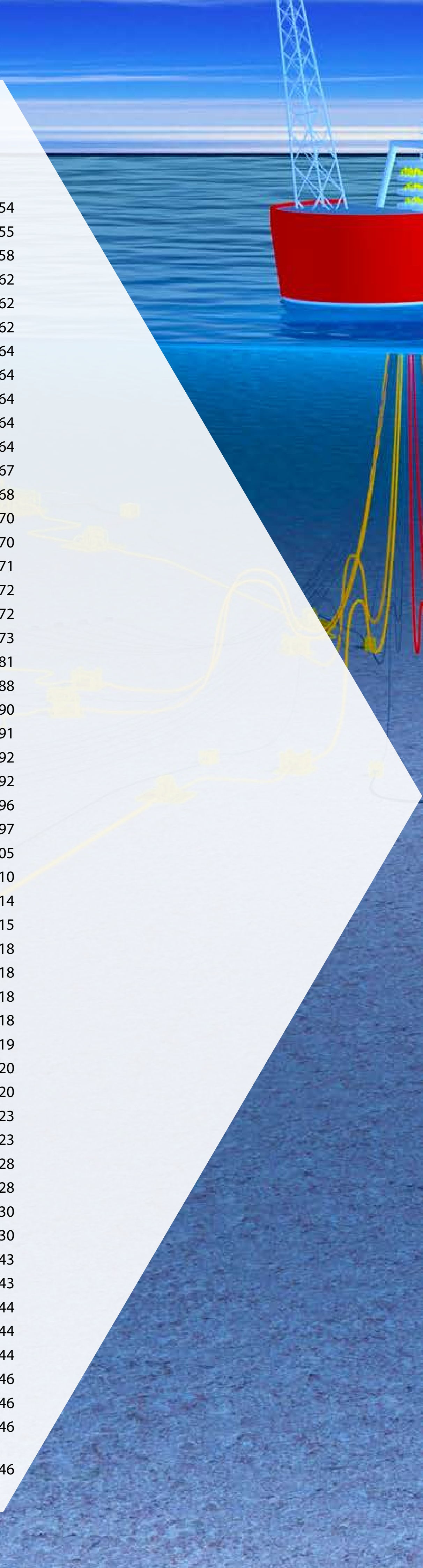
5 Description of the environment



Section 5 summary

Purpose:

This section describes the existing environment of the project area and wider region, including natural features, marine life and habitats, and any other non-oil and gas uses. Understanding the environment and the social, economic, and cultural features of the area helps to assess the potential impacts and risks (further described in **Section 6**) and develop the environmental performance outcomes for the project (further described in **Section 7**).

The OPP considers the environment in the context of the following geographical areas:

1. the **project area**, which consists of:
   - the **Barossa offshore development area** where the facilities and infrastructure will be located and where the marine environment may be affected by planned discharges (**Section 6**)
   - the **gas export pipeline corridor** within which the gas export pipeline route will be located.

   Given the early stage of the project, a buffer has been incorporated into this area. The area directly influenced by the project is expected to be significantly smaller.
2. the area of influence which (based on repeated modelling of the worst credible hydrocarbon spill scenarios) is the outer boundary of the environment that may be affected in the event of an unplanned release of hydrocarbons where no spill response measures are implemented.

Section at a glance:

Barossa marine studies program: ConocoPhillips explains how it developed a detailed understanding of the environment, including in-depth baseline studies that were completed in collaboration with the Australian Institute of Marine Science and scientific experts.

Regional setting: Australia's marine environment is classified into six regions. The North Marine Region is of primary relevance to this OPP being the region containing the Barossa offshore development area and the gas export pipeline corridor. The North-west Marine Region is also relevant as parts of it are within the area of influence.

Physical environment: The studies show that natural features including the climate, seabed, air quality, water currents and temperature, water and sediment quality, and underwater noise in the Barossa offshore development area are all typical of the region.

There are no significant seabed features in the Barossa offshore development area. The closest regionally important environmental features to the Barossa offshore development area are Evans Shoal (35 km west), Tassie Shoal (32 km west) and Lynedoch Bank (27 km east). Three shoals and banks (Goodrich Bank, Marie Shoal and Shepparton Shoal) are of particular relevance to the gas export pipeline corridor. In the area of influence, the most important features are Ashmore Reef (750 km south-west), Cartier Island (735 km south-west), Seringapatam Reef (960 km south-west) and Scott Reef (970 km south-west).

Marine fauna: There are 19 threatened species and 38 migratory species that may occur in the Barossa offshore development area and gas export pipeline corridor. The Barossa offshore development area has no unique or specific habitats for these marine fauna, so while they may pass through, they will not remain here. There is no land or other features that support nesting or feeding turtles, breeding populations of seabirds, or migratory shorebirds. The Tiwi Islands are about 100 km south of the Barossa offshore development area and about 6 km from the gas export pipeline corridor at its closest point. These islands support several important habitats, nesting sites for marine turtles, seabird rookeries and the conservation of dugongs. Further environmental surveys and engineering studies will be incorporated to finalise the pipeline route.

Socio-economic and cultural environment: There are no heritage properties or wetlands, nor ecological communities requiring specific protection measures in the Barossa offshore development area or gas export pipeline corridor. The gas export pipeline corridor traverses a portion of the Oceanic Shoals Commonwealth Marine Reserve and the Tiwi Islands hold heritage value for the Indigenous people. There is one shipwreck in the vicinity of the Tiwi Islands within the gas export pipeline corridor.

There are a number of fisheries in the region, with five currently active in the project area. Based on consultations to date, ConocoPhillips understand there are no areas of high fishing activity in the vicinity of the project.

Tourism activities such as organised recreational fishing rarely occur in or near the area due to its remote location. These activities are more likely to occur near the southern end of the gas export pipeline, near the Tiwi Islands, where there is also more commercial shipping activity.

5 Description of the environment

5.1 Overview

This section of the OPP describes the key physical, biological, socio-economic and cultural characteristics of the existing environment relevant to the proposal, including MNES as defined under the Commonwealth EPBC Act.

The description of the environment presented in this OPP is considered comprehensive and conservative based on the early stage project definition and optionality. It provides a description of environmental values and sensitivities within two areas:

- the project area, which consists of the Barossa offshore development area and the gas export pipeline corridor (as defined in **Section 4.2.1.1**)
- the potential area of influence associated with the project (as defined below). The potential area of influence will be further refined as future detailed engineering information becomes available and will be presented in the activity-specific EPs.

The description provided in this section has been used to inform the risk evaluation and impact assessment for the project (**Section 6**).

This section aligns with the NOPSEMA OPP Guidance Note (NOPSEMA 2016a): *"To provide information important to the context of the OPP by identifying and describing the existing environment that may be affected by the project"*.

The following key sources of information were used to inform the comprehensive assessment of environmental values and sensitivities in this OPP:

- ConocoPhillips Barossa marine studies program (2014–15), including a collaborative survey of surrounding shoals undertaken by the Australian Institute of Marine Science (AIMS) (Section 5.2)
- Environment Plan for the ConocoPhillips Bonaparte Basin Barossa Appraisal Drilling campaign, revision as accepted by NOPSEMA (2013)
- recent Environment Plans for the ConocoPhillips Barossa Appraisal Drilling Campaign and Caldita-Barossa Marine Seismic Survey activities as accepted by NOPSEMA (2016)
- previous ConocoPhillips environmental studies, including pre-drill environmental surveys for the Caldita-1 (URS 2005), Caldita-2 (URS 2008) and Barossa-1 (URS 2007) well locations
- material provided by the DoEE, including EPBC Protected Matters search tool, species profile and threats database, National Conservation Values Atlas biologically important areas (BIAs), recovery plans and conservation advices (**Section 3.5.1**), bioregional marine region plans, conservation value report cards, threat abatement plans, National strategies, marine reserve management plans, and CMR Review Panel reports
- published Environmental Impact Statement (EIS)/offshore referral study reports to inform the regional environmental context, including:
  - Woodside Energy Limited (Woodside). 2001. Sunrise Gas Project, Draft EIS, EPBC Referral, and EIS supplement (2002)
  - Methanol and Synfuels Pty. Ltd. 2002. Tassie Shoal Methanol Project Draft EIS, EPBC Referral 2000/108
  - GDF Suez Bonaparte. 2011. Bonaparte LNG Supplementary Report, September 2011
  - Woodside. 2011. Browse LNG Development, Draft Upstream EIS EPBC Referral 2008/4111 (November 2011)
  - Woodside. 2013. Floating LNG EPBC referral 2013/7079 (December 2013), Draft EIS (November 2014) and EIS Supplement (May 2015)
  - INPEX. 2010. Ichthys Gas Field Development Project Draft EIS, and subsequent EIS Supplement (April 2011).
- published literature on the regional environmental values and sensitivities, e.g. PTTEP surveys initiated in response to the Montara incident (Heyward et al. 2010; Heyward et al. 2011) and as published on the North West Atlas.
- engagement with recognised experts in specific discipline areas of biological science in the Bonaparte Basin.

Definition of the area of influence in the context of environmental baseline

The area of influence for the project is the outer boundary of the environment that may be affected in the event of an unplanned release of hydrocarbons where no spill response measures are implemented. The outer boundary has been defined using the largest geographic extent of the adverse exposure zone from modelling the worst case credible spill scenarios that could occur during the project (refer to **Section 6.4.10** for a definition of adverse exposure zone). Stochastic modelling was used to derive the largest extent of the adverse exposure zone based on the following three maximum credible spill scenarios:

- entrained hydrocarbons from a loss of well integrity (i.e. long-term well blowout) in the Barossa offshore development area
- surface hydrocarbons from an offtake tanker vessel collision in the Barossa offshore development area
- surface hydrocarbons from a pipelay vessel collision along the gas export pipeline. In the context of the gas export pipeline, a surface release has been used as stochastic modelling did not predict any entrainment of hydrocarbons.

The extent of the environment that may be affected from planned discharges that will occur during the project was informed by discharge modelling studies, as described in **Section 6.4.8**. In general, planned discharges are expected to be diluted below levels of environmental significance within a conservative radius of approximately 21 km from the discharge location in the Barossa offshore development area. Therefore, planned discharges are encompassed within both the project area and the outer boundary of the area of influence defined by the adverse exposure zone for hydrocarbons released from an unplanned spill scenario. No planned discharges are anticipated from the gas export pipeline once it is operational, with the exception of those from vessels undertaking periodic maintenance along the pipeline during operations. However, these discharges will be small, localised and temporary in nature, and therefore expected to be within the boundary of the gas export pipeline corridor.

Consideration of the area of influence, in addition to the project area, has allowed assessment of all environmental values and sensitivities that could potentially be affected by the project (see **Section 6**).

The boundaries of the project area and the area of influence are shown in **Figure 5-1**.

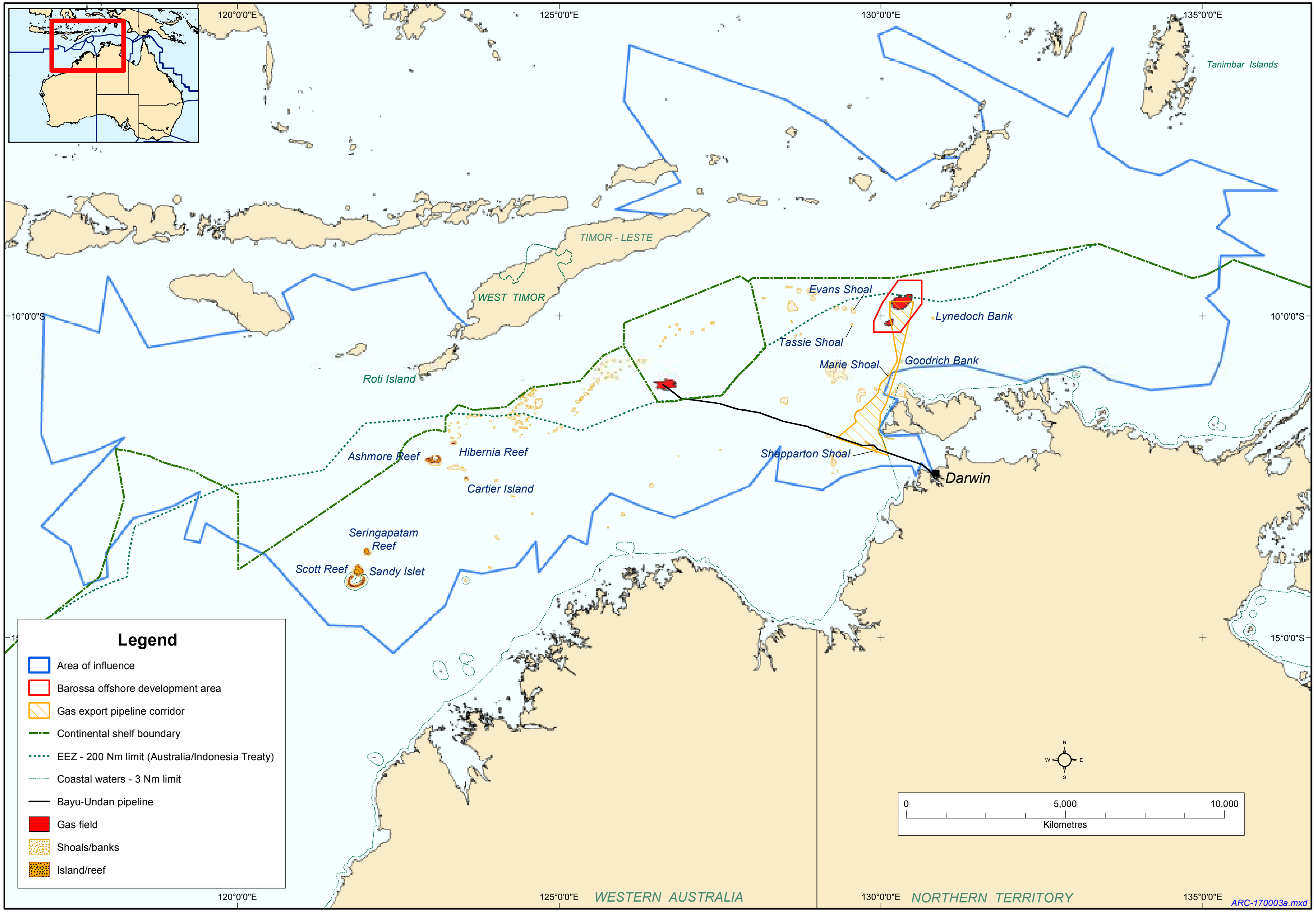


Figure 5-1: Definition of project boundaries in the context of environmental baseline

5.2 Barossa marine studies program

ConocoPhillips has undertaken an extensive and robust environmental baseline studies program, including collaborative studies with the Australian Institute of Marine Science (AIMS), to characterise the existing marine environment within and surrounding the Barossa offshore development area; herein referred to as the Barossa marine studies program. The Barossa marine studies program has involved the collection of detailed baseline data over 12 months (July 2014 to July 2015) in order to capture seasonal variability and to provide focused data to assist in informing the risk assessment of the development options such that they are relevant to the project environmental values and sensitivities (**Figure 5-2**).

In addition to providing specific data and information across the Barossa offshore development area, the studies collected data that have been used to validate the hydrodynamic model developed by RPS Asia-Pacific Applied Science Associates (APASA), which underpins all planned discharge and unplanned spill modelling studies (**Section 6**). Specifically, a hydrodynamic validation study was completed to compare the measured and model-predicted data (winds, waves and currents) to evaluate how accurately the hydrodynamic model could represent actual conditions. The validation study concluded that the model was able to accurately reproduce the conditions across the Barossa offshore development area and surrounding marine environment. This result provides a high level of confidence that the outputs from the planned discharge and unplanned spill modelling (which are based on the hydrodynamic model) are robust and offer an accurate representation of the potential distribution and characteristics of any planned or unplanned discharges relevant to the project.

The Barossa marine studies program undertaken by ConocoPhillips was preceded by early engagement with key agencies and informed by a comprehensive literature review of existing scientific data/studies and gap analysis (JacobsSKM 2014). This process assisted in verifying information that was publicly available and the level of understanding of the marine environment in the Barossa offshore development area and surrounds. This was then used, in conjunction with a review of the relevant project activities, to define the scope and geographical extent of the Barossa marine studies program within the area. The specific location and number of sampling sites was selected to provide a representative assessment of the key characteristics of the Barossa offshore development area, surrounding marine environment, nearest seabed features of significance (Evans Shoal, Tassie Shoal, Lynedoch Bank) and features of interest (i.e. seamounts and scarps). As part of the Australian National Environmental Science Programme, AIMS has subsequently built on regionally collated data with predictive modelling to further characterise the benthic habitats of the Oceanic Shoals CMR and surrounding areas relevant to the gas export pipeline corridor, and this has been incorporated into this assessment.

In addition, the professional views of recognised experts in specific discipline areas were sought via an advisory panel to confirm understanding of values and sensitivities relevant to this OPP. The advisory panel included representatives from the Centre for Whale Research (CWR), Charles Darwin University (CDU), Department of Parks and Wildlife (DPaW) and Monash University.

A summary of the Barossa marine studies program is provided in **Table 5-1** below.

As part of the forward environmental approvals process ConocoPhillips will undertake further targeted surveys of seabed features along the gas export pipeline route as the engineering design progresses, to inform route optimisation. The information from these surveys will further supplement knowledge of the existing marine environment along the proposed route.

Table 5-1: Summary of Barossa marine studies program

Study type	Description of study	Location	Reference (Appendix)
Field-based studies			
Metocean data collection	Collection of metocean data (e.g. current, conductivity, wave and wind data) on the surface and through the water column from July 2014 to March 2015 within and in the vicinity of the Barossa offshore development area (**Figure 5-2**).	Barossa area	Fugro 2015
Water quality survey	Collection of baseline data on physical and chemical components of water quality (**Figure 5-2**). The surveys were completed in June 2014, January 2015 and April 2015.		Jacobs 2016a **(Appendix B)**
Sediment quality and infauna survey	Collection of baseline data on sediment quality and infauna communities.		Jacobs 2016b **(Appendix C)**
Benthic habitat survey	Collection of baseline data to characterise topographic features, benthic habitats and macrofaunal communities, including around Evans Shoal, Tassie Shoal and Lynedoch Bank, through the use of a specialised ROV.		Jacobs 2016c **(Appendix D)**
Underwater noise monitoring survey	Collection of baseline data on ambient underwater noise (physical, biological and anthropogenic sources) at three locations from July 2014 to July 2015.		JASCO Applied Sciences (JASCO) 2016a **(Appendix E)**
Shoals and shelf survey (benthic habitats and fish communities)	A seabed biodiversity survey of three shoals to the west of the Barossa offshore development area (Evans Shoal, Tassie Shoal and Blackwood Shoal1) and two mid-continental shelf regions relevant to the potential gas export pipeline route. The survey was undertaken in September/October 2015 and involved characterisation of the seabed habitats, associated biota and fish communities (shoals only) through the use of multibeam, towed video and stereo baited remote underwater video stations (SBRUVs).	Barossa offshore development area and gas export pipeline, and regional shoals and banks	**Heyward et al. 2017 (Appendix F and Addendum)**
Desktop/modelling studies			
Environmental literature review and gap analysis	Collection and collation of all publicly available information pertaining to the marine environment within the vicinity of the project and gap analysis to determine whether there is sufficient information to inform environmental impact assessment of the project and any future regulatory approvals for a potential development of the Barossa offshore development area.	Regional – Bonaparte Basin	JacobsSKM 2014

Study type	Description of study	Location	Reference (Appendix)
Hydrodynamic model validation study	Data from the metocean study and through the deployment of drifter buoys were used to validate the underlying hydrodynamic model used to develop the spill and discharge models.	Barossa offshore development area	RPS APASA 2015[2]
Drill cuttings dispersion modelling study	To quantify achievable rates of dispersion for drill cuttings and fluids discharges from drilling and to investigate concentrations that could reach key environmental values and sensitivities and under various seasonal conditions.		APASA 2012 **(Appendix G)**
PFW discharge modelling study	To quantify achievable rates of dispersion for PFW discharges from the FPSO facility and to investigate concentrations that could reach key environmental values and sensitivities under various seasonal conditions.		RPS 2017a (**Appendix H**)
Cooling water discharge modelling study	To understand the change in temperature of cooling water and the dilution of residual chlorine predicted to be released as planned operational discharges from the FPSO facility.		RPS 2017b **(Appendix I)**
Wastewater discharge modelling study	To investigate the seasonal risk and potential exposure from planned wastewater discharges during commissioning and operations, from the FPSO facility.		RPS 2017c **(Appendix J)**
Hydrocarbon spill modelling study	To quantify the transformation and fate of spilled hydrocarbons that would result from an accidental, uncontrolled release from the FPSO facility, subsea infrastructure (e.g. wellhead, manifold, flowline) or vessel activities associated with the subsea pipeline.		RPS 2017d **(Appendix K)**
Toxicity assessment of Barossa condensate	Laboratory based experiments were completed to inform the assessment of species sensitivity to potential toxicity impacts from Barossa condensate.		Jacobs 2017 **(Appendix L)**
Underwater noise modelling study – FPSO facility anchor piling	To quantify probable source levels of underwater noise generated by pile driving activities for the FPSO facility moorings during the construction/installation stage of the project.		JASCO 2017 **(Appendix M)**
Underwater noise modelling study – FPSO facility operations	To quantify probable source levels of underwater noise generated by the FPSO facility during operations and offtake activities.		JASCO 2016b **(Appendix N)**

[1] As the shoals and shelf survey was undertaken as a collaborative study by ConocoPhillips and AIMS, Blackwood Shoal was surveyed as AIMS has a broader interest in understanding the benthic characteristics of shoals in the Timor Sea and this survey represented a timely opportunity to gain further scientific knowledge in this area.

[2] The key results of the hydrodynamic model validation study are incorporated into the planned discharge modelling reports (**Appendix H** to **Appendix J**) and hydrocarbon spill modelling report (**Appendix K**).

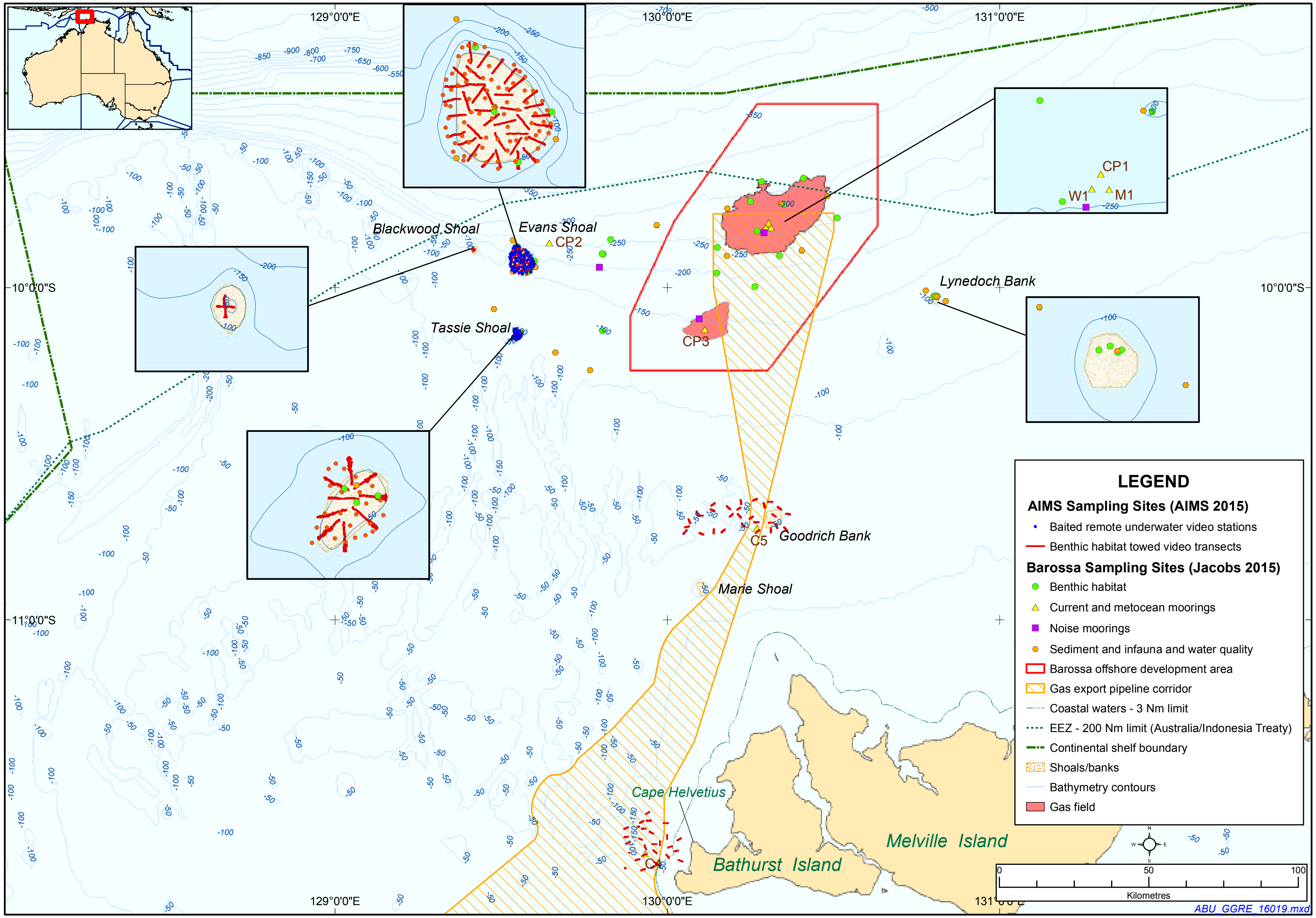


Figure 5-2: Barossa marine studies program sampling sites

5.3 Marine regions and bioregions

The Integrated Marine and Coastal Regionalisation of Australia (IMCRA version 4.0) is a regional ecosystem-based classification of Australia's marine and coastal environment, which has been developed by the Commonwealth Government to assist in regional planning and management of resource development and biodiversity protection (DoEE 2017b). The IMCRA classifies Australia's marine environment into six marine regions, which consist of 41 provincial bioregions.

For the project, the North Marine Region (NMR) is of primary relevance as the Barossa offshore development area and the gas export pipeline corridor are located within this region. However, the area of influence encompasses some of the North-west Marine Region (NWMR). These marine regions are summarised further below.

5.3.1 North Marine Region

The project is located within the NMR, as defined in DoEE's Marine Bioregional Plan for the North Marine Region (former Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) 2012a)). The NMR covers Commonwealth waters from the western side of Cape York in the east, to the WA–NT border in the west (**Figure 5-3**).

The NMR encompasses a number of regionally important marine communities and habitats, which support a high biodiversity of marine life and feeding and breeding aggregations, including the Gulf of Carpentaria coastal zone and the submerged coral reefs of the Gulf of Carpentaria.

The key physical characteristics of the NMR include:

- a wide continental shelf, with water depths averaging less than 70 m
- the Van Diemen Rise, which provides an important connection between the Joseph Bonaparte Gulf and the Timor Trough. This feature includes a range of geomorphological features, such as shelves, shoals, banks, terraces and valleys.
- a series of shallow calcium carbonate-based canyons (approximately 80 m–100 m deep and 20 km wide) in the northern section of the region
- numerous limestone pinnacles within the Bonaparte Basin that can extend up to tens of kilometres in length and width
- the Arafura Shelf, which is up to 350 km wide and has an average water depth of 50 m–80 m. The shelf is characterised by features such as canyons and terraces.
- reefs around the perimeter of the Gulf of Carpentaria
- the Gulf of Carpentaria coastal zone, which is characterised by comparatively high levels of productivity and biodiversity
- currents driven predominantly by strong winds and tides.

5.3.2 North-west Marine Region

The NWMR, is defined in DoEE's Marine Bioregional Plan for the North-west Marine Region (DSEWPaC 2012b). The NWMR covers Commonwealth waters from the WA-NT border in the north, to Kalbarri in the south (**Figure 5-3**).

The NWMR encompasses a number of regionally important marine communities and habitats, which support a high biodiversity of marine life with feeding and breeding aggregations, including at Ashmore Reef, Cartier Island and Seringapatam Reef. Other important ecological features in the NWMR include:

- the continental slope demersal fish communities that support important marine communities which have a high species diversity and endemism
- the carbonate bank and terrace system of the Sahul Shelf which is a unique seafloor feature contributing to the biodiversity and productivity of the local area
- Rowley Shoals
- Ningaloo Reef.

Refer to **Section 5.7.8** for discussion of the key ecological features (KEFs) as relevant to the project area.

