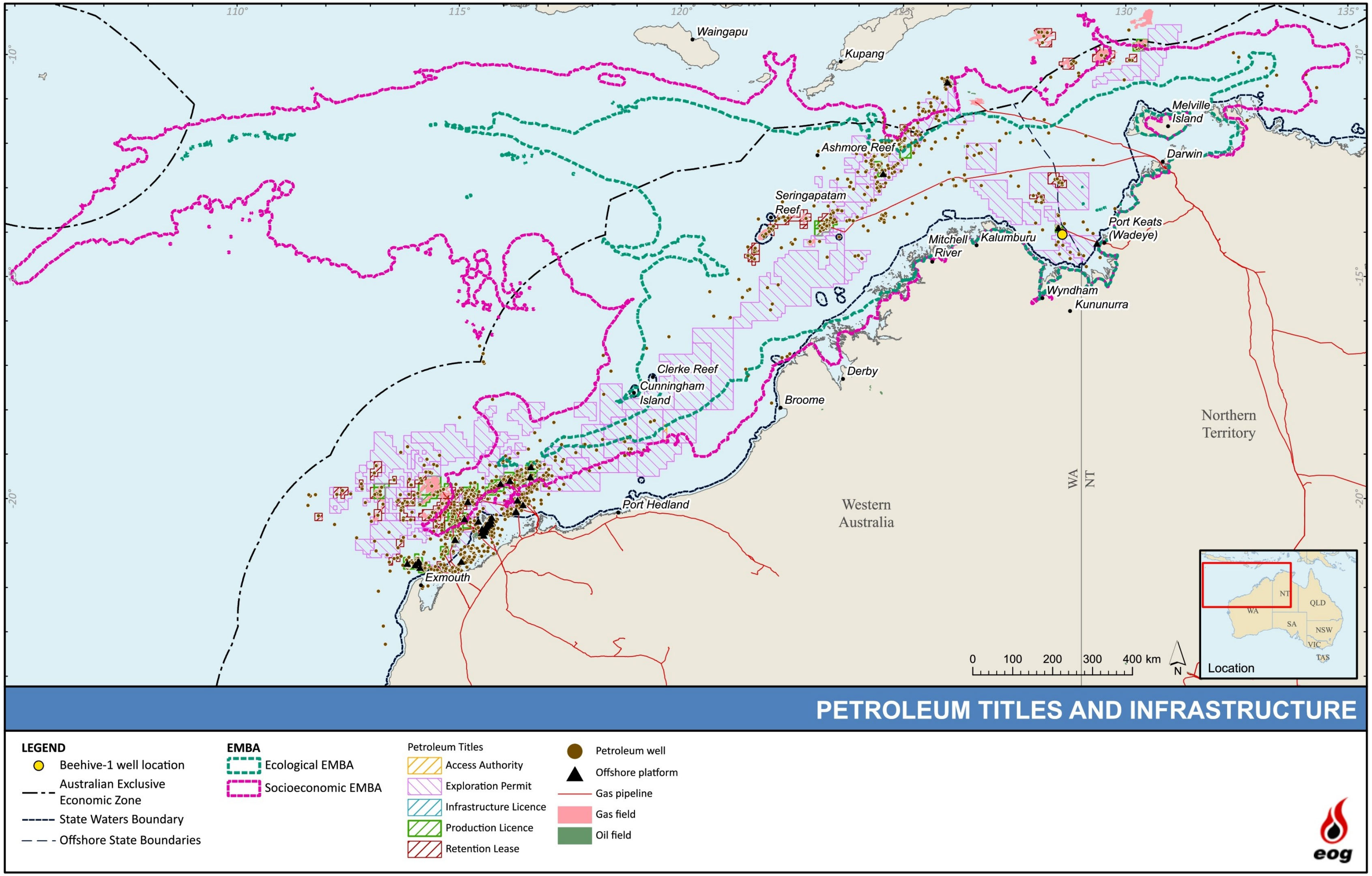


Figure 5.83. Petroleum titles and infrastructure in the EMBA

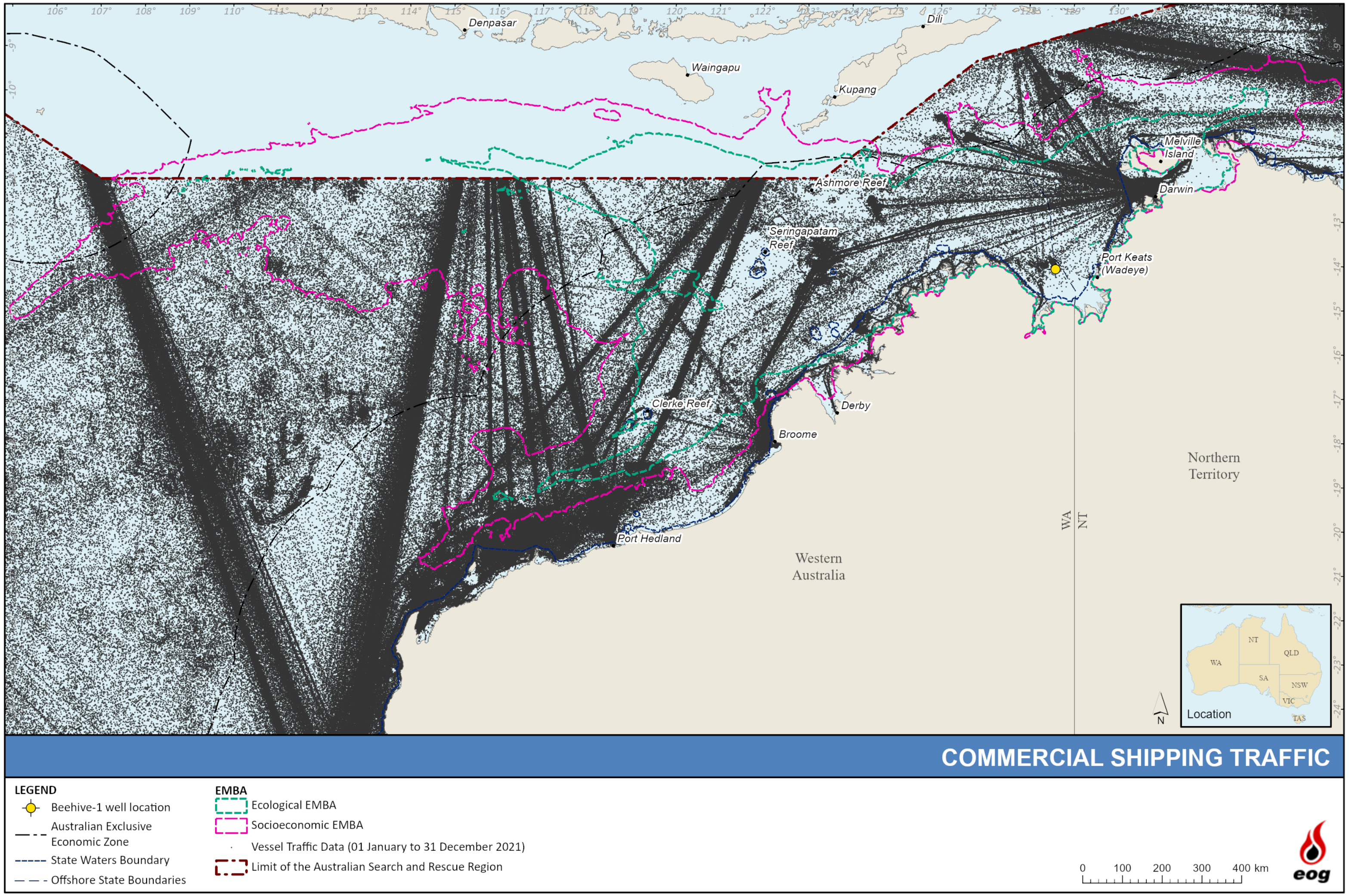


Figure 5.84. Commercial shipping in the EMBA

5.6.8. Defence Activities

The EMBA is overlapped by a defence training area, which is a maritime military zone administered by the Australian Defence Force (Figure 5.85). This is an area where exercises such as operational flying training or live weapon firing may occur. Training areas along the coastline of the EMBA include the Yampi Sound Training Area, Bradshaw Field Training Area and Kangaroo Flats Training Area (Figure 5.85).

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 area is a known area for travel between Indonesia and Australia for refugees seeking asylum in Australia.

The EMBA overlaps the exercise 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 used for operations including live weapons and missile firings. The NAXA 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 Australia's premier international maritime exercise bringing together multiple navy and air forces from the Asian, Pacific and Indian Ocean regions to test integration and war fighting abilities.

During Exercise KAKADU, access may be restricted to all vessels and aircraft. Avoidance of the area during exercises is requested by Defence.

There is also an Air-to-Air Refuelling (AAR) and Airborne Early Warning and Control (AEW&C) airspaces that overlap the activity area and EMBA.

The EMBA (but not the activity area) overlaps an area with potential for unexploded ordnance (UXO), illustrated in Figure 5.86.

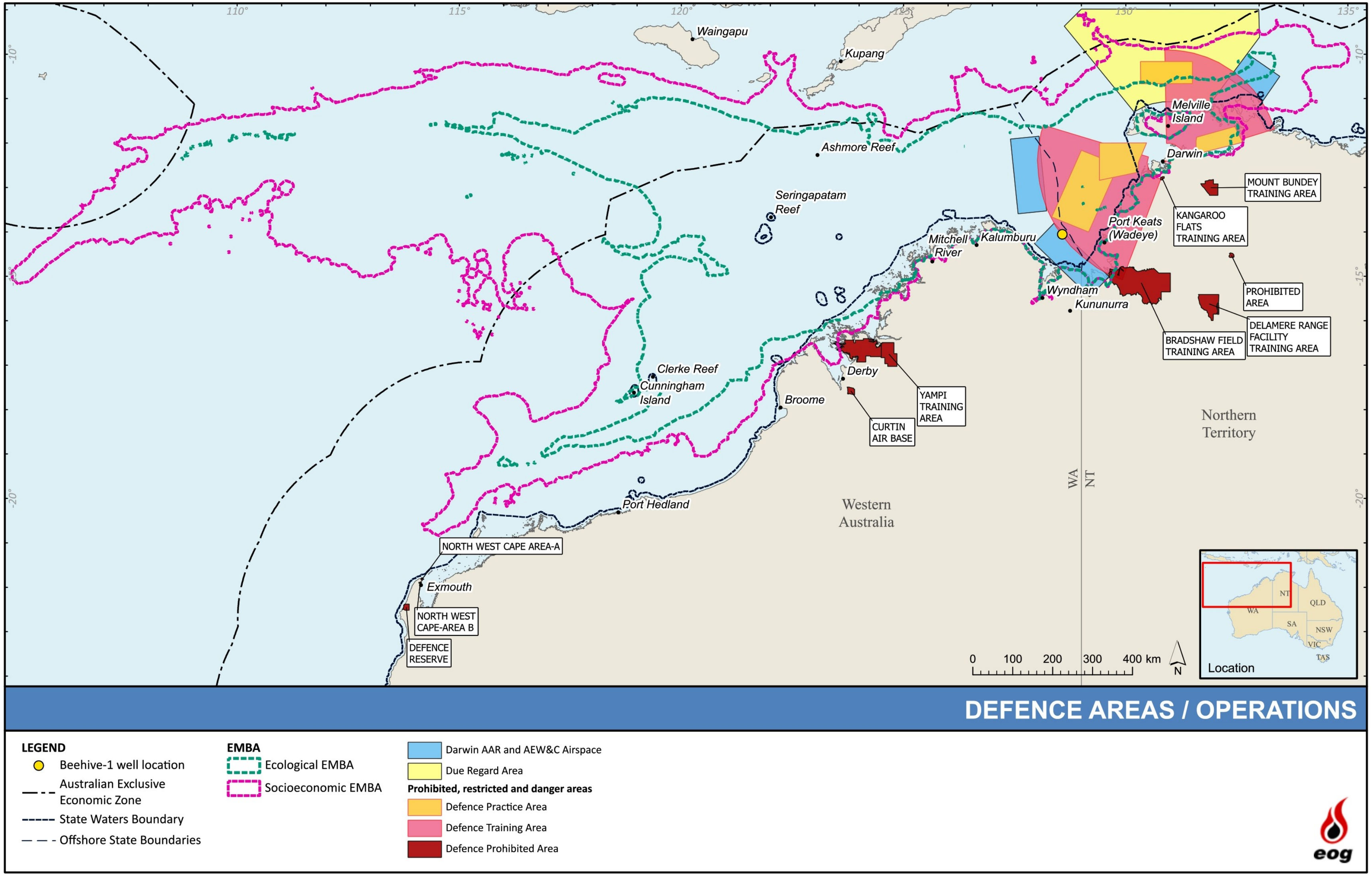
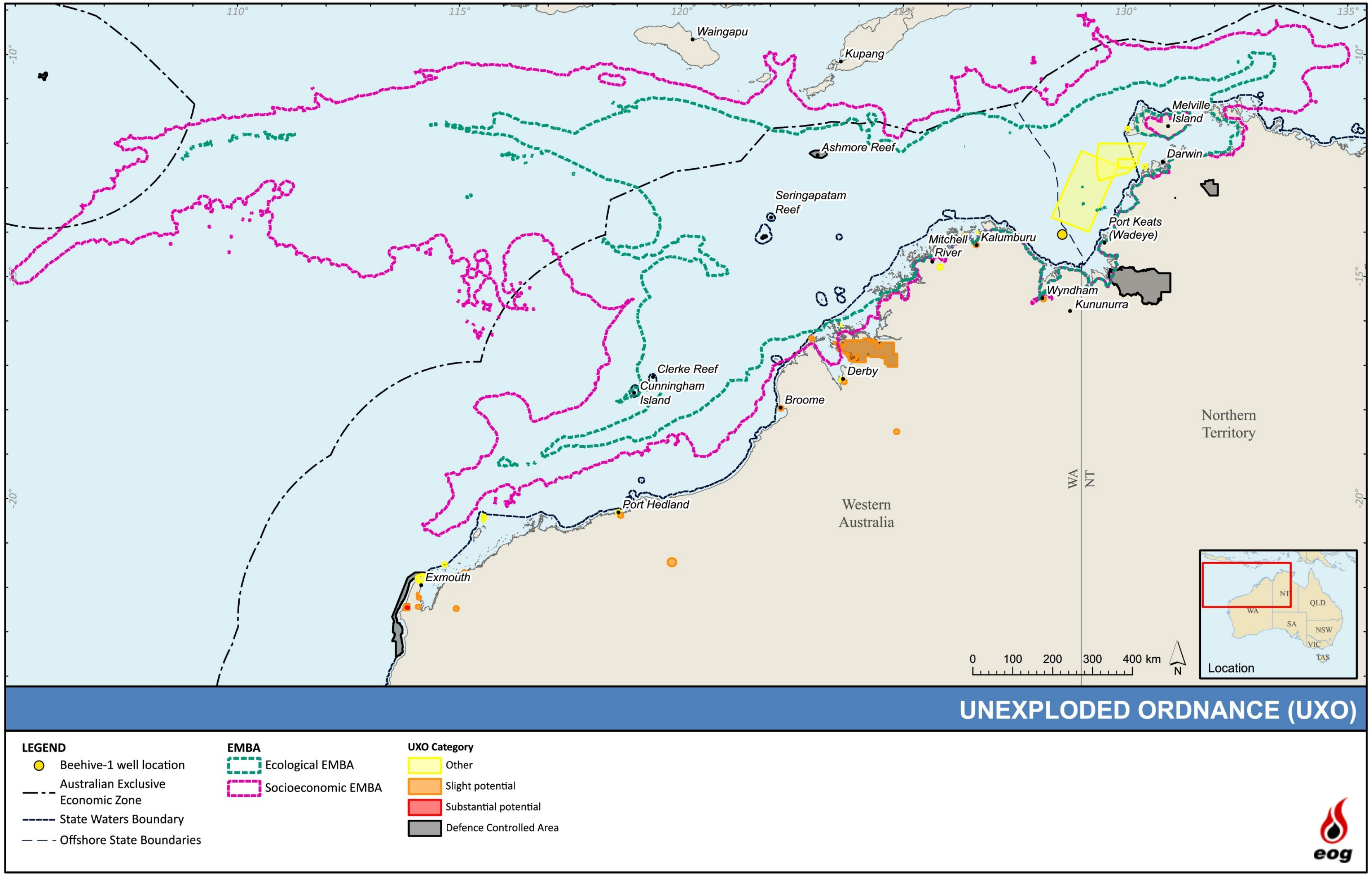


Figure 5.85. Defence exercise and training areas intersected by the spill EMBA



Source: DoD (2021).

Figure 5.86. Unexploded ordnance risks in the EMBA

<u>Appendix 6</u>

Beehive-1 Well Blowout Oil Spill Trajectory Modelling Report

BEEHIVE-1 – EXPLORATION DRILLING

Crude Oil Spill Modelling

MAQ1110J

Beehive-1 – Exploration Drilling

Rev1

18 January 2022

www.rpsgroup.com/mst

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Rev 0	Draft issued for Client review		Jeremie Bernard	Dr. Sasha Zigic	21/12/2021
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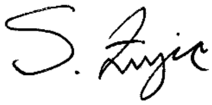
Approval for issue

Dr. Sasha Zigic  18 January 2022

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TERMS AND ABBREVIATIONS

°	Degrees
‘	Minutes
“	Seconds
µm	Micrometre (unit of length; 1 µm = 0.001 mm)
Actionable oil	Oil which is thick enough for the effective use of mitigation strategies
AIS	Automatic identification system
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment and Conservation Council
API	American Petroleum Institute gravity. A measure of how heavy or light a petroleum liquid is compared to water.
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASTM	American Society for Testing and Materials
Aventus	Aventus Consulting Pty Ltd
bbl	Barrel (unit of volume; 1 bbl = 0.159 m3)
bbl/d	Barrels per day
Bonn Agreement	An agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances, 1983, includes: Governments of the Kingdom of Belgium, the Kingdom of Denmark, the French Republic, the Federal Republic of Germany, the Republic of Ireland, the Kingdom of the Netherlands, the Kingdom of Norway, the Kingdom of Sweden, the United Kingdom of Great Britain and Northern Ireland and the European Union.
BP	Boiling point. The temperature at which the vapor pressure of the liquid is equal to the pressure exerted on it by the surrounding atmosphere
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
°C	degree Celsius (unit of temperature)
CFSR	Climate Forecast System Reanalysis
cm	Centimetre (unit of length)
cP	Centipoise (unit of dynamic viscosity)
Decay	The process where oil components are changed either chemically or biologically (biodegradation) to another compound. It includes breakdown to simpler organic carbon compounds by bacteria and other organisms, photo-oxidation by solar energy, and other chemical reactions.
Dynamic viscosity	The dynamic viscosity of a fluid expresses its resistance to shearing flows, where adjacent layers move parallel to each other with different speeds.
EOG	EOG Resources, Inc.
EP	Environment Plan
Floating oil exposure	Contact by floating oil on the sea surface at concentrations equal to or exceeding defined threshold concentrations. The consequence will vary depending on the threshold and the receptors

g/m2	Grams per square meter (unit of surface area density)
GODAE	Global Ocean Data Assimilation Experiment
HYCOM	Hybrid Coordinate Ocean Model. A data-assimilative, three-dimensional ocean model
HYDROMAP	Advanced ocean/coastal tidal model used to predict tidal water levels, current speed and current direction.
IBRA	Interim Biogeographic Regionalisation for Australia
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IOA	Index of Agreement
ITOPF	International Tanker Owners Pollution Federation Limited
KEF	Key Ecological Feature
km	Kilometre (unit of length)
km^2	Square Kilometres (unit of area)
Knots	unit of speed (1 knot = 0.514 m/s)
LOWC	Loss of well control
m	Meter (unit of length)
m3	Cubic meter (unit of volume)
m/s	Meter per Second (unit of speed)
MAE	Mean Absolute Error
MAHs	Monoaromatic Hydrocarbons
MNP	Marine National Park
MP	Marine Park
N	Number of observations
NASA	National Aeronautics and Space Administration (USA)
NCEP	National Centres for Environmental Prediction (USA)
nm	Nautical mile
NOAA	National Oceanic and Atmospheric Administration (USA)
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NP	National Park
NR	Nature Reserve
O	Observed variable
Oi	Observed surface elevation
OPEP	Oil Pollution Emergency Plan
P	Model-predicted variable
Pi	Model predicted surface elevation
PAH	Polynuclear Aromatic Hydrocarbons
PDSA	Pre-drilling seabed assessment

Pour Point	The pour point of a liquid is the temperature below which the liquid loses its flow characteristics
ppb	Parts per billion (concentration)
psu	Practical salinity nits
RSB	Reefs, Shoals and Banks
scf	Standard cubic feet (defined as one cubic foot of gas at 15.56 °C and at normal sea level air pressure)
Shoreline contact	Arrival of oil at or near shorelines at on-water concentrations equal to or exceeding defined threshold concentrations. Shoreline contact is judged for floating oil arriving within a 2 km buffer zone from any shoreline as a conservative measure
SIMAP	Spill Impact Model Application Package. SIMAP is designed to simulate the fate and effects of spilled hydrocarbons for surface or subsea releases
Single Oil spill modelling	Oil spill modelling involving a computer simulation of a single hypothetical oil spill event subject to a single sequence of wind, current and other sea conditions over time. Single oil spill modelling, also referred to as “deterministic modelling” provides a simulation of one possible outcome of a given spill scenario, subject to the metocean conditions that are imposed. Single oil spill modelling is commonly used to consider the fate and effects of ‘worst-case’ oil spill scenarios that are carefully selected in consideration of the nature and scale of the offshore petroleum activity and the local environment (NOPSEMA, 2017). Because the outcomes of a single oil spill simulation can only represent the outcome of that scenario under one sequence of metocean conditions, worst-case conditions are often identified from stochastic modelling. It is impossible to calculate the likelihood of any outcome from a single oil spill simulation. Single oil spill modelling is generally used for response planning, preparedness planning and for supporting oil spill response operations in the event of an actual spill
SRTM	Shuttle Radar Topography Mission
Stochastic oil spill modelling	Stochastic oil spill modelling is created by overlaying and statistically analysing the outcomes of many single oil-spill simulations of a defined spill scenario, where each simulation was subject to a different sequence of metocean conditions, selected objectively (typically by random selection) from a long sequence of historic conditions for the study area. Analysis of this larger set of simulations provides a more accurate indication of the environment that maybe affected (EMBA) and indicates which locations are more likely to be affected (as well as other statistics). Stochastic oil spill modelling avoids biases that affect single oil spill modelling (due to the reliance on only one possible sequence of conditions). However, when interpreting stochastic modelling, which is based on a wide range of potential conditions that might happen to occur, it is essential to understand that calculations will encompass a much larger area than could be affected in any single spill event, where a more limited set of conditions will occur. Consequently, it is misleading to imply that the region derived from stochastic modelling indicate the outcomes expected from a single spill event (NOPSEMA, 2017) Stochastic modelling is generally used for risk assessment and preparedness planning by indicating locations that could be exposed and may require response or subsequent impact assessment
TOPEX/Poseidon	A joint satellite mission between NASA and CNES to map ocean surface topography using an array of satellites equipped with detailed altimeters
USA	United States of America
US CG	United States Coast Guard
US EPA	United States Environmental Protection Agency
World Ocean Atlas	A collection of objectively analysed, quality controlled physicochemical parameters (e.g. temperature, salinity, oxygen, phosphate, silicate, and nitrate) based on profile data from the World Ocean Database (NCEI, 2021) established by NOAA’s National Centers for Environmental Information (NCEI)
WGS 1984	World Geodetic System 1984 (WGS84); reference coordinate system
Xmodel	Model predicted surface elevation

Xobs	Observed surface elevation

EXECUTIVE SUMMARY

Background

EOG Resources Australia Block WA-488 Pty Ltd (EOG) is planning to undertake the Beehive-1 drilling campaign within permit area WA-488-P located in the Bonaparte Basin in the Joseph Bonaparte Gulf, Western Australia.

Aventus Consulting Pty Ltd (Aventus) has been contracted by EOG to prepare the Environment Plan (EP) and Oil Pollution Emergency Plan (OPEP) for the planned activity.

To inform the potential environmental impact and risk assessments for the proposed drilling campaign, Aventus commissioned RPS to undertake a detailed crude oil spill modelling study assessing the following hypothetical scenario:

- **Scenario**: A 786,858 m^3 (or 4,949,338 bbl) surface release of crude oil over 77 days to represent a loss of well control (LOWC).

The purpose of the modelling is to provide an understanding of a conservative 'outer envelope' of the potential area that may be affected in the unlikely event of hydrocarbon spill. The modelling does not take into consideration any of the spill prevention, mitigation and response capabilities that would be implemented in response to the spill. Therefore, the modelling results represent the maximum extent that the released hydrocarbon may influence.

The spill modelling was performed using an advanced three-dimensional trajectory and fates model; Spill Impact Model Application Program (SIMAP). The SIMAP model calculates the transport, spreading, entrainment and evaporation of spilled hydrocarbons over time, based on the prevailing wind and current conditions and the physical and chemical properties.

Methodology

The modelling study was carried out in several stages. Firstly, a ten-year CFSR wind and HYCOM current dataset (2010–2019) was generated and the currents included the combined influence of three-dimensional large-scale ocean currents and tidal currents. Secondly, the currents, winds and detailed hydrocarbon characteristics were used as inputs in the three-dimensional oil spill model (SIMAP) to simulate the drift, spread, weathering and fate of the spilled oil.

As spills can occur during any set of wind and current conditions, modelling was conducted using a stochastic (random or non-deterministic) approach, which involved running 100 spill simulations initiated at random start times, using the same release information (spill volume, duration and composition of the oil). This ensured that each simulation was subject to different wind and current conditions and, in turn, movement and weathering of the oil for an annual based assessment.

The SIMAP system, the methods and analysis presented herein, use modelling algorithms which have been anonymously peer reviewed and published in international journals. Further, RPS warrants that this work meets and exceeds the ASTM Standard F2067-13 "Standard Practice for Development and Use of Oil Spill Models".

Oil Properties

An analogue crude oil was used to represent the LOWC scenario. The analogue crude oil was carefully selected based on EOG recommendations to represent the crude oil likely to be found within permit area WA-488-P. The crude oil has an API of 42.3 and a density of 813.9 kg/m^3 (at 15ºC) with a viscosity value (3.0 cP) classifying it as a Group II (light-persistent) oil according to the International Tankers Owners Pollution Federation (ITOPF, 2014) and US EPA/USCG classifications.

The crude is a mixture of volatile (79%) and persistent hydrocarbons (21%). In favourable evaporation conditions, about 24.2% of the oil mass should evaporate within the first 12 hours (BP < 180 °C); a further 20.8% should evaporate within the first 24 hours (180°C < BP < 160°C); and a further 33.9% should evaporate over several days (160°C < BP < 380°C). Approximately 21.0% of the oil is shown to be persistent.

Results

Scenario: LOWC – 786,858 m^3 Surface release of Crude Oil over 77 Days

- The maximum distance from the release location to the low (1–10 g/m^2), moderate (10–50 g/m^2) and high (> 50 g/m^2) exposure levels was 1,517 km (winter), 153 km (summer) and 61 km (winter) respectively.

- Of all the receptors considered in the assessment, the Joseph Bonaparte Gulf AMP was the only receptor predicted to be exposed to floating oil above the low, moderate and high thresholds during all seasonal conditions.

- The probability of accumulation to any shoreline at, or above, the low threshold (10-100 g/m^2) was 100% for all seasons and the minimum time before shoreline accumulation at, or above, the low threshold ranged between 10.29 days (transitional) to 11.58 days (summer).

- The maximum volume ashore for a single spill trajectory ranged between 406.9 m^3 (winter) and 704.67 m^3 (summer) and maximum length of shoreline contacted at the low threshold was 201 km for winter and 224 km for summer and transitional. The predicted shoreline length above the high (≥1,000 g/m^2) shoreline threshold decreased to a maximum of 16 km, 9 km and 8 km during summer, winter and transitional months respectively.

- In the surface (0-10 m) depth layer, low, moderate and high exposure to dissolved hydrocarbons was recorded for a range of receptors. The highest dissolved hydrocarbon concentrations were predicted for the Joseph Bonaparte Gulf AMP and the carbonate bank and terrace system of the Sahul Shelf KEF, followed by the North Kimberley MP and Kimberley AMP during all seasonal conditions. In addition, the nearshore waters of the Thamarrurr, Wyndham-East Kimberley, Dorcherty Island, Clump Island Quoin Island, Daly, Victoria Daly shorelines and Ord River floodplain (Ramsar) were some of the receptors with the highest entrained hydrocarbons concentrations for all seasonal conditions.

- In the surface (0-10 m) depth layer, low, moderate and high exposure to dissolved hydrocarbons was recorded for a range of receptors. The highest dissolved hydrocarbon concentrations were predicted for the Joseph Bonaparte Gulf AMP and the carbonate bank and terrace system of the Sahul Shelf KEF, followed by the North Kimberley MP and Kimberley AMP during all seasonal conditions. In addition, the nearshore waters of the Thamarrurr, Wyndham-East Kimberley, Dorcherty Island, Clump Island Quoin Island, Daly, Victoria Daly shorelines and Ord River floodplain (Ramsar) were some of the receptors with the highest entrained hydrocarbons concentrations for all seasonal conditions.

1 INTRODUCTION

1.1 Background

EOG Resources Australia Block WA-488 Pty Ltd (EOG) is planning to undertake a drilling campaign within permit area WA-488-P located in the Bonaparte Basin in the Joseph Bonaparte Gulf, Western Australia.

Aventus Consulting Pty Ltd (Aventus) has been contracted by EOG to prepare the Environment Plan (EP) and Oil Pollution Emergency Plan (OPEP) for the planned activity.

To inform the potential environmental impact and risk assessments for the proposed drilling campaign, Aventus commissioned RPS to undertake a detailed oil spill modelling study assessing the following hypothetical scenario:

- **Scenario**: A 786,858 m3 (or 4,949,338bbl) surface release of crude oil over 77 days to represent a loss of well control (LOWC).

Table 1.1 presents the Beehive-1 exploration well location used for Scenario 1. Figure 1.1 illustrates the exploration well location.

The potential risk of exposure to the surrounding waters and contact to shorelines was assessed for three distinct seasons defined by prevailing wind conditions.

i. summer (October to February),

ii. the transitional periods (March and September), and

iii. winter (April to August).

This approach assists with identifying the environmental values and sensitivities that would be at risk of exposure on a seasonal basis, given the dominant winds and water currents vary significantly among the seasons.

The purpose of the modelling is to provide an understanding of a conservative 'outer envelope' of the potential area that may be affected in the unlikely event of hydrocarbon spill. The modelling does not take into consideration any of the spill prevention, mitigation and response capabilities that would be implemented in response to the spill. Therefore, the modelling results represent the maximum extent that the released hydrocarbon may influence.

The spill modelling was performed using an advanced three-dimensional trajectory and fates model; Spill Impact Model Application Program (SIMAP). The SIMAP model calculates the transport, spreading, entrainment and evaporation of spilled hydrocarbons over time, based on the prevailing wind and current conditions and the physical and chemical properties.

Note that the oil spill model, the method and analysis presented herein uses modelling algorithms which have been anonymously peer reviewed and published in international journals. Furthermore, RPS warrants that this work meets and exceeds the American Society for Testing and Materials (ASTM) Standard F2067-13 "*Standard Practice for Development and Use of Oil Spill Models*".

Table 1.1 Coordinates for the Beehive-1 exploration well (GDA2020).

Location	Latitude	Longitude
Beehive-1	14° 03' 14.4" S	128° 34' 35.76" E

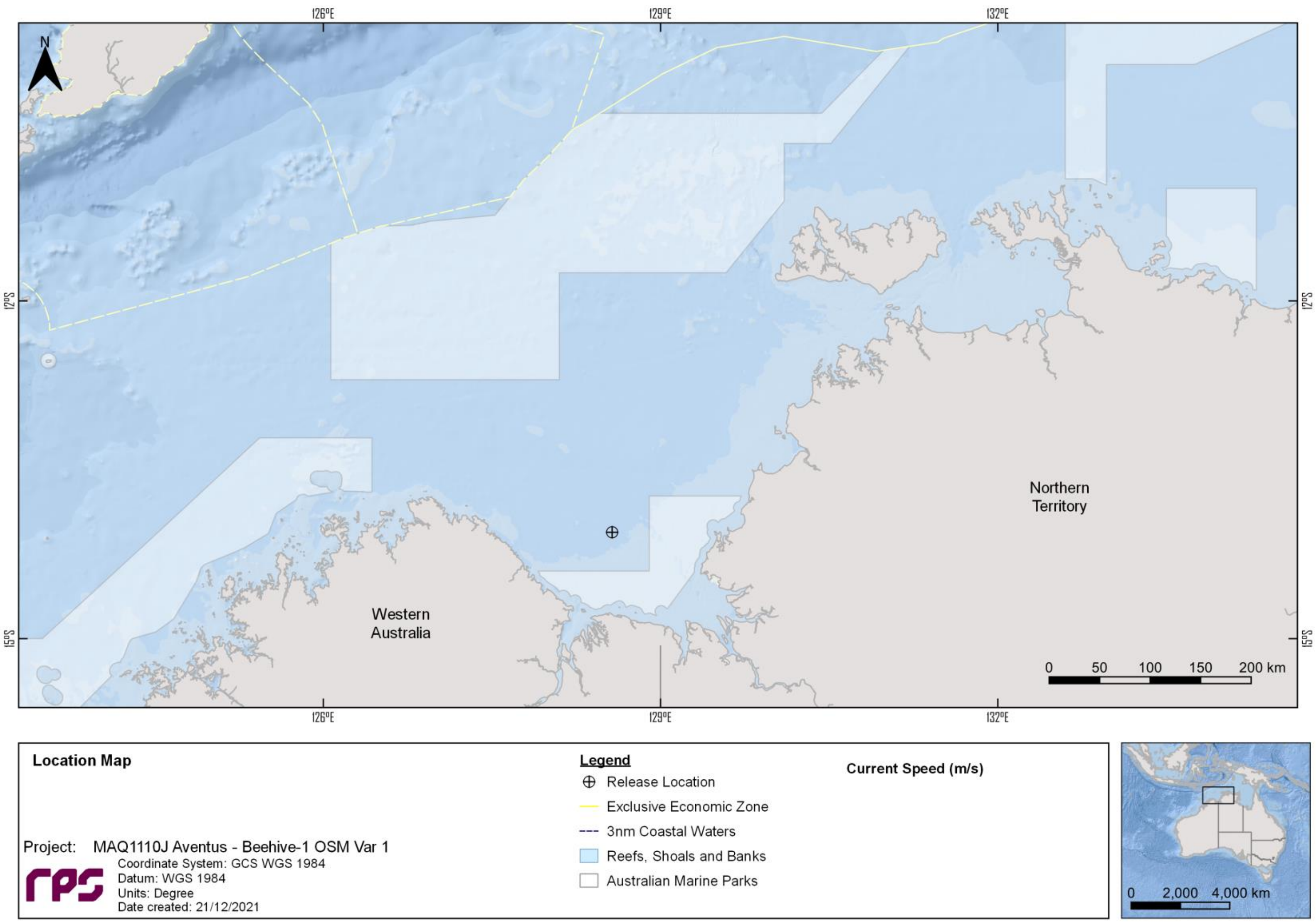


Figure 1.1 Map of the Beehive-1 exploration well.

1.2 What is Oil Spill Modelling?

Oil spill modelling is a valuable tool widely used for risk assessment, emergency response and contingency planning where it can be particularly helpful to proponents and decision makers. By modelling a series of the most likely oil spill scenarios, decisions concerning suitable response measures and strategic locations for deploying equipment and materials can be made, and the locations at most risk can be identified. The two types of oil spill modelling often used are stochastic (Section 1.2.1) and deterministic (Section 1.2.2) modelling.

1.2.1 Stochastic Modelling (Multiple Spill Simulations)

Stochastic oil spill modelling is created by overlaying a great number (often hundreds) of individual, computer-simulated hypothetical spills (NOPSEMA, 2018; Figure 1.2).

Stochastic modelling is a common means of assessing the potential risks from oil spills related to new projects and facilities. Stochastic modelling typically utilises hydrodynamic data for the location in combination with historic wind data. Typically, 100 iterations of the model will be run utilising the data that is most relevant to the season or timing of the project.

The outcomes are often presented as a probability of exposure and is primarily used for risk assessment purposes in view to understand the range of environments that may be affected or impacted by a spill. Elements of the stochastic modelling can also be used in oil spill preparedness and planning.

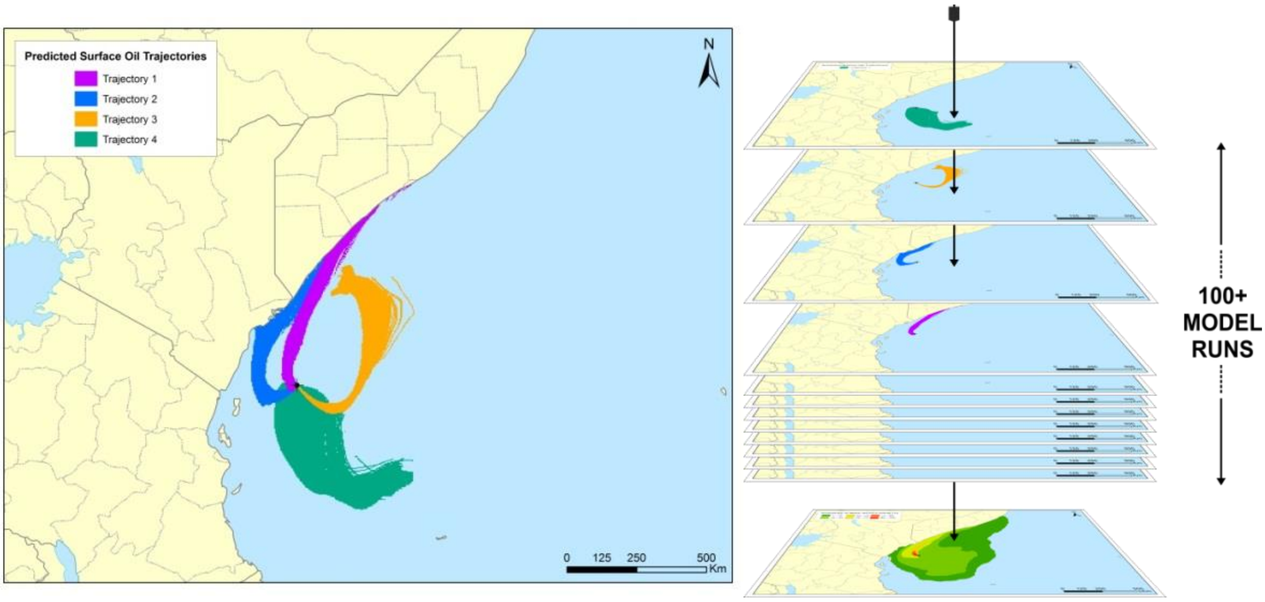


Figure 1.2 Examples of four individual spill trajectories (four replicate simulations) predicted by SIMAP for a spill scenario. The frequency of contact with given locations is used to calculate the probability of impacts during a spill. Essentially, all model runs are overlain (shown as the stacked runs on the right) and the number of times that trajectories contact a given location at a concentration is used to calculate the probability.

1.2.2 Deterministic Modelling (Single Spill Simulation)

Deterministic modelling is the predictive modelling of a single incident subject to a single sample of wind and weather conditions over time (NOPSEMA, 2018; Figure 1.3).

Deterministic modelling is often paired with stochastic modelling to place the large stochastic footprint into perspective. This deterministic analysis is generally a single run selected from the stochastic analysis and serves as the basis for developing the plans and equipment needs for a realistic spill response. Deterministic spills can be selected on several basis such as minimum time to shoreline, largest swept area, maximum volume ashore and longest length of shoreline contacted by oil.

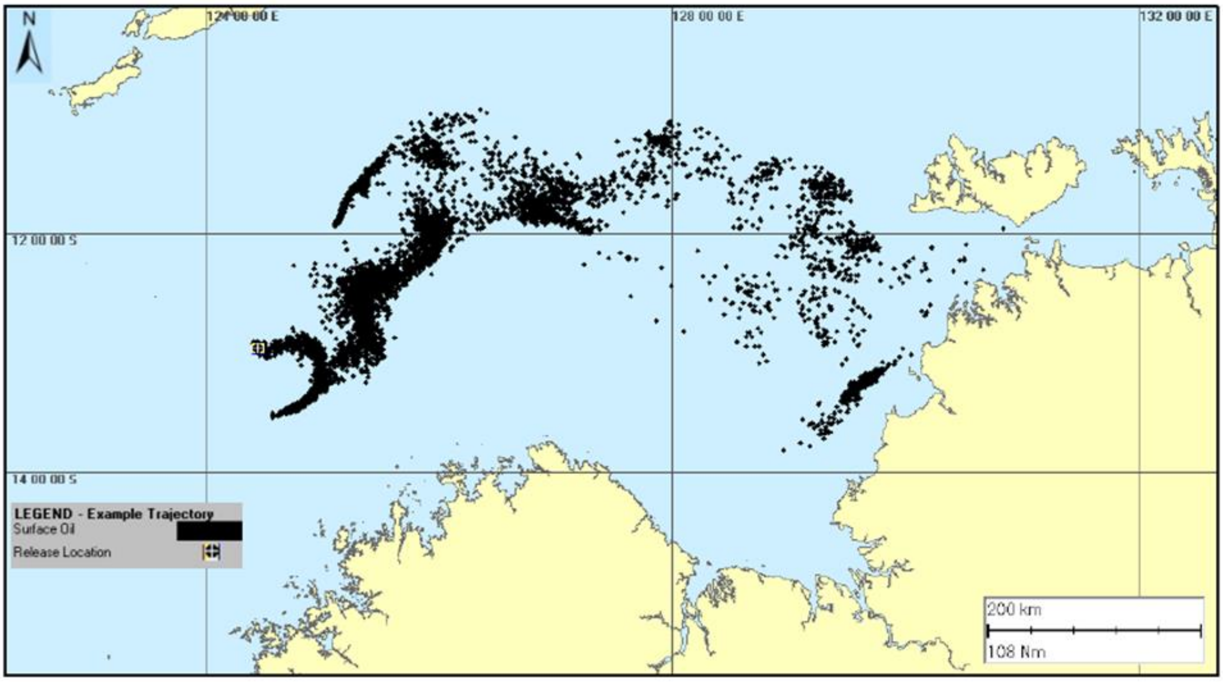


Figure 1.3 Example of an individual spill trajectory predicted by SIMAP for a spill scenario. Note, this image represents surface oil as spillets and do not take any thresholds into consideration.

2 SCOPE OF WORK

The scope of work included the following components:

- Generate 10 years of CFSR winds and three-dimensional hindcast HYCOM currents from 2010 to 2019 (inclusive). The currents include the combined influence of HYDROMAP tidal and HYCOM ocean currents;
- Include the wind and current data and hydrocarbon characteristics of the crude oil as input into the three-dimensional oil spill model SIMAP, to model the movement, spreading, weathering and shoreline accumulation by hydrocarbons over time;
- Use SIMAP's stochastic model (also known as a probability model) to calculate exposure to surrounding waters and shorelines. This involved running 100 randomly selected single trajectory simulations (per season), with each simulation having the same spill information (spill volume, location, duration and composition of hydrocarbons) but with varying start times. This ensured that each spill trajectory was subject to a unique set of wind and current conditions; and
- Review the stochastic model results and present the worst-case deterministic runs based on the following criteria:

    a. Largest swept area of floating oil above 1 g/m^2 (visible floating oil);

    b. Minimum time before shoreline accumulation above 10 g/m^2;

    c. Largest volume of oil ashore;

    d. Longest length of shoreline accumulation above 10 g/m^2;

    e. Largest area of entrained hydrocarbons above 10 ppb; and

    f. Largest area of dissolved hydrocarbons above 10 ppb.

3 REGIONAL CURRENTS

The Operational Area is located within the Joseph Bonaparte Gulf, a shallow (generally <100 m) waterbody bordered by the Indian Ocean and Timor Sea. The gulf is characterised by complex geomorphology (i.e. shoals, valleys and terraces) and is dominated by tidal (ranges > 4 m) and wind driven currents which are dependent on season (DEWHA, 2007).

The Indonesian Throughflow brings southwest flowing, less saline, warm waters from the tropics, however the internal gyres generate local currents in any direction. As these gyres migrate through the area, large spatial variations in the speed and direction of currents will occur at a given location over time. The Holloway current, which flows southwest and close to the coastline, intensifies during April to July due to increased wind forcing.

A comprehensive description of the circulation patterns of the Northwest Shelf and Timor Sea is provided in a review by Condie and Andrewartha (2008). A schematic of the ocean currents along the Northwest Australian continental shelf is shown in Figure 3.1.

While, the tidal currents are generally weaker in the deeper waters (beyond the Gulf), its influence is greatest along the near shore, within the Gulf, coastal passage regions and, in and around the islands. Therefore, to accurately account for the movement of an oil spill, which can move between the offshore and near shore region, ocean and tidal currents were combined as part of the study.

