

ENVIRONMENT PLAN

Beehive-1 Exploration Drilling

WA-488-P

17 May 2024

Rev 6

5-Description of Existing Environment

eog resources

5. Description of the Existing Environment

In accordance with OPGGS(E) Regulation 21(2), this chapter provides a description of the EMBA by the activity, together with its values and sensitivities. Regulation 5 of the OPGGS(E) defines the environment as:

- 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 the above-listed matters.

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

- EPBC Act Protected Matters Search Tool (PMST) database (DCCEEW, 2022a), conducted for the impacts EMBA on 4th March 2022, repeated on 5th September 2022 and again on 25th of September 2023, with the search for the flaring EMBA undertaken on 23rd of January 2023 and again on 25th of September 2023 (Appendix 10);
- Species Profile and Threats (SPRAT) Database (DCCEEW, 2022b);
- The Northwest Marine Bioregional Plan Bioregional Profile (DEWHA, 2008b);
- Marine bioregional plan for the North Marine Region (NMR) (DSEWPC, 2012);
- National Conservation Values Atlas (NCVA) (DCCEEW, 2022c);
- 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).

Where appropriate, descriptions of the JBG environment (beyond the immediate impacts EMBA) are provided for context. 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. The Environment That May Be Affected

The spatial extent of the EMBA is divided into that for planned activities (impacts) and unplanned activities (risks).

5.1.1. Planned Activities

The extent of the EMBA for each of the impacts from the project is listed in Table 5.1 (see also Chapter 7). This indicates that the greatest extent of the EMBA for planned activities is no greater than a 20-km radius from Beehive-1. This EMBA is simply referred to as the 'impacts EMBA' (Figure 5.1) and is the area of focus for the description of the environment in this chapter.

The impacts EMBA for flaring is estimated to extend to 42 km; this distance is included in the PMST search results despite uncertainty as to whether flaring will take place (see Section 2.7.4).The flaring EMBA is disused further within sections 5.4.6 (Marine Reptiles) and 5.4.7 (Avifauna) due to these species being particularly vulnerable to artificial lighting.

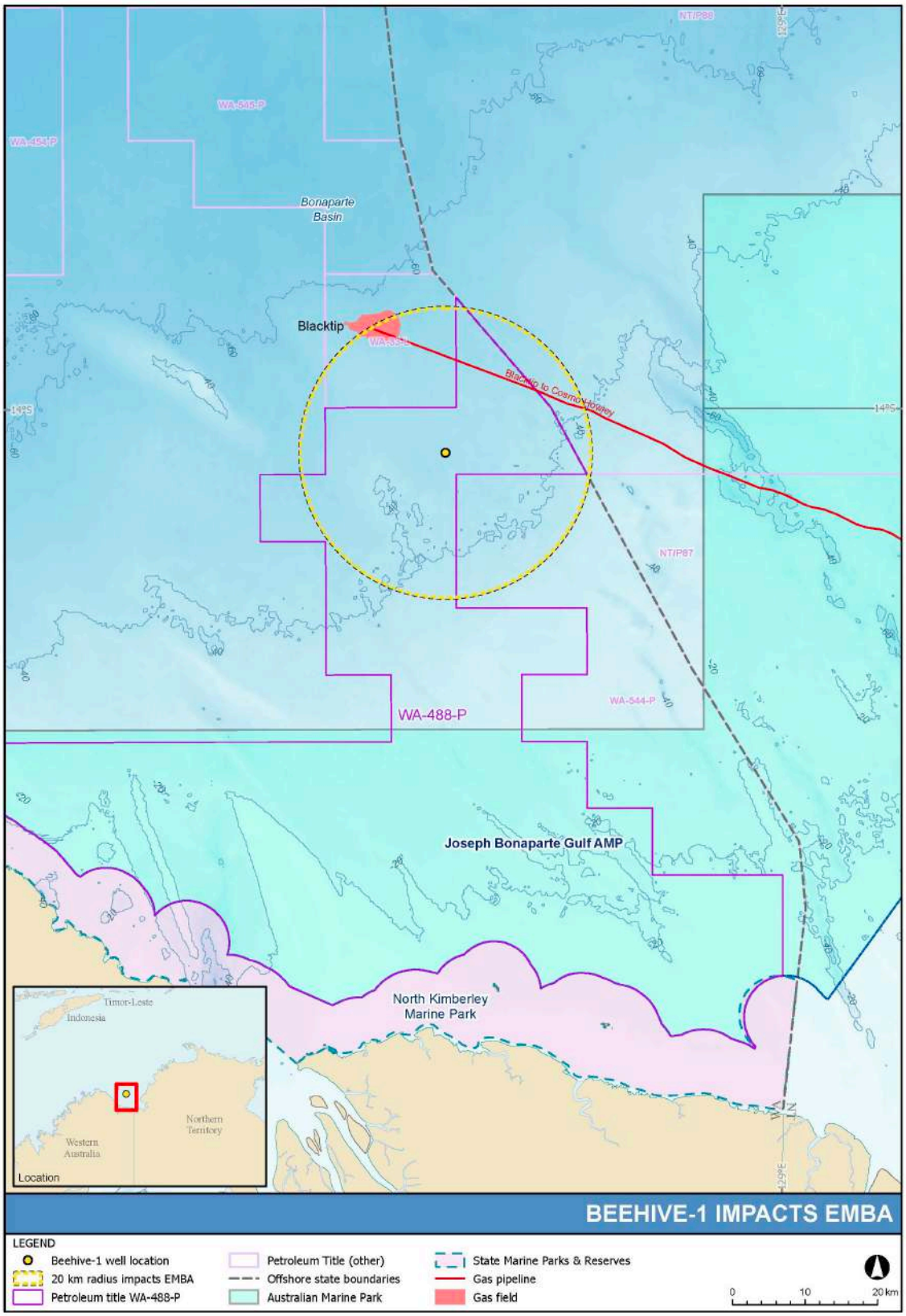


Figure 5.1. The impacts EMBA

Table 5.1. Extent of the impact EMBAs

Planned event	Extent of EMBA (radius around Beehive-1)	EIA section
Seabed disturbance	Tens of metres	7.1
Displacement of marine users	500 m	7.2
Light glow	20 km	7.3
	Extends to 42 km if flaring is undertaken. See earlier notes.	
Air emissions	Hundreds of metres	7.4
Underwater sound	Hundreds of metres	7.5
Drill cuttings discharges	1.55 km	7.6
Drill muds discharges	6.95 km	7.6
Cement discharges	6.95 km	7.7
Putrescible waste	100 m	7.8
Treated sewage discharges	50 m	7.9
Cooling water discharges	100 m	7.10
Bilge water discharges	100 m	7.11

5.1.2. Unplanned Activities

The EMBA for unplanned activities is defined by modelling of the loss of well control (LoWC), noting that the EMBA from an MDO spill is contained within the broader LoWC EMBA. The description of the existing environment for the EMBA defined by the LoWC is provided in Appendix 11.

The boundary for the EMBA associated with a LoWC is defined by the hydrocarbon spill thresholds defined in the *NOPSEMA Bulletin #1 Oil Spill Modelling* (NOPSEMA, 2019). This bulletin uses 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 (Table 5.2).

The low contact values used to inform the extent of the socio-economic 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 (2019) as having the potential to cause impacts to ecological receptors (see Table 5.2).

The socio-economic EMBA and the ecological EMBA are referred collectively as the ‘spill EMBA’, and the environment of the spill EMBA is described in Appendix 11.

Table 5.2. Oil spill thresholds used to define the spill EMBA

Hydrocarbon phase	Exposure values	
	Socio-economic EMBA	Ecological EMBA
Shoreline	Low – **10 g/m²** (equivalent to 10 ml/m², or 2 teaspoons) Potential for some socio-economic impact.	Moderate – **100 g/m²** (equivalent to 100 ml/m²) Area likely to cause environmental impacts and to require clean-up effort.
		High – **1,000 g/m²** (equivalent to 1 litre/m²) Area likely to require intensive clean-up effort.
Sea surface (floating)	Low – **1 g/m²** (equivalent to 1,000 L/km²) Approximates socio-economic effects and planning area for scientific monitoring.	Moderate – **10 g/m²** (equivalent to 10,000 L/km²) Lower limit for harmful contact to birds and marine mammals.
		High – **50 g/m²** (equivalent to 50,000 L/km²) Approximates surface oil slick and informs response planning.
Dissolved	Low – **10 ppb** Planning area for scientific monitoring as potential water quality trigger exceedance.	Moderate – **50 ppb** Potential toxic effects, particularly sub-lethal effects to sensitive species.
		High – **400 ppb** Toxic effects, including lethal effects to sensitive species.
Entrained	Low – **10 ppb** Planning area for scientific monitoring as potential water quality trigger exceedance.	High – **100 ppb** To inform risk evaluation.

Source: NOPSEMA (2019).

5.2. Regional Context

Under the EPBC Act, management of Australian offshore waters is divided into six marine bioregions. Marine bioregional plans describe the marine environment and conservation values (protected species, protected places and key ecological features) of the marine region, sets broad biodiversity objectives, identify regional priorities, and outlines strategies and actions to achieve these (DCCEEW, 2022a).

The impacts EMBA is located within the Northwest Marine Region (NWMR). Based on the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) Version 4.0, the impacts EMBA is situated completely within the 'Northwest Transition' provincial bioregion (CoA, 2006), as illustrated in Figure 5.3 and the 'Bonaparte Gulf' mesoscale bioregion (Figure 5.3).

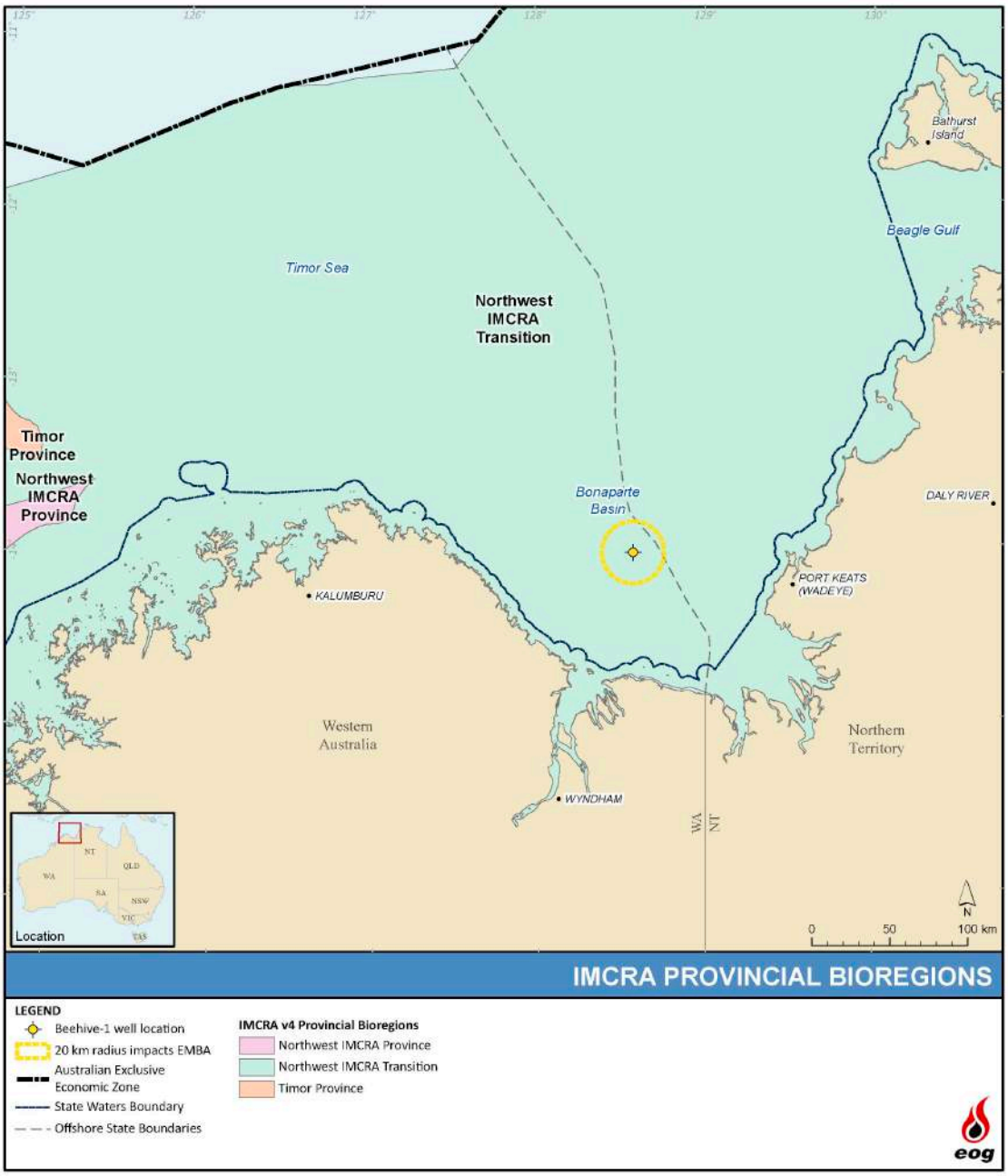


Figure 5.2. Provincial bioregion overlapped by the impacts EMBA

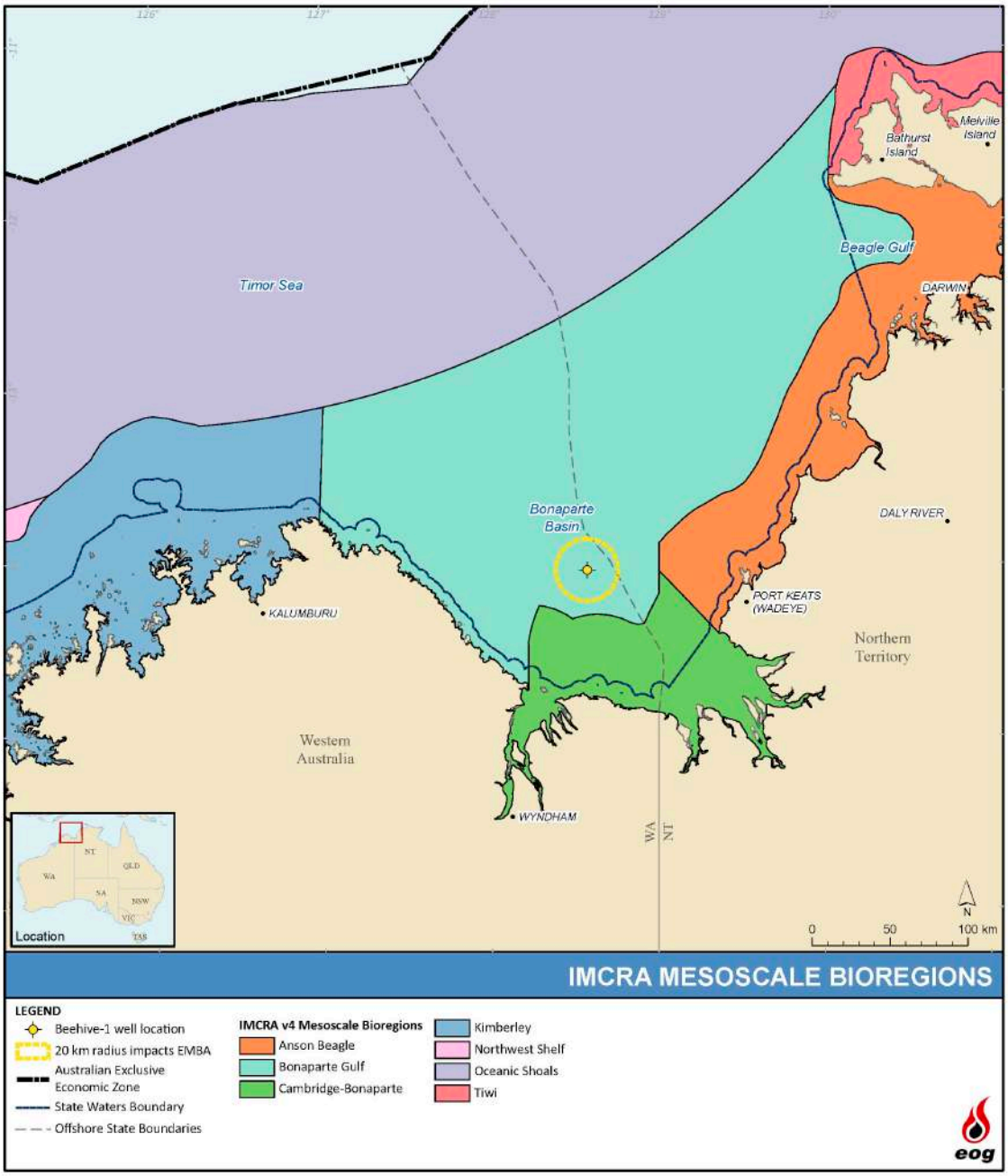


Figure 5.3. Mesoscale bioregion overlapped by the impacts EMBA

5.2.1. Climate

The impacts EMBA is located in a region with a pronounced tropical monsoonal climate consisting of two distinct seasons known as the northwest monsoon ('wet season') and southeast monsoon ('dry season').

The northwest monsoon occurs from late October to mid-March. Regular and high rainfall is a characteristic of the northwest monsoon, mainly over coastal areas and during 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. The southeast monsoon occurs from May to mid-October. This originates from the southern hemisphere high-pressure belt and is relatively dry and cool (DSEWPaC, 2012a).

Temperature and Rainfall

Wadeye Airport (Port Keats), located on the NT mainland approximately 85 km east of Beehive-1, is the location of the nearest meteorological station. Data collected from 1997 to 2019 show that the highest maximum temperature (mean of 34.4°C) occurs in April, October and November, whilst the lowest maximum temperature (mean of 16.8°C) occurs in July (BoM, 2021a). Data collected from 1997 to 2019 at the Wadeye Airport weather station show that the mean annual rainfall is 1,317.8 mm, with the highest rainfall in January (312.2 mm) and the least in August (0.7 mm) (BoM, 2021a). Typically, the majority of rain occurs from December to March (mean of 1,025 mm).

Winds

Wind patterns in the region are controlled by the seasonal migration of high-pressure cells from latitudes 25-30°S in winter to 35-40°S in summer (Pearce *et al*., 2003). Sea surface wind data spanning five years sourced from the NCEP/NCAR global reanalysis project shows two predominant (general) directions:

1. West to northwest winds prevail during the months of September to February; and
2. Easterly to south-easterly winds prevail from April to July (Kalnay *et al*., 1996; Kistler *et al*., 2001).

March and August are transitional periods with a higher variability in wind directions. Wind speed and direction used in the stochastic spill modelling are provided in Table 5.3 and presented in Figure 5.4 (RPS, 2021).

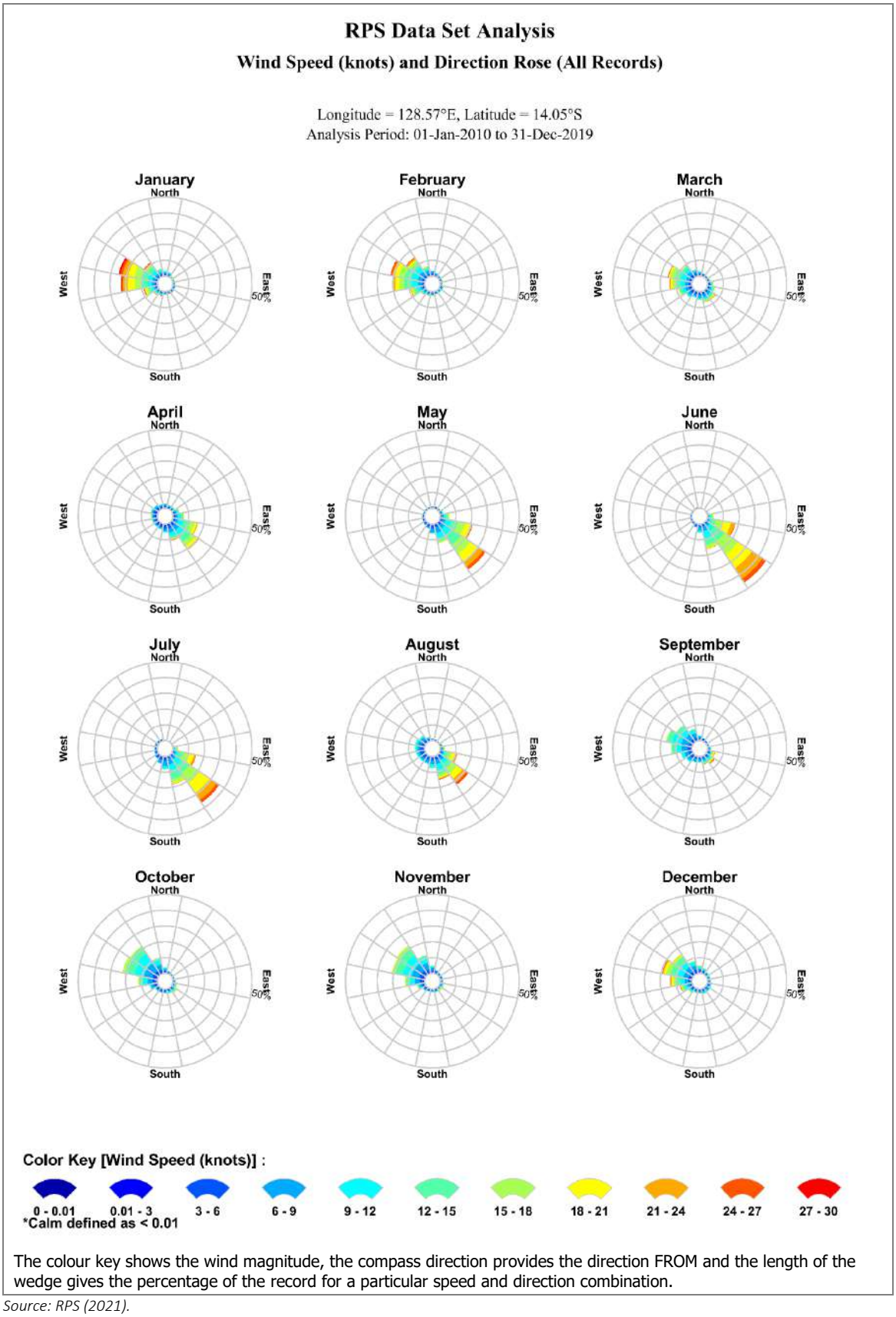
Cyclones

Tropical 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, 2022).

Table 5.3. Predicted average and maximum winds for the wind station nearest the impacts EMBA for 2010-2019 (inclusive)

Season	Month	Avg. 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	

Source: RPS (2021).



The colour key shows the wind magnitude, the compass direction provides the direction FROM and the length of the wedge gives the percentage of the record for a particular speed and direction combination.

Source: RPS (2021).

Figure 5.4. Modelled monthly wind rose distributions from 2010-2019 (inclusive) for the wind station closest to the impacts EMBA

5.2.2. Oceanography

Currents

Broad-scale ocean circulation of the North Australian Shelf is dominated by the Indonesian Throughflow current system. Circulation in the JBG is dominated by tidal and wind driven currents according to the season (Figure 5.5) (Przeslawski *et al*., 2011).

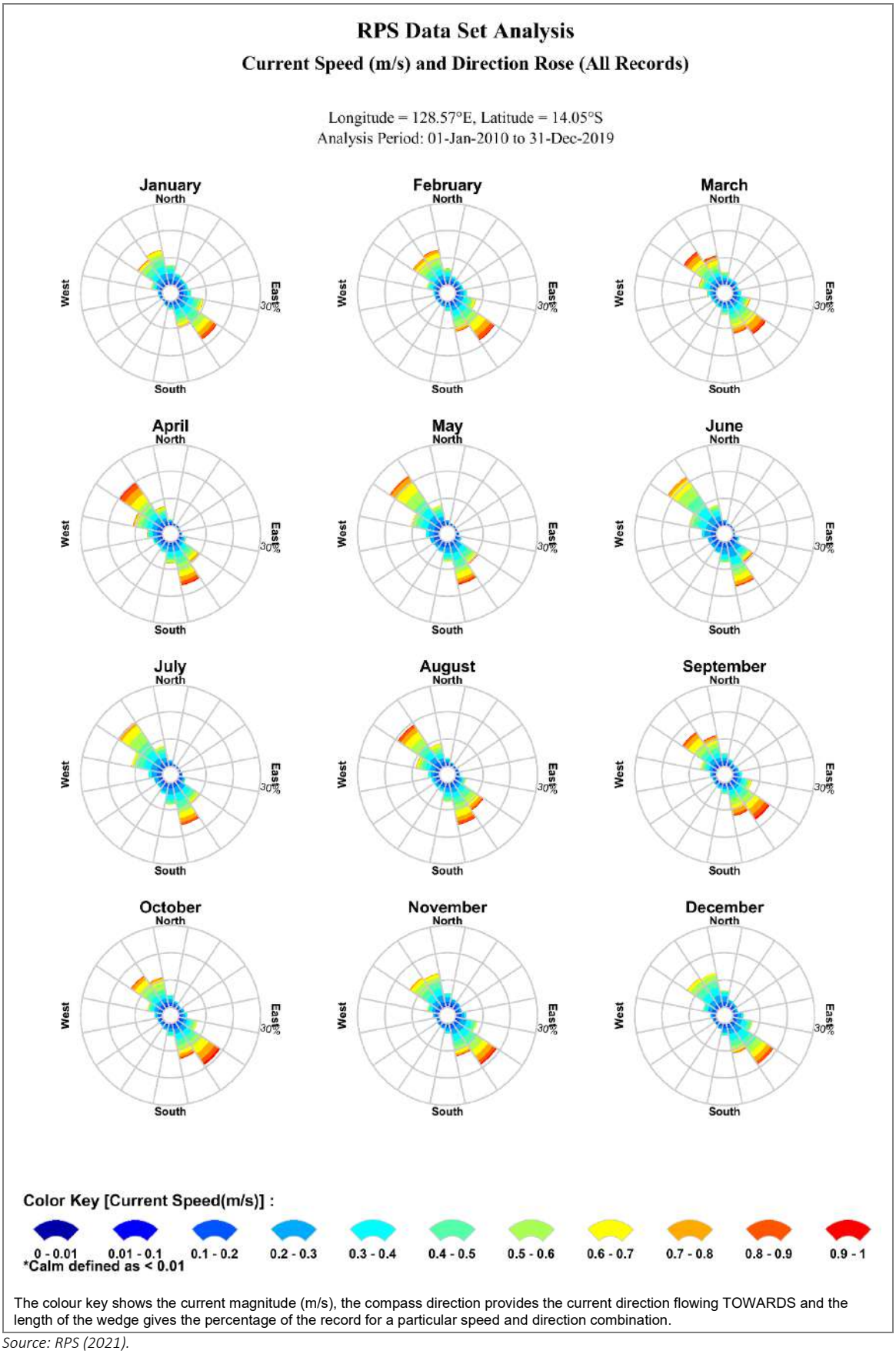
Table 5.4 provides the average and maximum combined surface current speeds (ocean plus tides) located within the impacts EMBA. This data indicates that surface currents flow predominantly along the northwest to southeast axis. The monthly current speeds averaged between 0.33 to 0.40 m/s and reached a peak of 0.96 to 1.17 m/s.

Figure 5.6 illustrates the monthly surface current rose plots located at the Beehive-1 location from 2010 to 2019 (inclusive). Figure 5.7 presents the major ocean currents in north-western Australian waters.

Table 5.4. Predicted average and maximum surface current speeds within the impacts EMBA from 2010-2019 (inclusive)

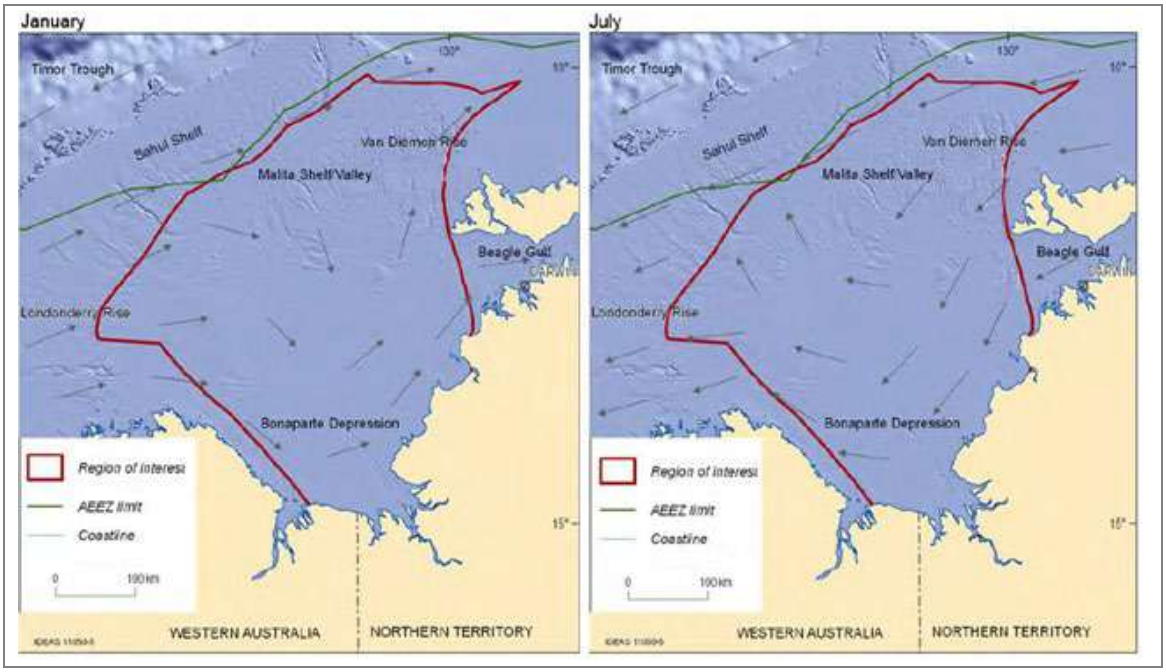
Season	Month	Avg. current speed (m/s)	Maximum current speed (m/s)	General direction (towards)
Summer	January	0.35	1.10	Northwest and southeast
	February	0.37	1.12	
Transitional	March	0.40	1.05	
Winter	April	0.39	1.06	
	May	0.35	1.17	
	June	0.34	1.07	
	July	0.35	0.96	
	August	0.37	1.15	
Transitional	September	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	

Source: RPS (2021).