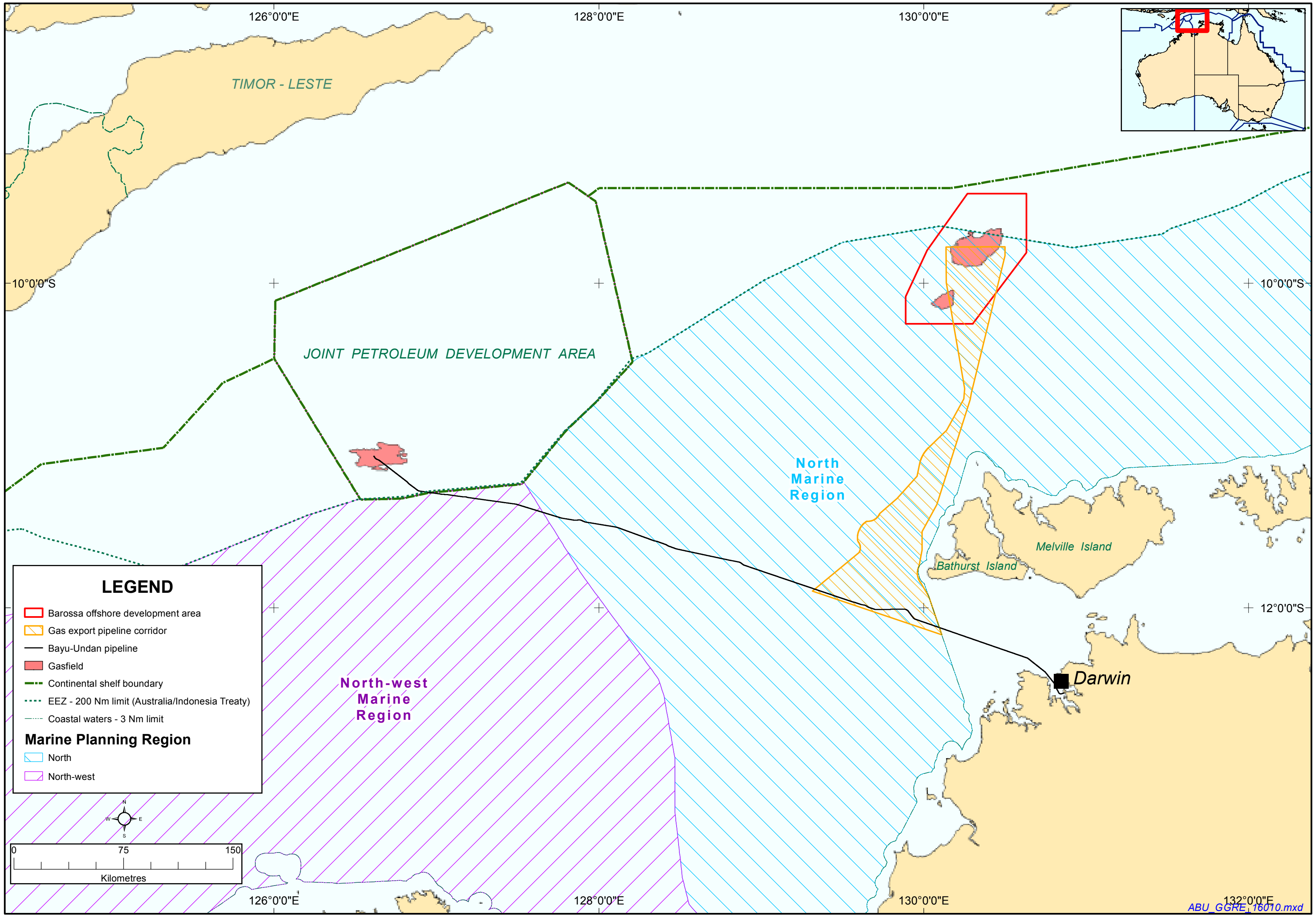


Figure 5-3: Marine regions relevant to the proposal

5.3.3 Timor Transition bioregion

The project is located in the Timor Transition bioregion which is within the broader NMR and covers an area of 24,040 km^2. It predominantly comprises shelf terrace and slope that extends into waters 200m-300m deep in the Arafura Depression. The substrate ranges from sand and soft muddy sediments to hard rocky substrate that contains distinct benthic communities associated with cooler water upwellings (DSEWPaC 2012a). The oceanographic environment is mainly influenced by tides, with some influence from the Indonesian Throughflow (ITF). These open ocean waters support pelagic species, including whale sharks, an unusual array of threadfin fish species and distinct genetic stocks of red snapper (*Lutjanus erythropterus*).

5.3.4 North-west Shelf Transition bioregion

The gas export pipeline corridor traverses both the Timor Transition (**Section 5.3.2**) and the North-west Shelf Transition bioregions. The North-west Shelf Transition covers the mostly shallow waters (< 100 m) between Cape Leveque (WA) and the Tiwi Islands (NT). This transition has a diverse seafloor topography including submerged terraces, carbonate banks, pinnacles, reefs and sand banks.

5.4 Physical environment

This section describes the broader climatic and oceanographic (metocean) conditions, bathymetry and seabed features, water and sediment quality, underwater noise and air quality in relation to the project area. The physical environment has a key influence on the biological environment, as discussed in **Section 5.5**. The information presented is based on the data collected by ConocoPhillips and AIMS for the Barossa marine studies program and supplemented by publicly available data.

5.4.1 Climate

The Bonaparte Basin and Timor Sea region experience a tropical climate and a distinct summer monsoonal "wet" season from October to March followed by a typically cooler winter "dry" season from April to September. During the wet season the south-westerly winds can generate thunderstorm activity, high rainfall and cyclones, while in the dry season the easterly winds result in dry and warm conditions with very little rainfall (Fugro 2015). In addition, the region may also be subject to tropical squalls which are characterised by very high short period wind gusts.

The variation in seasonal air temperatures in the region is small. The mean maximum summer and winter air temperatures recorded at Pirlangimpi Airport on Melville Island (the closest meteorological station to the project) range between 33.6 °C in October/November and 31.2 °C in July (Bureau of Meteorology (BoM) 2017a). The annual maximum temperature is 32.4 °C and the minimum temperature 22.3 °C (BoM 2017a). The average tropical cyclone frequency for the Timor and Arafura Seas region is one cyclone per year with cyclones most commonly occurring between November and April (BoM 2017b).

Meteorological data are based on long-term climate records from the BoM weather station located at Melville Island, which is considered representative of the regional environment of the project area. Refer to **Section 5.4.6** for a summary of the local meteorological conditions recorded during the Barossa marine studies program.

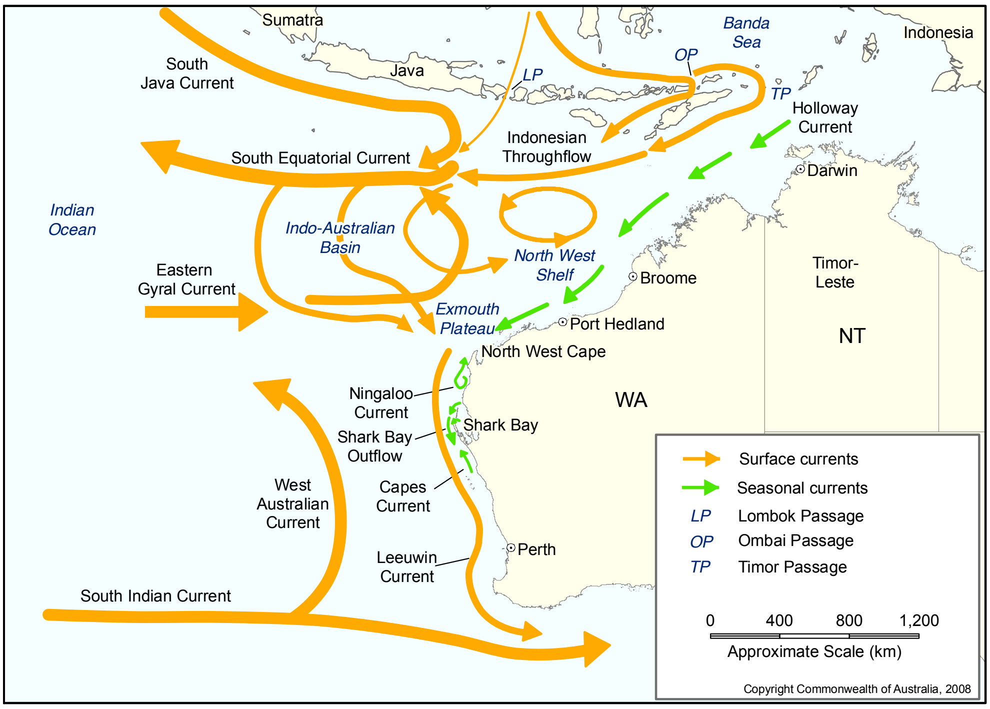
5.4.2 Oceanography

Broad scale oceanography in the northern Australian offshore area is complex, due to the barrier of islands and submerged reefs in the Torres Strait that prevent tidal energy entering the region from the Coral Sea (DSEWPaC 2012a).

The large-scale currents of the Timor and Arafura seas are dominated by the ITF current system (**Figure 5-4**). This current is generally strongest during the south-east monsoon from May to September (Qiu et al. 1999). The ITF brings warm, low salinity, oligotrophic waters through a complex system of currents, linking the Pacific and Indian Ocean via the Indonesian Archipelago (Department of State Development (DSD) 2010). The strength of the ITF fluctuates seasonally, reaching maximum strength during the south-east monsoon, and weakening during the north-west monsoon.

The Holloway Current, a relatively narrow boundary current that flows along the north-west shelf of Australia between 100 m and 200 m depth, also influences the seas in the area (Fugro 2015). The direction of the current changes seasonally with the monsoon, flowing towards the north-east in summer and the south-west in winter (Fugro 2015).

Local tidal and wind influences also play an important role in affecting the broad scale oceanography along the north-west shelf of Australia. For example, the large tides along the north Australian coast can generate large internal waves (amplitudes of up to 100 m) across the region that can then produce unusually high currents (Fugro 2015). Tidal flows are also responsible for driving the long-term transport patterns through the region.



(source: DEWHA 2008c)

Figure 5-4: Key regional currents influencing north-west Australian waters

5.4.2.1 Currents and tides

Water movement in the NMR is influenced primarily by wind and tidal activity and less by ocean currents. Smaller scale surface currents reflect seasonal wind activity, flowing easterly to north-easterly during the wet season and west to south-westerly during the dry season (Heyward et al. 1997). Local wind-driven surface currents can reach speeds of 0.6 metres per second (m/s) during monsoonal wind surges, however, more typical speeds are in the range of 0.2 to 0.3 m/s (Heyward et al. 1997). Average current speeds in the Barossa offshore development area ranged from 0.22 m/s at the near-surface to 0.14 m/s at 210 m below mean sea level (MSL) (Fugro 2015). In situ measurements have shown that current directions can vary with water depth and at specific sites within the Barossa offshore development area demonstrating the complexity of water movement in the area.

Tide activity across the region is complex, resulting in a combination of both diurnal and semi-diurnal tides. However, tidal activity is typically dominated by semi-diurnal tides, with two daily high tides and two daily low tides. The highest astronomical tide recorded at Tassie Shoal (32 km west of the Barossa offshore development area) is 1.4 m above MSL and the lowest astronomical tide is 1.8 m below MSL (Consulting Environmental Engineers (CEE) 2002). The mean tidal range is 2.2 m at spring tides and 0.3 m at neaps (CEE 2002). Measurements of ocean currents at Tassie Shoal show water movement is strongly tidal, with typical speeds in the range of 0.1 to 0.4 m/s and peak speeds up to 0.8 m/s (CEE 2002).

Baseline metocean studies – overview and methods

Over a 12-month period (July 2014 – July 2015), three mooring sites were deployed within the Bonaparte Basin to record temperature and salinity throughout the water column (**Figure 5-2**), two within the Barossa offshore development area (CP1 and CP3) and one near Evans Shoal (CP2). An additional two mooring sites were deployed between March and July 2015; one approximately 100 km south of the Barossa offshore development area (C4) and another approximately 10 km west of Bathurst Island (C5) to record oceanographic conditions in the vicinity of the potential gas export pipeline. The locations of the mooring sites were carefully selected and are considered adequate to inform a detailed understanding of the baseline metocean conditions experienced in the Barossa offshore development area and surrounds, and the hydrodynamic model which underpinned the discharge modelling studies.

The mooring sites consisted of a combination of conductivity, temperature and depth (CTD) sensors (mid to upper water column) (14 at CP1 and CP2) and Aanderaa Seaguards (SG) (one at CP1, CP2, C4 and C5, and two at CP3; lower water column) that measured currents (speed and direction), conductivity, temperature and pressure. From these measurements salinity and depth data were derived. In addition, one Seabird SBE 53 temperature and depth sensor was located at the base of the mooring south-west of the Barossa offshore development area (CP3).

During the same period, these moorings also captured current speed and direction. One TRDI Workhorse Acoustic Doppler Current Profiler was installed on all three moorings, one TRDI Quarter Master Acoustic Doppler Current Profiler was installed on CP1 and CP2 to measure these parameters in the mid to upper water column, and one SG (as mentioned above) to measure data in the lower water column. The Seabird on the mooring located to the south of the Barossa offshore development area (CP3) was used to determine water level.

Another two moorings (in addition to CP1 to C5), W1 and M1, were deployed approximately 1.7 km south-west and south-east respectively of mooring CP1 in the Barossa offshore development area (**Figure 5-2**). Mooring W1 consisted of a Datawell Waverider Buoy configured to measure wave parameters throughout the monitoring period. Mooring M1 consisted of a Met Buoy configured to measure meteorological parameters including wind, air temperature, air pressure and humidity.

The key observations from the baseline metocean studies are incorporated into the following sections.

5.4.2.2 Waves

Waves in the region are composed of locally generated sea waves in response to local wind activity and swell waves created by distant wind activity. Wave height is generally between 0.6 m and 0.8 m, coming from the west in the wet season and from the east in the dry season. Waves at Tassie Shoal typically approach from west to southwest throughout the year (CEE 2002). Cyclones and tropical storms can greatly increase wave heights by up to 8 m in the outer Timor Sea during the cyclone season (Przeslawski et al. 2011).

The wave climate offshore of the north-west shelf of Australia is normally dominated by the passage of storms over the southern Indian Ocean (Fugro 2015). However, between October and March, the wave climate is controlled by the south-westerly monsoon winds. This combination of wind directions may lead to concurrent swells approaching from different directions. The sea wave climate also reflects the seasonal wind regime, with waves predominantly from the south-west in summer and from the east in winter.

Soliton (i.e. solitary wave) activity (both solitons of elevation and depression) was observed during the field surveys in both the Barossa offshore development area (CP1) and in the vicinity of Evans Shoal (CP2). Soliton activity occurs as a result of large internal waves propagating along an oceanic density interface, such as the thermocline. In general, the soliton events recorded were characterised by a sharp increase in current speed, a rapid change in current direction and fluctuation in seawater temperature (Fugro 2015). While many of the solitons were individual events, most were part of a soliton packet, i.e. two or more events travelling at similar speeds and depth. Most activity occurred between April and July and, while recorded from all current directions, the main direction associated with soliton events was towards the south-east and east (Fugro 2015). The effects of the events were observed to influence current from around 70 m down to approximately 200 m below mean sea level (MSL).

5.4.2.3 Temperature

Surface water temperatures in the Barossa offshore development area generally ranged between 27 °C and 30 °C while temperatures above the seabed ranged between 11 °C and 13 °C (Jacobs 2016a). Sea temperatures in the upper water column of the Barossa offshore development area (represented by instrument recordings at approximately 34 m below MSL at CP1) were recorded as reaching a maximum of 30.9 °C in summer and a minimum of 24.7 °C in spring (Fugro 2015). The minimum sea temperature of 10.6 °C was recorded near the seabed at 253 m below MSL in spring. Mean temperatures ranged from 28.1 °C at 34 m below MSL (summer) to 12.6 °C at 253 m below MSL (summer).

Other studies have shown that mean monthly temperatures in the central Timor Sea are typically between 26 °C and 30 °C, decreasing to approximately 12 °C at 300 m, with waters expected to be stratified all year round, but with the thermocline nearer the surface (50 m depth) in summer, compared to winter (100 m depth) (Woodside 1999).

Waters are characterised by thermal stratification that varies in strength according to the season (IMCRA Technical Group 2006). Thermoclines were encountered at all sites, indicating the potential presence of separate subsurface current streams. During marine water quality studies, the thermocline (considered to lie in the zone in which the greatest temperature decrease occurs) was closest to the surface during the wet season (between 40 m and 70 m) and deeper in the water column during the dry and transitional seasons (between 70 m and 150 m and between 100 m and 150 m respectively) (Jacobs 2016a). This is understood to be due to strong, continual winds during the dry and transitional seasons causing the depth of the mixed layer to be greater (Jacobs 2016a). Extreme weather events, such as cyclones, also promote mixing of water layers.

5.4.3 Bathymetry and seabed features

5.4.3.1 Barossa offshore development area

The water depths in the Barossa offshore development area are between approximately 130 m and 350 m, with the southern portion being shallower. The seabed within the area is generally flat as the field is located on a plain feature that is devoid of any significant bathymetric features (Jacobs 2016c; **Appendix C**). The only relic seabed features observed were slight undulating sand waves (< 25 cm in height) and widespread bioturbation (i.e. burrows, mounds and tracks) (Jacobs 2016c). The marine sediments are predominantly silty sand and generally lack hard substrate. An example of the typical seabed terrain observed across the Barossa offshore development area is provided in **Figure 5-5**.

A geophysical survey undertaken in 2015 across the Barossa offshore development area also reported that the seabed was smooth and featureless with the sediments interpreted to comprise predominantly fine clayey sand (Fugro 2016).

In general, the benthic habitats observed in the Barossa offshore development area were typical of those expected in offshore environments and were consistent with studies conducted both in areas with similar features and in areas of a similar geographic location (Jacobs 2016c).

Figure 5-5: Typical seabed terrain in the Barossa offshore development area

5.4.3.2 Gas export pipeline

While the gas export pipeline route within the corridor presented in this OPP is still subject to refinement, a preliminary geophysical survey was completed by Fugro in November 2015 to characterise the seabed along a notional pipeline route within the corridor. The survey methods included multibeam echo sounding, side scan sonar and sub-bottom profiling to provide information on seabed topography. The survey observed that the seabed varied from relatively smooth and gently sloping to irregular areas including seabed channels and ridges with steep gradients (Fugro 2016). Water depth ranged from approximately 240 m in the Barossa offshore development area to approximately 50 m towards the southern end of the pipeline (Fugro 2016).

The seabed in the northern offshore section of the gas export pipeline was characterised by relatively smooth to moderate slopes comprising fine to medium sands/silt and clay, with pockmarks and the occasional outcrop of cemented sediments (Fugro 2016). These seabed features broadly align with those recorded during seabed surveys along the Ichthys pipeline route, which traverses the offshore waters of the NWMR and NMR. The Ichthys pipeline surveys recorded featureless, unconsolidated clay-silt sands along the majority of the route and noted that the most commonly observed features were pockmarks and sand waves, with rock outcrops rare (INPEX 2010).

The southern end of the pipeline, to the west of the Tiwi Islands, was characterised by a combination of highly irregular relief and smooth sandy/silty seabed with the occasional outcrops of cemented sediments (Fugro 2016). The areas of irregular relief consisted of predominantly cemented sediments, rock and reef outcrops with patchy areas of soft, loose sediments (Fugro 2016). The areas of mobile sediments were characterised by fine, soft sand which formed megaripples and sandwaves while coarse sediments, comprising sand, gravel and shells, were associated with the rock/reef outcrops (Fugro 2016). Coarser sediments were also located in closer proximity to the offshore shoals/banks (e.g. Goodrich Bank and Marie Shoal), as consistent with that observed from the Barossa marine studies program. An area to the west and north of the Tiwi Islands is a key consideration in terms of technical constraints associated with installation of the pipeline in shallow seabed topography, and will inform the practicability of the final gas export pipeline route.

Future detailed surveys along the gas export pipeline will provide more detailed spatial information about environmental features, such as benthic habitat communities, and engineering constraints (e.g. irregular relief and steep seabed gradient), all of which will inform optimisation of the pipeline route.

5.4.4 Water quality

This section describes the water quality as recorded across the Barossa offshore development area and surrounding features of regional interest (i.e. shoals and banks) during three seasonal field surveys between June 2014 and March 2015 (Jacobs 2016a; **Appendix B**). Water samples, water column profiles, phytoplankton and zooplankton samples were collected on three separate occasions (once each during the wet, dry and transitional seasons) from 17 sites in order to represent the seasonal variability for the region. Water quality sampling sites for the field surveys were located in the Barossa offshore development area (six sites), and in the vicinity of Evans Shoal (four sites), Tassie Shoal (four sites) and Lynedoch Bank (three sites) (**Figure 5-2**). Water samples were collected from three depths at each of the sites; near-surface (2 m–5 m), mid-water (half the bottom depth) and one near the bottom (within 5 m of the seabed).

Where appropriate, water quality data have been compared to the Australian and New Zealand Environment and Conservation Council and Agricultural and Resource Management Council of Australia and New Zealand (ANZECC & ARMCANZ) (2000) guidelines. However, it is important to note that the guidelines are for shallow water areas and not deeper offshore habitats which are exposed to high pressure, low temperature and low oxygenation relative to shallow waters. The chemistry and ecotoxicity of minerals and nutrients are significantly different under these conditions and hence ecological interpretation must account for that. There are currently no water quality or sediment quality guidelines for offshore environments in Australia. The ANZECC & ARMCANZ guidelines are currently the subject of a review, however, the revised guidelines are yet to be published.

Temperature, pH, salinity and dissolved oxygen remained relatively consistent throughout the seasons. Surface water temperatures ranged from approximately 27°C (winter) to approximately 30°C (summer and autumn) with the temperature gradually decreasing with depth to approximately 11°C–13°C above the seabed (Jacobs 2016a). The pH in the surface waters ranged from 8.1 to 8.3 pH units while the pH at the seabed ranged from 7.7 to 7.9 pH units (Jacobs 2016a). The decrease in pH is due to oxidation of organic matter (Jacobs 2016a). When dead organisms fall from the surface layers and start decaying they liberate CO_2, which dissolves into the water producing carbonic acid that undergoes almost instantaneous ionisation into hydrogen ions and thus decreases pH (Hinga 2002).

There was little difference in salinity between the surface water and the bottom water at all sites during all seasons. Salinity at the surface waters was approximately 34 ppt, which was approximately 0.7 ppt lower than the bottom water of the deepest sites (Jacobs 2016a). As these water quality sampling sites were remote from any large land masses, the only potential factors affecting surface water salinity were climatic ones (i.e. precipitation or evaporation).

Dissolved oxygen was high in the surface water (90–100% saturation at all sites for each season) decreasing to approximately 35% saturation in the bottom water of the deepest sites (Jacobs 2016a). The dissolved oxygen of the shallowest sites stayed constant from surface to bottom waters. Dissolved oxygen was highest near the surface waters, where light for photosynthesis is strongest and oxygen exchange between the atmosphere and the ocean is at a maximum (Jacobs 2016a). Waves, wind and currents act to mix dissolved oxygen through the upper section of the water column. These processes become progressively weaker as depth increases. Below the upper mixed layer, the oxygen content decreased with an increase in depth due to oxidation of organic matter resulting in the consumption of oxygen.

The main seasonal variation observed was the depth of the thermocline (see **Section 5.4.2.3**), which was relatively small in comparison to oceans further away from the equatorial line, which experience greater seasonal variation. The shift in the thermocline is directly linked to the change in profiles of both the dissolved oxygen, salinity and warming of the mid water layers during summer. Surface water temperatures, trade winds and the Coriolis effect have a distinct correlation to the movement of such mid-water temperature changes; the data collected over the seasonal changes successfully demonstrates the natural processes in place and their effect on deep water mixing for the latitude of the specific area.

Turbidity was very low throughout the water column and displayed minimal seasonal variability (< 0.2 nephelometric turbidity units (NTU)) (Jacobs 2016a). Approximately 20 m–50 m above the seabed, the turbidity was slightly elevated and increased with depth, possibly caused by the action of currents passing over the seabed causing some turbulence and re-suspension of sediments (Jacobs 2016a).

Chlorophyll a concentrations were low throughout the water column at all sites and during each season, less than the ANZECC & ARMCANZ (2000) trigger value of 0.9 µg/L. Chlorophyll a concentrations peaked at shallower depths during winter (30 m–50 m) and deeper depths during summer and autumn (50 m–70 m) (Jacobs 2016a). During summer, the zone of maximum productivity lies some distance below the surface, most likely due to optimising the requirement for light and nutrients (Jacobs 2016a).

Nutrient concentrations increase with depth and light penetration is greater in summer, therefore, the depth of maximum productivity would be greater in summer than winter.

Whilst the majority of metal concentrations were below the ANZECC & ARMCANZ (2000) guidelines, copper concentrations were occasionally (four sites sampled in winter and five sampled in summer) slightly above the ANZECC & ARMCANZ guideline for 99% species protection of 0.3 µg/L. There were also slight increases in arsenic, barium chromium and nickel in the bottom waters of the deepest sites within the Barossa offshore development area and Evans Shoal, however, all were below ANZECC & ARMCANZ guidelines. The distribution of some metals in seawater have been reported to be significantly influenced by the uptake of phytoplankton in the surface waters, subsequent decomposition of the organic matter produced and remineralisation in deep waters (Abe 2004).

Total recoverable hydrocarbons and benzene, toluene, xylenes and naphthalene (BTEXN) were below the laboratory reporting limits at all sites and depths for each season (Jacobs 2016a). There was little difference in the hydrocarbon profiles between sites, indicating a lack of hydrocarbons in the areas sampled (Jacobs 2016a).

The naturally occurring radioactive materials (NORMs) radium^{226} and radium^{228} were above the minimum reporting limit at a number of sites during the three surveys, while thorium^{228} was not detected at any site (Jacobs 2016a). There are no ANZECC & ARMCANZ (2000) trigger values associated with NORMs, however, there are guideline values for drinking water National Health and Medical Research Council (NHMRC) & ARMCANZ (2011). According to these guidelines, concentrations of radium^{226} and radium^{228} should not be above 4.89 becquerel per litre (Bq/L) and 1.98 Bq/L respectively. All concentrations at all sites sampled during the three surveys were low (< 0.49 Bq/L) and below the threshold concentrations cited above.

Overall, there was very little change in the majority of water quality parameters recorded between the surveys, indicating that minimal seasonal variation is experienced in the Barossa offshore development area. The water quality throughout the water column was consistent with expected trends given the location and natural processes like wind, waves and current movements that are found in deeper water offshore marine environments.

Assessment of existing hydrocarbon seeps

Airborne laser fluorosensor studies (Martin and Cawley 1991; Cowley 2001) and satellite-based synthetic aperture radar (SAR) studies (Logan et al. 2006) have been carried out in the Arafura Sea, including coverage of the Barossa offshore development area, to detect possible hydrocarbon seepage. The data from these studies shows no evidence of hydrocarbon seepage when compared with areas of confirmed hydrocarbon seepage globally. An integrated study conducted at a site of surface slicks interpreted from the SAR data, involving side-scan sonar and echo-sounder techniques, found no evidence of active hydrocarbon flares related to seepage (Rollet et al. 2009). Additional analysis of the sediments in the area did find elevated levels of CH_4 and CO_2, however, these were confirmed to originate from the decay of organic matter rather than from hydrocarbon seepage (Grosjean et al. 2007; Logan et al. 2006).

A review of Australian offshore hydrocarbon seepage studies (Logan et al. 2010) concluded that the majority of Australia's offshore basins are unlikely to be characterised by active hydrocarbon seepage given the relatively (on a global scale) low level of sediment deposition that is considered insufficient to drive active seepage (Logan et al. 2010). The only sites of proven natural hydrocarbon seepages in offshore Australian waters occurred on the Yampi Shelf (located approximately 450 km south-west of the Barossa offshore development area). Occurrences of waxy bitumens have been recorded in waters off the NT, however, these tend to be highly weathered, and while they provide direct evidence of natural hydrocarbon seepage, they have been confirmed as originating from Indonesian waters (Logan et al. 2010).

5.4.5 Sediment quality

The characteristics of the marine sediments in the Barossa offshore development area and surrounding features of regional interest (i.e. shoals and banks) were determined from 14 sites; six sites in the Barossa offshore development area, three sites at Evans Shoal, three sites at Tassie Shoal and two sites at Lynedoch Bank (**Figure 5-2**; **Appendix C**). These sites were in the same location, or in close proximity to, the water quality sampling sites. Sediment samples were not collected at three of the water quality sampling sites (SP7, SP11 and SP16) due to the occurrence of benthic primary producer habitat (BPPH) (see **Section 5.5.2**). The sites surveyed ranged in depth from around 70 m on the top of shoals/banks to approximately 280 m in the Barossa offshore development area.

The sediment types observed during the survey were comparable with those found in local and broader regional seabed habitat mapping studies undertaken in the Eastern Joseph Bonaparte Gulf and Timor Sea (URS 2005, 2008; Fugro 2006a, b; Anderson et al. 2011; Przeslawski et al. 2011).

Sediments sampled showed a gradual transition in composition over large spatial scales, particularly between the Barossa offshore development area and the shallow shoals (Jacobs 2016b). This trend is related to depth (and, therefore, current speeds) and prevailing current or weather direction. In general, sediments transitioned from the finer deep sediments in the Barossa offshore development area to the coarse shallow water sediments (gravelly sands) around the shoals/banks (Jacobs 2016b). Within the Barossa offshore development area there was a slight east–west transition in sediment type, with finer sediments (sandy muds) in the east to coarser muddy sands in the west (Jacobs 2016b). This is likely due to the prevailing current direction, which flows along a south-eastward to north-westward axis near the seabed (Fugro 2015).

Whilst the majority of metal concentrations were below the ANZECC & ARMCANZ (2000) guidelines, cobalt (11 sites) and nickel (two sites) were recorded at concentrations above the trigger values (Jacobs 2016b). Nickel is commonly recorded at high levels in Australian sediments (Commonwealth of Australia 2009). Total recoverable hydrocarbons and BTEXN were below the laboratory reporting limits at all sites (Jacobs 2016b).

NORMs were not detected at any site, with the exception of radium^{226} at two sites (Jacobs 2016b). While radium^{226} was recorded above the minimum reporting limit at these sites the levels were well below the ANZECC & ARMCANZ (2000) trigger value.