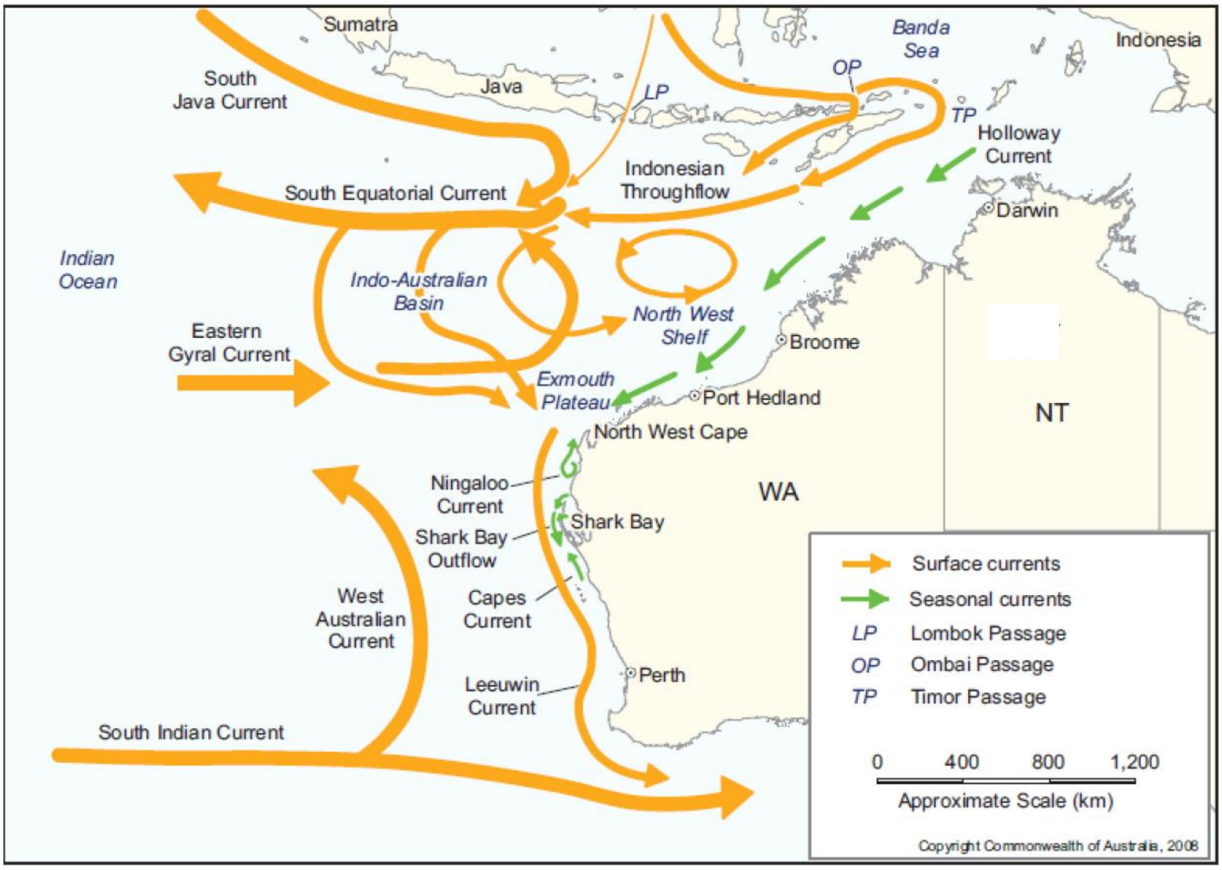


Figure 3.1 Schematic of ocean currents along the Northwest Australian continental shelf. Image adapted from DEWHA (2008).

3.1 Tidal currents

Tidal current data was generated using RPS's advanced ocean/coastal model, HYDROMAP. The HYDROMAP model has been thoroughly tested and verified through field measurements throughout the world for more than 30 years (Isaji & Spaulding, 1984; Isaji, et al., 2001; Zigic, et al., 2003). HYDROMAP tidal current data has been used as input to forecast (in the future) and hindcast (in the past) pollutant spills in Australian waters and forms part of the Australian National Oil Spill Emergency Response System operated by AMSA (Australian Maritime Safety Authority).

HYDROMAP employs a sophisticated sub-gridding strategy, which supports up to six levels of spatial resolution, halving the grid cell size as each level of resolution is employed. The sub-gridding allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, and/or of interest to a study.

The numerical solution methodology follows that of Davies (1977a and 1977b) with further developments for model efficiency by Owen (1980) and Gordon (1982). A more detailed presentation of the model can be found in Isaji and Spaulding (1984) and Isaji et al. (2001).

3.1.1 Grid Setup

RPS has a global tidal model with global coverage. The model is sub-gridded to a resolution of 500 m for shallow and coastal regions, starting from an offshore (or deep water) resolution of 8 km. The finer grids are progressively allocated in a step-wise fashion to more accurately resolve flows along the coastline, around islands and over regions with more complex bathymetry. Figure 3.2 shows the tidal model grid covering the study domain.

A combination of datasets was used and merged to describe the shape of the seabed within the grid domain (Figure 3.3). These included spot depths and contours which were digitised from nautical charts released by the hydrographic offices as well as Geoscience Australia database and depths extracted from the Shuttle Radar Topography Mission (SRTM30_PLUS) Plus dataset (see Becker et al., 2009).

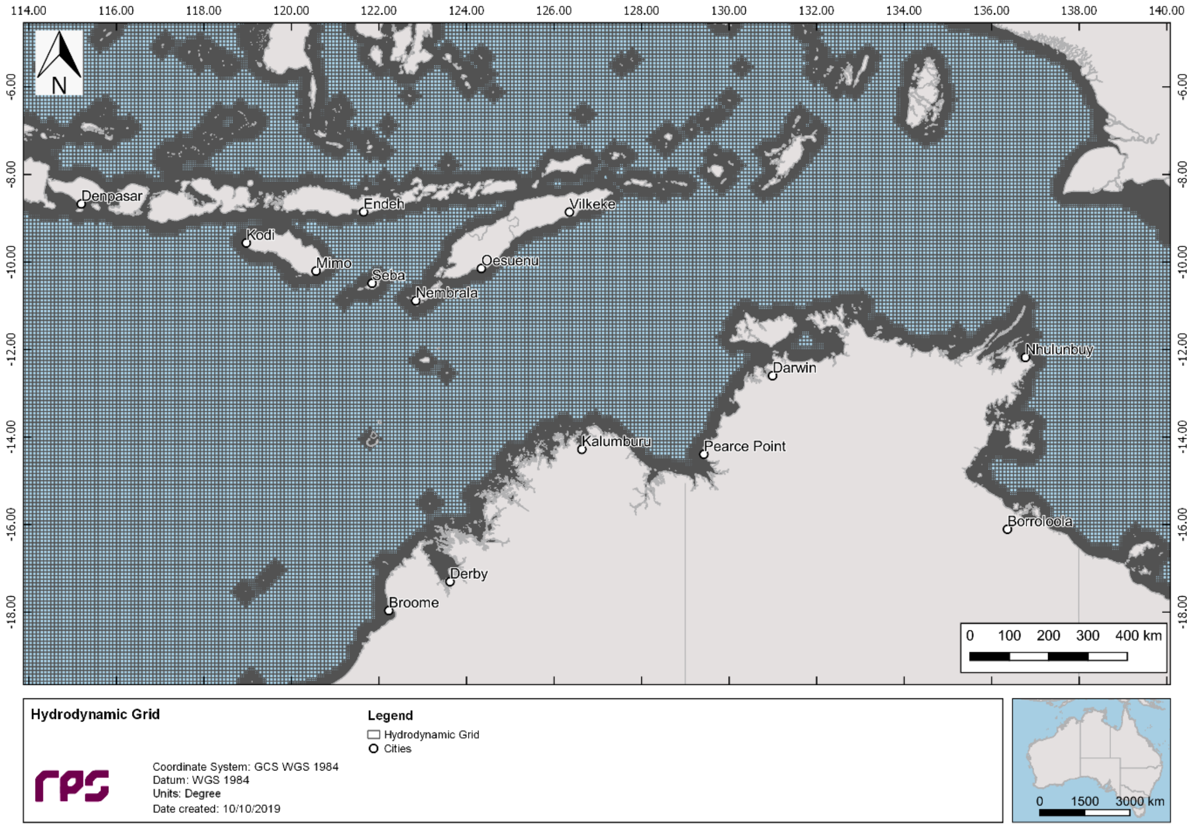


Figure 3.2 Sample of the model grid used to generate the tidal currents for the study region. Higher resolution areas are shown by the denser mesh.

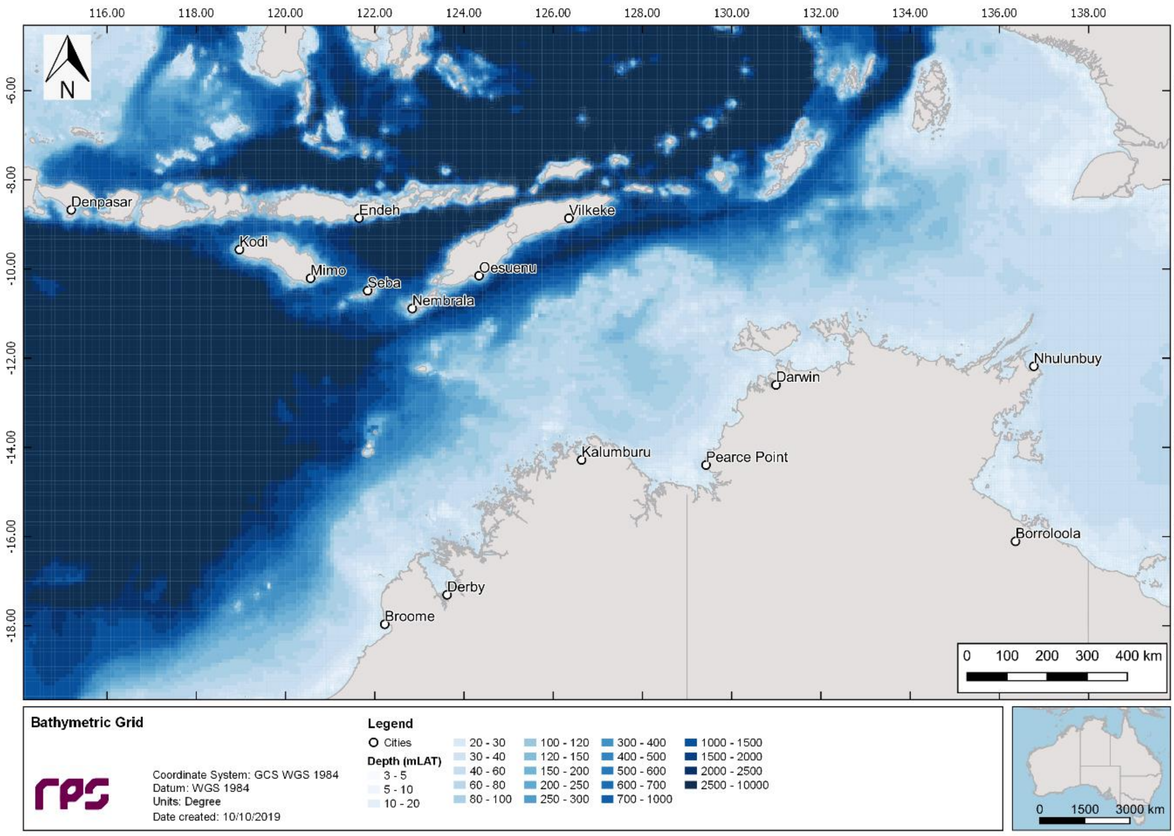


Figure 3.3 Bathymetry defined throughout the tidal model domain.

3.1.2 Tidal Conditions

The ocean boundary data for the regional model was obtained from satellite measured altimetry data (TOPEX/Poseidon 8.0) which provided estimates of the eight dominant tidal constituents at a horizontal scale of approximately 0.25 degrees. The eight major tidal constituents used were K_2, S_2, M_2, N_2, K_1, P_1, O_1 and Q_1. Using the tidal data, time series surface heights were calculated along the open boundaries for the simulation period.

The Topex/Poseidon satellite data has a resolution of 0.25 degrees globally, with higher resolution in coastal regions, and is produced and quality controlled by NASA (National Aeronautics and Space Administration). The data capturing satellites, equipped with two altimeters capable of taking sea level measurements accurate to less than ± 5 cm, measured oceanic surface elevations (and the resultant tides) for the period 1992–2005. In total these satellites carried out 62,000 orbits of the planet. The Topex-Poseidon tidal data has been widely used amongst the oceanographic community, being referenced in more than 2,100 research publications (e.g. Andersen, 1995; Ludicone et al., 1998; Matsumoto et al., 2000; Kostianoy et al., 2003; Yaremchuk & Tangdong, 2004; Qiu & Chen 2010). The Topex/Poseidon tidal data is considered suitably accurate for this study.

3.1.3 Surface Elevation Validation

To ensure that tidal predictions were accurate, predicted surface elevations were compared to data observed at a location situated within the study area (Figure 3.4).

To provide a statistical measure of the model performance, the Index of Agreement (IOA – Willmott, 1981) and the Mean Absolute Error (MAE – Willmott, 1982; Willmott & Matsuura, 2005) were used.

The MAE (Eq.1) is simply the average of the absolute values of the difference between the model-predicted (P) and observed (O) variables. It is a more natural measure of the average error (Willmott and Matsuura, 2005) and more readily understood. The MAE is determined by:

$$MAE = N^{-1} \sum_{i=1}^{N} |P_i - O_i| \qquad \text{Eq.1}$$

Where: N = Number of observations

Pi = Model predicted surface elevation

Oi = Observed surface elevation

The Index of Agreement (IOA; Eq. 2) in contrast, gives a non-dimensional measure of model accuracy or performance. A perfect agreement between the model predicted and observed surface elevations exists if the index gives an agreement value of 1, and complete disagreement between model and observed surface elevations will produce an index measure of 0 (Wilmott, 1981). Willmott et al. (1985) also suggests that values larger than 0.5 may represent good model performance. The IOA is determined by:

$$IOA = 1 - \frac{\sum |X_{model} - X_{obs}|^2}{\sum (|X_{model} - \overline{X_{obs}}| + |X_{obs} - \overline{X_{obs}}|)^2} \qquad \text{Eq.2}$$

Where: Xmodel = Model predicted surface elevation

Xobs = Observed surface elevation

Clearly, a greater IOA and lower MAE represent a better model performance.

Figure 3.5 and Figure 3.6illustrate a comparison of the predicted and observed surface elevations in January 2014. As shown on the graph, the model accurately reproduced the phase and amplitudes throughout the spring and neap tidal cycles.

Table 3.1 shows the IOA and MAE values for the selected tide station locations indicating that the model is performing well.

Table 3.1 Statistical comparison between the observed and HYDROMAP predicted surface elevations.

Tide Station	IOA	MAE (m)
Calder Shoal	0.95	0.21
Evans Shoal	0.97	0.14
Lacrosse Island	0.97	0.44
Snake Bay	0.98	0.16
The Boxers	0.94	0.23

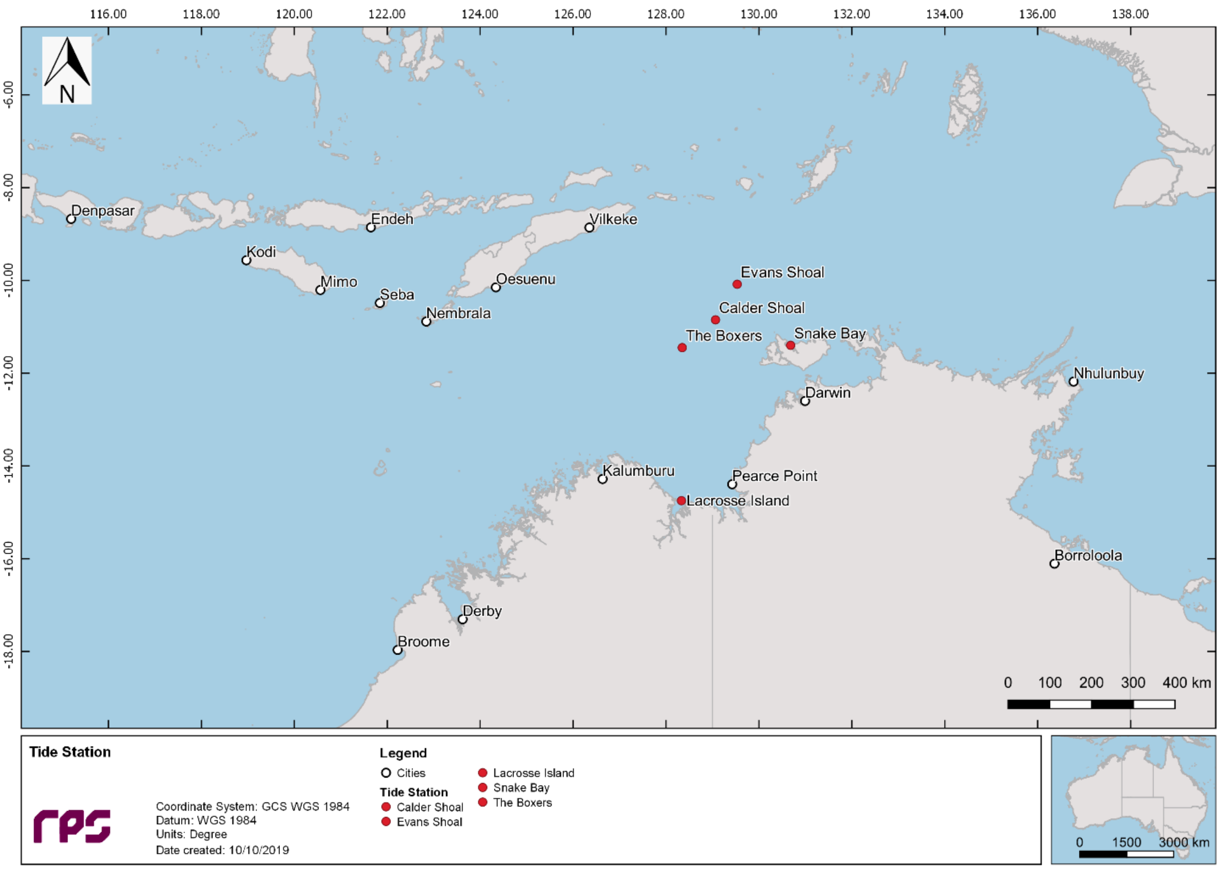


Figure 3.4 Location of the tide stations used in the surface elevation validation.

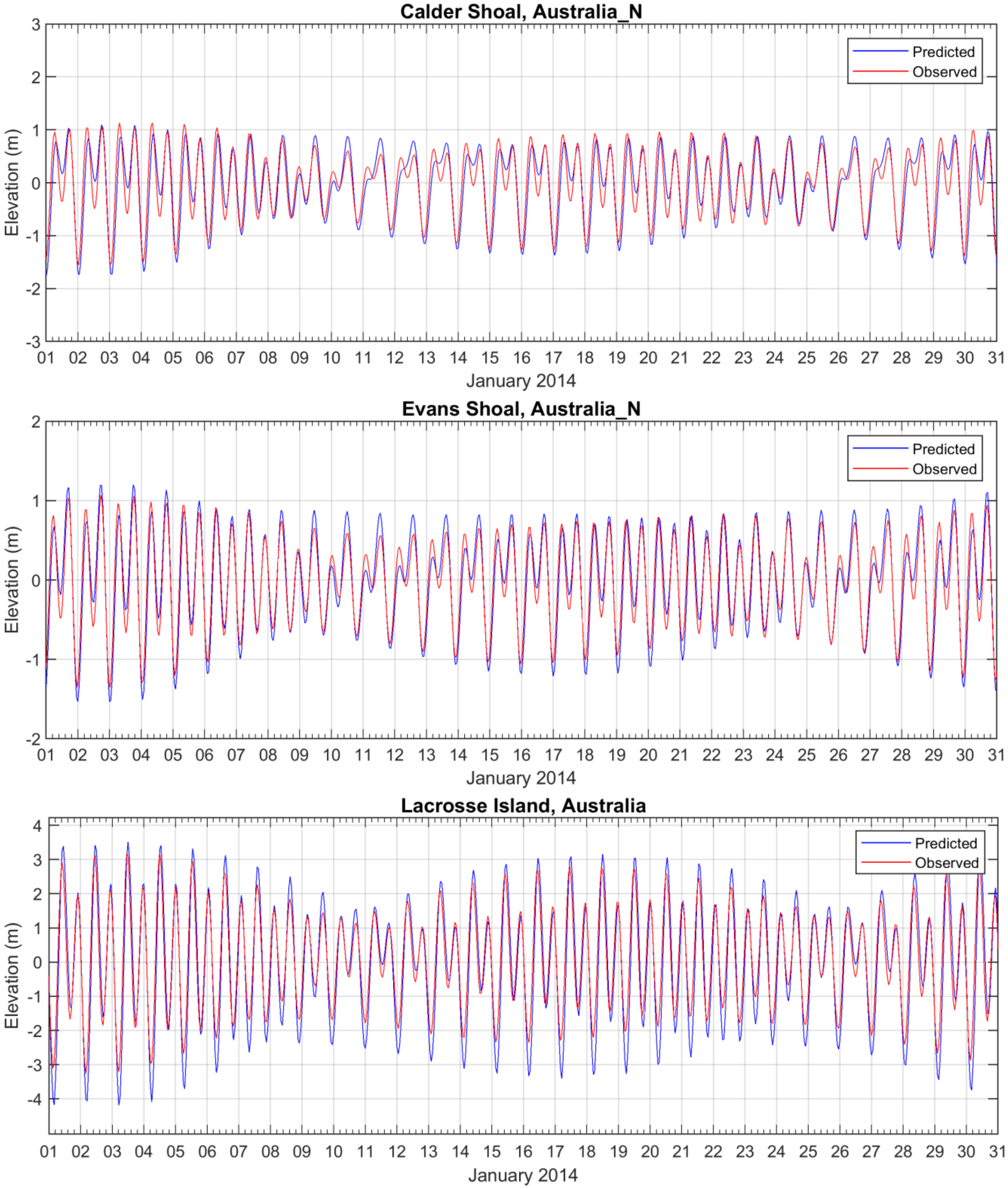


Figure 3.5 Comparison between HYDROMAP predicted (blue line) and observed (red line) surface elevation at tidal stations Calder Shoal (upper image), Evans Shoal (middle image) and Lacrosse Island (lower image).

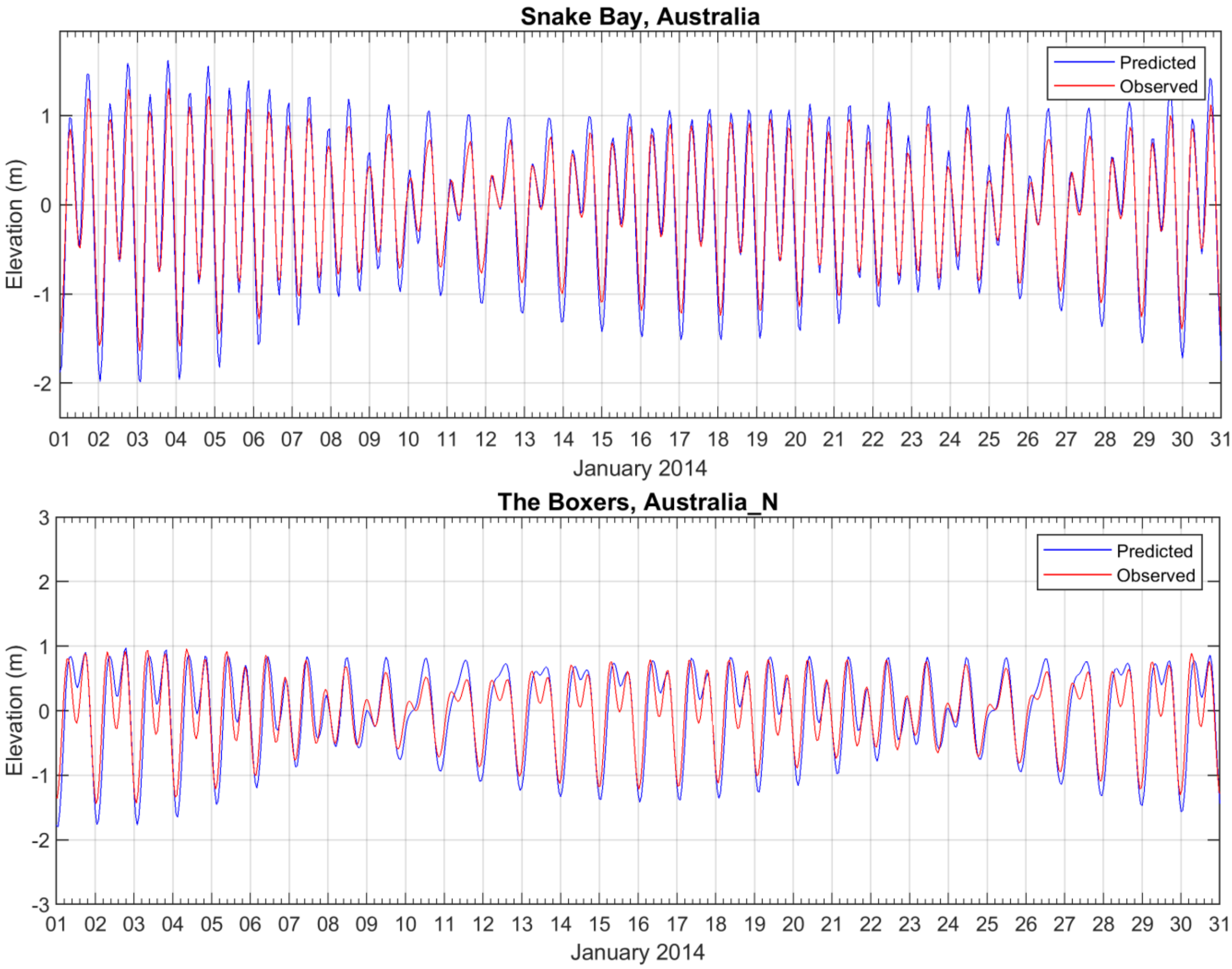


Figure 3.6 Comparison between HYDROMAP predicted (blue line) and observed (red line) surface elevation at tidal stations Snake Bay (upper image) and The Boxers (lower image).

3.2 Ocean Currents

Data describing the flow of ocean currents was obtained from HYCOM (Hybrid Coordinate Ocean Model, (Chassignet et al., 2007), which is operated by the HYCOM Consortium, sponsored by the Global Ocean Data Assimilation Experiment (GODAE). HYCOM is a data-assimilative, three-dimensional ocean model that is run as a hindcast (for a past period), assimilating time-varying observations of sea surface height, sea surface temperature and in-situ temperature and salinity measurements (Chassignet et al., 2009). The HYCOM predictions for drift currents are produced at a horizontal spatial resolution of approximately 8.25 km (1/12th of a degree) over the region, at a frequency of once per day. HYCOM uses isopycnal layers in the open, stratified ocean, but uses the layered continuity equation to make a dynamically smooth transition to a terrain-following coordinate in shallow coastal regions, and to z-level coordinates in the mixed layer and/or unstratified seas.

For this study, the HYCOM hindcast currents were obtained for the years 2010 to 2019 (inclusive). Figure 3.7 illustrates the spatial resolution of HYCOM currents.

Table 3.2 presents the average and maximum net current speeds from combined HYCOM and tidal currents nearby the Beehive-1 release location. Current speed and direction in the study area were shown to be dominated by the tides, flowing predominantly along the northwest to southeast axis. The monthly current speeds averaged between 0.33 to 0.40 m/s and reached a peak of 0.96 to 1.17 m/s.

Figure 3.8 and Figure 3.9 show the monthly and total current rose distributions resulting from the combination of HYCOM ocean current data and HYDROMAP tidal data nearby the release location.

Note the convention for defining current direction is the direction the current flows towards, which is used to reference current direction throughout this report. Each branch of the rose represents the currents flowing to that direction, with north to the top of the diagram. Sixteen directions are used. The branches are divided into segments of different colour, which represent the current speed ranges for each direction. Speed intervals of 0.1 m/s are predominantly used in these current roses. The length of each coloured segment is relative to the proportion of currents flowing within the corresponding speed and direction.

Table 3.2 Predicted monthly average and maximum surface current speeds nearby the Beehive-1 release location. The data was derived by combining the HYCOM ocean data and HYDROMAP tidal data from 2010–2019 (inclusive).

Season	Month	Average current speed (m/s)	Maximum current speed (m/s)	General direction (Towards)
Summer	January	0.35	1.10	Northwest and Southeast
	February	0.37	1.12	
Transitional	March	0.40	1.05	
Winter	April	0.39	1.06	
	May	0.35	1.17	
	June	0.34	1.07	
	July	0.35	0.96	
	August	0.37	1.15	
Transitional	September	0.39	1.10	
Summer	October	0.37	1.09	
	November	0.34	1.06	
	December	0.33	0.98	
Minimum		0.33	0.96	
Maximum		0.40	1.17	

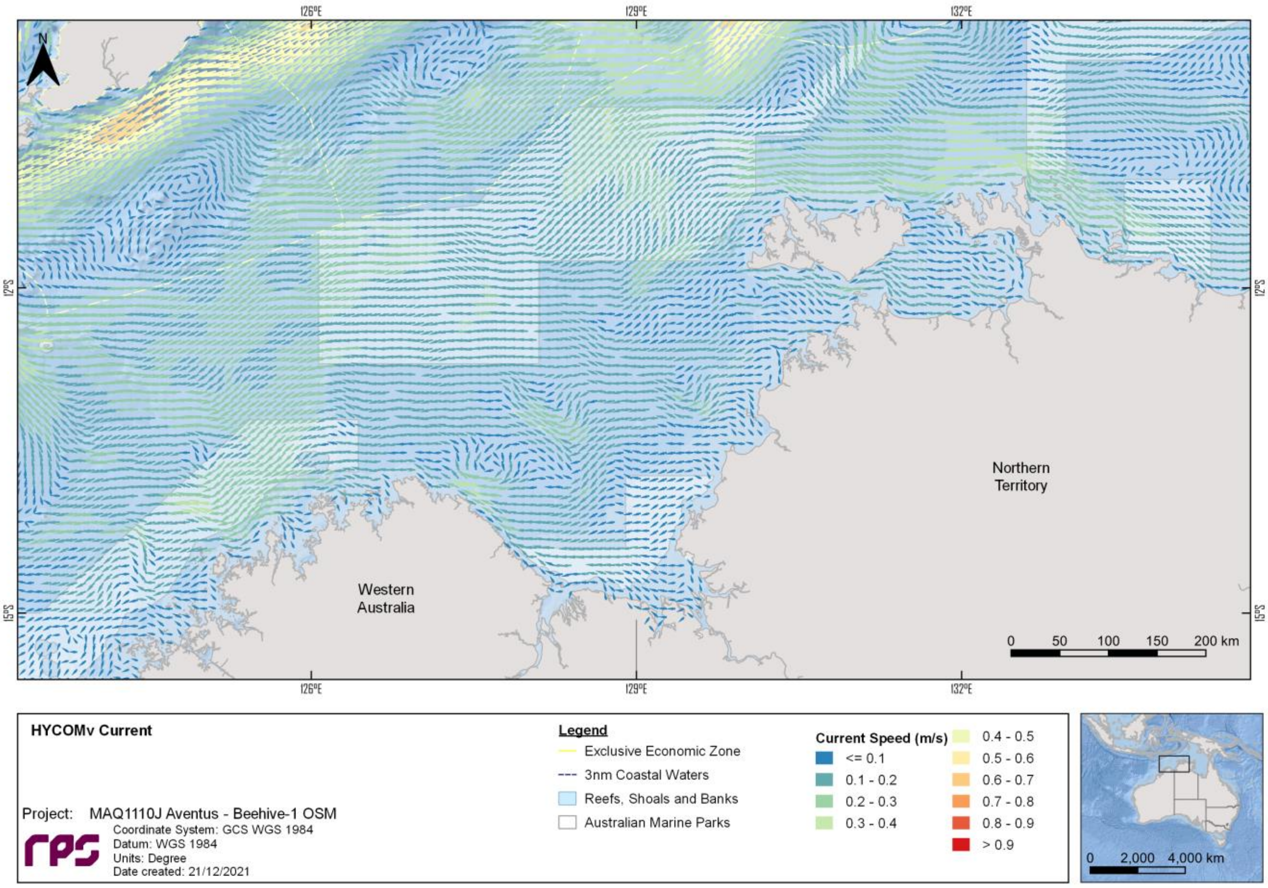
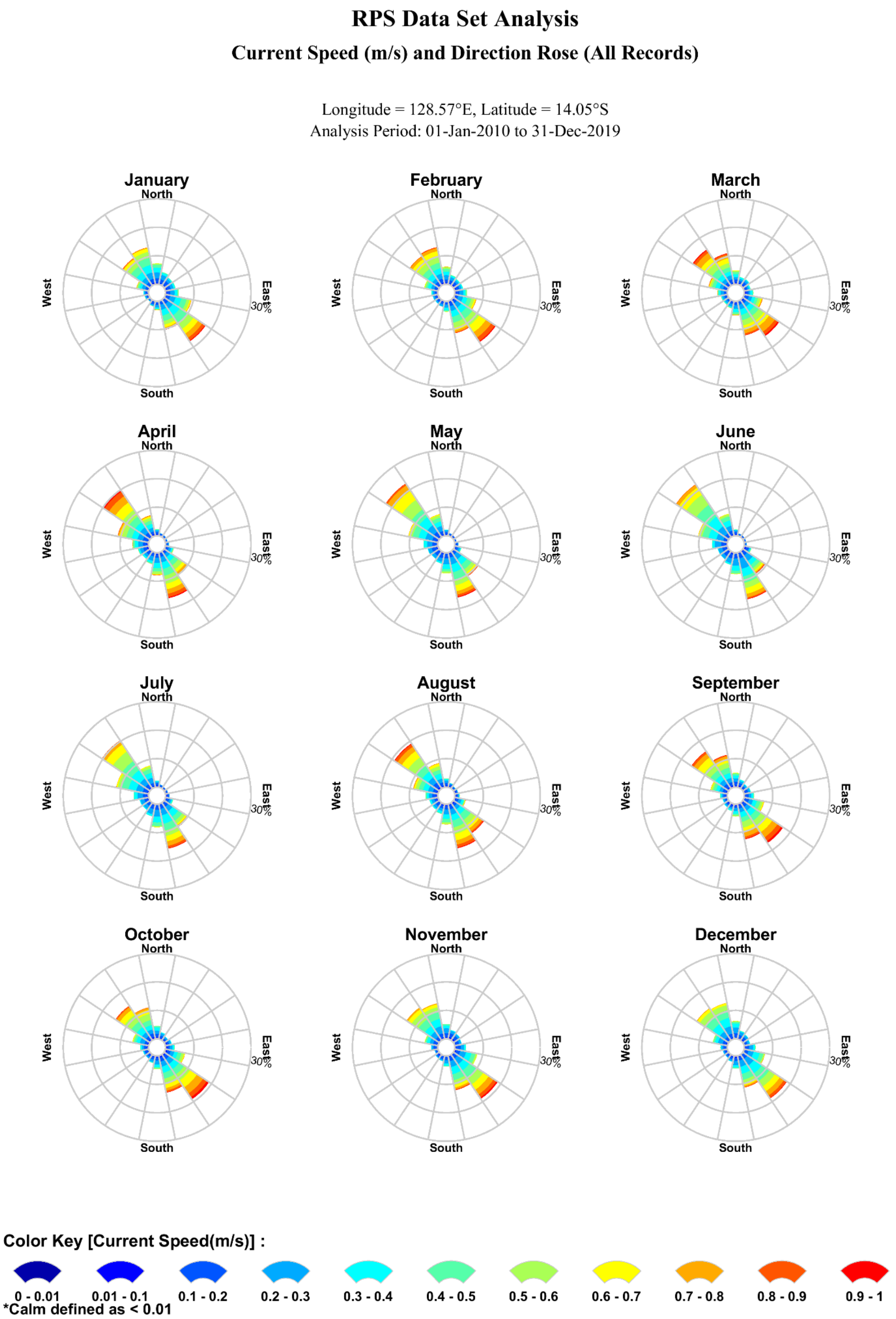


Figure 3.7 Map illustrating the spatial resolution of HYCOM currents.



RPS Data Set Analysis
Current Speed (m/s) and Direction Rose (All Records)
Longitude = 128.57°E, Latitude = 14.05°S
Analysis Period: 01-Jan-2010 to 31-Dec-2019
January
February
March
April
May
June
July
August
September
October
November
December
North
South
West
East
30%
Color Key [Current Speed(m/s)] :
0 - 0.01
0.01 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1
*Calm defined as < 0.01

Figure 3.8 Monthly surface current rose plots nearby the Beehive-1 release location (derived by combining the HYDROMAP tidal currents and HYCOM ocean currents for 2010–2019 (inclusive).

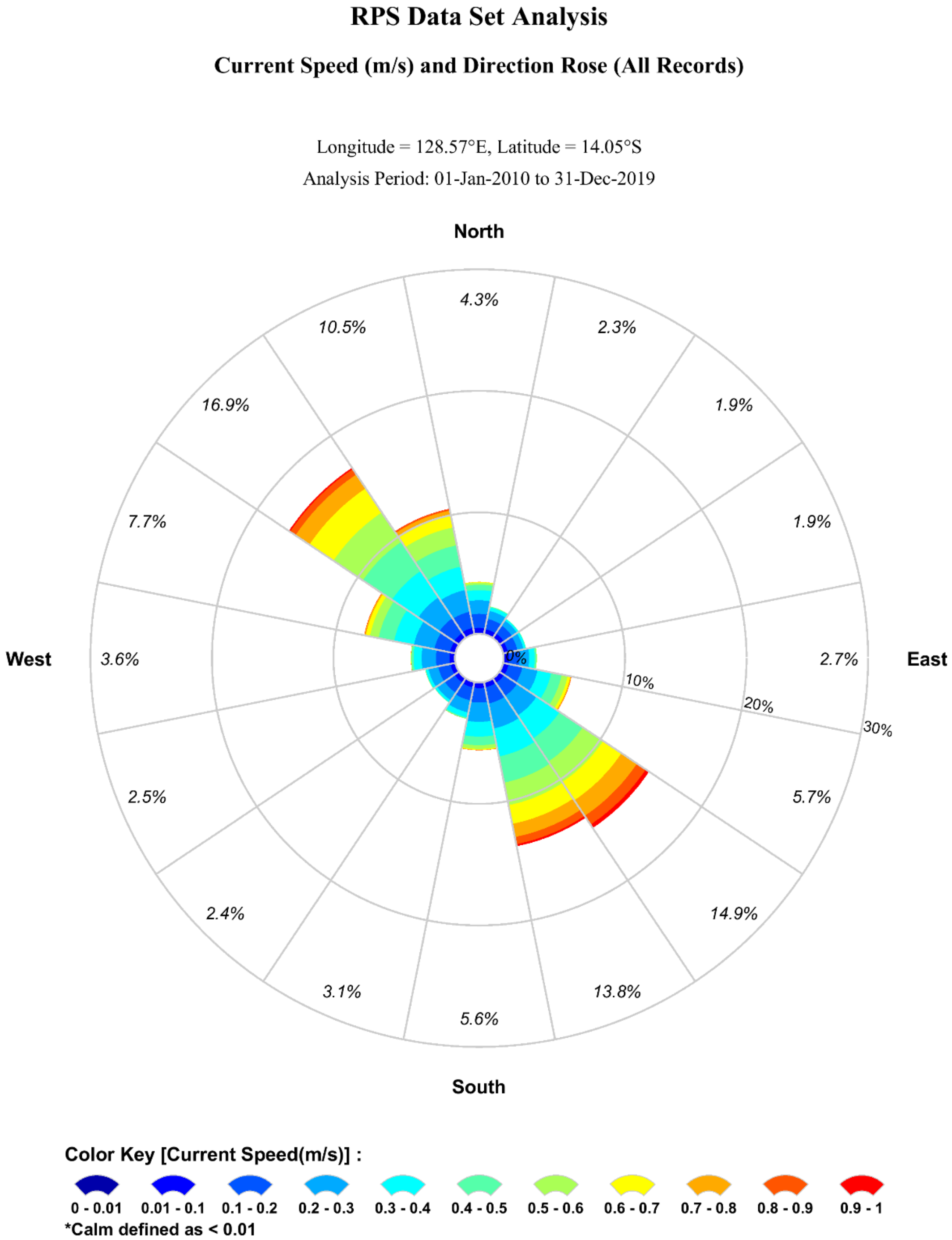


Figure 3.9 Modelled total surface current rose plot nearby the Beehive-1 release location (derived by combining the HYDROMAP tidal currents and HYCOM ocean currents for 2010–2019 (inclusive).

4 WIND DATA

High resolution wind data was sourced from the National Centre for Environmental Prediction (NCEP) Climate Forecast System Reanalysis dataset (CFSR; see Saha et al., 2010). The CFSR wind model is a fully coupled, data-assimilative hindcast model representing the interaction between the earth's oceans, land and atmosphere. The gridded wind data output is available at ¼ of a degree resolution (~33 km) and 1-hourly time intervals.

The CFSR wind data for the years 2010–2019 (inclusive) was extracted across the entire current model domain for input into the oil spill model. Figure 4.1 shows the spatial resolution of the wind field used as input into the oil spill model. Table 4.1 presents the monthly average and maximum winds derived from a CFSR wind node nearby the release location.

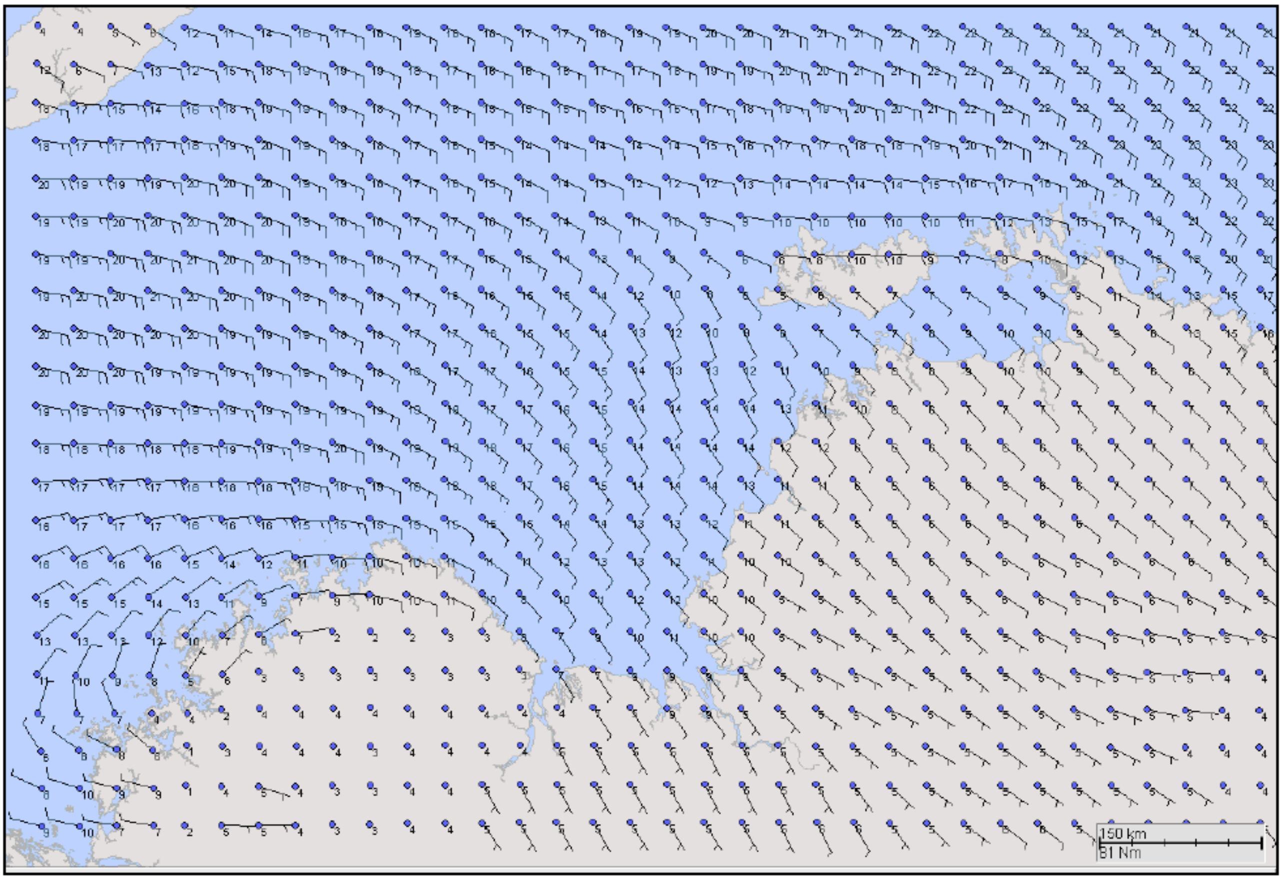


Figure 4.1 Spatial resolution of the CFSR modelled wind data used as input into the oil spill model.

Figure 4.2 and Figure 4.3 show the monthly and total wind rose distributions derived from the CFSR data for the nearest CFSR wind node to the release location. The wind data demonstrated a clear seasonality throughout the year with winds from the west-northwest in summer and southeast during the winter months. Monthly average wind speeds ranged between 8.7 and 14.1 knots whilst monthly maximums oscillated between 24.1 and 46.2 knots.

Note that the atmospheric convention for defining wind direction, that is, the direction the wind blows from, is used to reference wind direction throughout this report. Each branch of the rose represents wind coming from that direction, with north to the top of the diagram. Sixteen directions are used. The branches are divided into segments of different colour, which represent wind speed ranges from that direction. Speed ranges of 3 knots are predominantly used in these wind roses. The length of each segment within a branch is proportional to the frequency of winds blowing within the corresponding range of speeds from that direction.

Table 4.1 Predicted average and maximum winds for the nearest CFSR wind node to the Beehive-1 release location. Data derived from CFSR hindcast model from 2010–2019 (inclusive).