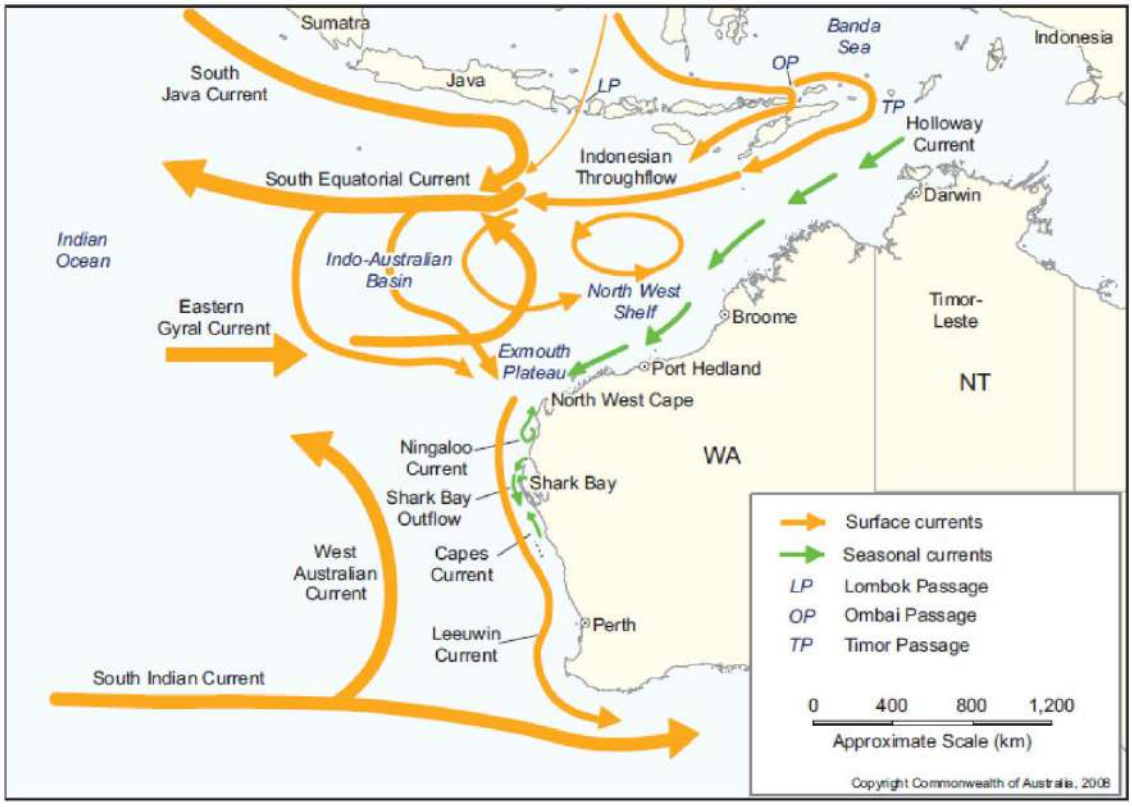
Source: RPS (2021).

Figure 5.5. Monthly surface current rose plots nearby the impacts EMBA (2010-2019 inclusive)



Source: Przeslawski et al 2011.

Figure 5.6. Currents of the JBG



Source: DEWHA, 2008b.

Figure 5.7. Ocean currents along the Northwest Australian continental shelf

Sea Temperature and Salinity

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

Tides

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 mesoscale 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.

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 JBG. 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 along the JBG coastline, the potential for existing pollution is limited.

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.

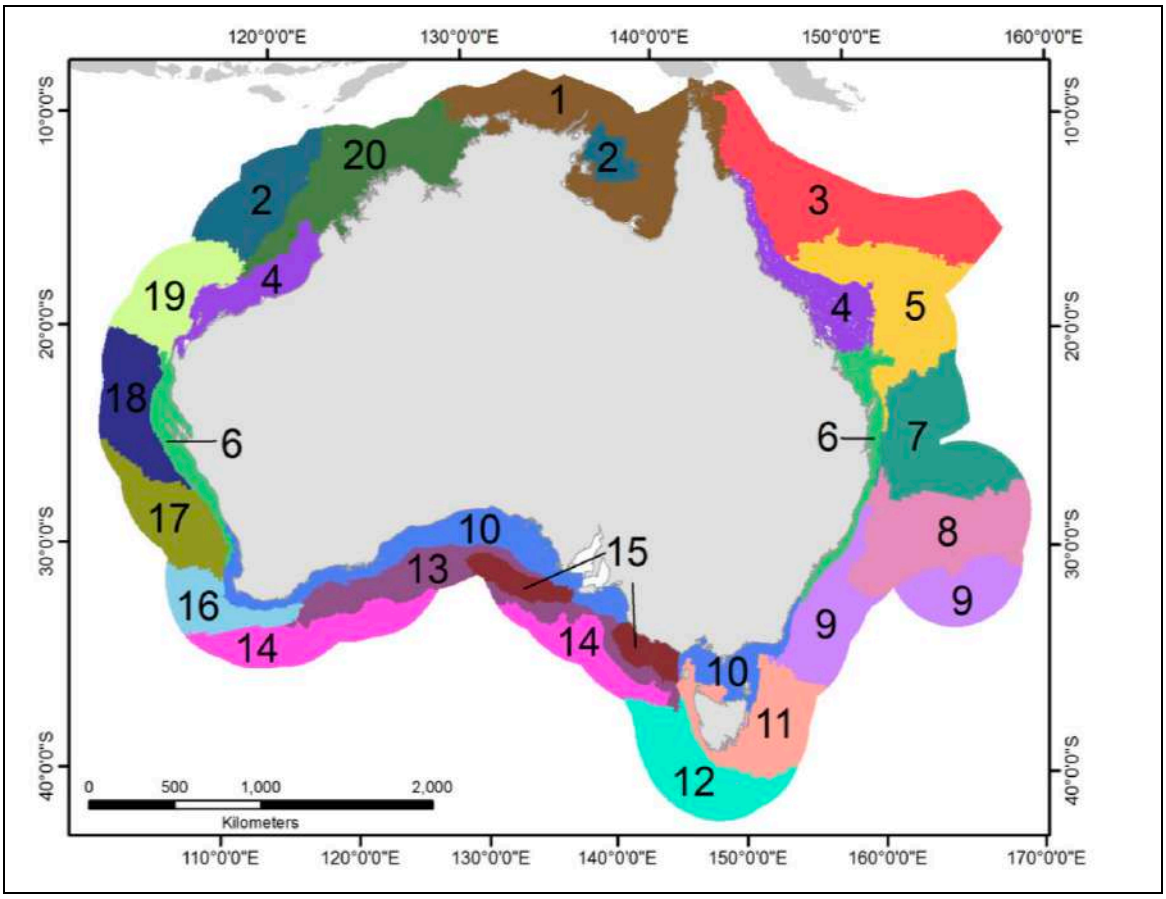
Turnpenny and Nedwell (1994) found that in sensitive species such as the cod, continuous ambient sound alone resulted in auditory masking, and that sound had to be 20 dB above ambient sound to be audible. Table 5.5 presents a comparison of biological and anthropological sounds in the marine environment.

Table 5.5. Sound intensity and pressure (dB re 1µPa @ 1 m from source) for some common marine sources

Source	Sound intensity (dB re 1 µPa)	Frequency (Hz)	Reference
Natural sound			
Ambient sea sound	80-120	Varied	2
Undersea earthquake	272	50	2
Seafloor volcanic eruption	255+	Varied	2
Lightning strike on sea surface	250	Varied	2
Iceberg calving, shoaling and disintegration	220-245	Varied	4
Bottlenose dolphin click	Up to 229	Up to 120,000	2
Breaching whale	200	20	2
Blue whale vocalisations	190	12 – 400 (16 – 25 dominant)	2
Blue whale moans	188	12 – 390 (16 – 25 dominant)	1
Southern right whale vocalisations	172-186	30 – 2,200 (50 – 500 dominant)	1
Humpback whale vocalisations	144-174	30 – 8,000 (song) (120 – 4,000 dominant) 50 – 10,000 (social calls)	1, 3
Sperm whale clicks	Up to 235	100 – 30,000	2
Anthropogenic sound			
Seismic acoustic source (32 guns)	178-210	Most energy 5 to 200 Hz	1
Ship sound (close to hull)	200	10 – 100	2
Fishing trawler	158	100	3
7 m outboard motorboat	156	630	3
Tanker (179 m)	180	60	3
Supertanker (340 m)	190	7	3
Containership (274 m)	181	8	3
Navigation transponders	180 – 200	7,000 – 60,000	3
Side scan sonar (SSS)	220 – 230	50,000 – 500,000	3

Source	Sound intensity (dB re 1 µPa)	Frequency (Hz)	Reference
Bottom profilers	200 – 230	400 – 30,000	3
Helicopter flyover (Bell 212)	142 – 155	162	1, 3
Drill rig (Ocean Bounty semi-submersible)	145 maximum (>120 for 1% of time at 5.1 km)	20 – 1,000 (15-30 dominant)	5
FPSO (maximum at Griffin Venture)	176	10 – 500 (up to 2,000)	6
References			
1 – Richardson et al (1995).	*2 – APPEA (2004).*	*3 – WDCS (2004).*	
4 – Matsumoto et al (2014).	*5 – Woodside (2003).*	*6 – Apache Energy (2008).*	

Erbe et al (2021) have classified the marine acoustic zones of Australia based on 10 km x 10 km grids that are characterised by sea surface temperature, salinity and sound speed profiles (for the month of July). The study resulted in the creation of 20 acoustic zones around Australia, with the impacts EMBA occurring within zone 20 ('Western Tropical Shelf') (Figure 5.8). Zone 20 is described as having shallow water with a wide sandy continental shelf and a hot sea surface that is strongly downward refracting (Erbe *et al.,* 2021). For zone 20 at 40 m water depth (the water depth at Beehive-1), the sound speed profile gradients ranged between -0.03 and 0.04 (m/s)/s.



Source: Erbe et al (2021).

Figure 5.8. Map of the 20 acoustic zones of the Australian EEZ for the Austral winter

5.2.3. Physical Environment

Bathymetry

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. Water depth in the impacts EMBA ranges from 40-50 m. 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 JBG and the impacts EMBA is presented in Figure 5.9.

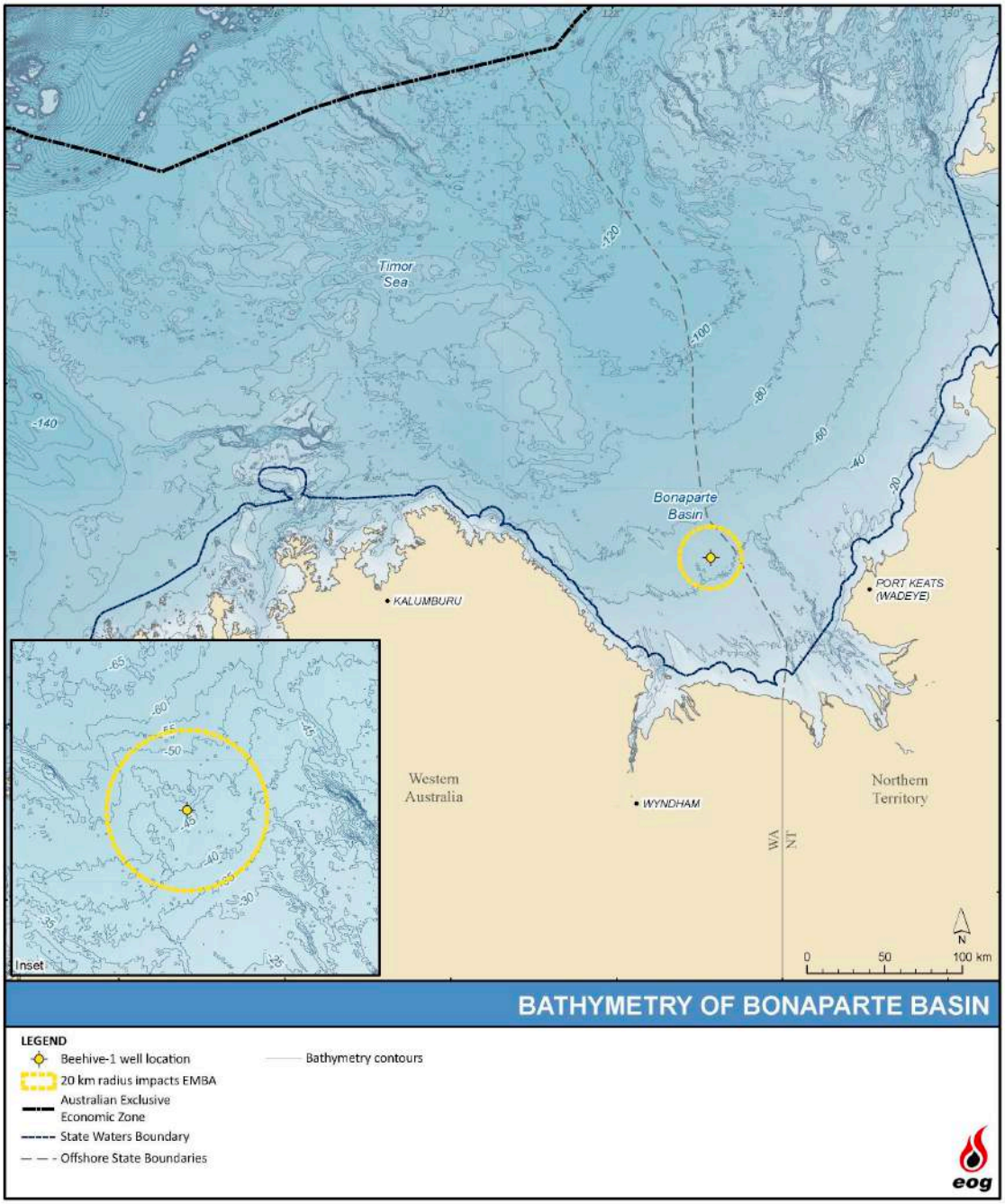


Figure 5.9. Bathymetry of the impacts EMBA and surrounds

The geophysical survey undertaken by Fugro for EOG in June 2022 around the proposed Beehive-1 site (Fugro, 2022) found that the bathymetry of the drill site is 45.6 m MSL with a 0.35° slope. The area immediately around the drill site is generally flat with a regional gradient of less than 1° to the west (Figure 5.10).

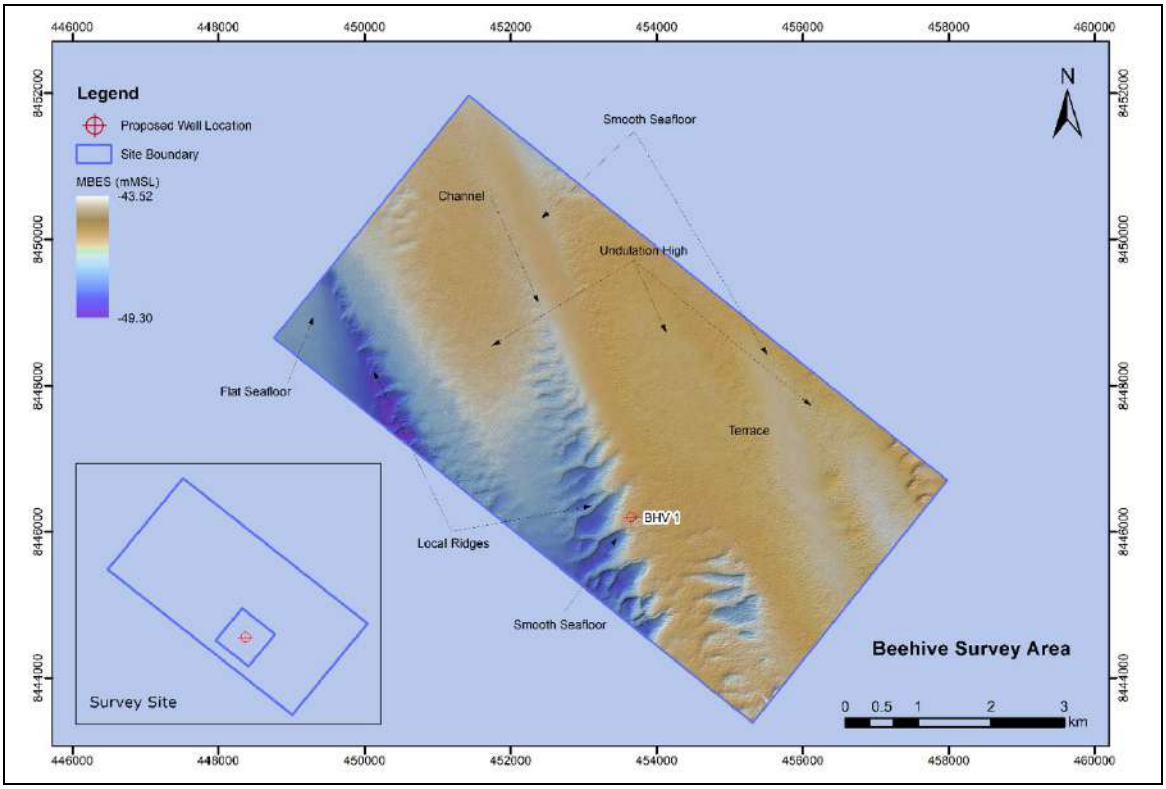


Figure 5.10. Bathymetry around the Beehive-1 location

Seabed

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 (near Lacrosse Island, at the mouth of Cambridge Gulf, about 50 km south of the impacts EMBA), have been generated by the strong outflows of sediment-laden water from Cambridge Gulf. Similar sandbars can be found in the southeast of the JBG. Beehive-1 is located on the 'shelf' geomorphic feature, which is typically characterised by extensive sediment plains and high sediment deposition from the coastal rivers to the south, while the impacts EMBA also overlaps the 'tidal-sandwave/sand-bank' geomorphic feature (Figure 5.11).

The geophysical survey undertaken around the proposed Beehive-1 site (Fugro, 2022) found that the topographical features in the survey area include broad undulations, terraces with uneven surfaces, local ridges, scarps and smooth seafloor areas. Seabed features found in the survey are listed below and illustrated in Figure 5.12:

- Low to moderate undulations and low to moderate acoustic reflectivity – inferred as silts and sands (medium to coarse);
- Moderate undulations and moderate acoustic reflectivity – inferred as sands (medium to coarse);

- Uneven and moderate acoustic reflectivity – inferred as sands (medium to coarse) and shells; and
- Uniform low acoustic reflectivity – inferred as silts, sandy silt and silty sand (fine).

At the Beehive-1 location, the seabed is inferred as sands (medium to coarse) and shells (see Figure 5.12), and the data from the shallow seismic survey indicates these sediments are 5.5 m deep in the top unit. The acoustic reflectivity (hardness) of the Beehive-1 location (generated from the side-scan sonar data) confirms an absence of seabed features around the drill site such as rocky reefs (Figure 5.13).

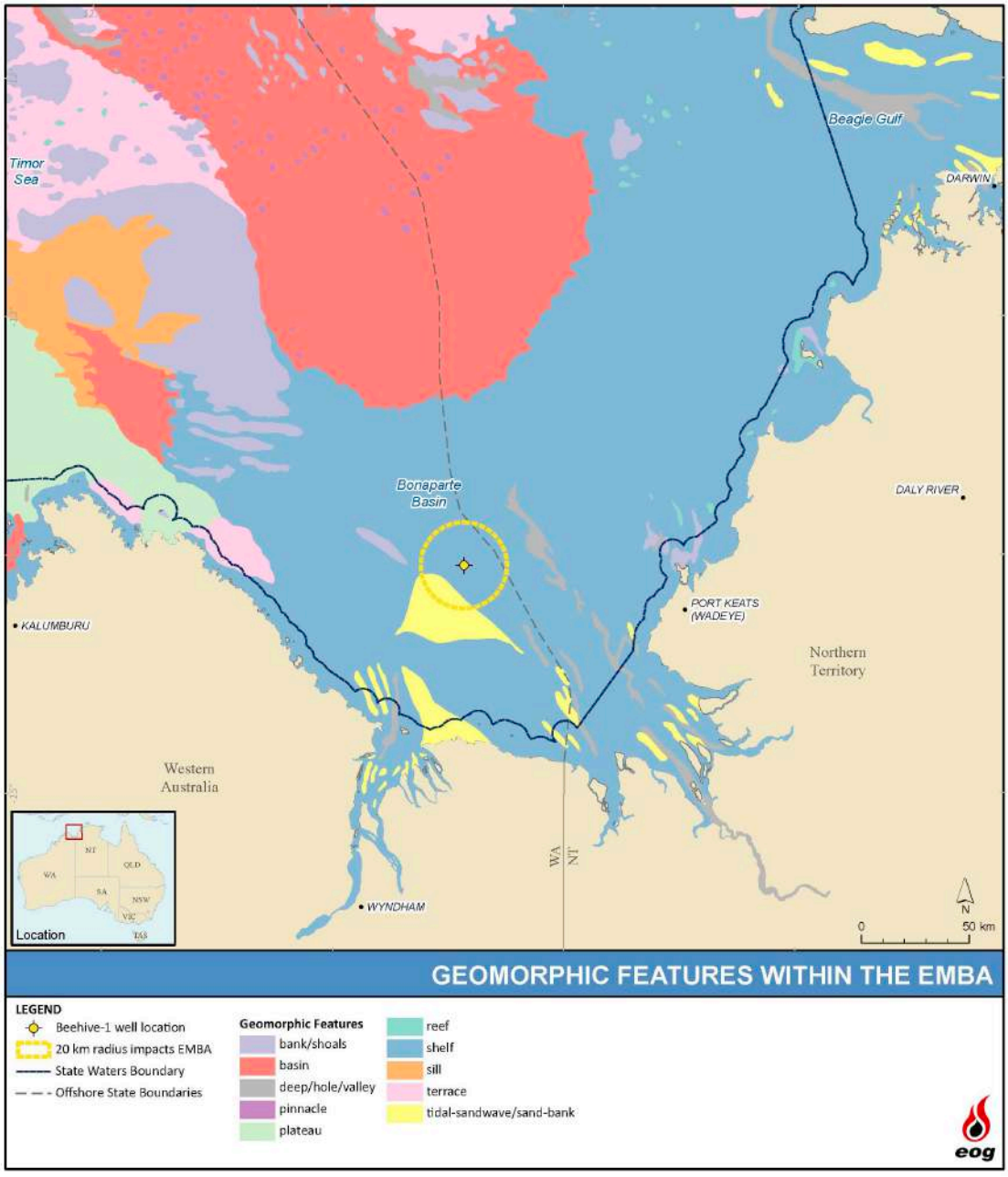


Figure 5.11. Geomorphic features of the impacts EMBA and surrounds

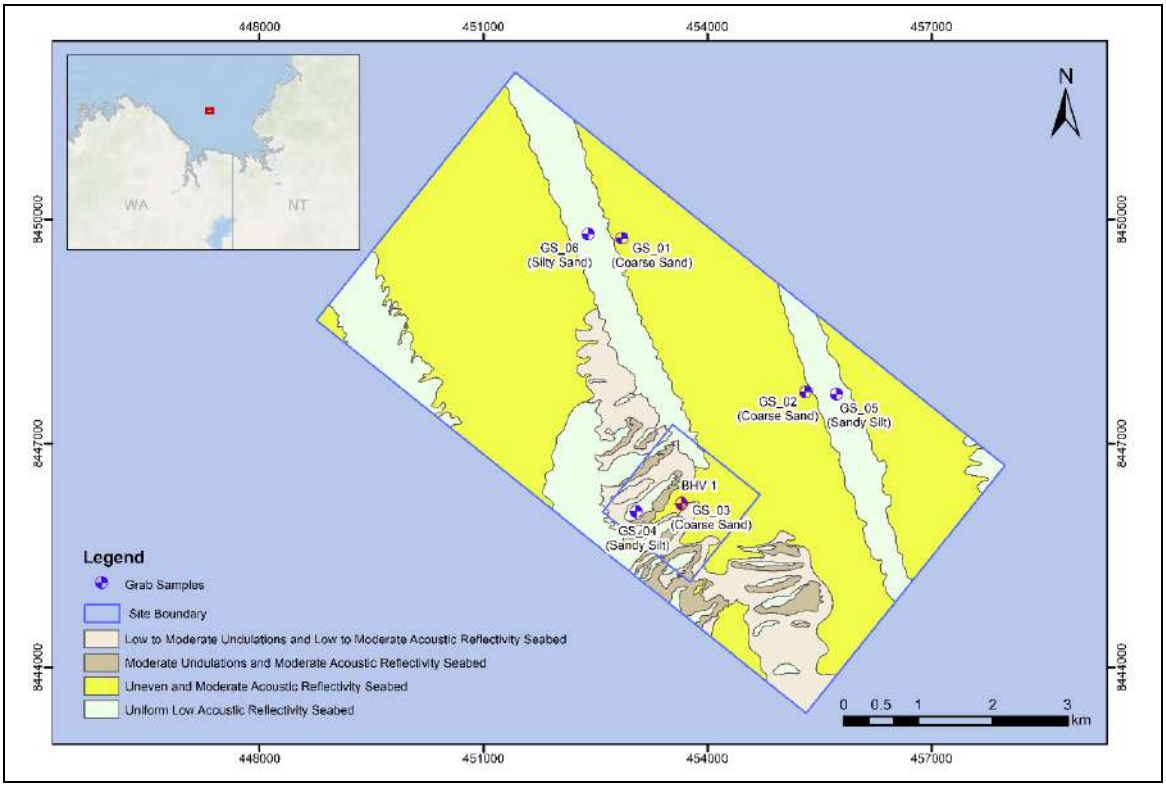


Figure 5.12. Seabed around the Beehive-1 location

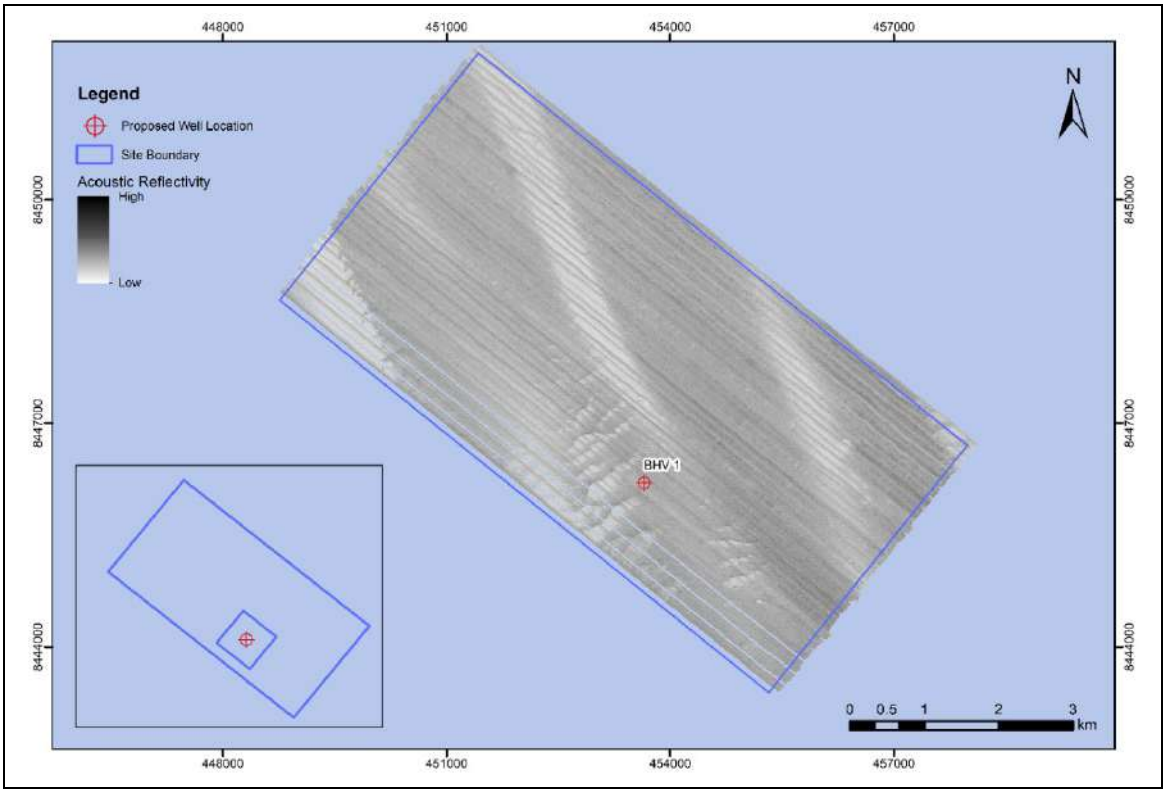


Figure 5.13. Acoustic reflectivity around the Beehive-1 location

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, 2012). 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, 96 km north of the impacts EMBA) 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 20 km northwest of Beehive-1. 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).

5.3. Coastal Environment

The coastal environment is outside the impacts EMBA and is described in Appendix 11.

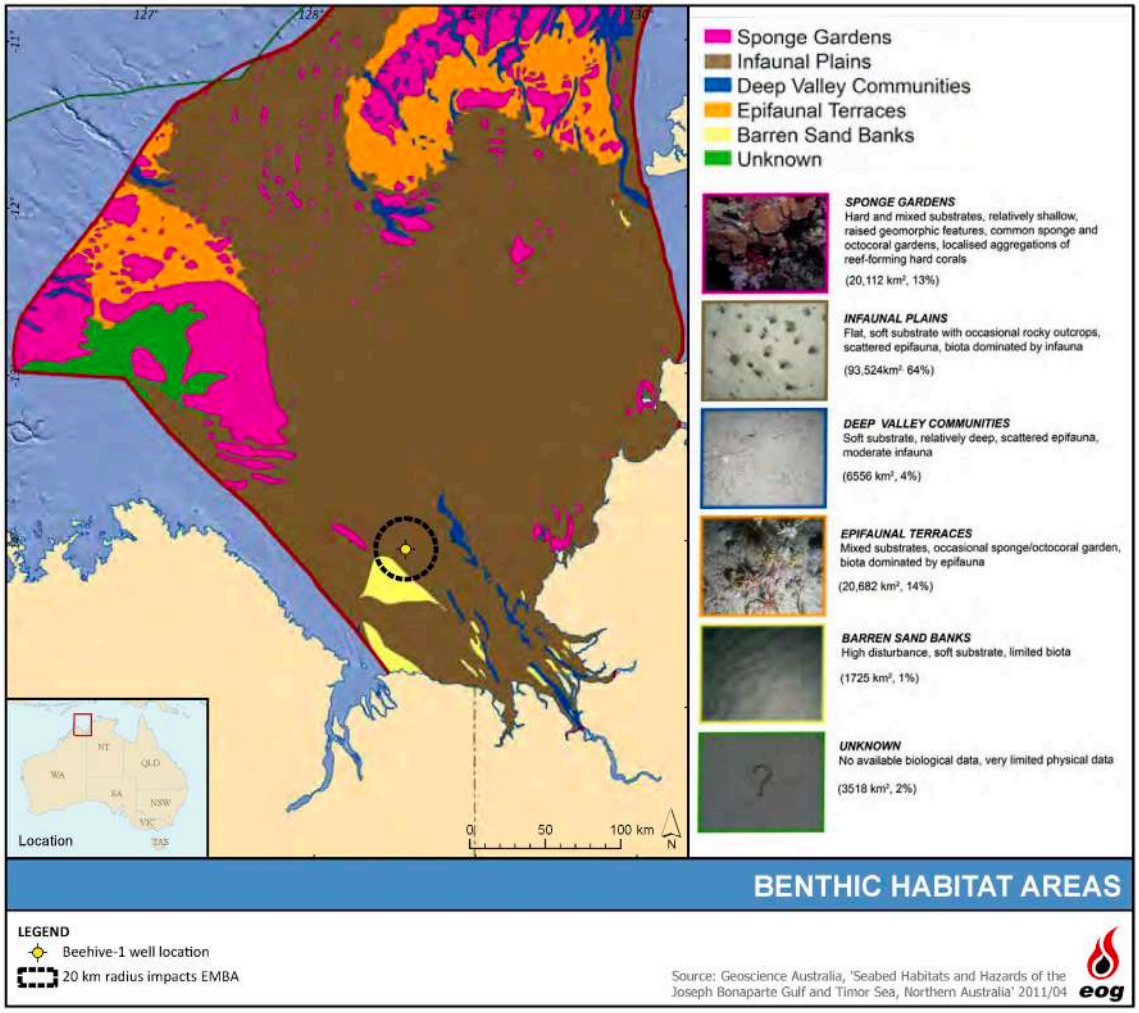
5.4. Biological Environment

The sources listed at the start of this chapter have been used in the preparation of this section. Additionally, biologically important areas (BIAs) are identified for those species that may occur within the impacts EMBA. BIAs are spatially defined areas, defined by the DCCEEW 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 (DCCEEW, 2022a). The BIAs do not represent a species' full distribution range.