Nitrogen, phosphorus and organic carbon are released when organic compounds decay. The highest concentrations of nitrogen and organic carbon were associated with deepest and the finest sediment in the Barossa offshore development area (Jacobs 2016b). Deep-water sediment habitats are predominantly depositional, as indicated by their relatively high particle size distribution fines component and nutrient content. The benthic communities of these habitats are consumers rather than primary producers and, therefore, utilise the increased nutrient component of sediments (Jacobs 2016b).

5.4.6 Air quality and meteorology

The project is offshore and remote from residential and permanent urban populations or sensitivities. Therefore, local air quality is not expected to be significantly influenced by anthropogenic sources. Only localised and temporary reductions in air quality associated with offshore shipping and oil and gas exploration and development activities are expected in the vicinity of the project.

Summary statistics of local meteorological conditions recorded by the Met Buoy (Mooring M1) located within the Barossa offshore development area are provided in **Table 5-2** (Fugro 2015).

Table 5-2: Summary of local meteorological conditions

Parameter	Maximum	Minimum	Average
Wind speed (metres per second (m/s))	17.8	0.0	6.4
Wind gust (m/s)	21.0	0.2	7.3
Air temperature (°C)	34.0	22.8	27.7
Atmospheric pressure (millibars)	1,017.9	1,002.2	1,010.8
Relative humidity (%)	96.2	45.0	75.5

5.4.7 Underwater noise

JASCO conducted a long-term baseline acoustic environment study program in the Barossa offshore development area over the period July 2014 to July 2015 (JASCO 2016a; **Appendix E**).

Data were acquired with three Autonomous Multichannel Acoustic Recorders (AMARs) deployed close to the seabed for extended periods at three stations. The acquired acoustic data were analysed to quantify the ambient sound levels, the presence of anthropogenic (human-generated) activity, and the acoustic presence of marine mammals and fish. The locations of the AMAR logger sites (J1, J2 and J3), relative to the metocean moorings (CP1, CP2 and CP3), are shown in **Figure 5-2**.

Key conclusions from the results of the baseline noise study are:

- the soundscape is dominated by naturally occurring sources (i.e. wind and waves), with some contributions from biological sources (primarily fish and Omura's whales)
- the average ambient sound levels for this region were recorded as ranging between approximately 97 re 1 micropascal (µPa) and 119 decibels (dB) re 1 µPa (recommended sound pressure level (SPL)), with low anthropogenic sound presence noted
- there were minor daily variations in ambient sound levels (due to fish chorusing events), with weather events being the main influence
- there was generally a low level of anthropogenic activity, with the exception of the period where the Barossa appraisal drilling rig and associated support vessels were in the area (departed April 2015). While these sources were a dominant feature of the soundscape at close range, they were considered less influential than the natural and biological sources typical of the region. Therefore, the impact can be considered localised.
- vessel movements were a minor contributor to the soundscape with the mean daily vessel detections ranging from 0.1–2.8 vessels.

In terms of biological presence, it was determined that:

- Omura's whale (dwarf fin whale) were frequently present in the area between April and September inclusive, with a peak in June and July
- Pygmy blue whales were detected in August 2014 and between late May and early July 2015, during their northward migration. No detections were made from the southward migration, suggesting a different migration path may be used.
- Bryde's whales were present in the region from January to early October
- Humpback whales were absent from the area. This data aligns with currently recognised migration patterns for this species (**Section 5.6.2**).
- Unknown beaked whale species were detected on four days over the monitoring period
- A number of odontocete species (toothed whales) were detected, with many species detected on a daily basis. Identification of specific species is difficult and requires detailed manual analysis. However, analysis of the data collected has indicated the presence of short-finned pilot whales. Other odontocete species that may be present in the area including false killer whales, pygmy killer whales, melon-headed whales, Risso's dolphins, Fraser's dolphins, spotted dolphins, rough-toothed dolphins, and spinner dolphins as they have previously been observed in the broad area.

- Fish chorusing at dawn and dusk was present throughout the year at all stations. The intensity of the chorusing activity varied with season but the timing was relatively consistent. Fish chorusing is not currently able to be analysed through automated detections and there is a general lack of knowledge around vocalisations of the most common fish species present in the Timor Sea. However, it is considered possible that a large number of the chorusing calls are from members of the Lutjanidae (snapper) family.

The results of this baseline noise study are considered in the context of the known migration and aggregation patterns of marine fauna in the regional area (refer **Section 5.6**), and have also helped inform the assessment of potential noise effects taking into account ambient conditions (**Section 6.4.5**).

5.5 Biological environment

5.5.1 Overview and Matters of National Environmental Significance

This section describes the existing biological values and sensitivities in relation to the project and surrounding marine environment. Three separate searches of the online EPBC Act Protected Matters database were undertaken: the Barossa offshore development area, gas export pipeline corridor and area of influence.

The EPBC database searches of the Barossa offshore development area and gas export pipeline corridor are considered appropriate to represent those listed marine species that may occur, or have habitat, in the immediate project area (**Figure 4-2** and **Figure 4-3**). A search based on the area of influence was undertaken to identify those species potentially affected in the unlikely event of a large-scale spill.

The results of the Protected Matters search are summarised in **Table 5-3** and included in **Appendix O**. The summary in **Table 5-3** represents a consolidation of the search outcomes for all three of the above search areas.

Table 5-3: Summary of MNES identified as relevant to the project

MNES	Number	Status
World Heritage properties	None	Not applicable
National Heritage places	None	Not applicable
Wetlands of International Importance	Project area: None Area of influence: Ashmore Reef National Nature Reserve	While significantly distant from the Barossa offshore development area (750 km south-west), the Ashmore Reef National Nature Reserve is within the area of influence
Listed Threatened Ecological Communities	None	Not applicable
Listed threatened species (**Section 5.6**)	Project area: **19** (Mammals – 4, Reptiles – 6, Fish – 1, Sharks – 6, Birds – 2) Area of influence: **29** (Mammals – 4, Reptiles – 8, Fish – 1, Sharks – 6, Birds – 8)	Project area: Critically endangered – 3, Endangered – 5, Vulnerable – 11 Area of influence: Critically endangered – 7, Endangered – 7, Vulnerable – 15

MNES	Number	Status
Listed Migratory species (**Section 5.6**)	Project area: **38** (Migratory marine species – 29, Migratory marine birds – 5, Migratory wetland species – 4) Area of influence: **71** (Migratory marine species – 29, Migratory marine birds – 15, Migratory wetland species – 21, Migratory terrestrial species – 6)	Project area: Critically endangered – 2, Endangered – 4, Vulnerable – 11 Area of influence: Critically endangered – 3, Endangered – 6, Vulnerable – 12
Commonwealth marine areas (**Section 5.7.5** and **Section 5.7.6**)	Exclusive Economic Zone and Territorial Sea Extended Continental Shelf Project area: CMRs – Oceanic Shoals Area of influence: CMRs – Oceanic Shoals, Arafura, Arnhem, Kimberley, Ashmore Reef and Cartier Island	CMRs: Oceanic Shoals, Arafura, Arnhem, Kimberley, Ashmore Reef and Cartier Island
Great Barrier Reef Marine Park	None	Not applicable
Nuclear actions (including uranium mines)	None	Not applicable
Protection of water resources from coal seam gas development or large coal mining development	Not applicable	Not applicable

5.5.2 Benthic habitats and communities

Benthic habitats predominantly refer to communities consisting of marine plants, such as seagrass and macroalgae, or invertebrates such as reef-building corals.

Previous surveys in the Timor Sea indicate that between 50 m and 200 m depth, the benthos consists of predominantly soft, easily re-suspended sediments (Heyward et al. 1997; URS 2005, 2007). The diversity and coverage of epibenthos is low and organisms present are predominantly sponges, gorgonians and soft corals (Heyward et al. 1997; URS 2005, 2007).

The characteristics of the benthic habitats in the Barossa offshore development area and surrounding shoals and banks were determined from 25 ROV sampling sites: 14 sites in the Barossa offshore development area and surrounds (includes seamounts 9 km–18 km to the west and scarps within the Barossa offshore development area), four sites at Evans Shoal, three sites at Tassie Shoal and four sites at Lynedoch Bank (**Figure 5-2**). The sites surveyed ranged in depth from approximately 300 m in the Barossa offshore development area, where light attenuation, temperature and water energy was low, to approximately 10 m–30 m on the top of shoals/banks. The depths surveyed at > 100 m are considered to be beyond the photic zone and, therefore, the benthic environments in these areas are unable to support photosynthetic organisms, such as photosynthetic algae and light-dependent coral communities. Infauna (i.e. burrowing fauna which live in the marine sediments) were sampled at 14 sites in conjunction with the sampling of the marine sediments (**Section 5.4.5**).

The nearest seabed features of regional interest to the Barossa offshore development area (Evans Shoal, Tassie Shoal and Lynedoch Bank) and the gas export pipeline corridor (Goodrich Bank, Marie Shoal and Shepparton Shoal) are discussed in **Section 5.5.3**.

5.5.2.1 Barossa offshore development area

The Barossa offshore development area is situated on a plain comprising homogenous flat, soft sediments (Przeslawski et al. 2011). Studies in the field have observed the seabed to comprise mostly of silty sand lacking in any hard substrate, with relic seabed features (such as sand waves) widespread (Jacobs 2016c). Benthic macrofauna groups observed in the video footage included octocorals (particularly sea pens) and motile decapod crustaceans (mostly prawns and squat lobsters), which were recorded in relatively low numbers. Other biota observed included anemones, starfish, brittle star and soft corals.

The frequent bioturbations (burrows, mounds and tracks) observed suggest a number of burrow-living decapods (such as prawns) may be present (Jacobs 2016c). These species are more active at dawn, dusk or at night in habitats lacking cover and hence, less likely to be recorded during daylight surveys (Jacobs 2016c).

Infaunal communities in the Barossa offshore development area were characterised by burrowing taxa and demersal fish, namely foraminifera (an amoeboid protist), nematodes, *Bregmaceros sp*. (codlets), tube-forming Onuphid polychaetes and the superb nut shell *Ennucula superba*. The communities were characterised by low abundance (five to 15 individuals) and species diversity (five to nine taxa). The most commonly represented phyla within the infaunal communities were Annelida (total of eight individuals across the sampling sites), Mollusca and Foraminifera (total of seven individuals) and Crustacea (total of six individuals). Due to the lack of hard substrate, the associated epibenthos was expected to be sparse.

The deep-water benthic characteristics of the Barossa offshore development area are broadly consistent with the results of similar surveys in offshore areas. Surveys for the Sunrise Gas Project, approximately 210 km west, found that epifauna were sparse and were predominantly comprised of hydroids, sponges and crinoids (SKM 2001). Benthic habitat in the GDF Suez (now Engie) Bonaparte Basin retention lease areas (approximately 310 km south-west of the Barossa offshore development area) was recorded as soft sediments with epifauna and sessile benthos generally being sparse and characterised by a limited number of common and widespread taxa (GDF Suez 2011). Infaunal communities were also observed to be typical of soft sediment habitat and dominated by polychaete worms (GDF Suez 2011).

As discussed in **Section 3.6**, a subset of the Perth Treaty area is present within the northern section of the Barossa offshore development area. Drawing on the results of the Barossa marine baseline program, seabed characteristics and benthic habitats of the Perth Treaty area are expected to be consistent with that described above for the Barossa offshore development area. One site within the Perth Treaty area and one site within close proximity were surveyed during the Barossa marine studies program. The sampling sites were located at 303 m and 309 m water depths with predominantly silty sand substrate, slightly undulating seabed (<25 cm in height) and widespread bioturbation (Jacobs 2016c). Observed biota across the two sites included anemones, brittle stars, sea pens, decapod crustaceans and three species of fish.

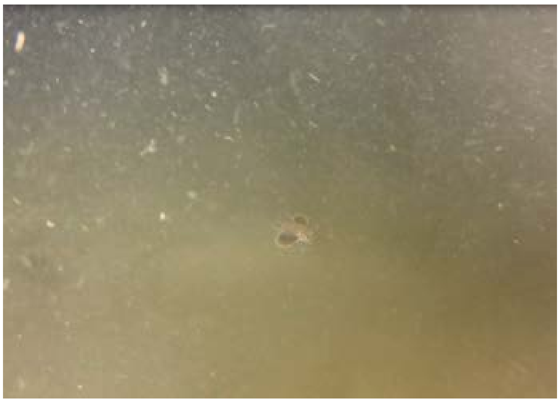
Representative images of the benthic habitats and macrofauna across the Barossa offshore development area are shown in **Figure 5-6** and the following sub-section (**Section 5.5.2.2**) provides spatial maps of the habitat types across the full Oceanic Shoals CMR and the project area, inclusive of the Barossa offshore development area and the gas export pipeline corridor, derived by AIMS spatial habitat modelling.

a) Silty sandy substrate with a burrowing anemone and widespread bioturbation (southern area)

b) Silty sandy substrate with a teleost fish and widespread bioturbation (southern area)

c) Silty sandy substrate with a sea pen (middle area)

d) Silty sandy substrate with gravelly silty sand substrate, a squat lobster and soft coral (middle area)



e) Silty sandy substrate with a teleost (gurnard) (northern area)

f) Silty sandy substrate with a prawn (northern area)

Figure 5-6: Representative images of benthic habitats and macrofauna across the Barossa offshore development area

5.5.2.2 Gas export pipeline corridor

A spatial predictive benthic habitat model of the Oceanic Shoals CMR has been developed by AIMS as part of the Australian National Environmental Science Programme to determine the spatial heterogeneity of the benthic environment and key classes of organisms within the reserve. To ensure the model was robust, ecologically meaningful and sufficiently accurate, it was verified through the use of field data and statistical relationships (between the predictors and field data presence/absence of benthic classes) using a non-parametric statistical method of classification trees (Radford and Puotinen 2016). The model was also subject to testing of random data points to assess accuracy. Using this method, 10 benthic habitat classes across the entire Oceanic Shoals CMR were modelled (Radford and Puotinen 2016). The benthic habitat model is shown in **Figure 5-7**, with an interactive version available at http://northwestatlas.org/node/1710. The benthic habitats within the area of the Oceanic Shoals CMR that is intersected by the gas export pipeline corridor comprise predominantly of burrowers/crinoids, filter feeders and abiotic areas that support no benthic habitat with some small areas of hard corals.

A targeted study was undertaken by Przeslawski et al. (2014) on sponge biodiversity and ecology of the Van Diemen Rise and eastern Joseph Bonaparte Gulf and involved sampling of five geomorphic features characteristic of these areas (e.g. bank, terrace, ridge, plain and valley). This study is of broad relevance as the gas export pipeline corridor traverses the Van Diemen Rise. The information from this study was also used to inform the spatial predictive benthic habitat model of the Oceanic Shoals CMR, as discussed above. The study noted that sponge diversity (species richness and biomass) was generally higher further offshore and on raised geomorphic features, particularly banks, when compared to surrounding valley and plain features (Przeslawski et al. 2014). The average sponge species richness recorded on the banks surveyed was 15 species, with terraces and ridges supporting an average of approximately 14 species and approximately nine species respectively (Przeslawski et al. 2014). The valley and plain seabed features had an average species richness of approximately five and one species respectively (Przeslawski et al. 2014). While previous studies have observed a correlation between sponge diversity/community structure and environmental factors such as substrate, depth or slope (or a combination of these), the findings of the targeted study did not observe such a relationship. Przeslawski et al. (2014) suggested that other environmental or biological factors (e.g. ocean currents, light availability and recruitment ability) may be more influential in the area surveyed. It was also stated that spatial and temporal variability may be a contributing factor.

The benthic habitat model of the Oceanic Shoals CMR was extended by AIMS to encompass the entire gas export pipeline corridor and the Barossa offshore development area. The model of these additional areas was developed using the same methods described above and was possible as benthic habitat data were available within the region outside of the CMR. The model was informed by comprehensive habitat assessments at 18 field sites spanning 800 km of the oceanic shoals of the Sahul Shelf and included additional benthic habitat data held by AIMS and data collected as part of the Barossa marine studies program (Heyward et al. 2017). The accuracy of the model was assessed and showed a good level of accuracy. The majority of the benthic habitats were accurately classified (approximately 80%), with the exception of the 'None' benthic category. The 'None' category had a lower accuracy (approximately 50%) as the model under predicted filter feeder and Halimeda communities, which by their nature can be discrete, stochastic and challenging to model (Heyward et al. 2017).

The seabed habitats and associated biota of two bathymetrically complex areas on the mid-continental shelf that may be within, or in close proximity to, the potential pipeline corridor were characterised in a detailed field survey undertaken by AIMS. The areas of interest are located adjacent to the western side of Goodrich Bank, which is characterised by a series of limestone plateaus (adjacent to the gas export pipeline corridor) separated by channels, and to the west of Cape Helvetius on the south-west corner of Bathurst Island (approximately 10 km from the gas export pipeline corridor). While the gas export pipeline route is still subject to detailed engineering, and further refinement, the alignment will look to avoid these features wherever technically possible.

The shelf areas were characterised by plateaus (i.e. terraces and banks) and channels of varying depths and slope aspects with strong tidally driven currents contributing to turbid water conditions over the ridges and valleys (Heyward et al. 2017). The turbid waters associated with the shelf areas significantly reduced light attenuation and, therefore, limited the amount reaching the seabed. The initial review of the water column light profiles indicated progressive drops in water clarity from the outer shelf shoals shorewards, with surface light attenuating to < 5% at approximately 45 m deep on the shoals, 30 m near Goodrich Bank and 10 m near Cape Helvetius (Heyward et al. 2017). As a result of the reduced light attenuation, the shelf areas typically had large areas of bare seabed with the benthic communities present dominated by sparse patchy sessile filter feeders that were associated with limited areas of consolidated substrate (sandy pavement or minor rocky outcrops). Phototrophic species such as hard corals were rare and only encountered on the shallowest survey transects (depths less than 30 m) near Goodrich Bank (Heyward et al. 2017). Macroscopic biota was generally sparse, however, low to medium density filter feeder habitats were encountered in both the Goodrich Bank and Cape Helvetius areas **(Figure 5-9**). Sponges tended to be the dominant fauna, as consistent with other studies in turbid shelf areas in this region, with various small to medium sized soft corals contributing to a small portion of the mixed filter feeder communities.

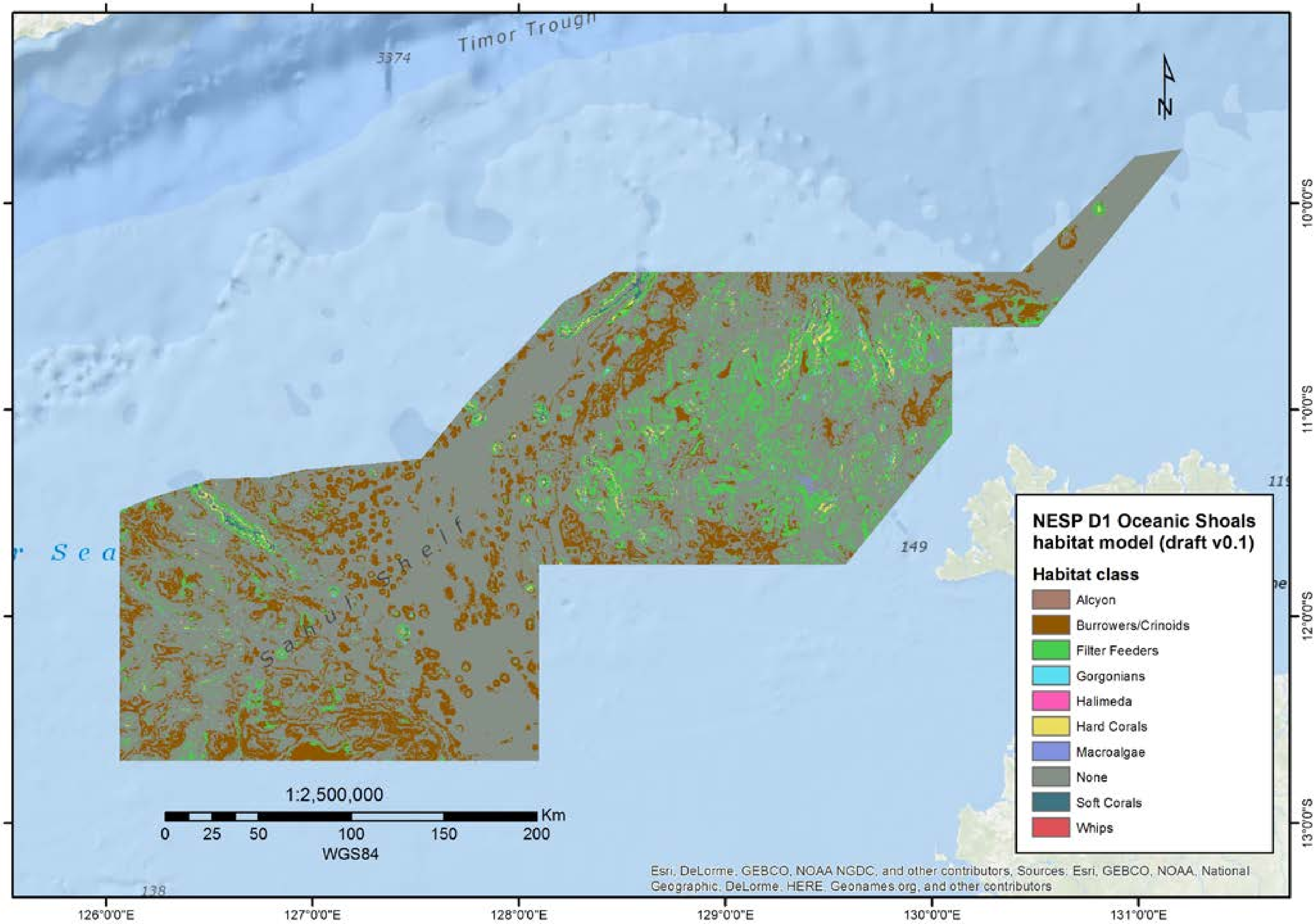


Figure 5-7: Benthic habitat of the Oceanic Shoals CMR as modelled by AIMS (http://northwestatlas.org/ node/1710)

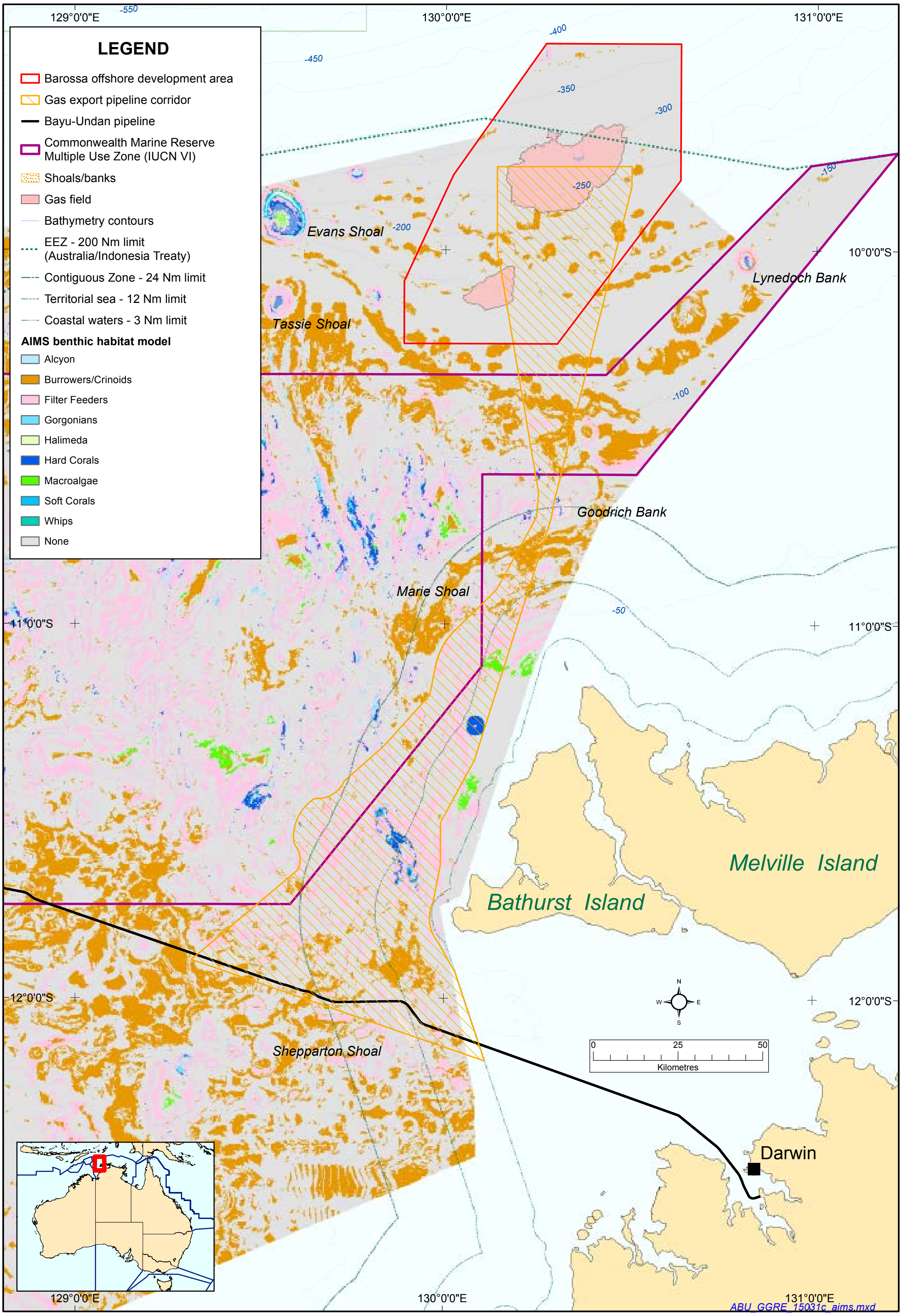
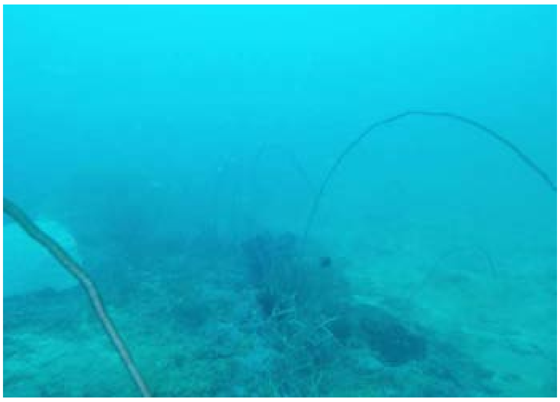


Figure 5-8: Benthic habitat of the Oceanic Shoals CMR and surrounds (extended model) as modelled by AIMS

a) Coarse sandy substrate with sparse filter feeders

b) Hard coral habitat at 25 m depth



c) Medium density mixed filter feeder community associated with patches of low relief outcropping rock

Figure 5-9: Benthic habitats associated with the mid-shelf area near Goodrich Bank

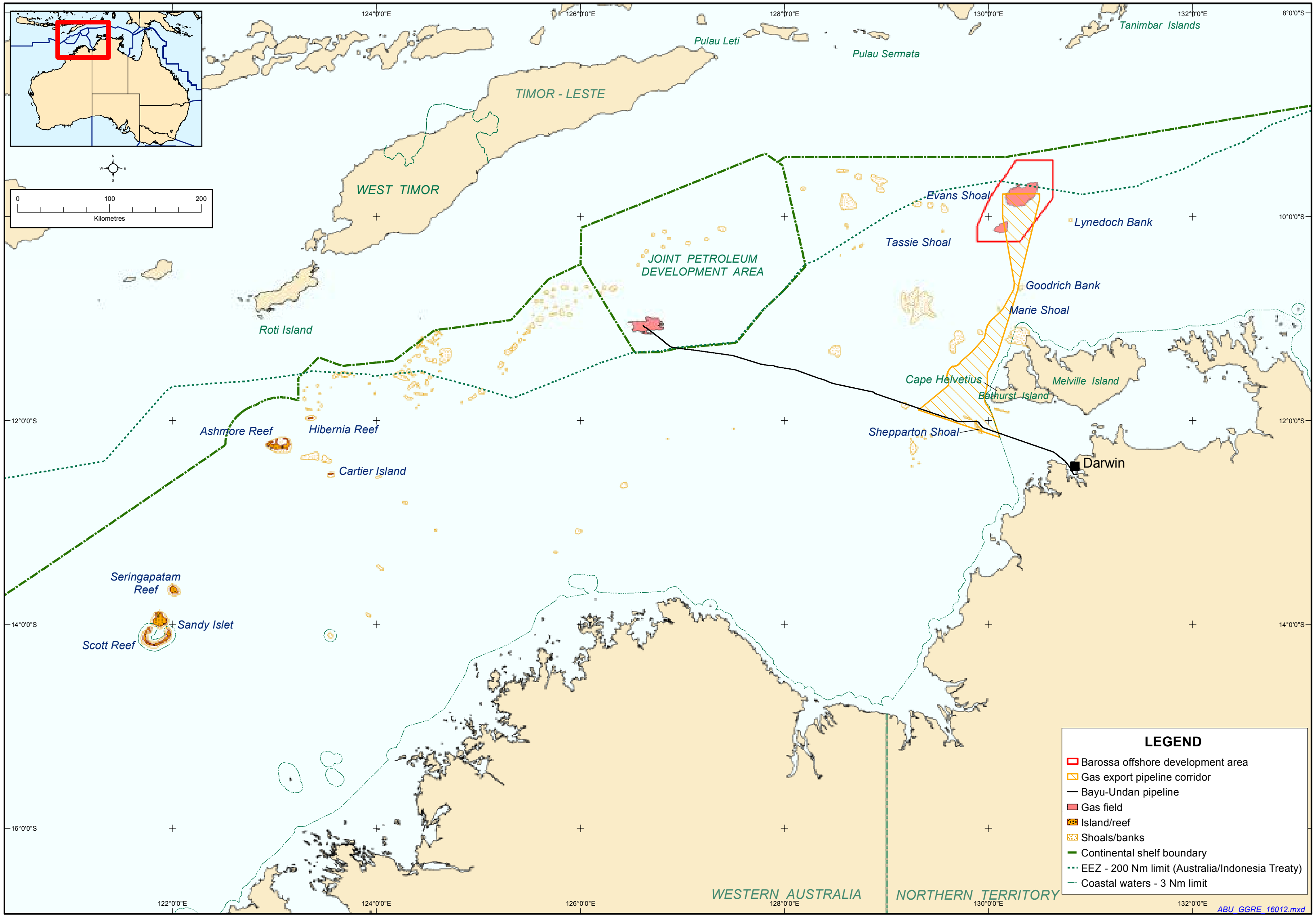


Figure 5-10: Regionally important shoals, banks, reefs and islands in the Timor Sea

5.5.3 Regionally important shoals and banks

Key regionally important environmental features are shown in **Figure 5-10**. The shoals and banks that are of relevance to the project area are described in **Section 5.5.3.2** (Barossa offshore development area) and **Section 5.5.3.3** (gas export pipeline corridor). An overview of those that occur within the area of influence are summarised in **Section 5.5.3.1**, with those that were assessed for exposure from hydrocarbons as a result of unplanned events presented in **Appendix K**.