Season	Month	Average wind speed (knots)	Maximum wind speed (knots)	General direction (from)
Summer	January	13.2	44.9	West-Northwest
	February	11.4	35.2	
Transitional	March	9.7	46.2	Variable
Winter	April	9.3	32.7	Southeast
	May	11.7	28.8	
	June	14.1	27.4	
	July	12.3	30.9	
	August	10.4	29.5	
Transitional	September	8.7	29.3	Variable
Summer	October	8.8	24.7	West-Northwest
	November	8.8	24.1	
	December	9.9	35.9	
Minimum		8.7	24.1	
Maximum		14.1	46.2	

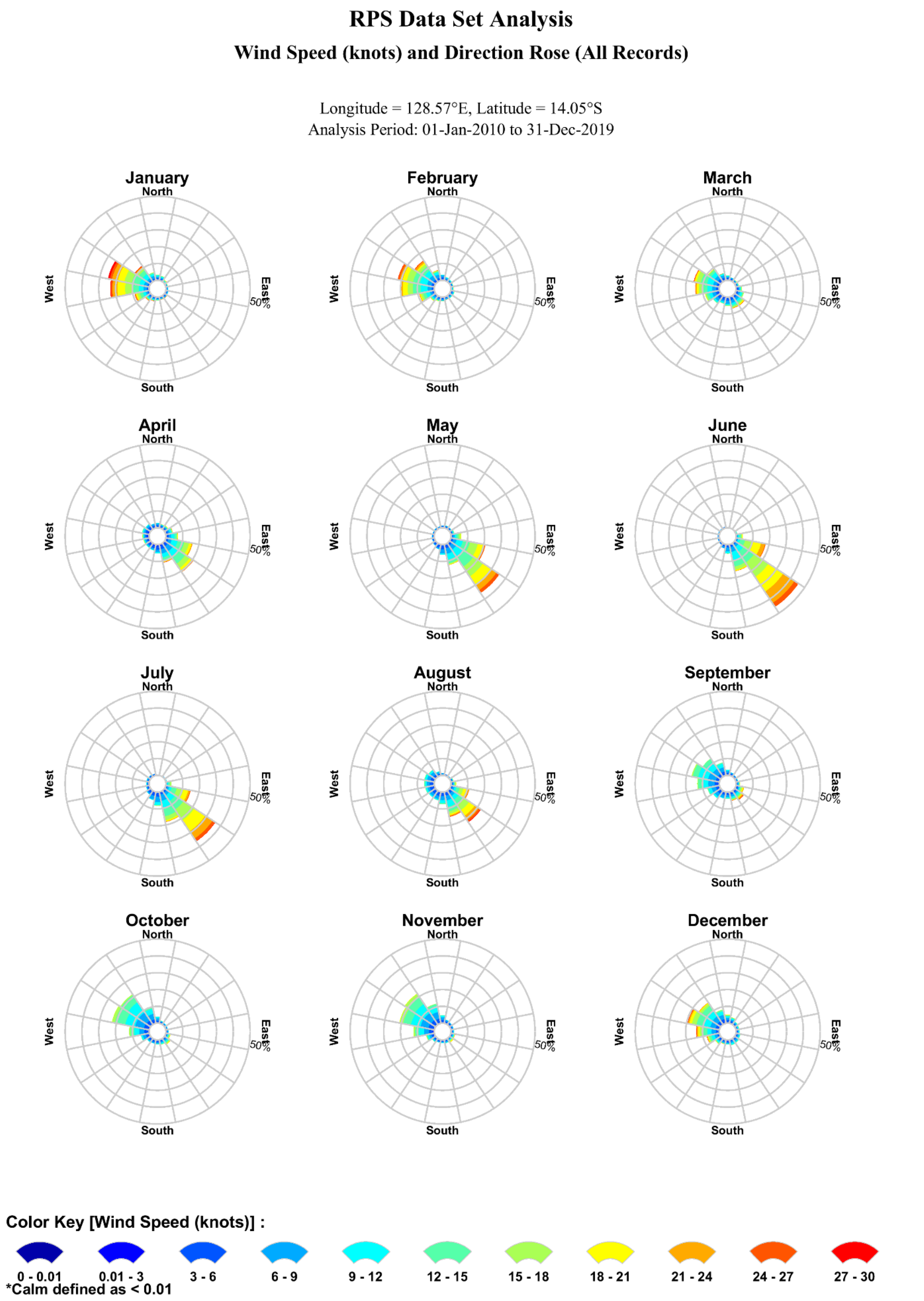


Figure 4.2 Modelled monthly wind rose distributions from 2010–2019 (inclusive), for the closest wind node to the Beehive-1 release location.

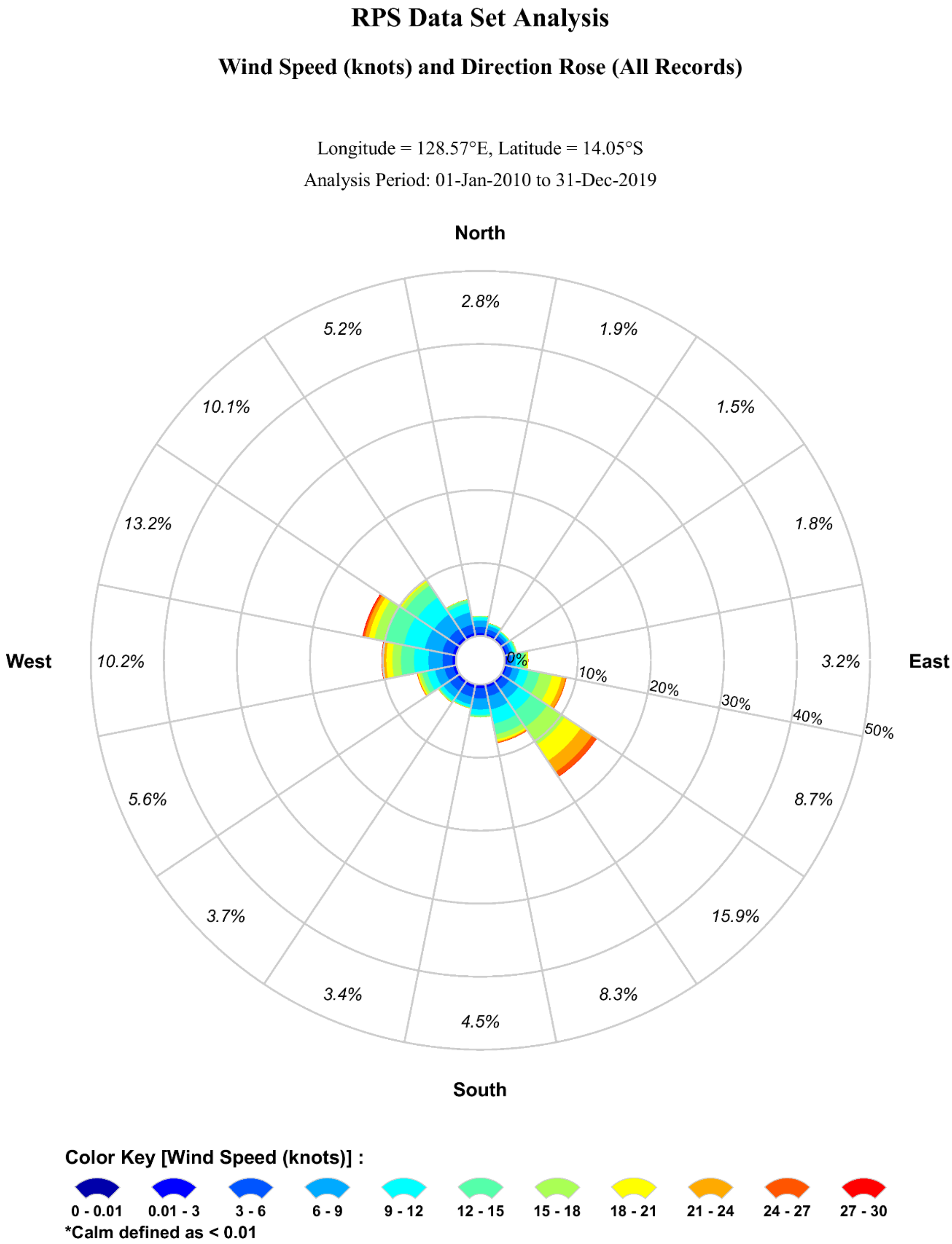


Figure 4.3 Modelled total wind rose distributions from 2010–2019 (inclusive), for the closest wind node to the Beehive-1 release location.

5 WATER TEMPERATURE AND SALINITY

The monthly sea temperature and salinity profiles of the water column within the study was obtained from the World Ocean Atlas 2013 database produced by the National Oceanographic Data Centre (National Oceanic and Atmospheric Administration) and its co-located World Data Center for Oceanography (see Levitus et al., 2013).

To account for depth-varying sea temperature and salinity the modelling used monthly average sea temperature and salinity profiles. Table 5.1 presents the sea temperature and salinity of the surface layer nearby the release sites.

The monthly average sea surface temperatures ranged between 25.9°C (July) and 30.9°C (March). The monthly average salinity values remain relatively consistent ranging between 33.4 psu and 35.2 psu, observed during April and October, respectively.

These parameters were used as factors to inform the weathering, movement and evaporative loss of hydrocarbon spills in the surface and sub-surface layers.

Figure 5.1 illustrates the vertical profile of sea temperature and salinity nearby the release location.

Table 5.1 Monthly average sea surface temperature and salinity in the study area.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (ºC)	29.5	30.1	30.9	29.6	28.0	26.8	25.9	26.4	26.8	28.6	30.1	30.0
Salinity (psu)	34.1	34.5	34.9	33.4	33.6	34.8	34.3	34.8	34.2	35.2	34.8	34.8

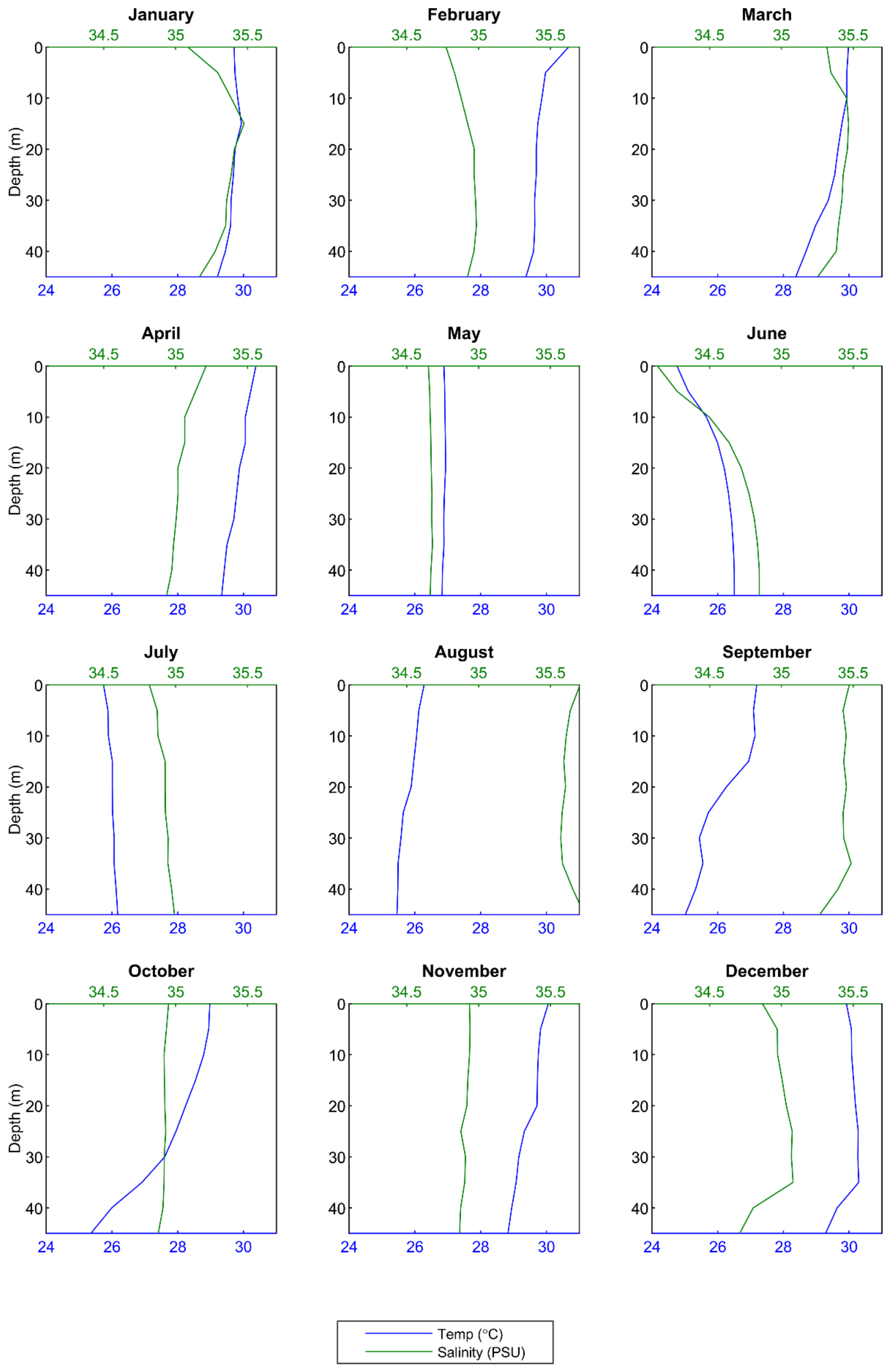


Figure 5.1 Temperature and salinity profiles nearby the Beehive-1 release location.

6 OIL SPILL MODEL – SIMAP

Modelling of the fate of oil was performed using the Spill Impact Mapping Analysis Program (SIMAP). SIMAP is designed to simulate the fate and effects of spilled hydrocarbons for both the surface and subsurface releases (Spaulding et al., 1994; French et al., 1999; French-McCay, 2003, 2004; French-McCay et al., 2004).

SIMAP has been used to predict the weathering and fate of oil spills during and after major incidents including: Montara (Australia) well blowout August 2009 in the Timor Sea (Asia-Pacific ASA, 2010); Macondo (USA) well blowout April 2010 in the Gulf of Mexico; Bohai Bay (China) oil spill August 2011; and the pipeline oil spill July 2013 in the Gulf of Thailand.

The SIMAP model calculates the transport, spreading, entrainment, evaporation and decay of surface hydrocarbon slicks as well as the entrained and dissolved oil components in the water column, either from surface slicks or from oil discharged subsea. The movement and weathering of the spilled oil is calculated for specific oil types. Input specifications for oil mixtures include the density, viscosity, pour point, distillation curve (volume lost versus temperature) and the aromatic/aliphatic component ratios within given boiling point ranges.

SIMAP is a three-dimensional model that allows for various response actions to be modelled including oil removal from skimming, burning, or collection booms, and surface and subsurface dispersant application.

The SIMAP oil spill model includes advanced weathering algorithms, specifically focussed on unique oils that tend to form emulsions and/or tar balls. The weathering algorithms are based on 5 years of extensive research conducted in response to the Deepwater Horizon oil spill in the Gulf of Mexico (French-McCay et al., 2015).

Biodegradation is included in the oil spill model. In the model, SIMAP, degradation is calculated for the surface slick, deposited oil on the shore, the entrained oil and dissolved constituents in the water column, and oil in the sediments. For surface oil, water column oil and sedimented oil, a first order degradation rate is specified. Biodegradation rates are relatively high for hydrocarbons in dissolved state or in dispersed small droplets.

6.1 Stochastic Modelling

Stochastic oil spill modelling is created by overlaying a great number (often 100 hundred) simulated hypothetical oil spills (Section 1.2.1). Stochastic modelling involves running numerous individual oil spill simulations using a range of prevailing wind and current conditions that are historically representative of the season and location of where the spill event may occur.

For the stochastic modelling undertaken in this study, 100 oil spills were modelled per season (300 spills in total) using the same spill information (spill volume, duration and oil type) but with varied start dates and times. During each simulation, the model records whether any grid cells are exposed to any oil concentrations, the concentrations involved and the elapsed time before exposure. The results of all 100 oil spill simulations (per season) were analysed to determine the following annualised statistics for every grid cell:

- Exposure load (concentrations and volumes);
- Minimum time before exposure;
- Probability of contact above defined concentrations;
- Volume of oil that may strand on shorelines from any single simulation;

- Concentration that might occur on sections of individual shorelines;
- Exposure (instantaneous and/or over a specified duration) to dissolved hydrocarbons in the water column; and
- Exposure (instantaneous and/or over a specified duration) to entrained hydrocarbons in the water column.

6.1 Floating, Shoreline and In-Water Thresholds

The thresholds and their relationship to exposure for the sea surface, shoreline, and water column (entrained and dissolved hydrocarbons) are presented in Sections 6.1.1 to 6.1.3. Supporting justifications of the adopted thresholds applied during the study and additional context relating to the area of influence are also provided. It is important to note that the thresholds herein are based on NOPSEMA (2019).

6.1.1 Floating Oil Exposure Thresholds

The modelling results can be presented to any levels; therefore, thresholds have been specified (based on scientific literature) to record floating oil exposure to the sea-surface at meaningful levels only, described in the following paragraphs.

The low threshold to assess the potential for floating oil exposure, was 1 g/m^2, which equates approximately to an average thickness of 1 µm, referred to as visible oil. Oil of this thickness is described as rainbow sheen in appearance, according to the Bonn Agreement Oil Appearance Code (Bonn Agreement, 2009; AMSA, 2014) (see Table 6.1). Figure 6.1 shows photographs highlighting the difference in appearance between a silvery sheen, rainbow sheen and metallic sheen. This threshold is considered below levels which would cause environmental harm and it is more indicative of the areas perceived to be affected due to its visibility on the sea surface and potential to trigger temporary closures of areas (i.e., fishing grounds) as a precautionary measure. Table 6.1 provides a description of the appearance in relation to exposure zone thresholds used to classify the zones of floating oil exposure.

Ecological impact has been estimated to occur at 10 g/m^2 (a film thickness of approximately 10 µm or 0.01 mm) according to French et al. (1996) and French-McCay (2009) as this level of fresh oiling has been observed to mortally impact some birds through adhesion of oil to their feathers, exposing them to secondary effects such as hypothermia. The appearance of oil at this average thickness has been described as a metallic sheen (Bonn Agreement, 2009). Concentrations above 10 g/m^2 is also considered the lower actionable threshold, where oil may be thick enough for containment and recovery as well as dispersant treatment (AMSA, 2015).

Scholten et al. (1996) and Koops et al. (2004) indicated that at oil concentrations on the sea surface of 25 g/m^2 (or greater), would be harmful for all birds that have landed in an oil film due to potential contamination of their feathers, with secondary effects such as loss of temperature regulation and ingestion of oil through preening. The appearance of oil at this thickness is also described as metallic sheen (Bonn Agreement, 2009). For this study the high exposure threshold was set to 50 g/m^2 and above based on NOPSEMA (2019). This threshold can also be used to inform response planning.

Table 6.2 defines the thresholds used to classify the zones of floating oil exposure reported herein.

Table 6.1 The Bonn Agreement Oil Appearance Code.

Code	Description Appearance	Layer Thickness Interval (g/m^2 or µm)	Litres per km^2
1	Sheen (silvery/grey)	0.04 - 0.30	40 - 300
2	Rainbow	0.30 – 5.0	300 – 5,000
3	Metallic	5.0 – 50	5,000 – 50,000
4	Discontinuous True Oil Colour	50 – 200	50,000 – 200,000
5	Continuous True Oil Colour	≥ 200	≥ 200,000

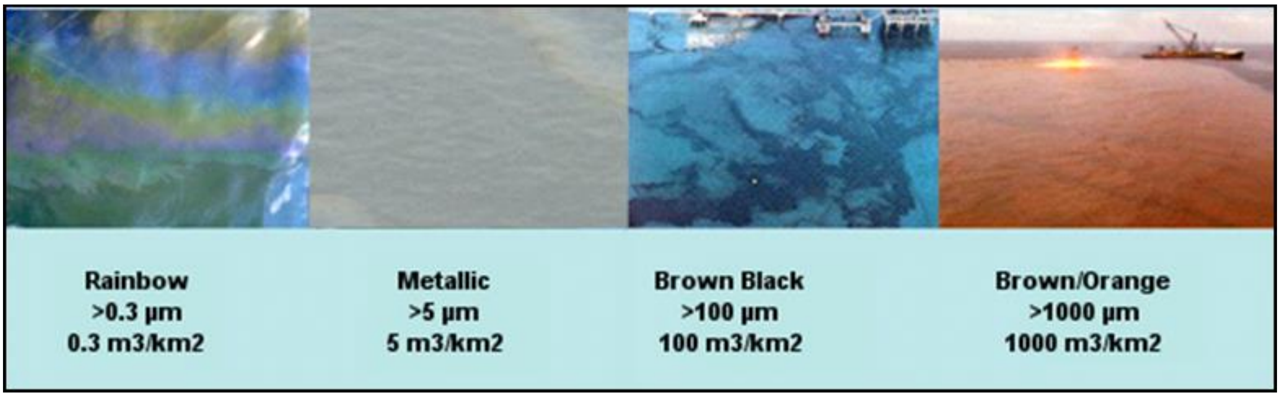


Figure 6.1 Photographs showing the difference between oil colour and thickness on the sea surface (source: adapted from Oilspillsolutions.org, 2015).

Table 6.2 Floating oil exposure thresholds used in this report (in alignment with NOPSEMA (2019)).

Threshold level	Floating oil (g/m^2)	Description
Low	1	Approximates range of socio-economic effects and establishes planning area for scientific monitoring
Moderate	10	Approximates lower limit for harmful exposures to birds and marine mammals
High	50*	Approximates surface oil slick and informs response planning

* 50 g/m^2 also used to define the threshold for actionable floating oil.

6.1.2 Shoreline Accumulation Thresholds

There are many different types of shorelines, ranging from cliffs, rocky beaches, sandy beaches, mud flats and mangroves, and each of these influences the volume of oil that can remain stranded ashore and its thickness before the shoreline saturation point occurs. For instance, a sandy beach may allow oil to percolate through the sand, thus increasing its ability to hold more oil ashore over tidal cycles and various wave actions than an equivalent area of water; hence oil can increase in thickness onshore over time. A rocky shoreline was assumed as the default shoreline type for the modelling in this study, as a large part of the shoreline in the study area (especially the western part of the Joseph Bonaparte Gulf) is characterised by exposed rocky shorelines.

In previous risk assessment studies, French-McCay et al. (2005a; 2005b) used a threshold of 10 g/m2 to assess the potential for shoreline accumulation. This is a conservative threshold used to define regions of socio-economic impact, such as triggering temporary closures of adjoining fisheries or the need for shore clean-up on beaches or man-made features/amenities (breakwaters, jetties, marinas, etc.). It would equate to approximately 2 teaspoons of hydrocarbon per square meter of shoreline accumulation. The appearance is described as a stain/film. On that basis, the 10 g/m^2 shoreline accumulation threshold has been selected to define the zone of potential “low shoreline accumulation”.

French et al. (1996) and French-McCay (2009) define a shoreline oil accumulation threshold of 100 g/m2, or above, would potentially harm shorebirds and wildlife (fur-bearing aquatic mammals and marine reptiles on or along the shore) based on studies for sub-lethal and lethal impacts. This threshold has been used in previous environmental risk assessment studies (see French-McCay, 2003; French-McCay et al., 2004, French-McCay et al., 2011; 2012; NOAA, 2013). Additionally, a shoreline concentration of 100 g/m^2, or above, is the minimum concentration that the oil can be effectively cleaned according to AMSA (2015). This threshold equates to approximately ½ a cup of oil per square meter of shoreline accumulation. The appearance is described as a thin oil coat. Therefore, 100 g/m^2 has been selected to define the zone of potential “moderate shoreline accumulation”.

Observations by Lin & Mendelssohn (1996), demonstrated that loadings of more than 1,000 g/m^2 of hydrocarbon during the growing season would be required to impact marsh plants significantly. Similar thresholds have been found in studies assessing hydrocarbon impacts on mangroves (Grant et al., 1993; Suprayogi & Murray, 1999). Hence, 1,000 g/m^2 has been selected to define the zone of potential “high shoreline accumulation”. It equates to approximately 1 litre of hydrocarbon per square meter of shoreline accumulation. The appearance is described as a hydrocarbon cover.

These shoreline accumulation thresholds derived from extensive literature review (outlined in Table 6.3) align with the commonly used threshold values for oil spill modelling specified in NOPSEMA (2019).

Table 6.3 Thresholds used to assess shoreline accumulation.

Threshold level	Shoreline concentration (g/m^2)	Description
Low (socio-economic/sublethal)	10	Predicts potential for some socio-economic impact
Moderate	100*	Loading predicts area likely to require clean-up effort
High	> 1,000	Loading predicts area likely to require intensive clean-up effort

* 100 g/m2 also used to define the threshold for actionable shoreline oil.

6.1.3 In-water Exposure Thresholds

Oil is a mixture of thousands of hydrocarbons of varying physical, chemical, and toxicological characteristics, and therefore, demonstrate varying fates and impacts on organisms. As such, for in-water exposure, the SIMAP model provides separate outputs for dissolved and entrained hydrocarbons from oil droplets. The consequences of exposure to dissolved and entrained components will differ because they have different modes and magnitudes of effect.

Entrained hydrocarbon concentrations were calculated based on oil droplets that are suspended in the water column, though not dissolved. The composition of this oil would vary with the state of weathering (oil age) and may contain soluble hydrocarbons when the oil is fresh. Calculations for dissolved hydrocarbons specifically calculates oil components which are dissolved in water, which are known to be the primary source of toxicity exerted by oil.

6.1.3.1 Dissolved Hydrocarbons

Laboratory studies have shown that dissolved hydrocarbons exert most of the toxic effects of oil on aquatic biota (Carls et al., 2008; Nordtug et al., 2011; Redman, 2015). The mode of action is a narcotic effect, which is positively related to the concentration of soluble hydrocarbons in the body tissues of organisms (French-McCay, 2002). Dissolved hydrocarbons are taken up by organisms directly from the water column by absorption through external surfaces and gills, as well as through the digestive tract. Thus, soluble hydrocarbons are termed “bioavailable”.

Hydrocarbon compounds vary in water-solubility and the toxicity exerted by individual compounds is inversely related to solubility, however bioavailability will be modified by the volatility of individual compounds (Nirmalakhandan & Speece, 1988; Blum & Speece, 1990; McCarty, 1986; McCarty et al., 1992a, 1992b; Mackay et al., 1992; McCarty & Mackay, 1993; Verhaar et al., 1992, 1999; Swartz et al., 1995; French-McCay, 2002; McGrath and Di Toro, 2009). Of the soluble compounds, the greatest contributor to toxicity for water-column and benthic organisms are the lower-molecular-weight aromatic compounds, which are both volatile and soluble in water. Although they are not the most water-soluble hydrocarbons within most oil types, the polynuclear aromatic hydrocarbons (PAHs) containing 2-3 aromatic ring structures typically exert the largest narcotic effects because they are semi-soluble and not highly volatile, so they persist in the environment long enough for significant accumulation to occur (Anderson et al., 1974, 1987; Neff & Anderson, 1981; Malins & Hodgins, 1981; McAuliffe, 1987; NRC, 2003). The monoaromatic hydrocarbons (MAHs), including the BTEX compounds (benzene, toluene, ethylbenzene, and xylenes), and the soluble alkanes (straight chain hydrocarbons) also contribute to toxicity, but these compounds are highly volatile, so that their contribution will be low when oil is exposed to evaporation and higher when oil is discharged at depth where volatilisation does not occur (French-McCay, 2002).

French-McCay (2002) reviewed available toxicity data, where marine biota was exposed to dissolved hydrocarbons prepared from oil mixtures, finding that 95% of species and life stages exhibited 50% population mortality (LC_{50}) between 6 and 400 ppb total PAH concentration after 96 hrs exposure, with an average of 50 ppb. Hence, concentrations lower than 6 ppb total PAH value should be protective of 97.5% of species and life stages even with exposure periods of days (at least 96 hours). Early life-history stages of fish appear to be more sensitive than older fish stages and invertebrates.

Exceedances of 10, 50 or 400 ppb over a 1 hour timestep (see Table 6.4) were applied in this study to indicate the increasing potential for sub-lethal to lethal toxic effects (or low to high), based on NOPSEMA (2019).

6.1.3.2 Entrained Hydrocarbons

Entrained hydrocarbons consist of oil droplets that are suspended in the water column and insoluble. Insoluble compounds in oil cannot be absorbed from the water column by aquatic organisms, therefore they are not bioavailable through absorption of compounds from the water. Exposure to these compounds would require routes of uptake other than absorption of soluble compounds. The route of exposure of organisms to whole oil alone include direct contact with tissues of organisms and uptake of oil by direct consumption, with potential for biomagnification through the food chain (NRC, 2005).

The 10 ppb threshold represents the very lowest concentration and corresponds generally with the lowest trigger levels for chronic exposure for entrained hydrocarbons in the ANZECC (2000) water quality guidelines. Due to the requirement for relatively long exposure times (> 24 hours) for these concentrations to be expressed, they are likely to be more meaningful for juvenile fish, larvae and planktonic organisms that might be entrained (or otherwise moving) within the entrained plumes, or when entrained hydrocarbons adhere to organisms or trapped against a shoreline for periods of several days or more.

This exposure zone is not considered to be of significant biological impact and is therefore outside the adverse exposure zone. This exposure zone represents the area contacted by the spill. This area does not define the area of influence as it is considered that the environment will not be affected by the entrained hydrocarbon at this level.

Thresholds of 10 ppb and 100 ppb were applied over a 1 hour time exposure (Table 6.4), to cover the range of thresholds outlined in ANZECC, (2000) water quality guidelines, the incremental change for greater potential effect and is per NOPSEMA (2019).

A complicating factor that should be considered when assessing the consequence of dissolved and entrained oil distributions is that there will be some areas where both physically entrained oil droplets and dissolved hydrocarbons co-exist. Higher concentrations of each will tend to occur close to the source where sea conditions can force mixing of relatively unweathered oil into the water column, resulting in more rapid dissolution of soluble compounds.

Table 6.4 Dissolved and entrained hydrocarbon exposure values assessed over a 1-hour time step, as per NOPSEMA (2019).

Threshold level	Dissolved hydrocarbon concentration (ppb)	Entrained hydrocarbon concentrations (ppb)
Low	10	10
Moderate	50	-
High	400	100

7 OIL PROPERTIES

7.1 Oil Characteristics

7.1.1 Overview

Table 7.1 and Table 7.2 present the physical properties and boiling point ranges analogue crude oil used in this study. The analogue crude oil was carefully selected based on EOG recommendations to represent the crude oil likely to be found within permit area WA-488-P, which is likely to have an API gravity of 43° (light crude). EOG narrowed down oils in the region with a similar API to be Jabiru, Puffin, Mutineer-Exeter and Legendre crudes, all of which have APIs between 42 and 44. Based on having an API closest to that expected at Beehive-1, together with being the most conservative in terms of the residual components, EOG elected to use Jabiru crude as the analogue for spill modelling purposes.

Table 7.1 Physical properties of the oil types used in this study.

Characteristic	Crude Oil
Density (kg/m^3)	813.9 (at 15°C)
API	42.3
Dynamic viscosity (cP)	3.0 (at 20°C)
Pour point (°C)	18
Hydrocarbon property category	Group II
Hydrocarbon property classification	Light-persistent

Table 7.2 Boiling point ranges of the oil types used in this study.

Oil Type	Component	Volatile (%)	Semi-volatile (%)	Low-volatility (%)	Residual (%)
	Boiling point (°C)	<180 C_4 to C_{10}	180-160 C_{11} to C_{15}	160-380 C_{16} to C_{20}	>380 >C_{20}
Jabiru crude oil	% of total	24.2	20.9	33.9	21.0

The boiling points (BP) are dictated by the length of the carbon chains, with the longer and more complex compounds having a higher boiling point, and therefore lower volatility and evaporation rate.

The aromatic components within the volatile to low-volatility range are also soluble (with decreasing solubility following decreasing volatility) and will dissolve across the oil-water interface. The rate of dissolution will increase with increased surface area. Hence, dissolution rates will be higher under discharge conditions that generate smaller oil droplets.

Atmospheric weathering will commence if and when oil droplets float to the water surface. Typical evaporation times once the hydrocarbons reach the surface and are exposed to the atmosphere are:

- Up to 12 hours for the C_4 to C_{10} compounds (or less than 180°C BP).
- Up to 24 hours for the C_{11} to C_{15} compounds (180-160°C BP).
- Several days for the C_{16} to C_{20} compounds (160-380°C BP).

- Not applicable for the residual compounds (BP > 380°C), which will resist evaporation, persist in the marine environment for longer periods, and be subject to relatively slow degradation.

The actual fate of released oil in the marine environment will depend greatly on the amount of oil that reaches the surface, either through the initial release or by rising after discharge in the water column.

7.1.2 Crude Oil

The analogue crude oil has an API of 42.3 and a density of 813.9 kg/m^3 (at 15ºC) with a viscosity value (3.0 cP) classifying it as a Group II (light-persistent) oil according to the International Tankers Owners Pollution Federation (ITOPF, 2014) and US EPA/USCG classifications.

The crude is a mixture of volatile (79%) and persistent hydrocarbons (21%). In favourable evaporation conditions, about 24.2% of the oil mass should evaporate within the first 12 hours (BP < 180 °C); a further 20.8% should evaporate within the first 24 hours (180 °C < BP < 160 °C); and a further 33.9% should evaporate over several days (160 °C < BP < 380 °C). Approximately 21.0% of the oil is shown to be persistent.

7.2 Weathering Characteristics

7.2.1 Overview

A series of model weather tests were conducted to illustrate the potential behaviour of the Jabiru crude oil when exposed to idealised and representative environmental conditions:

- A 1-hour release onto the water surface at a discharge rate of 25 m^3/hr under calm wind conditions (constant 5 knots), assuming low seasonal water temperature (25 °C) and average air temperature (29 °C). The slick was also subject to ambient tidal and drift currents.

- A 1-hour release onto the water surface at a discharge rate of 50 m^3/hr under variable wind conditions (1-12 knots, drawn from representative data files), assuming low seasonal water temperature (25 °C) and average air temperature (29 °C). The slick was also subject to ambient tidal and drift currents.

The first case is indicative of cumulative weathering rates under calm conditions that would not generate entrainment, while the second case may represent conditions that could cause a minor degree of entrainment. Both scenarios provide examples of potential behaviour during periods of a spill event once the oil reaches the surface.

7.2.2 Crude Oil Mass Balance Forecasts

The mass balance forecast for the constant-wind case (Figure 7.1) shows that 45.3% of the oil is predicted to evaporate within 24 hours. Under calm conditions, the majority of the remaining oil on the water surface will weather at a slower rate due to being comprised of the longer-chain compounds with higher boiling points. Evaporation of the residual compounds will slow significantly, and they will then be subject to more gradual decay through biological and photochemical processes.

Under the variable-wind case (Figure 7.2), where the winds are of greater strength on average, entrainment of the crude oil into the water column is predicted to increase. Approximately 24 hours after the spill, 54.1% of the oil mass is forecast to have entrained and a further 42.8% is forecast to have evaporated, leaving only a small proportion of the oil floating on the water surface (<1%). The residual compounds will tend to remain entrained beneath the surface under conditions that generate wind waves (approximately >6 m/s).

The increased level of entrainment in the variable-wind case will result in a higher percentage of biological and photochemical degradation, where the decay of the floating slicks and oil droplets in the water column occurs at an approximate rate of ~1.3% per day with an accumulated total of ~9.1% after 7 days, in comparison to a rate of ~0.3% per day and an accumulated total of ~2.4% after 7 days in the constant-wind case. Given the proportion of entrained oil and the tendency for it to remain mixed in the water column, the remaining hydrocarbons will decay over several weeks.

Table 7.3 illustrates the summary of the mass balance for the calm wind and variable wind case at day 7.

Table 7.3 Summary of the mass balance at day 7. Results are based on a 25 m^3 surface release of crude oil over 1 hour, tracked for 7 days under calm and variable wind conditions.

End of the simulation (day 7)		
Exposure Metrics	**Calm wind conditions**	**Variable wind conditions**
Surface/Floating Oil (%)	44.4	0.0
Ashore/Shoreline (%)	0.0	0.0
Entrained (%)	3.6	44.5
Evaporated (%)	49.2	44.2
Decay (%)	2.4	9.1

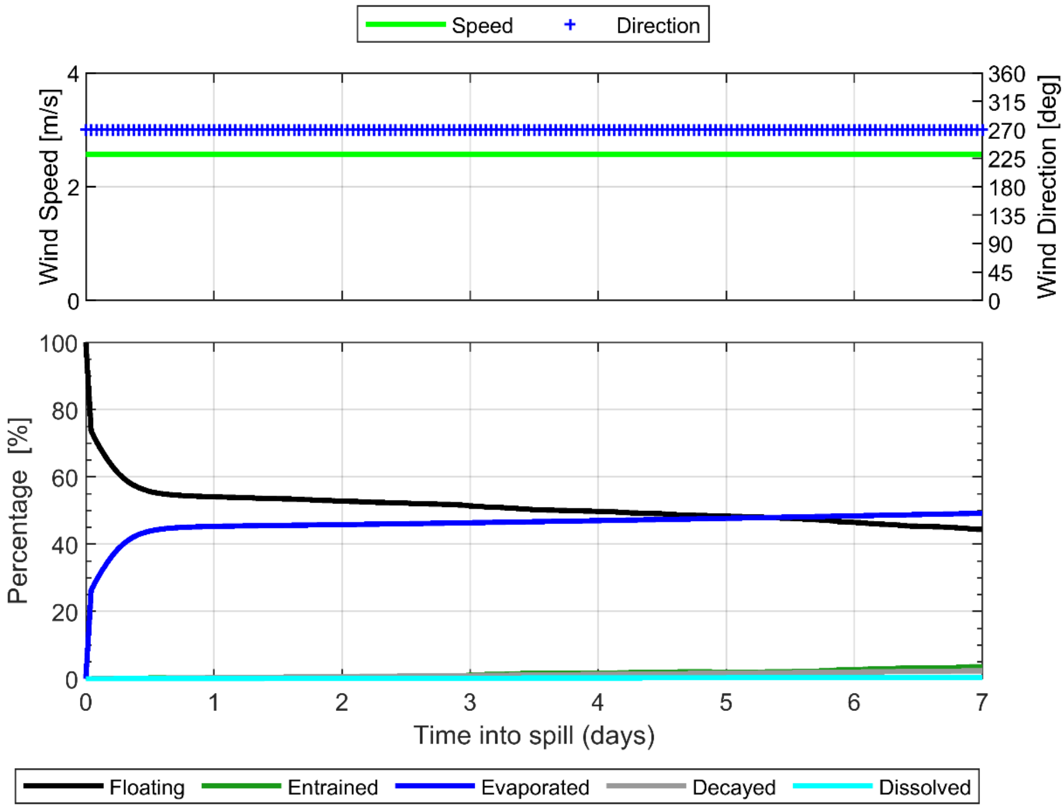


Figure 7.1 Proportional mass balance plot representing the weathering of crude oil spilled onto the water surface over 1 hour and subject to a constant 5 knots (2.6 m/s) wind speed at 25°C water temperature and 29 °C air temperature.

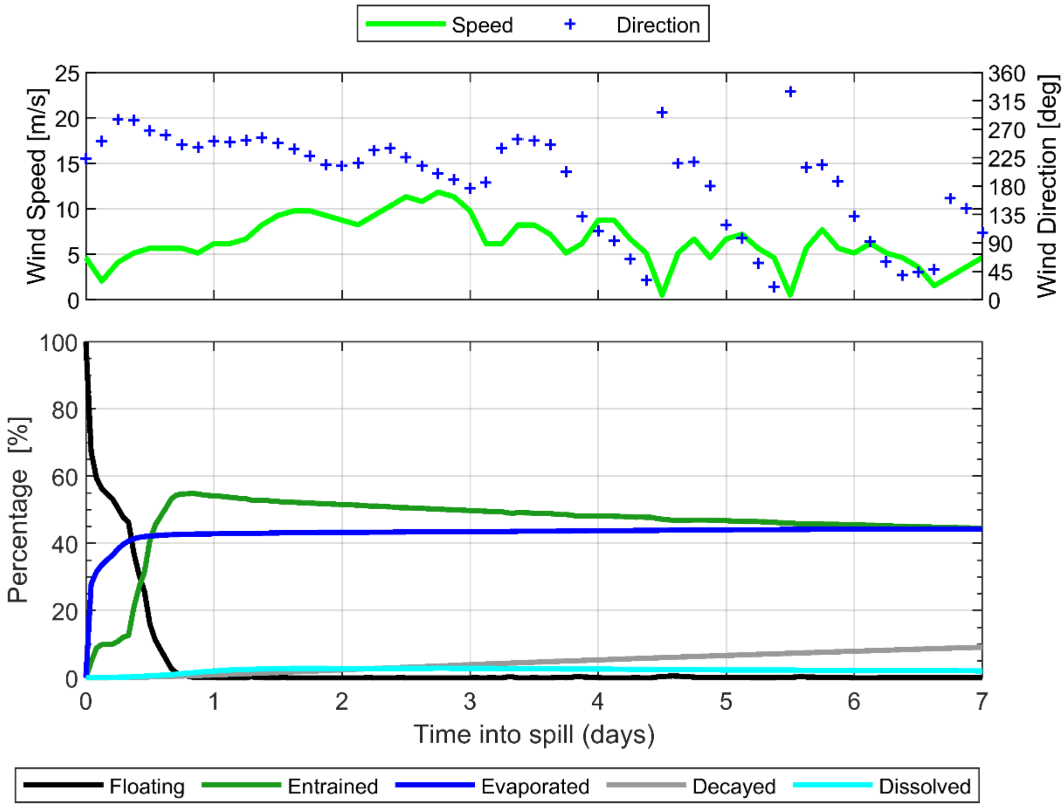


Figure 7.2 Proportional mass balance plot representing the weathering of crude oil spilled onto the water over 1 hour and subject to variable wind speeds (1-12 knots) at 25°C water temperature and 29 °C air temperature.

8 MODEL SETTINGS

Table 8.1 provides a summary of the oil spill model settings for the scenario.

Each season uses the same 100 random spill locations.

Table 8.1 Summary of the oil spill model settings used in this assessment.

Parameter	Scenario
Description	LOWC
Number of randomly selected spill start times per season for each scenario	100 (300 in total)
Release location	Single location at the Beehive-1 exploration well
Model period	Summer (October to February) Transitional (March and September) Winter (April to August)
Oil type	Crude oil
Spill volume	786,858 m^3 (4,949,192 bbl)
Release type	Surface
Release duration	77 days
Simulation length (days)	98
Surface oil concentration thresholds (g/m^2) (NOPSEMA Thresholds)	1, potential low exposure 10, potential moderate exposure 50, potential high exposure
Shoreline load thresholds (g/m^2) (NOPSEMA Thresholds)	10, potential low exposure 100, potential moderate exposure 1,000, potential high exposure
Dissolved hydrocarbon concentrations (ppb) (NOPSEMA Thresholds)	10, potential low exposure 50, potential moderate exposure 400, potential high exposure
Entrained hydrocarbon concentrations (ppb) (NOPSEMA Thresholds)	10, potential low exposure 100, potential high exposure

9 PRESENTATION AND INTERPRETION OF MODEL RESULTS

The results from the modelling study are presented in a number of tables and figures, which aim to provide an understanding of the predicted sea-surface and water column (subsurface) exposure and shoreline accumulation (if predicted).

9.1 Annual Analysis

9.1.1 Statistics

The statistics are based on the following principles:

- The greatest distance travelled by a spill trajectory – is determined by a) recording the maximum and b) second greatest distance travelled (or 99th percentile) by a single trajectory, within a scenario, from the release location to the identified exposure thresholds.
- The probability of oil exposure to a receptor – is determined by recording the number of spill trajectories to reach a specified sea surface or subsea threshold within a receptor polygon, divided by the total number of spill trajectories within that scenario.
- The minimum time before oil exposure to a receptor – is determined by ranking the elapsed time before sea surface exposure, at a specified threshold, to grid cells within a receptor polygon and recording the minimum value.
- The probability of oil accumulation at a receptor – is determined by recording the number of spill trajectories to reach a specified shoreline accumulation threshold within a receptor polygon, divided by the total number of spill trajectories within that scenario.
- The maximum potential oil loading within a receptor – is determined by identifying the maximum loading to any grid cell within a receptor polygon, for a scenario.
- The dissolved and entrained hydrocarbon exposure – is determined by recording the maximum instantaneous concentrations at each grid cell by applying a 96-hour time-based averaging.

9.2 Deterministic Trajectories

The seasonal stochastic modelling results were assessed for each scenario, and the “worst case” deterministic runs were identified and are presented in the result section based on the following criteria:

a. Largest swept area of floating oil above 1 g/m^2 (visible floating oil);

b. Minimum time before shoreline accumulation above 10 g/m^2;

c. Largest volume of oil ashore;

d. Longest length of shoreline accumulation above 10 g/m^2;

e. Largest area of entrained hydrocarbons above 10 ppb; and

f. Largest area of dissolved hydrocarbons above 10 ppb.

When no shoreline accumulation above the lowest shoreline accumulation threshold was predicted for any of the seasons modelled, only the largest swept area of floating oil, the largest area of entrained hydrocarbons and the largest area of dissolved hydrocarbons is presented.

9.2.1 Receptors Assessed

A range of environmental receptors and shorelines were assessed for sea surface exposure, shoreline contact and water column exposure as part of the study (see Figure 9.1 to Figure 9.7). Receptor categories (see Table 9.1) include sections of shorelines and offshore islands. All other sensitive receptors other than submerged reefs, shoals and banks (RSB) were sourced from Australian Government Department of Agriculture, Water and the Environment (http://www.environment.gov.au/). Risks of exposure were separately calculated for each sensitive receptor area and have been tabulated.

Table 9.1 Summary of receptors used to assess floating oil, shoreline and in-water exposure to hydrocarbons.