The PMST identifies that in total, there are 20 threatened species and 38 migratory species (or habitat for such species) that may occur in the impacts EMBA.

5.4.1. 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. Figure 5.14 illustrates the habitat types in the JBG, with the impacts EMBA located within infaunal plains and barren sand banks, which are primarily characterised by flat soft substrate with occasional rocky outcrops, scattered epifauna and biota dominated by infauna (Przeslawski *et al*., 2011).



Source: Przeslawski et al (2011)

Figure 5.14. Generalised habitat map showing likely distribution of habitats and biological communities in the impacts EMBA and surrounds

Studies conducted on the infauna within the Blacktip Project area (the closest sampling station, located 20 km northwest of Beehive-1 and thus within the impacts EMBA) found infauna to be diverse and abundant, with two major phyla, Arthropoda (crustaceans) and Annelida (polychaete worms), contributing over 80% of the total number of individuals (Woodside, 2004). Recorded Arthropoda species include tanaids (shrimps), brachyurans (crabs) and grammarid amphipods. The Annelida were diverse comprising of 36 families, with the most abundant families being Terebellidae, Spionidae, Onphidae, Maldanidae and Ampharetidae. Members of these families are mainly tube-dwelling worms that feed on detrital material on the surface or in the surface sediments. Other abundant infauna are the Cnidaria (hydroids, soft corals), Mollusca (mainly bivalves) and Echinodermata (brittle stars, sea urchins).

The Blacktip baseline studies found that infauna species richness and abundance in the JBG was related to sediment particle size. Richness and species abundance increased with distance from the mouth of the Victoria River (100 km southeast of the impacts EMBA), which coincided with an increasing proportion of fine particles in the sediment (Woodside, 2004). Sites near the Victoria River mouth generally had coarser sediments and lower species richness and abundance. The Blacktip sampling sites supported a richer assemblage than sites closer to the Victoria River mouth (Woodside, 2004).

During this survey, 135 nominal species were identified. However, faunal abundance was low with only 528 individuals recorded and only 14 species recording more than 10 individuals across all the offshore samples. The composition of the infaunal community was somewhat unusual. Continental shelf infauna is generally dominated by polychaete worms. However, nearly three times as many crustaceans were collected as polychaetes. Bryozoans and hydroids were the next most abundant group after the crustaceans, and nearly as many molluscs and echinoderms were collected as polychaetes. The most abundant species was a porcelain crab followed by a brittle star (Woodside, 2004).

The study also observed that sites near the Victoria River mouth, which generally had coarser sediments, had a greater proportional abundance of crustaceans and cnidarians (hydroids and soft corals) compared to sites further offshore, which supported a predominantly detritus feeding infauna (Woodside, 2004).

Crustaceans

In a study of prawn trawl bycatch in the JBG, which included sampling locations close to the impacts EMBA, Tonks et al (2008) found that four crustacean species dominated the invertebrate component of the bycatch: *Charybdis callianassa* (Portunidae); *Trachypenaeus gonospinifer* (Penaeidae); *Metapenaeopsis novaeguineae* (Penaeidae); and *Solenocera 101ertebrate101* (Solenoceridae).

The dominant prawn species of the JBG are the penaeid species, namely tiger prawn (*Penaeus esculentus*), banana prawn (*P. merguiensis*) and red-legged banana prawn (*P. indicus*). These species occur in coastal waters to depths of approximately 200 m and are widely distributed through sub-tropical and tropical waters from WA to New South Wales (NSW) (Jones and Morgan, 1994). Shallower inshore waters act as nursery grounds for juveniles, such as the river and tidal creek systems of the JBG. Small numbers of prawns can also be found in mangrove habitats. More is known about the distribution and abundance of prawns in the JBG compared to other crustaceans due to their commercial significance.

As discussed in detail in Section 5.8.1, prawns are commercially caught in areas of the JBG, mainly in the west of the gulf and in Fog Bay, NT (more than 200 km to the northeast of the impacts

EMBA). The juvenile prawns that migrate offshore to the fishery come from mangrove nursery habitats from the Victoria River in the east of the JBG, to the Ord River and Cambridge Gulf in the west, forming a very extensive migration throughout the lower region of the JBG. This migration is likely to be from February to April and October to December. Migration of the juveniles is thought to be triggered by rainfall and river discharge. The areas most intensely fished for prawns are located in the Gulf of Carpentaria (over 900 km east of the impacts EMBA).

Prawns

There are several prawn species present in the JBG that occupy benthic habitats and prey on micro-organisms, small shellfish, worms and decaying organic matter. Several of the species develop their juveniles in nearshore estuarine and mangrove habitat before moving further offshore in adulthood. Based on information from the NPFI, commercial prawn species such as banana, tiger and endeavour prawns may spawn within the activity area during the warmer months of the year. The habitat, distribution and reproduction of these species is presented in Table 5.6 based on several sources of literature, and Figure 5.15 illustrates the spawning periods for the key commercial prawn species.

Based on information from the NPFI, commercial prawn species such as banana, tiger and endeavour prawns may spawn within the impacts EMBA during the warmer months of the year. Banana prawns spawn offshore throughout the year with two spawning peaks: the late dry season (September-November) and the late wet season (March-May).

Endeavour prawns spawn throughout the year, with blue endeavour prawns having spawning peaks in March and September and red endeavour prawns have a spawning peak in September to December. Based on the endeavour prawn spawning habitat preferences it is unlikely that they would spawn in the impacts EMBA.

Brown tiger prawns peak spawning period is between July and October. A twelve-month-old female prawn can produce hundreds of thousands of eggs at a single spawning and may spawn more than once in a season. The eggs sink to the bottom after release, where they hatch into larvae within about 24 hours. Less than 1% of these offspring survive the two-to-four-week planktonic larval phase to reach suitable coastal nursery habitats where they may settle. After one to three months on the nursery grounds, the young prawns move offshore onto the fishing grounds. See Section 5.7.1 for more information.

Molluscs

The JBG has relatively low mollusc species diversity due to the restricted number of habitats available and silty conditions, with less than 100 species (mainly bivalves) recorded in the region (Walker *et al*., 1996). Many different types of molluscs are found in the mangroves, including clams (Walker *et al*., 1996). The soft sediment infaunal plains habitat that dominates the impacts EMBA does not provide extensive hard substrate for bivalve molluscs or other fixed invertebrates to attach and reproduce (Przeslawski *et al*., 2011).

Silver lipped pearl oysters are known to be sparsely distributed in the JBG up to the 100 m isobath. Primary spawning occurs from the middle of October to December, with a smaller secondary spawning occurring in February and March (Hart *et al*., 2015). Pearling licensees have not raised any concerns with EOG regarding the presence of pearl oysters or pearling activities in and around the impacts EMBA.

During in-person meetings held in Broome and Kalumburu as part of the relevant persons consultation process, some individuals raised concerns about the potential impacts of drilling on scallops. The available literature indicates that scallops are scarce within the activity area and surrounds. Marine ecological surveys of the Joseph Bonaparte Gulf AMP (16 km east of the impacts EMBA) conducted in 2023 did not report the presence of scallops (Udyawer *et al.,* 2023). Additionally, the eco-narrative of Joseph Bonaparte Gulf AMP (Galaiduk *et al.,* 2019) also did not indicate the presence of scallops. The only scallop species that are abundant enough to be commercially fished in WA waters are saucer scallops (*Amusium balloti*), which are found between Broome and east of Esperance and are particularly abundant in Shark Bay and Abrolhos Islands (outside of the impacts EMBA and the spill EMBA) (DPIRD, 2013).

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 impacts EMBA. The closest identified coral reef habitat is located within the JBG Australian Marine Park (JBG AMP). Reefs, shoals and banks present within the spill EMBA are described in Section 11.3.1 of Appendix 11.

Table 5.6. Key prawn species habitat, distribution, and reproduction in the JBG

Species	Habitat	Stock structure & distribution	Spawning
Banana prawns Redleg banana prawn (*Penaeus indicus)* White banana prawn (*P. merguiensis*)	Banana prawns live in tropical and sub-tropical coastal waters and are found over muddy and sandy bottoms in coastal waters and estuaries (AFMA, 2021). White banana prawns can generally be found at depths of 16-25 m but can occur to depths of 45 m, while red-legged banana prawns are found at depths of 35-90 m (AFMA, 2021). Juvenile redleg banana prawns are found in estuarine habitats up to 120 km south and 240 km east-southeast of the southern and eastern limits of the *P. indicus* fishery in the JBG. Although mangrove habitats are the closest inshore habitats to the fishery, they are not used by *P. indicus.* Given the habitat preference for *P. indicus*, the larvae resulting from spawning in the fishing grounds rely on tides and currents. Move large distances to the south and east to their nursery habitats (Loneragan *et al.,* 2002). This implies that the emigrating juveniles and sub-adults migrate from the mangrove nursery habitats, north and west, across shallower sand substrates (30-40 m deep) to the deep-water fishery (on mud substrates about 50-80 m deep). Juvenile white banana prawns are found in estuarine habitats in the western part of JBG, about 50 km to the southwest of the *P. indicus* fishery.	Banana prawn species are mainly found in tropical and sub-tropical waters around Australia from Shark Bay in WA to the NT and Queensland coastlines (including waters in Torres Strait between Australia and Papua New Guinea) (AFMA, 2021). The104ertebrical stock structure of banana prawn is uncertain. Redleg banana prawns are widely distributed across the Indo-West Pacific Ocean. In the JBG, a single separate stock is assumed for stock assessment and management purposes (Patterson *et al*., 2021). In the NPF, there is some evidence of white banana prawn sub-stock structuring associated with significant river catchments and their annual flow regimes; however, there is an absence of clear evidence on biological stock structure, status is determined for a single fishery-level stock (Patterson *et al*., 2021).	Banana prawns reach reproductive maturity at approximately 6 months of age (AFMA, 2021). They spawn offshore throughout the year with two spawning peaks: the late dry season (September – November) and the late wet season (March – May) (AFMA, 2021) (see Figure 5.12). Banana prawns are serial spawners. Each female lays several egg batches each year. Females produce 100,000 to 450,000 eggs per year. Eggs hatch within 24 hours of fertilisation (AFMA, 2021). Less than 1% of larvae survive the 2-4 week planktonic larval phase to reach suitable coastal nursery habitats where they settle, however there are no written records to verify these statistics other than postlarval and juvenile mortality are known to be high (Rob Kenyon CSIRO Division of Marine Research, pers.comm. February 2022). After 1-3 months in the nursery grounds, the young prawns migrate offshore. Migration of the main cohort occurs November-March. A possible second cohort migrates April-June. Migration is thought to be triggered by rainfall and river discharge. Juveniles reach sexual maturity at 6 months and have a lifespan of 1-2 years (Yearsley *et al.,* 1999).

Species	Habitat	Stock structure & distribution	Spawning
Tiger prawns Brown tiger prawn (*Penaeus esculentus*) Grooved tiger prawn (*P. semisulcatus*).	Tiger prawns live in coastal waters to depths of 200 m (AFMA, 2021). Adult brown tiger prawns are found over coarse sediments and adult grooved tiger prawns are found in fine mud sediments (AFMA, 2021). Juvenile tiger prawns are found in shallow waters, often where seagrass beds are present, and sometimes on top of coral reef platforms (AFMA, 2021).	Brown tiger prawns are endemic to tropical and subtropical waters of Australia, while grooved tiger prawns have a wider Indo–West Pacific distribution. There is some genetic evidence of separation of brown tiger prawn stocks from the east and west coasts of Australia (Patterson *et al*., 2021). Assessment of stock status for the brown tiger and grooved tiger is undertaken at the management unit level – NPF (Commonwealth) (Patterson *et al*., 2021).	For brown tiger prawns, spawning occurs throughout the year, in both inshore and offshore areas, while grooved tiger prawns spawn in offshore areas (AFMA, 2021). Brown tiger prawns have a spawning peak between July and October (see Figure 5.12) (AFMA, 2021). Grooved tiger prawns have a spawning peak in August-September, with a secondary peak in February (see Figure 5.12) (AFMA, 2021). Females produce about 186,000 eggs (brown tiger prawns) and 365,000 eggs (grooved tiger prawns) per year depending on their body size. Eggs hatch within 24 hours of fertilisation (AFMA, 2021). There is little to no information available on the spawning locations of tiger prawns (Rob Kenyon CSIRO Division of Marine Research, pers.comm. February 2022). Juveniles reach sexual maturity at about 6 months and have a lifespan of 2 years (Yearsley *et al.,* 1999).
Endeavour prawns Blue endeavour prawn (*Metapenaeus endeavouri*) Red endeavour prawn (*M. ensis*).	Endeavour prawns live in tropical coastal waters (AFMA, 2021). Blue endeavour prawns are found over sandy or mud-sand substrates to depths of about 60 m, while red endeavour prawns prefer muddy substrates and have been found to depths of 95 m (AFMA, 2021). Juvenile blue endeavour prawns are commonly associated with seagrass beds in shallow estuaries, while juvenile red endeavour prawns are more widely distributed across seagrass beds, mangrove banks, mud flats and open channels (AFMA, 2021).	Endeavour prawn fisheries are located in Shark Bay, Exmouth Gulf, the north coast of WA, the Gulf of Carpentaria, the Torres Strait and the east coast of Queensland. Little is known about the biological stock structure of the populations of blue and red endeavour prawns. Assessment of stock status for each species is undertaken at the NPF (Commonwealth) management level (Patterson *et al*., 2021).	Spawning occurs throughout the year (AFMA, 2021). Blue endeavour prawns have spawning peaks in March and September, while red endeavour prawns have a spawning peak in September to December (see Figure 5.12) (AFMA, 2021). There is little to no information available on the spawning locations of endeavour prawns (Rob Kenyon CSIRO Division of Marine Research, pers.comm. February 2022). Females produce about 296,000 eggs per year (AFMA, 2021). Juveniles reach sexual maturity at 6 months and have a lifespan of 1-2 years (Yearsley *et al.,* 1999).

Note: AFMA and CSIRO were contacted by EOG in February 2022 to verify gaps in information specifically spawning locations for banana prawns, tiger prawns and endeavour prawns. Where available, data is referenced within the table.

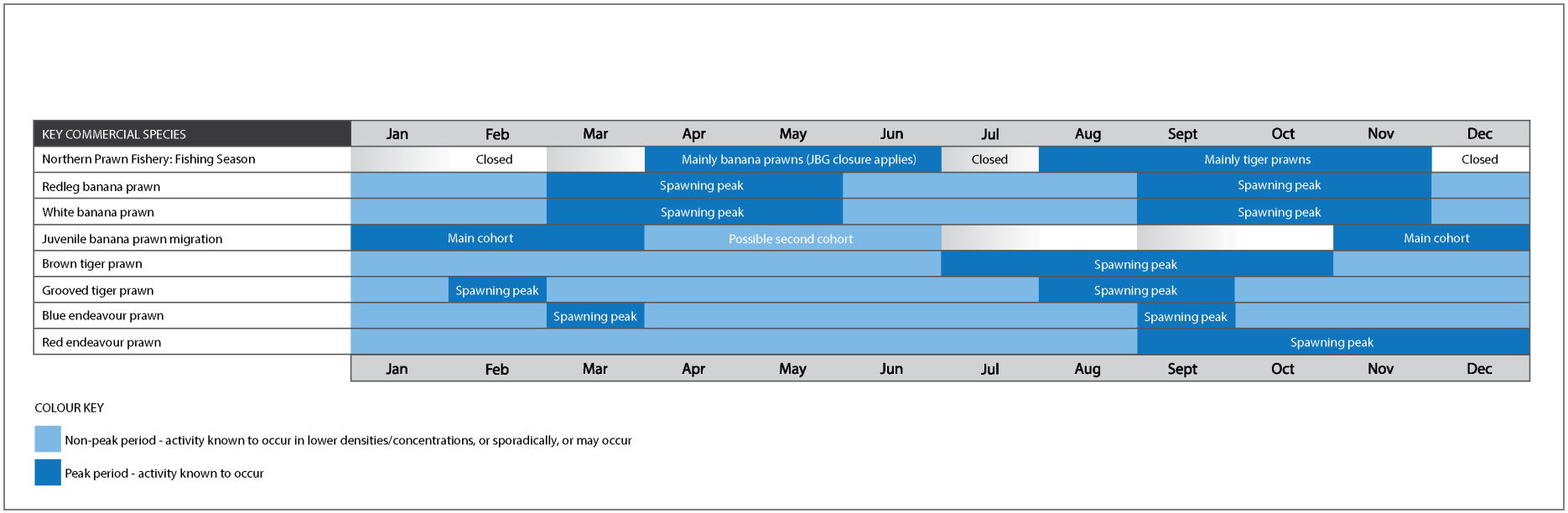


Figure 5.15. Commercial prawn species spawning periods

5.4.2. Flora

Marine flora, such as macroalgae, seagrass beds and mangroves occur in shallow waters outside the impacts EMBA. As such, these are described in Section 11.3.2 of Appendix 11.

5.4.3. Plankton

Phytoplankton

Phytoplankton (photosynthetic microalgae) comprise 13 divisions of mainly microscopic algae, including diatoms, dinoflagellates, gold-brown flagellates, green flagellates and cyanobacteria and prochlorophytes (McLeay *et al*., 2003). Phytoplankton drift with the currents, although some species have the ability to migrate short distances through the water column using ciliary hairs. Phytoplankton has the capacity to multiply rapidly in response to bursts of nutrient availability and are107ertebratetly consumed by zooplankton that in turn are consumed by other marine fauna species.

Zooplankton

Zooplankton is the faunal component of plankton, comprising small crustaceans (such as krill), fish eggs and fish larvae. Zooplankton includes species that drift with the currents and also those that are motile. Nutrients and planktonic organisms (including many species of larval recruits) are transported to and from the JBG by the southerly movement of the Indonesian Throughflow and the southeast and northwest monsoonal wind-driven currents (Brewer *et al*., 2007).

5.4.4. Finfish, Sharks and Rays

There are 37 fish species listed under the EPBC Act that are known to occur, likely to occur or may occur in both the flaring and the impacts EMBA (Table 5.7) (DCCEEW, 2022a). Of these, there are six shark, four sawfish and 24 sygnathiforme (seahorses, pipefishes and their relatives) species. Seven species are listed as threatened and 11 are migratory (five of the migratory species are also listed as threatened). Figure 5.16 illustrates the likely temporal presence and absence of these fish species in the impacts EMBA. The species listed as threatened or migratory are described in this section.

The flaring EMBA PMST results for finfish, sharks and rays was identical to the species detected within the impacts EMBA. In light of this, the flaring EMBA will not be discussed further.

Table 5.7. EPBC Act-listed finfish, sharks and rays that may occur in the impacts and flaring EMBA

Scientific name	Common name	EPBC Act Status			Type of presence in impacts EMBA	Type of presence in flaring EMBA	BIA intersected by impacts EMBA?	BIA intersected by flaring EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine					
Classed as sharks									
Anoxypristis cuspidate	Narrow sawfish	-	Yes	-	Likely	Likely	No	No	-
Carcharodon carcharias	Great white shark	V	Yes	-	May occur	May occur	No	No	RP
Carcharhinus longimanus	Oceanic whitetip shark	-	Yes	-	May occur	May occur	No	No	-
Glyphis garricki	Northern river shark	E	-	-	May occur	May occur	No	No	CA, RP
Isurus oxyrinchus	Shortfin mako	-	Yes	-	Likely	Likely	No	No	-
Isurus paucus	Longfin mako	-	Yes	-	Likely	Likely	No	No	-
Manta alfredi	Reef manta ray	-	Yes	-	Likely	Likely	No	No	-
Manta birostris	Giant manta ray	-	Yes	-	Likely	Likely	No	No	-
Pristis clavata	Dwarf sawfish	V	Yes	-	Known	Known	No	No	CA, RP
Pristis pristis	Largetooth sawfish	V	Yes	-	May occur	May occur	No	No	CA, RP
Pristis zijsron	Green sawfish	V	Yes	-	Known	Known	No	No	CA, RP
Rhincodon typus	Whale shark	V	Yes	-	May occur	May occur	No	No	CA
Sphyrna lewini	Scalloped hammerhead shark	CD	-	-	Likely	Likely	No	No	-
Classed as fish									
Campichthys tricarinatus	Three-keel pipefish	-	-	Yes	May occur	May occur	No	No	-
Choeroichthys brachysoma	Pacific short-bodied pipefish	-	-	Yes	May occur	May occur	No	No	-

Scientific name	Common name	EPBC Act Status			Type of presence in impacts EMBA	Type of presence in flaring EMBA	BIA intersected by impacts EMBA?	BIA intersected by flaring EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine					
Choeroichthys suillus	Pig-snouted pipefish	-	-	Yes	May occur	May occur	No	No	-
Corythoichthys amplexus	Fijian banded pipefish	-	-	Yes	May occur	May occur	No	No	-
Corythoichthys flavofasciatus	Reticulate pipefish	-	-	Yes	May occur	May occur	No	No	-
Corythoichthys schultzi	Schultz's pipefish	-	-	Yes	May occur	May occur	No	No	-
Doryrhamphus excisus	Bluestripe pipefish	-	-	Yes	May occur	May occur	No	No	-
Doryrhamphus janssi	Cleaner pipefish	-	-	Yes	May occur	May occur	No	No	-
Halicampus brocki	Brock's pipefish	-	-	Yes	May occur	May occur	No	No	-
Halicampus grayi	Mud pipefish	-	-	Yes	May occur	May occur	No	No	-
Halicampus spinirostris	Spiny-snout pipefish	-	-	Yes	May occur	May occur	No	No	-
Haliichthys taeniophorus	Ribboned pipehorse	-	-	Yes	May occur	May occur	No	No	-
Hippichthys penicillus	Beady pipefish	-	-	Yes	May occur	May occur	No	No	-
Hippocampus histrix	Spiny seahorse	-	-	Yes	May occur	May occur	No	No	-
Hippocampus kuda	Spotted seahorse	-	-	Yes	May occur	May occur	No	No	-
Hippocampus planifrons	Flat-face seahorse	-	-	Yes	May occur	May occur	No	No	-
Hippocampus spinosissimus	Hedgehog seahorse	-	-	Yes	May occur	May occur	No	No	-
Micrognathus micronotopterus	Tidepool pipefish	-	-	Yes	May occur	May occur	No	No	-
Solegnathus hardwickii	Pallid pipehorse	-	-	Yes	May occur	May occur	No	No	-
Solegnathus lettiensis	Gunther's pipehorse	-	-	Yes	May occur	May occur	No	No	-

Scientific name	Common name	EPBC Act Status			Type of presence in impacts EMBA	Type of presence in flaring EMBA	BIA intersected by impacts EMBA?	BIA intersected by flaring EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine					
Solenostomus cyanopterus	Robust ghost pipefish	-	-	Yes	May occur	May occur	No	No	-
Syngnathoides biaculeatus	Double-end pipehorse	-	-	Yes	May occur	May occur	No	No	-
Trachyrhamphus bicoarctatus	Bentstick pipefish	-	-	Yes	May occur	May occur	No	No	-
Trachyrhamphus longirostris	Straightstick pipefish	-	-	Yes	May occur	May occur	No	No	-

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*.

Key

EPBC status (@ Sep 2023)	V	Vulnerable
	E	Endangered
	CE	Critically endangered
BIA	A	Aggregation
	D	Distribution (i.e., presence only)
	F	Foraging
	M	Migration
Recovery plans (under EPBC Act 1999)	CA	Conservation Advice
	CMP	Conservation Management Plan
	RP	Recovery Plan
	WCP	Wildlife Conservation Plan

Type of presence	Known	Species or species habitat known to occur in area
	Likely	Species or species habitat likely to occur in area
	May occur	Species or species habitat may occur in area
	Congregate	Congregation/aggregation known to occur in area

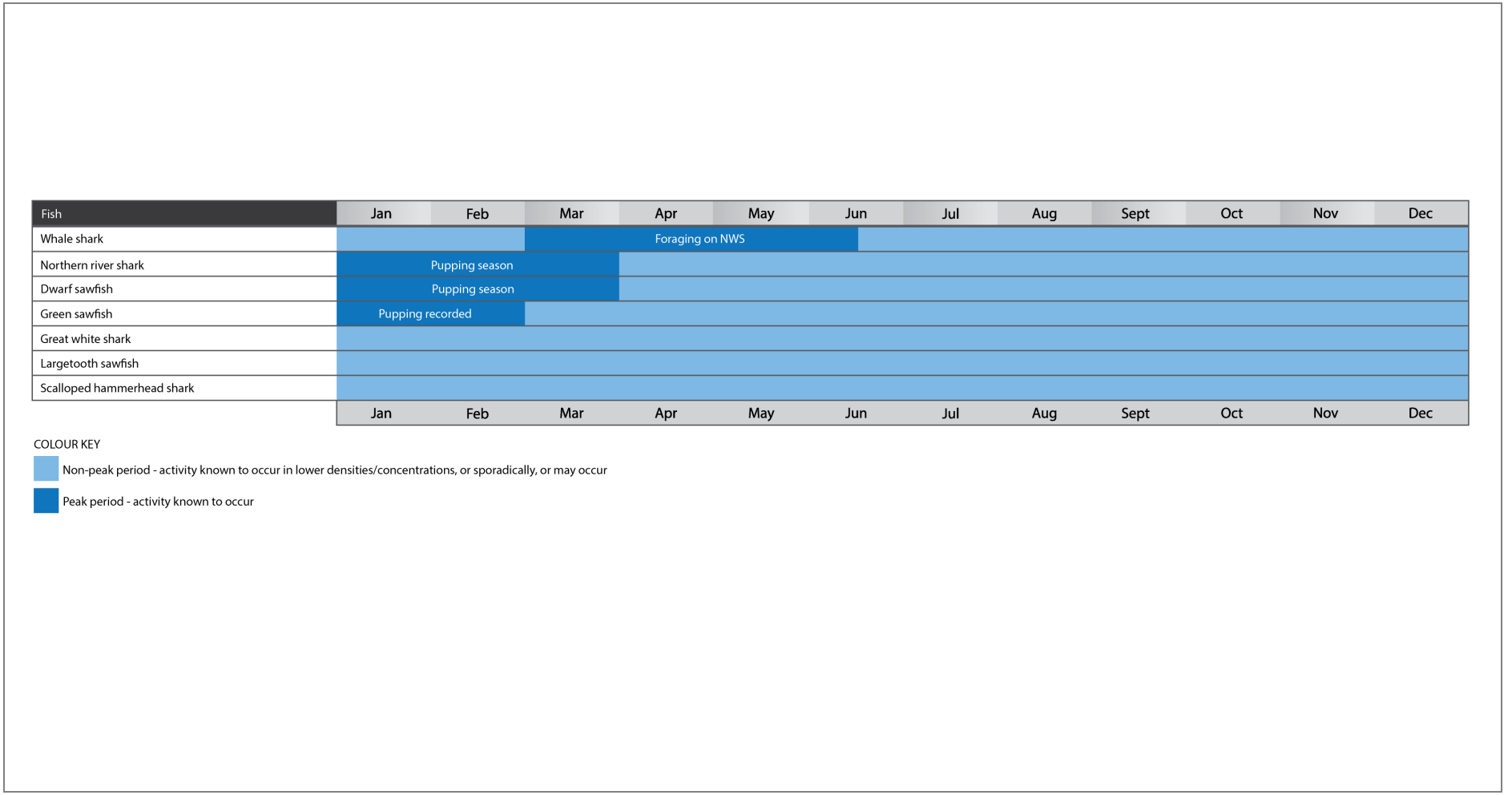


Figure 5.16. Likely temporal presence and absence of EPBC Act-listed threatened fish species in the impacts EMBA

The exact locations and timing of spawning and/or aggregations of fish and shark species are unknown, but the DPIRD provide an indication of species that may spawn within the North Coast bioregion, which includes the JBG (DoF, 2013a) (Table 5.8).

Table 5.8. Peak spawning/aggregation times for key commercial fish species in the North Coast Bioregion

Common name	Species name	Spawning / aggregation times
Blacktip shark	*Carcharhinus tilstoni* & *C.limbatus*	November – December
Goldband snapper	*Pristipomoides multidens*	January – April
Pink snapper	*Pagrus auratus*	May – July
Rankin cod	*Epinephelus multiinotatus*	August – October
Red emperor	*Lutjanus sebae*	October, January, March
Sandbar shark	*Carcharhinus plumbeus*	October – January
Spanish mackerel	*Scomberomorus commerson*	August – November

Threats and pressures on fish

Several of the fish species listed in Table 5.8 are subject to pressures, which are described in various recovery plans and conservation advice. Table 5.9 summarises the pressures listed in the plans/advice relevant to each of these species that could result from drilling activities.

Table 5.9. Summary of threats to fish species

Species	Recovery Plan, Management Plan or Conservation Advice	Key threat/s relevant to drilling
Great white shark	Recovery Plan for the White Shark (*Carcharodon carcharias*) (DSEWPC, 2013b)	Ecosystem effects as a result of habitat modification
Northern river shark	Approved conservation advice for Glyphis garricki (northern river shark) (TECC, 2014)	Habitat degradation and modification
	Sawfish and River Sharks Multispecies Recovery Plan (DoE, 2015a)	Habitat degradation and modification
Dwarf sawfish	Approved Conservation Advice for *Pristis 113ertebr* (dwarf sawfish) (DEWHA, 2009)	Habitat degradation
	Sawfish and River Sharks Multispecies Recovery Plan (DoE, 2015a)	Habitat degradation and modification
Largetooth sawfish	Approved Conservation Advice for *Pristis pristis* (large sawfish) (DoE, 2014a)	Habitat degradation and modification
	Sawfish and River Sharks Multispecies Recovery Plan (DoE, 2015a)	Habitat degradation and modification
Green sawfish	Approved Conservation Advice for green sawfish (DEWHA, 2008c)	Habitat degradation and modification
	Sawfish and River Sharks Multispecies Recovery Plan (DoE, 2015a)	Habitat degradation and modification

Species	Recovery Plan, Management Plan or Conservation Advice	Key threat/s relevant to drilling
Whale shark	Conservation Advice for *Rhincodon typus* (whale shark) (TSSC, 2015d)	Boat strike Habitat disruption from mineral exploration Marine debris
Scalloped hammerhead shark	Listing Advice *Sphyrna lewini* (scalloped hammerhead) (TSSC, 2018a)	None. Historic and current fishing.

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 (DCCEEW, 2022b). 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 impacts 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 (DCCEEW, 2022b). Shortfin makos are also highly migratory and travel large distances (DCCEEW, 2022b). Due to their widespread distribution in Australian waters, their presence in the impacts 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 impacts 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 (DCCEEW, 2022b). It is considered to be an oceanic and coastal species, commonly seen far offshore but also closer inshore near coral atolls (DCCEEW, 2022b). Whale sharks generally prefer tropical to warm temperate waters where surface sea temperature ranges from 21° to 25 °C (DCCEEW, 2022b).

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 (DCCEEW, 2022b). While the whale shark foraging BIA is not intersected by the impacts EMBA, it may migrate through it.

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 5.17). 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 impacts 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 circum-global 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 species is unlikely to occur within the impacts EMBA.

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 operational, reef manta rays may be present in the impacts 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 AMP, which is located 138 km north-northwest of the impacts EMBA (Nichol *et al*., 2013). Despite there being no known aggregation sites within close proximity to the impacts EMBA, giant manta rays may be present in it as transiting individuals.