5.5.3.1 Regional overview

There are a number of shoals and banks in the Timor Sea and open offshore waters. Historically, few studies have been undertaken of these features with the majority of the understanding derived from the Big Bank Shoals study (Heyward et al. 1997) and PTTEP surveys initiated in response to the Montara incident (Heyward et al. 2010; Heyward et al. 2011). The regional shoal survey effort undertaken by AIMS for the Barossa marine studies program (Heyward et al. 2017; **Appendix F**) has contributed significantly to the understanding of these shoals/banks. As shown in **Figure 5-10** (and discussed in Heyward et al. 2017 (**Appendix F**) and **Appendix K**) there are various shoals/banks present within the area of influence defined for this project.

The shoals/banks in the area of influence share a tropical marine biota consistent with that found on emergent reef systems of the Indo West Pacific region such as Ashmore Reef, Cartier Island, Seringapatam Reef and Scott Reef (Heyward et al. 2017). There is a high level of interconnectivity between the shoals and banks within the area based on larval development rates of many of the species inhabiting the various shoals and banks, current speeds (commonly 20 km–30 km/day in mild weather) and the distance between shoals, banks and reefs (Heyward et al. 2017). The distribution of over 150 shoal/bank features across the Sahul Shelf (**Figure 5-10**), with individual shoals/banks often separated by 5 km –20 km, suggests an extensive series of "stepping stone" habitats are available to recruit larvae and connect these ecosystems at ecological time scales (Heyward et al. 2017). This region also sits within the strong ITF, providing a source of larvae from tropical benthic habitats within the region.

An analysis, undertaken by AIMS, of benthic communities surveyed in the Barossa marine studies program showed that neighbouring shoals and banks (i.e. within 100s of km's) frequently share approximately >80% of benthic community composition (Heyward et al. 2017). The most influential determinants of the benthic community composition observed to date include depth and light intensity, substrate type and complexity, hydrodynamic environment and position on the continental shelf (Heyward et al. 2017). In addition, cycles of natural disturbance and subsequent founder effects may also explain some of the variability between shoals (Heyward et al. 2017). Therefore, each of the shoals/banks are likely to have the potential to support the same types of benthic habitats, dependent on extent of these underlying variables with variability driven by variation in the dominance of key habitats and species (Heyward et al. 2017). Some shoals/banks may be notable for the abundance of particular biota (in terms of species abundance and relative contribution key taxa make to the benthic community), but that status can be dynamic with a large number of common species being shared in common across the region (Heyward et al. 2017). While temporal datasets for the region's shoals and banks are limited, observed changes from year to year are consistent with responses to natural disturbances such as thermal stress events, storms and cyclones (**Appendix F**).

Therefore, at the regional scale, the shoals and banks all support comparable levels of biodiversity, but may vary in the abundance and diversity of dominant benthic species, with subsets of species featuring more prominently on some than others (Heyward et al. 2017). Similarly, the associated fish fauna is highly diverse but variable between shoals and banks, being influenced by depth, substrate and exposure to prevailing weather, though with all shoals/banks sharing many species (Heyward et al. 2017).

The submerged features within the area are characterised by abrupt bathymetry, rising steeply from the surrounding outer continental shelf at depths of 100 m–200 m. The shoals and banks tend to flatten at depths of 40 m–50 m, with horizontal plateau areas of several square kilometres generally present at 20 m–30 m depths (Heyward et al. 2010). The shoals/banks support a diverse and varied range of benthic communities, including algae, reef-building soft corals, hard corals and filter-feeders (Heyward et al. 1997; Heyward et al. 2011). Heyward et al. (2017) reported that bare sand and consolidated reef, often supporting turfing algae, are major features of all shoals in the Timor Sea. It was also noted that hard corals and macroalgae, while ubiquitous, were variable in abundance with soft corals and sponges often forming key components of the benthos (Heyward et al. 2017). The plateau areas are generally dominated by BPPH, with interspersed areas of sand and rubble patches (Heyward et al. 2011).

The submerged shoals/banks support biologically diverse fish communities, with many of the species also known from other emergent reefs in the NWMR, including Ashmore Reef, Cartier Island, Seringapatam Reef and Scott Reef (Heyward et al. 2011). Fish species richness commonly increases with reef structure (i.e. coverage of calcareous reef) with fish diversity generally higher on the tops of the shoals/banks when compared to the rim habitats. The number of fish communities appears to correspond with the size of the shoal/bank as the larger shoals were inhabited by more communities (Heyward et al. 2011).

5.5.3.2 Shoals and banks in the vicinity of the Barossa offshore development area

Summary overview

While other shoals (e.g. Blackwood Shoal), banks and seabed features of interest were surveyed as part of the Barossa marine studies program, the shoals and banks of most relevance to this OPP due to their closest proximity to the Barossa offshore development area (i.e. Evans Shoal, Tassie Shoal and Lynedoch Bank) are described below. In summary, analysis of the results from the Barossa marine studies program showed a high degree of similarity between the sites at these shoals/banks, based on the consistent diversity observed in habitat features and biota present. One exception to this was the eastern slope of Evans Shoal, which showed a higher degree of similarity to a scarp feature (**Section 5.5.3.3**) (Jacobs 2016c). This may be due to depth or greater exposure to predominant currents and weather.

In general, the reef flat at Evans Shoal was characterised by sand and algae-covered rubble with communities dominated by hard corals, soft corals, various algae and sponges which were present in varying degrees of diversity and abundance (Jacobs 2016c, Heyward et al. 2017). The plateaus of Evans Shoal and Tassie Shoal also had extensive areas of sand and rubble (Heyward et al. 2017). Gorgonians and sea whips often dominated the reef crest, whereas the hard substrate of the slope predominantly supported sponges and filter feeders (such as gorgonians, feather stars, sea whips). Filter feeders became more prevalent on rocky outcrops beyond approximately 60 m (Heyward et al. 2017). Of particular note were the northern and southern slopes of Evans Shoal as they supported large areas of dense plate coral (at 40 m–50 m water depth) and dense sub-massive coral (northern slope at approximately 47 m water depth) (Jacobs 2016c).

Heyward et al. (2017) also recorded areas of medium to high density foliaceous coral at Evans Shoal and Tassie Shoal and noted that this habitat was very similar to that observed further west in the Sahul Shoals and within the deeper lagoon at Scott Reef. Overall coral cover of approximately 9% was observed at both Evans and Tassie Shoals (Heyward et al. 2017). An interesting feature on both Evans and Tassie Shoals was the presence of single large bommies of the coral *Pavona clavus*.

The AIMS survey reported that the benthic habitats at Evans Shoal and Tassie Shoal appeared to be in healthy condition, although there was a notable lack of giant clams (only two were observed from the transects) (Heyward et al. 2017). While the detectability of clams using towed video is unknown, their general absence may be a result of illegal fishing practices in the area. With the exception of the lack of clams, there was little or no mortality observed amongst coral species with the presence of large table corals suggesting no recent major disturbances from storms (Heyward et al. 2017).

Heyward et al. (2017) noted that the seabed habitats present at the shoals were broadly consistent with those observed from studies across the region. It was also noted that while there are many similarities between the shoals in the region, there are differences, which may be the result of the broader physical environment. For example, the status of the benthic communities on each shoal may reflect different disturbance events (e.g. cyclone/storm damage and coral bleaching) and recruitment histories due to variations in biological connectivity (Heyward et al. 2017). While the levels of ecological connectivity among the shoals remain to be demonstrated, strong surface currents tracked using satellite drifters throughout this bioregion indicate transport rates of 20 km/day under light to moderate wind conditions and much higher during storms or seasonal trade wind periods (Heyward et al. 2017). Consequently, connectivity between shoal features is expected (Heyward et al. 2017).

The slopes supported a diverse range of fish species typical of reef-fish assemblages as well as pelagic species. Species richness in the fish community was influenced most by the calcareous reef composition of the substrata, and the percentage cover of hard coral on this substratum type (Heyward et al. 2017). Therefore, species richness decreased with depth as seabeds exhibited bare substrata. Detailed characterisation of the fish communities at Evans Shoal and Tassie Shoal were undertaken by AIMS with a summary of the findings presented in **Section 5.6.5.3**. White tip reef and silvertip sharks were also observed at the shoals/banks (Jacobs 2016c).

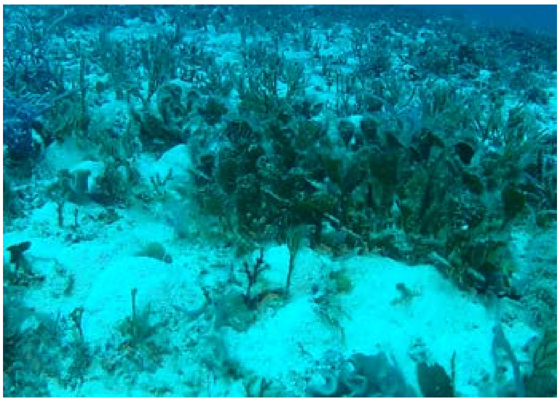
The AIMS survey of Evans and Tassie Shoal also observed four species of shark (silvertip shark, reef shark, white tip reef shark and tawny nurse shark), none of which are listed under the EPBC Act, and three species of sea snake (olive sea snake, turtle-headed sea snake and an unidentified species) (Heywood et al. 2016).

Evans Shoal

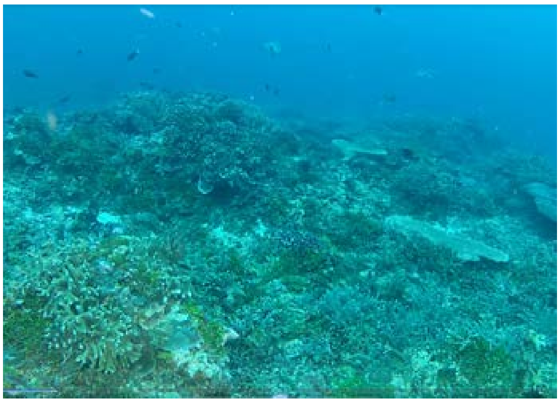
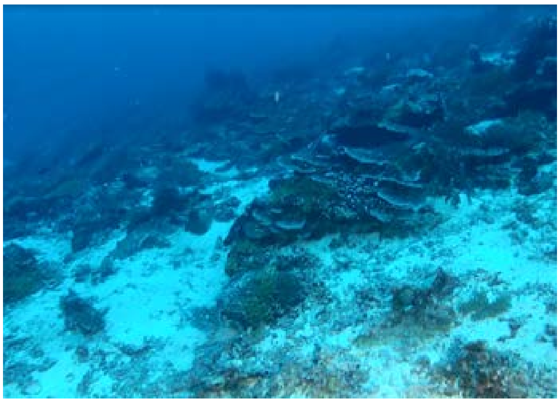
Evans Shoal, located approximately 35 km to the west of the Barossa offshore development area, is a flat topped shoal that reaches a plateau at approximately 18 m–28 m below the sea surface.

The infauna communities were reasonably diverse and abundant (3 to 63 individuals representing 3 to 42 taxa in the coarser sediments) with species present being dominated by molluscs (e.g. laevidentaliidae), crustaceans (e.g. tanaids, amphipods, isopods, callianassids) and annelid worms (e.g. syllids, *Nematonereis* species, lumbrinerids) (Jacobs 2016b). The coarser sediments at Evans Shoal supported higher species diversity and abundance. The relationship between coarse sediments, high infaunal abundances and species richness has been previously identified in the north-west shelf with Huang et al. (2013) noting that greater species richness and total abundance were associated with coarse-grained, heterogeneous sediments (cited in Jacobs 2016b).

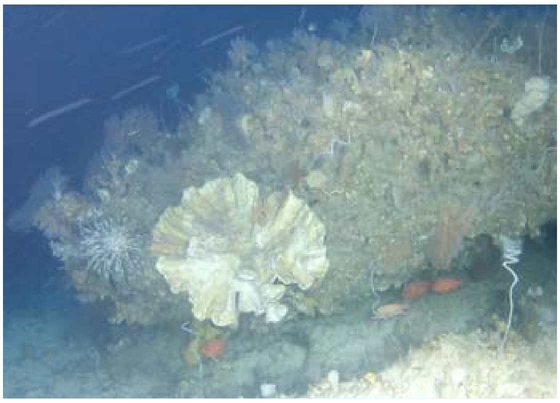
The key benthic habitats and dominant fish species associated with the shoal are discussed below (Jacobs 2016c).

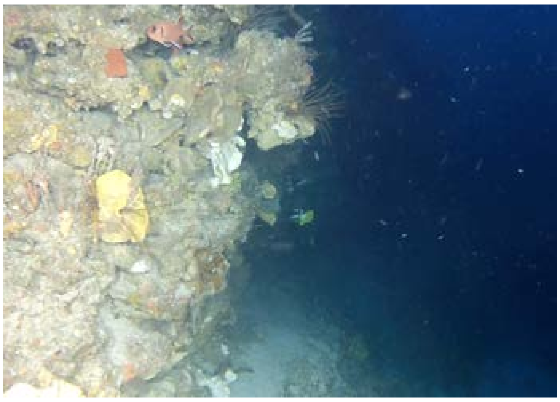
a) *Reef flat (centre of the shoal)*: The transect was located at a water depth of approximately 28 m. The substrate was predominantly sand with patchy mixed beds of filter feeders (e.g. sponges and soft corals) and macroalgae. Hard corals were observed at a small bommie (Jacobs 2016c). Heyward et al. (2017) noted that hard corals were generally sparse or absent across large areas of the plateau, however, their density increased towards the outer edges of the plateau. Several taxa of fish including species from families Labridae, (wrasse), Pomacanthidae (damselfish and clownfish), Acanthuridae (surgeonfishes, tangs and unicornfishes), Zanclidae (Moorish idols), Balistidae (triggerfishes) and Monacanthidae (leatherjacket).

b) *Southern slope*: Transects on this slope commenced on the reef flat in 18 m water depth. While the substrate of the reef flat was dominated by sand and rubble, some areas supported high-density coral cover (mostly plate and branching forms but also soft corals) and Halimeda species (calcareous algae). A diverse assemblage of reef-fish occurred in these areas and whitetip reef sharks were also observed. The reef crest of the shoal (approximately 32 m deep) was dominated by plate coral, whereas the upper slope was dominated by sand. As water depth increased the substrate changed from being dominated by plate corals (approximately 42 m depth) to macroalgae with scattered sponges and sea cucumbers (approximately 55 m depth).

c) *Eastern slope*: Transects on this slope began at approximately 83 m water depth. The reef flat was characterised by sandy substrate with occasional small macroalgae. Silvertip sharks were observed in this habitat. The crest of the shoal (approximately 88 m deep) supported a rocky overhang with various types of filter feeders. The slope was dominated by steep rock faces and rocky overhangs with small sandy ledges which supported filter feeders (such as gorgonians, feather stars, sea whips, sponges) and reef-fish.

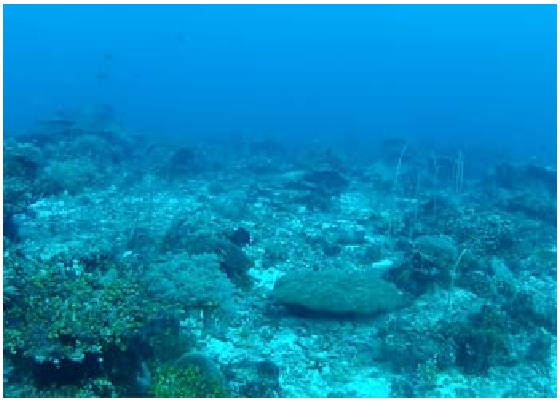
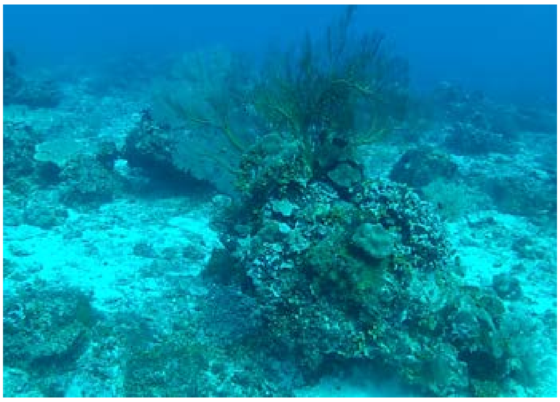
d) *Northern slope*: Transects on the northern slope began at approximately 45 m water depth. The reef flat on this slope alternated between areas dominated by plate coral, sub-massive coral and macroalgae (including *Halimeda* species) with sponges. Whitetip reef sharks and one tawny nurse shark were observed on the reef flat as were representatives from the fish families Labridae, Pomacentridae and Pomacanthidae. Small discrete piles of rubble were also observed and were likely to be triggerfish nests. The crest of the shoal (approximately 80 m deep) was colonised by sponges, filter feeders and algae. The reef slope was characterised by rocky substrate with small sand-covered ledges and supported communities dominated by sponges and filter feeders (such as gorgonians, feather stars, sea whips, sponges). One moray eel (Muraenidae) and various species of fish (families Chaetodontidae (butterflyfish), Carangidae (queenfishes, runners, scads and trevallies), Caesionidae (fusiliers), Serranidae (groupers and reef cod) and Holocentridae (squirrelfish)) were observed in the rocky overhangs of the reef slope.

Tassie Shoal

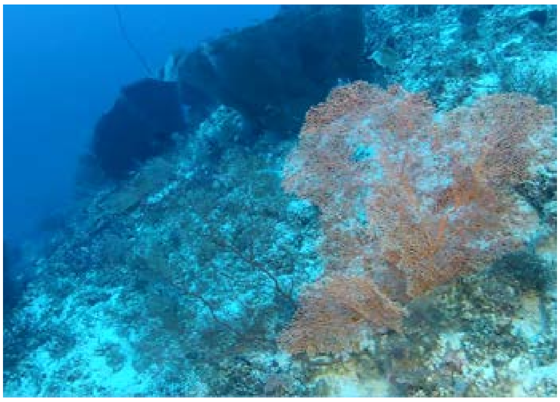
Tassie Shoal, located approximately 32 km to the west of the Barossa offshore development area, is a flat topped shoal that reaches a plateau at approximately 14 m–15 m below the sea surface.

The infauna communities were reasonably diverse and abundant (12 to 33 individuals representing 12 to 24 taxa), with species present being dominated by syllid polychaetes, tanaid crustaceans, foraminifera, brittlestars and fibularid echinoderms (urchins) (Jacobs 2016b).

The key benthic habitats and dominant fish species associated with the shoal are discussed below (Jacobs 2016c).

a) *Reef flat*: The reef flat was sampled at two sites at a water depth of approximately 15 m. The substrate consisted of sand, rubble and patchy reef structure. The reef structure was dominated by massive, sub-massive, plate and branching coral forms, and the hard substrate supported a range of sea whips, soft corals, *Halimeda* species, turf algae and sponges. Feather stars, large clams and a decapod crustacean were also recorded. A diverse range of tropical fish species were sighted including representatives from the families Labridae, Pomacentridae, Zanclidae, Pomacanthidae and Acanthuridae. Two whitetip reef sharks were also observed.



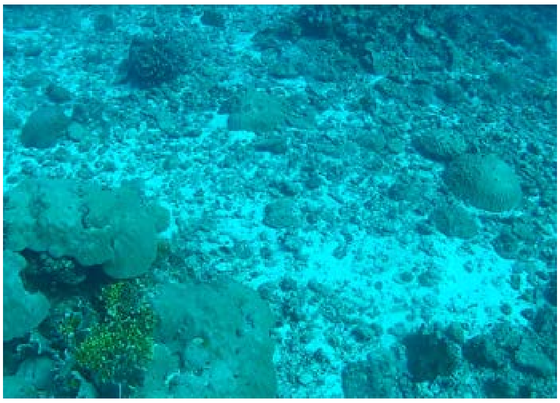

b) *Eastern slope*: The transect began in approximately 28 m water depth. The reef crest was dominated by hard coral, soft coral and sponges, but also supported *Halimeda* species. Schools of fish (Acanthurids and Carangids), sea snakes were observed on both the reef flat and upper slope. The top of the reef slope (30 m–50 m) was dominated by sponges and soft corals, such as gorgonians and sea whips. The substrate became dominated by sand and rock at approximately
50 m and began to flatten out and become dominated by sand around 70 m. A sea snake and a whitetip reef shark were observed at the bottom of the reef slope (approximately 48 m).

Lynedoch Bank

Lynedoch Bank, located approximately 27 km to the east of the Barossa offshore development area, is a flat topped bank which reaches a plateau at approximately 14 m–16 m below the sea surface.

The infauna communities were reasonably diverse and abundant (56 individuals representing 39 taxa) with species present being dominated by nematodes, tanaid crustaceans, and polychaetes (tube-dwelling onuphids and chaetopterids, and lumbrinerids), brittlestars (ophiuroids) and mud shrimp (callianassids) (Jacobs 2016b).

The key benthic habitats and fish communities of the shoal are discussed below (Jacobs 2016c).




a) *Reef flat (centre of the shoal)*: The reef flat was sampled at two sites at a water depth of approximately 16 m. The reef flat was dominated by sand and rubble with hard corals (mostly branching, massive and sub-massive), sponges, soft coral and *Halimeda* species present. Small reef-fish were common (including representatives of the families Chaetodontidae, Labridae and Zanclidae) with whitetip reef sharks, a sea snake and a moray eel also observed.


b) *Eastern slope*: The transect began on the reef flat in approximately 26 m water depth, which was observed to be similar to that described above. The reef sloped gently to a depth of approximately 85 m and was characterised by a sand and rubble substrate. There was a noticeable low abundance of fish, sharks and other motile biota.

c) *Western slope*: The transect began on the reef flat in a water depth of approximately 20 m. The reef flat was characterised by sand and rubble with hard corals (mostly branching, encrusting and massive forms), sponges and *Halimeda* species present. Small triggerfish (Balistidae) were common with sharks (most likely silvertip and whitetip reef sharks) and a sea snake also observed. The reef crest (approximately 40 m water depth) and the slope were dominated by sand and rubble, with occasional sponges, sea stars, sea cucumbers, and reef-fish (Pomacanthidae). The slope flattened out at approximately 70 m deep and became dominated by sand.

5.5.3.3 Shoals and banks within the vicinity of the gas export pipeline corridor

Goodrich Bank, Marie Shoal and Shepparton Shoal

Goodrich Bank, Marie Shoal and Shepparton Shoal are located directly adjacent to or within the gas export pipeline corridor.

As discussed in **Section 5.5.2.2**, AIMS undertook a seabed biodiversity survey in 2015 at two mid-shelf seabed locations adjacent to Goodrich Bank and Cape Helvetius (Heyward et al. 2017). The survey findings can be used to provide some insight into the potential types of benthic habitats that may occur at the shoals/banks closest to the gas export pipeline. The benthic habitat surrounding Goodrich Bank supported sparse to moderate density filter feeders (dominated by small sponges) on areas of bare rock or sand covered pavement, with larger organisms observed on outcropping low relief reef or rocks. Hard corals were rare in the waters surrounding Goodrich Bank and were only encountered at depths less than 30 m. The extended benthic habitat map produced by AIMS suggests that benthic communities at Goodrich Bank are dominated by filter feeders, with areas of hard corals, gorgonians, burrowers/crinoids and alcyons (**Figure 5-8**).

A survey was undertaken in 2010 by Geoscience Australia and AIMS to map the seabed environments of the Van Diemen Rise (Anderson et al. 2011). The survey involved towed-video transects at 77 sites to characterise the benthic habitats and epibenthos in the four geomorphic environments (banks, terraces, valleys and plains) within the Van Diemen Rise survey area (784 km^2). The shallow banks sampled within the contained complex benthic features with diverse and often dense epibenthic assemblages. A total of 175 video characterisations were recorded from 13 bank sampling sites in the study area and sampled from depths of 10.5 m–54.3 m (mean depth of 34 m). The sites were characterised by mostly low-lying rock outcrops that supported dense and diverse habitat (Anderson et al. 2011). Benthic assemblages observed on these outcrops included hard corals (18% occurrence; recorded only in shallow waters (<35 m) and included reef-building plating and branching corals), sponges (87% occurrence; dominated by fan, branching and digitate growth forms) and octocorals (99% occurrence; dominated by whips, hydroids and soft corals), along with smaller colonies of bryozoa and ascidians (Anderson et al. 2011). The rocky outcrops were interspersed by small areas of coarse-grained soft sediments that were relatively barren and supported few organisms (Anderson et al. 2011).

The AIMS extended benthic habitat map shows that burrowers/crinoids and filter feeder communities are expected at Marie and Shepparton Shoals (**Figure 5-8**).

As discussed in **Section 5.5.3.1**, connectivity between shoal features is expected given the strong surface currents experienced by the region (Heyward et al. 2017). Therefore, it is anticipated that the ecological characteristics of the Goodrich Bank, Marie Shoal and Shepparton Shoal are broadly consistent with the above description of the shoals and banks located within the vicinity as well as the characteristics described for Evans Shoal, Tassie Shoal and Lynedoch Bank.

5.5.4 Regionally important offshore reefs and islands

This section discusses those offshore reefs and islands that occur within the area of influence.

Ashmore Reef

Ashmore Reef lies approximately 750 km to the south-west of the Barossa offshore development area and is protected by the Commonwealth managed Ashmore Reef National Nature Reserve (**Section 5.7.2**) and Ashmore Reef CMR (**Section 5.7.6**). Ashmore Reef is also a designated Ramsar wetland of international significance (**Section 5.7.4**).

Ashmore Reef is a large platform reef of 227 km^2, consisting of an atoll-like structure with three low, vegetated islands, numerous banks of shifting sand and two large lagoon areas. The surrounding reef consists of a well-developed reef crest — most prominent on the south and east sides — and a broad reef flat that can be up to 3 km across. Along the edge of this reef flat area are large areas of drying sand that become exposed at low tide, particularly along the southern side. Water depth within the lagoon is highly variable, ranging from extremely shallow around the sand banks and up to 45 m in the deeper areas. The three islands located within the lagoon — West Island (281,000 km^2), East Island (134,200 km^2), and Middle Island (129,800 km^2) — are mostly flat, being composed of coarse sand with a few areas of exposed beach rock and limestone outcrops (Clarke 2010; Shell 2009).

Cartier Island

Cartier Island lies approximately 735 km to the south-west of Barossa offshore development area. The island and surrounding reefs are protected by Cartier Island CMR (**Section 5.7.6**). Cartier Island is an un-vegetated sand cay surrounded by mature reef flats; it sits at the centre of a reef platform that rises steeply from the seabed. The island is composed of coarse sand and is stabilised by patches of beach rock around its perimeter. The island supports large populations of nesting marine turtles.

Hibernia Reef

Although part of the same group as Ashmore Reef and Cartier Island, Hibernia Reef does not form part of the Ashmore Reef and Cartier Island External Territory of Australia. Hibernia Reef is approximately 740 km to the south-west of Barossa offshore development area and is situated approximately 40 km north-east from Ashmore Reef and 60 km north-west of Cartier Island. Hibernia Reef consists of an approximately oval-shaped reef that tapers to a point on the western side. The reef covers an area of approximately 11.5 km^2 and has no permanent land, but large areas of the reef can become exposed at low tide. Hibernia Reef is also characterised by a deep central lagoon and drying sand flats.

Seringapatam Reef

Seringapatam Reef (approximately 960 km to the south-west from the Barossa offshore development area) is a remote atoll covering an area of approximately 55 km^2 and encloses a lagoon of relatively consistent depth of approximately 20 m (maximum depth of 30 m) (Heyward et al. 2013). The lagoon is connected to the ocean by a narrow passage in the northeast part of the reef.

Seringapatam Reef is recognised as a KEF (**Section 5.7.8**). The reef is a regionally important scleractinian coral reef as it has a high biodiversity, which is comparable to Ningaloo Reef (Heyward et al. 2013). Results from the Western Australian Museum (WAM) survey in 2006 noted 159 species of scleractinian corals with a hard coral cover of approximately 16% (WAM 2009). A 2010 survey by Heyward et al. (2010) on the condition of shallow reef communities at Seringapatam Reef noted that the coral cover on slopes (20–25%) and reef flats (< 10%) to be similar to Ashmore Reef and Cartier Island surveyed in the same study.