Receptor Category	Acronym	Hydrocarbon Exposure Assessment		
		Water Column	Floating oil	Shoreline
Australian Marine Park	AMP	✓	✓	×
Marine Park	MP	✓	✓	×
National Marine Reserves	MNP	✓	✓	×
Nature Reserve	NR	✓	✓	×
Key Ecological Feature	KEF	✓	✓	×
Shoreline	Shoreline	✓ (Reported as: Nearshore Waters)	✓ (Reported as: Nearshore Waters)	✓ (Reported as: Shore)
Ramsar wetland	Ramsar	✓	✓	×
Reefs, Shoals and Banks	RSB	✓	✓	×
State Waters	State Waters	✓	✓	×

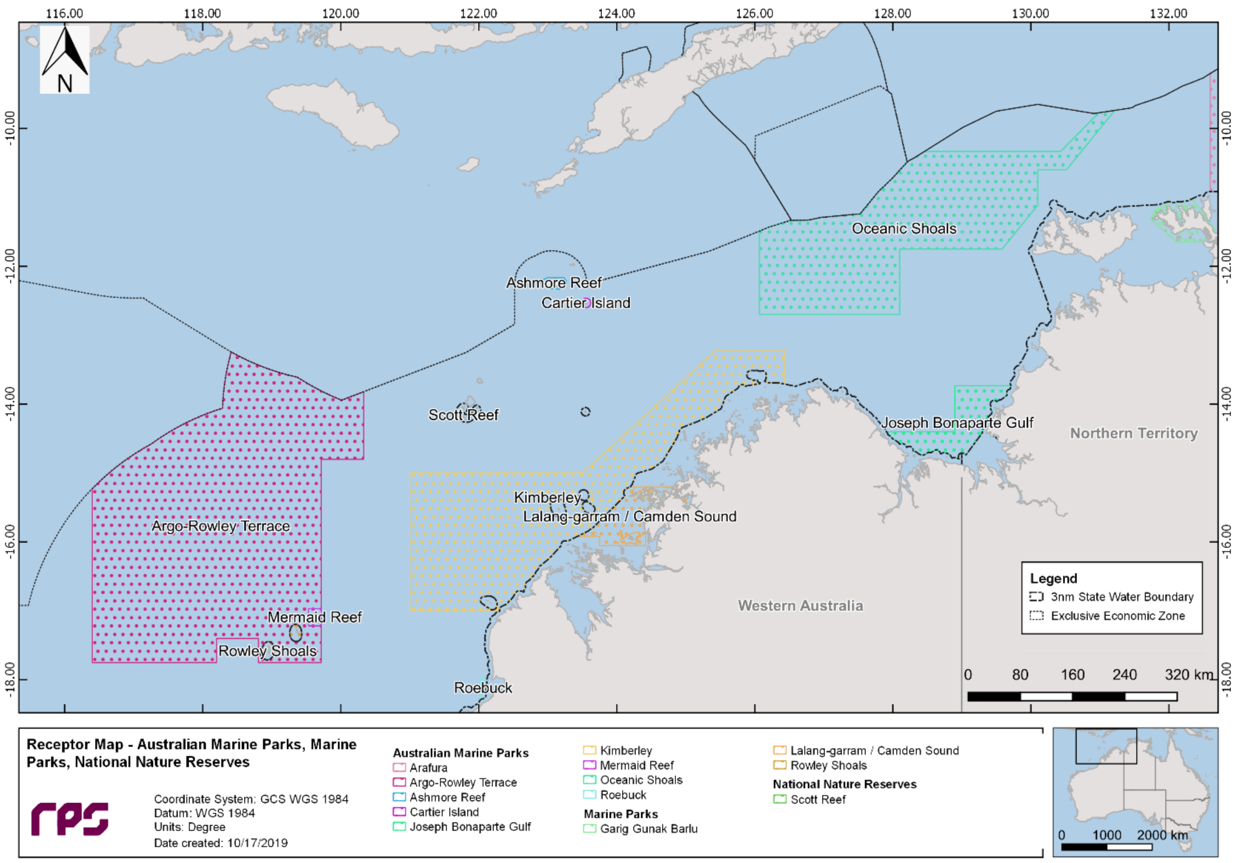


Figure 9.1 Receptor map for Australian Marine Parks, Marine Parks and National Nature Reserves.

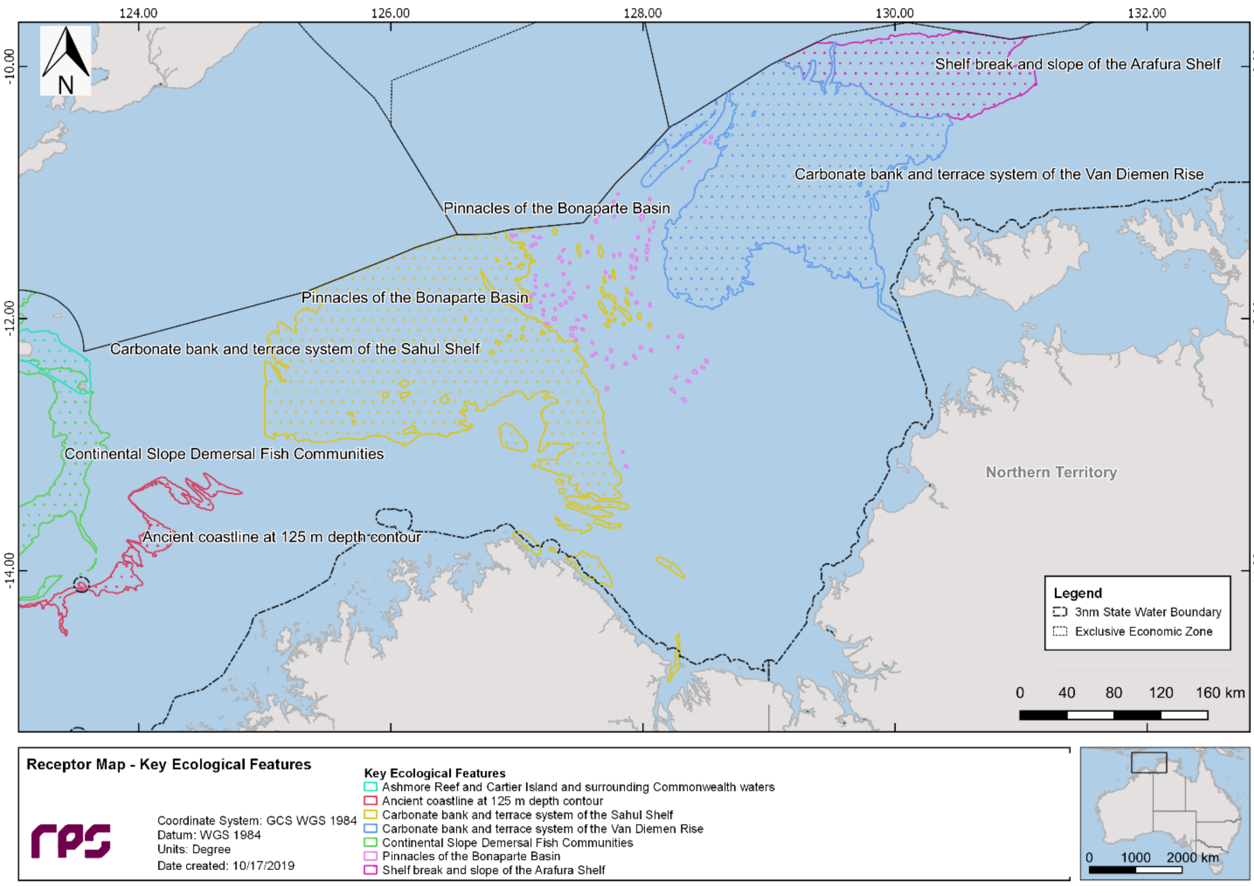


Figure 9.2 Receptor map of Key Ecological Features (KEF) (1 of 2).

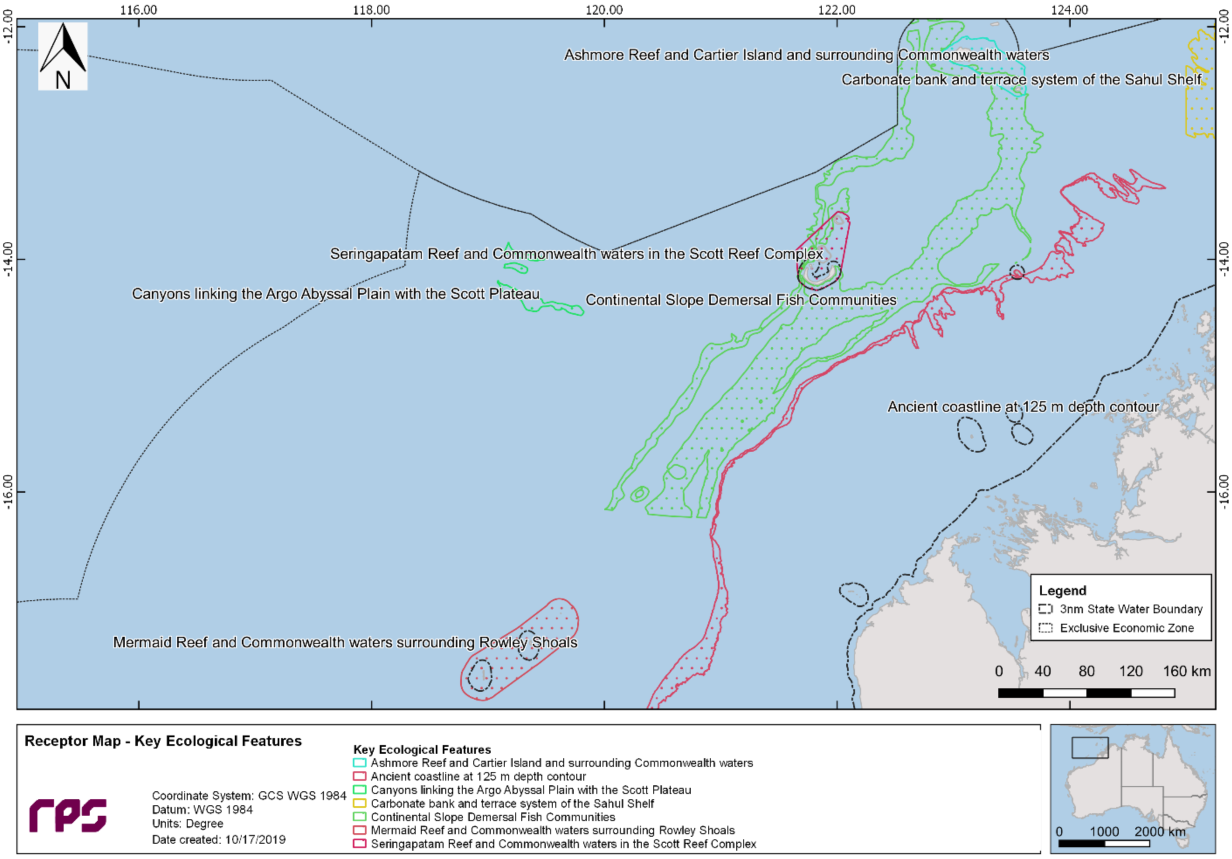


Figure 9.3 Receptor map of Key Ecological Features (KEF) (2 of 2).

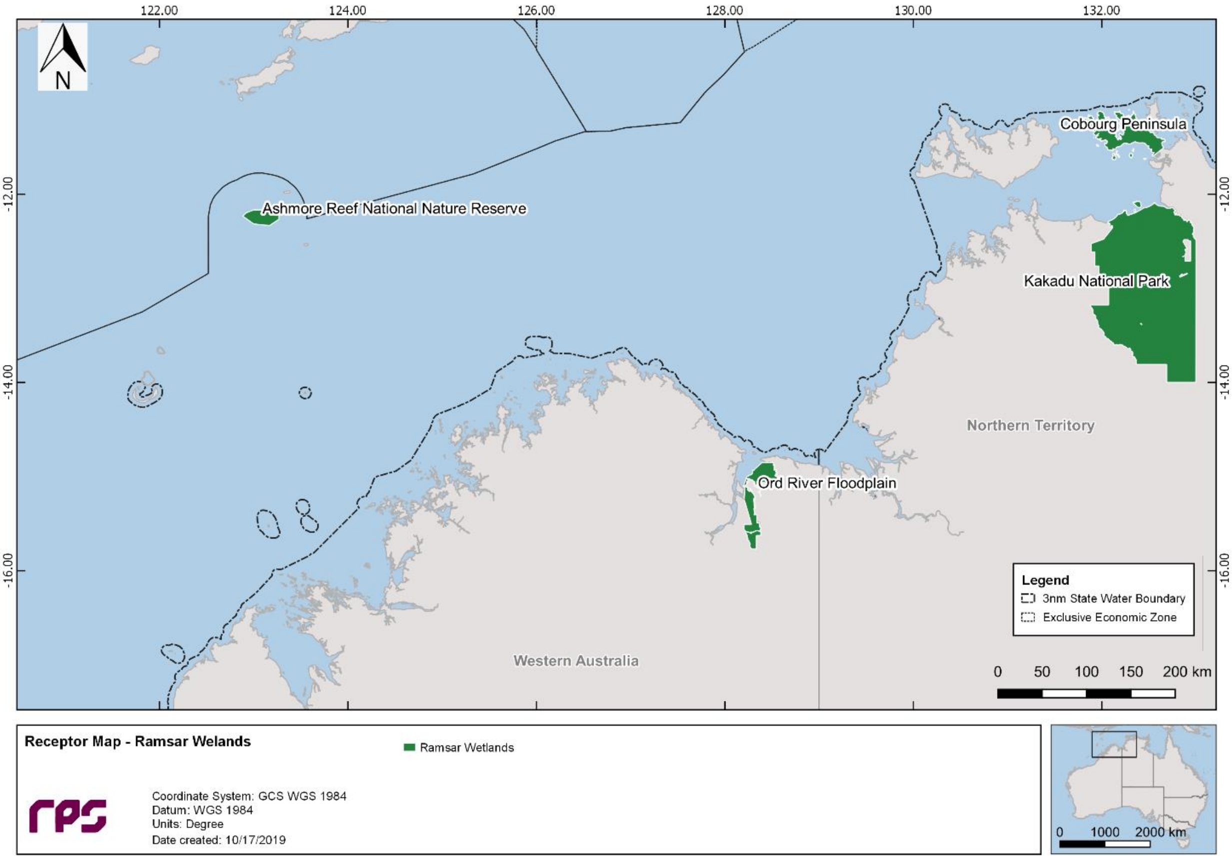


Figure 9.4 Receptor map for RAMSAR wetlands.

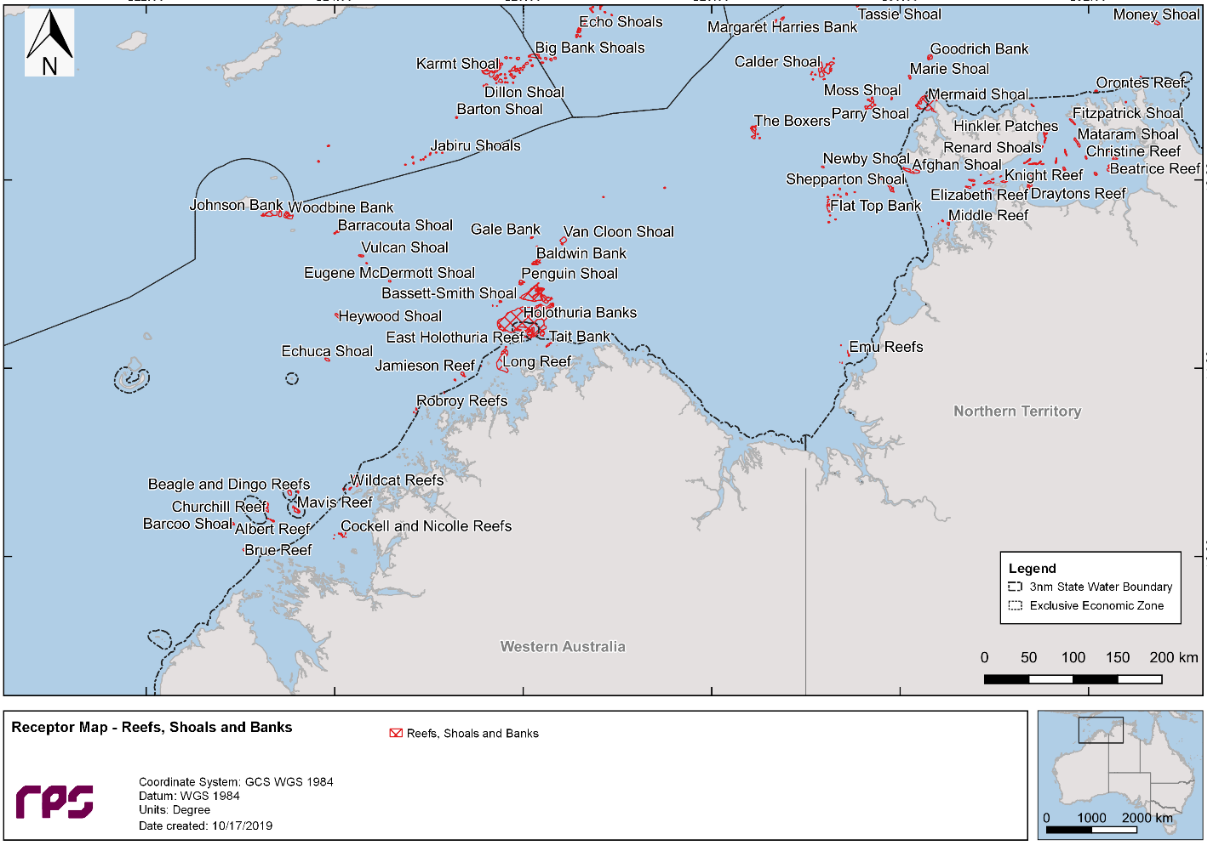


Figure 9.5 Receptor map for Reefs, Shoals and Banks.

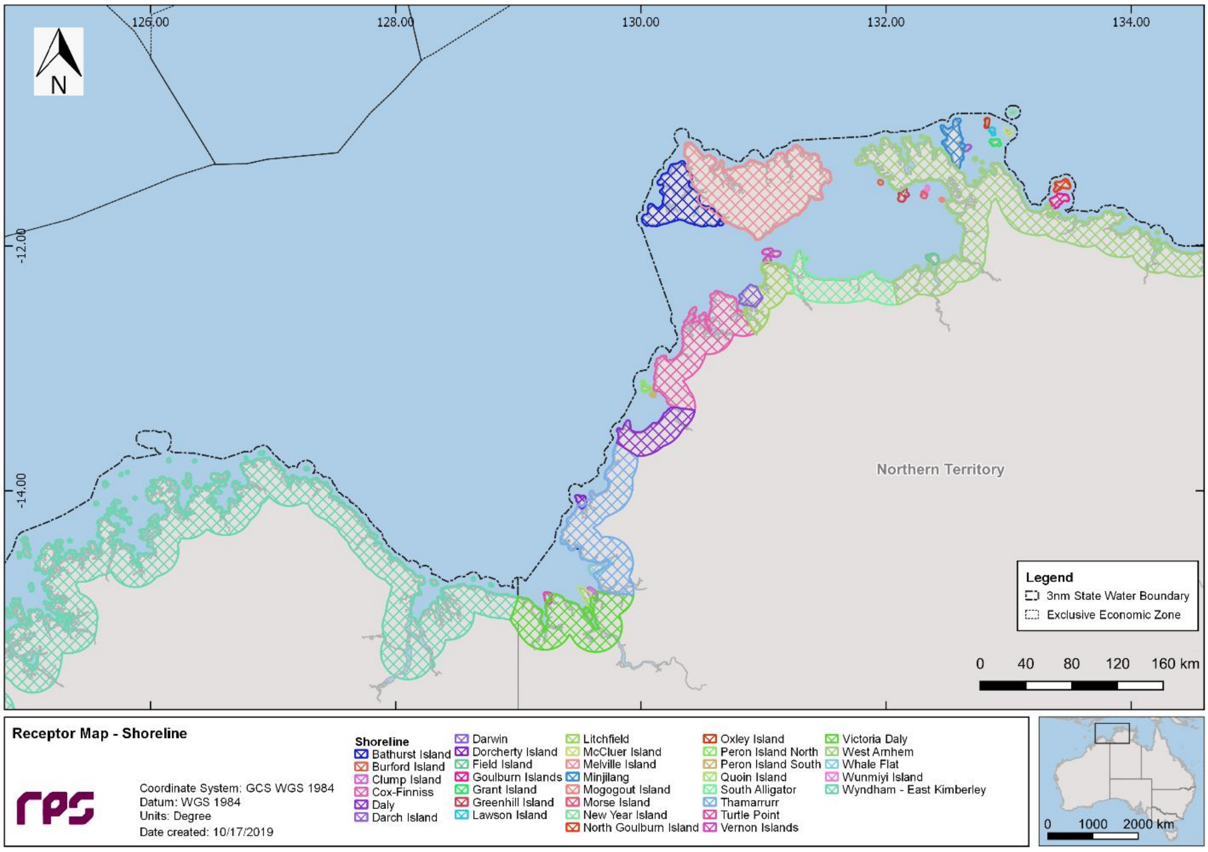


Figure 9.6 Receptor map for the shoreline sectors – names and locations (1 of 2).

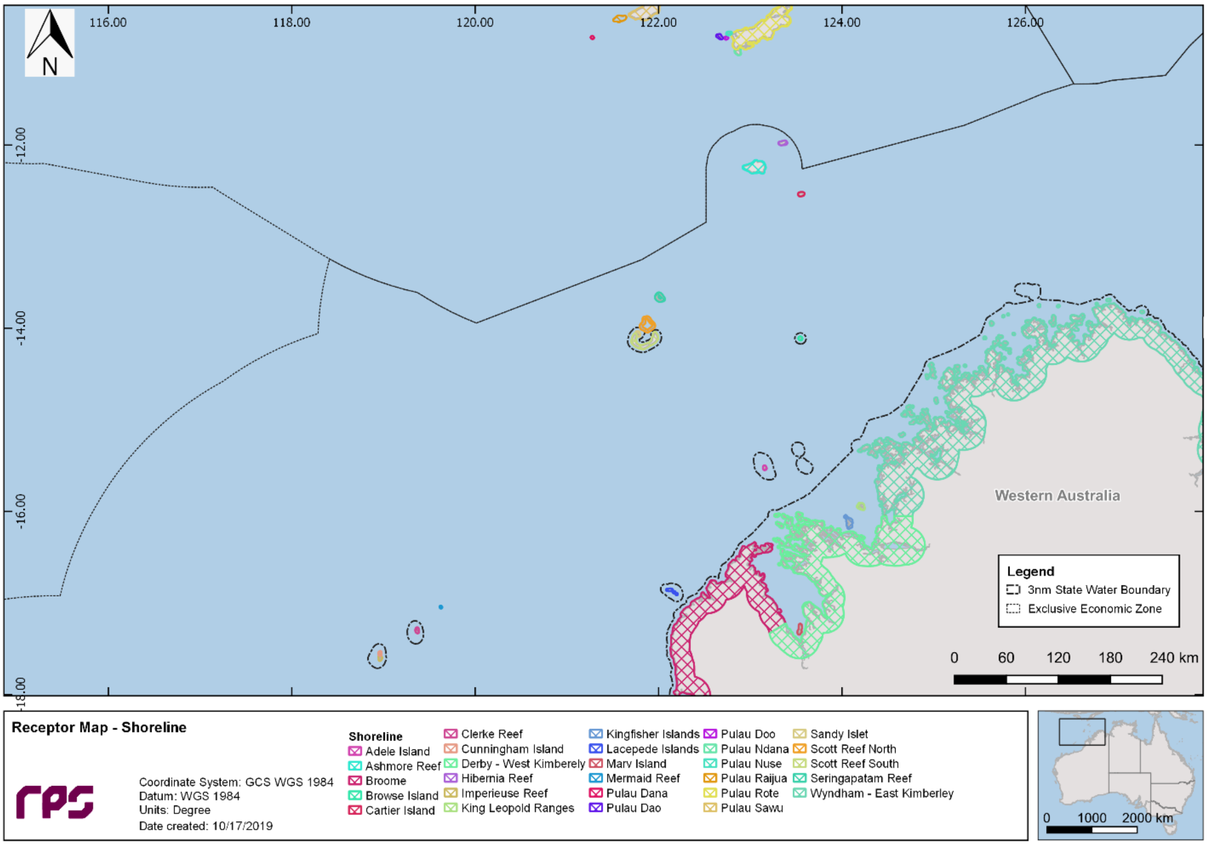


Figure 9.7 Receptor map for the shoreline sectors – names and locations (2 of 2).

10 RESULTS – SCENARIO – LOWC – 786,858 M^3 SURFACE RELEASE OF CRUDE OIL OVER 77 DAYS

This scenario examined a loss of well control of 786,858 m^3 surface release of crude oil over 77 days, tracked for a period of 98 days. A total of 100 spill trajectories were simulated per season (300 in total).

10.1 presents the seasonal stochastic analysis and Section 10.2 presents the deterministic results.

10.1 Stochastic Analysis

10.1.1 Floating Oil Exposure

Table 10.1 summarises the maximum distance travelled by oil on the sea surface at each threshold for the seasonal conditions assessed. The maximum distance from the release location to the low (1–10 g/m^2), moderate (10–50 g/m^2) and high (> 50 g/m^2) exposure levels was 1,517 km (winter), 153 km (summer) and 61 km (winter) respectively.

Table 10.2 summarises the potential floating oil exposure to individual receptors for each season.

Of all the receptors considered in the assessment, the Joseph Bonaparte Gulf AMP was the only receptor predicted to be exposed to floating oil above the low, moderate and high thresholds during all seasonal conditions.

Figure 10.1 to Figure 10.3 present the zones of potential floating oil exposure for the NOPSEMA thresholds under summer, transitional and winter conditions, respectively.

Table 10.1 Potential zones of floating oil exposure, at each threshold. Results are based on a 786,858 m3 surface release of crude oil over 77 days, tracked for 98 days, during seasonal conditions. The results were calculated from 100 spill trajectories per season.

Season	Distance and direction travelled	Zones of potential floating oil exposure		
		Low	Moderate	High
Summer	Maximum distance (km) from the release location	1,048	153	49
	Maximum distance (km) from the release location (99th percentile)	731	95	45
	Direction	West-Southwest	East-Northeast	South-Southeast
Transitional	Maximum distance (km) from the release location	1,136	79	49
	Maximum distance (km) from the release location (99th percentile)	903	62	46
	Direction	West-Southwest	South-Southeast	South-Southeast
Winter	Maximum distance (km) from the release location	1,517	79	61
	Maximum distance (km) from the release location (99th percentile)	730	68	55
	Direction	West-Northwest	Southeast	Southeast

Table 10.2 Summary of the potential floating oil exposure to individual receptors. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days, during seasonal conditions. The results were calculated from 100 spill trajectories per season.

Receptor		Summer						Transitional						Winter					
		Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)			Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)			Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
AMP	Argo-Rowley Terrace	2	-	-	93.17	-	-	7	-	-	88.63	-	-	2	-	-	73.21	-	-
	Ashmore Reef	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	80.79	-	-
	Cartier Island	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	66.75	-	-
	Joseph Bonaparte Gulf	100	47	5	1.88	3.13	3.63	96	36	4	2.13	3.46	14.96	87	22	9	2.67	3.96	4.29
	Kimberley	43	-	-	21.71	-	-	57	-	-	12	-	-	70	-	-	16.13	-	-
	Oceanic Shoals	22	-	-	24.54	-	-	2	-	-	24.13	-	-	21	-	-	35.29	-	-
EEZ	Indonesian Exclusive Economic Zone	-	-	-	-	-	-	7	-	-	77.33	-	-	12	-	-	46.54	-	-
KEF	Ancient coastline at 125 m depth contour	24	-	-	43.54	-	-	44	-	-	28.46	-	-	27	-	-	33.88	-	-
	Ashmore Reef and Cartier Island and surrounding Commonwealth waters	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	66.75	-	-
	Carbonate bank and terrace system of the Sahul Shelf	94	36	-	2.54	8.54	-	91	34	1	1.75	2.58	36.08	97	19	1	1.58	5.71	11.25
	Carbonate bank and terrace system of the Van Diemen Rise	6	-	-	58.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Continental Slope Demersal Fish Communities	21	-	-	50.25	-	-	38	-	-	31.54	-	-	23	-	-	39.08	-	-
	Mermaid Reef and Commonwealth waters surrounding Rowley Shoals	-	-	-	-	-	-	1	-	-	95.21	-	-	-	-	-	-	-	-
	Pinnacles of the Bonaparte Basin	6	-	-	47.42	-	-	2	-	-	30.38	-	-	11	-	-	25.88	-	-
	Seringapatam Reef and Commonwealth waters in the Scott Reef Complex	7	-	-	62	-	-	-	-	-	-	-	-	1	-	-	62.33	-	-
MP	Lalang-garram / Camden Sound	-	-	-	-	-	-	2	-	-	51.38	-	-	-	-	-	-	-	-
	North Kimberley	91	9	-	5.63	22.54	-	90	-	-	7.33	-	-	98	-	-	8.08	-	-
	North Lalang-garram	1	-	-	73.54	-	-	3	-	-	89.38	-	-	-	-	-	-	-	-
	Rowley Shoals	-	-	-	-	-	-	1	-	-	95.25	-	-	-	-	-	-	-	-
NR	Scott Reef	3	-	-	69.92	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ramsar	Ashmore Reef National Nature Reserve	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	80.79	-	-
	Ord River Floodplain	12	-	-	28.71	-	-	13	-	-	46.08	-	-	8	-	-	47.33	-	-
RSB	Albert Reef	-	-	-	-	-	-	2	-	-	93.42	-	-	-	-	-	-	-	-
	Baldwin Bank	15	-	-	22.29	-	-	8	-	-	52.71	-	-	3	-	-	46.83	-	-
	Barracouta Shoal	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	64.63	-	-
	Bass Reef	7	-	-	27.71	-	-	1	-	-	98	-	-	-	-	-	-	-	-
	Bassett-Smith Shoal	7	-	-	41.92	-	-	15	-	-	31.29	-	-	10	-	-	42.29	-	-
	Beagle and Dingo Reefs	3	-	-	86.67	-	-	2	-	-	68.63	-	-	1	-	-	80.96	-	-
	Branch Banks	27	-	-	37.75	-	-	35	-	-	28.13	-	-	25	-	-	23.38	-	-
	Churchill Reef	-	-	-	-	-	-	2	-	-	94.46	-	-	1	-	-	73.04	-	-
	Draytons Reef	1	-	-	41.29	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	East Holothuria Reef	33	-	-	37.21	-	-	40	-	-	17.04	-	-	33	-	-	18.5	-	-
	Echuca Shoal	16	-	-	49.63	-	-	28	-	-	48.63	-	-	10	-	-	41.08	-	-

Receptor		Summer						Transitional						Winter					
		Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)			Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)			Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
	Emu Reefs	59	-	-	6.96	-	-	8	-	-	65.04	-	-	11	-	-	31.46	-	-
	Eugene McDermott Shoal	4	-	-	67.88	-	-	-	-	-	-	-	-	6	-	-	57.79	-	-
	Favell Bank	4	-	-	49.75	-	-	-	-	-	-	-	-	1	-	-	48.71	-	-
	Fish Reef	6	-	-	58.38	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Flat Top Bank	2	-	-	66.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Foelsche Bank	2	-	-	28.96	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Gale Bank	1	-	-	58	-	-	-	-	-	-	-	-	2	-	-	51.92	-	-
	Goeree Shoal	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	65.58	-	-
	Hancox Shoal	1	-	-	72.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Heritage Reef	12	-	-	64.25	-	-	17	-	-	40.58	-	-	4	-	-	35.92	-	-
	Heywood Shoal	7	-	-	52.58	-	-	1	-	-	88.04	-	-	1	-	-	89.21	-	-
	Holothuria Banks	40	-	-	19.29	-	-	53	-	-	13	-	-	61	-	-	17.38	-	-
	Howland Shoals	47	-	-	11.63	-	-	13	-	-	36.42	-	-	11	-	-	26.83	-	-
	Ingram Reef	14	-	-	61.25	-	-	21	-	-	42.13	-	-	10	-	-	38.5	-	-
	Jamieson Reef	16	-	-	59.33	-	-	26	-	-	34.54	-	-	20	-	-	31.63	-	-
	Jones Bank	2	-	-	87	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Knight Reef	1	-	-	38.79	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Long Reef	29	-	-	40	-	-	39	-	-	29.42	-	-	36	-	-	23.75	-	-
	Lowry Shoal	1	-	-	71.71	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Lyne Reef	1	-	-	29.92	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Marsh Shoal	2	-	-	63.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mavis Reef	3	-	-	76.71	-	-	2	-	-	74.25	-	-	2	-	-	74.25	-	-
	Middle Reef	1	-	-	88.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Moresby Shoals	1	-	-	72.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Oliver Reef	2	-	-	72.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Oliver Rock	9	-	-	52.46	-	-	15	-	-	30.92	-	-	5	-	-	33.83	-	-
	Otway Bank	24	-	-	42.42	-	-	31	-	-	23.17	-	-	24	-	-	23.96	-	-
	Parry Shoal	1	-	-	67.38	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Penguin Shoal	16	-	-	28.67	-	-	16	-	-	28.96	-	-	8	-	-	38.5	-	-
	Robroy Reefs	10	-	-	64.5	-	-	12	-	-	39.13	-	-	3	-	-	50.33	-	-
	Rothery Reef	17	-	-	49.71	-	-	21	-	-	29.46	-	-	7	-	-	33.88	-	-
	Shepparton Shoal	2	-	-	82.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Skottowe Shoal	2	-	-	55.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tait Bank	29	-	-	37	-	-	38	-	-	29.17	-	-	33	-	-	19.88	-	-
	Tregenna Reef	1	-	-	60.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Van Cloon Shoal	8	-	-	42.17	-	-	1	-	-	53.04	-	-	4	-	-	38.63	-	-
	Vulcan Shoal	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	60.29	-	-
	West Holothuria Reef	9	-	-	47.83	-	-	15	-	-	26.58	-	-	2	-	-	28.38	-	-
Nearshore Waters	Adele Island	-	-	-	-	-	-	3	-	-	86.46	-	-	1	-	-	71.29	-	-
	Ashmore Reef	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	80.79	-	-
	Bathurst Island	1	-	-	74.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Browse Island	13	-	-	50.96	-	-	14	-	-	47.79	-	-	4	-	-	62.17	-	-

Receptor		Summer						Transitional						Winter					
		Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)			Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)			Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
	Clump Island	25	-	-	18.13	-	-	15	-	-	31.46	-	-	5	-	-	65.08	-	-
	Cox-Finniss	16	-	-	24.79	-	-	1	-	-	95.71	-	-	-	-	-	-	-	-
	Daly	35	-	-	15.33	-	-	-	-	-	-	-	-	1	-	-	80.5	-	-
	Darwin	1	-	-	78.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Dorcherty Island	55	-	-	17.29	-	-	13	-	-	23.71	-	-	19	-	-	35.88	-	-
	Peron Island North	19	-	-	17.38	-	-	2	-	-	91.71	-	-	-	-	-	-	-	-
	Peron Island South	6	-	-	22.71	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Quoin Island	33	-	-	18	-	-	29	-	-	27.75	-	-	29	-	-	41.33	-	-
	Sandy Islet	1	-	-	70.92	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Scott Reef North	2	-	-	63.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Scott Reef South	4	-	-	63.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	South Alligator	2	-	-	83.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Thamarrurr	71	-	-	14.5	-	-	40	-	-	22.79	-	-	29	-	-	42.63	-	-
	Turtle Point	37	-	-	23.5	-	-	16	-	-	29.33	-	-	27	-	-	14.92	-	-
	Vernon Islands	6	-	-	30.04	-	-	1	-	-	97.42	-	-	-	-	-	-	-	-
	Victoria Daly	67	-	-	18.08	-	-	36	-	-	14.29	-	-	48	-	-	14.92	-	-
	Whale Flat	33	-	-	21.54	-	-	22	-	-	29.79	-	-	13	-	-	54.75	-	-
	Wyndham - East Kimberley	70	2	-	14.92	28.88	-	77	-	-	14.5	-	-	93	-	-	9.46	-	-
State Waters	Northern Territory Sate Waters	83	3	-	9.75	46.46	-	50	-	-	7.29	-	-	59	-	-	10.83	-	-
	Western Australia State Waters	91	9	-	5.63	22.54	-	90	-	-	7.33	-	-	98	-	-	8.08	-	-

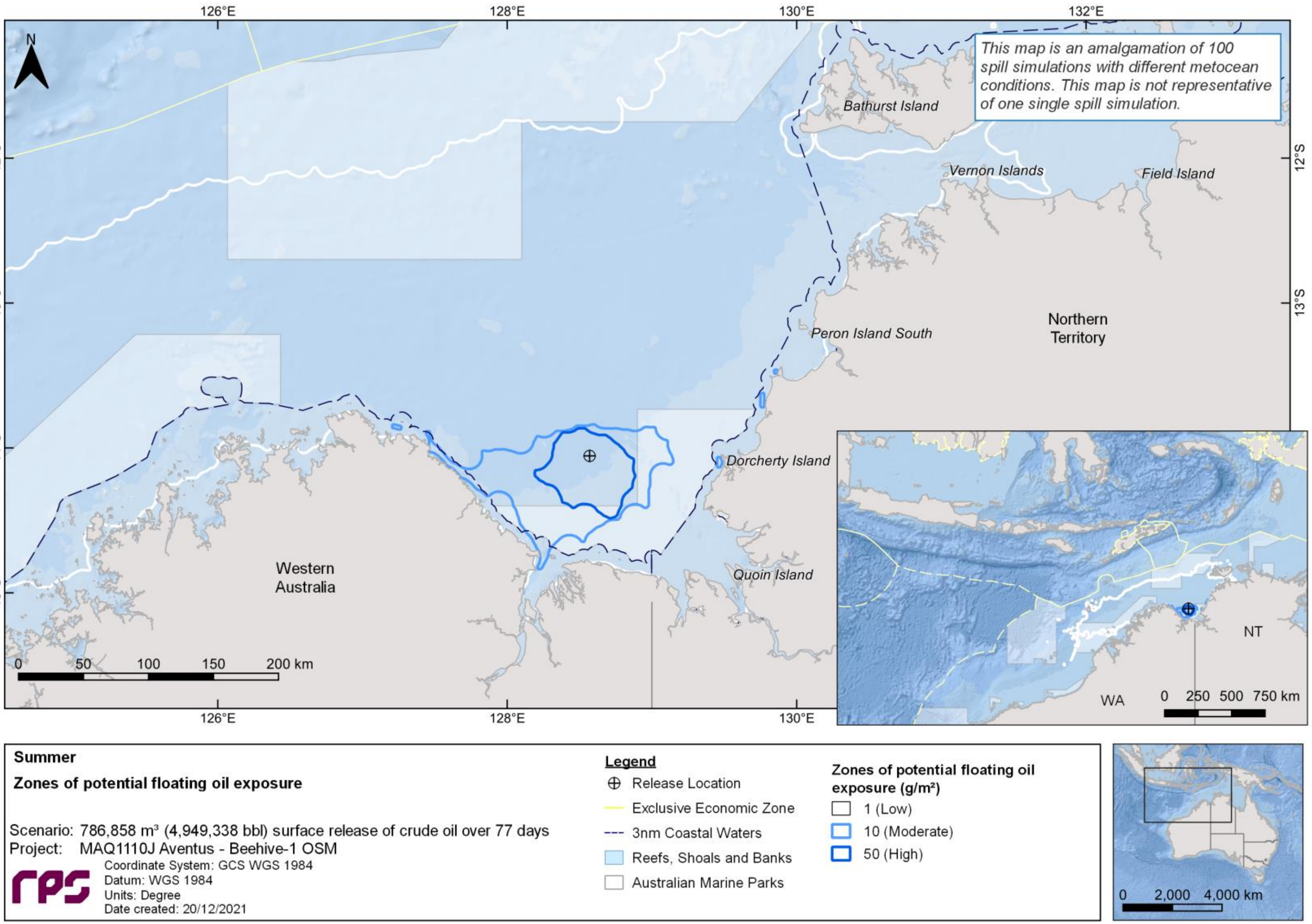


Figure 10.1 Zones of potential floating oil exposure, in the event of a 786,858 m^3 of crude oil over 77 days, tracked for 98 days during summer conditions. The results were calculated from 100 spill trajectories.

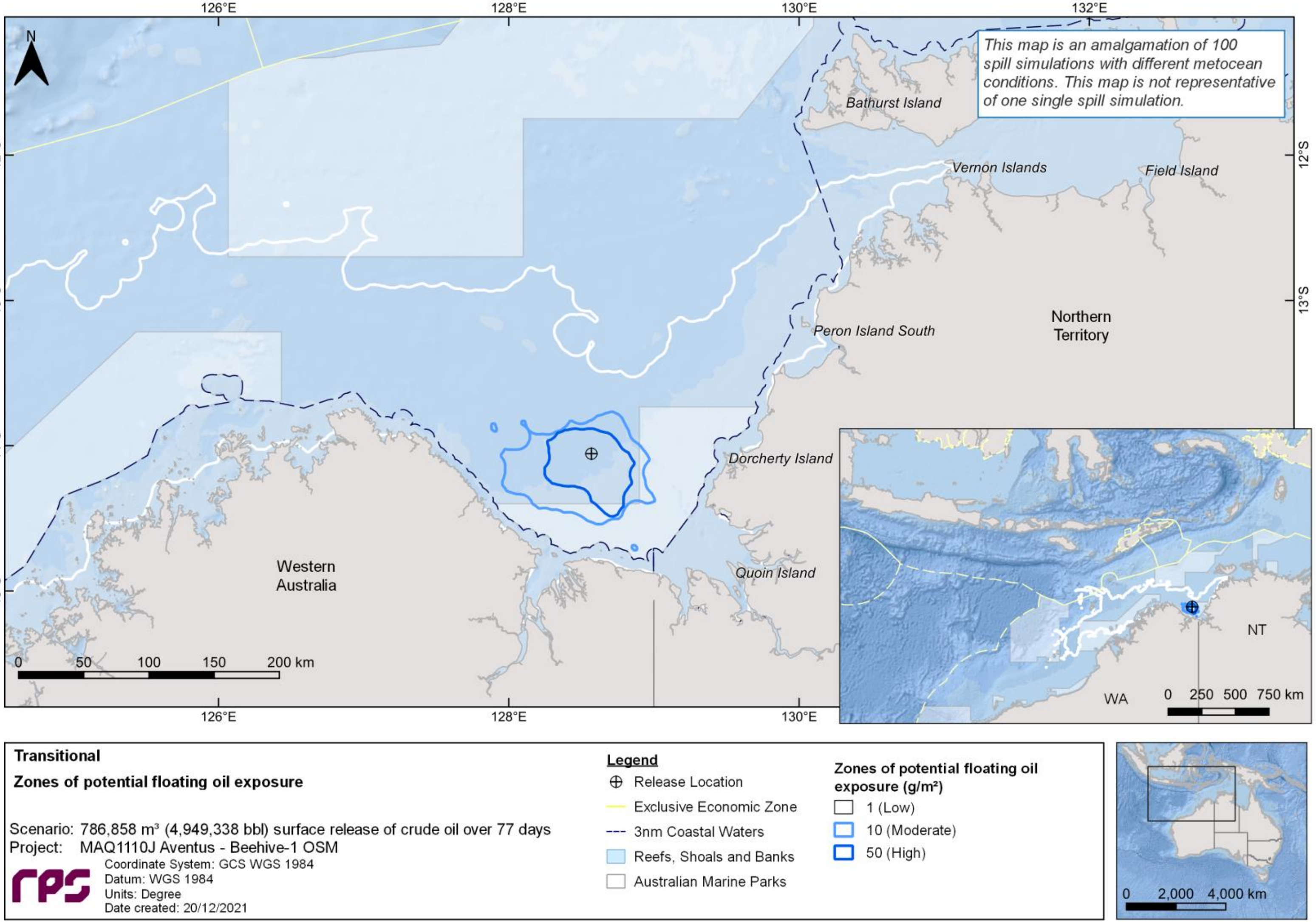


Figure 10.2 Zones of potential floating oil exposure, in the event of a 786,858 m³ of crude oil over 77 days, tracked for 98 days during transitional conditions. The results were calculated from 100 spill trajectories.

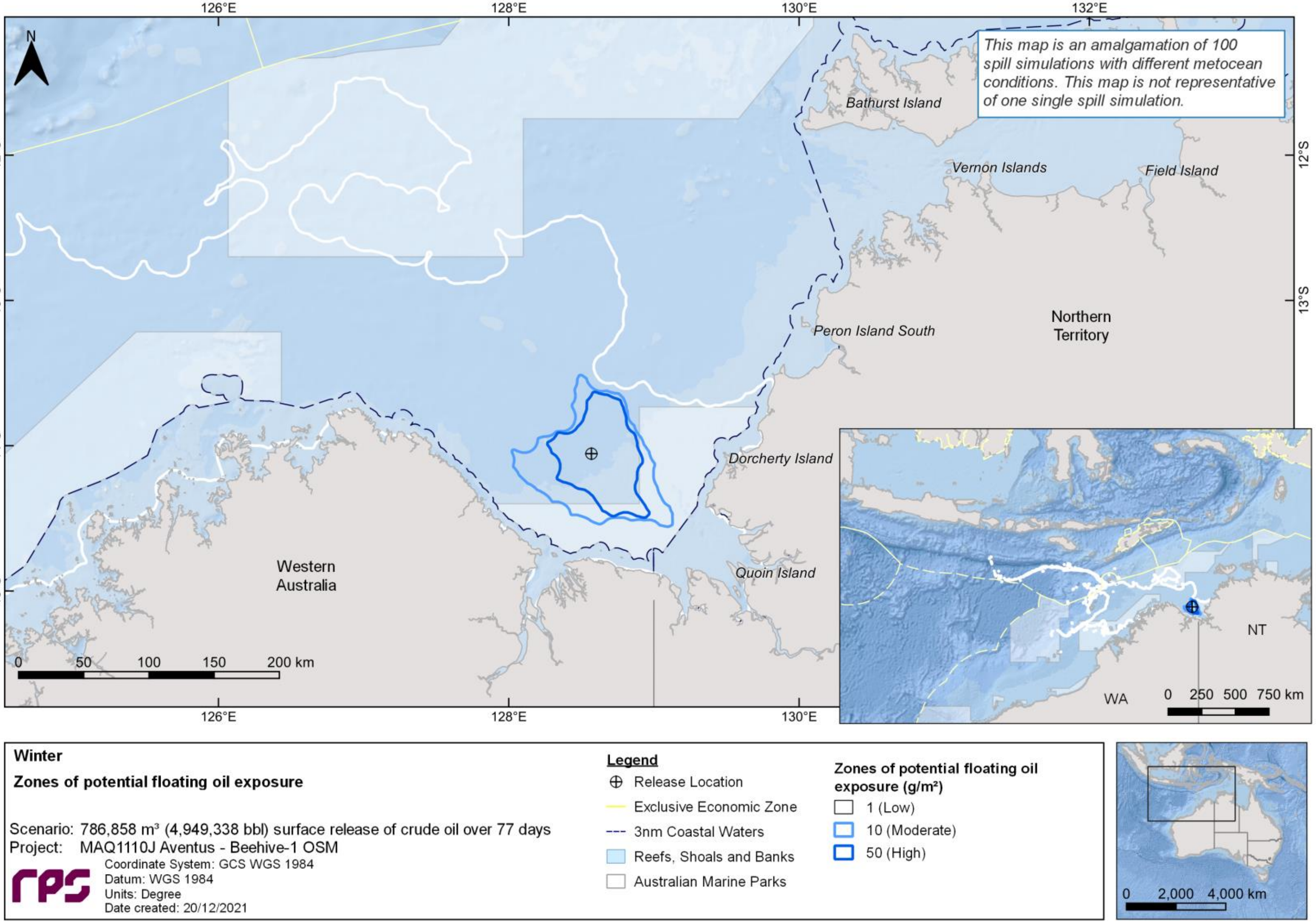


Figure 10.3 Zones of potential floating oil exposure, in the event of a 786,858 m^3 of crude oil over 77 days, tracked for 98 days during winter conditions. The results were calculated from 100 spill trajectories.