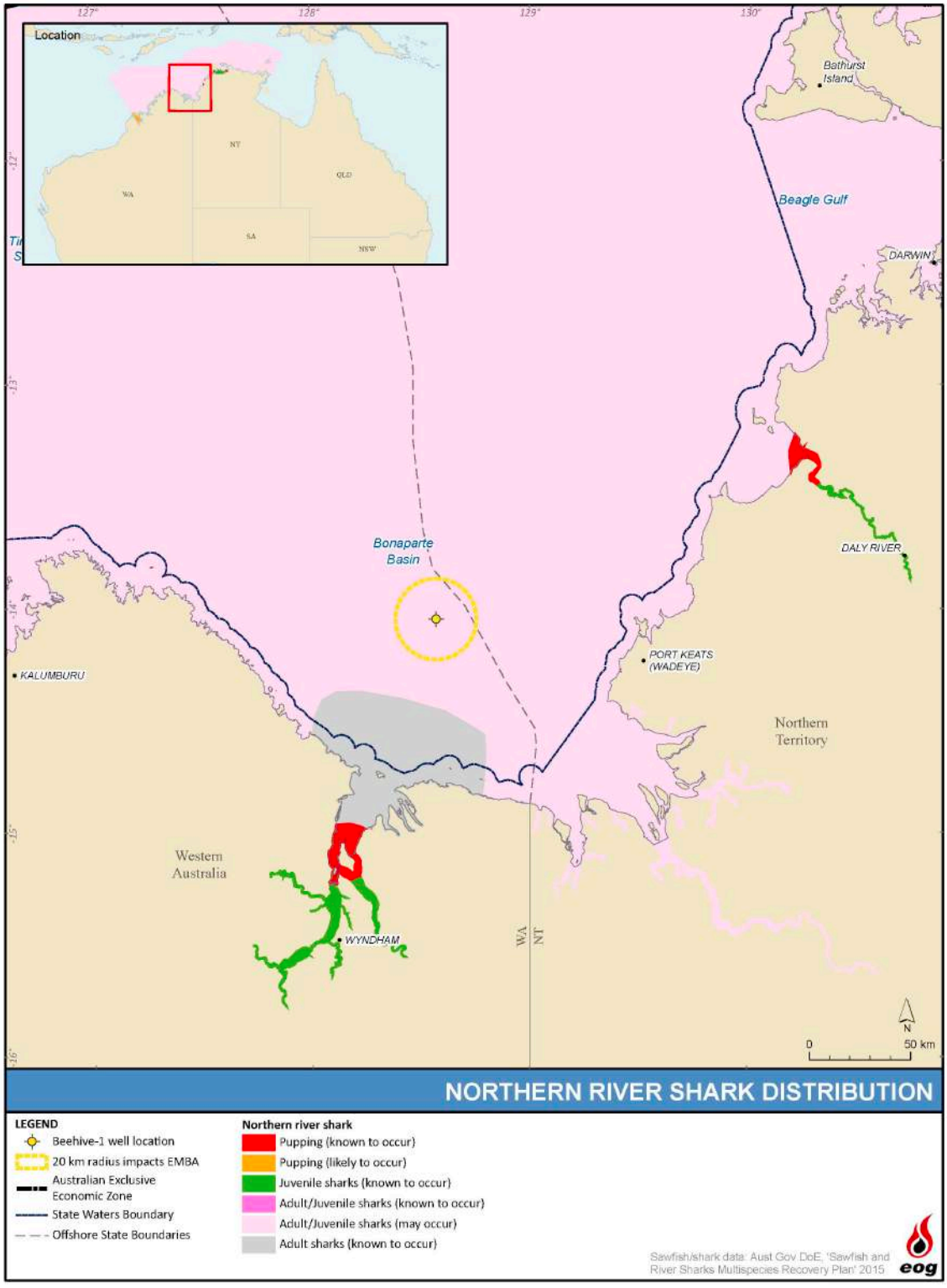


Figure 5.17. Northern river shark presence in the impacts EMBA and surrounds

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 impacts 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 117ertebr*) 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 (DCCEEW, 2022b). 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 impacts EMBA (Figure 5.18).

Largetooth sawfish (EPBC Act: Vulnerable, Listed migratory)

Largetooth sawfish (*Pristis pristis*) 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). The freshwater 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. The impacts EMBA overlaps areas where adult largetooth sawfish are known to occur (Figure 5.19).

Green sawfish (EPBC Act: Vulnerable, Listed migratory)

The green sawfish (*Pristis zijsron*) occurs in both inshore and offshore marine coastal waters of northern Australia. Its current known distribution stretches from Broome, WA around northern Australia and down the east coast as far as Jervis Bay, NSW (DCCEEW, 2022b). The main threats to green sawfish are habitat loss and entanglement in fishing nets.

The impacts EMBA overlaps areas where adult sawfish are known to occur and is adjacent to waters where juveniles are known to occur (Figure 5.20). It has also been caught as bycatch from the NPF in the area overlapped by the impacts EMBA and therefore is likely to be present (Tonks *et al*., 2008).

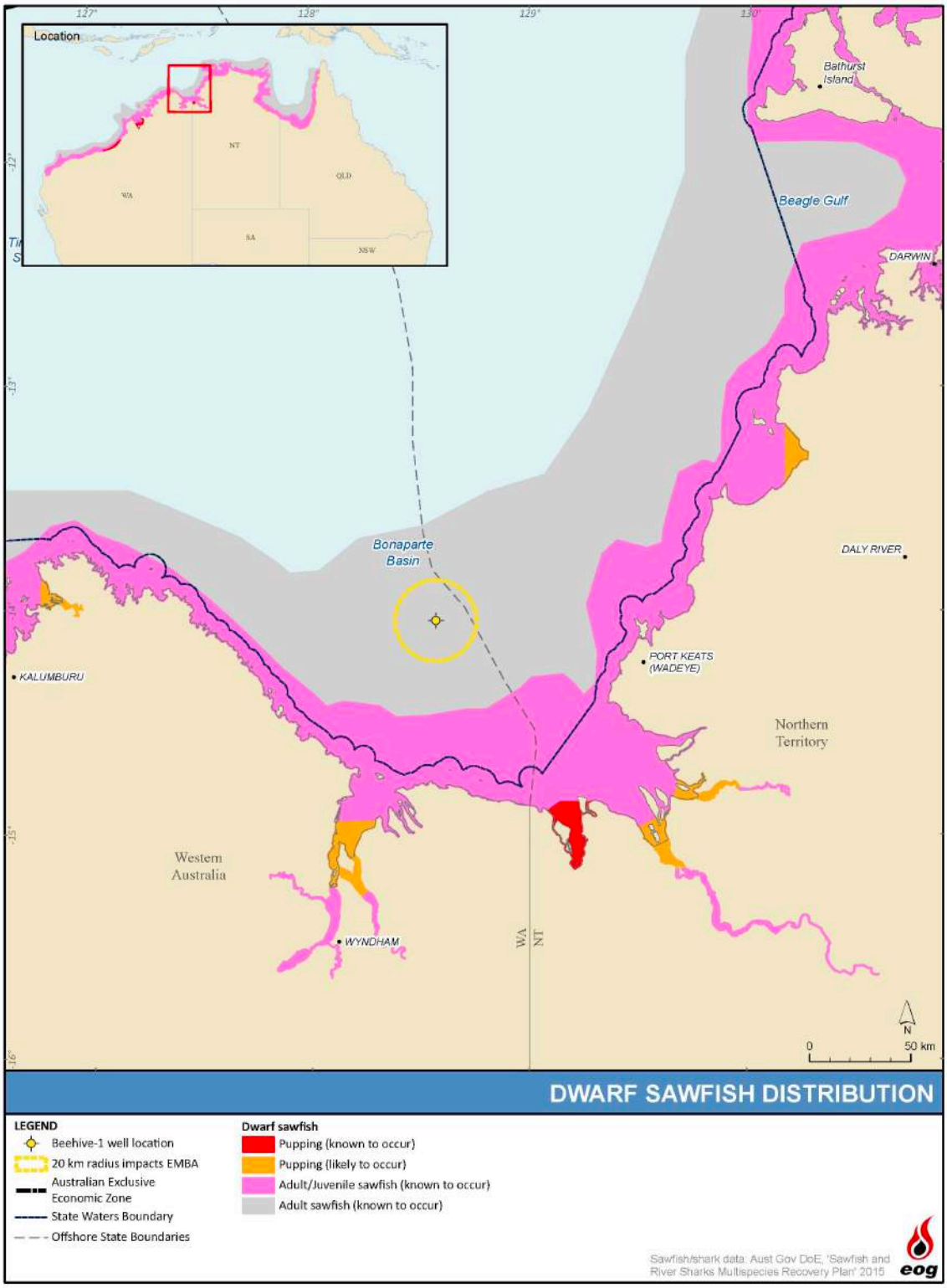


Figure 5.18. Dwarf sawfish presence in the impacts EMBA and surrounds

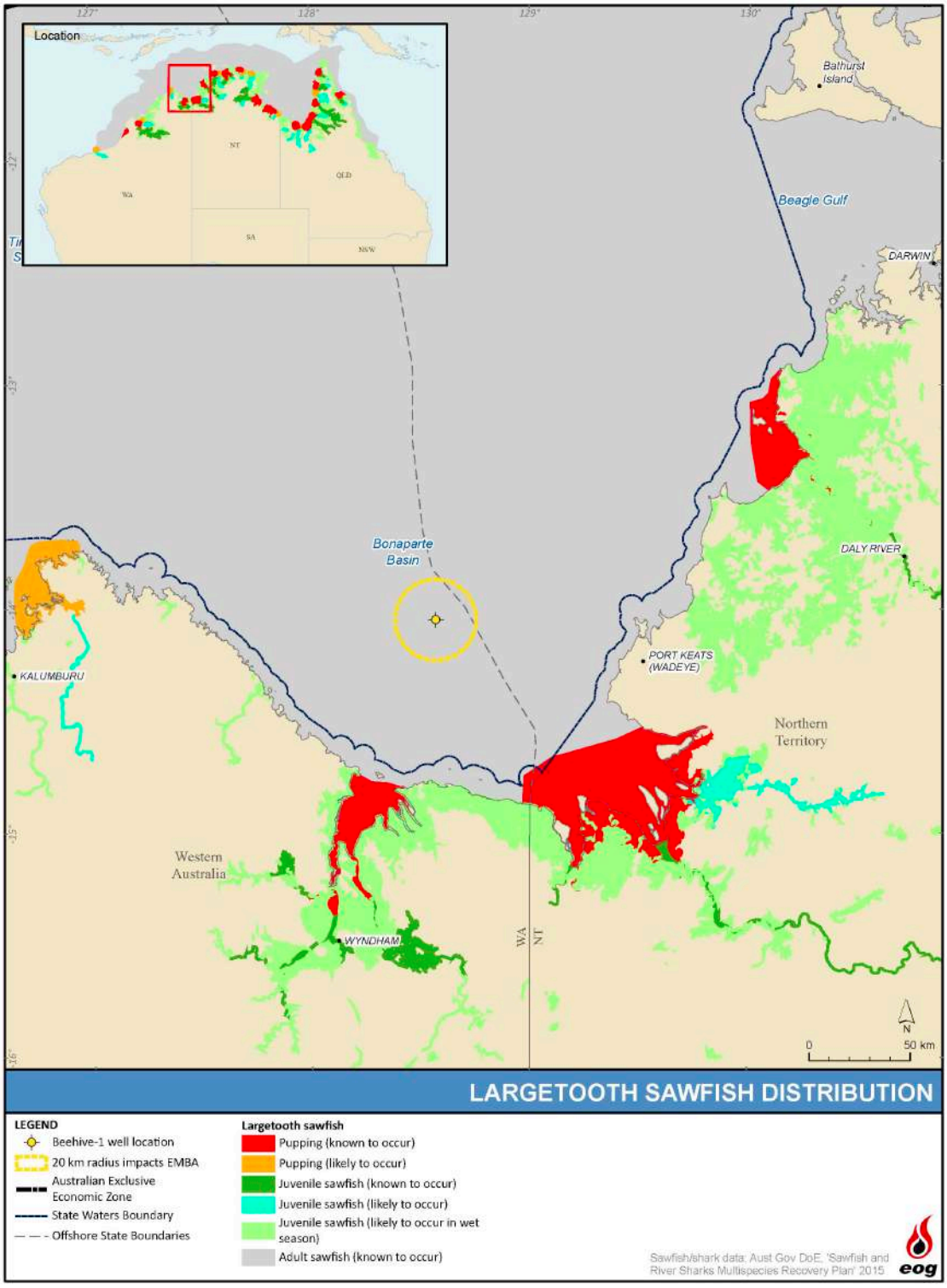


Figure 5.19. Largetooth sawfish presence in the impacts EMBA and surrounds

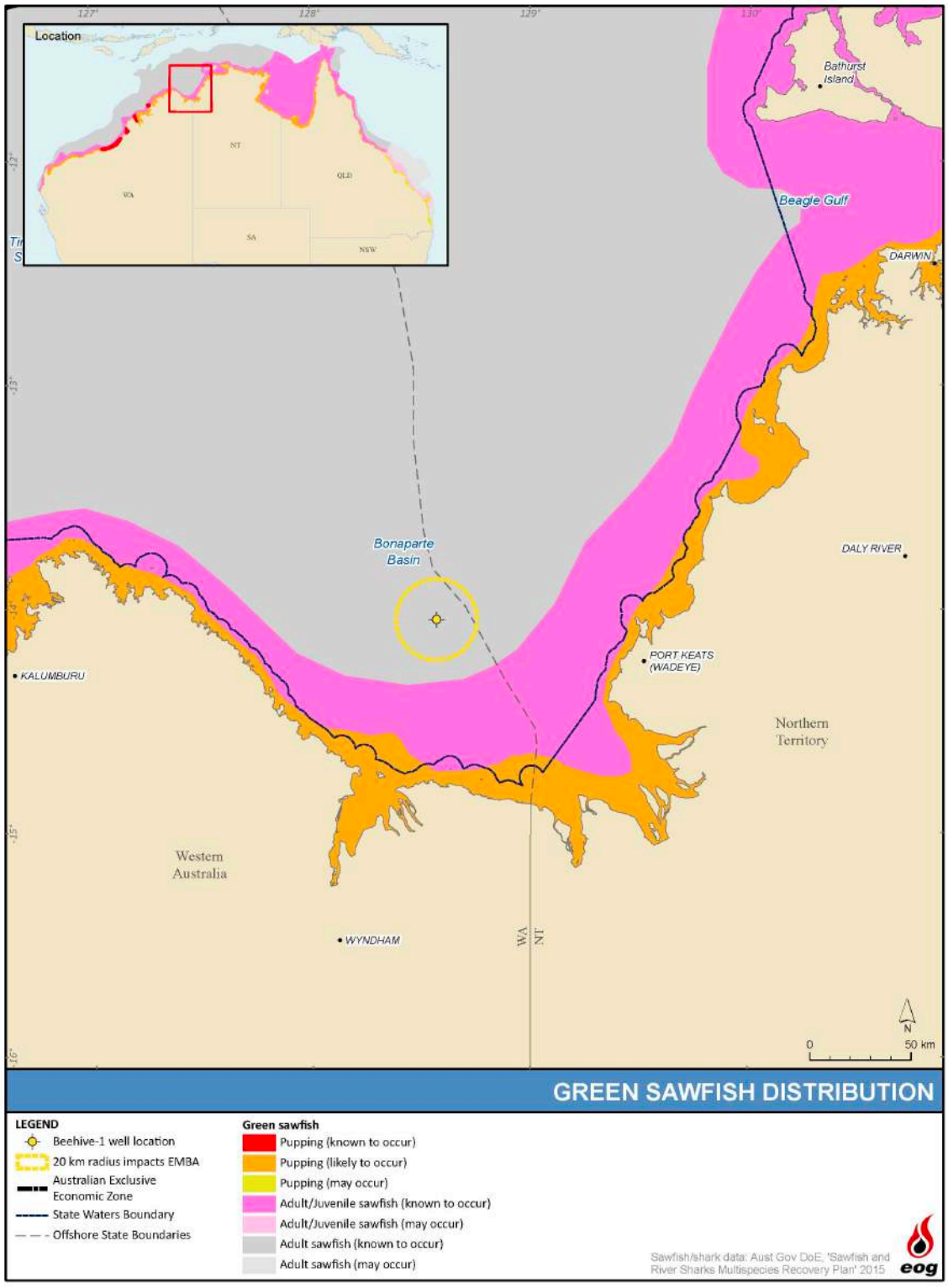


Figure 5.20. Green sawfish presence in the impacts EMBA and surrounds

Scalloped hammerhead shark (EPBC Act: Conservation Dependent)

The scalloped hammerhead shark (*Sphyrna lewini*) was listed as Conservation Dependent in 2018 (TSSC, 2018a). This species is a long-lived large slender shark (growing up to 3.5 m) with a laterally expanded skull shaped like a hammer, known as a cephalofoil (TSSC, 2018a).

The scalloped hammerhead shark has a circum-global distribution in tropical and sub-tropical waters, ranging widely over shallow coastal shelf waters but rarely venturing into or across deep ocean waters (TSSC, 2018a). In Australia, the species range occurs from the southern coast of WA, across the north coast and extending south along the Australian coast to south of Sydney (TSSC, 2018a). Little is known of the scalloped hammerhead's movements in Australia, though it is known to sometimes form large migratory schools (Last & Stevens, 2009). Their diet is reported to comprise ray-finned fish and cephalopods, suggesting a pelagic life (Last & Stevens, 2009). Adult females are rarely caught inshore and may live in deeper water, only moving into shallower coastal waters to mate and give birth (Last & Stevens, 2009). The pups remain in the shallow inshore waters for the first few years of their lives (TSSC, 2018a).

The scalloped hammerhead shark is threatened by fishing (TSSC, 2018a). Given the species' wide distribution in Australian tropical and sub-tropical waters and its preference for the continental shelf, it may occur within the impacts EMBA.

Sygnathids (EPBC Act: Listed marine species)

Twenty-four (24) species identified in the EPBC Act PMST are sygnathiformes, which includes seahorses, seadragon, pipehorse and pipefish. They are all listed as 'may' occur within the impacts EMBA. 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 unlikely that sygnathid species occur in high numbers in the impacts EMBA given the likely absence of reef and seagrass habitat that they prefer.

5.4.5. Marine Mammals

The PMST indicates that five whale species, ten dolphin species and the dugong are likely to occur or may occur within or migrate through the impacts EMBA (DCCEEW, 2022a). These species are presented in Table 5.10 and a description focused on threatened or migratory species follows. Figure 5.21 illustrates the likely temporal presence and absence of cetaceans in the impacts EMBA.

Table 5.10. EPBC Act-listed marine mammals that may occur in the impacts EMBA

Scientific name	Common name	EPBC Act Status			Type of presence in impacts EMBA	Type of presence in flaring EMBA	BIA intersected by impacts EMBA?	BIA intersected by flaring EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine					
Whales									
Balaenoptera edeni	Bryde's whale	-	Yes	-	May occur	May occur	No	No	-
B. borealis	Sei whale	V	Yes	-	May occur	May occur	No	No	-
B. physalus	Fin whale	V	Yes	-	May occur	May occur	No	No	CA
Balaenoptera musculus	Blue whale	E	Yes	-	May occur	May occur	No	No	CMP
Megaptera novaeangliae	Humpback whale	-	Yes	-	Likely	Likely	No	No	CA
Dolphins									
Delphinus delphis	Common dolphin	-	-	-	May occur	May occur	No	No	-
Grampus griseus	Risso's dolphin	-	-	-	May occur	May occur	No	No	-
Orcaella heinsohni	Australian snubfin dolphin	-	Yes	Yes	May occur	May occur	-	No	-
Orcinus orca	Killer whale	-	Yes	-	May occur	May occur	No	No	-
Pseudorca crassidens	False killer whale	-	-	-	Likely	Likely	No	No	-
Sousa sahulensis	Australian humpback dolphin	-	Yes	-	May occur	May occur	No	No	-
Stenella attenuata	Spotted bottlenose dolphin	-	Yes	-	May occur	May occur	No	No	-
Tursiops aduncus	Indian Ocean bottlenose dolphin	-	-	-	May occur	May occur	No	No	-

Scientific name	Common name	EPBC Act Status			Type of presence in impacts EMBA	Type of presence in flaring EMBA	BIA intersected by impacts EMBA?	BIA intersected by flaring EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine					
Tursiops aduncus (Arafura/Timor Sea populations)	Indian Ocean bottlenose dolphin *(Arafura/Timor Sea populations)*	-	Yes	-	Likely	Likely	No	No	-
Tursiops truncatus	Bottlenose dolphin	-	-	-	May occur	May occur	No	No	-
Other									
Dugong dugon	Dugong	-	Yes	Yes	May occur	May occur	No	No	-

Key is the same as per Table 5.8.

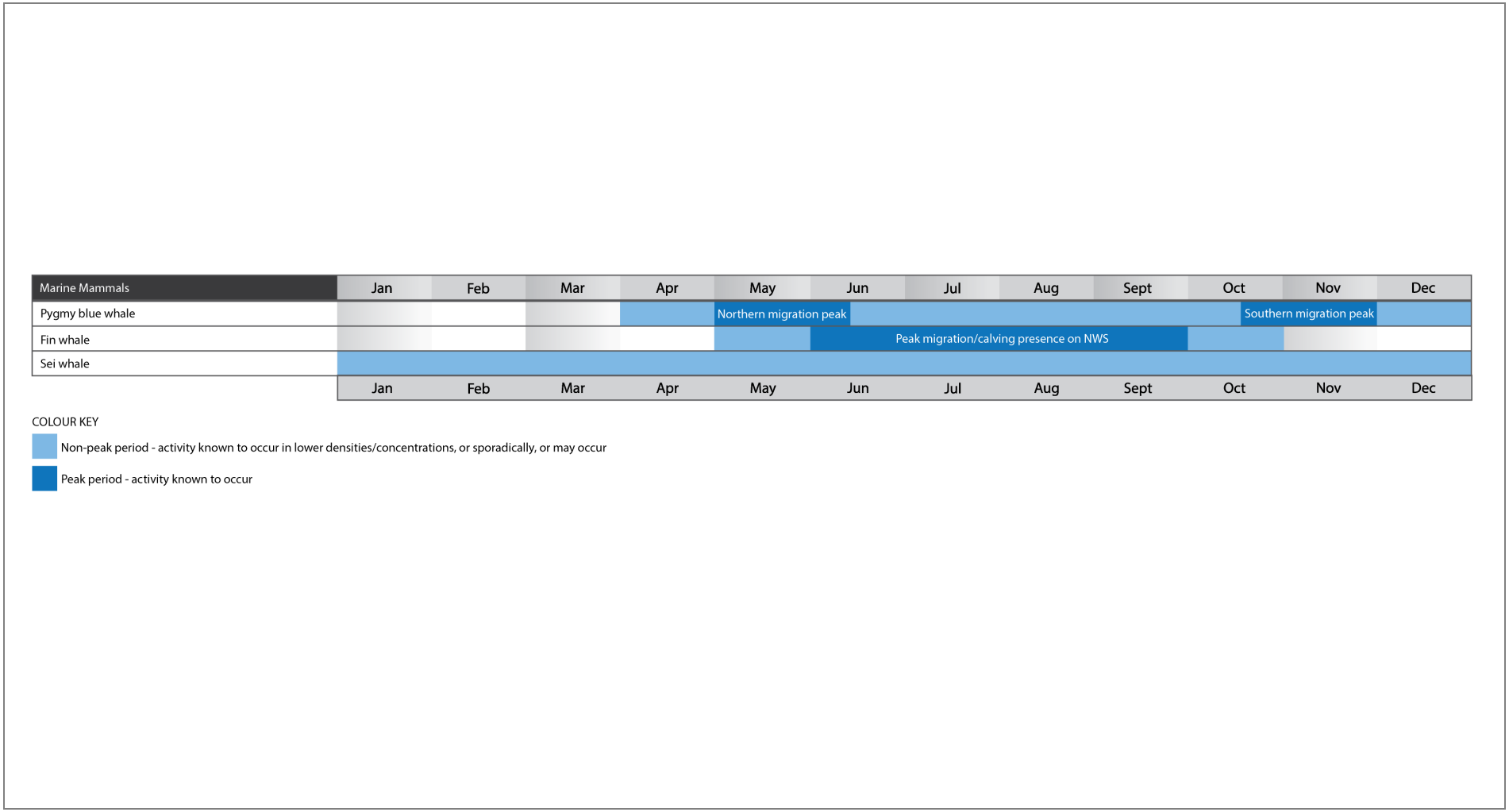


Figure 5.21. Likely temporal presence and absence of EPBC Act-listed threatened marine mammal species in the impacts EMBA

Threats and pressures on marine mammals

Four of the whale species listed in Table 5.10 are subject to pressures, which are described in various recovery plans and conservation advice. Table 5.11 summarises the pressures listed in the plans/advice relevant to each of these whale species relevant to drilling activities.

Table 5.11. Summary of threats to marine mammals

Species	Recovery Plan, Management Plan or Conservation Advice	Key threat/s relevant to drilling
Blue whale	Conservation management plan for the blue whale 2015-2025 (DoE, 2015b)	Noise interference Habitat modification (marine debris) Vessel disturbance (collisions)
Humpback whale	Conservation advice *Megaptera novaeangliae* (humpback whale) (TSSC, 2015a)	Noise interference Habitat degradation Vessel disturbance and strike
Sei whale	Conservation advice *Balaenoptera borealis* (sei whale) (TSSC, 2015b)	Noise interference Habitat degradation Pollution Vessel strike
Fin whale	Conservation advice *Balaenoptera physalus* (fin whale) (TSSC, 2015c)	

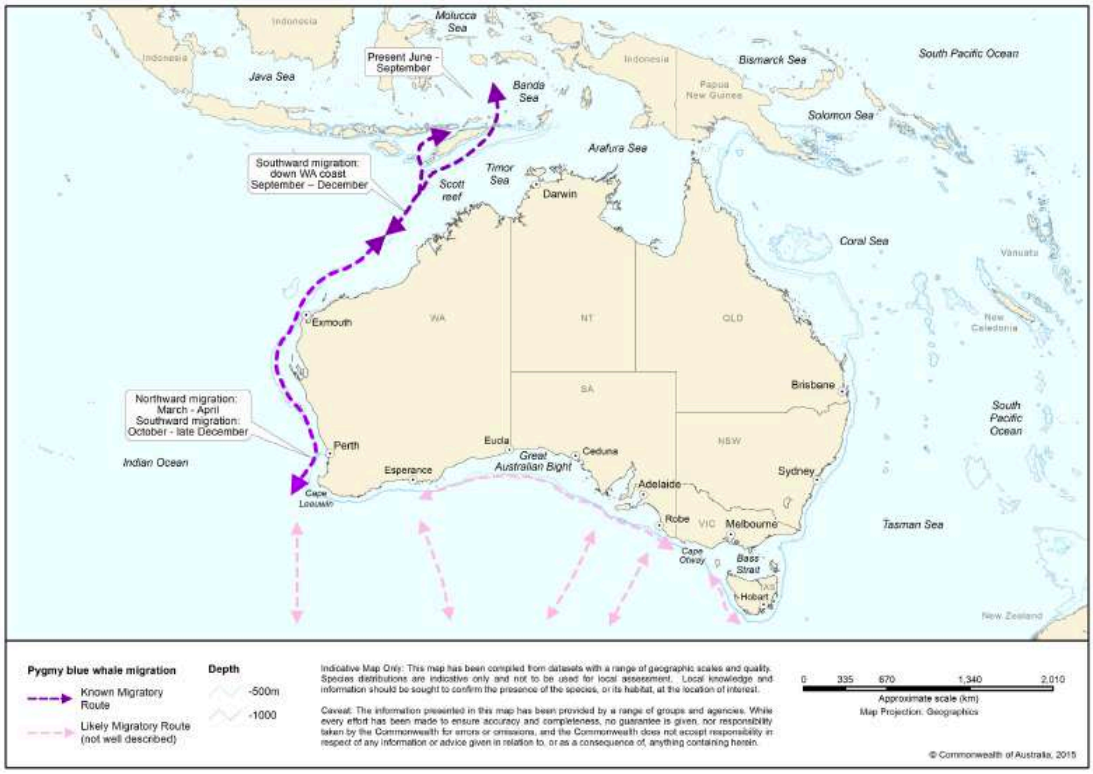
Blue whale (EPBC Act: Endangered, Listed migratory)

Blue whales (*Balaenoptera musculus*) are the largest living animals, growing to a length of over 30 m and weighing up to 180 tonnes (DoE, 2015b). In Australia, there are two recognised sub-species of blue whale; the Antarctic blue whale (*Balaenoptera musculus intermedia*) and the pygmy blue whale (*B. m. brevicauda*).

Blue whales have a worldwide distribution but tend to move between warm water (low latitudes) for breeding and cold water (high latitudes) for feeding. Pygmy blue whales are thought to migrate from Australian feeding areas to breeding grounds that include Indonesia (based on sightings in Indonesia in the austral winter), while Antarctic blue whale winter migratory destinations include lower latitudes of the Pacific and Indian Oceans (DoE, 2015b). Thus, the pygmy blue whale is more likely to be encountered in tropical waters and hence the information provided herein is based on the pygmy blue whale.

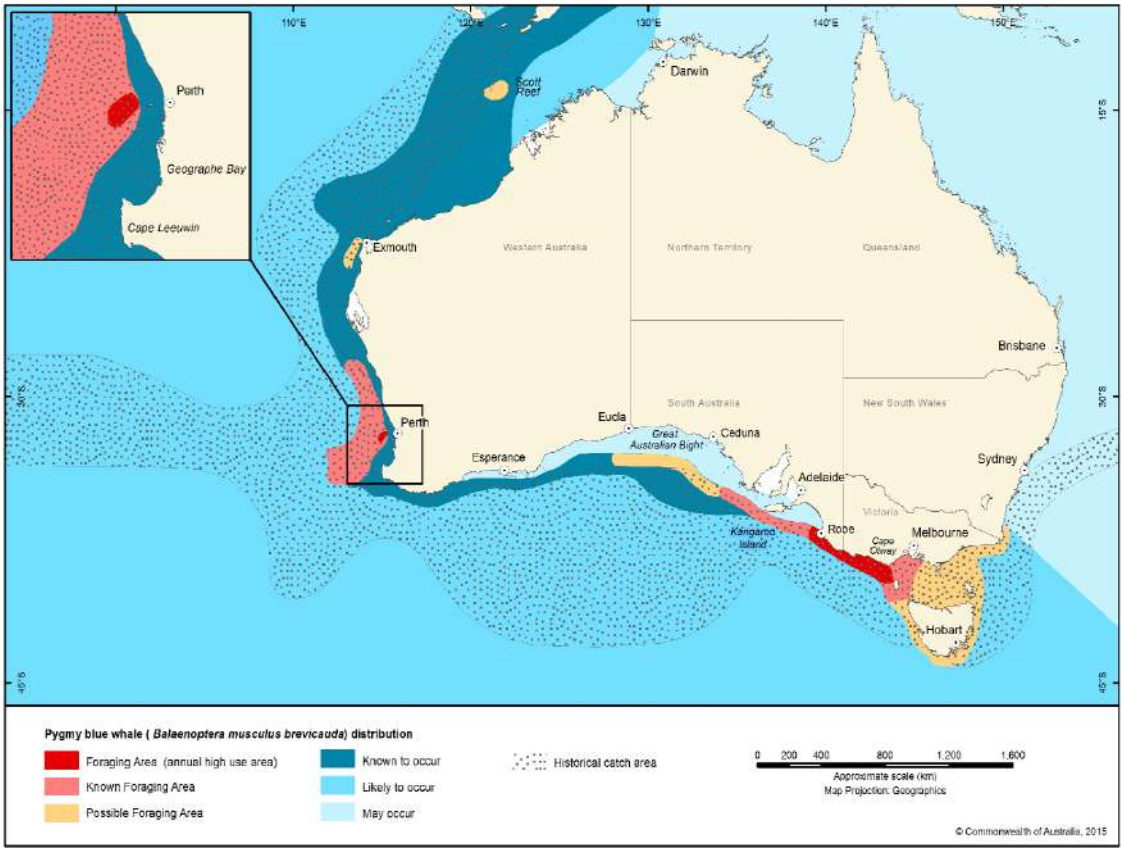
Tracking of pygmy blue whales identified that they migrate north from the Perth Canyon (known feeding area) in March/April reaching Indonesia by June where they remain until at least September (DoE, 2015b). Southern migration from Indonesia may occur from September and finish by December after which the animals may make their way slowly northwards towards the Perth Canyon by March/April (Double *et al*., 2014). Blue whale migration is thought to follow deep oceanic routes, and a tagging study by Double et al (2014) identified that the shallowest waters occupied was ~1,300 m. Figure 5.22 shows the migration of pygmy blue whales around Australia.