ConocoPhillips commissioned a number of baseline studies at Seringapatam Reef in 2013, as part of their interests in the Greater Poseidon Field in the Browse Basin, to understand the characteristics of the benthic habitats and fish communities. The dominant benthic habitats of the reef were observed to include turf algae, macroalgae, hard and soft corals, algae and filter feeders (e.g. sponges, gorgonians, hydroid, seapens) (Heyward et al. 2013).

Scott Reef

Scott Reef (approximately 970 km to the south-west from the Barossa offshore development area) includes North Scott Reef and South Scott Reef. North Scott Reef is an annular reef, approximately 17 km long and 16 km wide, enclosing a shallow lagoon (up to 20 m deep) that is connected to the ocean by passages in the north-east and south-west (Gilmour et al. 2013, Woodside 2014). South Scott Reef is a crescent-shaped reef that is approximately 20 km wide. The lagoon at South Scott Reef ranges in depth (20 m to 70 m) and support significant benthic communities such as hard and soft corals. Sandy Islet, to the north of South Scott Reef, represents the only sandy shoreline habitat at Scott Reef and is a significant nesting site for green turtles, predominantly during the summer months (Gilmour et al. 2013).

Scott Reef is recognised as a KEF (**Section 5.7.8**). Corals communities at Scott Reef occur across shallow (< 30 m) and deep (> 30 m) habitats, with 306 species from 60 genera and 14 families having been identified (Gilmour et al. 2009). Coral communities varied from shallow to deep water with 295 species recorded from shallow water environments and 51 species from deep water. Eleven species were only found in deep water environments. Of the corals recorded, none were endemic to Scott Reef (Gilmour et al. 2009) and all predominantly widespread Indo–Pacific species.

Tiwi Islands

The Tiwi Islands are situated approximately 80 km north of Darwin and are comprised of Melville Island, Bathurst Island, and nine smaller uninhabited islands off the northern and southern shores. The Tiwi Islands are approximately 100 km south of the Barossa offshore development area and approximately 6 km east of the gas export pipeline corridor (closest point). The islands cover an area of approximately 8,320 km^2 and support a number of important habitats, including extensive stands of mangroves, tidal mudflats, sandy beaches, seagrass meadows and fringing reef habitats (INPEX 2010). Many species found on the islands are not recorded anywhere else in the NT, primarily due to their isolation and climatic extremes (high rainfall) (Department of Natural Resources, Environment, The Arts and Sport (NRETAS) 2009a). The Tiwi Islands are Aboriginal freehold land owned by the Tiwi Aboriginal Land Trust (NRETAS 2009a).

The Tiwi Islands, and small islands in the vicinity, support important nesting sites for marine turtles, internationally significant seabird rookeries, and some major aggregations of migratory shorebirds (DLRM 2009). The sandy beaches on the Tiwi Islands, specifically the west coast of Bathurst Island and the north coast of Melville Island, are particularly important for marine turtle nesting. Nesting is dominated by flatback and olive ridley turtles (Chatto and Baker 2008). However, green and hawksbill turtles also nest on the Tiwi Island. Significant numbers of olive ridley turtles are known to nest on the beaches of Seagull Island and the north-west coast of Melville Island (Chatto and Baker 2008). The DoEE National Conservation Values Atlas (DoEE 2017c) shows a number of biologically important areas for turtles surrounding the Tiwi Island coastline (**Section 5.6.3**).

Five seabird breeding colonies have been reported on small offshore islands surrounding Melville and Bathurst Islands (Chatto 2001) that range in size from two to over 30,000 birds (Chatto 2001). The colony on Seagull Island, off the north-west tip of Melville Island, supports a BIA of approximately 60,000 crested terns (Woinarski et al. 2003), which is thought to be the largest breeding colony of this species and is considered an internationally significant colony (> 1% global population) (NRETAS 2009a). A 20 km buffer has been designated around the BIA as a foraging zone for the crested terns (see **Section 5.6.4.2**). The breeding period for the crested tern is from March to July, with most eggs being laid between from late April to early June (Chatto 2001). In general, colonial seabird breeding in the NT occurs throughout most of the year, though mostly between May and November (Chatto 2001). The extensive areas of tidal flats, particularly on the south-east of Melville Island, have also been noted as providing important wading and feeding habitats for shorebirds. The highest total count at this site was 40,000 shorebirds in 1993 with the most common species being Great Knots (Chatto 2003). Other species recorded in high numbers include red-necked stints, greater and lesser sand plovers and bar-tailed godwits (Chatto 2003).

The north coast of the Tiwi Islands is recognised as a key site for the conservation of dugongs (Parks and Wildlife Service NT (PWSNT) 2003). Further discussion of the presence of dugongs in the vicinity of the Tiwi Islands is provided in **Section 5.6.2.2**.

The Australian snubfin dolphin (*Orcaella heinsohni*), listed as migratory under the EPBC Act, has been sighted in waters in close proximity to the Tiwi Islands and NT/WA coastline. Further discussion of the species is provided in **Section 5.6.2.2**.

5.5.5 Other regional seabed features of interest

Seamounts

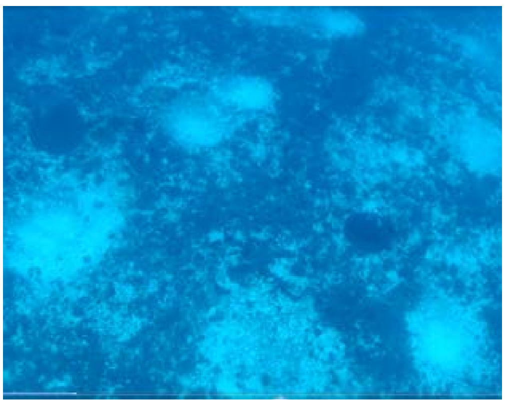
The Barossa marine studies program included sampling sites at several seamounts in the broader vicinity of the Barossa offshore development area (within approximately 9 km–18 km to the west). The seamounts are generally raised up from the seabed to water depths between 50 m and 80 m and are characterised by predominantly sand and rubble (Jacobs 2016c). The hard substrate of the seamount slopes supported epibenthic communities dominated by sponges and filter feeders such as gorgonians (e.g. sea whips, sea fans and soft corals) and feather stars. Other epibenthic species observed included holothurians (sea cucumbers), sea fans and algae (Jacobs 2016c). Representative images of the seamounts are shown in **Figure 5-11**.

Triggerfish nesting areas were apparent at the seamounts. The triggerfish (family Balistidae) appeared to make depressions in the sand and rubble at the top of the southernmost seamount surveyed as they were observed in and around these depressions (Jacobs 2016c). At a seamount directly west of the Barossa offshore development area (approximately 18 km), small discrete piles of rubble had been accumulated that also may have been fish nests or as the result of tidal/current movement. These piles were also observed on the northern slope of Evans Shoal. The seamounts also appeared to support schools of fish (predominantly from families Lutjanidae, Carangidae and Caesionidae, and including larval or juveniles) both near the top of the seamount and at depth. Goldband snapper individuals were tentatively identified at depth at seamount sites, with one individual also observed at the scarps south of the Barossa offshore development area. Silver tip sharks, a sea snake (unidentified species) and small ray were also observed at the seamounts.

Four grey nurse sharks were observed at one of the seamounts in approximately 130 m–160 m water depth, including at least one female that appeared to be pregnant. This was considered unusual as neither the east or west coast populations are known to extend that far north and are generally associated with shallower, more coastal waters (DoEE 2017d). However, a paper published in March 2015 recorded four grey nurse sharks (three females and one male) being caught in the vicinity of Browse Island (approximately 800 km south-west of the Barossa offshore development area) and described this catch as the first known from the Timor Sea (Momigliano and Jaiteh 2015, cited in Jacobs 2016c). It is unknown whether the individuals observed during this survey would be linked to the east (listed as critically endangered) or west coast (listed as vulnerable) populations, or another discrete population.

a) Substrate with soft coral (gorgonians) and feather star

b) Triggerfish on rocky substrate



c) Distribution of triggerfish nests in the sand and rubble substrate near the top of the seamount

d) Boulders at the base of the slope with a squirrel fish (family Holocentridae)

Figure 5-11: Seamount benthic habitat and communities

Scarps

The Barossa marine studies program included sampling sites at two scarps in the Barossa offshore development area (between the Barossa Field and Caldita Field), which were in water depths ranging between 160 m and 190 m. The substrate of the scarps was similar and characterised by a hard bedrock pavement at the top, with a rocky profile along the ridge and sand habitats at the base (Jacobs 2016c). The scarps provided habitat for gorgonians (e.g. sea whips), feather stars and other filter feeders, sponges, and hydroid/bryozoan turf. A deep-water snapper species (possibly goldband snapper) was also observed in a rocky overhang at the base of the slope and small silver fish and one ray were observed on the sand flat at one of the scarps (Jacobs 2016c). Representative images of the scarps are shown in **Figure 5-12**.

a) Rocky substrate covered with silty sand with gorgonians and other filter feeders on the high side of the scarp

b) Rocky scarp profile with filter feeders

Figure 5-12: Scarp benthic habitat and communities

5.5.6 NT and WA mainland coastline

The summary of key regional values and sensitivities provided in preceding sections is focused on the primary features of relevance to the project area – namely the submergent shoals and banks, emergent reefs, and islands that have recognised conservation value.

The NT and WA mainland coastline is only relevant to the project in the context of the area of influence, as some areas of the coastline may be contacted in the unlikely event of a large-scale unplanned release scenario (see **Section 6.4.10**). While the modelling presented in this OPP does not predict contact with the WA coastline, high level consideration has been given to the Kimberley coastline for completeness.

In the NT, the Darwin Harbour coastline extends approximately 500 km^2 and feeds estuaries of rivers that drain from the surrounding hinterland during the wet season (INPEX 2010). Approximately 1,000 km^2 of wetlands are present in the surrounding catchments, including Darwin Harbour, which contains 260 km^2 of mangroves (INPEX 2010). In addition to mangroves, the subtidal and intertidal communities in Darwin Harbour include rocky shore, hard coral, filter feeder (primarily soft corals and sponges), macroalgae and sparse seagrass communities (INPEX 2010). The coastline is also characterised by various habitats such as rocky shores and pavements, sand beaches and mud flats (INPEX 2010). The area is also significantly important to the local Larrakia Aboriginal people with cultural connection to the area, as well as for local tourism, recreation and commercial fishing purposes. The attributes of the coastal area of Darwin Harbour and surrounds are representative of the values of the mainland coastline of the NT, as relevant to the area of influence defined in this OPP.

The nearshore and coastal environments of the Kimberley (WA) support a diverse array of marine habitats and communities including coral reefs, sandy beaches, rocky shores, seagrass meadows, mangroves, sponge gardens, wetlands, estuaries, creeks and rivers (Department of Environment and Conservation (DEC) 2009). The area also provides Indigenous and European heritage value as well as for local tourism, recreation and commercial fishing purposes.

The nearshore and coastal environments of the Kimberley and Darwin Harbour coastlines support EPBC listed protected species including seabirds and migratory shorebirds, turtles, sea snakes, dugongs, dolphins, fish, sharks and rays (DEC 2009, NRETAS 2009b). The environments also provide important habitat for a number of culturally and commercially important marine fauna species such as marine turtles, dugongs, fish and prawns (DEC 2009). Species of conservation significance that occur within the area of influence that intersects with the NT and WA mainland coastline are described in **Section 5.6**. The various Commonwealth Recovery Plans and conservation advices for species of conservation significance present in these areas have been outlined in **Section 3.5.1** and the requirements taken into consideration within the EPBC listed species descriptions in **Section 5.6**.

5.5.7 Plankton

5.5.7.1 Regional overview

Plankton refers to generally passively, mobile, single-celled organisms that are present within the water column. Forms include a highly diverse mix of phytoplankton and zooplankton, ranging in size from micrometres to centimetres that fulfil a diverse range of ecological roles.

Plankton distribution is often patchy and linked to localised and seasonal productivity that produces sporadic bursts in phytoplankton, zooplankton and tropical krill production (DEWHA 2008c). Fluctuations in abundance and distribution occur both horizontally and vertically in response to the tidal cycles, seasonal variation (light, water temperature and chemistry, rainfall, currents and nutrients) and cyclonic events. The seasonal cycles and spatial distribution/abundance of biological productivity still remain largely unknown (DSD 2010). However, in general, the mixing of warm surface waters with deeper, more nutrient-rich waters (i.e. areas of upwelling) generates phytoplankton production and zooplankton blooms.

5.5.7.2 Barossa offshore development area

During the Barossa marine studies program, phytoplankton and zooplankton species were sampled along approximately 300 m long surface water transect tows during the field surveys using plankton nets. Four of the sites were within the Barossa offshore development area (only three of which were sampled in winter), three at Evans Shoal (with only two sampled in winter), three at Tassie Shoal (only one sampled in winter) and two sites at Lynedoch Bank (autumn and summer only) (**Figure 5-2**).

The phytoplankton assemblage composition was relatively similar across the seasons. Diatoms (Bacillariophyceae), blue-green algae (Cyanobacteria) and dinoflagellates (Dinophyceae) were recorded in all seasons, cryptomonads (Crytophyceae) in two seasons (summer and autumn), and silicoflagellates (Dictyochophyceae) and green algae (Chlorophyceae) in only a single season (winter and autumn respectively) (Jacobs 2016a).

Blue-green algae were the most abundant phytoplankton assemblage as they were recorded in approximately 87% of the transect tows and had a mean abundance of approximately 74% across all three surveys. *Trichodesmium erythraeum* (a blue-green alga) was the most abundant phytoplankton species at the majority of sites during each season. *Trichodesmium* species occur in large numbers in tropical areas of the Indian Ocean, where their ability to fix nitrogen enables them to thrive when nutrient concentrations are low (Riley and Chester 1971). Dinoflagellates were the most diverse group during the autumn survey, whereas diatoms were the most diverse group during the summer and winter surveys (Jacobs 2016a).

The zooplankton assemblage composition was relatively similar across the seasons, with summer and winter being most similar (Jacobs 2016a). The summer survey recorded the most diverse assemblage (14 Classes of organisms) while autumn was the least diverse (eight Classes) (Jacobs 2016a). Across all seasons copepods displayed the highest number of different species whereas most other Classes contained only one species (Jacobs 2016a).

5.6 Marine fauna of conservation significance

A summary of the marine fauna of conservation significance identified in the three search areas of the online EPBC Act Protected Matters database is provided below and in **Table 5-4**.

- Barossa offshore development area – the search identified 18 listed threatened fauna species and 29 listed migratory species (17 of which are also listed as threatened species) that may occur or have habitat in the area (DoEE 2017e). All species identified in the Barossa offshore development area were also identified in the gas export pipeline corridor.
- Gas export pipeline corridor – the search identified 19 listed threatened fauna species and 38 listed migratory species (17 of which are also listed as threatened species) that may occur or have habitat in the area (DoEE 2017f). One threatened species and eight migratory species were identified in the pipeline corridor in addition to those identified in the Barossa offshore development area.
- Area of influence – the search identified 29 listed threatened fauna species and 71 listed migratory species (21 of which are also listed as threatened species) that may occur or have habitat in the area (DoEE 2017g). Nine mammal, one reptile and seven bird species identified in the EPBC search as threatened species have not been presented in the table below as they are considered not relevant to the project. These species are either terrestrial fauna or threatened bird species that are typically found in habitats distributed on the coastal fringes of Australia, but not necessarily present on shorelines (e.g. wetlands), and/or have not been recorded within the area of influence. Whilst the outer extent of the area of influence does contact some coastal areas (hence flagging these species in the search area), the likelihood of a large-scale spill interacting with these species, given their distribution away from shorelines that may be affected, is remote. Therefore, these species are not discussed further in this report but are listed in **Appendix O** for reference.

The results of the Protected Matters search are summarised in **Section 5.5.1** and presented in **Appendix O**. The listed threatened species and migratory species are described below in the following sub-sections.

Table 5-4: EPBC Protected Matters search results summary for threatened and migratory species

Species	Threatened status	Listed as migratory	Search area		
			Barossa offshore development area	Gas export pipeline corridor	Area of influence
Cetaceans					
Blue whale (*Balaenoptera musculus*)	Endangered	✓	✓	✓	✓
Humpback whale (*Megaptera novaeangliae*)	Vulnerable	✓	✓	✓	✓
Sei whale (*Balaenoptera borealis*)	Vulnerable	✓	✓	✓	✓
Fin whale (*Balaenoptera physalus*)	Vulnerable	✓	✓	✓	✓
Antarctic minke whale (*Balaenoptera bonaerensis*)		✓	✓	✓	✓
Bryde's whale (*Balaenoptera edeni*)		✓	✓	✓	✓
Killer whale (*Orcinus orca)*		✓	✓	✓	✓
Sperm whale (*Physeter macrocephalus*)		✓	✓	✓	✓
Dugong (*Dugong dugon*)		✓		✓	✓
Australian snubfin dolphin (*Orcaella heinsohni*; formerly known as the Irrawaddy dolphin)		✓		✓	✓
Indo-Pacific humpback dolphin (*Sousa sahulensis*)		✓		✓	✓
Spotted bottlenose dolphin (Arafura/Timor Sea populations) (*Tursiops aduncus*)		✓	✓	✓	✓
Marine reptiles					
Loggerhead turtle (*Caretta caretta*)	Endangered	✓	✓	✓	✓
Green turtle (*Chelonia mydas*)	Vulnerable	✓	✓	✓	✓

Species	Threatened status	Listed as migratory	Search area		
			Barossa offshore development area	Gas export pipeline corridor	Area of influence
Leatherback turtle (*Dermochelys coriacea*)	Endangered	✓	✓	✓	✓
Hawksbill turtle (*Eretmochelys imbricata*)	Vulnerable	✓	✓	✓	✓
Olive ridley turtle (*Lepidochelys olivacea*)	Endangered	✓	✓	✓	✓
Flatback turtle (*Natator depressus*)	Vulnerable	✓	✓	✓	✓
Salt-water crocodile (*Crocodylus porosus*)		✓		✓	✓
Short-nosed sea snake (*Aipsurus apraefrontalis*)	Critically endangered				✓
Leaf-scaled sea snake (*Aipysurus foliosquama*)	Critically endangered				✓
Seabirds					
Curlew sandpiper (*Calidris ferruginea*) [1]	Critically endangered	✓	✓	✓	✓
Eastern curlew (*Numenius madagascariensis*) [1]	Critically endangered	✓	✓	✓	✓
Australian lesser noddy (*Anous tenuirostris melanops*)[1]	Vulnerable				✓
Greater sand plover (*Charadrius leschenaultii*)[1]	Vulnerable	✓			✓
Lesser sand plover (*Charadrius mongolus*) [1]	Endangered	✓			✓
Streaked shearwater (*Calonectris leucomelas*) [1]		✓	✓	✓	✓
Common noddy (*Anous stolidus*)[1]		✓	✓	✓	✓
Fork-tailed swift (*Apus pacificus*) [1]		✓		✓	✓
Osprey (*Pandion haliaetus*)		✓		✓	✓
Brown booby (*Sula leucogaster*)[1]		✓			✓
Red footed booby (*Sula sula*)[1]		✓			✓
Greater frigatebird (*Fregata minor*)[1]		✓	✓	✓	✓
Lesser frigatebird (*Fregata ariel*)[1]		✓	✓	✓	✓
Crested tern (*Thalasseus bergii*)[1]		✓		✓	✓
Little tern (*Sterna albifrons*)[1]		✓			✓
Roseate tern (*Sterna dougallii*)[1]		✓			✓

Species	Threatened status	Listed as migratory	Search area		
			Barossa offshore development area	Gas export pipeline corridor	Area of influence
Wedge-tailed shearwater (*Ardenna pacifica*)[1]		✓			✓
White-tailed tropicbird (*Phaethon rubricauda*)[1]		✓			✓
Western Alaskan bar-tailed godwit (*Limosa lapponica bauera*)[1]	Vulnerable				✓
Northern-Siberian bar-tailed godwit (*Limona lapponica menzbieri*)[1]	Critically endangered				✓
Bar-tailed godwit (*Limonsa lapponica*)[1]		✓			✓
Black-tailed godwit (*Limosa limosa*)[1]		✓			✓
Red-tailed tropic bird (*Phaethon rubricuda*)[1]		✓			✓
Bridled tern (*Sterna anaethetus*)[1]		✓			✓
Masked booby (*Sula dactylatra*)[1]		✓			✓
Barn Swallow (*Hirundo rustica*)[1]		✓			✓
Ruddy turnstone (*Arenaria interpres*)[1]		✓			✓
Sanderling (*Calidris alba*)[1]		✓			✓
Whimbrel (*Numenius phaeopus*)[1]		✓			✓
Grey plover (*Pluvialis squatarola*)[1]		✓			✓
Common greenshank (*Tringa nebularia*)[1]		✓			✓
Great knot (*Calidris tenuirostris*)[1]	Critically endangered	✓			✓
Red knot *(Calidris canutus)*	Endangered	✓			✓
Abbott's booby *(Papasula abbotti)*	Endangered				✓
Sharp-tailed sandpiper *(Calidris acuminata)*		✓			✓
Pectoral sandpiper *(Calidris melanotos)*		✓			✓
Oriental reed-warbler (*Acrocephalus orientalis*)[1]		✓			✓
Red-rumped swallow (*Cecropis daurica*)[1]		✓			✓
Oriental cuckoo (*Cuculus opatus*)[1]		✓			✓
Oriental plover (*Charadrius veredus*)[1]		✓			✓

Species	Threatened status	Listed as migratory	Search area		
			Barossa offshore development area	Gas export pipeline corridor	Area of influence
Oriental pratincole (*Glareola maldivarum*)[1]		✓			✓
Grey wagtail (*Motacilla cinereal*)[1]		✓			✓
Yellow wagtail (*Motacilla flava*)[1]		✓			✓
Common sandpiper (*Actitis hypoleucos*)[1]		✓			✓
Rufous Fantail (*Rhipidura rufifrons*)		✓			✓
Fish					
Whale shark (*Rhincodon typus*)	Vulnerable	✓	✓	✓	✓
Sharks and rays					
Great white shark (*Carcharodon carcharias*)	Vulnerable	✓	✓	✓	✓
Green sawfish (*Pristis zijsron*)	Vulnerable	✓	✓	✓	✓
Largetooth sawfish (*Pristis pristis*)	Vulnerable	✓	✓	✓	✓
Dwarf sawfish (*Pristis clavata*)	Vulnerable	✓		✓	✓
Speartooth shark (*Glyphis glyphis*)	Critically endangered		✓	✓	✓
Northern river shark (*Glyphis garricki*)	Endangered		✓	✓	✓
Narrow sawfish (*Anoxypristis cuspidata*)		✓	✓	✓	✓
Longfin mako (*Isurus paucus*)		✓	✓	✓	✓
Shortfin mako (*Isurus oxyrinchus*)		✓		✓	✓
Reef manta ray (*Manta alfredi*)		✓	✓	✓	✓
Giant manta ray (*Manta birostris*)		✓	✓	✓	✓

[1] These species may be associated with offshore island habitats and have been recorded at Ashmore Reef and Cartier Island (Clarke 2011).

5.6.1 Biologically important areas

BIAs are defined by DoEE as *"spatially defined areas where aggregations of individuals of a regionally significant species are known to display biologically important behaviours such as breeding, foraging, resting or migration"* (DoEE 2017c).

A review of the DoEE National Conservation Values Atlas (an interactive web-based tool which supports the implementation of Marine Bioregional Plans) determined that the Barossa offshore development area is not located within BIAs for any regionally significant marine species. The gas export pipeline corridor traverses the biologically important internesting areas for flatback and olive ridley turtles, and a breeding foraging area for the crested tern (waters offshore of the Tiwi Islands). The area of influence includes a number of BIAs including foraging areas and internesting areas for marine turtles, a migration corridor for pygmy blue whales, migration area for humpback whales, foraging areas for whale sharks, breeding/foraging/resting areas for a number of seabird species, and a breeding, calving and foraging area for the Indo-pacific humpback dolphin. The identified BIAs are discussed under the relevant species sections below.

5.6.2 Marine mammals

5.6.2.1 Regional overview

Marine mammals (cetaceans) are generally widely distributed and highly mobile. In general, distribution patterns reflect seasonal feeding areas, characterised by high productivity, and migration routes associated with reproductive patterns.

Twenty-nine species listed under the EPBC Act (including four threatened and 12 migratory cetaceans), including baleen whales, toothed whales and dolphins, were identified as potentially occurring or having habitat in the area of influence. The four threatened species that may occur in the Barossa offshore development area or gas export pipeline corridor were the blue whale (*Balaenoptera musculus*; endangered), humpback whale (*Megaptera novaeangliae*; vulnerable), sei whale (*Balaenoptera borealis*; vulnerable) and fin whale (*Balaenoptera physalus*; vulnerable).

Of those species identified in the EPBC Protected Matters search, the pygmy blue whale (endangered) and Bryde's whale (migratory) are most likely to occur in the project area. Both species were recorded in the project area during noise monitoring undertaken for the project in 2014/2015 (refer to **Section 5.4.7**). The species of primary relevance, and other species that may traverse through the area, are discussed in detail below.

While not identified in the EPBC Protected Matters search, the Omura's whale (unlisted) is also discussed as the species was observed during the Barossa marine studies program.

5.6.2.2 Key values and sensitivities of relevance to the Barossa offshore development area and gas export pipeline corridor

Pygmy blue whale

The blue whale (*Balaenoptera musculus*; endangered) has four distinct sub-species, of which two are found in the southern hemisphere; the pygmy blue whale (Indo-Australian and Tasman-Pacific populations) and the Antarctic blue whale (DoE 2015a). The pygmy blue whale has been recorded in the surrounds of the Barossa offshore development area (JASCO 2016a). Noise monitoring undertaken for the Barossa marine studies program (**Section 5.4.7**) recorded pygmy blue whales moving in a northward direction in August 2014 and between late May and July 2015, as they migrated north towards Indonesian waters (JASCO 2016a). These detections are over approximately 400 km north-east of the BIA associated with the pygmy blue whale migration corridor. No detections of the species were made during the period of their southward migration, indicating that they may utilise a different migration path (JASCO 2016a).

Key aggregation/feeding areas:

- The Perth Canyon off WA, and the Bonney Upwelling System and adjacent waters off Victoria, South Australia and Tasmania are known feeding grounds (**Figure 5-13**; DoE 2015a). These areas are utilised from November to May.
- Pygmy blue whales appear to feed regularly along their migration route (i.e. at least once per week or more frequently) and are likely to have multiple food caches along their migratory route (e.g. Rowley Shoals and Ningaloo Reef) (pers. comm. C. Jenner, CWR, 2014).
- A biologically important foraging area encompasses Seringapatam Reef, Scott Reef and the open waters to the west of these features (**Figure 5-13** and **Figure 5-14**; DoE 2015a; DoEE 2017c. These steep gradient features tend to stimulate upwelling and, therefore increased productivity (seasonally variable) (pers. comm. C. Jenner, CWR, 2014). Hence, they provide a favourable foraging area.

Key migratory pathways/timing:

- At a broader regional scale, the species is known to migrate along the shelf edge at depths between the 500 m and 1,000 m depth contours from the North West Cape south to Geographe Bay (**Figure 5-13**; DoE 2015a).
- A biologically important migration corridor is recognised in deep offshore waters off WA (**Figure 5-14**; DoEE 2017c).
- Northerly migration occurs in March/April to June (migration to the equator calving grounds) (DoE 2015a). The species is more scattered in distribution when migrating northward (pers. comm. C. Jenner, Centre for Whale Research (CWR), 2014).

- Southerly migration occurs in September/October to December (DoE 2015a). Annual acoustic detections of pygmy blue whales at Scott Reef (presumed to be moving south-wards) have been recorded between late October and December (DoE 2015a).
- Generally, they appear to travel as individuals or in small groups based on acoustic data. For example, analysis of pygmy blue whale calls from noise loggers deployed around Scott Reef (2006 to 2009) for the Woodside Browse project showed that 78% of the calls were from lone whales, 18% were from two whales and 4% were from three or more whales (McCauley 2011; Woodside 2014). A maximum of five individuals were recorded calling concurrently.

Conservation advice from the DoEE (2015a) for the blue whale states that biologically important areas should be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area. Based on the known distribution, preferred feeding habitats and migration pathways of pygmy blue whales, and observations from the noise monitoring program (**Section 5.4.7**), it is considered possible that individuals may be encountered in low numbers during the project. However, there are no BIAs for pygmy blue whales within the project area. Individuals are most likely to be present in the Barossa offshore development area and northern end of the gas export pipeline where it is located in deep offshore waters. Pygmy blue whales are unlikely to aggregate within the Barossa offshore development area for feeding given there are no significant upwellings or benthic habitat features in the area.

Bryde's whale

Bryde's whales (*Balaenoptera edeni*; migratory) are considered the least migratory of the whale species found in Australian waters as they do not appear to undertake long distance low-high latitude migrations. However, some populations have been observed to move toward the equator in the winter and away from it in the summer (Best 1977; Valdivia et al. 1981; Wiseman et al. 2011; cited in JASCO 2016a). In general, the species is restricted to waters between 40° south and 40° north year round (Bannister et al. 1996; DoEE 2017d). The species occurs in both oceanic and nearshore waters, following zones of upwelling where they feed on shrimp-like crustaceans (Bannister et al. 1996). Little is known about the population abundance of Bryde's whale and there are no estimates of the exact breeding and calving grounds (DoEE 2017d; Chevron 2011a).