10.1.2 Shoreline Accumulation

Table 10.3 presents a summary of the predicted potential shoreline accumulation during seasonal conditions. The probability of accumulation to any shoreline at, or above, the low threshold (10-100 g/m^2) was 100% for all seasons and the minimum time before shoreline accumulation at, or above, the low threshold ranged between 10.29 days (transitional) to 11.58 days (summer). The maximum volume ashore for a single spill trajectory ranged between 406.9 m^3 (winter) and 704.67 m^3 (summer) and maximum length of shoreline contacted at the low threshold was 201 km for winter and 224 km for summer and transitional. The predicted shoreline length above the high (≥1,000 g/m^2) shoreline threshold decreased to a maximum of 16 km, 9 km and 8 km during summer, winter and transitional months respectively.

Table 10.4 summarises the shoreline accumulation on individual receptors during seasonal conditions. The shoreline assessment identified Wyndham - East Kimberley, Thamarrurr, Daly, Victoria Daly and Docherty Island shorelines as the sectors with the largest potential shoreline oil accumulation during summer conditions with volumes ranging between 134.81 m^3 to 404.39 m^3. During the transitional and winter months, the Wyndham - East Kimberley, Victoria Daly and Thamarrurr shorelines recorded potential shoreline oil accumulation ranging between 164.9 m^3 to 414.9 m^3 (transitional) and 155.6 m^3 and 406.9 m^3 (winter). Additionally, Wyndham - East Kimberley recorded the earliest shoreline contact (11.25 days) and the longest length (58.1 km) of shoreline accumulation above the low threshold during transitional conditions.

The maximum potential shoreline loading above the low, moderate and high shoreline thresholds are presented for each season in Figure 10.4 to Figure 10.6.

Table 10.3 Summary of oil accumulation across all shorelines. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days, during seasonal conditions. The results were calculated from 100 spill trajectories per season.

Shoreline Statistics	Summer	Transitional	Winter
Probability of accumulation on any shoreline (%)	100	100	100
Absolute minimum time for visible oil to shore (days)	11.58	10.29	11.25
Maximum volume of hydrocarbons ashore (m^3)	704.67	414.9	406.9
Average volume of hydrocarbons ashore (m^3)	259.5	176.9	145.8
Maximum length of the shoreline at 10 g/m^2 (km)	224	224	201
Average shoreline length (km) at 10 g/m^2 (km)	119.7	82.6	90.9
Maximum length of the shoreline at 100 g/m^2 (km)	129	116	99
Average shoreline length (km) at 100 g/m^2 (km)	61.6	45.5	40.9
Maximum length of the shoreline at 1,000 g/m^2 (km)	16	9	8
Average shoreline length (km) at 1,000 g/m2 (km)	5.2	3.5	2.7

Table 10.4 Summary of oil accumulation on individual shoreline sectors. Results are based on a 786,858 m³ surface release of crude oil over 77 days, tracked for 98 days, during summer conditions. The results were calculated from 100 spill trajectories.

Shoreline sector	Maximum probability of shoreline loading (%)			Minimum time before shoreline accumulation (days)			Load on shoreline (g/m^2)		Volume on shoreline (m^3)		Mean length of shoreline contacted (km)			Maximum length of shoreline contacted (km)		
	Low	Moderate	High	Low	Moderate	High	Mean	Peak	Mean	Peak	Low	Moderate	High	Low	Moderate	High
Adele Island	6	1	-	70.92	96.08	-	65.9	131.7	0.1	1.7	1.3	1.0	-	2.0	1.0	-
Bathurst Island	4	3	-	69.08	71.75	-	65.1	248.0	0.3	12.2	10.8	2.0	-	17.1	3.0	-
Broome	1	-	-	97.21	-	-	38.9	38.9	<0.1	0.5	1.0	-	-	1.0	-	-
Browse Island	23	20	1	48.54	50.54	91.92	299.0	2,059.4	2.9	64.4	3.5	3.0	3.0	4.0	4.0	3.0
Clump Island	55	42	-	18.58	19.58	-	164.5	927.8	3.6	20.6	3.2	1.9	-	8.0	5.0	-
Cox-Finniss	20	14	-	23.79	26.13	-	90.8	582.4	4.6	51.4	20.5	10.8	-	43.2	19.1	-
Daly	57	41	2	18.33	25.79	46.12	103.9	3,692.4	8.4	199.6	9.2	4.6	4.0	32.2	24.1	6.0
Darwin	8	3	-	48.08	51.71	-	69.3	133.6	0.1	2.6	1.9	1.0	-	3.0	1.0	-
Derby - West Kimberley	2	-	-	90.33	-	-	42.8	44.0	<0.1	1.0	1.5	-	-	2.0	-	-
Dorcherty Island	66	54	12	17.38	19.25	50.45	238.6	7,065.5	12.4	134.8	4.8	3.4	1.6	12.1	8.0	2.0
Lacepede Islands	1	-	-	95.33	-	-	39.4	39.4	<0.1	0.5	1.0	-	-	1.0	-	-
Litchfield	8	-	-	60.33	-	-	51.9	60.3	0.1	2.0	1.5	-	-	3.0	-	-
Melville Island	9	-	-	61.96	-	-	47.2	89.1	0.2	4.2	3.5	-	-	8.0	-	-
Minjilang	3	-	-	70.83	-	-	61.5	87.7	<0.1	1.1	1.0	-	-	1.0	-	-
New Year Island	2	-	-	80.25	-	-	43.6	44.6	<0.1	0.6	1.0	-	-	1.0	-	-
Oxley Island	2	-	-	81.33	-	-	43.8	44.1	<0.1	0.5	1.0	-	-	1.0	-	-
Peron Island North	27	17	-	18.71	21.58	-	144.2	880.0	2.4	32.4	3.8	3.4	-	8.0	7.0	-
Peron Island South	12	6	-	22.67	22.75	-	102.0	399.3	0.5	10.6	2.6	1.7	-	4.0	4.0	-
Quoin Island	64	49	2	17.38	17.63	59.58	124.5	1,056.2	8.4	59.1	7.5	4.7	1.0	20.1	11.1	1.0
Sandy Islet	3	-	-	70.67	-	-	48.9	50.0	<0.1	1.2	1.3	-	-	2.0	-	-
Scott Reef North	10	3	-	64.08	64.13	-	60.6	215.9	0.4	12.4	4.9	4.0	-	14.1	6.0	-
Scott Reef South	12	7	-	62.13	63.50	-	87.4	611.0	1.9	57.5	10.6	7.8	-	29.2	18.1	-
Seringapatam Reef	8	1	-	70.25	97.58	-	65.7	116.8	0.1	3.4	2.3	2.0	-	4.0	2.0	-
South Alligator	8	4	-	54.21	57.75	-	57.7	116.9	0.1	3.1	2.4	1.0	-	5.0	1.0	-
Thamarrurr	80	74	31	11.58	14.46	18.91	190.4	6,903.1	55.0	271.2	27.1	15.6	2.2	60.3	40.2	7.0
Turtle Point	58	47	-	18.63	24.17	-	154.9	818.6	4.9	29.4	4.0	2.7	-	7.0	6.0	-
Vernon Islands	18	11	-	30.54	39.17	-	98.1	627.1	1.4	26.4	5.8	3.4	-	14.1	8.0	-
Victoria Daly	76	73	28	14.75	19.13	25.21	189.4	4,229.0	54.3	258.3	27.8	14.6	2.6	57.3	42.2	6.0
Whale Flat	65	54	6	18.29	22.54	67.87	179.6	1,946.6	9.1	78.7	5.2	3.6	1.8	13.1	10.1	3.0
Wyndham - East Kimberley	78	70	41	16.17	17.38	28.37	207.9	4,643.8	105.3	404.4	51.2	30.6	4.5	156.8	85.5	9.1

Table 10.5 Summary of oil accumulation on individual shoreline receptors. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days, during transitional conditions. The results were calculated from 100 spill trajectories.

Shoreline sector	Maximum probability of shoreline loading (%)			Minimum time before shoreline accumulation (days)			Load on shoreline (g/m^2)		Volume on shoreline (m^3)		Mean length of shoreline contacted (km)			Maximum length of shoreline contacted (km)		
	Low	Moderate	High	Low	Moderate	High	Mean	Peak	Mean	Peak	Low	Moderate	High	Low	Moderate	High
Adele Island	6	3	-	75.29	84.38	-	172	538	0.3	10	2	2.3	-	3	3	-
Ashmore Reef	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bathurst Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Broome	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Browse Island	38	27	7	40.58	47.33	59.71	303	2,053	5.1	57.2	2.8	2.8	1.9	4	4	3
Cartier Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clump Island	41	32	-	10.29	24.21	-	171	790	2.8	22.5	3.2	2.1	-	8	5	-
Cox-Finniss	1	1	-	94.63	96.71	-	135	273	< 0.1	5	3	1	-	3	1	-
Daly	9	1	-	63.5	93.17	-	56	209	0.1	4.9	1.6	1	-	5	1	-
Darwin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Derby - West Kimberley	2	-	-	54.75	-	-	50	58	< 0.1	1.1	1.5	-	-	2	-	-
Dorcherty Island	21	13	2	22.96	25.21	72.08	187	1,061	2.4	23.3	4.5	3.9	1	7	6	1
Hibernia Reef	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lacepede Islands	1	-	-	73.92	-	-	48	48	< 0.1	0.6	1	-	-	1	-	-
Litchfield	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Melville Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Minjilang	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Year Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxley Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peron Island North	2	2	-	92.08	92.54	-	160	496	0.2	17.6	5	3	-	6	5	-
Peron Island South	1	-	-	93.17	-	-	73	73	< 0.1	0.9	1	-	-	1	-	-
Quoin Island	42	40	1	18.38	19.92	86.04	148	1,067	6.3	45.1	8.4	4.6	1	16.1	10.1	1
Sandy Islet	1	-	-	66.88	-	-	51	51	< 0.1	0.6	1	-	-	1	-	-
Scott Reef North	1	-	-	66.25	-	-	52	52	< 0.1	1.3	2	-	-	2	-	-
Scott Reef South	3	2	-	43.33	44.42	-	59	130	< 0.1	4.8	4.4	1	-	6	1	-
Seringapatam Reef	4	1	-	68.63	94.21	-	51	156	< 0.1	3.4	3	1	-	6	1	-
South Alligator	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thamarrurr	45	41	21	15.67	22.79	29.75	222	4,062	28.1	164.9	21.5	13.6	2	47.2	27.1	4
Turtle Point	31	24	-	22.75	24.63	-	142	745	2.2	20.1	3.7	2.8	-	7	6	-
Vernon Islands	1	1	-	97.13	97.5	-	117	191	< 0.1	7.2	5	3	-	5	3	-
Victoria Daly	48	40	14	12.33	15.79	26.25	197	6,068	32.2	228.8	24.3	15	3.1	49.3	28.1	6
Whale Flat	36	29	-	26.88	30.83	-	146	697	2.5	22.8	3.7	2.3	-	6	5	-
Wyndham - East Kimberley	83	79	30	11.83	12.79	25.29	182	4,373	100.9	414.9	55.3	30.9	4.4	165.9	100.5	9

Table 10.6 Summary of oil accumulation on individual shoreline receptors. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days, during winter conditions. The results were calculated from 100 spill trajectories.

Shoreline sector	Maximum probability of shoreline loading (%)			Minimum time before shoreline accumulation (days)			Load on shoreline (g/m^2)		Volume on shoreline (m^3)		Mean length of shoreline contacted (km)			Maximum length of shoreline contacted (km)		
	Low	Moderate	High	Low	Moderate	High	Mean	Peak	Mean	Peak	Low	Moderate	High	Low	Moderate	High
Adele Island	2	2	-	69.29	70.08	-	231	461	0.1	7.6	2.5	1.5	-	3	2	-
Ashmore Reef	7	3	-	69.75	80.88	-	55	225	0.3	14.4	6.6	2	-	19.1	3	-
Bathurst Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Broome	1	-	-	88.83	-	-	41	41	< 0.1	0.5	1	-	-	1	-	-
Browse Island	22	11	-	37.04	37.92	-	114	444	0.8	14.3	2.1	2.6	-	4	4	-
Cartier Island	11	5	-	66.08	67.13	-	73	277	0.4	11.2	3.4	2.2	-	9	3	-
Clump Island	41	31	-	27.54	36.63	-	134	693	1.7	16.9	2.3	1.6	-	5	4	-
Cox-Finniss	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daly	8	3	-	53	71	-	85	286	0.2	7	1.9	1.3	-	5	2	-
Darwin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Derby - West Kimberley	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dorcherty Island	26	19	-	38.54	39.54	-	138	936	1.3	22.5	2.7	1.8	-	6	6	-
Hibernia Reef	6	3	-	70.63	87.29	-	61	281	0.2	7.8	4.4	1	-	8	1	-
Lacepede Islands	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Litchfield	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Melville Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Minjilang	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Year Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxley Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peron Island North	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peron Island South	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quoin Island	50	43	1	28	31.63	76.17	131	1,232	6.2	38.2	7.3	4.1	1	15.1	11.1	1
Sandy Islet	1	-	-	92	-	-	48	48	< 0.1	0.6	1	-	-	1	-	-
Scott Reef North	5	-	-	63.79	-	-	43	53	< 0.1	2	2.2	-	-	4	-	-
Scott Reef South	7	-	-	74.75	-	-	53	99	< 0.1	3.5	2.2	-	-	6	-	-
Seringapatam Reef	2	-	-	56.54	-	-	54	57	< 0.1	0.7	1	-	-	1	-	-
South Alligator	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thamarrurr	41	35	16	31.17	37.17	56.08	178	3,959	16.9	155.6	16.8	11.2	1.3	46.2	30.2	3
Turtle Point	48	38	-	13.92	14.96	-	140	666	3.2	23.8	3.8	2.7	-	7	5	-
Vernon Islands	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Victoria Daly	58	54	17	13.96	14.5	49.88	181	3,492	29.7	160.7	21.5	11.8	2.4	53.3	29.2	4
Whale Flat	32	18	-	38.58	39.67	-	93	359	1.2	11.1	3.1	1.5	-	7	3	-
Wyndham - East Kimberley	99	93	23	11.25	12.54	27.88	131	2,206	88.5	406.9	58.1	25.9	2.6	164.9	93.5	8

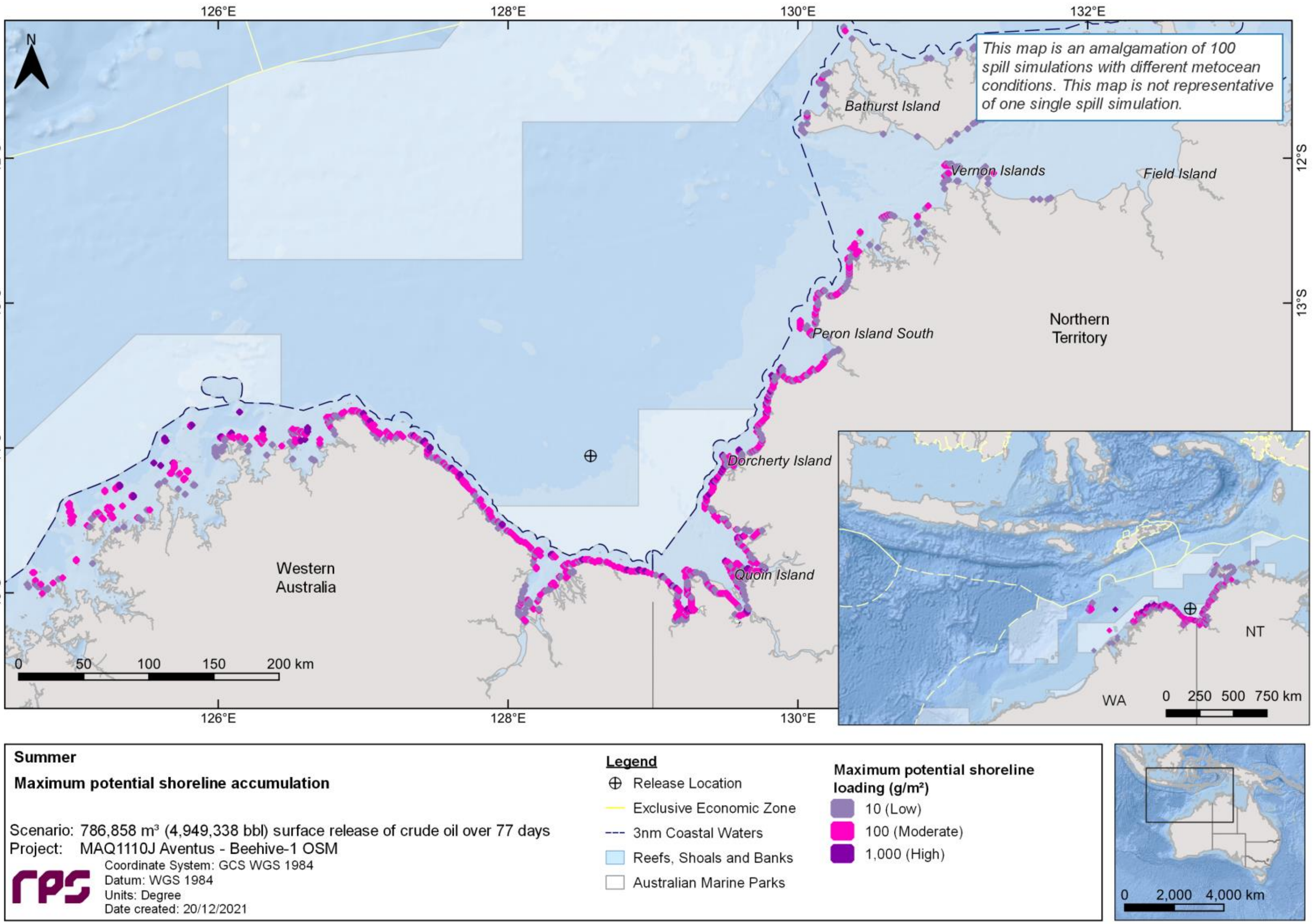


Figure 10.4 Maximum potential shoreline loading, in the event of a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days during summer conditions. The results were calculated from 100 spill trajectories.

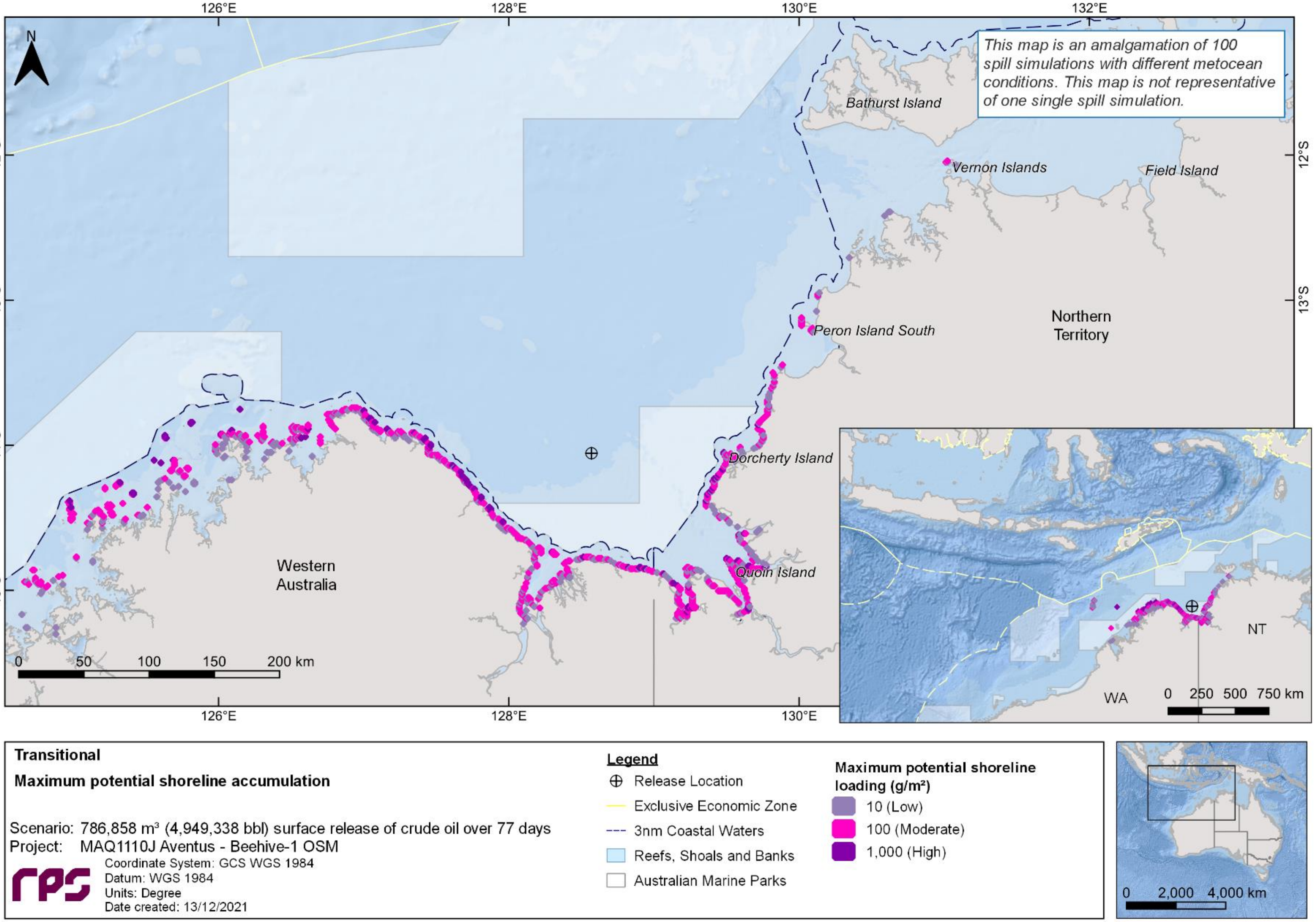


Figure 10.5 Maximum potential shoreline loading, in the event of a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days during transitional conditions. The results were calculated from 100 spill trajectories.

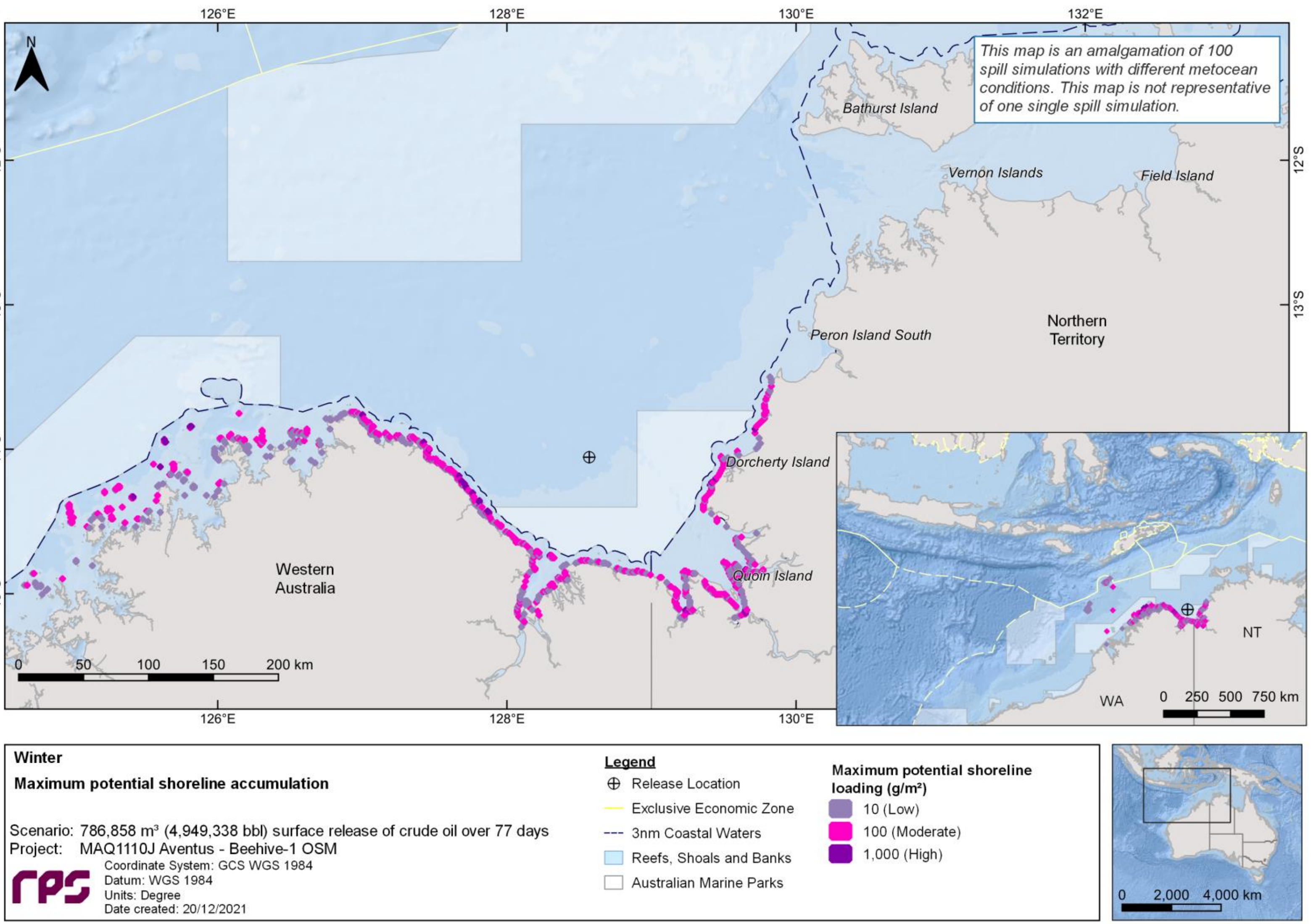


Figure 10.6 Maximum potential shoreline loading, in the event of a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days during winter conditions. The results were calculated from 100 spill trajectories.

10.1.3 In-water exposure

10.1.3.1 Dissolved Hydrocarbons

Table 10.7 summarises the probability of exposure to individual receptors from dissolved hydrocarbons in the 0-10 m depth layer during seasonal conditions.

In the surface (0-10 m) depth layer, low, moderate and high exposure to dissolved hydrocarbons was recorded for a range of receptors (refer to Table 10.7). The highest dissolved hydrocarbon concentrations were predicted for the Joseph Bonaparte Gulf AMP and the carbonate bank and terrace system of the Sahul Shelf KEF, followed by the North Kimberley MP and Kimberley AMP during all seasonal conditions. In addition, the nearshore waters of the Thamarrurr, Wyndham-East Kimberley, Dorcherty Island, Clump Island Quoin Island, Daly, Victoria Daly shorelines and Ord River floodplain (Ramsar) were some of the receptors with the highest entrained hydrocarbons concentrations for all seasonal conditions.

Figure 10.7 to Figure 10.9 presents the zones of potential dissolved hydrocarbon exposure in the 0-10 m depth layer for the low (10-50 ppb), moderate (50-400 ppb) and high (≥400 ppb) exposure levels (NOPSEMA, 2019) for each season.

Table 10.7 Probability of exposure to individual receptors from dissolved hydrocarbons in the 0–10 m depth layer. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days during seasonal conditions. The results were calculated from 100 spill trajectories per season.

Receptor		Summer				Transitional				Winter			
		Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure		
			Low	Moderate	High		Low	Moderate	High		Low	Moderate	High
AMP	Arafura	19	1	-	-	-	-	-	-	-	-	-	-
	Argo-Rowley Terrace	59	3	1	-	297	7	5	-	66	2	1	-
	Ashmore Reef	-	-	-	-	-	-	-	-	49	5	-	-
	Cartier Island	-	-	-	-	-	-	-	-	37	4	-	-
	Joseph Bonaparte Gulf	9,955	100	97	89	8,712	90	79	66	6,659	98	95	73
	Kimberley	5,086	49	47	24	3,271	62	58	20	1,705	84	67	15
	Mermaid Reef	-	-	-	-	195	3	2	-	46	2	-	-
	Oceanic Shoals	570	15	12	1	34	3	-	-	798	34	21	2
EEZ	East Timorian Exclusive Economic Zone	-	-	-	-	-	-	-	-	28	2	-	-
	Indonesian Exclusive Economic Zone	32	1	-	-	103	7	2	-	141	11	2	-
KEF	Ancient coastline at 125 m depth contour	679	24	16	1	1,479	45	29	2	496	21	9	1
	Ashmore Reef and Cartier Island and surrounding Commonwealth waters	-	-	-	-	-	-	-	-	69	5	1	-
	Canyons linking the Argo Abyssal Plain with the Scott Plateau	-	-	-	-	-	-	-	-	14	1	-	-
	Carbonate bank and terrace system of the Sahul Shelf	5,161	92	85	63	7,293	89	86	79	7,462	100	98	95

Receptor		Summer				Transitional				Winter			
		Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure		
			Low	Moderate	High		Low	Moderate	High		Low	Moderate	High
	Carbonate bank and terrace system of the Van Diemen Rise	231	14	6	-	-	-	-	-	23	1	-	-
	Continental Slope Demersal Fish Communities	484	21	8	1	562	28	16	1	237	13	5	-
	Mermaid Reef and Commonwealth waters surrounding Rowley Shoals	-	-	-	-	195	3	2	-	56	2	1	-
	Pinnacles of the Bonaparte Basin	524	8	8	1	335	7	5	-	1,187	16	8	3
	Seringapatam Reef and Commonwealth waters in the Scott Reef Complex	107	3	2	-	18	1	-	-	66	4	1	-
MP	Garig Gunak Barlu	24	1	-	-	-	-	-	-	-	-	-	-
	Lalang-garram / Camden Sound	89	6	1	-	127	9	2	-	67	3	1	-
	North Kimberley	4,874	68	55	33	6,842	85	78	44	6,741	97	96	88
	North Lalang-garram	353	9	6	-	260	18	8	-	129	5	2	-
	Rowley Shoals	-	-	-	-	23	3	-	-	56	2	1	-
NR	Scott Reef	107	3	1	-	8	-	-	-	10	-	-	-
Ramsar	Ashmore Reef National Nature Reserve	-	-	-	-	-	-	-	-	49	5	-	-
	Cobourg Peninsula	13	1	-	-	-	-	-	-	-	-	-	-
	Ord River Floodplain	774	33	18	1	1,000	36	25	5	689	50	27	2
RSB	Abbott Shoal	73	4	1	-	-	-	-	-	-	-	-	-

Receptor	Summer				Transitional				Winter			
	Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure		
		Low	Moderate	High		Low	Moderate	High		Low	Moderate	High
Afghan Shoal	85	10	1	-	-	-	-	-	-	-	-	-
Albert Reef	144	6	6	-	198	6	4	-	180	5	3	-
Ann Shoals	10	1	-	-	-	-	-	-	-	-	-	-
Baldwin Bank	418	26	15	1	188	10	4	-	496	31	12	1
Barbara Shoal	61	2	1	-	-	-	-	-	-	-	-	-
Barcoo Shoal	10	-	-	-	37	4	-	-	99	2	1	-
Barracouta Shoal	-	-	-	-	-	-	-	-	50	8	-	-
Bass Reef	1,109	15	10	4	809	2	2	1	-	-	-	-
Bassett-Smith Shoal	491	29	18	1	877	34	23	6	568	38	21	1
Beagle Shoals	129	5	2	-	-	-	-	-	-	-	-	-
Beagle and Dingo Reefs	141	7	4	-	325	11	4	-	140	5	3	-
Bill Shoal	225	6	4	-	-	-	-	-	-	-	-	-
Branch Banks	1,947	45	40	20	2,766	60	57	16	1,461	80	59	6
Brue Reef	21	3	-	-	54	4	1	-	95	2	1	-
Calder Shoal	26	2	-	-	-	-	-	-	-	-	-	-
Churchill Reef	101	6	1	-	205	6	4	-	150	5	3	-
Clerke Reef	-	-	-	-	23	3	-	-	54	1	1	-
Cootamundra Shoal	14	2	-	-	-	-	-	-	-	-	-	-
Deep Shoal 1	90	4	4	-	-	-	-	-	170	16	6	-
Deep Shoal 2	72	4	1	-	-	-	-	-	92	8	2	-
Draytons Reef	752	6	5	2	1	-	-	-	-	-	-	-
East Holothuria Reef	1,979	43	38	16	1,882	61	56	15	1,111	74	54	7
Echuca Shoal	564	24	15	1	523	36	23	1	267	16	6	-
Elizabeth Reef	693	6	5	2	1	-	-	-	-	-	-	-

Receptor	Summer				Transitional				Winter			
	Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure		
		Low	Moderate	High		Low	Moderate	High		Low	Moderate	High
Elphinstone Reef	12	2	-	-	-	-	-	-	-	-	-	-
Emu Reefs	2,932	77	74	35	1,237	26	24	6	1,403	23	19	3
Eugene McDermott Shoal	109	6	1	-	18	3	-	-	140	17	6	-
Fantome Shoal	-	-	-	-	-	-	-	-	28	2	-	-
Favell Bank	247	14	9	-	15	2	-	-	294	18	10	-
Fish Reef	1,458	16	10	5	669	2	2	1	-	-	-	-
Fitzpatrick Shoal	15	1	-	-	-	-	-	-	-	-	-	-
Flat Top Bank	161	14	4	-	62	1	1	-	3	-	-	-
Foelsche Bank	567	18	6	2	111	1	1	-	-	-	-	-
Gale Bank	152	14	7	-	9	-	-	-	214	16	7	-
Giles Shoal	14	1	-	-	-	-	-	-	-	-	-	-
Goeree Shoal	-	-	-	-	2	-	-	-	98	8	2	-
Goodrich Bank	64	3	1	-	-	-	-	-	-	-	-	-
Hancox Shoal	392	15	5	-	52	1	1	-	-	-	-	-
Harris Reef	429	13	4	1	32	1	-	-	-	-	-	-
Heritage Reef	707	27	22	3	532	55	39	2	575	44	15	1
Heywood Shoal	74	9	1	-	69	13	4	-	108	15	2	-
Hinkler Patches	13	2	-	-	-	-	-	-	-	-	-	-
Holothuria Banks	3,206	46	40	19	2,993	60	57	18	1,529	78	55	8
Howland Shoals	2,331	75	72	27	1,306	39	30	9	1,205	24	24	9
Hunt Patch	146	6	3	-	-	-	-	-	-	-	-	-
Imperieuse Reef	-	-	-	-	15	1	-	-	26	1	-	-
Ingram Reef	638	28	22	2	769	56	48	4	383	48	25	-
Jamieson Reef	927	31	25	5	785	57	51	7	804	56	30	3

Receptor	Summer				Transitional				Winter			
	Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure		
		Low	Moderate	High		Low	Moderate	High		Low	Moderate	High
Johnson Bank	-	-	-	-	-	-	-	-	24	3	-	-
Jones Bank	1,020	12	9	4	538	2	2	1	-	-	-	-
Kelleway Reef	467	9	6	3	117	2	2	-	-	-	-	-
Knight Reef	719	12	5	1	88	1	1	-	-	-	-	-
Long Reef	1,863	42	33	19	1,337	59	54	16	1,223	72	50	5
Lowry Shoal	98	13	3	-	14	1	-	-	-	-	-	-
Lyne Reef	533	14	6	2	90	1	1	-	-	-	-	-
Marie Shoal	54	3	1	-	-	-	-	-	-	-	-	-
Marsh Shoal	504	16	7	3	86	1	1	-	-	-	-	-
Mataram Shoal	13	1	-	-	-	-	-	-	-	-	-	-
Mavis Reef	108	7	6	-	146	9	3	-	115	5	2	-
Mermaid Reef	-	-	-	-	73	3	2	-	46	2	-	-
Mermaid Shoal	136	3	3	-	-	-	-	-	-	-	-	-
Middle Reef	1,434	12	8	5	309	2	1	-	-	-	-	-
Moira Reef	343	12	8	-	131	1	1	-	-	-	-	-
Moresby Shoals	63	11	1	-	4	-	-	-	-	-	-	-
Moss Shoal	51	3	1	-	-	-	-	-	-	-	-	-
Newby Shoal	73	5	2	-	-	-	-	-	1	-	-	-
Oliver Reef	380	16	5	-	43	1	-	-	-	-	-	-
Oliver Rock	846	34	27	9	784	57	52	10	541	61	43	3
Ommaney Shoals	12	1	-	-	-	-	-	-	-	-	-	-
Osborn Reefs	46	7	-	-	65	11	1	-	47	4	-	-
Otway Bank	1,577	43	38	17	1,758	60	57	16	931	77	53	6
Parry Shoal	66	4	2	-	-	-	-	-	-	-	-	-

Receptor		Summer				Transitional				Winter			
		Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure		
			Low	Moderate	High		Low	Moderate	High		Low	Moderate	High
	Parsons Bank	17	3	-	-	-	-	-	-	-	-	-	-
	Penguin Shoal	703	31	24	3	809	22	18	4	617	34	16	1
	Rainbow Shoals	16	2	-	-	17	3	-	-	26	2	-	-
	Renard Shoals	84	1	1	-	-	-	-	-	-	-	-	-
	Robroy Reefs	561	24	21	3	415	46	32	1	657	29	10	1
	Rothery Reef	1,323	41	33	11	1,307	59	55	19	901	68	45	6
	Shepparton Shoal	218	15	9	-	-	-	-	-	-	-	-	-
	Skottowe Shoal	219	16	6	-	74	1	1	-	-	-	-	-
	Tait Bank	2,150	42	36	14	1,436	58	47	12	1,355	83	62	8
	Taiyun Shoal	147	8	4	-	-	-	-	-	-	-	-	-
	Taylor Patches	604	6	4	1	-	-	-	-	-	-	-	-
	The Boxers	13	1	-	-	-	-	-	-	2	-	-	-
	Tregenna Reef	297	10	4	-	24	1	-	-	-	-	-	-
	Van Cloon Shoal	196	15	8	-	25	1	-	-	545	26	14	1
	Vee Shoal	-	-	-	-	-	-	-	-	32	3	-	-
	Victoria Shoal	13	1	-	-	-	-	-	-	-	-	-	-
	Vulcan Shoal	-	-	-	-	-	-	-	-	115	9	3	-
	Wells Shoal	17	2	-	-	-	-	-	-	-	-	-	-
	West Holothuria Reef	871	32	29	3	804	57	39	5	1,114	46	24	2
	Wildcat Reefs	19	5	-	-	25	4	-	-	18	3	-	-
	Woodbine Bank	-	-	-	-	-	-	-	-	33	3	-	-
Nearshore Waters	Adele Island	82	6	1	-	159	6	4	-	99	3	2	-
	Ashmore Reef	-	-	-	-	-	-	-	-	38	5	-	-
	Bathurst Island	88	6	2	-	-	-	-	-	-	-	-	-

Receptor	Summer				Transitional				Winter			
	Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure		
		Low	Moderate	High		Low	Moderate	High		Low	Moderate	High
Browse Island	532	20	11	1	305	30	13	-	311	13	5	-
Burford Island	15	1	-	-	-	-	-	-	-	-	-	-
Cartier Island	-	-	-	-	-	-	-	-	22	3	-	-
Clerke Reef	-	-	-	-	17	3	-	-	27	1	-	-
Clump Island	2,404	54	43	18	2,122	46	42	17	1,656	45	35	13
Cox-Finniss	1,025	38	20	5	727	2	2	1	-	-	-	-
Cunningham Island	-	-	-	-	10	1	-	-	15	1	-	-
Daly	1,186	57	43	5	359	16	9	-	153	9	3	-
Darwin	497	12	5	1	45	1	-	-	-	-	-	-
Dorcherty Island	1,916	74	64	30	2,443	40	33	23	2,207	27	24	20
Hibernia Reef	-	-	-	-	-	-	-	-	24	2	-	-
Imperieuse Reef	-	-	-	-	11	1	-	-	12	1	-	-
Litchfield	685	13	6	2	81	1	1	-	-	-	-	-
Melville Island	124	7	2	-	2	-	-	-	-	-	-	-
Mermaid Reef	-	-	-	-	73	3	2	-	26	1	-	-
Peron Island North	769	41	33	4	205	2	1	-	-	-	-	-
Peron Island South	338	38	16	-	35	2	-	-	-	-	-	-
Quoin Island	2,806	56	42	16	1,598	47	41	16	1,963	46	37	14
Sandy Islet	73	3	1	-	7	-	-	-	14	1	-	-
Scott Reef North	72	3	2	-	9	-	-	-	31	3	-	-
Scott Reef South	107	3	1	-	14	1	-	-	15	1	-	-
Seringapatam Reef	4	-	-	-	5	-	-	-	26	3	-	-
South Alligator	543	6	5	2	5	-	-	-	-	-	-	-
Thamarrurr	2,327	74	63	34	2,934	48	46	28	2,363	49	41	21

Receptor		Summer				Transitional				Winter			
		Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure			Maximum instantaneous dissolved hydrocarbon exposure	Probability of instantaneous dissolved hydrocarbon exposure		
			Low	Moderate	High		Low	Moderate	High		Low	Moderate	High
	Turtle Point	1,226	61	50	10	1,115	45	39	8	1,736	52	41	13
	Vernon Islands	844	16	6	3	123	1	1	-	-	-	-	-
	Victoria Daly	2,472	59	49	19	2,274	46	39	18	3,922	50	42	21
	West Arnhem	18	1	-	-	-	-	-	-	-	-	-	-
	Whale Flat	1,003	58	48	8	2,181	46	39	11	893	41	30	6
	Wyndham - East Kimberley	4,819	61	49	27	3,767	79	68	40	4,223	97	95	82
State Waters	Northern Territory Sate Waters	4,113	79	72	38	3,694	58	53	31	3,922	61	56	28
	Western Australia State Waters	4,874	68	55	33	6,842	85	78	44	6,741	97	96	88

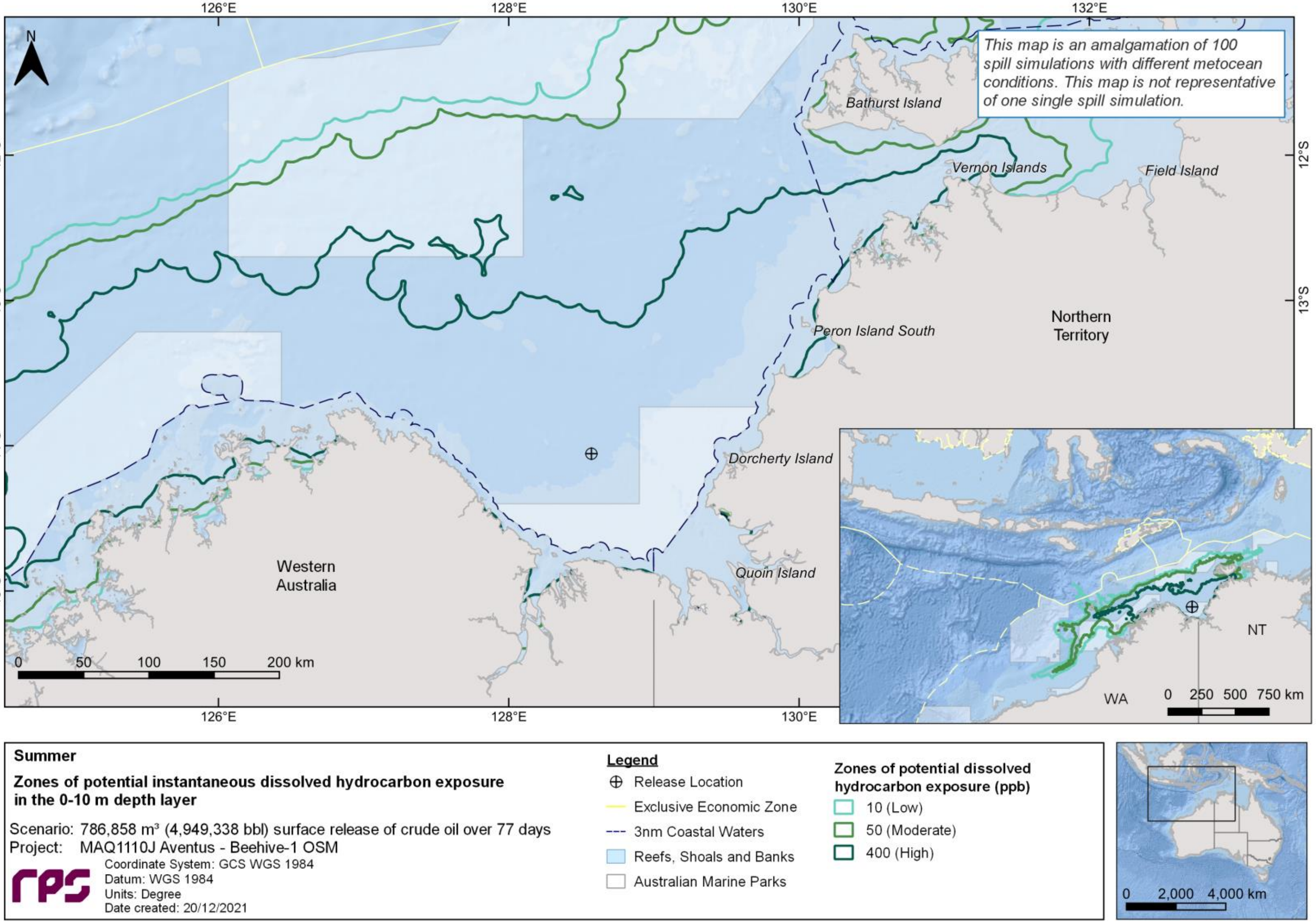


Figure 10.7 Zones of potential dissolved hydrocarbon exposure at 0-10 m below the sea surface, in the event of a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days, during summer conditions. The results were calculated from 100 spill trajectories.