There is a foraging, migration and distribution BIA located off the North West Shelf (Figure 5.23), which is not intersected by the impacts EMBA. Though there are no BIAs that are intersected by the impacts EMBA, the impacts EMBA occurs within the 'may occur' distribution of the species (DoE, 2015b).



Source: DoE (2015a)

Figure 5.22. Pygmy blue whale migration routes



Source: DoE (2015a)

Figure 5.23. Pygmy blue whale BIAs

Sei whale (EPBC Act: Vulnerable, Listed migratory)

Sei whales (*B. borealis*) are primarily found in deep water oceanic habitats and their distribution, abundance and latitudinal migrations are largely determined by seasonal feeding and breeding cycles (TSSC, 2015b). The global population is estimated to have declined by 80% over the previous three generation period (TSSC, 2015b). Sei whales were the most commonly observed whales during Australian National Antarctic Research Expedition voyages in the 1960s and 1970s, with the majority recorded south of 60°S in the Southern Ocean (TSSC, 2015b).

These whales are thought to complete long annual seasonal migrations from subpolar summer feeding grounds to lower latitude winter breeding grounds (TSSC, 2015b); details of this migration and whether it involves the entire population are unknown. There are no defined foraging and feeding areas nor are there known mating or calving areas in Australian waters.

In the Australian region, sei whales occur within Australian Antarctic Territory waters and Commonwealth waters, and have been infrequently recorded off Tasmania, NSW, Queensland, the Great Australian Bight, NT and WA (TSSC, 2015b). There are no known mating or calving areas in Australia.

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, there is likely to be a low likelihood of sei whales migrating through the impacts EMBA.

Fin whale (EPBC Act: Vulnerable, Listed migratory)

The fin whale (*B. physalus*) is the second largest whale species after the blue whale, growing up to 27 m long and weighing up to 70 tonnes (TSSC, 2015c). Fin whales are considered a cosmopolitan species and occur from polar to tropical waters, and rarely in inshore waters. The full extent of their distribution in Australian waters is uncertain but they occur within Commonwealth waters and have been recorded in most state waters and from Australian Antarctic Territory waters (TSSC, 2015c).

Fin whales are generally thought to undertake long annual migrations from higher latitude summer feeding grounds to lower latitude winter breeding grounds (TSSC, 2015c). It is likely they migrate in November – May between Australian waters and Antarctic feeding areas (the Southern Ocean), sub-Antarctic feeding areas (the Southern Subtropical Front) and tropical breeding areas (Indonesia, the northern Indian Ocean and south-west South Pacific Ocean waters) (TSSC, 2015c). Migration patterns are not well understood. In Australia, there are confirmed records of fin whales for all coastal waters except in NSW and the NT, but the available information suggests that the species is more commonly present in deeper water (DEH, 2005a) of the Indonesian Archipelago, using north western Australia as a migration route.

Based on the fin whale preference for deep offshore waters, there is likely to be a low likelihood of fin whales migrating through the impacts EMBA.

Bryde's whale (EPBC Act: Listed migratory)

The Bryde's whale (*Balaenoptera edeni*) is restricted to tropical and temperate waters and has been recorded off all Australian states with exception of the NT (Bannister *et al*., 1996). Bryde's whales can be found in both oceanic (500 to 1,000 m isobath) and inshore waters (<200 m isobath) (DCCEEW, 2022b). Population estimates are not available for Bryde's whales, globally or in Australia, and no migration patterns have been documented in Australian waters (DCCEEW, 2022b). Bryde's whale is considered to be a fairly opportunistic feeder and it appears that the

coastal and offshore forms may be distinguished by their prey preferences, with the smaller coastal form feeding on schooling fishes, such as pilchard, anchovy, sardine, mackerel, herring and others. In contrast, the larger offshore form appears to feed on small crustaceans, such as euphausids, copepods, pelagic red crabs and cephalopods.

There are no feeding or breeding BIAs within the impacts EMBA for this species, and there is a low likelihood of Bryde's whale migrating through the impacts EMBA.

Humpback whale (EPBC Act: migratory)

Humpback whales (*Megaptera novaeangliae*) have a global distribution. In Australia, they occur along the east and west coasts during their annual migrations. The whales migrate north from their Antarctic feeding grounds around May each year, and reach the tropical calving grounds in the NWMR in early June (DCCEEW, 2022b). The exact timing of migration varies each year by up to six weeks in response to water temperature, sea ice distribution, predation risk, prey abundance and the location of feeding grounds (DEWR, 2007).

Humpback whales travel northbound from North West Cape, along the continental shelf and pass the west of the Muiron, Barrow and Montebello Islands, 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 (Jenner *et al*., 2001).

Given the well-known distribution of humpback whales in Australia, it is unlikely that this species migrates through the impacts EMBA.

Omura's whale (EPBC Act: not listed)

Omura's whale (*Balaenoptera omurai*) may occur in and around the impacts EMBA but is not listed under the EPBC Act. It is understood that DCCEEW is considering listing this species and as such, it is described briefly here. It is listed under the International Union for the Conservation of Nature (IUCN) Red list as 'data deficient.'

Omura's whale was first described in 2003 and is morphologically similar to but genetically distinct from the Bryde's and sei whales (Cerchio *et al*., 2019). This species is widely distributed in tropical and warm-temperate locations in all ocean basins except the central and eastern Pacific Ocean. Field research indicates Omura's whale has a strong preference for shallow water, on-shelf habitat, with only short ventures into adjacent deep waters (Cerchio *et al*., 2019).

Cerchio et al (2019) report that there have been several accounts of Omura's whale along Australia's northwest coast, from Exmouth (WA) into the Timor Sea. McPherson et al (2016) recorded Omura's whale calls around the Barossa and Caldita gas fields (440-470 km northeast of the impacts EMBA) in 2014-15 as part of the monitoring undertaken for ConocoPhillips Australia's Barossa Development proposal. The calls were primarily observed from May to August, with no detection of the species' calls from November to late December.

Given the limited information available for this species, it is assumed that it may migrate through the impacts EMBA.

Killer whale (EPBC Act: Listed migratory)

The killer whale (*Orcinus orca*) (the largest member of the dolphin family) is thought to be the most cosmopolitan of all cetaceans and appear to be more common in cold, deep waters, though they have often been observed along the continental slope and shelf particularly near seal colonies (Bannister *et al*., 1996). The killer whale is widely distributed from polar to equatorial regions and has been recorded in all Australian waters with concentrations around Tasmania. The only recognised key locality in Australia is Macquarie Island and Heard Island in the Southern Ocean (outside the EMBA) (Bannister *et al*., 1996).

The habitat of killer whales includes oceanic, pelagic and neritic (relatively shallow waters over the continental shelf) regions, in both warm and cold waters (DCCEEW, 2022b). The breeding season is variable, and the species moves seasonally to areas of food supply (Bannister *et al*., 1996; Morrice *et al*., 2004). The impacts EMBA and EMBA are unlikely to represent important habitat for this species. Therefore, killer whales are unlikely to be present in the impacts EMBA or 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 (DCCEEW, 2022b). 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 (DCCEEW, 2022b). 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). Given their habitat preferences, it is unlikely that this species occurs in the impacts EMBA.

Indian Ocean bottlenose dolphin (Arafura/Timor Sea populations) (EPBC Act: Listed migratory)

The Indian Ocean bottlenose dolphin (Arafura/Timor Sea) (*Tursiops aduncus*) resemble common bottlenose dolphins (*T. truncatus*) in their general colour pattern, but can be differentiated from the *T.truncatus* by the absence of a blaze on the dorsal cape and by the presence of ventral spotting in sexually mature individuals (DCCEEW, 2022b).

Indian ocean bottlenose dolphins occur in tropical and sub-tropical coastal and shallow offshore waters of the Indian Ocean, Indo-Pacific Region and the western Pacific Ocean and occur in estuarine and coastal waters of northern Australia, including the eastern Indian Ocean and Arafura/Timor Seas (DCCEEW, 2022b). The total population size of this species is not known, though it is likely that this species is common in inshore and nearshore waters of eastern, western and northern Australia where they feed on a range of fish and cephalopods (DCCEEW, 2022b). There is limited information regarding the Arafura/Timor Sea populations of the Indian ocean bottlenose dolphin, the EPBC Act recognises them as a separate population and lists them as migratory. Additionally, the Arafura/Timor Sea populations are listed on Appendix II of the *review of small cetaceans* (Culik, 2004), where insufficient data was reported regarding present knowledge about the population, and their migration patterns were reported as ‘possible’. Culik

(2004) emphasise that more research is needed to establish the range and importance of different species, subspecies and their populations of the Indian ocean bottlenose dolphin. Although there is a sparsity of research available on the Arafura/Timor Sea populations, it is likely they will be encountered within the impacts EMBA due to the location of the EMBA being within the Timor Sea. Movement patterns in Australia are variable, and include year-round residency in small areas, long-range movements and migration (DCCEEW 2022b). The largest threat to the species is bycatch in trawl nets and gillnets and habitat degradation (DCCEEW , 2022b).

It is likely that spotted bottlenose dolphins occur in the impacts EMBA, either residing in the area or migrating through.

Australian snubfin dolphin (EPBC Act: listed migratory, listed marine)

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 (DCCEEW, 2022b). Within Australian waters, Australian snubfin dolphins have been recorded almost exclusively in coastal and estuarine waters (DCCEEW, 2022b). 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 (DCCEEW, 2022b). 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 (DCCEEW, 2022b).

Feeding primarily occurs in shallow waters (less than 20 m) close to river mouths and creeks (DCCEEW, 2022b). 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 (DCCEEW, 2022b).

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 (DCCEEW, 2022b).

Dugong (EPBC Act: Listed migratory, Listed marine)

Dugongs (*Dugong dugon*) inhabit protected shallow coastal areas, such as wide shallow bays and mangrove channels. They feed on seagrass, and major concentrations of dugongs tend to coincide with sizeable seagrass beds. Research undertaken in the NT, including aerial surveys, has focused on dugong populations in the Gulf of Carpentaria and in the northern parts of the NT, such as the Tiwi Islands and Coburg Peninsula. No surveys have been undertaken in the JBG, therefore little is known about the distribution of dugongs in the Gulf. However, as high turbidity in the JBG limits the development of seagrass beds, dugongs are not expected to be abundant (Woodside, 2004).

Though not abundant in the JBG, 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 (585 km to the west of the impacts EMBA), with additional foraging BIA on the Kimberley coastline off the Dampier Archipelago.

During the relevant persons consultation process, the cultural significance of dugongs was brought to EOG's attention during in person meetings in June 2023, by the Yawuru People and Ardyaloon community. The cultural significance of the dugong is described in Section 11.3.5 of Appendix 11.

Based on their habitat preferences, dugongs are unlikely to be present in the impacts EMBA.

5.4.6. Marine Reptiles

Six species of marine turtle are listed is the PMST results as known or likely to occur within both the impacts EMBA and flaring EMBA (Table 5.12) (DCCEEW, 2022a). Three of the turtle species are listed as endangered with the other three listed as vulnerable. Additionally, 17 species of sea snake are identified as 'may occur' in the impacts EMBA, along with the saltwater crocodile being 'likely to occur.' The flaring EMBA detected an additional two species of sea snake, both of which have a presence of 'may occur' and are not threatened. The species listed as threatened or migratory are described in this section. Ecological stages and temporal occupation of the turtle species is presented in Figure 5.24. The flaring EMBA is considered within the species discussion due to their sensitivity to artificial light.

Habitat critical to the survival of a species is defined by the MNES (2013) as areas that are necessary for activities such as foraging, breeding, roosting, or dispersal, areas necessary for the long-term maintenance of the species, areas necessary to maintain genetic diversity and long-term evolutionary development, or areas necessary for the reintroduction of populations or recovery of the species. Such habitat may be but is not limited to habitat identified in a recovery plan for the species as habitat critical for that species, and/or habitat listed on the Register of Critical Habitat maintained by the minister under the EPBC Act (Commonwealth of Australia, 2013).

No "critical habitat" as defined under Section 207A of the EPBC Act (Register of Critical Habitat) has been identified and listed for marine turtles. However, the Recovery Plan for Marine Turtles in Australia 2017-2027 (Commonwealth of Australia, 2017) identifies 'nesting and interesting habitat critical to the to the survival of marine turtles' (hereafter referred to as 'habitat critical').

During the relevant persons consultation process, the cultural significance of sea turtles was brought to EOG's attention during in-person meetings in June 2023, by the Tiwi Land Council, Yawuru People, and both the Ardyaloon and Kalumburu community. The cultural significance of turtles is described is Section 11.3.6 of Appendix 11.

Table 5.12. EPBC Act-listed marine reptiles that may occur in the impacts EMBA

Scientific name	Common name	EPBC Act Status			Habitat type/ presence in impacts EMBA	Habitat type/ presence in flaring EMBA	BIA intersected by impacts EMBA?	BIA intersected by flaring EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine					
Turtles									
Caretta caretta	Loggerhead turtle	E	Yes	Yes	Likely	Likely	No	No	RP for all turtles in Australia
Chelonia mydas	Green turtle	V	Yes	Yes	Known	Known	Yes	Yes	
Dermochelys coriacea	Leatherback turtle	E	Yes	Yes	Likely	Likely	No	No	
Eretmochelys imbricate	Hawksbill turtle	V	Yes	Yes	Likely	Likely	No	No	
Lepidochelys olivacea	Olive ridley turtle	E	Yes	Yes	Known	Known	Yes	Yes	
Natator depressus	Flatback turtle	V	Yes	Yes	Known	Known	Yes	Yes	
Sea snakes									
Acalyptophis peronii	Horned sea snake	-	-	Yes	May occur	May occur	No	No	-
Aipysurus duboisii	Dubois' sea snake	-	-	Yes	May occur	May occur	No	No	-
Aipysurus eydouxii	Spine-tailed sea snake	-	-	Yes	May occur	May occur	No	No	-
Aipysurus foliosquama	Leaf-scaled sea snake	CE	-	Yes	May occur	May occur	No	No	-
Aipysurus laevis	Olive sea snake	-	-	Yes	May occur	May occur	No	No	-
Chitulia inornata	Plain seasnake	-	-	Yes	-	May occur	-	No	
Astrotia stokesii	Stokes' sea snake	-	-	Yes	May occur	May occur	No	No	-
Chitulia ornata	Spotted sea snake	-	-	Yes	May occur	May occur	No	No	-
Disteira kingii	Spectacled sea snake	-	-	Yes	May occur	May occur	No	No	-

Scientific name	Common name	EPBC Act Status			Habitat type/ presence in impacts EMBA	Habitat type/ presence in flaring EMBA	BIA intersected by impacts EMBA?	BIA intersected by flaring EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine					
Disteira major	Olive-headed sea snake	-	-	Yes	May occur	May occur	No	No	-
Emydocephalus annulatus	Turtle-headed sea snake	-	-	Yes	May occur	May occur	No	No	-
Enhydrina schistosa	Beaked sea snake	-	-	Yes	May occur	May occur	No	No	-
Hydrelaps darwiniensis	Black-ringed sea snake	-	-	Yes	May occur	May occur	No	No	-
Hydrophis atriceps	Black-headed sea snake	-	-	Yes	May occur	May occur	No	No	-
Hydrophis elegans	Elegant sea snake	-	-	Yes	May occur	May occur	No	No	-
Hydrophis mcdowelli	Small-headed sea snake	-	-	Yes	May occur	May occur	No	No	-
Lapemis curtus	Spine-bellied sea snake	-	-	Yes	May occur	May occur	No	No	-
Leioselasma pacifica	Large-headed sea snake	-	-	Yes	-	May occur	-	No	-
Pelamis platurus	Yellow-bellied sea snake	-	-	Yes	May occur	May occur	No	No	-
Crocodiles									
Crocodylus porosus	Salt-water crocodile	-	Yes	Yes	Likely	Likely	No	No	-

Key is the same as per Table 5.8.

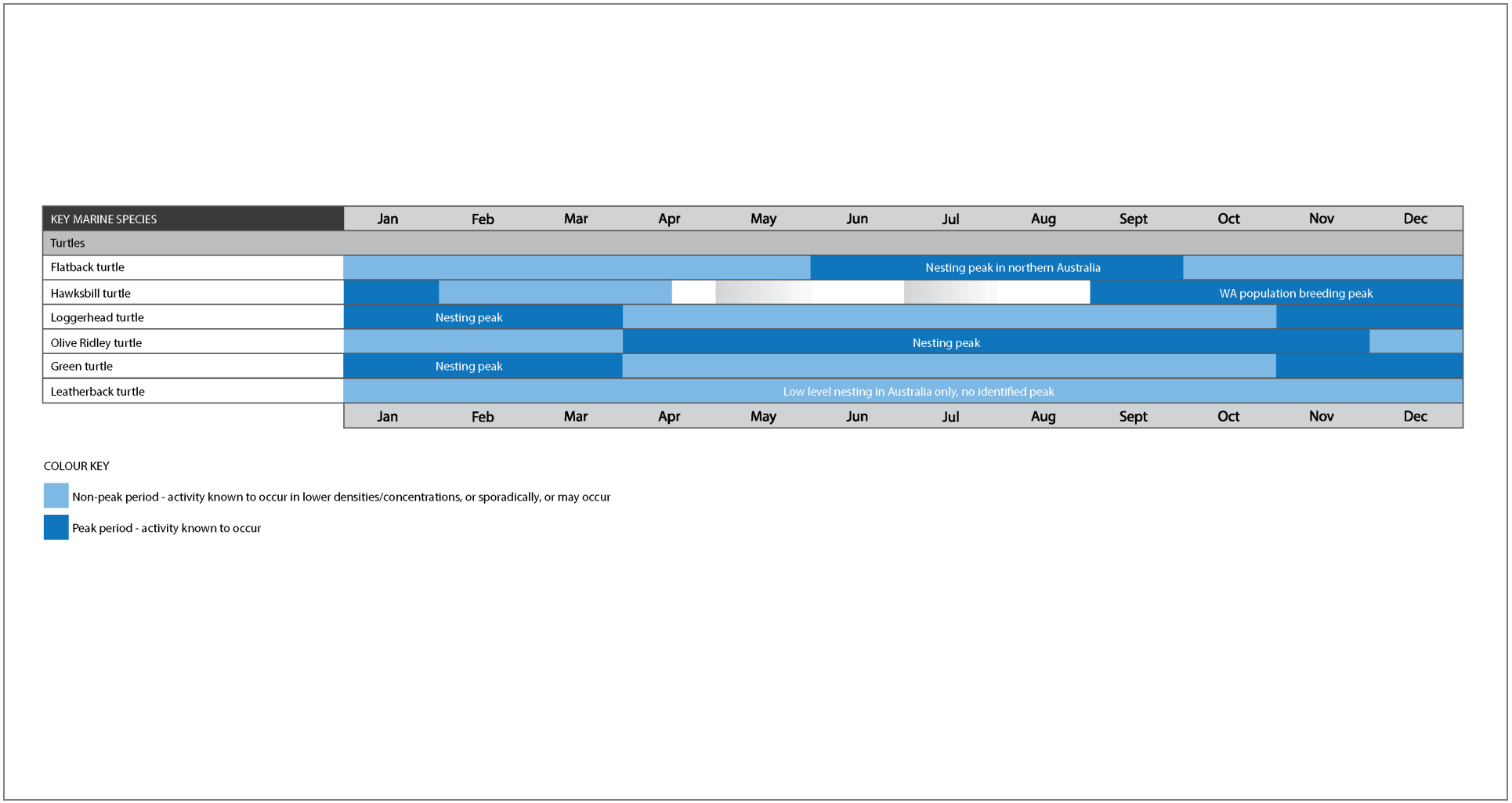


Figure 5.24. Likely temporal presence and absence of EPBC Act-listed threatened turtle species in the impacts and flaring EMBAs

Threats and pressures on marine reptiles

Five of the turtle species listed in Table 5.12 are subject to pressures, which are described in various recovery plans and conservation advice. Table 5.13 summarises the pressures listed in the plans/advice relevant to each of these species relevant to drilling activities.

Table 5.13. Summary of threats to marine reptiles

Species	Recovery Plan, Management Plan or Conservation Advice	Key threat/s relevant to drilling
Loggerhead turtle	Recovery Plan for Marine Turtles in Australia 2017-2027 (DoEE, 2017c)	Marine debris Light pollution Habitat modification Vessel disturbance Noise interference
Green turtle		
Leatherback turtle		
Hawksbill turtle		
Flatback turtle		
All turtles	Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE, 2018)	Marine debris (plastics)
	National Light Pollution Guidelines for Wildlife including marine turtles, seabirds and migratory shorebirds	Artificial light

Leatherback turtle (EPBC Act; Endangered, listed migratory)

The leatherback turtle (*Dermochelys coriacea*) is a pelagic feeder found in tropical, sub-tropical, and temperate waters throughout the world. Whilst it is less abundant off the northern Australian continental shelf, it is occasionally sighted in the Gulf of Carpentaria and near the Cobourg Peninsula (460 km northeast of the impacts EMBA) (DSEWPC, 2012).

No major nesting has been recorded in Australia, with isolated nesting recorded in Queensland and the NT (DSEWPC, 2012). The closest confirmed inter-nesting site for the leatherback turtle is at Cobourg Peninsula (DCCEEW, 2022b).

Leatherback turtles forage on pelagic soft bodied creatures (such as jellyfish, squid, salps, siphonophores and tunicates) all year round in Australian waters (DCCEEW, 2022b). No habitat critical to the survival of the leatherback turtle or BIAs occurs within the impacts or flaring EMBA.

Loggerhead turtle (EPBC Act: Endangered, listed migratory)

The loggerhead turtle (*Caretta caretta*) has a global distribution throughout tropical, sub-tropical and temperate waters. In Australia, the loggerhead turtle occurs in waters of coral and rocky reefs, seagrass beds, and muddy bays throughout eastern, northern and WA (DCCEEW, 2022b).

While nesting is mainly concentrated on sub-tropical beaches in southern Queensland and from Shark Bay to the North West Cape in WA between November and March, foraging is more widespread. Loggerhead turtles show fidelity to both their foraging and breeding areas and can migrate over 2,600 km between the two (DCCEEW, 2022b). The WA stock forage from Shark Bay through to Arnhem Land, NT (DCCEEW, 2022b).

Juveniles feed on algae, pelagic crustaceans, molluscs and flotsam, whilst as an adult the species feeds on gastropod molluscs, clams, jellyfish, starfish, coral, crabs and fish (DCCEEW, 2022b). 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. The foraging BIA for the loggerhead turtle is not intersected by the flaring or impacts EMBA (Figure 5.25).

No habitat critical to the survival of the loggerhead turtle occurs within the impacts or flaring EMBA.

Given the proximity of the foraging BIA, it is likely that loggerhead turtles will be present in both the impacts and flaring EMBA.

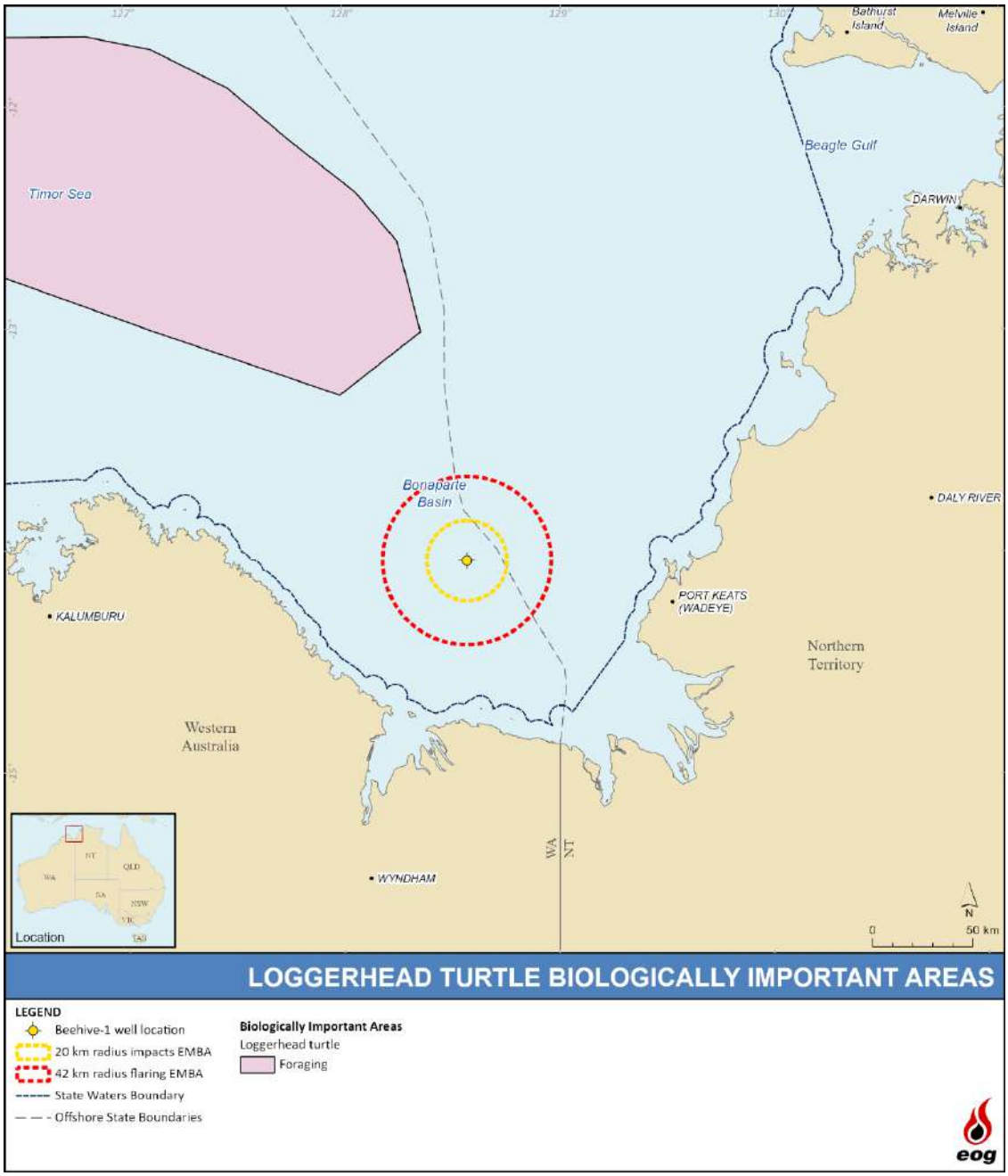


Figure 5.25. Loggerhead turtle BIA near the impacts and flaring EMBAs

Green turtle (EPBC Act: Vulnerable, listed migratory)

Green turtles (*Chelonia mydas*) nest, forage and migrate across tropical northern Australia (DCCEEW, 2022b) and are commonly found foraging and nesting in the Gulf of Carpentaria (DSEWPC, 2012). In WA, nesting is between November and March and green turtles can migrate over 2,600 km between their feeding and nesting grounds (DCCEEW, 2022b). The pinnacles of the Bonaparte Basin are thought to be a KEF where green turtles move between foraging and nesting grounds (DSEWPC, 2012). The species primarily forages in shallow benthic habitats (<10 m) such as tropical tidal and subtidal coral and rocky reef habitat or inshore seagrass beds, feeding on seagrass beds or algae mats (Hazel *et al*., 2009; DCCEEW, 2022b). Large feeding aggregations of green turtles are present at Ashmore Reef and is the only reef recorded on the Sahul Shelf where such large numbers of green turtles gather to feed.

The NCVA identifies that the impact and flaring EMBAs overlap with a foraging BIA for this species (Figure 5.26). The closest nesting and inter-nesting BIAs are located 286 km west of the impacts EMBA along the northwest Kimberley coastline. Within foraging areas, adult green turtles feed on seagrass, sponges and algae (DCCEEW, 2022b).

No habitat critical to the survival of the green turtle occurs within the impacts or flaring EMBA.

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 nests and forages in northern Australia. Breeding occurs all year round; however, in northern Australia most nesting occurs between June and August (DCCEEW, 2022b). Flatback turtle nesting is widespread across the islands and mainland beaches east of Dampier Peninsula in winter, with Cape Domett (87 km south of the impacts 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 (DoEE, 2017c) is based primarily on the movements of tagged inter-nesting flatback turtles along the North West Shelf reported by Whittock et al (2014). 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. Both the impacts and flaring EMBAs intersect an inter-nesting BIA, as illustrated in Figure 5.27.

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 (DCCEEW, 2022b). 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 impacts EMBA is on the cusp of an area identified as habitat critical to the survival of the flatback turtle, and the flaring EMBA overlaps a small portion of habitat critical to the survival of the flatback turtle as illustrated in Figure 5.27. The habitat critical to the survival of the flatback turtle refers to nesting activity that occurs between August to September.