A few individuals of Bryde's whale were detected in the Barossa marine studies program from January to early October. JASCO (2015) commented that the presence of the species would be expected based on the findings of a number of studies, which noted the occurrence of the species in the Timor Sea and surrounding waters. Therefore, it is possible that Bryde's whale may transit through the project area and area of influence but they are not expected to be present in significant numbers.

Omura's whales

Omura's whales (*Balaenoptera omurai*) were only described as a new species basal to the Bryde's whale group in 2003 (Wada et al. 2003) and remain poorly understood in terms of their spatio-temporal distribution. While distantly related to Bryde's whales (Cerchio et al. 2015), the two species share some life history traits such as remaining in tropical waters, as opposed to undertaking large-scale seasonal migrations characteristic of other baleen whales (JASCO 2016a). Omura's whales are not listed under the EPBC Act but are listed on the IUCN Red List as Data Deficient (IUCN 2017).

A scientific study undertaken by Cerchio et al. (2015), which assessed the ecology and behaviour of Omura's whales off the north-west Madagascar, has provided some valuable insight into the species. Omura's whales, when present in the Madagascar region (October to November), appeared to be distributed solely on the shallow continental shelf habitat, within approximately 10 km–15 km of the shelf break and predominantly in water depths of 10 m–25 m (however, they were observed in depths of up to 202 m) (Cerchio et al. 2015). Cerchio et al. (2015) noted that other studies have suggested that the species also inhabits deeper waters, with observations made only off the Cocos Islands and eastern Indian Ocean from research whaling data. Feeding in the shelf habitat was frequently observed and was thought to be related to patchy food resources that were most likely zooplankton (Cerchio et al. 2015).

Omura's whales were recorded within the Barossa offshore development area throughout April to September inclusive, with a peak in June and July (JASCO 2016a). Based on the recordings, the whales appeared to pass through the region in a south-west to north-east direction. A higher number of recordings were observed in the vicinity of Evans Shoal and south of the Barossa offshore development area during the autumn and winter months. Therefore, it is likely that Omura's whales may transit the Barossa offshore development area, northern end of the gas export pipeline corridor and area of influence.

Sei whale

Sei whales (*Balaenoptera borealis*; vulnerable) have a wide distribution and display well-defined migratory movements between polar, temperate and tropical waters (DoEE 2017d). While the species has been observed infrequently in Australian waters, they are known to move through Australian waters to feeding areas in the Antarctic/sub-Antarctic (DoEE 2017d). Sei whales breed in tropical and sub-tropical waters, however, there are no known mating or calving areas in Australian waters.

Based on their known distribution and movements, it is considered possible that individual sei whales may be encountered in low numbers during the project; most likely in the Barossa offshore development area and northern end of the gas export pipeline corridor where it is located in deep offshore waters.

Fin whale

Fin whales (*Balaenoptera physalus*; vulnerable) have a wide distribution in offshore waters and, like the sei whale, display well defined migratory movements between polar, temperate and tropical waters (DoEE 2017d). These migratory movements appear to be effectively north–south with little longitudinal dispersion as the whales move between the higher latitude summer feeding grounds, such as the Australian Antarctic waters and Bonney upwelling area off Victoria, to lower latitude winter breeding grounds (DoEE 2017d).

Considering the species known distribution and movements, it is considered possible that individual fin whales may pass through the project area in low numbers; most likely in the Barossa offshore development area and northern end of the gas export pipeline corridor where it is located in deep offshore waters.

Humpback whales

Humpback whales (*Megaptera novaeangliae*; vulnerable) have a wide distribution, with recordings throughout Australian Antarctic waters and offshore from all Australian states (Bannister et al. 1996). Humpback whales breed and calve in the NWMR between Broome and the northern end of Camden Sound in the months of June to September each year (DoE 2015b; DoEE 2017d). A biologically important breeding and calving area for humpback whales is recognised in nearshore waters adjacent to the northern half of the Dampier Peninsula and encompasses Camden Sound (**Figure 5-14**; DoEE 2017c).

Humpback whales migrate between summer feeding grounds in Antarctica and winter breeding and calving grounds in the sub-tropical and tropical inshore waters of north-west Australia (Jenner et al. 2001). A biologically important migration area for humpback whales is recognised in nearshore waters (< 100 km) along the coast from west of Esperance to 100 km north of Broome (DoEE 2017c). The northbound migration peaks between late July and early August, and the southbound migration peaks between late August and early September (Jenner et al. 2001). Relatively few humpback whales have been known to travel north of Camden Sound (Jenner et al. 2001), which is located more than approximately 820 km south-west of the Barossa offshore development area. In addition, no humpback whales were recorded during the 12 months of noise monitoring undertaken as part of the Barossa marine studies program (JASCO 2016a). Therefore, the species is considered unlikely to transit through the project area but may occur within the area of influence.

Antarctic minke whale

Antarctic minke whales (*Balaenoptera bonaerensis*; migratory) occur worldwide and have been recorded off all Australian states, primarily in offshore waters (DoEE 2017d). The species has not been recorded in the NT (DoEE 2017d). Antarctic minke whales undertake extensive breeding migrations between Antarctic feeding grounds and temperate/tropical waters during the Australian winter, although the exact location of their breeding grounds is unknown (Bannister et al. 1996). It is suggested that Antarctic minke whales migrate up the WA coast as far north as 20°S (Bannister et al. 1996). Based on the extent of the species range, it is considered unlikely that they will be present in area of influence. However, if they do occur it is expected that only a few individuals may transit through the area.

Killer whale

The killer whale (*Orcinus orca*; migratory) is found in all the world's oceans and has been recorded in waters of all Australian states/territories (DoEE 2017d). While killer whales are known to undertake seasonal migrations, and follow regular migratory routes, little is known about these movements (DoEE 2017d). No areas of significance and no determined migration routes have been identified for this species within the project area or area of influence. It is possible that killer whales may transit through the area of influence but they are not expected to be present in significant numbers.

Sperm whale

Sperm whales (*Physeter microcephalus*; migratory) are found worldwide in deep waters (> 200 m) off continental shelves and shelf edges (Bannister et al. 1996). Sperm whale sightings have been recorded from all Australian states, however, key localities for sperm whales are between Cape Leeuwin and Esperance in WA (Bannister et al. 1996), which is more than 1,500 km from the area of influence. The area of influence is unlikely to represent important habitat for this species, and it is therefore expected that only very low numbers of individuals may be present.

Dugong

Dugongs (*Dugong dugon*; migratory) occur in tropical and sub-tropical coastal and island waters broadly coincident with the distribution of seagrasses (DoEE 2017d). Seagrass habitats typically occur in shallow intertidal zone areas to water depths of around 25 m. To a lesser extent seagrasses have been recorded at depths up to 50-60 m, however seagrass meadows at these depths are likely to be inaccessible given the limitations of dugongs diving range beyond approximately 35 m (DoEE 2017d). Dugong feeding aggregations tend to occur in large seagrass meadows within wide shallow protected bays, shallow mangrove channels and in the lee of large inshore islands.

The north coast of the Tiwi Islands (located approximately 100 km south and approximately 6 km east of the Barossa offshore development area and gas export pipeline corridor closest point, respectively) is recognised as a key site for the conservation of dugongs (Parks and Wildlife Service NT (PWSNT) 2003). A well-known major dugong aggregation of approximately 4,400 individuals occurs in waters seaward (within approximately 50 km) of the Tiwi Islands and ranks in the top eight of dugong populations in Australia (PWSNT 2003). **Figure 5-15** shows significant sites for dugongs and seagrass around the Tiwi Islands.

Dugongs have been tracked moving long distances of up to 300 km between the Australia mainland and the Tiwi Islands (Whiting 2008). Satellite-tracking data from dugongs tagged as part of the INPEX Ichthys Project baseline surveys observed that dugongs around the Vernon Islands, south of Melville Island, spent time in Darwin Harbour and around the Tiwi Islands (INPEX 2010). The number of dugongs observed in Darwin Harbour is relatively low and is thought to reflect the scarcity of seagrass habitat (Whiting 2008). Routine dugong monitoring surveys undertaken for the INPEX Ichthys project recorded a number of dugongs at various locations along the NT coastline, including within Darwin Harbour, to the south of Melville Island, within Shoal Bay to the north of Darwin Harbour (highest frequency of sightings) and within the vicinity of Grose Island, Dum In Mirrie Island and Indian Island (south-west of Darwin Harbour) (Cardno 2013).

Dugongs in the NT coastal waters have been observed foraging on intertidal rocky reef flats supporting sponges and algae as seagrass habitat is thought to be rare in the NMR bioregion (Whiting 2008, cited in INPEX 2010). However, seagrass communities are known along the north coast of the Tiwi Islands (Woinarski et al. 2003; McKenzie 2008, cited in JacobsSKM 2014) and, to a smaller extent, in Darwin Harbour (JacobsSKM 2014).

Given the habitat preferences of dugongs and the known distribution of seagrass around the Tiwi Islands, the species may occur in the shallow or nearshore waters of the area of influence.

Dolphins

Dolphins have been reported as being abundant in some offshore areas of the Timor Sea and are regularly seen by commercial fishers near Evans Shoal (CEE 2002). Migratory species known to occur in the region include the spotted bottlenose dolphin (Arafura/Timor Sea populations) (*Tursiops aduncus*), Indo-pacific humpback dolphin (*Sousa chinensis*), and the Australian snubfin dolphin (*Orcaella heinsohni* (formally known known as the Irrawaddy dolphin). No breeding areas are known to occur within the project area.

Spotted bottlenose dolphin

The spotted bottlenose dolphin (Arafura/Timor Sea populations) (*Tursiops aduncus*), listed as migratory under the EPBC Act, favours deeper, more open coastal waters, primarily in continental shelf waters (< 200 m deep), including coastal areas around oceanic islands (DSEWPaC 2012a). Biologically important foraging (provisioning of young), feeding and breeding area has been identified in Darwin Harbour, in which the species is mostly present during the dry season (April–November) (DSEWPaC 2012a). Breeding and foraging behaviour has not been seen beyond the mouth of harbour (C. Palmer, pers. comm., 2011, cited in DSEWPaC 2012a).

A study undertaken by Brooks et al. (2017) monitored abundance, distribution and movement patterns of three coastal dolphin species, including the bottlenose dolphin (*Tursiops* sp.), in Darwin Harbor and two neighboring sites (Shoal Bay to the north and Bynoe Harbour to the south) over three and a half years (October 2011-April 2015). The study observed that bottlenose dolphins appeared to move relatively freely between all sites and that population numbers were relatively stable and comparable to other local populations in Australia. Furthermore, the study reported that an unusually large increase in the October 2012 estimate suggests immigration occurs and that there is a degree of connectivity between the Darwin area population and dolphins outside the sample area.

Indo-pacific humpback dolphin

The Indo-pacific humpback dolphin (*Sousa sahulensis*), which is listed as migratory under the EPBC Act, is known to occur along the northern Australian coastline from Exmouth in WA to the Queensland/New South Wales (NSW) border region (DoEE 2017d). The species' preferred habitat is shallow (generally < 20 m in depth) coastal, estuarine and riverine (occasional) waters. However, individuals have been observed in shallow waters up to 55 km offshore. The species breeds throughout the year, with calving peaks reported to occur in the spring and summer months across most of their range (DoEE 2017d).

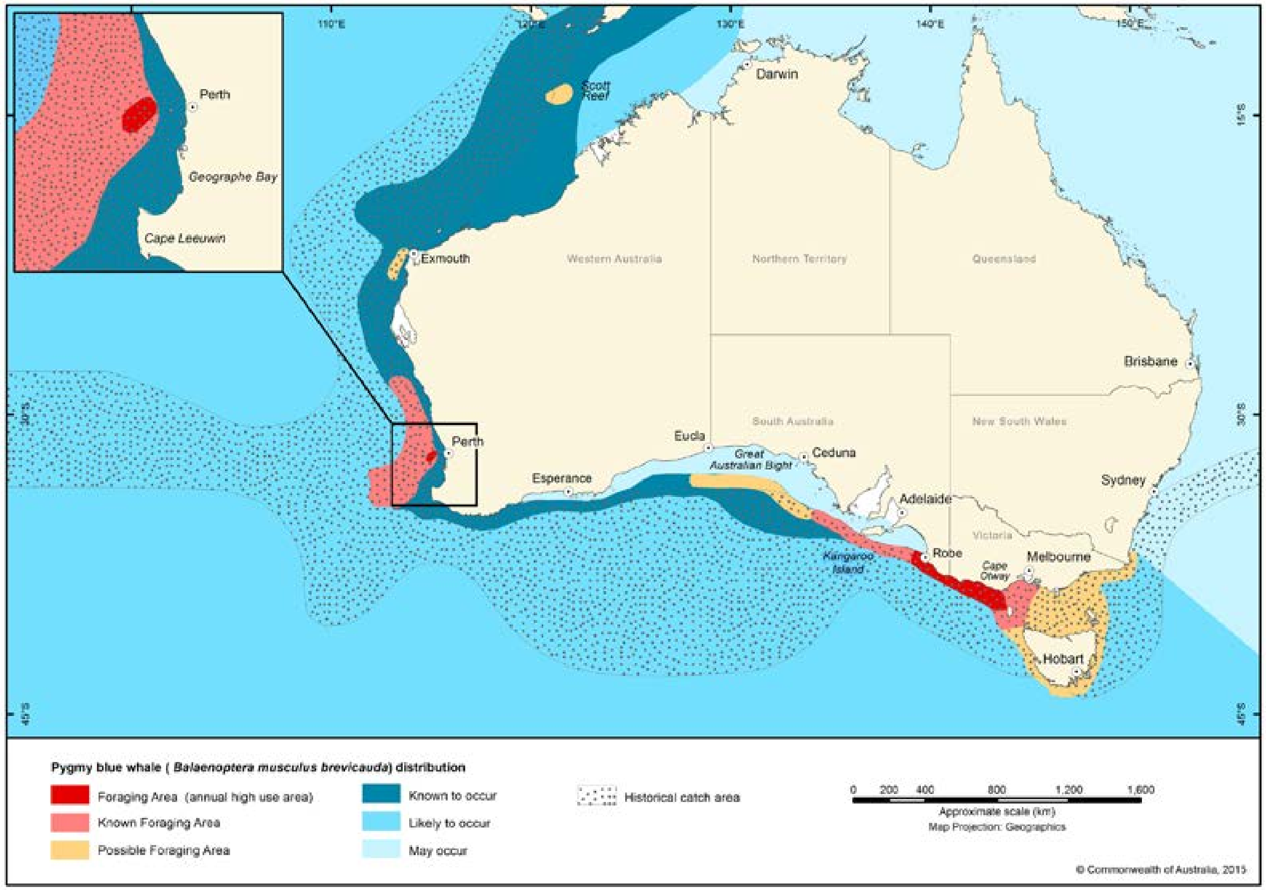
The study undertaken by Brooks et al. (2017), as outlined above, observed that the species was distributed over the entire area surveyed, with sightings in the majority of the available habitats. The study also noted the population was stable and that immigration and emigration of individuals occurred between sites and outside areas (Brooks et al. 2017). It is thought that the movement and ranging patterns of coastal dolphins, such as the Indo-pacific humpback dolphin, in monsoonal northern Australia reflect seasonal influences and spatial and temporal variation in the abundance of prey species (Brooks et al. 2017).

The Indo-pacific humpback dolphin is relevant to the project only in terms of the area of influence as a large unplanned release in the vicinity of the southern end of the gas export pipeline has the potential to overlap a small portion of the biologically important breeding, calving and foraging area in Darwin Harbour and surrounding waters (**Figure 5-14**). Numbers generally tend to be greater within the biologically important area in Darwin Harbour between November and March (DSEWPaC 2012d).

Australian snubfin dolphin

The Australian snubfin dolphin (*Orcaella heinsohni*; formerly known as the Irrawaddy dolphin) shares similar habitat preferences with the Indo-Pacific humpback dolphin, occurring in shallow coastal and estuarine waters (typically less than 20 m deep) (DoEE 2017d). The species has been recorded out to 23 km offshore. In Australia, the species distribution covers the coastal waters of Queensland, NT and north-western Australia. The population in Australian waters is thought to be continuous with the Papua New Guinea species, but separate from populations in Asia. Brooks et al. (2017) noted that the species showed clear evidence of connectivity between the local population of dolphins in Darwin Harbour and those in the surrounding area. While the breeding season in the NT is not defined, the species is understood to mate from April to June at 0°–1° south (Ross 2006, cited in DoEE 2017d). Calves are generally born in August/September following a 14 month pregnancy (DoEE 2017d). Given the preferred coastal range of the species, it is likely that the project may only influence the Australian snubfin dolphin in the event of a major unplanned spill event.

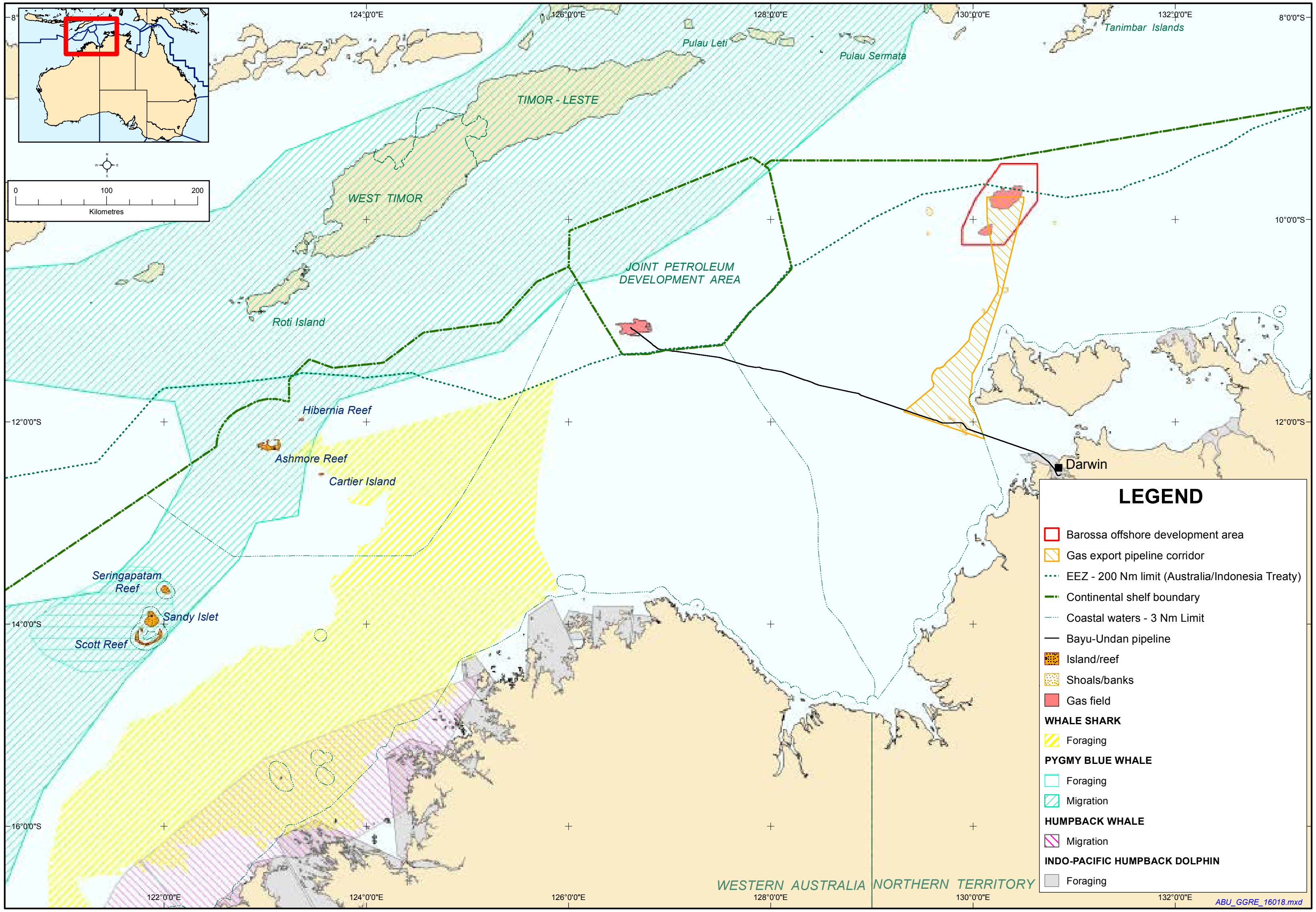
The oceanic species and populations of dolphins that may occur within area of influence are nomadic feeders, in contrast to coastal populations that tend to have defined territories. Therefore, if present, they are likely to transit through the area as opposed to being resident in a defined area for significant periods of time.



Foraging Area (Annual high use area)	Blue whales are regularly observed feeding on a seasonal basis	Known to occur	Blue whales are known to occur based on direct observations, satellite tagged whales or based on acoustic detections
Known Foraging Area	Known foraging occurs in these areas but is highly variable both between and within seasons	Likely to occur	Blue whales are likely to occur based on occasional observations in the area and nearby areas
Possible Foraging Area	Evidence for feeding is based on limited direct observations or through indirect evidence, such as occurrence of krill in close proximity of whales, or satellite tagged whales showing circling tracks. Blue whales travel through on a seasonal basis, possibly as part of their migratory route	May occur	Evidence for the presence of blue whales through strandings or rare observations
		Historical catch area	Blue whales were caught during the whaling period based on whaling data

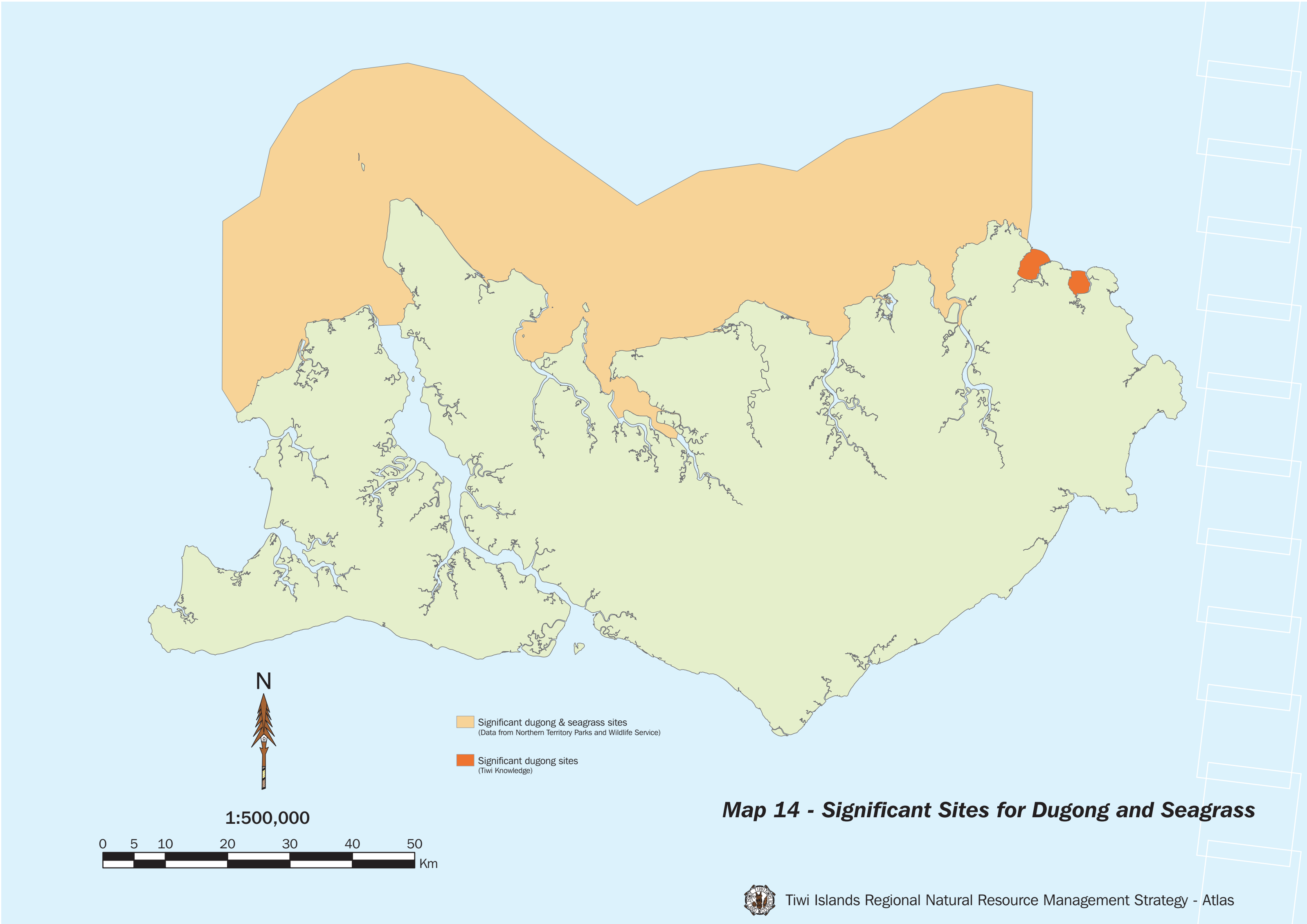
(Source: DoEE 2015a)

Figure 5-13: Pygmy blue whale distribution around Australia



(Source: National Conservation Values Atlas; DoEE 2017c)

Figure 5-14: Biologically important areas for marine mammals and whale sharks



(source: Tiwi Land Council 2017)

Figure 5-15: Significant sites for dugongs and seagrass around the Tiwi Islands

5.6.3 Marine reptiles

5.6.3.1 Regional overview

A range of marine reptiles were identified as potentially occurring or having habitat in the project area and surrounding waters of the Timor Sea. Of these, marine turtles, sea snakes and salt water crocodiles are mostly likely to occur within the project area or the area of influence and are discussed further below.

5.6.3.2 Key values and sensitivities of relevance to the Barossa offshore development area and gas export pipeline corridor

Marine turtles

A search of the EPBC Act Protected Matters database identified six threatened species of marine turtle that may occur in the project area and area of influence (**Section 5.5.1**). The biologically important areas for turtle species in the NMR are shown in **Figure 5-16** (DoEE 2017c).

The Recovery Plan for Marine Turtles in Australia (DoEE 2017a) identifies habitat critical to the survival of the various turtle species. "Habitat critical to the survival of a species" is defined as areas necessary:

- for activities such as foraging, breeding or dispersal
- for the long-term maintenance of the species (including the maintenance of species essential to the survival of the species)
- to maintain genetic diversity and long term evolutionary development
- for the reintroduction of populations or recovery of the species.

The nesting beaches on the Tiwi Islands, and the biologically important internesting buffers surrounding these islands, are considered habitat critical to the survival of flatback turtles (Arafura Sea genetic stock) and olive ridley turtles (NT genetic stock), and has been taken into account in the impact and risk assessment presented in Section 6.

Turtles are oceanic species except at nesting time when they come ashore (DoEE 2017a). The nesting season is species-dependent and varies along the NT coastline in response to the different seasonal conditions. Female turtles also exhibit an internesting phase where they spend 2–3 months in the vicinity of the nesting island (Guinea 2013). During this period, the turtles typically remain in shallow waters close to the nesting beach or rookery while they produce the next clutch of eggs (DoEE 2017a). Turtles do not feed during the internesting period but will rest on the seabed (pers. comm. M. Guinea, CDU, 2015; Plotkin et al. 1994, cited in Whiting et al. 2005). The incubation time between turtle nesting and emergence of hatchlings varies between species, but is generally about 2 months (DoEE 2017a).