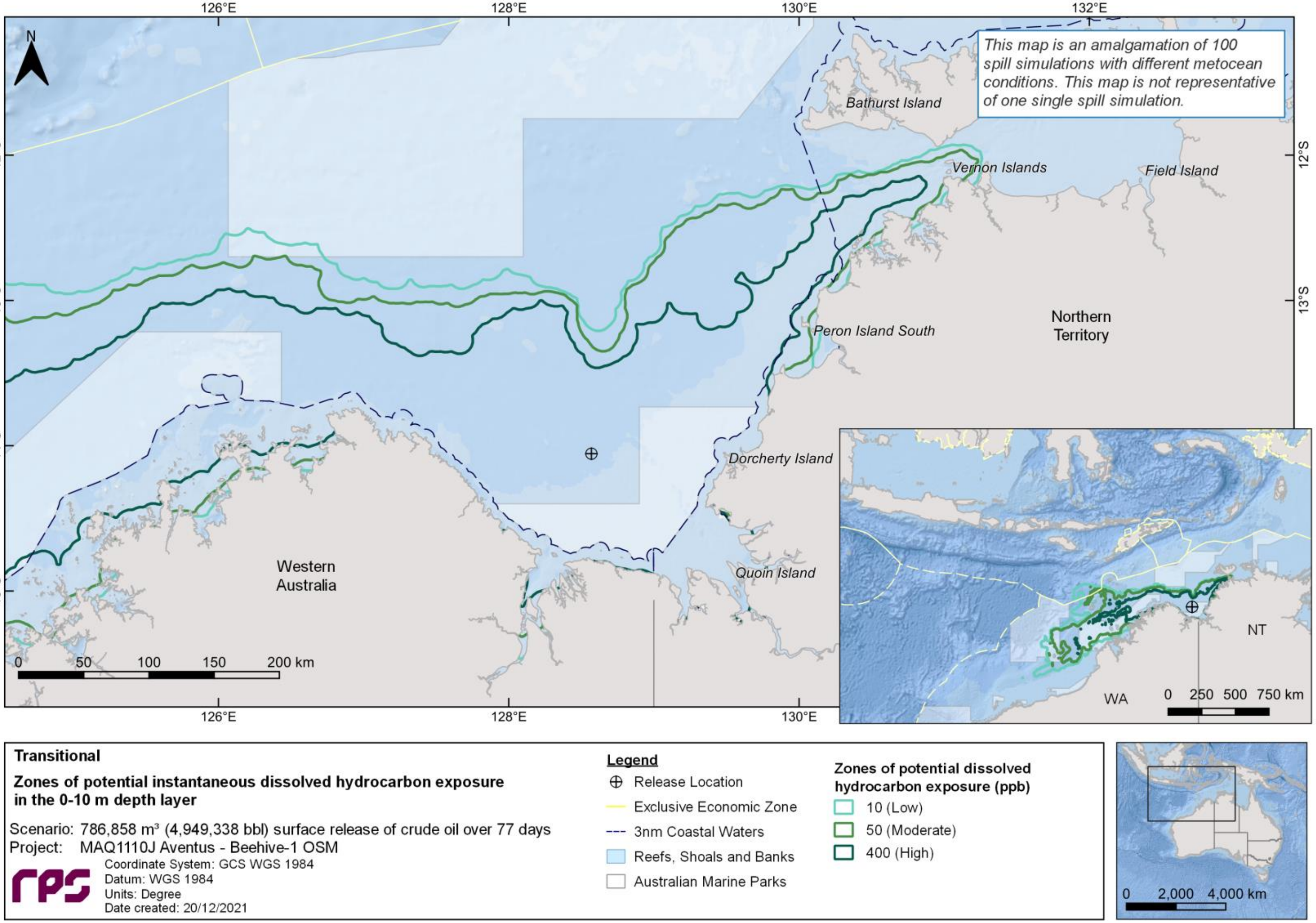


Figure 10.8 Zones of potential dissolved hydrocarbon exposure at 0-10 m below the sea surface, in the event of a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days, during transitional conditions. The results were calculated from 100 spill trajectories.

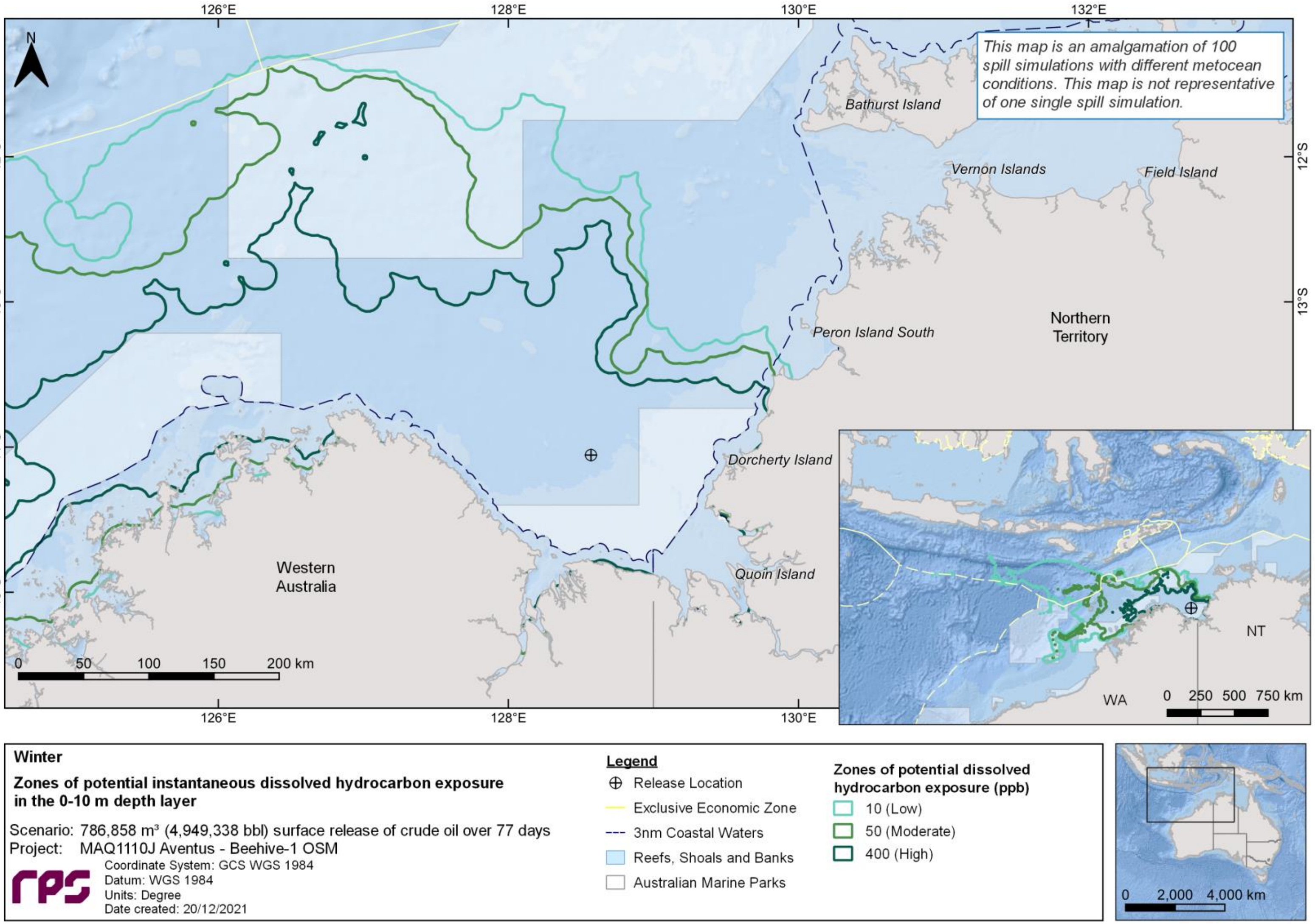


Figure 10.9 Zones of potential dissolved hydrocarbon exposure at 0-10 m below the sea surface, in the event of a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days, during winter conditions. The results were calculated from 100 spill trajectories.

10.1.3.2 Entrained Hydrocarbons

Table 10.8 presents the probability of exposure to individual receptors from entrained hydrocarbons at the low (10-100 ppb) and high (≥ 100 ppb) exposure levels in the 0-10 m depth layers for all seasonal conditions.

In the surface (0-10 m) depth layer, low and high exposure by entrained hydrocarbons was predicted for a large range of receptors (refer to Table 10.8). The carbonate bank and terrace system of the Sahul Shelf KEF, Joseph Bonaparte Gulf AMP, Kimberley AMP, North Kimberley MP and nearshore waters of the Thamarrurr, Wyndham - East Kimberley, Dorcherty Island, Clump Island, Quoin Island, Daly, Victoria Daly shorelines and Ord River floodplain (Ramsar) were some of the receptors predicted with the highest entrained hydrocarbons concentrations for all three seasons.

Figure 10.10 to Figure 10.12 illustrate the zones of potential entrained hydrocarbon exposure for the 0-10 m depth layers at the low (10-100 ppb) and high (≥100 ppb) exposure levels, for each season, respectively.

Table 10.8 Probability of entrained hydrocarbons exposure to marine based receptors in the 0–10 m depth layer. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days, during seasonal conditions. The results were calculated from 100 spill trajectories per season.

Receptor		Summer			Transitional			Winter		
		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure	
			Low	High		Low	High		Low	High
AMP	Arafura	167	8	3	-	-	-	-	-	-
	Argo-Rowley Terrace	335	10	9	629	17	10	395	12	3
	Arnhem	36	6	-	-	-	-	-	-	-
	Ashmore Reef	-	-	-	4	-	-	643	25	14
	Cartier Island	-	-	-	4	-	-	289	32	15
	Joseph Bonaparte Gulf	19,580	100	100	17,299	94	83	17,429	100	98
	Kimberley	8,810	56	48	9,414	74	62	8,870	93	88
	Mermaid Reef	62	7	-	200	11	5	137	2	2
	Montebello	-	-	-	26	1	-	-	-	-
	Oceanic Shoals	2,144	35	21	969	18	11	2,810	71	49
	Christmas Island Exclusive Economic Zone	-	-	-	-	-	-	61	4	-
	East Timorian Exclusive Economic Zone	8	-	-	-	-	-	132	16	5
EEZ	Indonesian Exclusive Economic Zone	359	6	1	378	15	8	719	39	18
KEF	Ancient coastline at 125 m depth contour	3,866	27	26	3,763	54	47	4,013	61	46
	Ashmore Reef and Cartier Island and surrounding Commonwealth waters	1	-	-	4	-	-	643	33	15
	Canyons linking the Argo Abyssal Plain with the Scott Plateau	37	7	-	56	1	-	123	9	1
	Carbonate bank and terrace system of the Sahul Shelf	22,011	99	87	23,413	94	92	22,864	100	100
	Carbonate bank and terrace system of the Van Diemen Rise	1,729	28	20	14	1	-	99	13	-

Receptor		Summer			Transitional			Winter		
		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure	
			Low	High		Low	High		Low	High
	Continental Slope Demersal Fish Communities	3,341	24	24	1,819	52	44	1,900	48	32
	Glomar Shoals	-	-	-	35	1	-	-	-	-
	Mermaid Reef and Commonwealth waters surrounding Rowley Shoals	65	7	-	209	15	5	141	2	2
	Pinnacles of the Bonaparte Basin	4,399	24	14	1,891	18	8	5,563	52	37
	Seringapatam Reef and Commonwealth waters in the Scott Reef Complex	857	13	4	280	8	3	313	21	8
	Shelf break and slope of the Arafura Shelf	32	7	-	5	-	-	-	-	-
	Tributary Canyons of the Arafura Depression	81	5	-	-	-	-	-	-	-
MP	Garig Gunak Barlu	335	18	9	2	-	-	-	-	-
	Lalang-garram / Camden Sound	454	17	9	653	36	15	626	19	5
	Lalang-garram / Horizontal Falls	56	2	-	19	3	-	9	-	-
	North Kimberley	14,706	86	71	15,425	86	81	17,327	98	97
	North Lalang-garram	923	23	14	1,037	41	19	988	27	7
	Rowley Shoals	26	7	-	180	10	4	135	2	2
NR	Scott Reef	628	13	3	189	5	1	175	15	6
Ramsar	Ashmore Reef National Nature Reserve	-	-	-	4	-	-	643	25	14
	Cobourg Peninsula	278	18	6	1	-	-	-	-	-
	Kakadu National Park	88	6	-	-	-	-	-	-	-
	Ord River Floodplain	2,197	67	37	2,812	45	39	2,570	68	64
RSB	Abbott Shoal	640	23	13	3	-	-	-	-	-
	Afghan Shoal	1,126	28	18	6	-	-	-	-	-

Receptor	Summer			Transitional			Winter		
	Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure	
		Low	High		Low	High		Low	High
Albert Reef	613	9	9	834	34	12	831	11	5
Ann Shoals	246	7	6	1	-	-	-	-	-
Baldwin Bank	2,630	39	33	1,068	32	25	2,453	67	46
Barbara Shoal	531	18	9	3	-	-	-	-	-
Barcoo Shoal	268	11	9	646	27	12	613	9	2
Barracouta Shoal	-	-	-	-	-	-	431	29	19
Bass Reef	3,607	36	30	2,681	3	2	2	-	-
Bassett-Smith Shoal	4,942	35	30	5,043	62	47	3,057	76	59
Beagle Shoals	499	26	20	3	-	-	-	-	-
Beagle and Dingo Reefs	765	13	11	804	41	18	772	14	6
Beatrice Reef	174	7	5	1	-	-	-	-	-
Big Bank Shoals	-	-	-	-	-	-	15	2	-
Bill Shoal	1,110	23	15	9	-	-	-	-	-
Branch Banks	5,863	46	43	6,299	66	60	5,610	90	84
Britomart Shoal	47	8	-	-	-	-	-	-	-
Brue Reef	264	9	9	474	18	9	466	10	2
Calder Shoal	58	9	-	-	-	-	-	-	-
Christine Reef	284	16	7	3	-	-	-	-	-
Churchill Reef	569	10	9	1,129	35	11	1,136	12	5
Clerke Reef	21	7	-	171	10	4	125	2	2
Cockell and Nicolle Reefs	32	9	-	30	11	-	121	4	1
Cootamundra Shoal	38	10	-	-	-	-	-	-	-
Deep Shoal 1	660	18	4	44	1	-	1,045	42	17
Deep Shoal 2	536	6	4	3	-	-	889	23	11

Receptor	Summer			Transitional			Winter		
	Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure	
		Low	High		Low	High		Low	High
Draytons Reef	2,523	24	15	104	1	1	-	-	-
East Holothuria Reef	6,890	44	43	7,620	63	59	5,564	87	77
Echo Shoals	-	-	-	-	-	-	15	1	-
Echuca Shoal	3,814	24	24	2,091	51	47	1,196	50	35
Elizabeth Reef	2,547	27	15	125	1	1	-	-	-
Elphinstone Reef	87	11	-	-	-	-	-	-	-
Emu Reefs	9,285	84	81	6,442	53	35	4,607	34	23
Eugene McDermott Shoal	1,046	21	15	743	21	9	829	56	33
Fantome Shoal	-	-	-	-	-	-	167	8	4
Favell Bank	1,835	32	20	852	18	11	1,119	57	29
Fish Reef	3,144	33	29	2,098	3	2	1	-	-
Fitzpatrick Shoal	231	18	9	1	-	-	-	-	-
Flat Top Bank	1,053	29	14	15	1	-	41	8	-
Foelsche Bank	2,472	28	24	1,098	1	1	-	-	-
Gale Bank	1,105	24	17	250	8	3	1,082	44	24
Giles Shoal	452	19	11	2	-	-	-	-	-
Glomar Shoal	-	-	-	12	1	-	-	-	-
Goeree Shoal	47	13	-	185	4	1	466	43	26
Goodrich Bank	133	13	3	2	-	-	-	-	-
Hancox Shoal	1,743	28	24	646	1	1	-	-	-
Harris Reef	1,442	28	24	481	1	1	-	-	-
Heritage Reef	2,234	36	30	2,223	60	57	1,760	69	59
Heywood Shoal	1,084	23	21	888	30	19	954	49	38
Hinkler Patches	181	21	7	-	-	-	-	-	-

Receptor	Summer			Transitional			Winter		
	Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure	
		Low	High		Low	High		Low	High
Holothuria Banks	8,579	51	45	9,350	68	60	6,061	90	83
Howland Shoals	7,657	83	76	6,081	51	47	5,588	40	27
Hunt Patch	489	26	20	4	-	-	-	-	-
Imperieuse Reef	16	4	-	108	9	1	65	2	-
Ingram Reef	2,165	38	33	2,929	60	59	3,002	71	64
Jabiru Shoals	-	-	-	-	-	-	20	1	-
Jamieson Reef	2,734	38	35	3,804	60	59	3,724	74	67
Johnson Bank	-	-	-	2	-	-	264	27	9
Jones Bank	3,316	33	29	2,339	2	2	1	-	-
Jones Shoal	59	11	-	-	-	-	-	-	-
Kelleway Reef	1,442	29	26	969	2	2	-	-	-
Knight Reef	2,305	28	24	794	1	1	-	-	-
Long Reef	3,767	43	43	3,891	60	60	3,939	87	78
Lowry Shoal	700	29	22	240	1	1	-	-	-
Lyne Reef	2,762	28	24	1,113	1	1	-	-	-
Lynedoch Bank	22	3	-	4	-	-	-	-	-
Mangola Shoal	-	-	-	-	-	-	14	1	-
Margaret Shoal	154	7	2	-	-	-	-	-	-
Marie Shoal	204	14	6	3	-	-	-	-	-
Marsh Shoal	2,445	28	24	1,022	1	1	-	-	-
Mataram Shoal	392	17	9	3	-	-	-	-	-
Mavis Reef	519	11	10	709	35	15	722	11	6
Mermaid Reef	45	6	-	184	10	5	136	2	2
Mermaid Shoal	262	15	9	10	-	-	-	-	-

Receptor	Summer			Transitional			Winter		
	Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure	
		Low	High		Low	High		Low	High
Middle Reef	1,984	31	27	1,363	2	2	1	-	-
Moira Reef	1,395	31	26	1,020	2	2	-	-	-
Money Shoal	118	6	2	-	-	-	-	-	-
Moresby Shoals	733	29	22	92	1	-	-	-	-
Moss Shoal	234	16	9	2	-	-	-	-	-
Newby Shoal	467	12	7	6	-	-	11	1	-
Oliver Reef	2,213	28	24	765	1	1	-	-	-
Oliver Rock	2,585	39	37	3,801	60	58	3,758	82	70
Ommaney Shoals	197	21	10	-	-	-	-	-	-
Orontes Reef	53	11	-	-	-	-	-	-	-
Osborn Reefs	537	19	8	659	39	15	708	16	6
Otway Bank	6,204	43	43	6,715	62	59	5,603	88	82
Parry Shoal	251	15	8	4	-	-	-	-	-
Parsons Bank	347	28	16	31	1	-	-	-	-
Penguin Shoal	4,426	40	29	3,852	55	31	4,060	71	50
Rainbow Shoals	188	14	7	265	25	15	532	15	4
Rankin Bank	-	-	-	27	2	-	-	-	-
Renard Shoals	202	22	11	1	-	-	-	-	-
Robroy Reefs	2,091	33	27	2,099	60	56	2,163	66	46
Rothery Reef	3,203	43	43	4,433	60	59	4,377	85	75
Shepparton Shoal	1,377	30	21	16	1	-	1	-	-
Skottowe Shoal	908	29	24	393	2	1	-	-	-
Tait Bank	5,389	50	43	5,573	68	60	6,143	93	88
Taiyun Shoal	753	25	20	4	-	-	-	-	-

Receptor		Summer			Transitional			Winter		
		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure	
			Low	High		Low	High		Low	High
	Taylor Patches	1,892	24	18	94	1	-	-	-	-
	The Boxers	123	3	3	-	-	-	14	2	-
	Tregenna Reef	1,286	28	22	342	1	1	-	-	-
	Van Cloon Shoal	1,839	35	18	828	18	3	2,204	63	44
	Vee Shoal	-	-	-	-	-	-	175	9	4
	Victoria Shoal	261	11	6	3	-	-	-	-	-
	Vulcan Shoal	23	13	-	28	2	-	357	40	22
	Wells Shoal	520	20	11	2	-	-	-	-	-
	West Holothuria Reef	2,670	44	34	3,036	63	59	2,860	77	63
	Wildcat Reefs	289	15	8	370	35	15	602	12	5
	Woodbine Bank	-	-	-	-	-	-	178	28	9
Nearshore Waters	Adele Island	431	11	9	997	29	11	975	11	4
	Ashmore Reef	-	-	-	2	-	-	643	25	14
	Bathurst Island	413	20	12	8	-	-	-	-	-
	Broome	35	2	-	65	7	-	30	1	-
	Browse Island	3,042	24	24	1,542	52	46	954	45	32
	Burford Island	290	13	7	2	-	-	-	-	-
	Cartier Island	-	-	-	2	-	-	266	31	13
	Clerke Reef	20	7	-	166	10	4	125	2	2
	Clump Island	9,454	75	70	9,459	48	46	7,823	56	50
	Cox-Finniss	4,105	57	44	2,527	4	3	6	-	-
	Cunningham Island	14	4	-	92	9	-	60	2	-
	Daly	5,442	73	64	3,227	23	18	739	21	8
	Darwin	1,354	28	22	583	1	1	-	-	-

Receptor	Summer			Transitional			Winter		
	Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure	
		Low	High		Low	High		Low	High
Derby - West Kimberley	93	8	-	101	13	1	42	5	-
Dorcherty Island	9,502	82	79	11,379	52	45	11,284	41	31
Field Island	104	7	1	-	-	-	-	-	-
Grant Island	17	4	-	-	-	-	-	-	-
Greenhill Island	311	10	6	1	-	-	-	-	-
Hibernia Reef	-	-	-	-	-	-	196	19	5
Imperieuse Reef	16	4	-	108	7	1	60	2	-
Kingfisher Islands	33	2	-	19	2	-	6	-	-
Lacepede Islands	27	1	-	12	2	-	1	-	-
Lawson Island	30	6	-	-	-	-	-	-	-
Litchfield	2,345	28	24	867	1	1	-	-	-
McCluer Island	28	7	-	-	-	-	-	-	-
Melville Island	308	28	19	101	1	1	-	-	-
Mermaid Reef	41	6	-	184	10	4	125	2	2
Minjilang	53	8	-	-	-	-	-	-	-
Mogogout Island	155	6	1	-	-	-	-	-	-
Morse Island	156	7	2	-	-	-	-	-	-
New Year Island	39	6	-	-	-	-	-	-	-
Oxley Island	49	8	-	-	-	-	-	-	-
Peron Island North	3,934	59	49	1,333	5	4	10	1	-
Peron Island South	2,769	58	45	1,261	4	3	6	-	-
Quoin Island	9,021	75	70	8,841	49	47	8,554	58	51
Sandy Islet	279	10	3	103	5	1	181	13	6
Scott Reef North	428	13	3	151	6	1	206	12	6

Receptor		Summer			Transitional			Winter		
		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure		Maximum instantaneous entrained hydrocarbon exposure	Probability of instantaneous entrained hydrocarbon exposure	
			Low	High		Low	High		Low	High
	Scott Reef South	688	13	3	238	6	1	196	17	6
	Seringapatam Reef	72	12	-	145	8	3	313	20	7
	South Alligator	2,496	28	19	243	1	1	-	-	-
	Thamarrurr	13,795	82	77	16,021	57	51	15,790	59	52
	Turtle Point	3,687	77	66	3,766	51	41	4,962	60	59
	Vernon Islands	3,139	28	24	1,074	2	1	-	-	-
	Victoria Daly	9,021	80	70	9,459	53	46	9,153	60	59
	West Arnhem	234	18	7	1	-	-	-	-	-
	Whale Flat	4,419	74	70	4,431	47	46	4,196	52	49
	Wunmiyi Island	103	7	1	-	-	-	-	-	-
	Wyndham - East Kimberley	13,432	82	62	13,506	86	72	16,868	97	97
State Waters	Northern Territory Sate Waters	13,975	85	81	16,670	62	57	16,710	65	61
	Western Australia State Waters	14,706	86	71	15,425	86	81	17,327	98	97
MNP - Timor	KKPN Laut Sawu	1	-	-	-	-	-	34	2	-

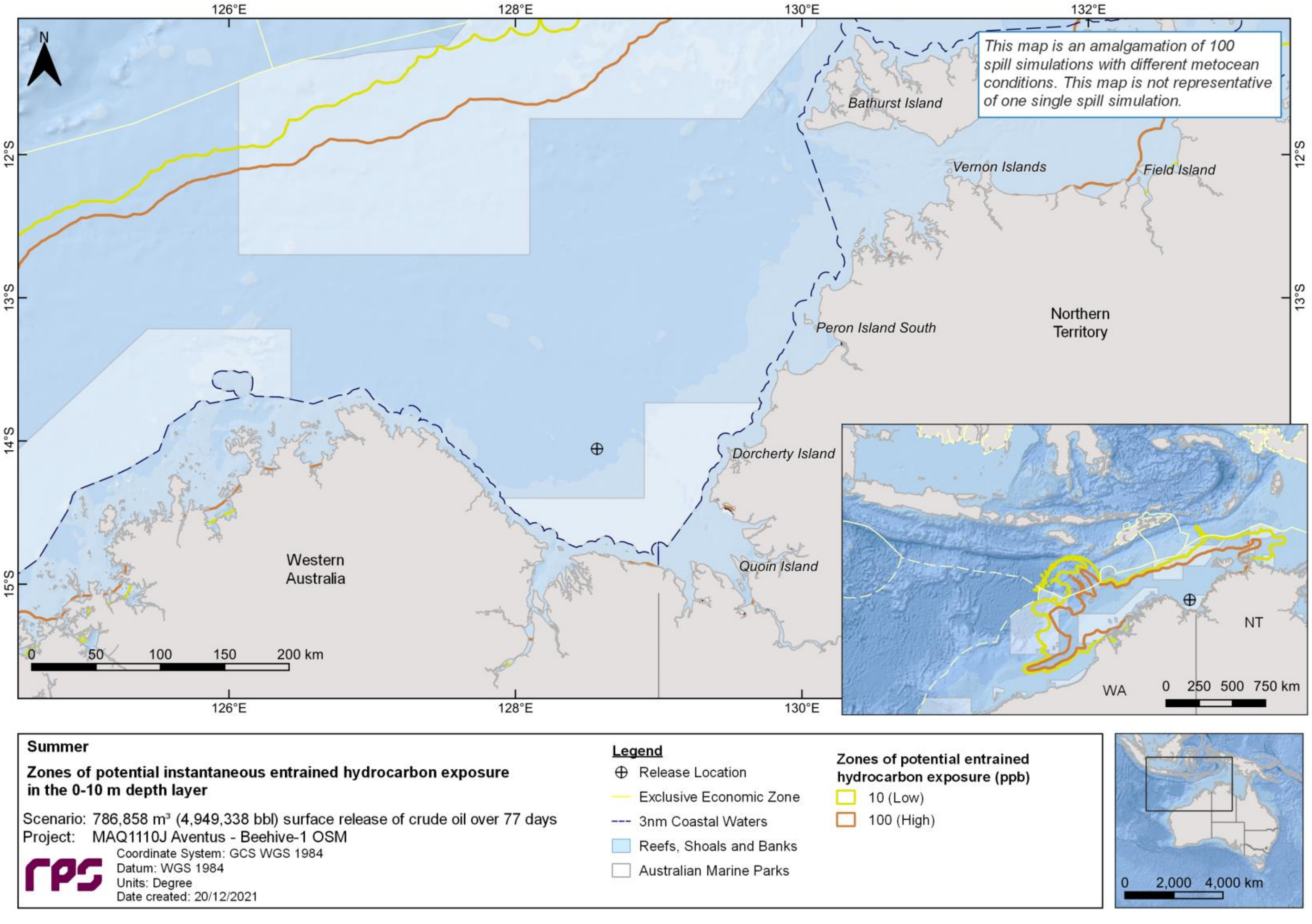


Figure 10.10 Zones of potential entrained hydrocarbon exposure at 0-10 m below the sea surface, in the event of a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days, during summer conditions. The results were calculated from 100 spill trajectories.

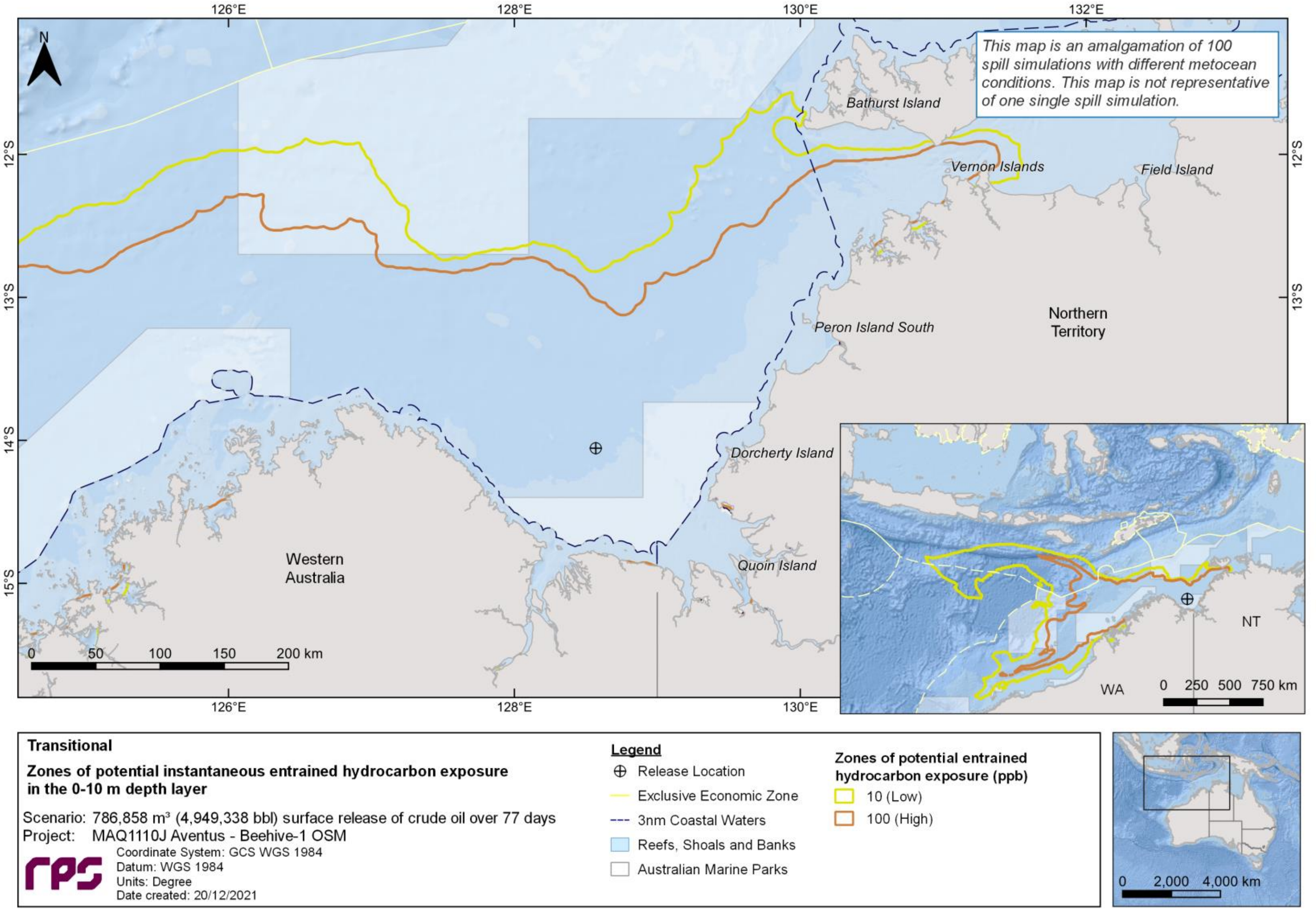


Figure 10.11 Zones of potential entrained hydrocarbon exposure at 0-10 m below the sea surface, in the event of a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days, during transitional conditions. The results were calculated from 100 spill trajectories.

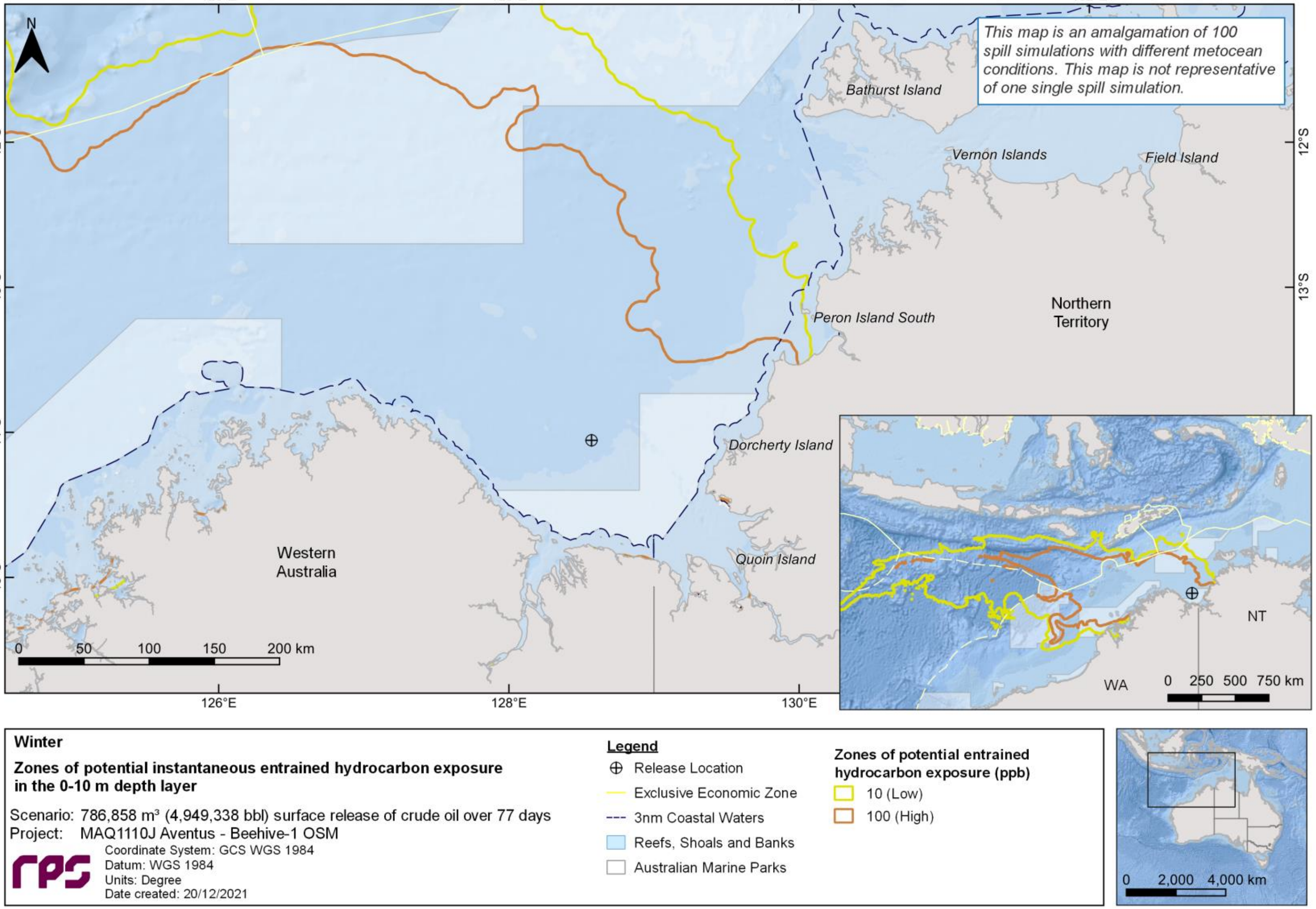


Figure 10.12 Zones of potential entrained hydrocarbon exposure at 0-10 m below the sea surface, in the event of a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days, during winter conditions. The results were calculated from 100 spill trajectories.

10.2 Deterministic Analysis

The stochastic modelling results were assessed, and the “worst case” deterministic runs were identified and presented below. The deterministic analysis assessed the largest swept area of floating oil above 1 g/m^2 (see Section 10.2.1), the minimum time before shoreline accumulation above 10 g/m^2 (see Section 10.2.2), the largest volume of oil ashore (see Section 1.1.1), the longest length of shoreline accumulation above 10 g/m^2 (see Section 1.1.1), the largest area of entrained hydrocarbons above 10 ppb (see Section 10.2.5), and the largest area of dissolved hydrocarbons above 10 ppb (see Section 1.1.1).

Table 10.9 presents a summary of all deterministic analysis criteria and the corresponding floating oil, shoreline accumulation, entrained hydrocarbon and dissolved hydrocarbon values at the assessed thresholds.

Table 10.9 Summary of the deterministic analysis. Results are based on a 786,858 m³ surface release of crude oil over 77 days, tracked for 98 days, during seasonal conditions.

Variable	Threshold	Deterministic Analysis Criteria					
		Largest swept area of floating oil above 1 g/m²	Minimum time before shoreline accumulation above 10 g/m²	Largest volume of oil ashore	Longest length of shoreline accumulation above 10 g/m²	Largest area of entrained hydrocarbons above 10 ppb	Largest area of dissolved hydrocarbons above 10 ppb
Season		Summer	Transitional	Summer	Summer	Winter	Summer
Run Number		79	88	17	33	1	7
Floating Oil Coverage (km²)	1 g/m²	**32,881**	26,229	13,839	16,086	6,331	16,851
	10 g/m²	1,524	1,740	1,879	1,514	734	1,480
	50 g/m²	886	1,047	883	855	446	890
Shoreline Length (km)	10 g/m²	90	212	186	**225**	37	198
	100 g/m²	48	124	115	86	17	72
	1,000 g/m²	1	16	10	0	0	0
Minimum Time (hours)	10 g/m²	835	**603**	476	644	855	732
	100 g/m²	1,300	605	644	806	1,217	752
	1,000 g/m²	2,203	1,107	1,085			
Maximum Volume (m³)		168	261	**705**	232	54	212
Entrained Area (km²)	10 ppb	141,066	83,846	30,291	235,748	**497,484**	238,868
	100 ppb	110,929	59,978	24,455	150,742	132,528	152,077
Dissolved Area (km²)	10 ppb	96,182	56,884	21,430	132,870	57,316	**134,488**
	50 ppb	61,042	46,082	19,147	73,065	25,871	70,991
	400 ppb	16,893	16,397	9,980	15,731	9,955	14,580
Start Date		16th January 2011	23rd September 2016	19th December 2011	25th November 2013	8th June 2011	27th November 2013

NC = No contact at, or above the specified shoreline accumulation threshold.

10.2.1 Deterministic Case: Largest swept area of floating oil above 1 g/m²

The deterministic trajectory that resulted in the largest swept area of floating oil above 1 g/m² (low threshold and visible floating oil) was identified during summer conditions as run number 79 which started on 16th January 2011 (map illustrated in Figure 10.13).

Figure 10.14 displays the time series of the swept area of low (1 g/m²), moderate (10 g/m²) and high (50 g/m²) floating oil over the 98-day simulation.

Figure 10.15 presents the fates and weathering graph for the corresponding single spill trajectory and Table 10.10 summarises the mass balance at the end of the simulation.

Table 10.10 Summary of the mass balance at day 98, for the trajectory that resulted in the largest swept area of floating oil above 1 g/m². Results are based on a 786,858 m³ surface release of crude oil over 77 days, tracked for 98 days.

Exposure Metrics	End of the simulation (day 98)
Surface/Floating Oil (m³)	0
Entrained (m³)	140,659
Dissolved (m³)	419
Evaporated (m³)	296,775
Decay (m³)	348,045
Ashore/Shoreline (m³)	166
Sediment (m³)	794

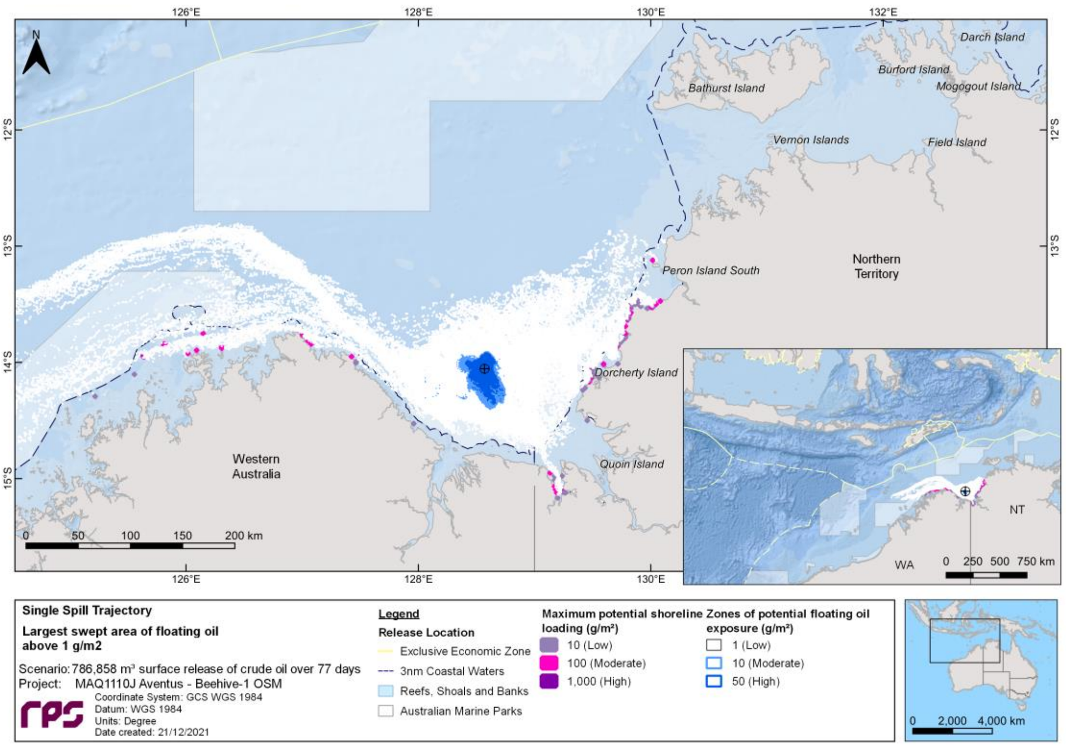


Figure 10.13 Zones of potential floating oil exposure and shoreline accumulation, for the trajectory with the largest swept area of floating oil above 1 g/m². Results are based on a 786,858 m³ surface release of crude oil over 77 days, tracked for 98 days.

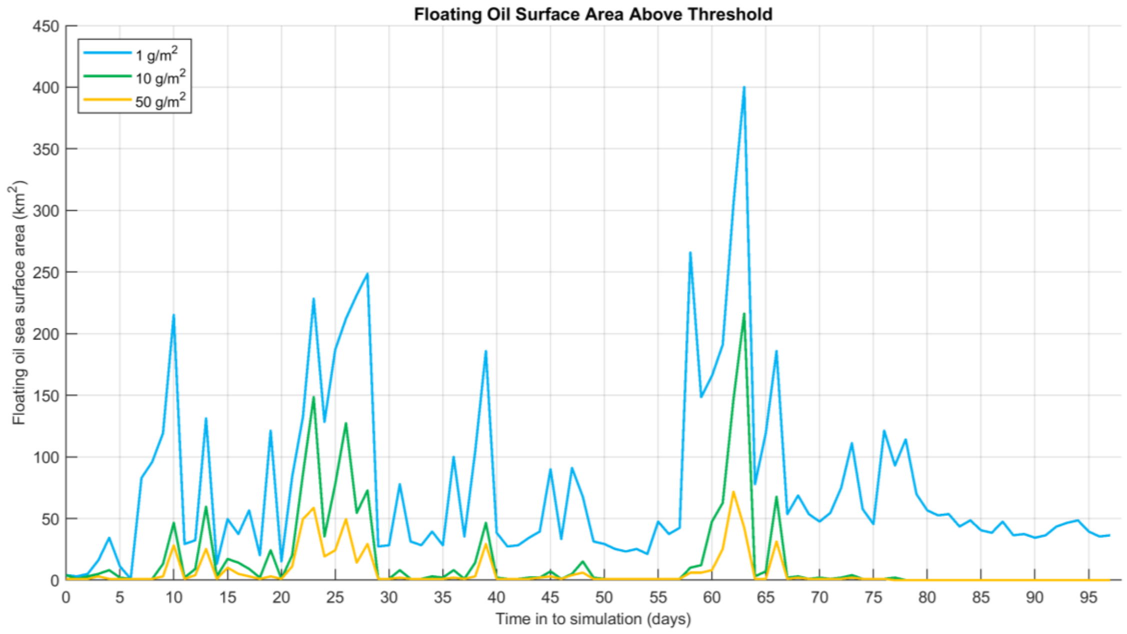


Figure 10.14 Time series of the area of low (1 g/m²), moderate (10 g/m²) and high (50 g/m²) floating oil for the trajectory with the largest swept area of floating oil above 1 g/m². Results are based on a 786,858 m³ surface release of crude oil over 77 days, tracked for 98 days.