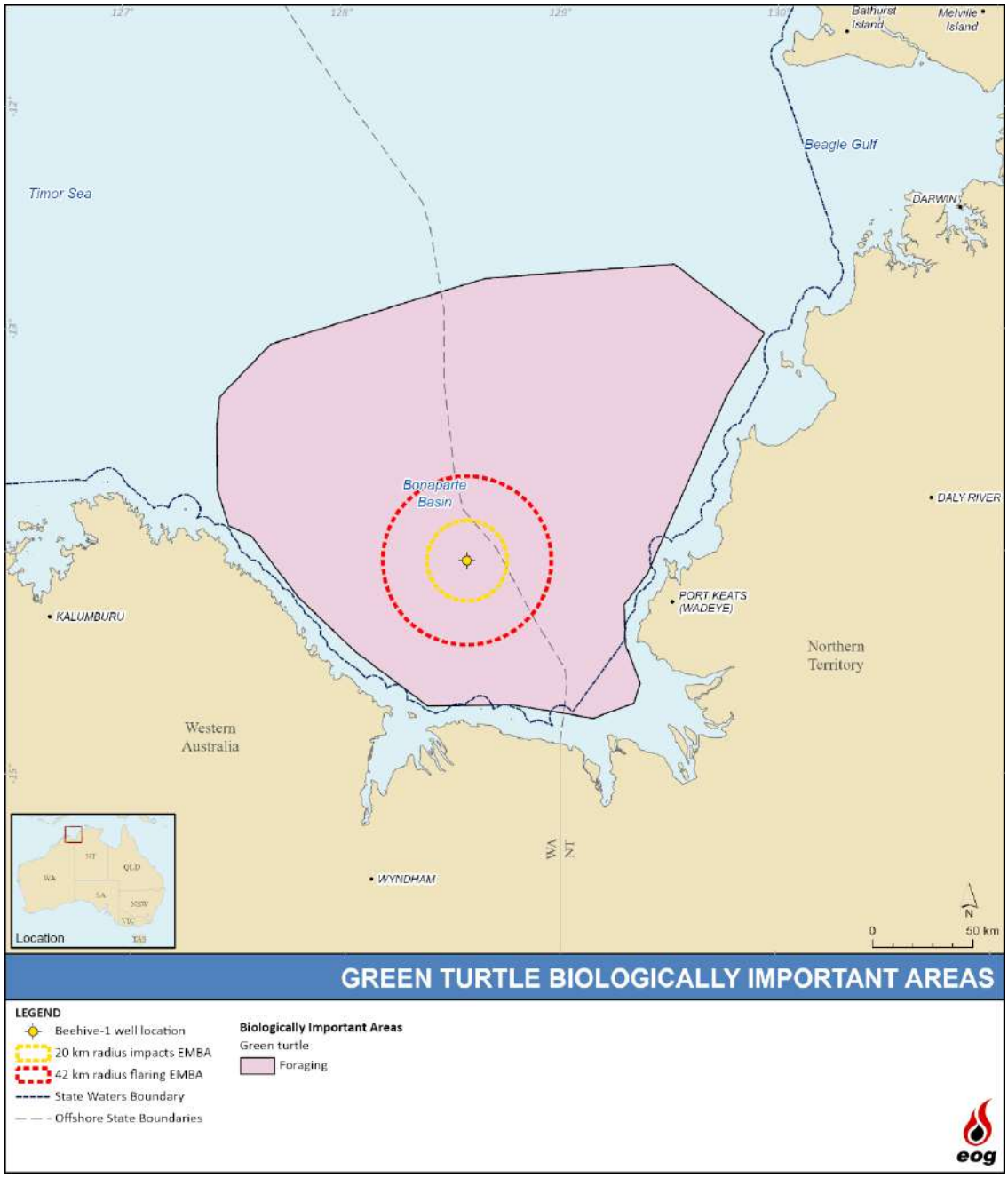


Figure 5.26. Green turtle BIA overlapped by the impacts and flaring EMBAs

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, outside the EMBA) to the northwest coast of Cape York Peninsula (outside of the EMBA) (DSEWPC, 2012). After nesting, Olive Ridley turtles are known to migrate up to 1,050 km to various foraging areas (DCCEEW, 2022b), including the pinnacles of the Bonaparte Basin and the carbonate bank and terrace system of the Sahul Shelf KEF (DSEWPC, 2012).

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 (DCCEEW, 2022b). The impacts and flaring EMBAs do not overlap with any identified habitat critical to the survival of the olive ridley turtle (Figure 5.28) with the waters surrounding Bathurst Island being the closest area of habitat critical to the survival of this species. The NCVA identifies that the impacts and flaring EMBAs overlap with a foraging BIA for this species (Figure 5.28); hence it is possible that individuals could be encountered in the impacts and flaring EMBAs, though nesting is unlikely to occur in the coastal sections of the impacts and flaring EMBAs.

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, nesting extensively along the coasts and foraging in the region.

As a juvenile, the hawksbill turtle feeds on plankton and then feeds on sponges, hydroids, cephalopods, gastropods, jellyfish, seagrass and algae as an adult (DCCEEW, 2022b). 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 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 (none of which are intersected by the flaring or impacts 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 (DSEWPC, 2012), while in the WA population breeding peaks around October to January. There are no BIAs or habitat critical to the survival for the species located within the impacts or flaring EMBAs. The species may be encountered in the impacts and flaring EMBAs as transient individuals.

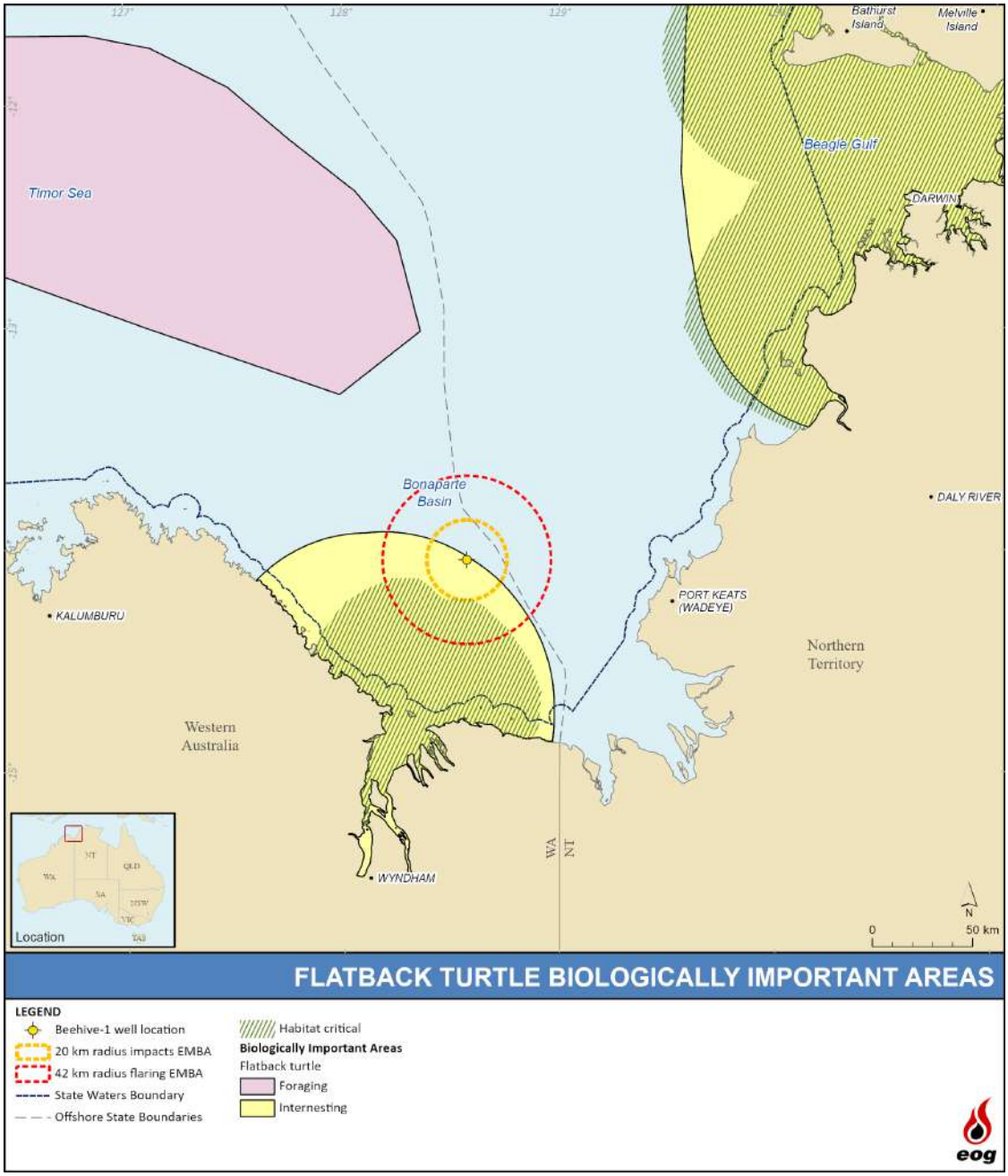


Figure 5.27. Flatback turtle BIA and habitat critical overlapped by the impacts and flaring EMBAs

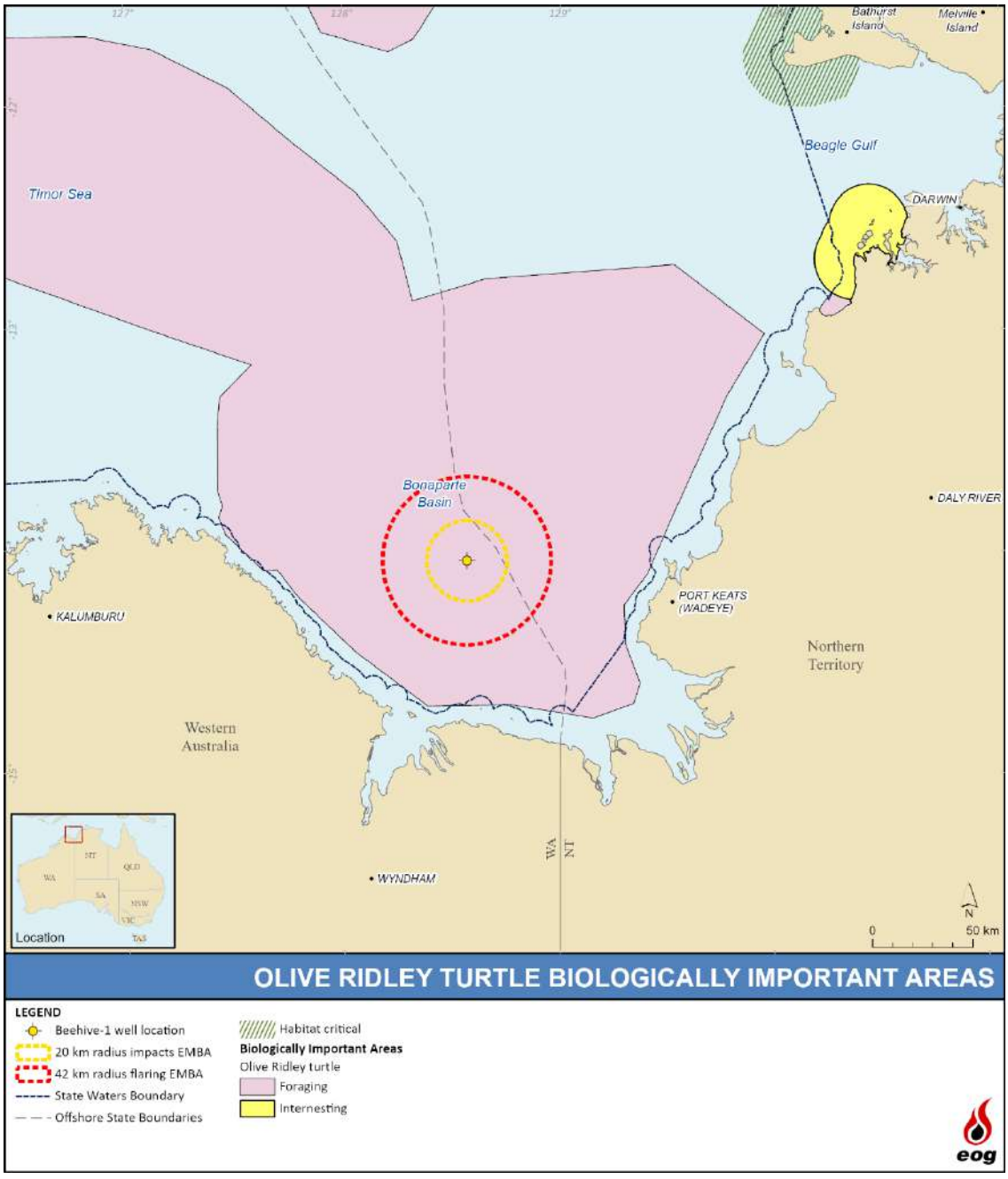


Figure 5.28. Olive Ridley turtle BIA and habitat critical overlapped by the impacts and flaring EMBAs

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 (DCCEEW, 2022b).

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 northwest banks of rivers (DCCEEW, 2022b). The species nest during the wet season with peak nesting during January and February. While sightings of saltwater crocodiles far out to sea have been recorded, it is more likely to be encountered in coastal areas than in the impacts EMBA.

Sea snakes

Sea snakes occur in tropical and subtropical waters around the world and are reported to occur in offshore and nearshore waters in northern Australia, mostly in shallower waters around reefs and inshore environments (DEWHA, 2008b).

Of the 17 species of sea snake listed in the PMST that may occur in the impacts area, the leaf-scaled sea snake (*Aipyurus foliosquama*) is listed as Critically Endangered due to its restricted geographic range and severe reduction in numbers from 2000-2010 caused by coral reef bleaching, which reduces fish diversity and abundance and therefore a food source (DSEWPC, 2010). Unsustainable and illegal fishing are reported as the most significant direct threat to this species (DSEWPC, 2010).

This species is most likely to occur along the WA coast from Shark Bay north to the Eighty Mile Beach (outside the impacts EMBA), and less likely from there north to the western part of the JBG (also outside the impacts EMBA). The leaf-scaled sea snake occurs mostly on reef flats or in shallow waters of outer reef edges to depths of 10 m, and is known from Ashmore and Hibernia reefs (600 km west of the impacts EMBA) (DSEWPC, 2010). The habitat preferences of the leaf-scaled sea snake means it is not likely to occur in the impacts EMBA.

5.4.7. Avifauna

There are ten bird species (five migratory wetland species and five migratory marine species) listed in the PMST that 'may occur' in the impacts EMBA (Table 5.14), and the flaring EMBA includes an additional two species; the common sandpiper (*Actitis hypoleucos)* and the lesser crested tern (*Thalasseus bengalensis*) (DCCEEW, 2022a). Three of these birds are listed as threatened. The birds listed in Table 5.14 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).

Seabirds that occur within Australia or migrate regularly are considered in the Wildlife Conservation Plan (WCP) for Seabirds 2020 (Commonwealth of Australia, 2020). The plan seeks to facilitate the protection and conservation of EPBC Act listed seabirds (excluding those that are threatened).

Figure 5.29 illustrates the likely temporal presence and absence and ecological stages of these bird species in the impacts EMBA. The species listed as threatened are described here. In brief, the five seabird species listed in Table 5.14 (the friagtebirds, common noddy, streaked shearwater and tropic bird) are birds with widespread global distributions and no breeding in or near the impacts EMBA. The flaring EMBA PMST includes a breeding BIA for the lesser crested tern, which is described in this section.

Red knot (EPBC Act: Endangered, Listed Migratory)

The red knot (*Calidris canutus*) is a small migratory shorebird that is common in all the main suitable habitats around the coast of Australia and with a global distribution and extremely large range (TSSCa, 2016). Very large numbers are regularly recorded in northwest Australia, with Eighty Mile Beach and Roebuck Bay being particular strongholds. 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. Red knots feed in intertidal mudflats or sandflats exposed during low tide and during high tide, they feed in lakes and other inundated areas (TSSCa, 2016). They roost on sandy beaches, spits and islets and mudflat (TSSCa, 2016).

The species does not breed in Australia. Based on its habitat preferences, this species is not likely to occur within the impacts or flaring EMBAs but may fly over them.

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

The curlew sandpiper (*Calidris ferruginea*) is a migratory species with a global distribution and in Australia, they occur around the coasts and is also quite widespread inland, though in smaller numbers (TSSC, 2015e). They are rarely recorded in the northwest Kimberley, around Wyndham and Lake Argyle, and in the NT, they are mostly recorded around Darwin, north to Melville Island and Cobourg Peninsula (TSSC, 2015e). Curlew sandpiper habitat in Australia occurs in intertidal mudflats in sheltered coastal areas and non-tidal swamps, lakes and lagoons close to the coast, where they feed on invertebrates and seeds (TSSC, 2015e). The main threats to the species are human disturbance, habitat loss and degradation from pollution, altered water regimes and invasive plants (TSSC, 2015e).

The species does not breed in Australia. Based on its habitat preferences, this species is not likely to occur within the impacts or flaring EMBAs but may fly over them.

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

The eastern curlew (*Numenius madagascariensis*) is the world's largest migratory shorebird, with a wingspan of 110 cm (DoE, 2015c). It does not breed in Australia and while here, it has a coastal distribution around the whole country (DoE, 2015c). Eastern curlews feed on crustaceans and insects in 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, 2015c). They typically roost in large flocks on sandy spits, sandbars and islets and among coastal vegetation (DoE, 2015c). During the

non-breeding season in Australia, they feed mainly on crustaceans and insects (DoE, 2015c). Based on its habitat preferences, the eastern curlew is not likely to occur within the impacts or flaring EMBAs but may fly over them.

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 prawns in the surf and over offshore waters in areas of reef and deeper shelf waters (DSEWPC, 2012). The lesser crested tern is listed as having a 'known occurrence' within the flaring EMBA, and a breeding BIA is also present in proximity to the flaring EMBA (Figure 5.30). It is likely the lesser crested tern occurs within the flaring EMBA but not the impacts EMBA.

Table 5.14. EPBC Act-listed bird species that may occur in the impacts EMBA

Scientific name	Common name	EPBC Act Status			Type of presence in impacts EMBA	Type of presence in flaring EMBA	BIA intersected by impacts EMBA?	BIA intersected by flaring EMBA?	Recovery Plan in place?
		Threatened	Migratory	Marine					
Seabirds									
Anous stolidus	Common noddy	-	Yes	Yes	May occur	May occur	No	No	WCP
Calonectris leucomelas	Streaked shearwater	-	Yes	Yes	Likely	Likely	No	No	WCP
Fregata ariel	Lesser frigatebird	-	Yes	Yes	Likely	Likely	No	No	WCP
Fregata minor	Great frigatebird	-	Yes	Yes	May occur	May occur	No	No	WCP
Phaethon lepturus	White-tailed tropicbird	-	Yes	Yes	May occur	May occur	No	No	WCP
Shorebirds/wetland species									
Actitis hypoleucos	Common sandpiper	-	Yes	Yes	-	May occur	-	No	-
Calidris acuminata	Sharp-tailed sandpiper	-	Yes	Yes	May occur	May occur	No	No	-
Calidris canutus	Red knot	E	Yes	Yes	May occur	May occur	No	No	CA
Calidris ferruginea	Curlew sandpiper	CE	Yes	Yes	May occur	May occur	No	No	CA
Calidris melanotos	Pectoral sandpiper	-	Yes	Yes	May occur	May occur	No	No	-
Numenius madagascariensis	Eastern curlew	CE	Yes	Yes	May occur	May occur	No	No	CA
Thalasseus bengalensis	Lesser crested tern	-	-	Yes	-	Known	-	Yes	-

Key is the same as per Table 5.8.

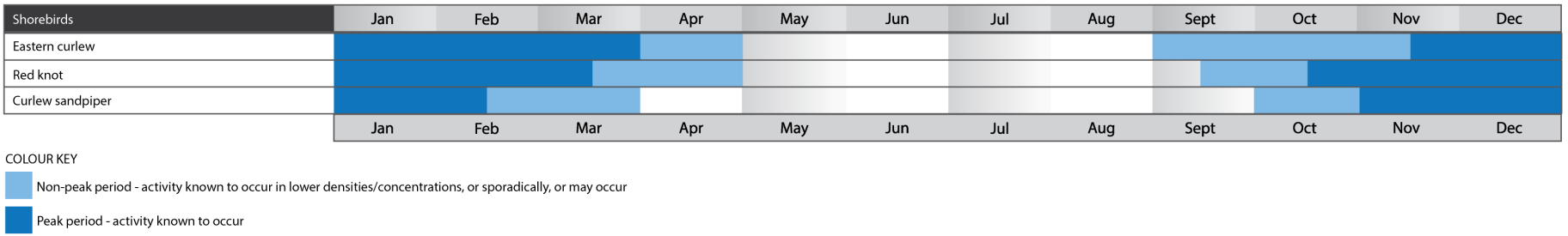


Figure 5.29. Likely temporal presence and absence of EPBC Act-listed threatened seabird species in the impacts EMBA

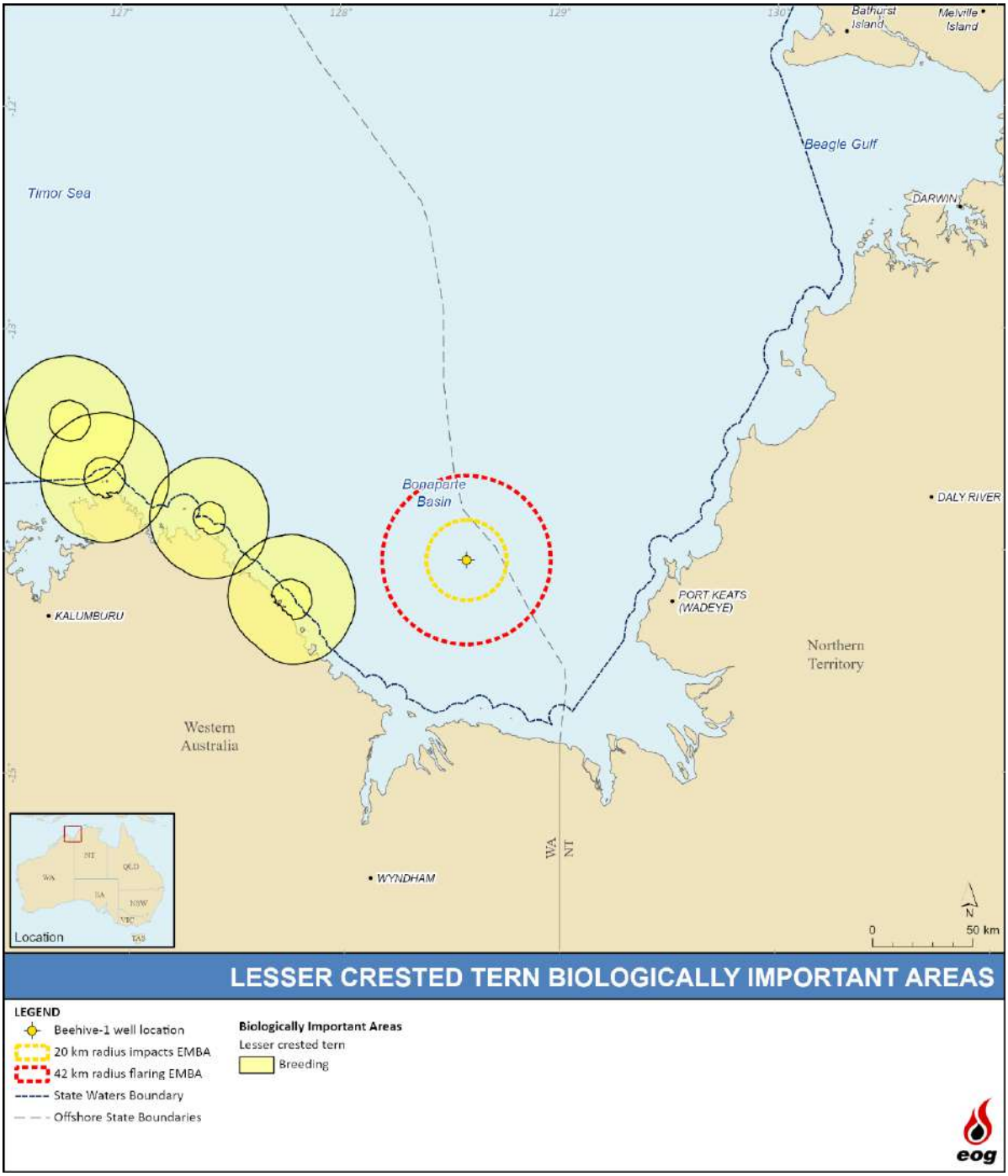


Figure 5.30. Lesser crested tern BIA in relation to the impacts and flaring EMBA

Threats and pressures on birds

Three of the shorebirds listed in Table 5.14 are subject to pressures, which are described in various recovery plans and conservation advice. Table 5.15 summarises the pressures listed in the plans/advice relevant to each of these species that could result from drilling activities.

Table 5.15. Summary of threats to birds

Species	Recovery Plan, Management Plan or Conservation Advice	Key threat/s relevant to drilling
Red knot	Conservation advice for *Calidris canutus* (red knot) (TSSC, 2016a)	Pollution/contamination Disturbance Direct mortality (bird strike from aircraft)
Curlew sandpiper	Conservation advice for *Calidris ferruginea* (curlew sandpiper) (TSSC, 2015e)	Human disturbance Degradation from pollution
Eastern curlew	Conservation advice for *Numenius madagascariensis* (eastern curlew) (DoE, 2015c)	Human disturbance Degradation from pollution
All seabirds and shorebirds	Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (DoEE, 2018)	Marine debris (plastics)
	National Light Pollution Guidelines for Wildlife including marine turtles, seabirds and migratory shorebirds	Artificial light
All EPBC Act listed seabirds (excluding those that are threatened)	Wildlife Conservation Plan for Seabirds (Commonwealth of Australia, 2020)	Light pollution Acute pollution Chronic pollution Climate change Shipping

5.4.8. 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 shallow 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.

5.5. Conservation Values and Sensitivities

The conservation values and sensitivities within the impacts EMBA are described in this section, with Table 5.16 providing an outline of the conservation categories described.

Table 5.16. Conservation values in the impacts EMBA

Category	Conservation classification	EP section
MNES under the EPBC Act	Australian Marine Parks (AMP)	5.5.1
	World Heritage-listed properties	5.5.2
	National Heritage-listed places	5.5.3
	Wetlands of international importance	5.5.4
	Nationally threatened species and threatened ecological communities	5.4
	Migratory species	5.4
	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.
Other areas of national importance	Commonwealth heritage-listed places	5.5.6
	Key Ecological Features (KEF)	5.5.7
	Nationally important wetlands (NIW)	5.5.8
State protected areas	State/territory protected areas	5.5.9

5.5.1. Australian Marine Parks

The impacts EMBA does not overlap any AMPs. The closest AMP is the JBG AMP, located 15 km to the east of the impacts EMBA and 35 km east of Beehive-1. AMPs in the spill EMBA are described in Section 11.4.1 of **Appendix 11**.

5.5.2. 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 20 properties (DCCEEW, 2022d). 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 impacts EMBA. The closest World Heritage Property is Kakadu National Park (onshore), which is located over 400 km northeast of the impacts EMBA. World Heritage-listed places intersected by the spill EMBA are described in Section 11.4.2 of **Appendix 11**.

5.5.3. National Heritage-Listed Properties

The National Heritage List is Australia's list of natural, historic and Indigenous places of outstanding significance to the nation (DCCEEW, 2022e). These places are protected under Chapter 5, Part 15 of the EPBC Act.

There are no National Heritage-listed places within or adjacent to the impacts EMBA. The closest National Heritage Place is the 'West Kimberley', which is located 51 km south-southwest of the impacts EMBA and 71 km south-southwest of Beehive-1.

National Heritage-listed places intersected by the spill EMBA are described in Section 11.4.3 of **Appendix 11**.

5.5.4. 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) (DCCEEW, 2022f). 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 no Ramsar wetlands within or adjacent to the impacts EMBA. The closest Ramsar wetland is the 'Ord River Floodplain', which is located 70 km south of the impacts EMBA and 90 km south of Beehive-1.

Ramsar wetlands intersected by the spill EMBA are described in Section 11.4.4 of **Appendix 11**.

5.5.5. 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).

There are no TECs within or adjacent to the impacts EMBA. The closest TEC is the 'Holothuria Banks', which is located 237 km west of the impacts EMBA and 257 km west of Beehive-1.

TECs intersected by the spill EMBA are described in Section 11.4.5 of **Appendix 11**.

5.5.6. Commonwealth Heritage-listed Places

Commonwealth Heritage-listed places are natural, indigenous and historic heritage places owned or controlled by the Commonwealth (DCCEEW, 2022g). In Australia, these properties are protected under Chapter 5, Part 15 of the EPBC Act.

There are no Commonwealth Heritage-listed places within or adjacent to the impacts EMBA. Commonwealth Heritage-listed places intersected by the spill EMBA are described in Section 11.4.6 of **Appendix 11**.

5.5.7. 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. There are no KEFs within or adjacent to the impacts EMBA. The closest KEF is the 'Carbonate bank and terrace system of the Sahul Shelf', which is located 6 km west of the impacts EMBA and 26 km east of Beehive-1. KEFs intersected by the spill EMBA are described in Section 11.4.7 of **Appendix 11**.

5.5.8. 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 (DCCEEW, 2022h).

There are no NIWs within or adjacent to the impacts EMBA. The closest NIW is the Ord Estuary System, which is located 70 km south west of the impacts EMBA and 90 km east of Beehive-1.

NIWs intersected by the spill EMBA are described in Section 11.4.8 of **Appendix 11**.

5.5.9. State/Territory Protected Areas

The impacts EMBA does not overlap any State- or Territory-managed protected areas. State and territory marine protected areas intersected by the spill EMBA are described in Section 11.4.9 of **Appendix 11**.

5.6. Cultural Heritage Values

Cultural heritage includes both tangible and intangible values. Non-tangible cultural heritage includes oral traditions, performing arts, social practices, rituals, festive events, knowledge, and practices concerning nature and the universe or the knowledge and skills to produce traditional crafts (UNESCO, 2022). Tangible cultural heritage includes artefacts, monuments, a group of buildings and sites and museums that have a diversity of values including symbolic, historic, artistic, aesthetic, ethnological or anthropological, scientific, and social significance. Cultural heritage also captures natural heritage such as culturally significant landscapes (UNESCO, 2009).

A search of the WA inHerit cultural heritage database (Government of Western Australia, 2021) and the NT Heritage Register (NT Heritage Council, 2023) does not identify any cultural heritage places within the proposed location of Beehive-1 or within the impacts EMBA. A description of cultural heritage sites within the spill EMBA based on these database searches is presented in Section 11.5 of **Appendix 11**.

This section describes the cultural heritage values of the impacts EMBA, which are broadly categorised as Indigenous and non-Indigenous (maritime archaeology).

The spill EMBA has the potential to encounter areas containing important cultural features to First Nations peoples. There are many HCPs that encompass the spill EMBA, and information from those HCPs is included in Section 11.5.3 of **Appendix 11**.

5.6.1. Underwater Cultural Heritage

The World Heritage Convention (UNESCO, 2011) defines cultural heritage as:

- Monuments - architectural works, works of monumental sculpture and painting, elements or structures of an archaeological nature, inscriptions, cave dwellings and combinations, which are of Outstanding Universal Value from the point of view of history, art or science.
- Groups of buildings - groups of separate or connected buildings which, because of their architecture, their homogeneity or their place in the landscape, are of Outstanding Universal Value from the point of view of history, art or science.
- Sites - works of man or the combined works of nature and man, and areas including archaeological sites which are of Outstanding Universal Value from the historical, aesthetic, ethnological or anthropological point of view.

Underwater cultural heritage as defined under section 15 of *the Underwater Cultural Heritage Act 2018* (Cth) means any trace of human existence that has a cultural, historical, or archaeological character; and is located under water. A trace of human existence includes: sites, structures, buildings, artefacts and human and animal remains, together with their archaeological and natural context, and vessels, aircraft and other vehicles or any part thereof, together with their archaeological and natural context, and articles associated with vessels, aircraft or other vehicles, together with their archaeological and natural context.

First Nations Underwater Cultural Heritage (FNUCH) is defined in the draft *Guidelines for working in the near and offshore environment to protect Underwater Cultural Heritage* (DCCEEW, 2023) as any trace of human existence that has a cultural, historical, or archaeological character, is located underwater, and relates to the Aboriginal or Torres Strait Islander occupation of Australia.

In July 2022, EOG undertook a geophysical survey in the activity area. EOG subsequently commissioned Cosmos Archaeology to undertake a desktop-based assessment of First Nations tangible underwater cultural heritage (UCH) (Cosmos Archaeology, 2023), in part using data from the geophysical survey. This report is available in **Appendix 12** and the following information is derived from this report.