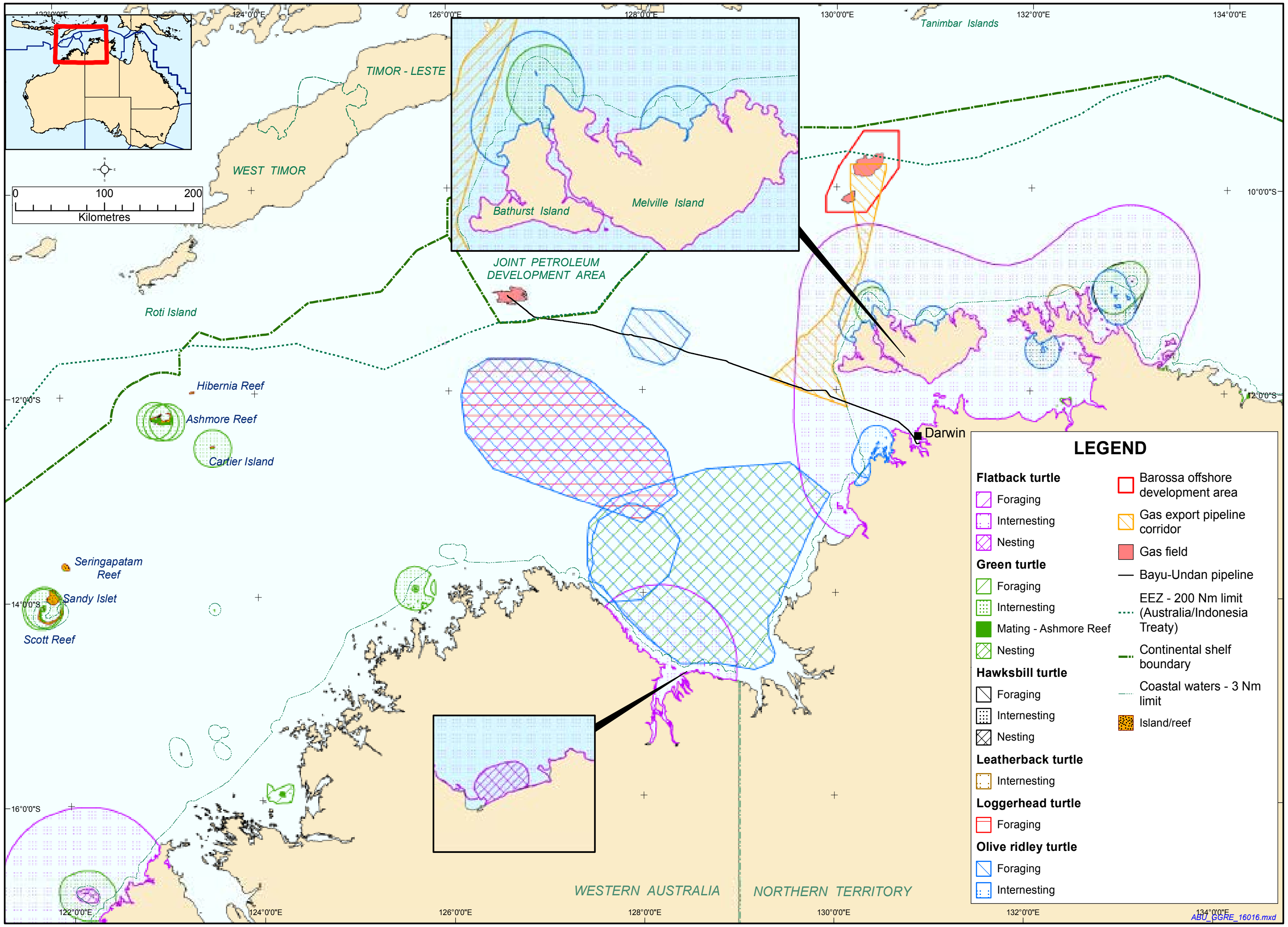
Key aggregation/nesting/feeding areas include:

- The NT coastal region is considered significant for turtle breeding, nesting and feeding aggregations. In particular, the northern coast of Melville Island is a nationally and internationally important nesting area (Chatto and Baker 2008).
- The sandy beaches on the Tiwi Islands, specifically the west coast of Bathurst Island and the north coast of Melville Island, are important, with nesting dominated by flatback turtles (*Natator depressus*; vulnerable) and olive ridley turtles (*Lepidochelys olivacea*; endangered) (Chatto and Baker 2008). Green turtles (*Chelonia mydas*; vulnerable) and hawksbill turtles (*Eretmochelys imbricata*; vulnerable) also nest on the Tiwi Islands, although in smaller numbers.
- Flatback turtles are the most widespread nesting species in the NMR. Flatback turtles nesting within the NT are all from the Arafura Sea breeding area (genetic stock) (DoEE 2017a) and the west coast of Bathurst Island is an important nesting area for flatback turtles (pers. comm. M. Guinea, CDU, 2015). Nesting occurs year round with a peak during June and August (DoEE 2017a).
- Olive ridley turtles nest in nationally significant numbers along the northern coast of the Tiwi Islands (Chatto and Baker 2008). Nesting of the NT genetic stock occurs between February and September, with a peak between April and June (DoEE 2017a).
- Green turtles have not been recorded nesting in the Bonaparte or Van Diemen Gulf bioregions, with the exception of two significant nesting sites; Black/Smith Point and Lawson Island, which are east of the Tiwi Islands and in the vicinity of Cobourg Peninsula (Chatto and Baker 2008). Some nesting has been recorded on the west coast of Bathurst Island (pers. comm. M. Guinea, CDU, 2015). The nesting period varies along the NT coast. However, the Cobourg Peninsula genetic stock of green turtles, which is the closest to the Tiwi Islands, nests between October and April with the peak nesting period occurring between December and January (DoEE 2017a).
- The NT sub-population of the hawksbill turtle is one of the few very large nesting populations remaining in the world, breeding year-round (Chatto and Baker 2008). However, there are no recorded nesting sites along the western NT coast.

[1] It is expected that the National Conservation Values Atlas will be updated in due course to reflect the more recently published recovery plan.

- Biologically important internesting areas for the flatback turtle encompass a large area of nearshore waters between approximately Daly River to the west and Goulbourn Island to the east and surround the entire Tiwi Island coastline (DoEE 2017c; **Figure 5-16**). The National Conservation Values Atlas presents an 80 km internesting buffer around the Tiwi Islands (DoEE 2017c). The Recovery Plan for Marine Turtles in Australia defines the internesting buffer around the Tiwi Islands as 60 km (DoEE 2017a)[1]. However, it has been demonstrated via an extensive study tracking 47 internesting flatback turtles from five different mainland and island rookeries over 1,289 tracking days that flatback females remained in water depths of <44 m, favouring a mean depth of <10 m (Whittock et al. 2016). Whittock et al. (2016) defined suitable internesting habitat as water 0 m–16 m deep and within 5 km–10 km of the coastline, and unsuitable internesting habitat was defined as water >25 m deep and >27 km from the coastline. There is no evidence to date to indicate flatback turtles swim out into deep offshore waters during the internesting period (Pendoley 2017 **Appendix P**). The seabed characteristics off Cape Fourcroy at the south-western tip of Bathurst Island (i.e. narrow continental shelf, steep seabed slope and relatively high current speeds) are not typical of the internesting habitat used by flatback turtles and consequently they are unlikely to inter-nest in the pipeline corridor waters in this area (Pendoley 2017). Further to the north where the continental shelf is wider and slopes more gently offshore, the 10 m deep internesting grounds are located approximately 10 km–20 km inshore of the pipeline corridor. Internesting of the Arafura genetic stock occurs year-round with a peak during June and September (DoEE 2017a). Based on the outcomes of these studies, most of the nesting females in the area are not expected to internest within the pipeline corridor, however, it is possible some individuals will use waters extending into the corridor up to 50 m deep.
- Biologically important internesting areas for the olive ridley turtle and green turtle are known to occur on the north coast of the Tiwi Islands and in the vicinity of Cobourg Peninsula (**Figure 5-16**). The National Conservation Values Atlas and Recovery Plan for Marine Turtles in Australia define an internesting buffer of 20 km from the Tiwi Islands for these turtle species (DoEE 2017a, c). Tracking of two olive ridley turtles nesting on the Tiwi Islands recorded that the individuals remained close to shore (water depths between 45 m–60 m) and within 40 km of the nesting beach during the internesting interval (Whiting et al. 2005). Internesting of the NT genetic stock of olive ridley turtles occurs year round with a peak between April and August (DoEE 2017a). Internesting of the Cobourg Peninsula genetic stock of green turtles occurs between October and April (DoEE 2017a).
- Marine turtles forage predominantly on shallow benthic habitats, either nearshore or at offshore reefs (generally in waters up to approximately 50 m deep), containing seagrass and/or algae, including coral and rocky reefs, and inshore seagrass beds. Benthic habitats at shoals and banks near the project area (described in **Section 5.5.2**), which are present at water depths ranging from 10 m–30 m (at the top of the shoal/bank), represent important foraging grounds for marine turtles.
- The waters of the Joseph Bonaparte Gulf represent a biologically important foraging area for green and olive ridley turtles (DoEE 2017c). Important foraging areas for the olive ridley turtle extend into more open offshore waters, mainly to the north-west in the NWMR (DoEE 2017c). Olive ridley turtles are known to be deep divers and have been recorded in water depths up to 200 m (pers. comm. S. Whiting, DPaW, 2016).
- The biologically important foraging area for flatback turtles, olive ridley turtles and loggerhead turtles (*Caretta caretta*; endangered) in the NWMR offshore from Cape Londonderry (**Figure 5-16**) is known to support a high density of turtles and is considered to extend further to the west than currently mapped on the National Conservation Values Atlas (pers. comm. S. Whiting, DPaW, 2016). The benthic communities in these areas provide high quality feeding habitats (DoEE 2017c).
- Flatback and olive ridley turtles are primarily carnivorous and feed predominantly on soft-bodied invertebrates (DoEE 2017a). Olive ridley turtles have been known to feed in water depths between 15 m and 200 m.
- Green turtles are primarily herbivorous and forage on shallow benthic habitats (in depths < 120 m) containing seagrass and/or algae, including coral and rocky reefs, and inshore seagrass beds (DoEE 2017a).
- Loggerhead turtles have been recorded occasionally offshore from the NT but nesting has not been observed for this species on the coastline (Chatto and Baker 2008; DoEE 2017a). The species is carnivorous and mainly feeds on benthic invertebrates in habitats ranging from nearshore to 55 m in depth (DoEE 2017a).
- Leatherback turtles (*Dermochelys coriacea*; endangered) feed on plankton and jellyfish in oceanic waters around Australia (DoEE 2017a). Small numbers of leatherback turtles nest on Cobourg Peninsula (DoEE 2017a).
- It has been suggested that Evans Shoal may be an important area for turtles (pers. comm. M. Guinea, CDU, 2015).

[1] It is expected that the National Conservation Values Atlas will be updated in due course to reflect the more recently published recovery plan.



(Source: National Conservation Values Atlas; DoEE 2017c)

Figure 5-16: Biologically important areas for marine turtles

Key migratory pathways:

- Most species of turtles are known to migrate large distances between foraging and nesting areas. For example, olive ridley turtles and green turtles are known to migrate up to 1,130 km and 2,600 km respectively between their nesting and foraging grounds (Whiting et al. 2005; DSEWPaC 2012b).
- Flatback turtles that nest within the Pilbara region migrate to their foraging grounds in the Kimberley region along the continental shelf at the end of the nesting season.
- Surveys of green turtle movements after nesting in the Kimberley region show many turtles traveling north to the Tiwi Islands south coast (RPS 2009, cited in URS 2010) and Gulf of Carpentaria in April/May (pers. comm. M. Guinea, CDU, 2015).
- Hawksbill turtles migrate along the Dampier Archipelago and between Scott Reef and the Joseph Bonaparte Gulf.

The Barossa offshore development area does not contain any emergent land or shallow features that may be of importance to nesting or feeding turtles and, therefore, they are unlikely to be present in the area in significant numbers. However, low numbers are likely to transit the area as they move from nesting beaches and offshore areas (pers. comm. M. Guinea, CDU, 2015). For example, flatback turtle hatchlings have been observed in offshore areas in the vicinity of Evans Shoal while hawksbill turtles were discovered aboard an illegal fishing vessel operating at Evans Shoal (pers. comm. M. Guinea, CDU, 2015). A small number of individual turtles, including flatback, olive ridley and hawksbill (juvenile) turtles, were also opportunistically observed during the Barossa marine studies program in both open waters and in close proximity to shoals/banks and Bathurst Island. Increased numbers of marine turtles may transit the southern end of the gas export pipeline given its closer proximity to emergent land or shallow features and there are known biologically important internesting areas surrounding the Tiwi Islands.

Sea snakes

All sea snakes in Australia are listed as protected species under the EPBC Act. A search of the EPBC Act Protected Matters database identified 24 species of sea snake that may occur in, or have potential habitat in the area of influence, with 18 of these species also potentially occurring in the project area. Nineteen species of sea snakes are known to occur in the NMR, with a further nine species potentially occurring (DSEWPaC 2012c).

Key aggregation/feeding areas:

- Sea snakes are typically distributed in shallow inshore regions and islands, which provide suitable seabed habitat and clear waters. However, they are also found at nearby islands and further offshore at atolls, including the shoals/banks in the Timor Sea (Guinea 2013).
- The majority of sea snakes are observed in water depths ranging between 10 m and 50 m deep (RPS 2010) and generally have shallow, benthic feeding patterns. Some species are known to dive deeper than this, but non-pelagic species seldom, if ever, dive deeper than 100 m (Heatwole and Seymour 1975). Very few species are known to inhabit deep pelagic environments, such as those occurring in the Barossa offshore development area, as they are air-breathing (Guinea 2006).
- Distribution and movements of sea snakes are largely species-dependent with some species, such as the pelagic yellow-bellied sea snake, known to travel large distances, while others, such as the olive sea snake, are usually resident in a particular area.
- Sea snake species residing on reefs do not actively disperse or migrate between reefs. Sea snakes are found to be present year-round at most reefs on the Sahul Shelf (Guinea and Whiting 2005).
- For those sea snake species that do migrate between reefs, within their broader home range, migration is thought to be influenced by ocean currents. However, there have been no studies undertaken to date on the migrations of open water sea snake species to determine their home ranges (Guinea 2013).
- Reef dwelling sea snakes appear to have very small home ranges (Guinea 2013).
- Research trawls indicate that the sea snakes move to the southern shallow regions of the Gulf of Carpentaria in the summer months and into deeper water at other times of the year (Redfield et al. 1978, cited in DSEWPaC 2012b).
- Sea snakes are known to breed in shallow embayments along the NT coastline around December-February, with the exception of the spine-bellied sea snake which breeds during June–August (DSEWPaC 2012b).

There have been few surveys undertaken on sea snakes within the NMR, with the majority of the knowledge originating from trawling by-catch. A study by Fry et al. (2001) found that there were four common sea snake species caught as by-catch by the Northern Prawn Fishery; olive-headed sea snake, elegant sea snake, spotted sea snake and spine-bellied sea snake. In addition, a researcher aboard a trawling vessel reported a healthy population of the yellow-bellied sea snakes that was not recorded in the trawl by-catch (Limpus 2001). A study undertaken at Tassie Shoal and five surrounding shoals identified two species of sea snake at the surface and foraging on the seabed: the olive sea snake and the turtle-headed sea snake (CEE 2002). Recent surveys undertaken for the Barossa marine studies program observed several sea snake individuals at Evans Shoal, Tassie Shoal, Lynedoch Bank and a seamount to the west of the Barossa offshore development area. A number of opportunistic sightings (species unknown) were also made in open offshore waters in the Timor Sea. The individuals that could be identified were the olive sea snake and turtle-headed sea snake (Heywood et al. 2015; Jacobs 2016c). A study undertaken at Tassie Shoal and five surrounding shoals identified two species of sea snake at the surface and foraging on the seabed: the olive sea snake and the turtle headed sea snake (CEE 2002).

Two threatened species that may occur in the area of influence are the short-nosed sea snake (*Aipysurus apraefrontalis*; critically endangered) and the leaf-scaled sea snake (*Aipysurus foliosquama*; critically endangered). Neither of these species were identified in the Barossa offshore development area or gas export pipeline corridor search areas.

The short-nosed sea snake and the leaf-scaled sea snake are commonly encountered at Ashmore and Hibernia Reefs, which are located approximately 750 km to the south-west of the Barossa offshore development area. The species prefers the reef flats or shallow waters along the outer reef edge in water depths to 10 m (DSEWPaC 2010a). The species were relatively common in reef surveys undertaken from 1994-1998 but have since become scarce. The species have not been recorded at Ashmore or Hibernia Reefs since the late 1990s and 2001 for the short-nosed sea snake and the leaf-scaled sea snake respectively, despite a fivefold increase in survey effort (DoEE 2017d). The decline of sea snakes at Ashmore Reef is likely multi-faceted and has been attributed to ecosystem degradation due to major coral bleaching events in the 1990s associated with warm ocean water events.

Based on the known distribution, habitat preference and sightings during the Barossa marine studies program, sea snakes are considered likely to transit the project area and area of influence.

Salt-water crocodile

The salt-water crocodile (*Crocodylus porosus*) is a listed migratory species identified as occurring in the project area and the area of influence. Protection of the salt-water crocodile under the EPBC Act is applied to regulate commercial hunting, particularly for the trade in crocodile skins, which has historically resulted in population declines (DoEE 2017d). However, the current export-orientated crocodile industry is regulated and wild populations of the species are not considered threatened (PWSNT 2005). The saltwater crocodile occurs within the nearshore marine and estuarine waters of the Kimberley coast (DoEE 2017d). In the NT most breeding sites are found on river banks or floating rafts of vegetation (DoEE 2017d). While there are no biologically important areas within the project area, such as breeding sites or critical habitat, transient individuals may occur in the shallow near-coast waters in the southern extent of the gas export pipeline corridor.

5.6.4 Birds (seabirds and migratory shorebirds)

5.6.4.1 Regional overview

A number of avifauna species, including seabirds and migratory shorebirds, are known to transit and have habitat within the Timor Sea region, as they range over large geographical areas. The EPBC Protected Matters search identified nine migratory birds as potentially occurring within the project area, two of which were listed as threatened. An additional 40 listed migratory and/or marine bird species (including an additional five threatened species) were identified to potentially occur or have habitat within the area of influence (**Appendix O**).

5.6.4.2 Key values and sensitivities of relevance to the Barossa offshore development area and gas export pipeline corridor

The EPBC Protected Matters search identified nine migratory birds within the project area, two of which were listed as threatened. These species include the curlew sandpiper (*Calidris ferruginea*; critically endangered), eastern curlew (*Numenius madagascariensis*; critically endangered), streaked shearwater (*Calonectris leucomelas*), common noddy (*Anous stolidus*), greater frigatebird (*Fregata minor*), lesser frigatebird (*Fregata ariel*), fork-tailed swift (*Apus pacificus*) (gas export pipeline corridor only), osprey (*Pandion haliaetus*) (pipeline corridor only) and the crested tern (*Thalasseus bergii*) (pipeline corridor only). These species are discussed in detail below.

Through consultation with recognised technical experts, it is noted that the following 15 EPBC Protected species (all listed as migratory marine), in addition to the nine listed above, are likely to also transit the project area on an annual basis; wedge-tailed shearwater (*Ardenna pacifica*), Bulwer's petrel (*Bulweria bulwerii*), Matsudaira's storm-petrel (*Hydrobates matsudairae*), Swinhoe's storm-petrel (*Hydrobates monorhis*), Wilson's storm-petrel (*Oceanites oceanicus*), red-tailed tropicbird (*Phaethon rubricauda*), white-winged black tern (*Chlidonias leucopterus*), bridled tern (*Onychoprion anaethetus*), common tern (*Sterna hirundo*), roseate tern (*Sterna dougallii*), lesser crested tern (*Thalasseus bengalensis*), little tern (*Sternula albifrons*), masked booby (*Sula dactylatra*), brown booby (*Sula leucogaster*) and red-footed booby (*Sula sula*).

No emergent land exists in the shoals or surrounding offshore areas in the vicinity of the Barossa offshore development area to support breeding populations of seabirds or migratory shorebirds. Most migrant birds are unlikely to land on the sea but will pass over the regional area as part of their transitory movements. Therefore, most seabird activity would be restricted to foraging, as opposed to seabird stopover and roosting points during annual migrations due to the absence of landing areas. It is also considered unlikely that migratory bird species would be observed near the sea surface of Tassie Shoal or surrounding shoals, given that there is no emergent land and the shoals are a considerable distance from Ashmore Reef (CEE 2002).

It is noted that seabirds are observed to spend some months at sea without returning to land, while shorebirds more typically do not interact with the sea surface and mostly overfly the area. Migratory wetland species also do not interact with the sea surface, therefore the only point of interaction is the potential for these species to land on infrastructure, especially during inclement weather, while flying between land masses.

Curlew sandpiper

The migratory wetland species of the curlew sandpiper has been recorded along the coasts of all Australian states and territories (DoEE 2017d). The species is also widespread inland, though their appearance is variable and often in small numbers (DoEE 2017d). In the NT, the curlew sandpiper occurs mostly around Darwin, north to Melville Island and Cobourg Peninsula, and east and south-east to Gove Peninsula, Groote Eylandt and Sir Edward Pellew Island (DoEE 2017d). The species most often inhabits intertidal mudflats in sheltered coastal areas species and forage in nearshore waters or mud at the edge of wetlands (DoEE 2017d). The curlew sandpiper does not breed in Australia as they migrate to northern breeding grounds in Siberia. While individuals can remain in northern Australian during the non-breeding season, the curlew sandpiper generally arrives in Australia around late August/early September and departs by mid-April (DoEE 2017d). Given the preferred habitat and feeding habits, the curlew sandpiper is very unlikely to land or interact with offshore waters during its migration over the Timor Sea.

Eastern curlew

The eastern curlew is found in coastal regions across all Australian states and territories and is rarely recorded inland (DoEE 2017c). The species undertakes annual migrations through the East Asian – Australasian Flyway to Russia and north-eastern China to breed and returns to Australia to feed (DoEE 2017d). The eastern curlew generally arrives in northern Australia through July to August and departs between late February and April (DoEE 2017c). In Australia, the species forages mostly on mudflats or sandflats, on saltflats and in sandmarsh, rockpools and among rubble on coral reefs, and on ocean beaches near the tideline (DoEE 2017d). As with the curlew sandpiper, the eastern curlew is very unlikely to land or interact with offshore waters during its migration over the Timor Sea given the species preferred habitat and feeding habits.

Streaked shearwater

The streaked shearwater is a migratory seabird that breeds on islands in the north-west Pacific Ocean near Japan. The bird migrates from this region into the tropical west Pacific during the non-breeding season. In Australia, the streaked shearwater has been recorded from Broome to the Timor Sea, and from Barrow Island to the Houtman Abrolhos Islands. The species has been recorded regularly in northern Australia from October to March, with some records as early as August and as late as May (Marchant and Higgins 1990b, cited in DSEWPaC 2012d). The species is likely to occur in moderate numbers in the project area (pers. comm. R. Clarke, Monash University, 2016).

Common noddy

The common noddy is a migratory seabird species commonly encountered off the north-west and central WA coast and to a lesser extent off the NT coast. During the breeding season, the common noddy usually occurs on or near islands, on rocky islets or on shoals or cays of coral or sand (DoEE 2017d). Individuals generally remain close to the nest (within 50 km), foraging in the surrounding waters (DSEWPaC 2012d). There is only one known breeding location used by the common noddy in the NT, located on Higginson Islet, off Gove Peninsula (Chatto 2001), which is > 500 km from the project area.

Greater frigatebird

The greater frigatebird is widespread and breeds on numerous tropical islands offshore north-western Australia. Biologically important areas for breeding include Adele Island (2–300 pairs) and Ashmore Reef (small numbers). Breeding mostly occurs between March and November. The species occur in the open ocean, although breeding birds forage within 100 km–200 km of the colony during the early stages of the breeding season (DSEWPaC 2012b).

Lesser frigatebird

The lesser frigatebird is usually observed in tropical or warmer waters around the coast of northern WA, the NT, Queensland and northern NSW. The species remains further out to sea during the day and in the inshore waters during rough weather or in the late evening (Chatto 2001). The closest known breeding areas to the project area are on Ashmore Reef and Cartier Island (DSEWPaC 2012b). The lesser frigatebird breeds from March through to September and generally forages close to breeding colonies (DSEWPaC 2012b).

Fork-tailed swift

The fork-tailed swift has been recorded in all Australian states/territories as well as in the Timor Sea, both in open offshore waters and in the vicinity of offshore islands such as Ashmore Reef (Higgins 1999, cited in DoEE 2017d). The species generally arrives in Australia around October and departs by the end of April, is almost exclusively aerial, and does not breed in Australia (DoEE 2017d). The fork-tailed swift does not land or interact with offshore waters during its migration over the Timor Sea (pers. comm. R. Clarke, Monash University, 2016).

Osprey

The osprey is widely distributed throughout Australia and most commonly frequents coastal habitats (including offshore islands) (DoEE 2017d). The species has been observed in a variety of wetland habitats such as inshore waters, reefs and mangrove swamps, and forages in areas where there is an abundance of open fresh brackish or saline water (DoEE 2017d). The osprey breeds from April to February in Australia. The species does not occur in offshore waters, for example no individuals have been observed at Ashmore Reef – a significant site for a large number of migratory bird species – in over 20 surveys (pers. comm. R. Clarke, Monash University, 2016). Considering the osprey is generally resident in Australia, and based on its coastal habitat preference, the species is unlikely to be present in the project area as there is no suitable habitat.

Crested tern

The crested tern is widespread and numerous along the NT coastline, with 20 breeding colonies reported (DSEWPaC 2012a). The majority of these colonies are on small islands and support over 5,000 birds. The colony on Seagull Island, off the north-west coast of Melville Island, supports over 50,000 birds and is considered globally significant (DSEWPaC 2012a). The species forages in a range of habitats including shallow waters of lagoons, coral reefs, bays, harbours, inlets and estuaries; along shorelines; rocky outcrops in open sea; in mangrove swamps; and in offshore and pelagic waters (Higgins and Davies 1996, cited in DSEWPaC 2012d). Non-breeding aggregations of the crested tern are present all year round in the NMR, with breeding occurring consistently between March and July on the NT coastline (DSEWPaC 2012d).

A BIA for the crested tern has been designated at the northern tip of Melville Island, including a 20 km buffer from the breeding shoreline of Seagull Island noted as a foraging zone (DoEE 2017c). The primary breeding period on the island occurs between April and July.

5.6.4.3 Offshore islands

As outlined above, 40 migratory and/or marine bird species as potentially occurring or having habitat within the area of influence.

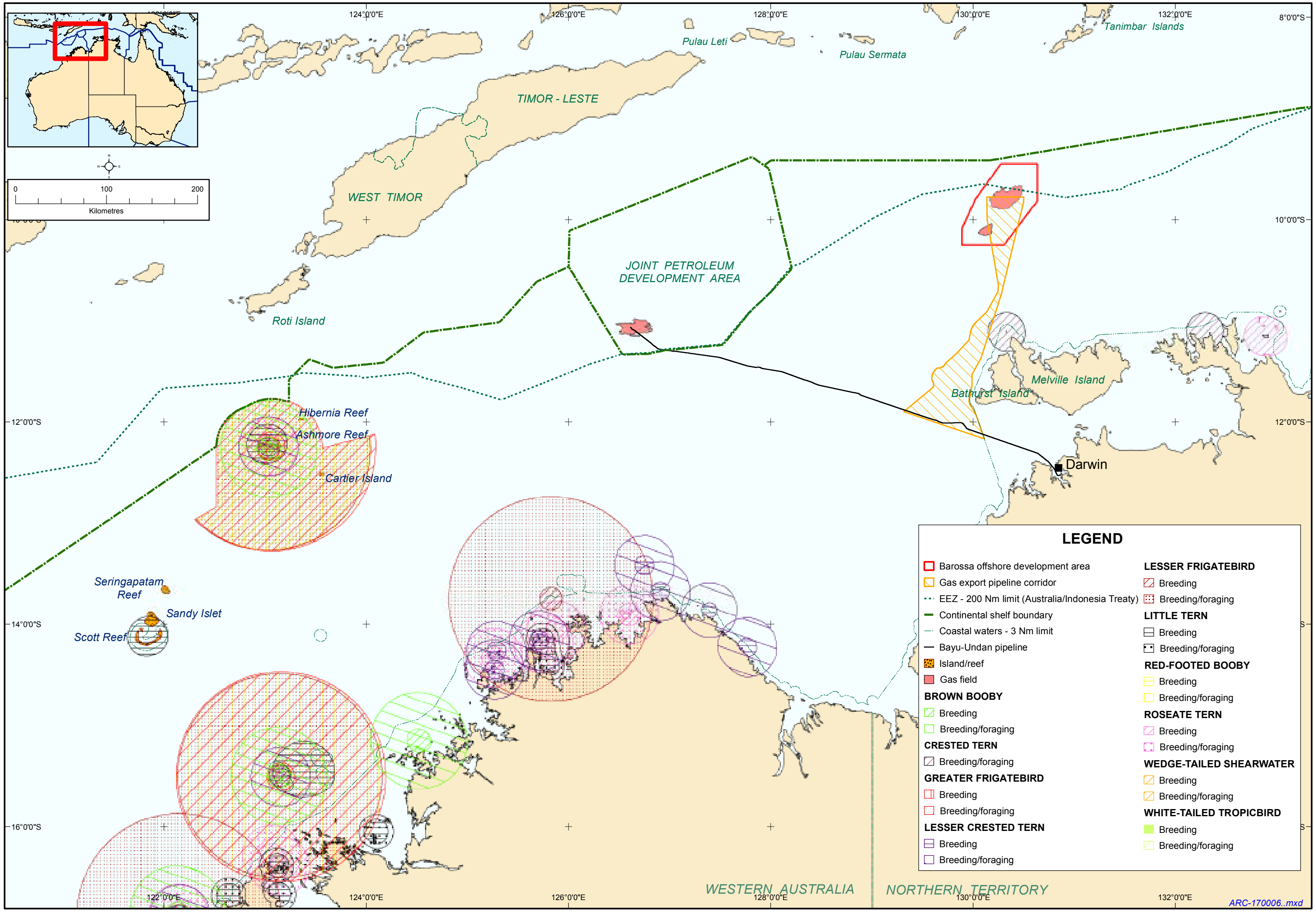
The Tiwi Islands, and small islands in the vicinity, support a large number of seabirds and migratory shorebirds. Refer to **Section 5.5.4** for further detail.

There are a few notable offshore island locations within the area of influence that support important seabird (e.g. terns, shearwaters, boobies, frigatebirds, noddy's and tropicbirds) and shorebird (e.g. sandpipers, barn swallow and greenshanks) feeding, breeding and nesting sites including Ashmore Reef and Cartier Island (Clarke 2010). There are also a number of BIAs for seabirds within the area of influence, as summarised in **Table 5-5** and shown in **Figure 5-17**.

Numbers of migratory shorebirds are highest between October and April, though large numbers of shorebirds are present year round as many species 'over winter' in their first years of life (Higgins and Davis 1996). The extensive sand flats exposed at low tide provide foraging opportunities for internationally significant species including the grey plover and sanderling (Swann 2005a, 2005b).