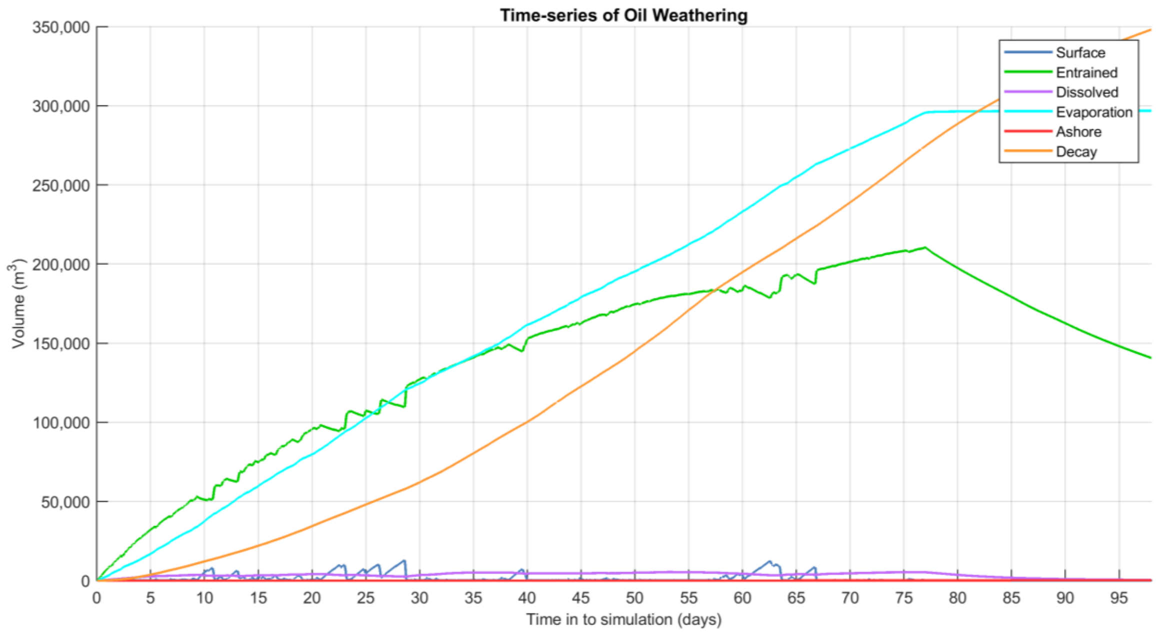


Figure 10.15 Predicted weathering and fates graph for the trajectory with the largest swept area of floating oil above 1 g/m². Results are based on a 786,858 m³ surface release of crude oil over 77 days, tracked for 98 days.

10.2.2 Deterministic Case: Minimum time before shoreline accumulation above 10 g/m²

The deterministic trajectory that resulted in the minimum time before shoreline accumulation above the low threshold (10 g/m²) was identified during transitional conditions as run number 88 which started on the 23rd September 2016 (map illustrated in Figure 10.16

Figure 10.17 presents the fates and weathering graph for the corresponding single spill trajectory and Table 10.11 summarises the mass balance at the end of the 98-day simulation.

Table 10.11 Summary of the mass balance at day 98, for the trajectory that resulted in the minimum time before shoreline accumulation above the low threshold (10 g/m²). Results are based on a 786,858 m³ surface release of crude oil over 77 days, tracked for 98 days.

Exposure Metrics	End of the simulation (day 98)
Surface/Floating Oil (m³)	0
Entrained (m³)	144,203
Dissolved (m³)	401
Evaporated (m³)	317,482
Decay (m³)	323,707
Ashore/Shoreline (m³)	271
Sediment (m³)	794

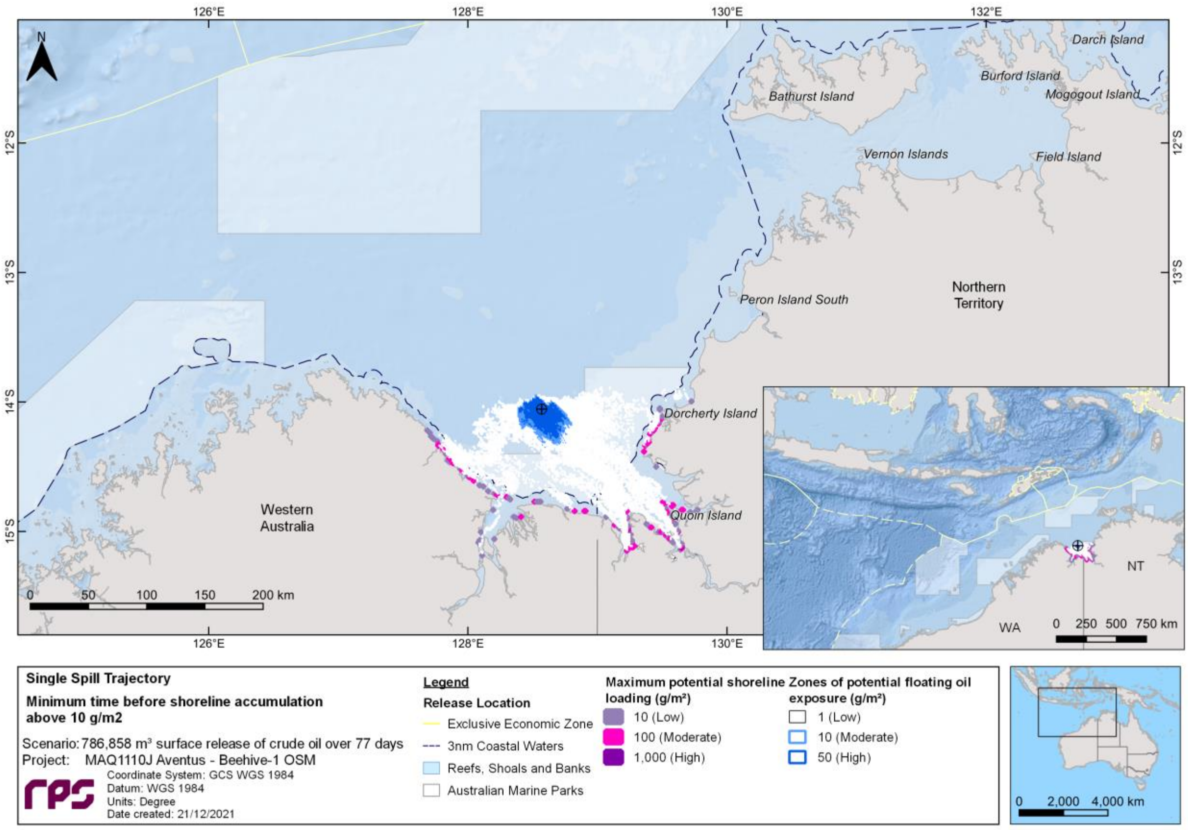


Figure 10.16 Zones of potential floating oil exposure and shoreline accumulation, for the trajectory with the minimum time before shoreline accumulation above 10 g/m². Results are based on a 786,858 m³ surface release of crude oil over 77 days, tracked for 98 days.

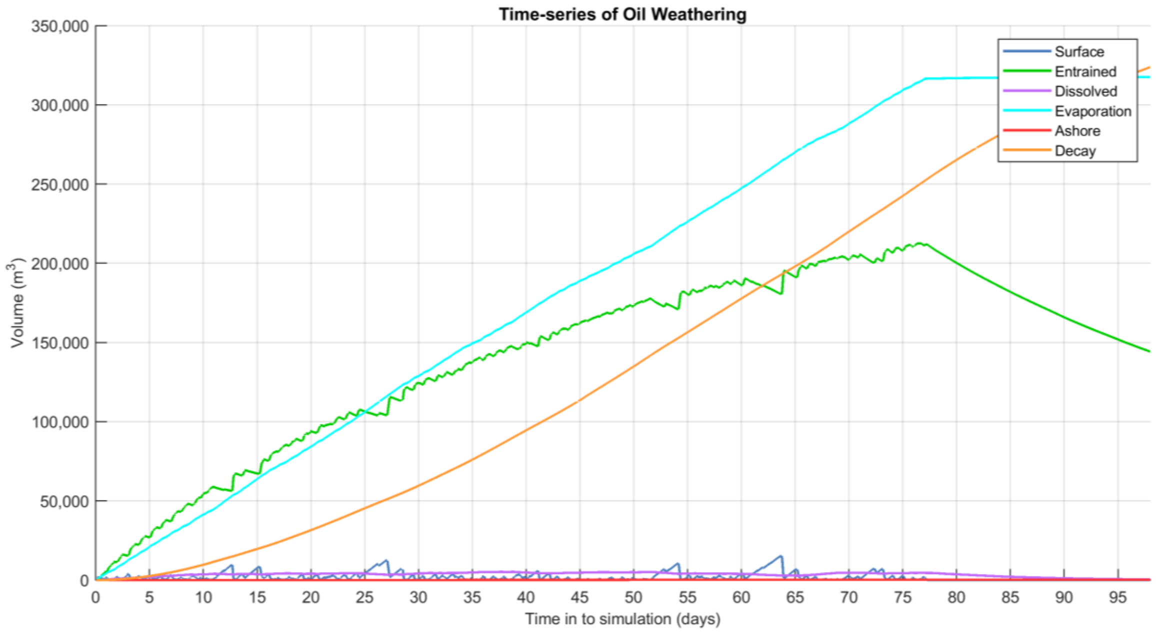


Figure 10.17 Predicted weathering and fates graph for the trajectory with the minimum time before shoreline accumulation above 10 g/m^2. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days.

10.2.3 Deterministic Case: Largest volume of oil ashore

The deterministic trajectory that resulted in the largest volume of oil ashore was identified during summer conditions as run number 84 which started on the 19th December 2011 (map illustrated in Figure 10.18).

Figure 10.19 displays the time series of the volume of oil accumulating on shorelines at the low (10 g/m^2), moderate (100 g/m^2) and high (1,000 g/m^2) thresholds over the 98-day simulation.

Figure 10.20 presents the fates and weathering graph for the corresponding single spill trajectory and Table 10.12 summarises the mass balance at the end of the simulation.

Table 10.12 Summary of the mass balance at day 98, for the trajectory that resulted in the largest volume of oil ashore. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days.

Exposure Metrics	End of the simulation (day 98)
Surface/Floating Oil (m^3)	0
Entrained (m^3)	141,875
Dissolved (m^3)	830
Evaporated (m^3)	325,596
Decay (m^3)	317,102
Ashore/Shoreline (m^3)	659
Sediment (m^3)	794

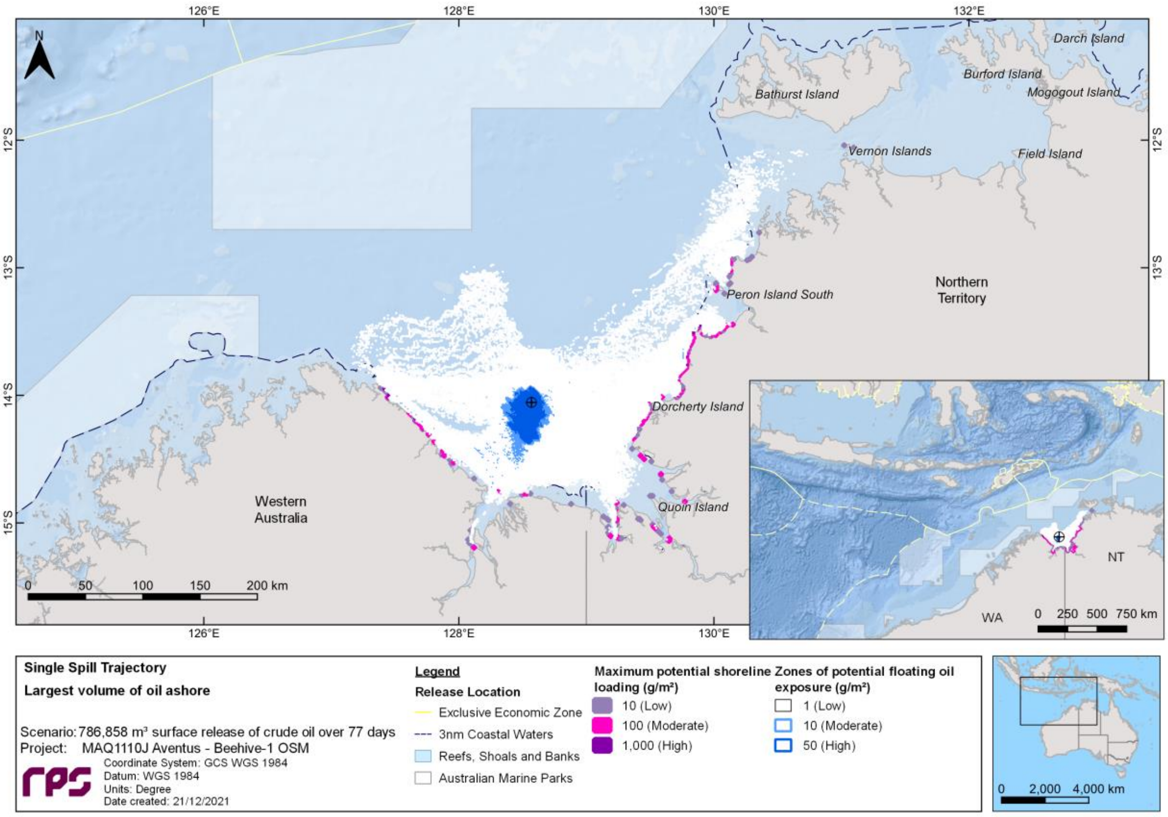


Figure 10.18 Zones of potential floating oil exposure and shoreline accumulation, for the trajectory with the largest volume of oil ashore. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days.

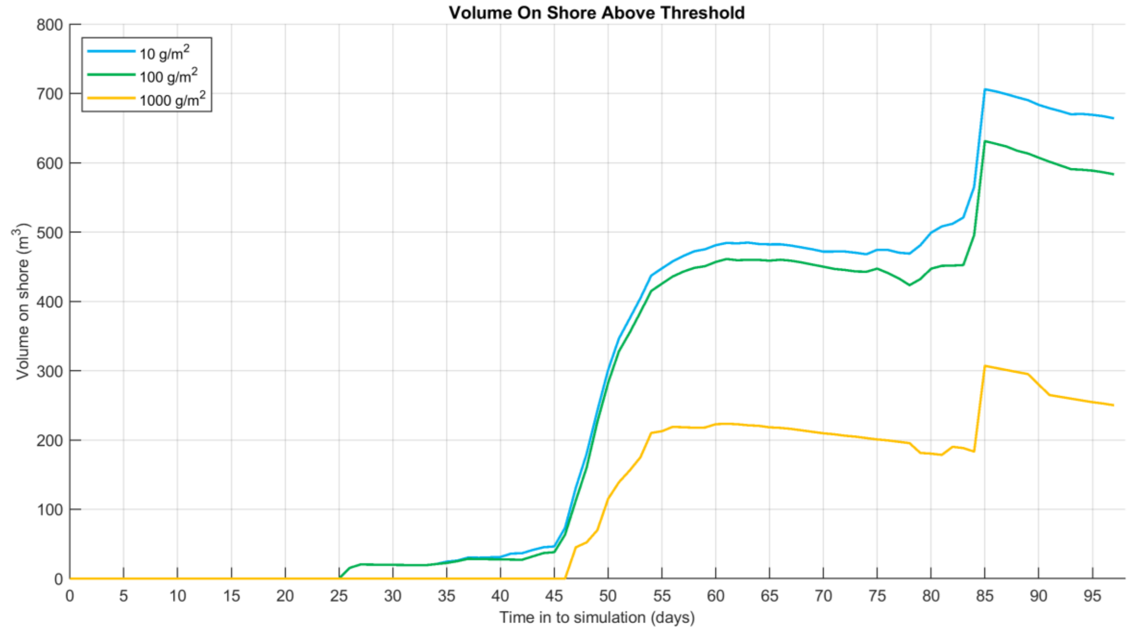


Figure 10.19 Time series of the volume of oil accumulating on shorelines at the low (10 g/m2), moderate (100 g/m2) and high (1,000 g/m2) thresholds for the trajectory with the largest volume of oil ashore. Results are based on a 786,858 m3 surface release of crude oil over 77 days, tracked for 98 days.

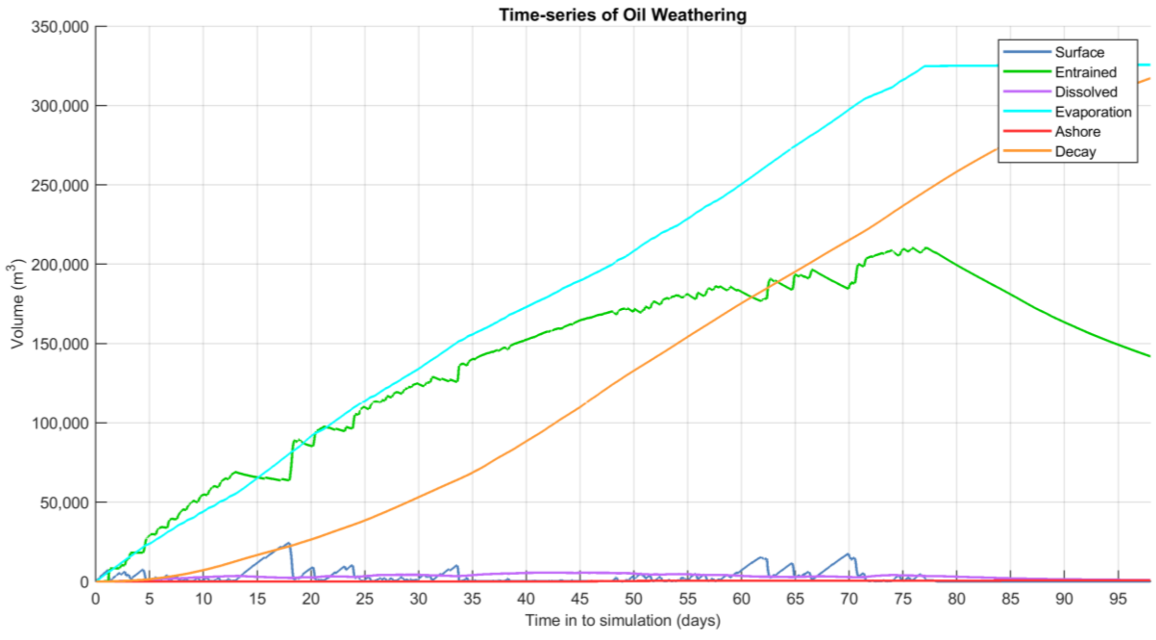


Figure 10.20 Predicted weathering and fates graph for the trajectory with the largest volume of oil ashore. Results are based on a 786,858 m3 surface release of crude oil over 77 days, tracked for 98 days.

10.2.4 Deterministic Case: Longest length of shoreline accumulation above 10 g/m^2

The deterministic trajectory that resulted in the longest length of shoreline accumulation above 100 g/m^2 was identified during summer conditions as run number 33 which started on the 25th November 2013 (map illustrated in Figure 10.21).

Figure 10.22 displays the time series of the length of oil accumulation on shorelines at the low (10 g/m^2), moderate (100 g/m^2) and high (1,000 g/m^2) thresholds over the 98-day simulation.

Figure 10.23 presents the fates and weathering graph for the corresponding single spill trajectory and Table 10.13 summarises the mass balance at the end of the simulation.

Table 10.13 Summary of the mass balance at day 98, for the trajectory that resulted in the longest length of shoreline accumulation above 10 g/m^2. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days.

Exposure Metrics	End of the simulation (day 98)
Surface/Floating Oil (m^3)	0
Entrained (m^3)	140,158
Dissolved (m^3)	491
Evaporated (m^3)	315,572
Decay (m^3)	329,599
Ashore/Shoreline (m^3)	245
Sediment (m^3)	794

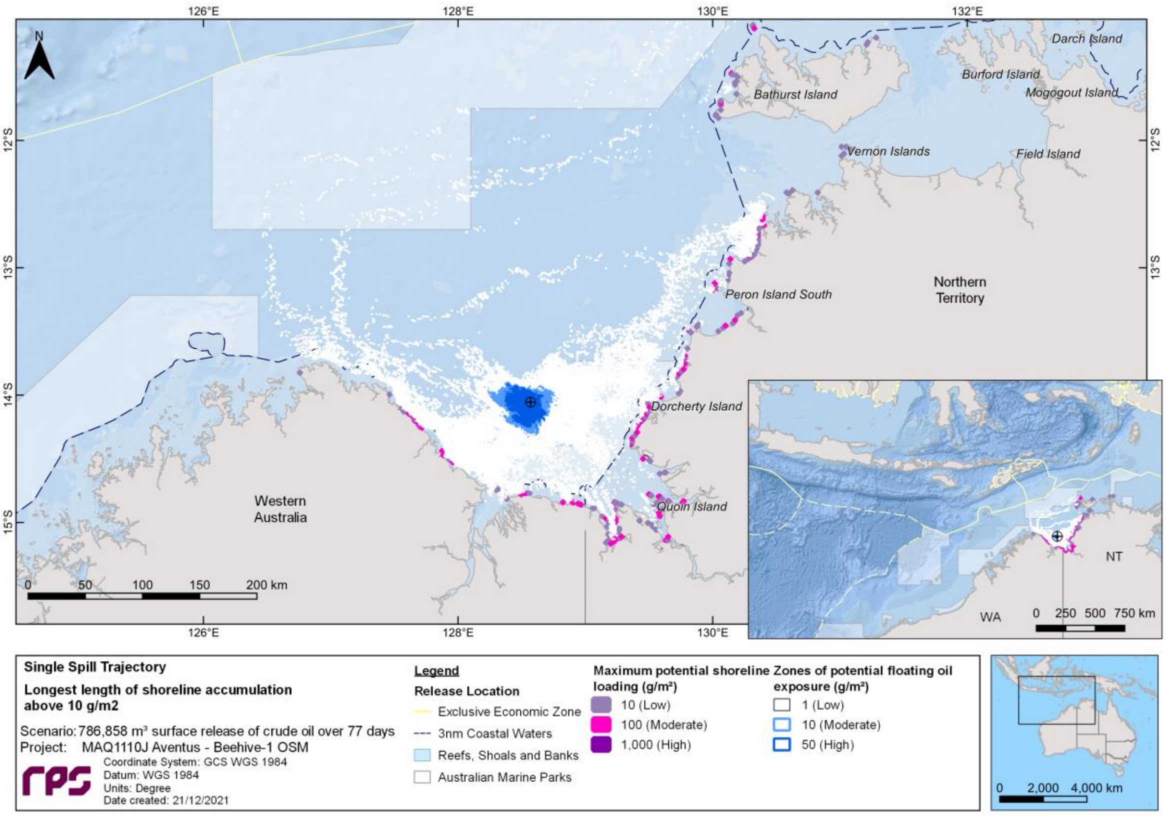


Figure 10.21 Zones of potential floating oil exposure and shoreline accumulation, for the trajectory with the longest length of shoreline accumulation above 10 g/m^2. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days.

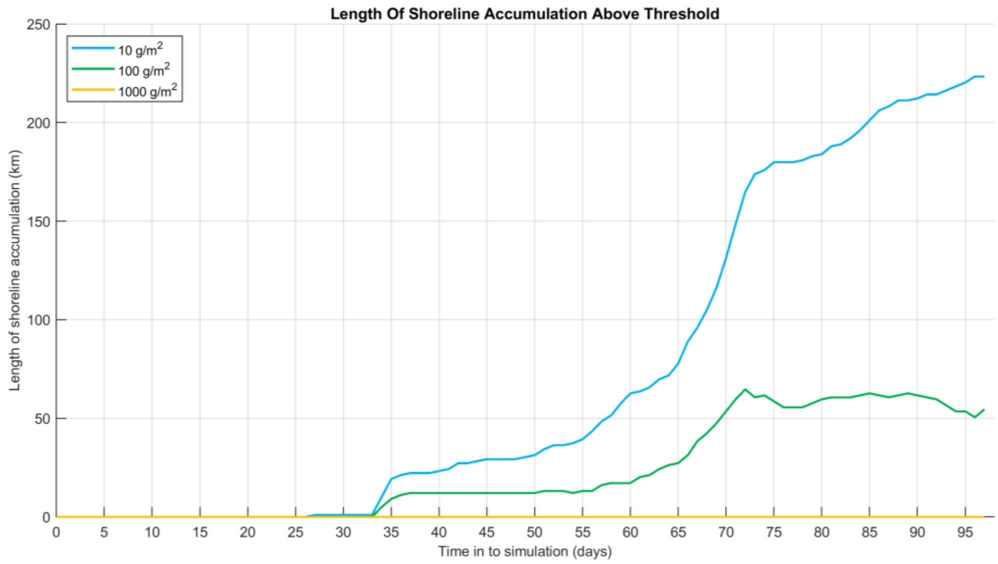


Figure 10.22 Time series of the length of shoreline at the low (10 g/m^2), moderate (100 g/m^2) and high (1,000 g/m2) thresholds for the trajectory with the longest length of shoreline accumulation above 10 g/m^2. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days.

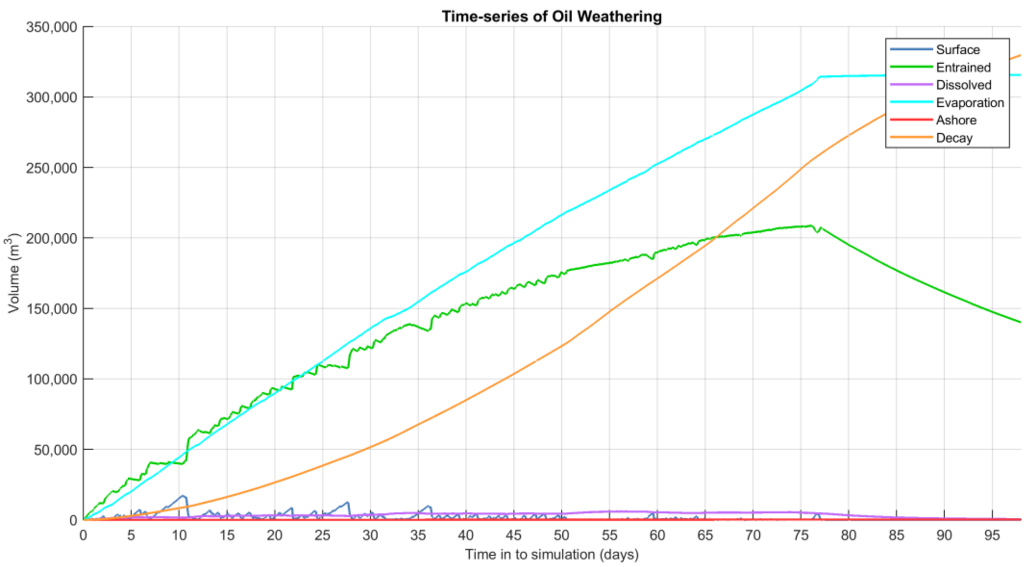


Figure 10.23 Predicted weathering and fates graph for the trajectory with the longest length of shoreline accumulation above 10 g/m^2. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days.

10.2.5 Deterministic Case: Largest area of entrained hydrocarbons above 10 ppb

The deterministic trajectory that resulted in the largest area of entrained hydrocarbons above 10 ppb (low threshold) was identified during winter conditions as run number 1 which started on the 8th June 2011 (map illustrated in Figure 10.24).

Figure 10.25 displays the time series of the area of entrained hydrocarbons at the low (10 ppb) and moderate (100 ppb) thresholds over the 98-day simulation.

Figure 10.26 presents the fates and weathering graph for the corresponding single spill trajectory and Table 10.14 summarises the mass balance at the end of the simulation.

Table 10.14 Summary of the mass balance at day 98, for the trajectory that resulted in the largest area of entrained hydrocarbons above 10 ppb. Results are based on 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days.

Exposure Metrics	End of the simulation (day 98)
Surface/Floating Oil (m^3)	0
Entrained (m^3)	142,358
Dissolved (m^3)	562
Evaporated (m^3)	291,765
Decay (m^3)	351,324
Ashore/Shoreline (m^3)	55
Sediment (m^3)	794

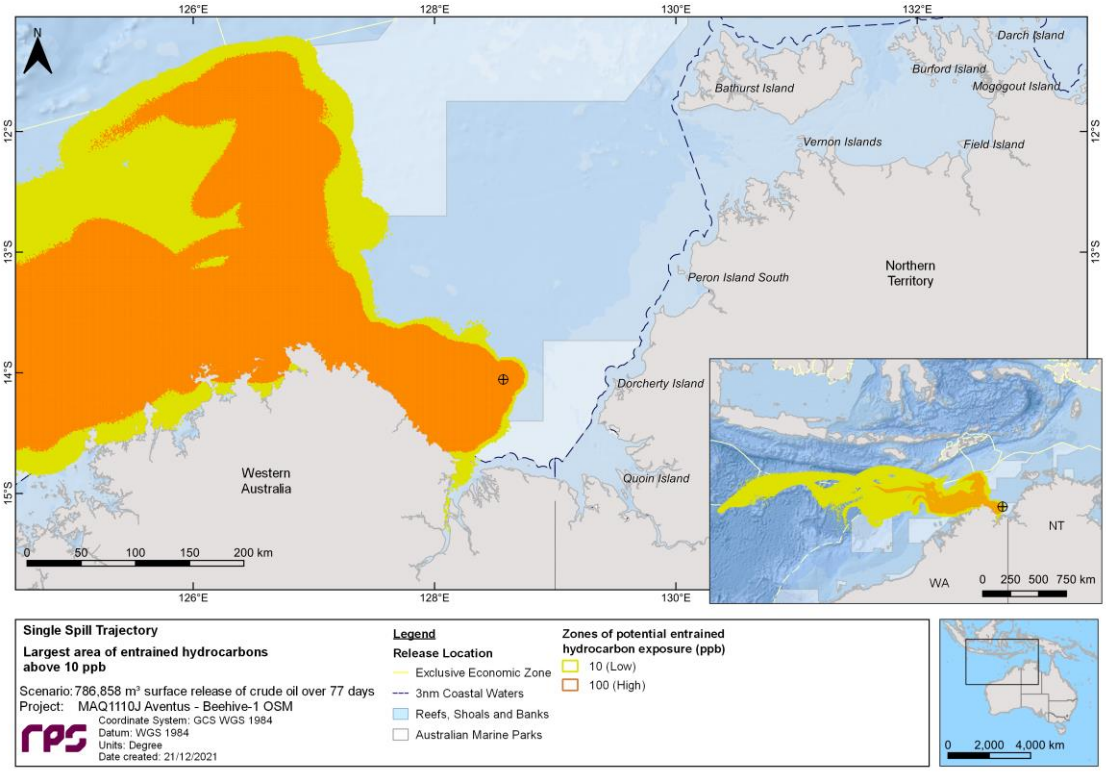


Figure 10.24 Zones of potential entrained hydrocarbon exposure, for the trajectory with the largest area of entrained hydrocarbons above 10 ppb. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days.

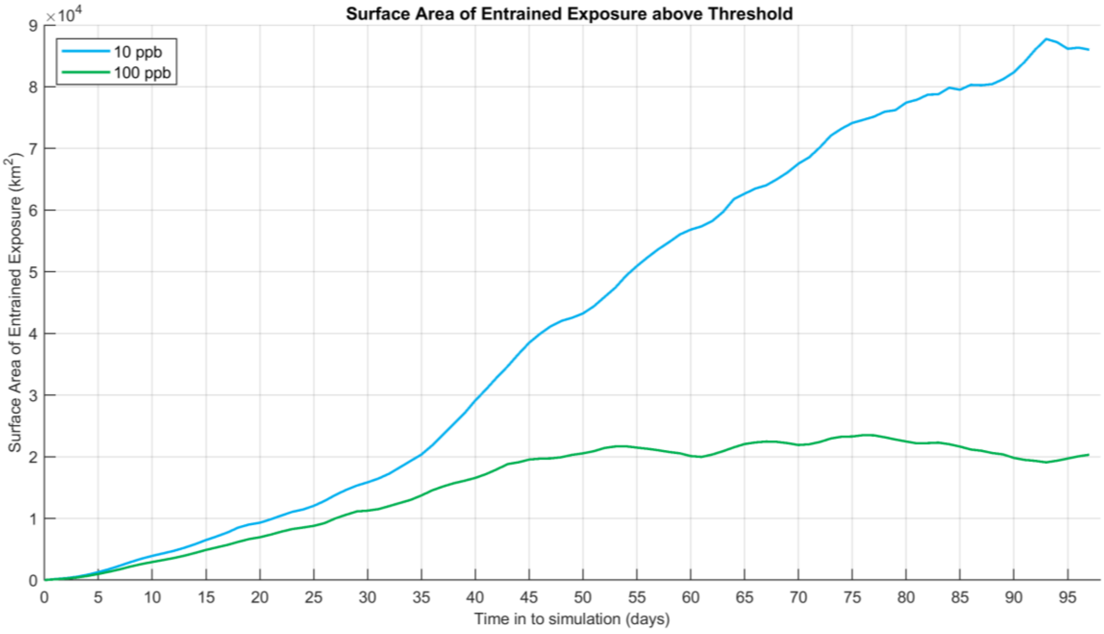


Figure 10.25 Time series of the area of low (10 ppb) and moderate (100 ppb) entrained hydrocarbons for the trajectory with the largest area of entrained hydrocarbons above 10 ppb. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days.

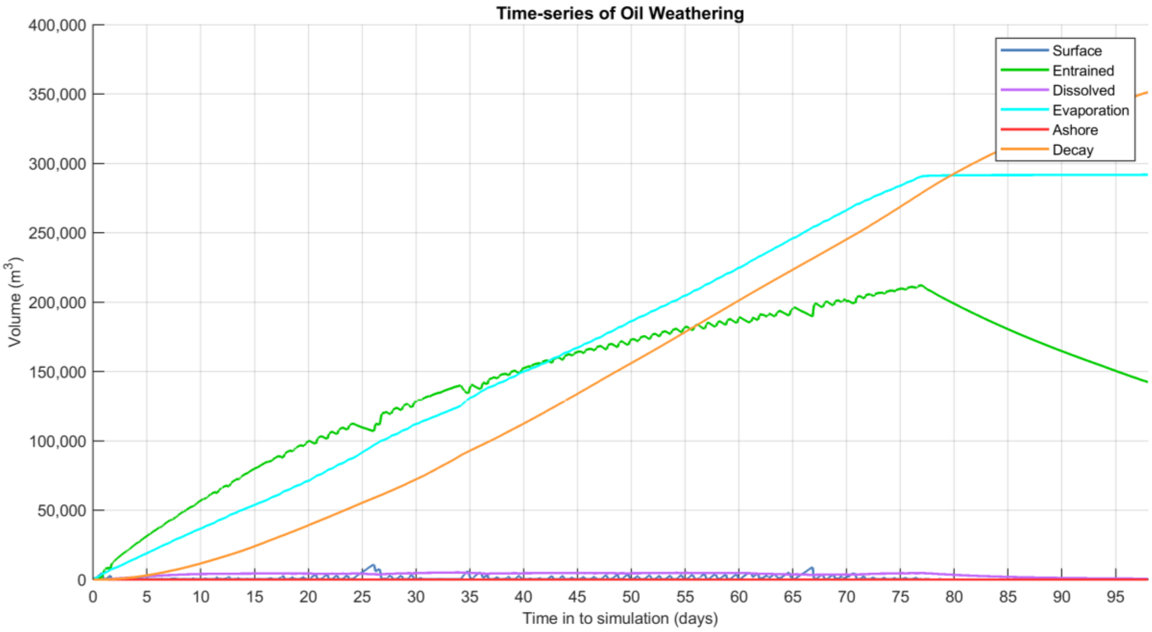


Figure 10.26 Predicted weathering and fates graph for the trajectory with the largest area of entrained hydrocarbons above 10 ppb. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days.

10.2.6 Deterministic Case: Largest area of dissolved hydrocarbons above 10 ppb

The deterministic trajectory that resulted in the largest area of dissolved hydrocarbons above 10 ppb (low threshold) was identified during summer conditions as run number 7 which started on the 27th November 2013 (map illustrated in Figure 10.27).

Figure 10.28 displays the time series of the area of dissolved hydrocarbons at the low (10 ppb), moderate (50 ppb) and high (400 g/m^2) thresholds over the 98-day simulation.

Figure 10.29 presents the fates and weathering graph for the corresponding single spill trajectory and Table 10.15 summarises the mass balance at the end of the simulation.

Table 10.15 Summary of the mass balance at day 98, for the trajectory that resulted in the largest area of dissolved hydrocarbons above 10 ppb. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days.

Exposure Metrics	End of the simulation (day 98)
Surface/Floating Oil (m^3)	0
Entrained (m^3)	140,338
Dissolved (m^3)	505
Evaporated (m^3)	315,546
Decay (m^3)	329,456
Ashore/Shoreline (m^3)	219
Sediment (m^3)	794

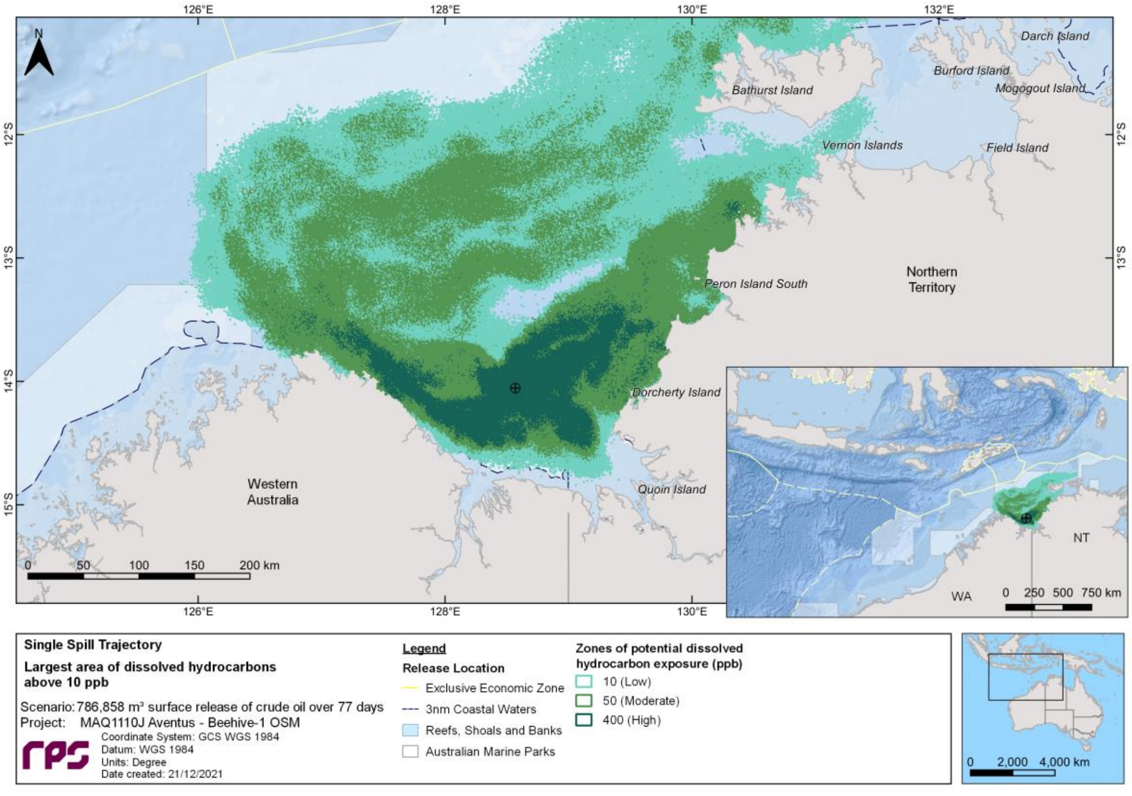


Figure 10.27 Zones of potential dissolved hydrocarbon exposure, for the trajectory with the largest area of dissolved hydrocarbons above 10 ppb. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days.

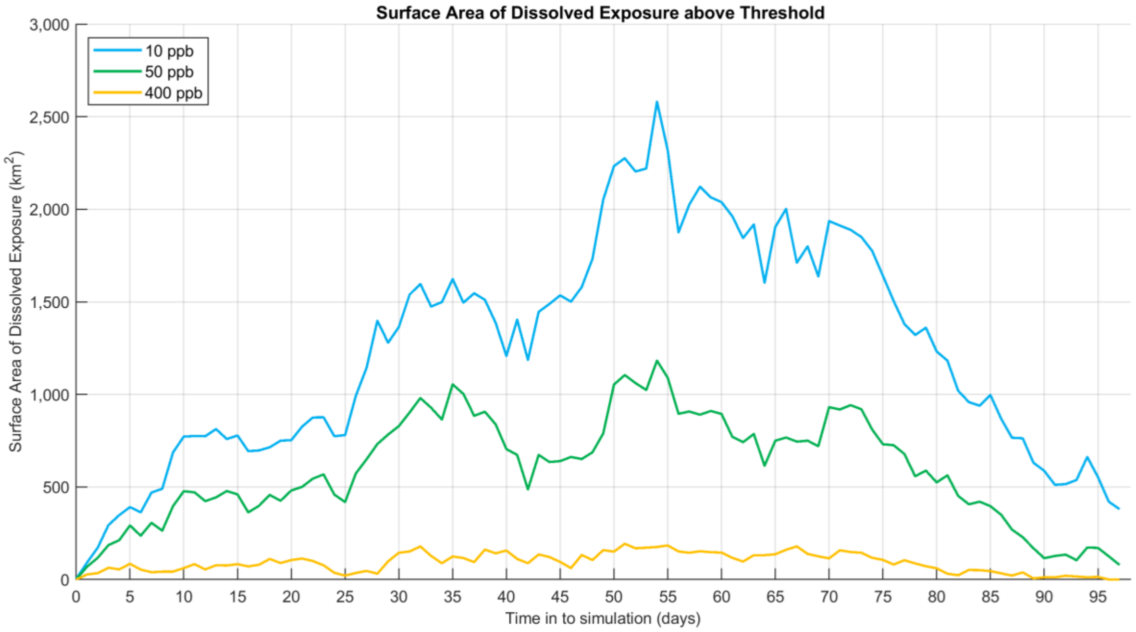


Figure 10.28 Time series of the area of low (10 ppb), moderate (50 ppb) and high (400 ppb) dissolved hydrocarbons for the trajectory with the largest area of dissolved hydrocarbons above 10 ppb. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days.

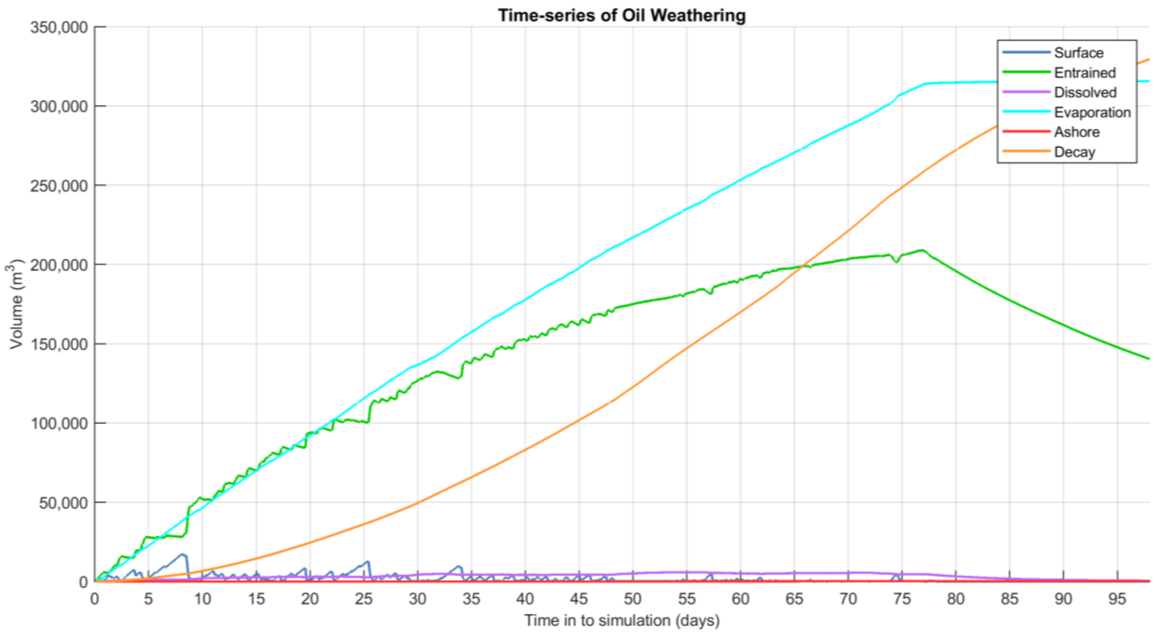


Figure 10.29 Predicted weathering and fates graph for the trajectory with the largest area of dissolved hydrocarbons above 10 ppb. Results are based on a 786,858 m^3 surface release of crude oil over 77 days, tracked for 98 days.

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Appendix 7

Spill Response Strategic Net Environmental Benefits Analysis and ALARP Demonstration

Strategic Spill Response NEBA and ALARP Demonstration

Strategic NEBA of Spill Response Strategies

The overall aim of a response to a LoWC is to stop or control the flow of oil and remove spilled oil to minimise damage to the environment. There are a number of potential spill response strategies that can be implemented, though not all of them are effective when considering the spilled hydrocarbon type, location and local and regional environmental sensitivities.

This section describes the strategic NEBA for a LoWC from Beehive-1. The NEBA assesses each potential spill response strategy on the basis of the following criteria:

- Environmental benefits;
- Environmental impacts and risks; and
- Operational constraints.

If a response strategy is considered applicable, then its appropriateness as a primary or secondary response strategy is evaluated. This strategic NEBA employs the following process:

- List the available response strategies;
- Identify the benefit, environmental impacts and risks and operational constraints of each response strategy;
- Evaluate the applicability of each response strategy;
- The response strategies are further delineated as:
    - Primary response strategy - to be used as soon as possible in the event of a spill.
    - Secondary response strategy - to be implemented as and if needed, and only when practicable if there is a net environmental benefit.
    - Not applicable (N/A) response strategies.
    - Rejected response strategy – based on the lack of net environmental benefit.

In the event of an oil spill resulting from a LoWC, operational NEBAs will be undertaken by the Drilling Incident Management Team (DIMT) during the Incident Action Plan (IAP) process to evaluate response options that have a net environmental benefit. As such, the combination of spill response strategies and their implementation may evolve over time as conditions change on the basis of the operational (real-time) NEBAs. Table A7.1 presents the Strategic NEBA for the OPEP.