Around the time of first human arrival around 65,000 years ago, the sea level was about 80 m lower than present and the Beehive-1 site was about 85 km inland of the ancient coastline. The Beehive-1 site became a coastal environment for a period between 60,000 and 50,000 years before present and gradually become situated further inland as sea level continued to fall until the peak of the last glacial maximum around 18,000 years before present. At this time, the Beehive-1 site was situated 450 km from open marine coastal environments, however it was proximal to (approximately 100 km) a large lacustrine system. The termination of the last glacial maximum saw rapid sea level rise, resulting in the Beehive-1 site becoming inundated about 13,500 years before present.

There are no prominent positive relief features present within the vicinity of the Beehive-1 site, which suggests that the palaeolandscape was subdued and likely dominated by negative relief features.

A terrestrial landform analogue to the interpreted Beehive -1 meander belt complex can be found in the lower reaches of the Ord River system, which is located approximately 170 km south of the Beehive-1 site. As the land surface slope decreases, the river begins to meander with evidence of an active meander bends with advancing scroll bars and eroding cut banks. There is also evidence of older abandoned channels forming oxbow lakes. As a result of this particular geomorphic system, archaeological material situated within a meaner belt should equally be relatively young. The Department of Planning, Land and Heritage (DPLH) archaeological site database identified a total of 8 archaeological sites along a 20 km section of the Ord River meander belt. All sites are registered as artifact scatters and would be considered to have a very low site density.

Given that Beehive-1 site is located within an interpreted meander belt, which has likely been an active fluvial system across the period of occupation, this would suggest that the natural down-stream migration of these meanders would have resulted in multiple phases of erosion and deposition (recycling) of the fluvial flood plain. This would mean that archaeological material periodically deposited within a meander belt system would eventually erode and be transported downstream, or in the case of larger lithics, simply deposited at the foot of the cut bank and buried by the advancing scroll bar. This type of fluvial process might explain the very low density of archaeological sites within the lower reaches of the Ord River and if used as an analogue for the Beehive-1 meander belt, it would equally suggest a very low density of archaeological sites having formed around the Beehive-1 area.

Due to the exposed nature of the Beehive-1 wellsite, the process of inundation wave and tidal energy may have further mobilised the lithic artefacts that comprised the more 'recent' sites, either dispersing or concentrating them depending on their exposure, rate of burial and micro-geomorphological context. As such, it is possible that some sites may have undergone relatively low levels of disturbance as has been demonstrated at the Dampier Archipelago (Murujuga), thereby retaining a relatively high level of archaeological integrity.

However, for the majority of exposed sites composed of artefact scatters, it can be expected that they have been dispersed or dissipated and for the most part have moved from an archaeological context towards a geomorphological/sedimentological context. This would reduce but not eliminate the archaeological/scientific values associated with these artefacts. The inherent cultural heritage values of the artefacts themselves that may be identified by the relevant First Nations stakeholders would not be diminished.

5.6.2. Information from Consultation

Consultation specifically undertaken during the development of this EP included several in-person information sessions, as listed in Section 4.2.1. These meetings identified a number of particular values and sensitivities, and concerns relevant to this EP.

The Broome meeting (7 June 2023) identified that:

- Introduced species pest management (particularly example of cane toads) is an issue of importance; and
- Turtle and dugong are migratory species and important cultural animals to manage in the project area.

The Ardyaloon meeting (8 June 2023) did not identify any concerns with this activity but did identify concerns related to offshore oil and gas in general, including:

- Hunting resources – Could an event impact freshwater hunting resources – "this is our food bowl". This includes sea country – fishing and dugong and turtle (including cultural significance of the resources).

The Kalumburu meeting (13 June 2023) identified:

- Important fishing areas for oysters, scallops, fish, crabs and sting rays;
- That marine life needs to be protected, particularly turtles, whales and mangroves;
- There are important cultural heritage resources in the area, including rock art, marine resources and camping locations along the shore; and
- That EOG should ensure that there are no negative impacts on tourism.

The Aboriginal Sea Company requested information on the processes of reporting:

- Accidental waste discharges; and
- Damage to sea life on the sea floor, such as, giant clam and any other protected or endangered species.

During the relevant persons consultation process, a Tiwi Islands Land Council anthropologist stated that due to the proposed location of Beehive-1, there are no cultural impacts relating to the Tiwi Islands.

EOG has sent project information to all other relevant persons and invited comments, including Native Title determination group representatives, Aboriginal land councils and other Aboriginal relevant persons intersected by the spill EMBA. To date, no information from these groups regarding the values and sensitivities of sea country have been obtained.

5.6.3. Aboriginal Heritage

First Nations 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) does not identify any registered Aboriginal heritage sites, other heritage sites or Aboriginal heritage survey areas within the proposed Beehive-1 location or impacts EMBA.

Aboriginal heritage sites within the spill EMBA are listed in Section 11.5 of Appendix 11. Information on the values and sensitivities of First Nations people closer to the coast (outside the impacts EMBA) is described in Sections 11.5.3 of Appendix 11.

Sea Country is described in Section 11.5.5 of Appendix 11.

5.6.4. Healthy Country Plans

There are no HCPs or publicly available data that describe the marine values within the activity area or impacts EMBA in relation to First Nation's perspective. The HCP that covers the area closest to the activity area and impacts EMBA is the Balanggarra HCP, which describes an area approximately 60 km southwest of the impacts EMBA.

The Balanggarra HCP 2012-2022 (BAC/KLC, 2011) describes how Balanggarra people want to look after their country. Some of the Balanggarra country has 'blue water'; from roughly north of the Forrest River drainage system and west to Kalumburu including Cape Londonderry, the Lyne, Berkeley and King George rivers, the lower Drysdale River, plus all the saltwater, the reef, and offshore islands, including Sir Graham Moore and Governor Islands. The rest of their country is called 'brown water', which is in the southern part of their claim and takes in all the land drained by the Forrest River system, and the muddy waters and some offshore islands of the Cambridge Gulf, like Adolphus and Lacrosse Islands. Balanggarra law and culture provides the rules and responsibilities for looking after Balanggarra culture, plants, animals, people and country.

The plan identifies the most important things to be looked after as:

- Balanggarra law and culture;
- Our gra (our land and sea country);

- Cultural sites (rock art sites, burial sites, heritage places);
- Right way fire;
- Native animals (all the culturally important land animals);
- Accessible bush tucker / medicine plants;
- Freshwater (places and freshwater fish);
- Saltwater fish and seafood; and
- Migratory saltwater species (turtle, dugong, whales, dolphins).

In addition to the Balanggarra HCP, the ecological character description of the Ord River Floodplain Ramsar Site (Hale, 2008), located 70 km south of the impacts EMBA, lists the following significant Aboriginal sites within the Ramsarsite:

- Burial sites;
- Artefact scatters;
- Mythological sites;
- Quarries;
- Paintings; and
- Ceremonial sites.

Past and present socio-cultural values of the Ord River Floodplain Ramsar Site and the Balanggarra HCP are described in Section 11.5.3 of Appendix 11.

5.6.5. 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.

A search of the National Shipwreck and Relic database identifies no shipwrecks within the impacts EMBA. Shipwrecks within the spill EMBA are listed in Section 11.5.8 of Appendix 11.

5.6.6. Native Title

According to the National Native Title Tribunal (NNTT) Register, there are no Native Title determination or application areas within the impacts EMBA. The Native Title areas within the spill EMBA are described in Section 11.5.4 of Appendix 11.

5.7. Socio-economic environment

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

5.7.1. Commercial Fishing

Several Commonwealth, WA and NT commercial fisheries are licensed to operate in the impacts 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 in the impacts EMBA are the:

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

Of these fisheries, only the NPF has evidence of recent (within the last three years) fishing activity in the impacts EMBA. During the relevant persons consultation process, AFMA stated that the NPF has a historic catch and effort around the proposed Beehive-1 location, catching red-legged banana prawns. The NPFI and CSIRO confirmed during the relevant persons consultation process that there is a low fishing effort/catch in the proposed Beehive-1 location, with most fishing occurring north and northwest of the proposed Beehive-1 location for adult prawns.

Table 5.17 summarises the key facts and figures of the NPF and Figure 5.30(a;b) illustrates the overlap between the fishery and the impacts EMBA. Commonwealth-managed fisheries intersected by the spill EMBA are described in Section 11.6.1 of Appendix 11.

Table 5.17. Commonwealth-managed NPF

Target species	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*) Red endeavour prawn (*M. ensis*)
Fishing season	The NPF operates in two seasons; • First – April to June, when banana prawns are the key catch species. • Second – August to November, when tiger prawns are the key catch species.
Fishing methods, vessels and licences	Otter trawl is the primary fishing method. In the 2021 fishing season, there were 54 active vessels in the fishery. An increase of two vessels compared to 2020. The primary landing ports are Darwin (NT), Cairns and Karumba (Qld).
Catch data and other information	Catch data and economic value available for the last five years: • 2022 – 5,325 tonnes valued at $91.7 million. • 2021 – 5,390 tonnes valued at $76.6 million. • 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.

Sources: Butler et al (2023), Patterson et al (2022, 2021; 2020; 2019; 2018).

Northern Prawn Fishery

Prawn species reach a commercial size at six months of age and can live for up to two years. Growth rates vary considerably between species and sexes, with females generally growing faster and to a larger size than males. The larger the prawn, the higher the price.

Most species are sexually mature at six months, but fertility increases with age. Females can produce hundreds of thousands of eggs at a single spawning at twelve months old and may spawn more than once in a season. After spawning in offshore waters, the eggs sink to the bottom after release, where they hatch into larvae within about 24 hours. Usually <1% of these offspring survive the two-to-four-week planktonic larval phase to reach suitable coastal nursery habitats where they may settle. After one to three months in the nursery grounds, the young prawns move offshore into the fishing grounds.

NPF catch in the JBG is comprised primarily of banana prawns (mainly *F. indicus* and some *F. merguiensis*), with banana prawn catch being more than double that of tiger prawns and endeavour prawns in 2019 combined (Patterson *et al*., 2020). The JBG comprises about 30,000 km^2 of the westernmost portion of the NPF (see Figure 5.31). Fishing for *F. indicus* is permitted day and night in both NPF fishing seasons. Fishing takes place in waters 35–70 m deep,

with most fishing effort between 50 m and 60 m. The trawling regime for this species is similar to the tiger prawn sub-fishery in other regions of the NPF, where the total duration of individual trawls is usually about 3 hours long. Although the JBG fishery comprises less than 5% of the area of the NPF, it contributes about 65% of the NPF's redleg banana prawn catch and around 20% of the NPF's total banana prawn catch (combined *F. merguensis* and *F. indicus*) (Loneragan *et al*., 2002).

Research to date indicates that *F. indicus* prawns spawn offshore near to the fishing area throughout the year with two spawning peaks: the late dry season (September to November) and the late wet season (March to May). The larvae move inshore and then wash out as juveniles with the wet season floods. The migration of juvenile *F. indicus* in the JBG (as described in Table 5.5) is illustrated in Figure 5.32. Loneragan et al (2002) reported that the offshore fishery for *F. indicus* occurs in water depths of 50 – 80 m in the northwestern offshore waters of the JBG, deeper than the majority of the waters of the impacts EMBA.

During the relevant persons consultation process, the NPFI stated that the redleg banana prawn moves within the proposed Beehive-1 location throughout its life cycle. Larvae and postlarvae are transported south and southeast from their offshore spawning grounds where they are fished, towards their coastal nursery habitats in mangrove forest and mudbanks. The Victoria River and Forsyth Creek, along with other rivers feeding into the Cambridge Gulf, support prime estuarine habitats for prawns. Juvenile prawns then migrate back to adult prawn habitats in the northwest central region of the JBG at depths of around 60-80 m deep.

Figures 5.31a-c show the NPF fishing intensity in relation to the impacts EMBA for the past three fishing seasons (2019, 2020 & 2021). All three years demonstrate low fishing intensity occurs within the impacts EMBA.

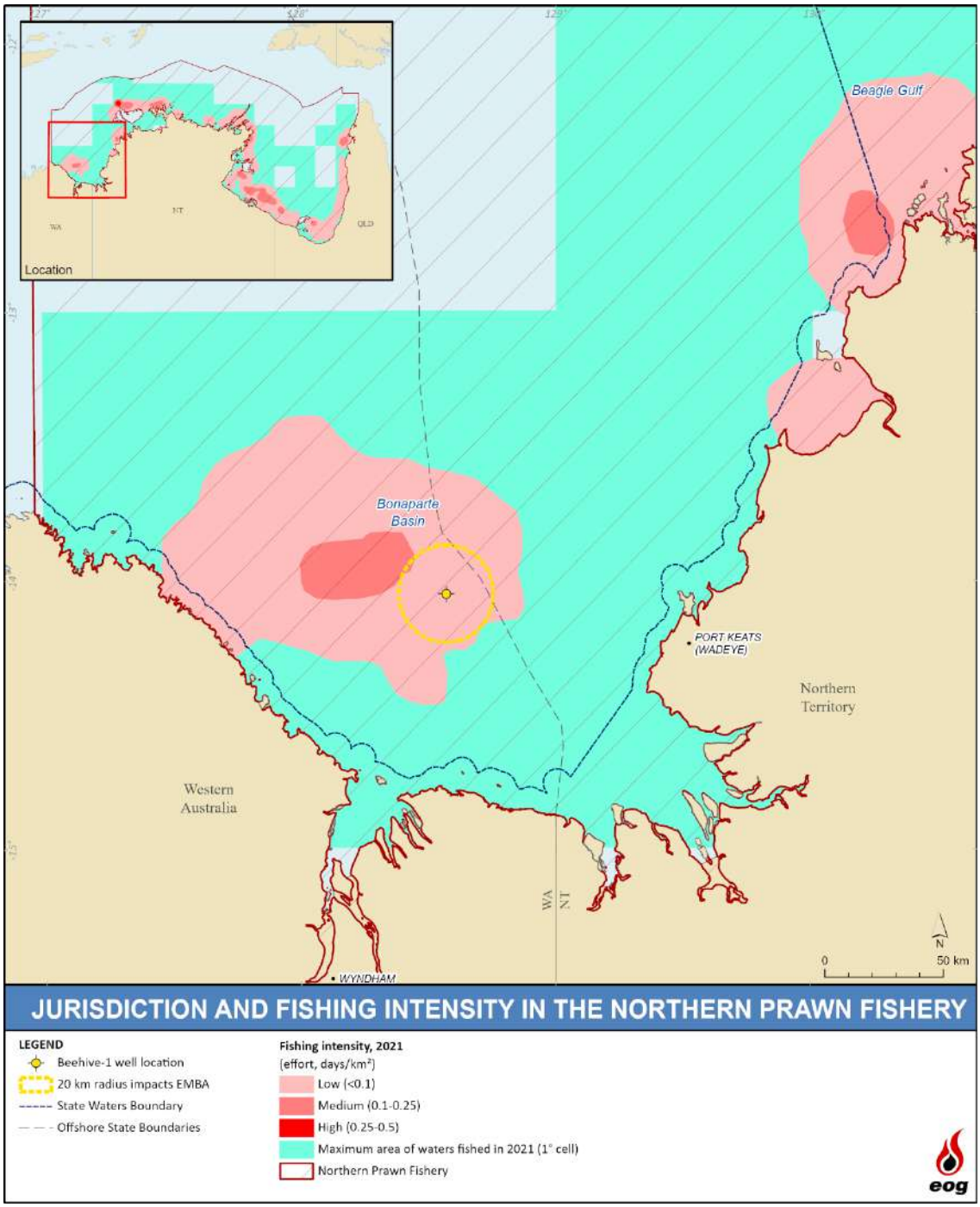


Figure 5.31a. NPF fishing intensity in the impacts EMBA (2021)

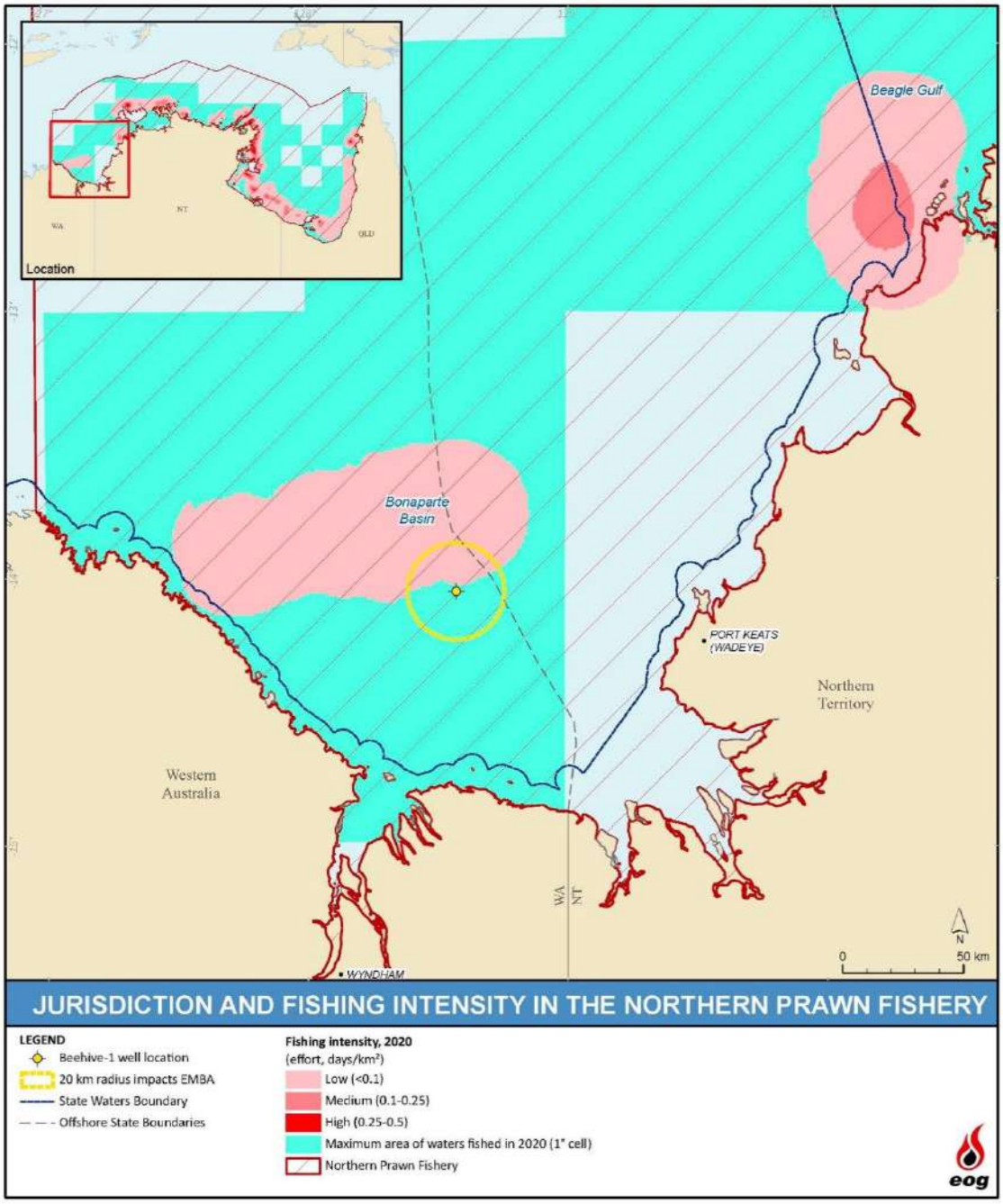


Figure 5.31b. NPF fishing intensity in the impacts EMBA (2020)

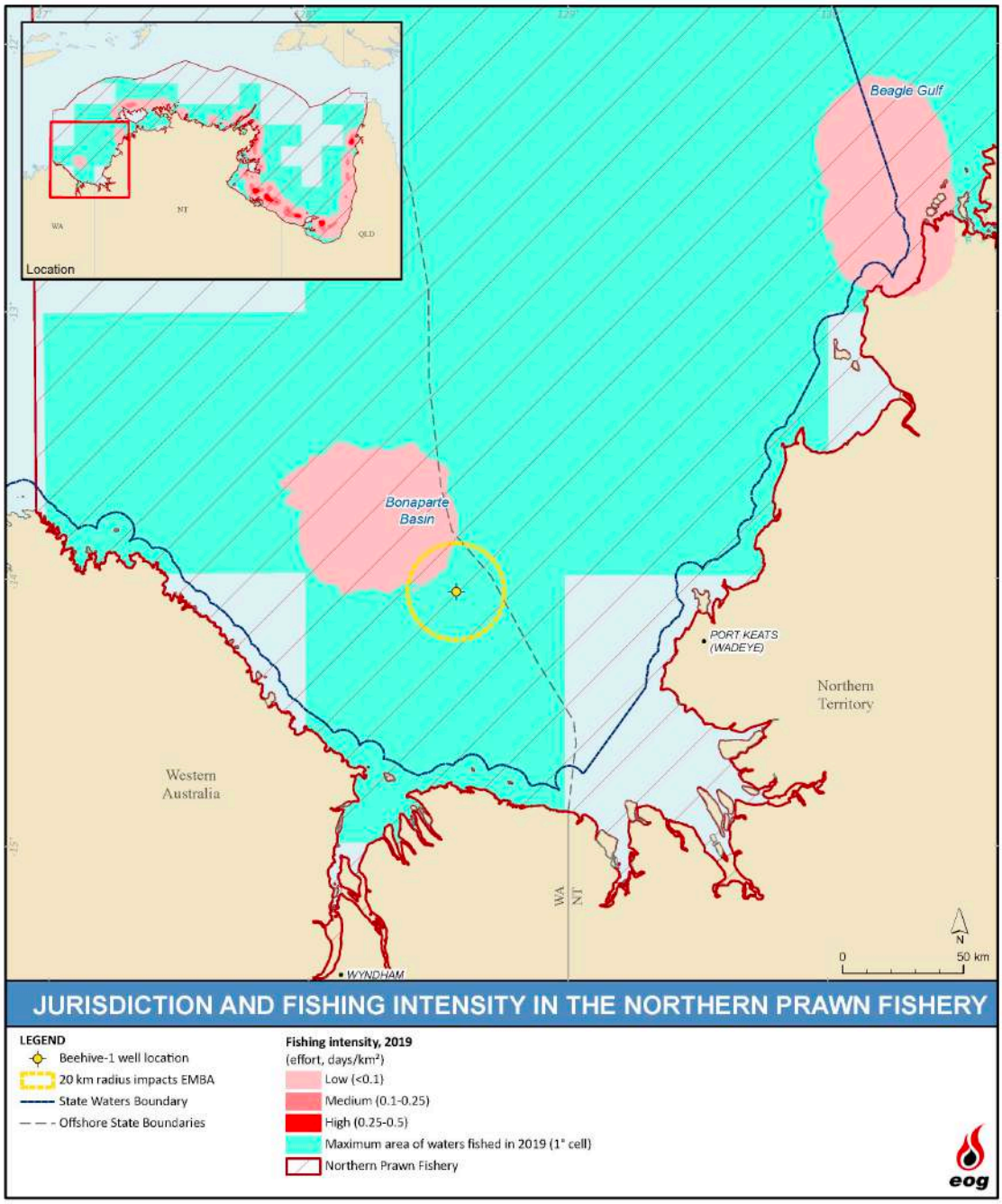
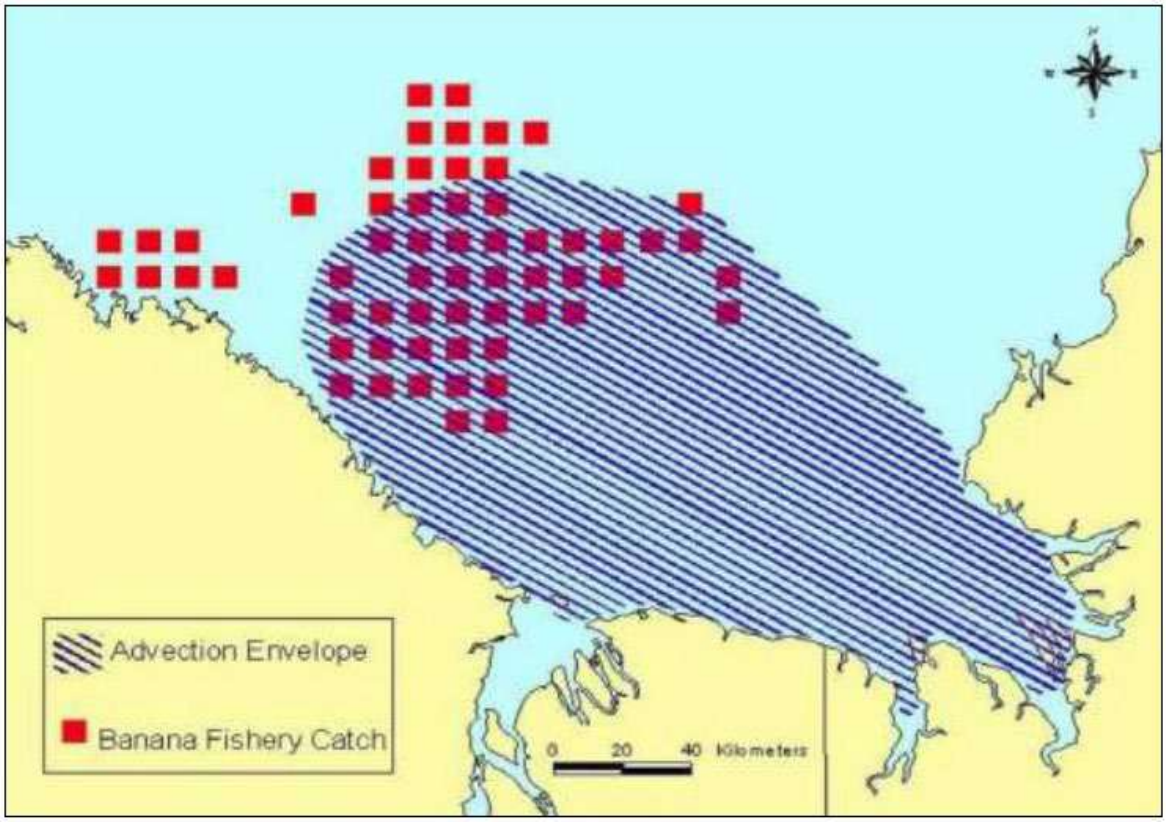


Figure 5.31c. NPF fishing intensity in the impacts EMBA (2019)



Source: Loneragan et al (2002).

Figure 5.32. Size and the probable advection envelope for post-larval redleg banana prawn (*Fenneropenaeus indicus*) in the JBG

A seasonal closure for the NPF in the JBG exists in the period 31 March –15 June (Figure 5.33) (AFMA, 2021). The seasonal closure is an exclusion zone in place for all licence holders within the NPF, and the purpose of this closure is to protect small juvenile prawns as they migrate offshore to deeper waters in the southern JBG, where the adults are targeted during the trawling operations (AFMA, 2021). Any catch south of the seasonal closure line is taken in the second fishing season only (August to November), whereas catch taken north of the closure line is taken during both the first and second seasons. The impacts EMBA is located within this exclusion zone.

Due to the large tidal range (6–8 m) in the JBG and its reputed influence on prawn abundance in the region, red-legged banana prawns are fished on the neap tides, when tidal range and currents are minimal (Tonks *et al*., 2008). Thus, over a tide cycle, fishing effort is high on the late spring-neap, neap and early neap-spring tides, and low to non-existent at other times when the fleet moves to fishing grounds north of Melville Island and Port Essington, outside the JBG. The extra steaming time that this fishing pattern generates, together with the remoteness of the JBG and the lower price of redleg banana prawns in comparison to other species of prawns, makes the JBG a less attractive area to fish than other parts of the NPF. as a result, the annual fishing effort in the JBG fishery is mostly dependent on the catch levels elsewhere in the NPF; if catches are good elsewhere, effort in the JBG is low (Loneragan *et al*., 2002).

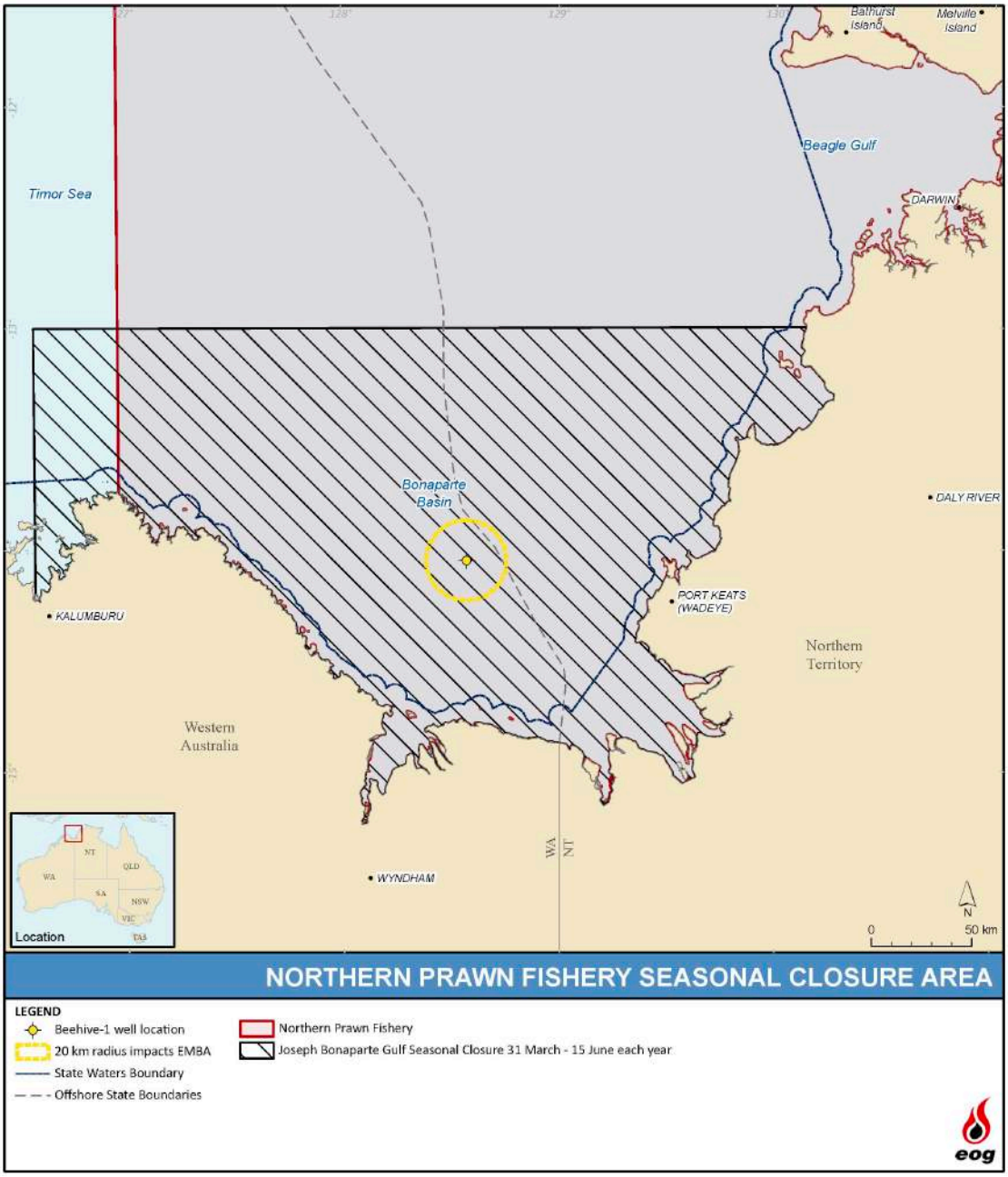


Figure 5.33. JBG closure area of the NPF

Western Australia-managed Fisheries

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

- Northern Demersal Scalefish Managed Fishery (NDSMF);
- Mackerel Managed Fisheries (MMF) (Area 1 – Kimberley);
- Kimberley Crab Managed Fishery (North Coast Crab Fishery) (KCMF);
- Kimberly Prawn Managed Fishery;
- Kimberley Gillnet and Barramundi Fishery;

- Pearl Oyster Managed Fishery (Zone 3)
- Abalone Managed fishery (Area 8);
- Marine Aquarium Fish Fishery; and
- Specimen Shell Fishery.

Through its consultation process with the WA DPIRD, EOG identified that only the NDSMF and MMF may fish in the impacts EMBA. Table 5.18 presents information for the fisheries that have recent evidence of fishing in the impacts EMBA. Western Australian-managed fisheries intersected by the spill EMBA are described in Section 11.6.1 of Appendix 11.

Northern Territory-managed Fisheries

The NT DITT confirms there are no NT-managed commercial fisheries that fish within the impacts EMBA. Throughout the relevant persons consultation process, the NT demersal fishery confirmed that no NT fisheries operate in within the impacts EMBA due to the location being wholly within a WA waters.

Northern Territory-managed fisheries intersected by the spill EMBA are described in Section 11.6.1 of Appendix 11.

Table 5.18. Western Australian-managed commercial fisheries with recent fishing effort in the impacts EMBA

Fishery	Target species	Fishing activity in the impacts EMBA?	Fishing season	Fishing methods, vessels and licences	Catch data and other information
NDSMF – Kimberley sector, Fishing Area 2, Zone A (Figure 5.34)	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*).	1,544 tonnes were caught in the Kimberley sector in 2021, with the majority of the catch (1,406t) was landed in Zone B, 325 km west of the impacts EMBA.	Assumed to be year-round.	Although permitted to use handlines, droplines and traplines, since 2002 the fishery has been essentially trap based. Seven vessels actively fished in 2021 (employing at least 23 people).	Catch data available for the last five years* for the whole fishery: • 2022 – 1,458 t. • 2021 – 1,544 t. • 2020 – 1,419 t. • 2019 – 1,507 t. • 2018 – 1,297 t. The economic value of the fishery is $10-20 million.
MMF - Area 1 (Kimberley) (Figure 5.35)	Spanish mackerel (*Scomberomorus commerson*)	The WA DoF reports that catch rates in the Kimberley are generally decreasing, partially due to changes in operators but also a decline in spawning stock after the 2016 northern heat pulse during the spawning period.	Fishing was primarily from May to November in 2019.	A total of 16 vessels operated during 2021 across the fishery, employing 30-40 people. 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* for the whole fishery: • 2022 – 212 t. • 2021 – 248 t, valued at $2.5-3 million. • 2020 – 299 t. • 2019 – 291 t. • 2018 – 213 t.

Newman et al. (2023a; 2023b, 2021); Gaughan and Santoro (2021; 2020; 2018); Gaughan et al (2019).

** 2023 catch data was not available at the time of EP preparation.*

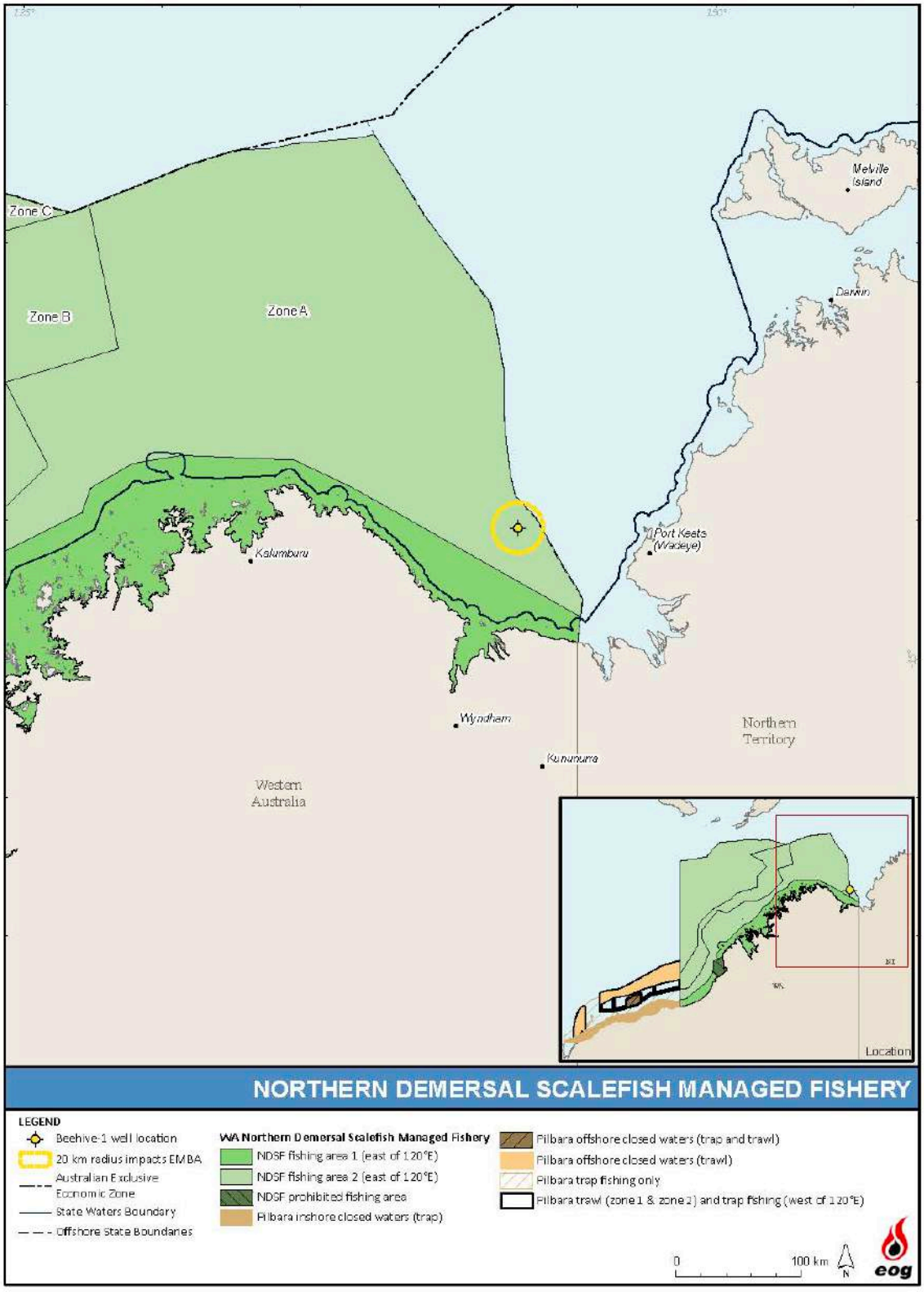


Figure 5.34. WA Northern Demersal Scalefish Fishery overlapped by the impacts EMBA

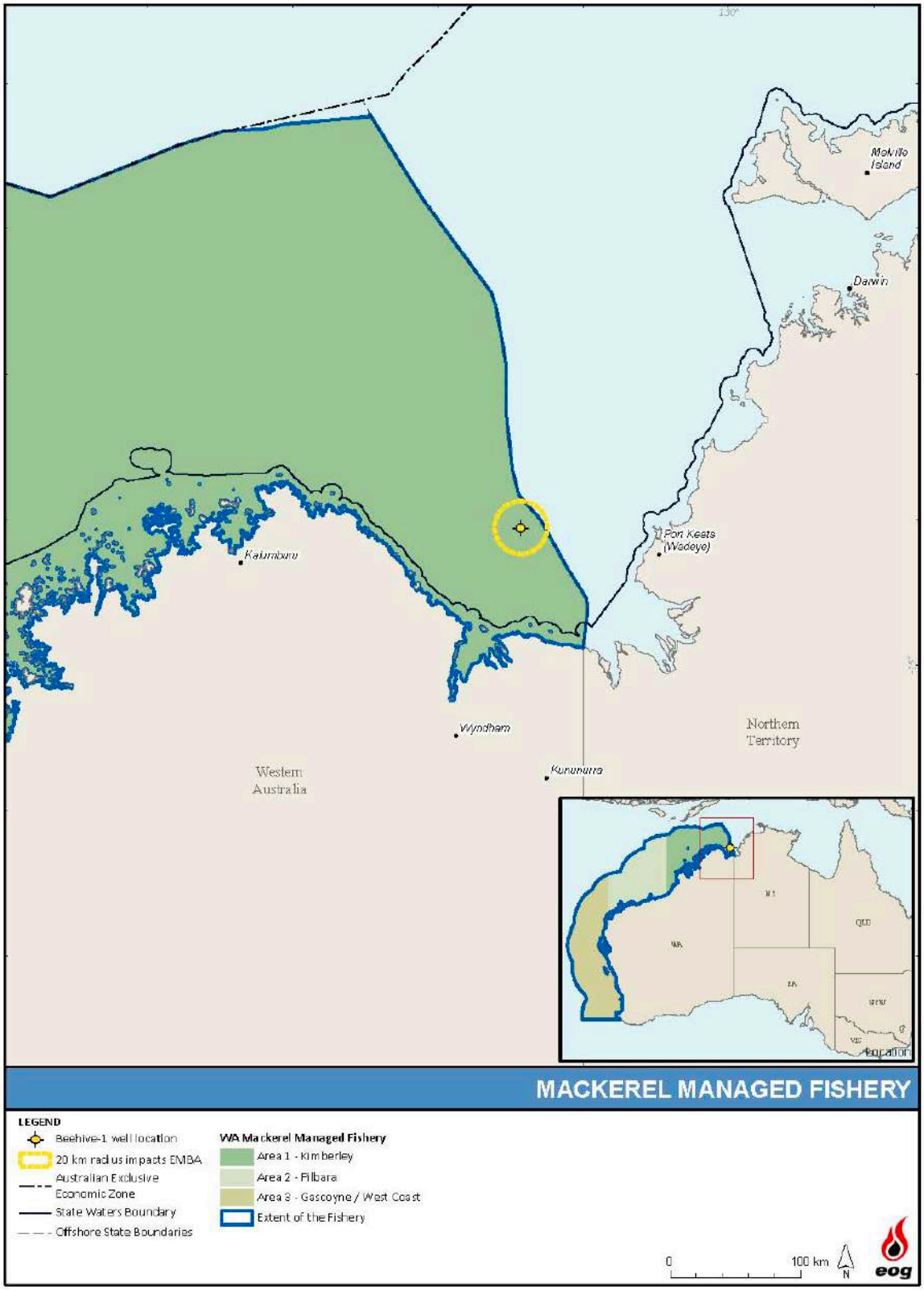


Figure 5.35. WA Mackerel Managed Fishery overlapped by the impacts EMBA

5.7.2. Recreational Fishing

Within the North Coast Bioregion, recreational fishing is experiencing significant growth, with a distinct seasonal peak in winter (Gaughan and Santoro, 2018). Offshore islands, coral reefs and 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, located 280 km northeast of the impacts EMBA. Given the long distance between the impacts EMBA and the mainland (60 km at its closest point) and main population areas (e.g., Wadeye), recreational fishing activities in the impacts EMBA are not expected.

During the relevant persons consultation process, AFANT have not raised any issues regarding recreational fishing in or around the impacts EMBA. RecFish West have also confirmed during the relevant persons consultation process that their activities are unlikely to be impacted by the proposed Beehive-1 location.

5.7.3. Traditional Aboriginal Fishing

Traditional Aboriginal fishing in NT waters predominately occurs within inshore tidal waters, outside the impacts EMBA. 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 generally three recognised Aboriginal fishery zones, which extend to 3 nm, 15 nm and 200 nm from the coast. Almost all Aboriginal fishing effort is concentrated within the 3 nm coastal waters boundary (93%) (65 km from the impacts EMBA at its closest point), with fishing spanning the entire coastline, though it is mostly focused around the Tiwi Islands (275 km northeast of the impacts EMBA). Aboriginal activities within the coastal waters of the Tiwi Islands includes fishing and hunting (including for 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 impacts EMBA is located. 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).

5.7.4. Coastal Settlements

The coastline adjacent to the JBG is sparsely populated, with the townships of Wadeye, NT (85 km east) and Wyndham, WA (163 km south) being the closest and the city of Darwin (280 km northeast of the impacts EMBA) being the largest nearby city.

5.7.5. Tourism

The JBG is very remote and therefore has not been significantly developed for tourism. For up to five months of the year, access to the JBG region is restricted to boat or helicopter access 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).

There are no attractions (e.g., known reefs, shipwrecks, canyons) in the impacts EMBA or immediate surrounds to attract tourists. Charter boats operating out of Darwin and Broome/Derby may occasionally visit or pass through the JBG. No scuba diving or snorkelling sites or dive shops or clubs have been identified in the JBG or adjacent townsites. The presence of saltwater crocodiles and other potentially dangerous fauna generally makes these waters unsuitable for such activities.

During the relevant persons consultation process, Oolin Sunday Island Cultural Tours confirmed that their operations will not be disrupted by the by the Beehive-1 drilling.

5.7.6. 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 5.36). The Blacktip Gas Field consists of an unmanned WHP, two producing wells, flowlines and a subsea gas export pipeline (GEP) that runs from the WHP to shore near Wadeye, NT. The Blacktip GEP is located 12 km northeast of Beehive-1 and is overlapped by the impacts EMBA. Vessels servicing the Blacktip WHP and GEP may occasionally pass through the impacts EMBA. There are numerous exploration and production permits and leases throughout the WA, NT and Commonwealth waters within the spill EMBA, and these are described in Section 11.6.5 of Appendix 11.

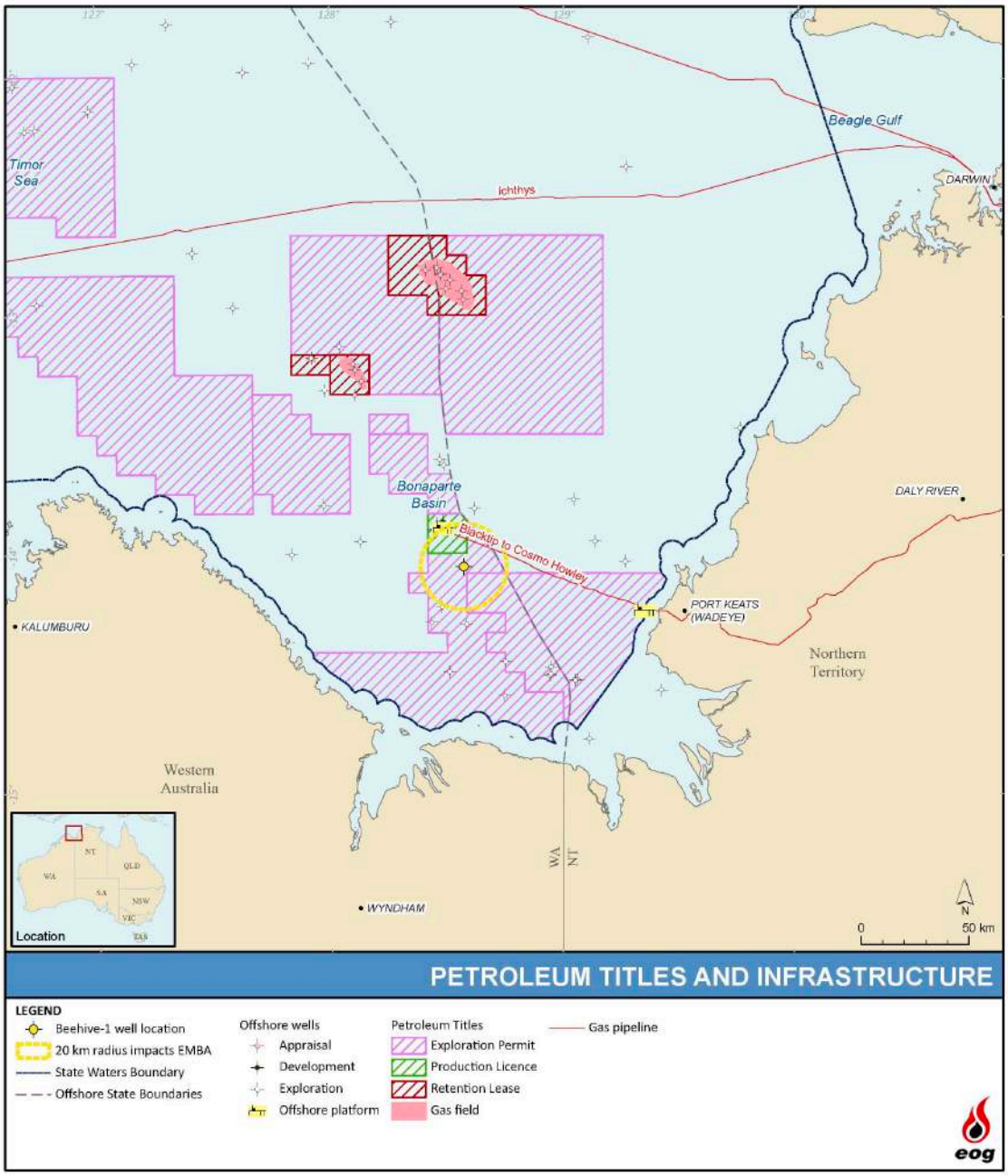


Figure 5.36. Petroleum activity in the impacts EMBA

5.7.7. Commercial Shipping

The closest major commercial shipping port is Darwin, located 280 km northeast of the impacts EMBA and 300 km northeast of Beehive-1. The location of the Darwin Port relative to Asia and the region's offshore oil and gas fields makes the surrounding area a key shipping region. Very low levels of shipping traffic occur through the impacts EMBA. Using Automatic Identification System (AIS) data from AMSA and spatial analysis, it was determined that there is also a low level of shipping traffic in and immediately around the impacts EMBA and that vessels in this area are mainly transiting and not lingering. An analysis of the shipping traffic for the 2021 calendar year recorded from the impacts EMBA (20-km radius around the drill site) is presented in Table 5.19. This shipping traffic is also illustrated in Figure 5.37, which shows that the impacts EMBA is located south of the major shipping lanes coming out of Darwin, which contributes to the very low level of shipping traffic recorded in the area. The concentration of shipping activity in the northwest

part of the impacts EMBA is associated with the Blacktip WHP. The highest volume of traffic is recorded in the months of June, July and August, with the latter months likely to occur outside the activity window.

Table 5.19. Commercial shipping traffic recorded in the impacts EMBA

Type	2021											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Undefined	-	-	-	-	4	4	-	1	-	-	-	-
Fishing	-	-	-	-	-	1	-	1	-	2	-	-
Other	-	-	-	-	-	-	1	1	1	-	-	-
Passenger ship	-	-	-	-	-	-	-	-	-	1	-	-
Pleasure craft	-	-	-	-	-	1	-	1	-	-	-	-
Port tender	-	-	-	-	-	-	2	1	1	-	-	1
Sailing	-	-	-	-	-	-	1	1	-	-	-	-
Tankers	-	1	-	-	-	-	-	-	-	-	-	1
Total	**0**	**1**	**0**	**0**	**4**	**6**	**4**	**6**	**2**	**3**	**0**	**2**

5.7.8. Defence Activities

The impacts EMBA is overlapped by a defence training area, which is a maritime military zone administered by the Australian Defence Force (Figure 5.38). This is an area where exercises such as operational flying training or live weapon firing may occur. The DoD has advised that military flying training may take place over the activity area, with aircraft flying as low as 500 feet above the water.

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

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. Refugees seeking asylum in Australia are also known to utilise the area, travelling between Indonesia and Australia.

The DoD 'Where Is UXO' database indicates there is no potential for unexploded ordnance (UXO) to occur within the impacts EMBA (Figure 5.39). The DoD advised EOG during the relevant persons consultation process that beyond the data presented in this database, there are no records of specific UXO in the area.

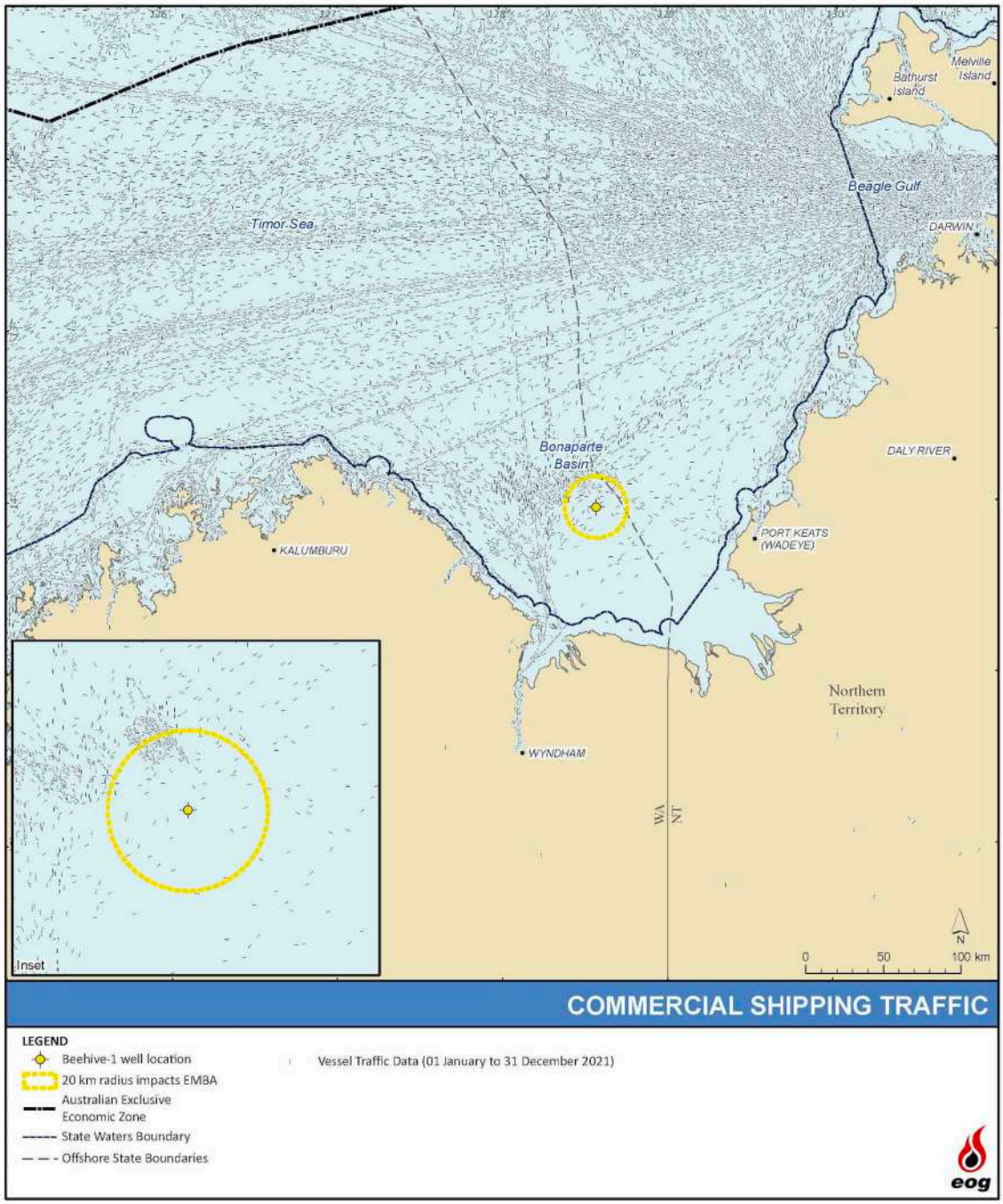


Figure 5.37. Commercial shipping traffic in the impacts EMBA

5.7.9. Submarine Cables

Submarine telecommunication cables provide telephone and internet connections across the world; they are laid on the ocean floor and are often thousands of kilometres in length.

During the relevant persons consultation process, the Australian Communications and Media Authority (ACMA) confirmed that there are no submarine protection zones declared by ACMA that occur within proximity to the proposed Beehive-1 location. The closest known submarine cable to the proposed Beehive-1 location is the Australian Singapore cable, which is 2,402 km west of the proposed Beehive-1 location and 2,387 km west of the impacts EMBA.

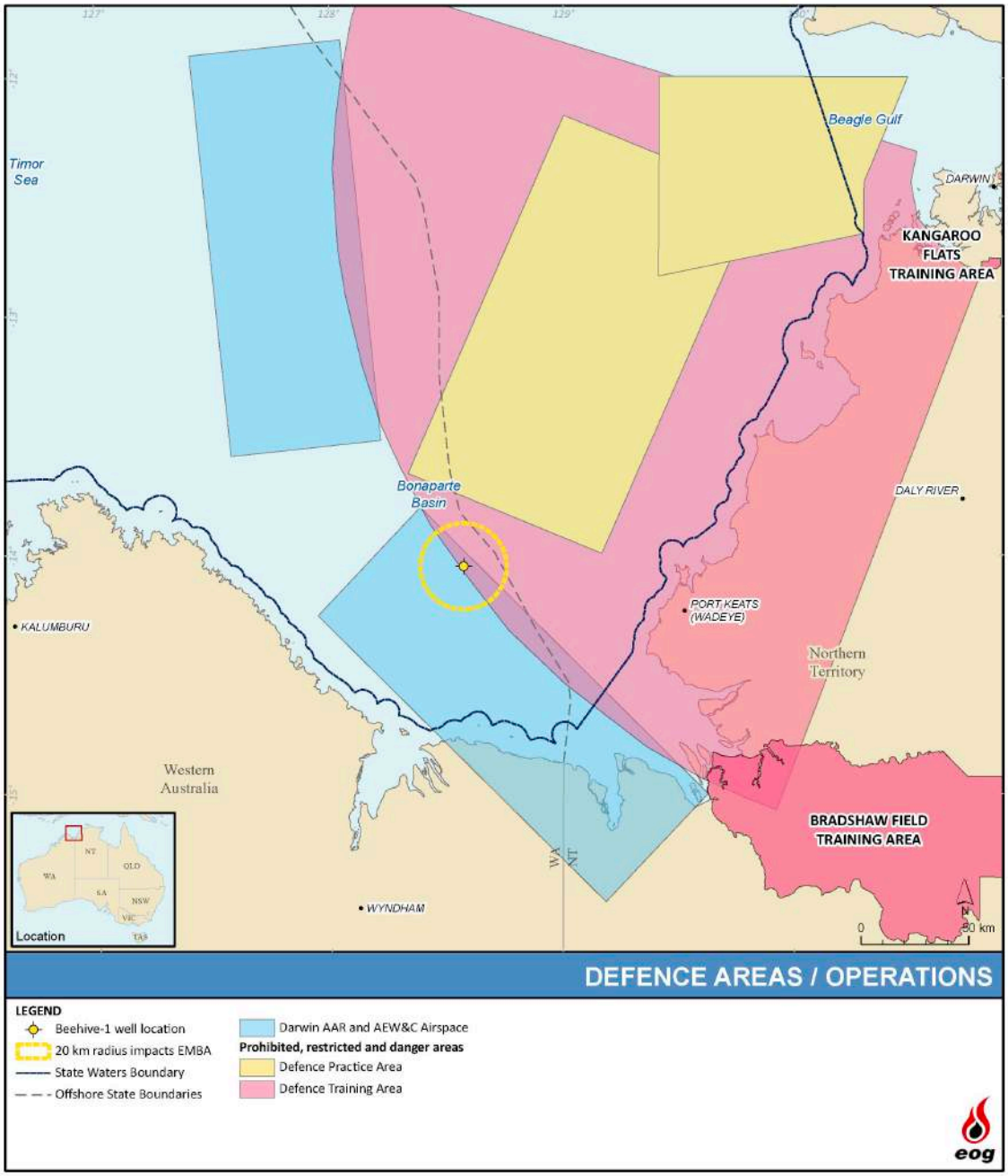


Figure 5.38. Defence areas overlapped by the impacts EMBA

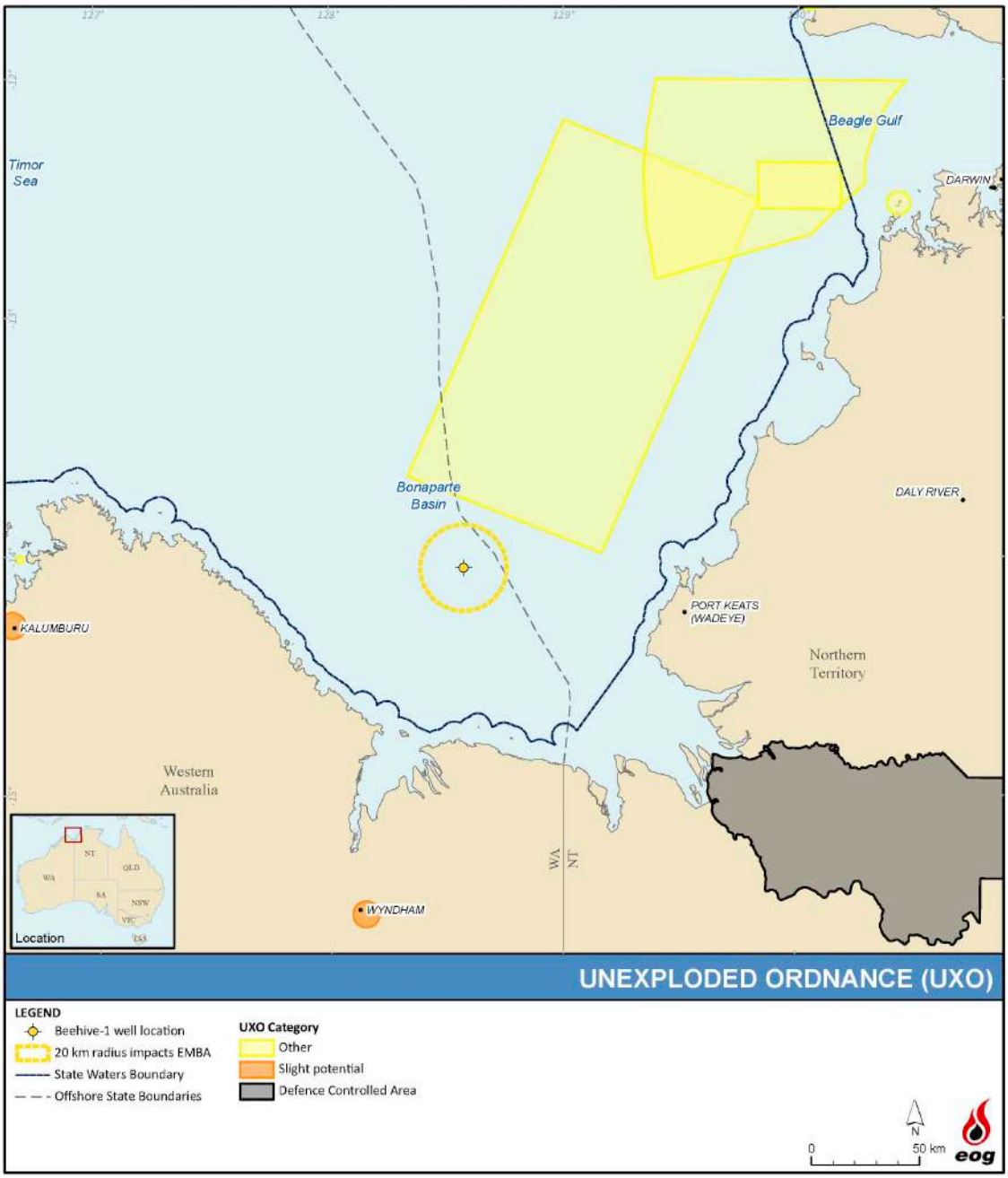


Figure 5.39. Unexploded ordnance risks near the impacts EMBA