Table A7.1. Strategic NEBA of oil spill response strategies

Response strategy	Environmental benefits	Environmental impacts and risks	Operational constraints	Suitable response?	Primary or secondary	Justification
Source control – relief well	Limits the volume of oil released to the environment. Successful drilling of relief well estimated to take 77 days after the LoWC.	Routine discharges from the MODU and support vessels (e.g., all the impacts and risks associated with vessel operations, see EP Chapters 7 & 8).	There are few jack-up MODUs generally available in Australia at any one time. Predicted to take 24 days to source and mobilise a MODU to the Beehive-1 location. Additional equipment is necessary to drill a relief well.	Yes	Primary	Most effective method to gain permanent control of the well and prevent further oil releases.
Source control – capping stack	Limits the volume of oil released to the environment until a successful relief well is drilled.	Localised physical disturbance to seabed. Risks from operation of vessel spread to support deployment of equipment (e.g., all the routine planned and unplanned events associated with vessel operations, see EP Chapters 7 & 8).	Well capping is not suitable for Beehive-1 because these systems are designed for subsea wellhead applications and therefore not suitable for jack-up MODU surface application systems as is the case for Beehive-1.	No	N/A	Per 'operational constraints.'
Source control – subsea dispersant application	Direct subsea application of dispersant at the wellhead decreasing volumes of dispersant required via aerial and/or vessel application. Reduced surface oil above the wellhead reduces safety hazard (volatile organic compounds [VOCs] and explosion risk) to allow use of other response strategies.	Minor localised physical disturbance to the seabed. Routine discharges from the MODU and support vessels (e.g., all the impacts and risks associated with vessel operations, see EP Chapters 7 & 8). Toxicity effects of chemical dispersant to marine fauna. Increased concentration of hydrocarbons in the water column (reducing the opportunity for evaporation from the sea surface).	Subsea dispersant application is not suitable for Beehive-1 because this response is designed for subsea wellhead applications, and therefore not suitable for jack-up MODU surface application systems as is the case for Beehive-1.	No	N/A	Per 'operational constraints.'
Monitor and evaluate	Vessel surveillance	Enables real-time decisions to be made to identify emerging environmental risks, to plan spill response and to assess response effectiveness. Risks from operations of monitoring vessels and aircraft (e.g., routine emissions and discharges, marine fauna interactions). Routine discharges from vessels (e.g., all the impacts and risks associated with vessel operations, see EP Chapters 7 & 8) and aircraft (fauna disturbance, noise, air emissions). Requires ready access to aircraft and trained oil observers. Access to both is available through AMOSC and OSRL. Satellite tracking buoys deployed at the time of the release will assist in directing aircraft and vessels to visually monitor the spill. Visual observations will be restricted at night or during poor weather conditions.	Provides real-time information on spill trajectory and behaviour (e.g. weathering). Informs implementation of other response strategies. Vessel personnel may not be trained observers. Vessel observers on leaking vessel may not have capacity to observe oil during emergency response procedure implementation. Constrained to daylight. Limited to visual range from the vessel. Limited capacity to evaluate possible interactions with sensitive receptors.	Yes	Primary	Constant monitoring and evaluation of the spill enables better real-time response decisions to be made.
	Aerial surveillance		Provides real-time information on spill trajectory and behaviour (e.g., weathering). May identify environmental sensitivities impacted or at risk of impact (e.g., seabird aggregations, other users such as fishers). Informs implementation of other response strategies.	Yes	Primary	
	Oil spill trajectory modelling		Can be implemented rapidly. Predictive – provides estimate of where the oil may go, which can be used to prepare and implement other responses. No additional field personnel required. Not constrained by weather conditions. Can predict floating, entrained, dissolved and stranded hydrocarbon fractions. May not be accurate. Requires in-field calibration.	Yes	Primary	

Response strategy	Environmental benefits	Environmental impacts and risks	Operational constraints	Suitable response?	Primary or secondary	Justification
	Satellite imagery		Ancillary information can be gathered in all weather, day/night, however Synthetic Radar Analysis (SAR) algorithm used to generate oil on water detection depends significantly on wind conditions. Specifically: 1.5 – 2m/s to 15m/s range. Outside this range the imagery provided uses colour codes to indicate confidence levels for detection in various parts of the designated area of interest captured. Mobilisation likely to be >24 hours. Requires processing. May return false positives.	Yes	Primary	
	Tracking buoys		Can be implemented rapidly. Tracking buoys simulate oil-on-water movement as defined roughly by 100% with current and 3% with the wind.	Yes	Primary	
In-situ burning (ISB)	Combustion of oil on sea surface reduces the volume remaining on the surface.	Generates black smoke, particulates and GHG, with potential health risks to responders. Generates modest waste products for recovery and disposal. Incomplete combustion residues may be toxicologically damaging and could be ingested by marine life or coat gills, feathers, and hair. Routine discharges from vessels (e.g., all the impacts and risks associated with vessel operations, see EP Chapters 7 & 8) and aircraft (fauna disturbance, noise, air emissions).	Thick hydrocarbon film is required for ignition/ combustion (5-10 mm). The predicted light nature of the crude means this may not occur. There are no fireproof booms available in Australia. ISB has never been conducted in Australia (limited personnel experience). Ignition of hydrocarbon requires specialist training and equipment. Wind and sea conditions a key constraint, with light wind and low wave heights required for safe and controlled burning (wind limited to 10 kts, and wave height <1 m, IPIECA-IOGP, 2015).	No	N/A	Per 'operational constraints.'
Surface dispersant application – vessel	Accelerates breakup of surface oil by reducing oil-water interfacial tension to increase entrained oil and its sub-surface dispersal, thereby reducing potential impacts at the sea surface (e.g., seabirds) and to sensitive shoreline receptors (e.g., mangroves, turtle nesting beaches). Oil stranded on shorelines will be more weathered and less toxic. Can be activated quickly (within first day after spill) over a wide area irrespective of sea surface conditions. Reduction in onshore hydrocarbon waste disposal requirements.	Adds chemical to the environment, introducing additional toxicity impacts to marine fauna that may not have otherwise been affected by the oil (e.g., pelagic species, coral reefs and shoals). Doesn't remove oil from the environment (simply pushes surface oil into the water column). Increased concentration of sub-surface hydrocarbons in the water column, which may take longer to weather. Routine discharges from vessels (e.g., all the impacts and risks associated with vessel operations, see EP Chapters 7 & 8) and aircraft (fauna disturbance, noise, air emissions).	Uncertain amenability of Beehive-1 oil to dispersant. A test spray would be required. Aerial application only possible with wind less than 35 knots, and wave height less than 5 m (IPIECA-IOGP, 2015). Vessel application may have a wider range of suitable weather conditions compared to aerial application, though the number of vessel boom spray equipment and vessels will be limited. The volume of suitable dispersant could potentially limit response implementation, but available stockpiles demonstrates that needs can be met (6,386 m^3 readily available from AMSA, AMOSC and OSRL, with a predicted need for 4,278 m^3). Requires clear area with no (or limited) simultaneous operations. Trajectory of sub-surface dispersed hydrocarbons is difficult to track (requires tracking of water currents rather than winds).	Yes	Secondary	Environmental benefits outweigh the impacts and risks. This is a strategy that the oil and gas industry is well-prepared to implement.
Surface dispersant application – aerial				Yes	Primary	

Response strategy	Environmental benefits	Environmental impacts and risks	Operational constraints	Suitable response?	Primary or secondary	Justification
Mechanical dispersion (vessel propellors)	Enhances dispersion and break-up of surface hydrocarbons to facilitate natural degradation processes.	Increases oil concentrations in the water column. Routine discharges from vessels (e.g., all the impacts and risks associated with vessel operations, see EP Chapters 7 & 8).	Vessels not designed to cavitate, not efficient at breaking up slicks. Potential OHS risks for vessel-based responders through ignition or inhalation of vapours from the oil, especially as Jabiru crude is so volatile (79% volatile components). Small oil droplet size required otherwise the oil can resurface. For some oil types there is limited benefit unless combined with dispersant application (suitability is unknown for Jabiru crude). Wind speeds above 20 knots provide natural dispersion, making this method redundant in windy weather.	No	No	AMOSC advices that this is not considered best practice and not recommended for either MDO or crude.
Containment & recovery	Contains the spill as close as possible to the source. Recovery reduces spread of surface oil and thereby risks to sensitive shoreline receptors. Removal of oil from the environment. Requires minimum slick concentrations >10 g/m^2, which the OSTM predicts to be extensive.	Routine discharges from vessels (e.g., all the impacts and risks associated with vessel operations, see EP Chapters 7 & 8). Cleaning and disposal of contamination from booms and response vessels may introduce oil to other areas (e.g., local ports).	Containment is possible using the right equipment in 3 – 5 knots of current (well within listed current range). Strategy does not require placing boom around very large oil slicks. Limitations and constraints (high release rate, low strike rate, storage and waste management, labour intensive, weather, VoO availability) are not reasons to eliminate or downgrade this as a strategy.	Yes	Secondary	Strong tidal conditions are unlikely to permit efficient offshore containment in proximity to the well with booms, weirs and skimmers. High release rate and the numerous vessels required for a meaningful recovery rate make this response option dubious. Strategy may be effective in nearshore low-energy areas (e.g., bays) to protect high priority receptors (such as turtle nesting or shorebird nesting beaches and mangroves).
Shoreline protection & deflection (booming operations)	Prevents or minimise oil exposure to sensitive receptors (e.g., turtle nesting beaches, mangroves, seagrass meadows) by deflecting oil to lower priority areas (e.g., rocky shores that are 'self-cleaning').	Disturbance to seabed sediments at booming anchor points. Potential for mixing of oil with beach sediments. Disturbance to shorelines (e.g., sandy beaches and sand dunes) where helicopter or foot access is required. Generation of waste from booms and disposal of recovered oil and water. Oiling of shorelines that oil is deflected towards. Routine discharges from vessels (e.g., all the impacts and risks associated with vessel operations, see EP Chapters 7 & 8).	Wind, waves and surface currents are key constraint in the deployment and operations of booms in nearshore coastal environments. Depending on the exact type of boom, currents cannot be >1-2 knots and breaking waves cannot be >30-50 cm. High tidal ranges in the region means keeping booms anchored could be challenging. Considerable resources and logistics support needed (i.e., equipment and labour intensive). Shoreline is remote with no facilities for responders. High OHS risks, including sun and heat exposure, risk of fauna bites/attack (mosquitoes, crocodiles, jellyfish), mud and high tidal ranges. Rescue and medical facilities are located a significant distance from shorelines. There is no road access – access is limited to vessels or aircraft only.	Yes	Secondary	Extremely poor site access and high OHS risks. Sensitive areas (e.g., mangroves, turtle nesting shorelines) may be targeted for protection by the DIMT (based on operational monitoring and real-time OSTM forecasting).

Response strategy	Environmental benefits	Environmental impacts and risks	Operational constraints	Suitable response?	Primary or secondary	Justification
Shoreline clean-up	Removes oil to minimise environmental risks to sensitive receptors and to accelerate recovery time. Reduces risk of oil re-entrainment from shoreline into marine environment. Areas of shoreline that are amenable to clean-up (contact >100 g/m^2) are predicted to occur over 120 km of shoreline in the worst-case deterministic modelling run (with a maximum shoreline loading of 825 m^2).	Potential shoreline disturbance to sensitive habitats (e.g., turtle nesting beaches) from clean-up operations (e.g., trampling by response personnel and equipment) may outweigh environmental benefits in some circumstances (such as natural weathering processes on the shoreline of biodegradation, photo-oxidation and volatilisation). Large volumes of waste will be generated from the removal of contaminated beach sediments. This may impact on coastal flora and fauna. Temporary storage of waste has the potential to cause contamination to areas not contacted by the spill. Presence of response personnel, equipment and facilities increase the risk of hydrocarbon cross-contamination from impacted to non-impacted sites. Routine discharges from vessels (e.g., all the impacts and risks associated with vessel operations, see EP Chapters 7 & 8).	Labour intensive (likely to require hundreds or thousands of people), with no local staging facilities or accommodation available. There is no road access – access is limited to vessels or helicopters only. Significant waste management logistics considerations required in a very remote area. Extensive areas of the shoreline are dominated by mangroves and mudflats, which are not accessible by foot and extremely difficult to remove oil from. High tidal ranges, with two high and two low tides per day, means shoreline clean-up hours are limited each day to period of low tide. High OHS risks, including sun and heat exposure, risk of fauna bites/attack (mosquitoes, crocodiles, jellyfish), mud and high tidal ranges. Rescue and medical facilities are located a significant distance from shorelines.	Yes	Secondary	Extremely poor site access and high OHS risks. Responses will be limited to sandy beaches only due to access constraints, high tidal ranges, safety of responders around rocky shorelines and in mudflats, and environmental sensitivity of mangrove forests (trampling may cause higher impacts than oil, assuming the oil is partially weathered by the time it reaches mangroves).
Oiled wildlife response (OWR) • Onshore exclusion barriers • Hazing • Pre-emptive capture • Capture, treatment and rehabil-itation	Reduces impacts to wildlife populations, particularly threatened species such as turtles. Minimising suffering of affected fauna. Euthanasia of animals that have no prospect of survival are not consumed by predators or scavengers, thereby avoiding secondary contamination of the food web.	Hazing may accidentally drive wildlife into spills or separate groups/individuals (e.g., parents/ offspring pairs). It may push them away from resources they require (food, habitat). Potential risk of fauna injury due to inappropriate field collection/handling during capture. Rehabilitation activities could result in inappropriate animal handling leading to stress, injury or death. Inappropriate fauna relocation points leading to disorientation or stress and consequent health impacts. Generation of medical wastes and requirement for suitable disposal. Routine discharges from vessels (e.g., all the impacts and risks associated with vessel operations, see EP Chapters 7 & 8).	There is no road access – access is limited to vessels and helicopters only. Labour intensive with significant logistical considerations. Limited to sandy beach areas (e.g., turtle nesting beaches during nesting or hatchling emerging times and shorebird nesting beaches) due to OHS risks associated with access to shorelines dominated by rocks, mangroves and mudflats. Sandy beaches comprise a very small percentage of the shoreline within the spill EMBA and coastlines closest to Beehive-1. The number of oiled wildlife kits are limited (AMOSC, AMSA, OSRL and state-based wildlife government agencies). OWR is limited to trained wildlife handlers from AMSA and state-based wildlife government agencies, meaning responder numbers are small. Access to trained wildlife handlers from wildlife rehabilitation organisations could be limited due to access constraints and OHS risks. Most of the shoreline is not suitable for staging facilities (e.g., treatment and rehabilitation) due to its remoteness. High OHS risks, including sun and heat exposure, risk of fauna bites/attack (mosquitoes, crocodiles, jellyfish), mud and high tidal ranges. Rescue and medical facilities are located a significant distance from shorelines.	Yes	Secondary	OWR is justified when oiled wildlife is identified and the capability to respond is in place (through existing state plans). Extremely poor site access. Limited to sandy beaches due to OHS risks of access to other shoreline types.

Response strategy	Environmental benefits	Environmental impacts and risks	Operational constraints	Suitable response?	Primary or secondary	Justification
Operational and Scientific Monitoring (OSM)	OSM and its supporting documents are instrumental in providing situational awareness of a hydrocarbon spill, enabling Incident Management Teams/Emergency Management Teams (IMT/EMTs) to mount a timely and effective spill response and continually monitor the effectiveness of the response. OSM is also the principal tool for determining the extent, severity and persistence of environmental impacts from a hydrocarbon spill and resultant remediation activities.	Routine discharges from vessels (e.g., all the impacts and risks associated with vessel operations, see EP Chapters 7 & 8) and aircraft (fauna disturbance, noise, air emissions).	Weather constraints. High OHS risks, including sun and heat exposure, risk of fauna bites/attack (mosquitoes, crocodiles, jellyfish), mud and high tidal ranges. Rescue and medical facilities are located a significant distance from shorelines.	Yes	Primary	Applicable as a primary response strategy to characterise impacts from oil spill and response activities, and subsequent recovery. EOG has adopted the APPEA Joint Industry OSM Framework and has committed to implementing the relevant plans if their initiation criteria are met.

ALARP Demonstration for Control Measures of Selected Response Strategies

The ALARP principle (described in EP Section 6.6) is applied to potential control measures of the selected spill response strategies from the strategic NEBA. Table A7.2 provides an overview of the ALARP demonstration process of each potential response strategy's control measure and Table A7.3 provides a summary of the assessment and the rationale for effectiveness rankings of potential criteria. This information is linked to the environmental risk assessment in Section 8.8 of the EP.

Table A7.2. Overview of ALARP demonstration for potential control measures associated with response strategies

Column Title	Description		
Control measures	A potential control measure of the response strategy.		
Hierarchy of Control (HOC)	Hierarchy of control category of the control measure.		
Rationale	Why is the control measure for the response strategy under consideration?		
Environmental benefit	What environmental benefit is derived from the control measure?		
Effectiveness	What is the effectiveness of the control measure in terms of functionality, availability, reliability, survivability, independence and compatibility?		
	Criteria	Effectiveness Ranking	
		Low	High
	A: Availability	Equipment/resources not readily available and EOG has no external arrangement or internal processes in place to expedite timely provision of equipment/resources.	Equipment/resources readily available or EOG has equipment/resources on standby, and/or contracts, arrangements, or MOU's in place for provision of equipment/ resources.
	F: Functionality	Control measure does not materially reduce risk/ impact.	Control measure does materially reduce risk/ impact.
	R: Reliability	Control measure not tested in Australian waters and/or low assurance assigned to success rate.	Control measure has been tested in Australian waters and/or high assurance assigned to success rate.
	S: Survivability	Control measure has low operational timeframe and will need to be replaced regularly to maintain effectiveness.	Control measure has a high operational timeframe and will not need to be replaced regularly to main effectiveness.

Column Title	Description		
	I/C: Independence/ Compatibility	Control measure is reliant on other control measures in place and/or is not compatible with other control measures in place.	Control measure is not reliant on other control measures in place and/or can be implemented with other control measures.
Implementation time	How soon could the control measure be implemented?		
Cost/ Effort	What is the cost to implement the control measure during the activity?		
ALARP Summary	Accept or reject control measure on basis of ALARP.		

Table 1.1 ALARP demonstration of potential control measures for selected response strategies of the strategic NEBA

Key: A = Availability; F = Functionality, R = Reliability; S = Survivability; IC = Independence/Capability.

Control Measures	Hierarchy of control	Rationale	Environmental benefit	Effectiveness	Implementation time	Cost/effort	ALARP summary
Source control – relief well (primary strategy)							
No relief well source control.	N/A	Do nothing option.	None	N/A	N/A	Nil	Reject – relief well strategy required.
Relief well operations managed in accordance with the Incident Action Plan (IAP), Relief Well Plan (RWP) and third-party requirements.	Administrative	Rapidly initiate relief well planning and pre-identification of equipment requirements.	Reduced spill period.	A, F, R, S, IC: High.	Immediate and ongoing. Calculated as 77 days to kill well after LoWC.	Minor	Accept – control measure is effective and has minor cost implications.
NOPSEMA-accepted WOMP and Safety Case(s) specific to the activity.	Administrative	Legislative requirement.	Legislative requirement.	A, F, R, S, IC: High.	Immediate and ongoing.	Minor	Accept – Control measure is effective and has minor cost implications.
Purchase casing, casing accessories and wellhead for relief well ahead of time.	Administrative	Reduces delays in equipment availability.	Reduced duration of LoWC and therefore lower volumes of oil released.	A, F, R, S, IC: High.	Implement prior to commencement of drilling.	>$2M, Contracting and logistics effort	Reject – High costs, grossly disproportionate to environmental benefit.
Supply arrangement in place for casing, casing accessories and wellhead for relief well.	Administrative	Reduces delays in equipment availability.	Reduced duration of LoWC and therefore lower volumes of oil released.	A, F, R, S, IC: High.	Implement prior to commencement of drilling.	Contracting and logistics effort	Accept – Control measure is effective and has minor cost implications.
Necessary casing widely used by titleholders with stockpiles in Australia accessible via APPEA MoU provisions.	Administrative	Reduces delays in equipment availability	Reduced duration of LoWC and therefore lower volumes of oil released.	A, F, R, S, IC: High	Implement prior to drilling operations.	Minor	Accept – Control measure practicable and effective, environmental benefit outweighs minor costs.
Pre-drill top hole of relief well.	Administrative	Reduces duration to drill relief well.	Reduced duration of LoWC and therefore lower volumes of oil released.	F, S, IC: High. A: Low (difficult to contract rig). R: Low.	Up to a year.	~$10-15 million	Reject – High costs, second operation risk exposure, and P&A liability grossly disproportionate to environmental benefit.
Mutual Aid MoU in place with other operators to release MODU for relief well.	Administrative	Allow rapid mobilisation of MODU.	Reduced duration of LoWC and therefore lower volumes of oil released.	A, F, S, IC: High. R: Low (MoU has not been tested).	N/A	Minor	Accept – Control measure practicable and effective, environmental benefit outweighs minor costs.
Prepare outline of relief well safety case (MoU MODU)	Administrative	Reduces delays in preparation of safety case for relief well.	Reduced duration of LoWC and therefore lower volumes of oil released.	A, F, R, S, IC: High	Implement post primary MODU safety case prior to entering reservoir.	~$100 k	Reject – Minimal time saving benefit due to unknown parameters, and existing safety case(s) of MoU MODUs. Cost disproportionate to environmental benefit.
MODU contract tracking and forecasting.	Administrative	Improves visibility of likely locations of relief well MODU during the activity.	Reduced duration of LoWC and therefore lower volumes of oil released.	A, F, R, S, IC: High	Ongoing	Minor	Accept – Control measure practicable and effective, environmental benefit outweighs minor cost.
Prepare mobilisation plan for Operator with appropriate Australian Safety Case MODU if no MoU MODU in Australia 3 months prior to start of drilling.	Administrative	Reduces delays in preparation of Safety Case for relief well – in the case of requiring a MODU to be mobilised from Southeast Asia.	Reduced duration of LoWC and therefore lower volumes of oil released.	A, F, R, S, IC: High	Implement with primary MODU provider (or other with Australian Safety Case experience) if no MoU MODU in Australia 3 months prior to commencement of drilling.	Moderate	Accept – If no MoU MODU in Australia - Control measure practicable and effective, environmental benefit outweighs moderate costs.

Control Measures	Hierarchy of control	Rationale	Environmental benefit	Effectiveness	Implementation time	Cost/effort	ALARP summary
Invasive Marine Species (IMS) clearance of MODUs not already in Australia.	Administrative	MODU cleared from IMS are able to mobilise directly to the relief well location.	Reduced duration of LoWC and therefore lower volumes of oil released.	A, R, F: High S, IC: Low	Prior to commencement of drilling.	Moderate	Reject – This control relies on contracting the required MODU ahead of time. High cost is disproportionate to environmental benefit.
IMS risk assessment of MoU MODUs in Australia.	Administrative	Risk assessment can be accessed from titleholders using the MODUs. This fast-tracks the mobilisation period.	Reduced duration of LoWC and therefore lower volumes of oil released.	A, R, F, S, IC: High.	Implement if no MoU MODU in Australia concurrent with mobilisation plan.	Minor	Accept – Control measure practicable and effective, environmental benefit outweighs minor costs.
Vessel brokerage weekly vessel updates.	Administrative	Weekly update on appropriate heavy lift vessels (HLV) for MODU transport. This fast-tracks the mobilisation period.	Reduced duration of LoWC and therefore lower volumes of oil released.	A, R, F, S, IC: High.	3 months prior to commencement of drilling until the end of drilling.	Minor	Accept – Control measure practicable and effective, environmental benefit outweighs minor costs.
Subscription to real-time vessel tracking and brokerage service.	Administrative	Rapid identification and selection of appropriate HLVs for MODU transport.	Reduced duration of LoWC and therefore lower volumes of oil released.	A, R, F, S, IC: High.	In place one month prior to drilling until the end of drilling.	Minor	Accept – Control measure practicable and effective, environmental benefit outweighs minor cost.
MODU on standby in case relief well needed.	Administrative	MODU immediately available to drill relief well.	Reduced duration of LoWC and therefore lower volumes of oil released.	F, R, S, IC: High. A: Low (difficult to get rig on standby).	14 days to mobilise standby MODU to drill relief well	~$40-50 million	Reject – High costs grossly disproportionate to environmental benefit.
Pre-mobilisation of relief well personnel	Administrative	Having relief well team in place at the start of drilling greatly reduces the mobilisation time for source control personnel.	Negligible – source control team can work remotely during initial phase and then mobilise over time.	A, R, S, IC: High. F: Low	In place at the start of drilling	~$1.5 million	Reject – High costs grossly disproportionate to negligible environmental benefit.
Aircraft on standby for source control personnel mobilisation	Administrative	Allows for source control team to be mobilised in one flight.	Negligible – source control team can work remotely during initial phase and then mobilise over time.	A, R, S, IC: High. F: Low	In place at the start of drilling	$10-15 million	Reject – High costs grossly disproportionate to negligible environmental benefit.
Relief well (source control) personnel resourcing plan in place.	Administrative	Source control team positions and provider identified for all positions. Contracts or arrangements in place for all positions means the team can be deployed ASAP.	Reduced duration of LoWC and therefore lower volumes of oil released.	A, R, F, S, IC: High	In place 2 months prior to commencement of drilling.	Minor	Accept – Control measure practicable and effective, environmental benefit outweighs minor cost.
Relief well MODU conductor validation	Engineering	Provide assurance that any relief well MODU will be able to utilise existing conductor design.	Reduced duration of LoWC and therefore lower volumes of oil released.	A, R, F, S, IC: High	In place 4 months prior to drilling.	Minor	Accept – Control measure practicable and effective, environmental benefit outweighs minor cost.
Site survey conducted for relief well location.	Engineering	Provides assurance that relief well location(s) is/are suitable for use and provide information to complete mooring analysis.	Reduced duration of LoWC and therefore lower volumes of oil released.	A, R, F, S, IC: High	In place 6 months prior to drilling.	Minor	Accept – Control measure practicable and effective, environmental benefit outweighs minor cost.

Control Measures	Hierarchy of control	Rationale	Environmental benefit	Effectiveness	Implementation time	Cost/effort	ALARP summary
Pinning analysis for relief well MODU(s).	Engineering	Provide assurance that any relief well MODU can be safely jacked-up at the relief well location.	Reduced duration of LoWC and therefore lower volumes of oil released.	A, R, F, S, IC: High	In place 4 months prior to drilling.	Minor	Accept – Control measure practicable and effective, environmental benefit outweighs minor cost.
Monitor and evaluate (primary strategy)							
No monitoring and evaluation of the spill	N/A	Do nothing option.	None	N/A	N/A	Nil	Reject – Monitor and evaluate (operational monitoring) strategy required to inform response planning and to assess response effectiveness.
Monitor and evaluate operations managed by DIMT through IAP process and guided by OPEP and OSMP.	Administrative	Information to plan and to monitor spill and response measures.	Knowledge of spill and evaluation of response measures informs a more targeted spill response.	A, F, R, S, IC: High.	Immediate and ongoing.	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Quasi-real-time OSTM predictions to support operational NEBA during IAP process.	Administrative	Predicted spill trajectory, effectiveness of response and risks to environmental receptors inform DIMT.	Forecasted spill behaviour to respond and to manage spill, and to identify sensitive receptors at risk.	A, F, R, S, IC: High.	<2 hours to initiate.	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Initial observations and reporting by MODU, support vessels and/or contracted helicopter(s).	Administrative	Vessels and helicopter(s) provide basic information (location, weather and spill character) to inform initial response.	Early indication of direction of spill to target immediate response and to establish situational awareness.	A, F, R, S: High. IC: Low (dependent on safety considerations and tasks of available on-/near- site vessels and/or contracted helicopters).	Immediate for support vessel and/or MODU crew. Aircraft - ~6 hours.	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Oil spill tracking buoys located on MODU and support vessels.	Administrative	Buoys deployed in event of LoWC to track spill movement and gain situational awareness.	Early indication of direction of spill to target immediate response and to establish situational awareness.	A, F, R, S, IC: High	Immediate	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Provision of satellite imagery.	Administrative	Quasi-real-time monitoring required to inform DIMT of spill distribution, expedited acquisition.	Informs DIMT IAP process to target response to yield greatest environmental benefit.	A, F, R, S, IC: High.	<24 hours for acquisition of first image.	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Aerial monitoring by trained observers (AMOSC) in fixed-wing aircraft.	Administrative	Fixed-wing aircraft and trained observers improve spill surveillance.	Ongoing spill surveillance to inform spill response.	A, F, R, S, IC: High.	Subject to aircraft and personnel availability, but ~24 hours.	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Dedicated monitoring plant, equipment and personnel on call-off arrangement.	Administrative	Dedicated monitoring resources improve spill monitoring.	Ongoing spill monitoring to inform spill response.	A, F, R, S, IC: High.	Subject to vessel and personnel availability, but <2 days from call-off.	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Trained observers, and dedicated equipment and plant on standby for aerial- and/or vessel-based surveillance.	Administrative	Decrease response time for plant (aircraft, vessels) and trained observers improve spill surveillance.	Ongoing spill monitoring to inform spill response.	F, R, S, IC: High. A: Low (trained observers typically have full-time jobs and may not be released for standby).	24 hours to get airborne or depart port with standby observers.	Standby costs of ~>$1M to maintain plant and trained observers.	Reject – high costs are grossly disproportionate to the limited environmental benefit.
Surface dispersant application – aerial (primary strategy) and vessel (secondary strategy)							
No surface dispersant system response strategy.	N/A	Do nothing option.	None	N/A	N/A	Nil	Reject – The option to apply a surface dispersant system under appropriate conditions is retained.

Control Measures	Hierarchy of control	Rationale	Environmental benefit	Effectiveness	Implementation time	Cost/effort	ALARP summary
Only chemical dispersants listed on the AMSA oil spill control agents [OSCA] list will be used (lower toxicity than non-OSCA listed dispersants).	Substitute	Reduce environmental effects by only selecting dispersants with low(est) toxicity.	Reduces toxicity impacts to marine fauna.	S, IC: High. A: Low (stocks potentially limited). F, R: Low (may not to be as effective as higher toxicity dispersants).	N/A	Minor	Accept – only dispersants listed on the OSCA register can be used in Australian waters.
Temporal windows of environmental sensitivity considered in operational NEBA.	Substitute	Surface dispersant application during temporal windows of environmental sensitivity (e.g., coral spawning, turtle nesting, shorebird & EPBC listed species migrations) a key consideration in operational NEBAs.	Reducing potential impacts during surface dispersant application.	A, F, R, S, IC: High.	N/A	Minor	Accept –practicable and effective, environmental benefit outweighs minor cost.
Operational control to prevent impacts on EPBC-listed megafauna.	Eliminate	Sightings of EPBC-listed megafauna (e.g., whale sharks, blue whales) in the immediate vicinity of any surface dispersant operations will trigger cessation of response until animal has moved and not been sighted for 30 minutes.	Reduced impact on EPBC-listed megafauna.	A, F, R, S, IC: High.	N/A	Minor	Accept –practicable and effective, environmental benefit outweighs minor cost.
Dispersant not applied in water depths <20 m, within an Australian Marine Park and within State waters (i.e., within 3 nm of the shoreline).	Eliminate	Restrictions on dispersant use that consider likely exposure to dispersant/ dispersed oil in sensitive areas is recognised good practice.	Reduced impact from dispersant and dispersed oil on sensitive receptors (e.g., shallow water habitats and coastal habitats).	A, F, R, S, IC: High.	N/A	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Arrangements in place with AMOSC, OSRL and other third parties for plant, equipment, dispersants and service provision of surface dispersant application.	Administrative	Rapid mobilisation of surface dispersant system to reduce surface oil volumes and the extent and volume of shoreline oiling. Plant, equipment and personnel to implement surface dispersant response strategy can be mobilised for first strike, escalation, and peak volume needs.	Arrangements in place for rapid initialisation of surface dispersant application resources that may reduce surface and shoreline oiling impacts. Mobilisation time frames for plant, equipment and personnel can meet first strike, escalation and peak volume needs and thereby do not limit response strategy implementation.	A, R, S, F, IC: High.	<2 hours to initiate	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
OSRL GDS membership.	Administrative	Access to global stockpiles of dispersant. Supply chain analysis confirms that sufficient dispersant stockpiles exist to meet volume and temporal needs for this strategy.	Global stockpile access provides sufficient volumes for SDA response to treat minimum oil thickness (>50 um) that may reduce surface and shoreline oiling impacts.	A, R, S, F, IC: High.	<2 hours to initiate.	Moderate (~$100,000)	Accept – practicable and effective, environmental benefit outweighs minor cost.
Rapid dispersant efficacy assessment.	Administrative	Rapid onsite effectiveness trial of available dispersants prior to surface application.	Determination of effectiveness of dispersants available at/near the spill site.	A, R, S, F, IC: High.	<2 days to initiate	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.

Control Measures	Hierarchy of control	Rationale	Environmental benefit	Effectiveness	Implementation time	Cost/effort	ALARP summary
Laboratory dispersant efficacy assessment.	Administrative	Detailed dispersant effectiveness evaluation to inform selection of priority of dispersant types for surface application	Determination of effectiveness of the range of dispersants with greater certainty than the rapid assessment.	A, R, S, F: High IC: Low (ability to acquire oil sample of sufficient volume and 'freshness').	<2 days to initiate.	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Dedicated response vessel(s) and/or fixed wing aircraft with surface dispersant system spread(s).	Administrative	On standby 24/7 during drilling to rapidly initiate surface dispersant system application in the event of a LoWC.	Rapid response reduces surface concentrations and shoreline loading.	A, R, S, F, IC: High.	<1 day to initiate.	Significant vessel and aircraft standby costs >~$1-5 million.	Reject – High costs are grossly disproportionate to environmental benefit given that AMOSC can respond in a similar time.
Dedicated personnel and equipment on standby implementation of surface dispersant application response strategy.	Administrative	On standby 24/7 during drilling to rapidly initiate surface dispersant system application in the event of a LoWC.	Rapid response reduces surface concentrations and shoreline loading.	A, R, S, F, IC: High.	<1 day to initiate.	Significant personnel standby costs ~$1 million.	Reject – High costs are grossly disproportionate to environmental benefit given that AMOSC can respond in a similar time.
Dispersant pre-mobilisation to nearby holding facilities (e.g., Wyndham or Wadeye) to support surface dispersant application response strategy.	Administrative	Sufficient dispersant stockpiles are available at Broome and Darwin, with supplies from elsewhere in Australia able to be rapidly deployed by air.	Rapid response reduces surface concentrations and shoreline loading.	A, R, S, F, IC: High.	<1 day to initiate.	Mobilisation of existing national and global stockpiles to Dampier not possible.	Reject – High costs are grossly disproportionate to environmental benefit given that nearby stockpiles can be rapidly deployed to site.
Engage suppliers to manufacture dispersant and store at Darwin and Broome for surface dispersant application response strategy.	Administrative	Sufficient dispersant stockpiles are available at Broome and Darwin, with supplies from elsewhere in Australia able to be rapidly deployed by air. Additional supplies are available from OSRL in Singapore.	Rapid response reduces surface concentrations and shoreline loading.	A, R, S, F, IC: High.	<1 day to initiate.	Manufacture and storage costs of sufficient dispersant volumes >$1 million.	Reject – High costs are grossly disproportionate to environmental benefit given that nearby stockpiles can be rapidly deployed to site.
Containment and recovery (secondary strategy)							
No containment and recovery response.	N/A	Do nothing option.	None	N/A	N/A	Nil	Reject – The option to apply a containment and recovery under appropriate conditions is retained.
Implement offshore containment and recovery operations near well.	Administrative	Recovers some oil offshore near the source to reduce the volume reaching sensitive shorelines.	Reduces the volume of oil reaching sensitive shorelines.	A: High. S: Low (booms will require frequent maintenance and replacement). F: Low (will not materially decrease oil from marine environment, long distances to transport oil to waste transfer stations). R: Low (limited effectiveness in typical offshore conditions). IC: Low (dependent on waste management capacity).	N/A	Major	Accept – practicable and effective, environmental benefit outweighs major costs, but only where surface oil is thickest and therefore amenable to recovery (near the well).

Control Measures	Hierarchy of control	Rationale	Environmental benefit	Effectiveness	Implementation time	Cost/effort	ALARP summary
Implement nearshore containment and recovery operations near sensitive shoreline receptors (e.g., mangroves, turtle nesting sites).	Administrative	Recovery of oil offshore near key sensitive receptors with a sufficient probability of contact by a slick.	Removal of surface oil primarily in the waters closest to sensitive environmental receptors that may be impacted by shoreline oiling (preventative).	A: High. S: Low (booms will require frequent maintenance and replacement). F: Low (will not materially decrease oil from marine environment, long distances to transport oil to waste transfer stations for most key sensitive receptors). R: Low (limited effectiveness in typical nearshore ocean conditions and low surface oil thickness). IC: Low (dependent on waste management capacity).	N/A	Major	Reject – will provide limited environmental benefit due to the insufficient thickness of the oil near sensitive shorelines.
Temporal windows of environmental sensitivity considered in operational NEBA.	Substitute	Response strategy during temporal windows of environmental sensitivity (e.g. turtle nesting, shorebird & EPBC listed species migrations) a key consideration in operational NEBAs.	Reducing potential impacts during containment and recovery response strategy.	A, F, R, S, IC: High.	N/A	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Operational control to prevent impacts on EPBC-listed megafauna.	Eliminate	Sightings of EPBC-listed megafauna (e.g., whale sharks, blue whales) in the immediate vicinity of any containment and recovery operations will trigger cessation of response until animal has moved and not been sighted for 30 minutes.	Reduced impact on EPBC-listed megafauna.	A, F, R, S, IC: High.	N/A	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
OSRL and AMOSC membership	Administrative	Ready access to a wide range and large quantity of spill response equipment and trained personnel that can be rapidly mobilised.	Potential limited reduction of oiling of sensitive shorelines.	A, F, R, S, IC: High.	Mobilised within <24 hours for AMOSC equipment. <3 days for OSRL equipment. Functional <7 days.	Moderate	Accept – practicable and effective, environmental benefit outweighs moderate cost.
Suitable response vessels sourced through external services contracting strategy.	Administrative	Enable deployment for containment and recovery operations at high priority sites with appropriate vessels.	Protection of very high sensitivity site(s) may be possible.	A, F, R, S, IC: High.	Mobilised within 7 days.	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Containment and recovery equipment and vessels with trained personnel on standby at/near key sensitive receptors.	Administrative	Enables rapid deployment to protect high priority sites.	Protection of very high sensitivity site(s) may be possible.	A, F, R: High. S: Low (regular inspection and maintenance of booms required at pre-positioned sites). IC: Low (dependent on waste management capacity).	Mobilisation <1 day, functional within 7 days	Standby cost of vessel(s), personnel and equipment >$1 million	Reject – grossly disproportionate compared to limited environmental benefit due to inability to predict exact areas of shoreline impact.

Control Measures	Hierarchy of control	Rationale	Environmental benefit	Effectiveness	Implementation time	Cost/effort	ALARP summary
Shoreline protection and deflection (secondary strategy)							
No shoreline protection and deflection response.	N/A	Do nothing option.	None	N/A	N/A	Nil	Reject – may mitigate impacts to sensitive shoreline environmental receptors.
Temporal windows of environmental sensitivity considered in operational NEBA.	Substitute	Response strategy during temporal windows of environmental sensitivity (e.g., turtle nesting, shorebird & EPBC listed species migrations) a key consideration in operational NEBAs.	Reducing potential impacts during protection and deflection response strategy.	A, F, R, S, IC: High.	N/A	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Operational control to prevent impacts on EPBC-listed megafauna.	Eliminate	Sightings of EPBC-listed megafauna (e.g., whale sharks, blue whales) in the immediate vicinity of any containment and recovery operations will trigger cessation of response until animal has moved and not been sighted for 30 minutes.	Reduced impact on EPBC-listed megafauna.	A, F, R, S, IC: High.	N/A	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
OSRL and AMOSC membership.	Administrative	Ready access to a wide range and large quantity of spill response equipment and trained personnel that can be rapidly mobilised.	Potential limited reduction of oiling of sensitive shorelines.	A, F, R, S, IC: High.	Mobilised within <24 hours for AMOSC equipment. <3 days for OSRL equipment. Functional <7 days	Moderate	Accept – practicable and effective, environmental benefit outweighs moderate cost.
Suitable response vessels sourced through external services contracting strategy.	Administrative	Enable deployment to protect high priority sites with appropriate mix of small to larger vessels.	Protection of very high sensitivity site(s) possible.	A, F, R, S, IC: High.	Mobilised within 7 days.	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Shoreline booms and associated equipment and vessels with trained personnel on standby at/near key sensitive receptors.	Administrative	Enable rapid deployment to protect high priority site.	Protection of very high sensitivity site(s) possible.	A, IC: High. F: Low (predicted surface oil concentrations low [<10 g/m^2] when arrive at shorelines). R: Low (potential minimal arrival time and location after release from wellhead difficult to predict). S: Low (regular inspection and maintenance required).	Mobilisation <1 day, functional within 7 days	Standby cost of vessel(s), personnel and equipment >$1-5 million	Reject – grossly disproportionate compared to limited environmental benefit due to inability to predict exact areas of shoreline impact.
Shoreline clean-up (secondary strategy)							
No shoreline clean-up response.	N/A	Do nothing option.	None	N/A	N/A	Nil	Reject – this strategy is required to mitigate impacts and risks to sensitive shoreline environmental receptors.
No machinery to be used in mangroves or within 20 m of an identified turtle nest.	Eliminate	Eliminates impacts of machinery (such as compaction, destruction) on sensitive receptors.	If required, arrangements in place for mobilisation for clean-up of oiled shorelines.	A, F, R, S, IC: High.	Immediate and ongoing	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.

Control Measures	Hierarchy of control	Rationale	Environmental benefit	Effectiveness	Implementation time	Cost/effort	ALARP summary
Call-off arrangements in place for resources to implement shoreline clean-up response.	Administrative	Access to shoreline clean-up equipment, personnel, support logistics. Effective implementation if required.	Arrangements in place for mobilisation for clean-up of oiled shorelines, if required.	A, F, R, S, IC: High.	<2 weeks	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Standby arrangements in place for shoreline clean-up.	Administrative	Rapid access to shoreline clean-up equipment, personnel, and support logistics.	Rapid commencement of shoreline clean-up.	A, F, R, S, IC: High.	<1 week	Standby costs >$1M	Reject –disproportionate to environmental benefit as equipment and personnel are rapidly available via call-off arrangements.
Contract with regulated and licenced waste management provider.	Administrative	Waste management services to remove shoreline clean-up waste.	Appropriate handling, storage and disposal of shoreline clean-up waste.	A, F, R, S, IC: High.	Immediate and ongoing	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Oiled wildlife response (secondary strategy)							
No OWR.	N/A	Do nothing option.	None.	N/A	N/A	Nil	Reject – OWR strategy is appropriate to mitigate impacts and risks to fauna.
OWR operations directed by WA and/or NT wildlife management agencies, with assistance from the DIMT.	Administrative	OWR operations directed to situations with a net environmental benefit.	Positive (greatest) environmental benefit from OWR to be based upon monitoring and evaluation (situational awareness).	A, F, R, S, IC: High.	Immediate and ongoing.	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
AMOSC and OSRL membership.	Administrative	Access to range of OWR personnel and equipment.	Ability to treat oiled wildlife with appropriate personnel and equipment.	A, F, R, S, IC: High.	<24 hours for triage equipment. <2 days for responders and containers.	Moderate	Accept – practicable and effective, environmental benefit outweighs moderate cost.
Establishing work areas that follow pre-designated plans of state/territory wildlife response plans.	Administrative	Reduce potential impacts to sensitive receptors be avoiding areas of environmental sensitivity.	Ability to treat oiled wildlife, and triage when appropriate.	A, F, R, S, IC: High.	Immediate and ongoing.	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Equipment for OWR (and triage) is pre-positioned at strategic locations.	Administrative	Wildlife treated at strategic locations where equipment (OWR containers) are available.	Ability to treat oiled wildlife more rapidly than otherwise.	F, R, S, IC: High. A: Low (AMOSC cannot provide container on standby, must purchase with long lead times).	<1 day for equipment and personnel.	Not available through AMOSC. Procurement and maintenance of container >$50,000.	Reject –cost is disproportionate to the limited environmental benefit.
Operational and scientific monitoring (primary strategy)							
No operational or scientific monitoring of the spill.	N/A	Do nothing option.	None	N/A	N/A	Nil	Reject – Operational and scientific monitoring is required to quantify spill impacts and subsequent recovery.
Operational and scientific monitoring managed by DIMT through IAP process, guided by Joint Industry OSM Framework and OSM Bridging Implementation Plan.	Administrative	Ensures monitoring information acquired to plan and monitor effectiveness of spill response. Ensure scientific objectives (i.e., to characterise impacts and subsequent recovery) are met.	Understanding impacts to sensitive environmental receptors from the spill and response strategies, and subsequent recovery after the spill and response strategies. Informs DIMT of effective spill response tactics to mitigate/reduce impacts from spill and responses.	A, F, R, S, IC: High.	Immediate and ongoing.	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.

Control Measures	Hierarchy of control	Rationale	Environmental benefit	Effectiveness	Implementation time	Cost/effort	ALARP summary
Call-off arrangements in place for operational and scientific monitoring.	Administrative	Readiness to implement scientific monitoring.	Ability to monitor spill impacts and recovery of sensitive receptors.	A, F, R, S, IC: High.	<1 day for DIMT to initiate mobilisation. <7 days for initial monitoring implementation.	Minor	Accept – practicable and effective, environmental benefit outweighs minor cost.
Operational and scientific monitoring personnel, plant and equipment on standby.	Administrative	Reduce response time to initiate scientific monitoring.	Marginal increase in ability to monitor sensitive receptors prior to hydrocarbon contact relative to non-standby arrangement.	A, F, R, S, IC: High.	<6 hours to initiate mobilisation. <3 days for initial monitoring implementation	>$1M	Reject – grossly disproportionate for the limited environmental benefit.