Table 5-5: BIAs for seabirds within the area of influence

Seabird species	BIA	General location(s)
Brown booby (*Sula leucogaster*)	Breeding/foraging	Ashmore Reef, Cartier Island, WA (Kimberley) coastline
Red-footed booby (*Sula sula*)		Ashmore Reef, Cartier Island, WA (Kimberley) coastline and adjacent offshore islands
Greater frigatebird (*Fregata minor*)		
Lesser frigatebird (*Fregata ariel*)		
Lesser crested tern (*Thalasseus bengalensis*)	Breeding	Ashmore Reef, Cartier Island, WA (Kimberley) coastline Through consultation with technical experts it is understood that this represents an error in existing literature. The lesser crested tern is mostly an inshore species and does not occur at Ashmore Reef of Cartier Islands (pers. comm. R. Clarke, Monash University, 2016).
Little tern (*Sternula albifrons*)	Breeding and resting	Breeding – WA (Kimberley) coastline Resting – Ashmore Reef Most individuals in offshore waters are migrants from Japan, however breeding birds from the Australian mainland also occur (pers. comm. R. Clarke, Monash University, 2016).
Roseate tern (*Sterna dougallii*)	Breeding	Ashmore Reef, WA (Kimberley) coastline
Wedge-tailed shearwater (*Ardenna pacifica*)	Breeding/foraging	Ashmore Reef, Cartier Island
White-tailed tropicbird (*Phaethon lepturus*)	Breeding	



(Source: National Conservation Values Atlas; DoEE 2017c)

Figure 5-17: Biologically important areas for seabirds

5.6.5 Fish

5.6.5.1 Regional overview

Fish communities occupy a range of habitats and play an important ecological role with many species being of conservation value and importance for commercial and recreational fishing.

The current state of knowledge of fishing activities in a socio-economic and indigenous use context is discussed further in **Section 5.7.12** and **Section 5.7.13**.

A search of the EPBC Act Protected Matters database identified 35 fish species that may occur or have habitat in the project area (**Appendix O**). The whale shark (*Rhincodon typus*) is the only one of these species considered threatened (vulnerable) and migratory. The remaining 34 listed marine species are ray-finned fishes and are either pipefish or seahorses (family Syngnathidae). These species may pass through the offshore waters of the project but are more likely to be associated with the shallow waters around the nearby shoals/banks (**Section 5.5.2**) and close to the NT coastline where benthic communities provide suitable shelter and foraging habitats.

5.6.5.2 Key values and sensitivities of relevance to the Barossa offshore development area and gas export pipeline corridor

Whale shark

Whale sharks (*Rhincodon typus*; vulnerable) are the largest species of fish in the world (DoEE 2017d). In Australia, whale sharks occur mainly off WA, particularly within the Ningaloo Marine Park. However, they are also known to occur off NSW, Queensland, NT, and occasionally South Australia, Victoria and Christmas Island, although records are limited (Compagno 1984; Last and Stevens 1994, in Pogonoski et al. 2002; Norman 1999). Whale sharks are known to be highly migratory, with studies demonstrating migrations of at least 13,000 km over 37 months (Eckert and Stewart 2001). Long-term information on the movement and distribution of whale sharks in Australia is limited (DPaW 2013), and is mostly centred on individuals recorded off the Ningaloo Marine Park and, therefore consistent migration pathways are yet to be identified.

The conservation advice for the whale shark highlights the 200 m isobath along the northern part of the WA coast as an important migration route, with migration occurring mainly between July and November (DoE 2015i). Whale sharks demonstrate aggregation patterns that are most likely associated with oceanographic features, including areas of upwelling and high productivity (Eckert and Stewart 2001). Whale sharks aggregate seasonally in coastal waters off the Ningaloo Marine Park between March and July each year, with the highest frequency of sightings occurring in April. Whale sharks are highly migratory and generally depart Ningaloo Reef sometime between May and June, travelling north-east along the continental shelf and then moving offshore into the north-eastern Indian Ocean (DEH 2005). The timing of this aggregation has been reported to coincide with the high levels of productivity associated with annual coral spawning, resulting in an increased planktonic biomass and a more active food chain in the waters adjacent to the Ningaloo Reef (Taylor 1996). Seasonal aggregation areas are also known in coastal waters off Christmas Island (between December and January) and in the Queensland Coral Sea (between November and December) (DEH 2005). A biologically important foraging area is recognised in open waters off the Kimberley coast (**Figure 5-15**; DoEE 2017c).

Due to their widespread distribution and highly migratory nature, whale sharks may occur — albeit in very low numbers — in the Barossa offshore development area and northern end of the gas export pipeline. There are no areas of biological importance recognised in the NMR for this species.

Other fish species

The Barossa offshore development area and gas export pipeline are likely to support offshore pelagic and demersal fish assemblages which are typical of those found in the NMR.

Although the tropical waters off the NT coast contain a diverse range (approximately 1,400 species) of fish with tropical Indo-West Pacific affinities, fish abundance is considered low in the deep, relatively featureless waters that characterise the Barossa offshore development area and surrounds. Approximately 20 types of ray-finned fish have been observed in the Barossa offshore development area in varying densities and diversities (Jacobs 2016c).

The shoals and banks located within, or in close proximity to, the gas export pipeline corridor (e.g. Goodrich Bank, Marie Shoal and Shepparton Shoal) are likely to attract a diverse range of fish species. It is expected that similar fish species to those described below surrounding Evans Shoal and Tassie Shoal will be present (**Section 5.6.5.3**).

5.6.5.3 Fish communities – Evans Shoal and Tassie Shoal

Detailed characterisation of the fish communities associated with Evans Shoal and Tassie Shoal was undertaken by AIMS in conjunction with the survey of benthic habitats (Heyward et al. 2017). The survey of fish community structure and abundance was conducted utilising SBRUVSs, which were deployed at 95 locations (72 at Evans Shoals and 23 at Tassie Shoal).

A total of 7,256 fish from 300 species were recorded and included a diverse range of demersal and semi-pelagic fishes, eels, sharks and rays (Heyward et al. 2017). The majority of the individual fish observed (approximately 91%), and consequently the most commonly recorded species (261 species), were perch-like fishes (Order Perciformes). The next most common fish were puffer and triggerfish (Order Tetraodontiformes) and herrings (Order Clupeiformes), which accounted for approximately 6% and 3% of individuals observed, respectively. It was noted that fish abundance was influenced most by the presence of any epibenthos on the seafloor and by calcareous reef composition of the substratum (Heyward et al. 2017).

Tassie Shoal displayed a higher diversity of fish when compared to Evans Shoal. Tassie Shoal was observed to support an average of 32 fish species while Evans Shoal was observed to support an average of 14 fish species (Heyward et al. 2017). The diversity and abundance was observed to decrease with increasing depth at both shoals, which is to be expected.

Heyward et al. (2017) commented that Tassie Shoal supported consistently high fish diversity and abundance that was similar to or greater than other shoals and reefs at similar depths around Australia, which had been surveyed by AIMS. For example, the closest shoals for comparison are the Margaret Harries Banks, which have been observed to support an average of 18–26 fish species (Heyward et al. 2017). The shoals surveyed in response to the Montara incident recorded an average of approximately 23 fish species. To provide context at an Australia-wide level, studies of the shoals of the Great Barrier Reef have recorded an average of 17 fish species (Heyward et al. 2017). AIMS suggested that the high diversity and abundance of fish observed at Tassie Shoal may be the result of the shoal's proximity to Indonesian fauna residing on the other side of the Timor Trench.

While no fish species listed under the EPBC Act were sighted during the AIMS survey, three of the species represent new records for Australia: undescribed emperor (*Lethrinus species*; not yet classified in scientific literature), and two parrotfish known to occur in Indonesia – yellowtail parrotfish (*Scarus hypselopterus*) and darktail parrotfish (*Scarus fuscodorsalis*).

The fish community comprised both shelf-based species normally found on reefs and some "oceanic" species, such as the spotted oceanic triggerfish (Heyward et al. 2017). Some commercially targeted fish species were recorded in low numbers in deeper waters and included the red emperor and goldband snapper. Heyward et al. (2017) commented that the numbers of large fish observed at the shoals were lower than expected for such habitats. This, in conjunction with the bait-shy behaviour displayed by the large-bodied cods, snappers and emperors, is consistent with fish communities exposed to both legal (regulated) and illegal (unregulated) trap and line fishing.

5.6.6 Sharks and rays

5.6.6.1 Regional overview

A search of the EPBC Act Protected Matters database identified 11 listed threatened/migratory shark/ray species that may occur in or have habitat in the area of influence. Of these total species, the shark/ray species listed as threatened (including four which are also listed as migratory) were the great white shark (*Carcharodon carcharias*; vulnerable), speartooth shark (*Glyphis glyphis*; critically endangered), northern river shark (*Glyphis garricki*; endangered), green sawfish (*Pristis zijsron*; vulnerable), largetooth sawfish (*Pristis*; vulnerable) and dwarf sawfish (*Pristis clavata*; vulnerable). The listed migratory species of shark/rays that may occur within the area of influence include the narrow sawfish (*Anoxypristis cuspidata*), longfin mako (*Isurus paucus*), shortfin mako (*Isurus oxyrinchus*), reef manta ray (*Manta alfredi*) and giant manta ray (*Manta birostris*). While not identified in the EPBC protected matters search, the grey nurse shark (*Carcharias taurus*; critically endangered/vulnerable) was observed during the Barossa marine studies program at a seamount approximately 18 km to the west of the Barossa offshore development area (**Section 5.5.5**).

There are no areas of biological importance recognised in the NMR for any of the shark species identified.

5.6.6.2 Key values and sensitivities of relevance to the Barossa offshore development area and gas export pipeline corridor

Great white shark

The great white shark (*Carcharodon carcharias*; vulnerable) is not known to have significant populations with regular migratory routes or breeding/foraging aggregations in the project area. Although the offshore waters of the Timor Sea are typically outside their preferred habitat of inshore reefs and shallow coastal bays, individuals are known to make open ocean excursions of several hundred kilometres and can cross ocean basins (e.g. from South Africa to the western coast of Australia) (Weng et al. 2007). No EPBC listed critical habitat or BIAs for great white sharks has been identified within the project area and area of influence.

Sightings of great white shark within the project area are not expected to be common. Their presence is likely to be limited to infrequent individuals transiting the broader marine environment, such as the area of influence.

Mako

The shortfin mako (*Isurus oxyrinchus*; migratory) and the longfin mako (*Isurus paucus*; migratory) are offshore epipelagic species found in tropical and warm-temperate waters. Both species occur in Australia in coastal waters off WA, NT, Queensland and NSW (DoEE 2017d) at depths ranging from shallow coastal waters to at least 500 m (Groeneveld et al. 2014). These species may migrate through the project area, particularly the southern end of the export pipeline corridor, and area of influence.

Speartooth shark and northern river shark

Within Australia, speartooth (*Glyphis glyphis*; critically endangered) and northern river sharks (*Glyphis garricki*; endangered) have predominantly been recorded in tidal rivers and estuaries in north and north-western Australia (DSEWPaC 2012e). The Commonwealth Recovery Plan for sawfish and river sharks identifies the primary habitat of speartooth sharks as large tropical river systems, with the majority of individuals inhabiting the tidal and estuarine sections of these rivers (DoE 2015j). Speartooth sharks have been found in all five river systems that flow into the Van Diemen Gulf in the NT (DoE 2015j). Based on physiological and life history similarities with bull sharks, it is assumed that adult speartooth sharks can also inhabit coastal waters (Stevens et al. 2005; Pillans et al. 2009, cited in DoE 2015j). While the life-cycle characteristics of the speartooth shark are largely unknown, pupping is thought to occur around October to December (Pillans et al. 2010, DSEWPAC 2012e).

The northern river shark appears to favour habitats that experience large tides (e.g. rivers, large tropical estuarine systems and macrotidal embayments), have fine muddy/silty substrates and high turbidity (DoE 2015j). The species also utilises inshore and offshore marine waters (DoE 2015j). Only adults have been recorded in marine environments while neonates, juveniles and sub-adults have been recorded in freshwater, estuarine and marine waters (DoE 2015j). Little is known about the breeding cycles, however limited observations suggest that northern river sharks give birth immediately before the wet season (around October) (Pillans et al. 2010, cited in DSEWPAC 2012e).

Based on the habitat preferences of these species and the location of the Barossa offshore development area and northern extent of the gas export pipeline (i.e. deep offshore marine environment), it is considered highly unlikely that speartooth or northern river sharks will occur within these areas in significant numbers. However, they may be found in the vicinity of the southern end of the gas export pipeline or within the area of influence in northern coastal waters.

Sawfish

Green sawfish (*Pristis zijsron*; vulnerable) are widely distributed in Australian waters and have been recorded in inshore marine waters, estuaries, river mouths, embayments and along sandy and muddy beaches (DoE 2015j). While the species has predominantly been recorded in inshore coastal areas, it has been recorded hundreds of kilometres offshore in relatively deep waters (up to 70 m) (Stevens et al. 2005). Short-term tracking of movement patterns has shown that green sawfish appears to have limited movements that are tidally influenced, and it is likely to occupy a restricted range of only a few square kilometres in the coastal fringe, with a strong association with mangroves and adjacent mudflats (Stevens et al. 2008). Pupping is thought to occur during the wet season (Peverell 2005, cited in DSEWPAC 2012e).

Largetooth sawfish (*Pristis pristis*; vulnerable) have been recorded in both inshore marine waters (including rivers and estuaries) and offshore waters up to 100 km from mainland Australia (DoE 2015j). Only adult largetooth sawfish have been observed in offshore waters, with records limited (DoE 2015j). In general, largetooth sawfish (particularly juveniles) appear to prefer sandy or muddy bottoms of shallow coastal waters, estuaries and river mouths, and the central and upper reaches of freshwater rivers and isolated water holes (DoE 2015j). As with the green sawfish, pupping is believed to occur during the wet season (DSEWPaC 2012a).

The dwarf sawfish (*Pristis clavata*; vulnerable) is considered to extend from the Pilbara coast in WA across northern Australia and into the Gulf of Carpentaria (Last and Stevens 1994; Stevens et al. 2008). The species generally inhabits shallow (2 m–3 m) coastal waters and estuarine habitats (DoE 2015j). The species breeds in estuarine or fresh waters during the wet season, with the adults then tending to move into marine waters (Peverell 2005 in Larson et al. 2006, cited in DSEWPAC 2012e). While it is unclear how far adults travel offshore, it is considered likely they inhabit a range within the coastal fringe of only a few square kilometres and display site fidelity (Stevens et al. 2008).

Narrow sawfish (*Anoxypristis cuspidata; migratory*) have been recorded in inshore marine or brackish waters in water depths up to 40 m (Great Barrier Reef Marine Park Authority 2012). While limited information is available on the narrow sawfish, it is thought that the species preferred habitat is on or near the seabed in shallow coastal waters and estuaries (Great Barrier Reef Marine Park Authority 2012). The distribution of the species in Australian waters is unknown, however, it is most common in the Gulf of Carpentaria with southward ranges extending to Broad Sound (Queensland) and the Pilbara coast (WA) (Great Barrier Reef Marine Park Authority 2012). Pupping is understood to coincide with the wet season (DSEWPaC 2012a).

Based on the habitat preferences of sawfish and the location of the Barossa offshore development area and northern extent of the gas export pipeline corridor (i.e. deep offshore marine environment), it is considered highly unlikely that sawfish will occur within these areas. However, they may be found within the southern end of the gas export pipeline corridor or area of influence in coastal waters off northern Australia.

Grey nurse shark

The grey nurse shark (*Carcharias taurus*) was not identified in the EPBC Protected Matters search but was recorded at a seamount approximately 18 km west of the Barossa offshore development area during the Barossa marine studies program (Jacobs 2016c). There are two known distinct populations of grey nurse sharks in Australia:

- East coast population: occurs from southern Queensland to southern NSW, with aggregations occurring at a number of reefs along the coastline. It is listed as critically endangered under the EPBC Act (DoEE 2017d).
- West coast population: occurs predominantly in the south-west coastal waters of WA (sub-tropical to cool temperate waters), however, the species has been recorded as far north as the North West Shelf (DoEE 2017d). It is listed as vulnerable under the EPBC Act.

It is unknown whether the individuals observed during the Barossa marine studies program would be linked to the east or west coast populations, or another discrete population.

The species is believed to be rare off the NT (Last and Stevens 1994) and has only been caught on one occasion in the Arafura Sea (Read and Ward 1986). In 2015 it was reported that four grey nurse sharks (three females and one male) were caught by local fishermen in the vicinity of Browse Island (approximately 800 km south-west of the Barossa offshore development area); representing the first known catches in the area (Momigliano and Jaiteh 2015).

While there is relatively little information about the grey nurse sharks' behaviour in Australian waters, the species is often observed in demersal waters above the seabed or near deep sandy-bottomed rocky caves, in the vicinity of inshore rocky reefs and islands (Otway and Parker 2000). It has been observed that at certain times of the year they appear to aggregate according to sex. For example, observational records indicate that females migrate southerly from central to south NSW and meet at aggregation hotspots, before returning to more northerly habitats (Otway and Parker 2000). It is also thought that the migration of sharks up and down the east coast is likely to be in response to water temperatures. Other observations from dive charter operations in NSW suggest that the species exhibits some degree of site fidelity as they regularly see grey nurse sharks in the same locations (Pollard et al. 1996). However, other studies along the WA coast suggest that individuals may not be restricted to particular localities or habitats (Chidlow et al. 2006). From this, it has been suggested that the west coast population may not aggregate to the same degree or in the same areas/habitat types as the east population (Chidlow et al. 2006).

Based on the findings of the Barossa marine studies program and the species' habitat preference, it is considered possible that individuals may be encountered in low numbers within the project area and area of influence.

Rays

The reef manta ray (*Manta alfredi*) is commonly sighted in or along productive nearshore environments, such as island groups, atolls or continental coastlines (IUCN 2015). However, the species has also been recorded around offshore coral reefs, rocky reefs and seamounts. Long term sighting records suggest that this species is mostly resident to tropical and subtropical waters (IUCN 2015). Individuals have been documented making seasonal migrations of several hundred kilometres between well-established aggregation sites (IUCN 2015).

The giant manta ray (*Manta birostris*) is common in tropical waters of Australia and primarily inhabits nearshore environments along productive coastlines with regular upwelling. However, they do appear to be seasonal visitors to coastal or offshore areas (e.g. islands, pinnacles and seamounts) (IUCN 2015).

The Barossa offshore development area is not located in or adjacent to any known key aggregation areas for these species (e.g. feeding or breeding). Based on the habitat preference of these species of rays and the location of the Barossa offshore development area (i.e. deep offshore marine environment with no significant benthic features), it is considered highly unlikely they will occur in significant numbers and would be restricted to individuals transiting through the area. However, they may be found within the southern extent of the gas export pipeline corridor given its proximity to coastal areas and the area of influence in the coastal waters of the north Kimberley.

5.7 Socio-economic and cultural environment

5.7.1 World Heritage properties

There are no World Heritage properties in, or in the immediate surrounds of, the project area. The nearest World Heritage Site is Kakadu National Park, which is approximately 315 km to the south-east of the Barossa offshore development area. While the majority of this site encompasses the NT mainland, the National Park includes the mangrove-fringed coast from Wildman River to East Alligator River and offshore islands of Barron Island and Field Island in the Van Diemen Gulf (DoEE 2017h).

Given the significant distance of the project from Kakadu National Park, and taking into consideration the modelling undertaken to inform this OPP (**Section 6.4.10**), no impacts to this value/sensitivity are anticipated. Therefore, World Heritage properties are not considered further in this OPP.

5.7.2 National Heritage places

There are no National Heritage properties in, or in the immediate surrounds of, the project area (DoEE 2017i). While significantly distant from the project area, the Ashmore Reef and Cartier Island National Nature Reserve (listed on the Register of National Estate; place identification: 14689), which is approximately 730 km south-west of the Barossa offshore development area, is within the area of influence. The reserve is a declared National Nature Reserve and Marine Protected Area under the EPBC Act, for the following features of nature conservation significance:

- Ashmore Reef has a rich and diverse marine life; specifically, the reef:
  - provides significant breeding and feeding habitat for marine turtles
  - is considered to have the world's greatest abundance and diversity of sea snakes
  - is an important seabird rookery and provides an important staging/feeding area for many migratory seabirds
  - provides breeding and feeding habitat for a small dugong population (< 50 individuals).
- Cartier Island and the surrounding waters support important seabird rookeries, many species of which are migratory and have their main breeding sites on the small isolated islands. The islands are also an important staging point and feeding area for numerous migratory seabirds. The island supports significant populations of feeding and nesting marine turtles and a high abundance and diversity of sea snakes.

5.7.3 Commonwealth Heritage places

The project is not located in, or in the immediate surrounds of, any Commonwealth Heritage places. While significantly distant from the project area, the Seringapatam Reef and Surrounds (place identification: 17567) and Scott Reef and Surrounds (place identification: 105480) Heritage places are located approximately 960 km and approximately 970 km, respectively, to the south-west of the Barossa offshore development area and are within the area of influence (**Figure 5-9**). These Heritage places are regionally important for the following features of conservation significance (DoEE 2017i):

- regionally important in terms of their high diversity of marine fauna, including corals, fish and marine invertebrates
- physical characteristics of the reefs create environmental conditions which are rare for shelf atolls, including clear deep oceanic water and large tidal ranges that provide a high physical energy input to the marine ecosystems
- high representation of species not found in coastal waters off WA and for the unusual nature of their fauna which has affinities with the oceanic reef habitats of the Indo-West Pacific, as well as the reefs of the Indonesian region.

The area of influence also encompasses a portion of the Commonwealth Heritage place of the Ashmore Reef National Nature Reserve (place identification: 105218), which is described above in **Section 5.7.2**.

5.7.4 Declared Ramsar wetlands

There are no "Wetlands of International Importance" under the Convention on Wetlands of International Importance (Ramsar 1975) in, or in the immediate surrounds of, the project area. However, the area of influence encompasses Ashmore Reef, which is located approximately 750 km south-west of the Barossa offshore development area. Ashmore Reef was designated as a Ramsar wetland due to its importance in providing a resting place for migratory shorebirds and supporting large seabird breeding colonies (DoEE 2017j). A summary of the key ecological character of the Ashmore Reef Ramsar site, as outlined by Hale and Butcher (2013), are provided in **Table 5-6**.

Table 5-6: Summary of ecological character of the Ashmore Reef Ramsar site

Component	Description
Marine flora	Five species of seagrass recorded with *Thalassia hemprichii* dominant, comprising over 85% of total cover. Total cover of 470 ha of seagrass, but much of this is sparse and there is only 220 ha with a mean cover of >10%. Over 3,000 ha of macroalgae, mostly on the reef slope and crest areas. Algae dominated by turf and coralline algae with fleshy macroalgae comprising typically less than 10% of total algal cover.
Marine invertebrates	275 species of hard coral, covering an area of around 700 ha. 39 taxa of soft coral, covering an area of around 300 ha. Over 600 species of mollusc, including two endemic species. Over 180 species of echinoderm, including 18 species of sea cucumber. Sea cucumber density is highly variable, but on average exceeds 30 per hectare. 99 species of decapod crustacean.
Fish	Over 750 species of fish, including five species listed as threatened (squaretail leopard grouper (*Plectropomus areolatus*; vulnerable); humphead wrasse (*Cheilinus undulates*; endangered); humpback grouper (*Cromileptes altivelis*; vulnerable); green humphead parrotfish (*Bolbometopon muricatum*; vulnerable) and blacksaddled coral grouper (*Plectropomus laevis*; vulnerable). Three species of shark listed as threatened (snaggletooth shark (*Hemipristis elongate*; vulnerable), scalloped hammerhead (*Sphyrna lewini*; endangered) and squat-headed hammerhead (*Sphyrna mokarran*; endangered). Predominantly shallow water, benthic taxa that are common throughout the Indo-Pacific. Density of small reef fishes is around 20,000 to 40,000 per hectare. Low density of sharks (< 1 per hectare).
Sea snakes	Prior to listing there was a high diversity and population, peaking in 1998 with an estimated total population of 40,000 snakes at the site. However, by the time of listing in 2002 the site was on a trajectory of decline and diversity and abundance was low.

Component	Description
Turtles	Three species of marine turtle: green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and loggerhead (*Caretta caretta*), all of which are listed threatened species. Green turtles are the most abundant, with a total estimated population of around 10,000. Nesting by two species: green turtles and hawksbill turtles.
Seabirds and Shorebirds	72 species of wetland dependent birds recorded, with 47 species listed under international migratory agreements. Average of around 48,000 seabirds and shorebirds annually. Six species are regularly recorded in numbers >1% of the population. Nesting of 20 species, 14 of which regularly breed in the site.
Dugongs	Small but significant population, that may breed within the site.

The nearest Ramsar site to the project area is the Cobourg Peninsula, which encompasses an area of 220,700 ha (DoEE 2017j). The site is located approximately 200 km south-east of the Barossa offshore development area (**Figure 5-19**) and approximately 176 km south-east of the gas export pipeline corridor at its closest point. Taking into consideration the modelling undertaken to inform this OPP and the project's area of influence, there is no risk of interaction with this Ramsar site. The Cobourg Peninsula Ramsar site boundary aligns with the Garig Gunak Barlu National Park boundary, and covers all wetlands of Cobourg Peninsula and nearby islands. The site includes freshwater and extensive intertidal coastal/marine ecosystems (such as dune communities, fringing coral reefs, rocky reefs/shores, sandy beaches, mudflats/saltflats, mangroves and seagrass communities), but excludes subtidal areas (DoEE 2107j). The site provides nesting habitat for marine turtles (green, flatback, leatherback, hawksbill, olive ridley and loggerhead turtles), and habitat for dugongs and several cetaceans, including the Australian snubfin dolphin, Indo-Pacific bottlenose dolphin, Indo-Pacific humpback, and the false killer whale (DoEE 2107j). The site also supports significant waterbird (seabird) breeding colonies and important feeding/nesting habitat for migratory shorebirds travelling along the East Asian Australasian Flyway (DoEE 2107j). Permanent billabongs and river channels provide dry season refugia for aquatic species as well as water-dependent terrestrial vertebrate species (e.g. birds, reptiles and frogs).

5.7.5 Commonwealth marine area

The project is located within the Commonwealth marine area, which includes *"any part of the sea, including the waters, seabed and airspace, within Australia's exclusive economic zone and/or over the continental shelf of Australia, that is not state or NT waters. The Commonwealth marine area stretches from three to 200 nautical miles from the coast"* (DoEE 2017k). The southern end of the gas export pipeline corridor is in close proximity to the NT coastal waters boundary (**Figure 1-1**).

5.7.6 Commonwealth marine reserves

The Barossa offshore development area is not located within the CMRs which form part of the North CMR network (**Figure 5-18**). The Oceanic Shoals CMR is the closest marine reserve and is located approximately 10 km south of the Barossa offshore development area.

The gas export pipeline corridor traverses the Oceanic Shoals CMR, which is one of eight reserves within the North CMRs network covering an area of 71,744 km^2. The Oceanic Shoals CMR is designated as entirely Multiple Use Zone (IUCN category VI) (DoEE 2017l). However, as discussed in **Section 3.5.2** the independent review of the CMRs networks has recommended changes to the zoning within the reserve and a draft management plan is currently being prepared. The CMR area has a number of conservation values; specifically, it provides an important resting and internesting area for the flatback and olive ridley turtles, and an important foraging area for loggerhead and olive ridley turtles (DoEE 2017l). The CMR also includes examples of ecosystems of two provincial bioregions (the Northwest Shelf Transition Province (which includes the Bonaparte, Oceanic Shoals, and Tiwi meso-scale bioregions) and the Timor Transition Province) and includes four KEFs (the carbonate bank and terrace system of the Van Diemen Rise, carbonate banks of the Joseph Bonaparte Gulf, pinnacles of the Bonaparte Basin, and shelf break and slope of the Arafura Shelf) (DoEE 2017l).

The following North and North-west CMRs are also of relevance to this project in the area of influence (see **Section 6.4.10**):

- *Arafura CMR:* covers a large area (22,924 km^2) and is comprised of a Multiple Use Zone (IUCN category VI). It is located appropriately 215 km (at its closest point from the project) and has a number of conservation values. Specifically, it provides an important internesting area for a number of marine turtle species and important foraging habitat for breeding aggregations of the migratory roseate tern (DoEE 2017l).
- *Arnhem CMR:* covers an area of 7,125 km^2 and is comprised of a Special Purpose Zone (IUCN category VI). It is located approximately 365 km east of the project (at its nearest boundary) and provides an important internesting area for flatback turtles (DoEE 2017l). The CMR also provides important foraging habitat for breeding aggregations of the crested tern, bridled tern and roseate tern.
- *Kimberley CMR:* covers a large area (74,469 km^2) and is comprised of a Marine National Park Zone (IUCN category II) and Habitat Protection Zone (IUCN category IV, specifically intended to protect humpback whale calving) and Multiple Use Zone (IUCN category VI). It is located approximately 500 km south-west of the project (at its nearest boundary) and has a number of conservation values. Specifically, it provides important foraging areas for migratory seabirds, dugongs, dolphins, marine turtles and a migration pathway and nursery areas for humpback whales (DoEE 2017l).
- *Ashmore Reef CMR:* covers a reasonably small area (583 km^2) and is comprised of a sanctuary zone (IUCN category Ia) and a recreational use zone (IUCN category II). It is located approximately 750 km south-west of the project (at its nearest boundary) and has a number of conservation values. Specifically, it provides an important area for a number of EPBC listed species, including sea snakes, turtles, dugongs and migratory seabirds (DoEE 2017l). Ashmore Reef also supports important cultural and heritage sites, such as Indonesian artefacts and grave sites.
- *Cartier Island CMR:* covers a reasonably small area (172 km^2) and is comprised of a sanctuary zone (IUCN category Ia). It is located approximately 730 km south-west of the project (at its nearest boundary) and has a number of conservation values. Specifically, it provides an important area for a number of EPBC listed species, including sea snakes, turtles and migratory seabirds (DoEE 2017l).

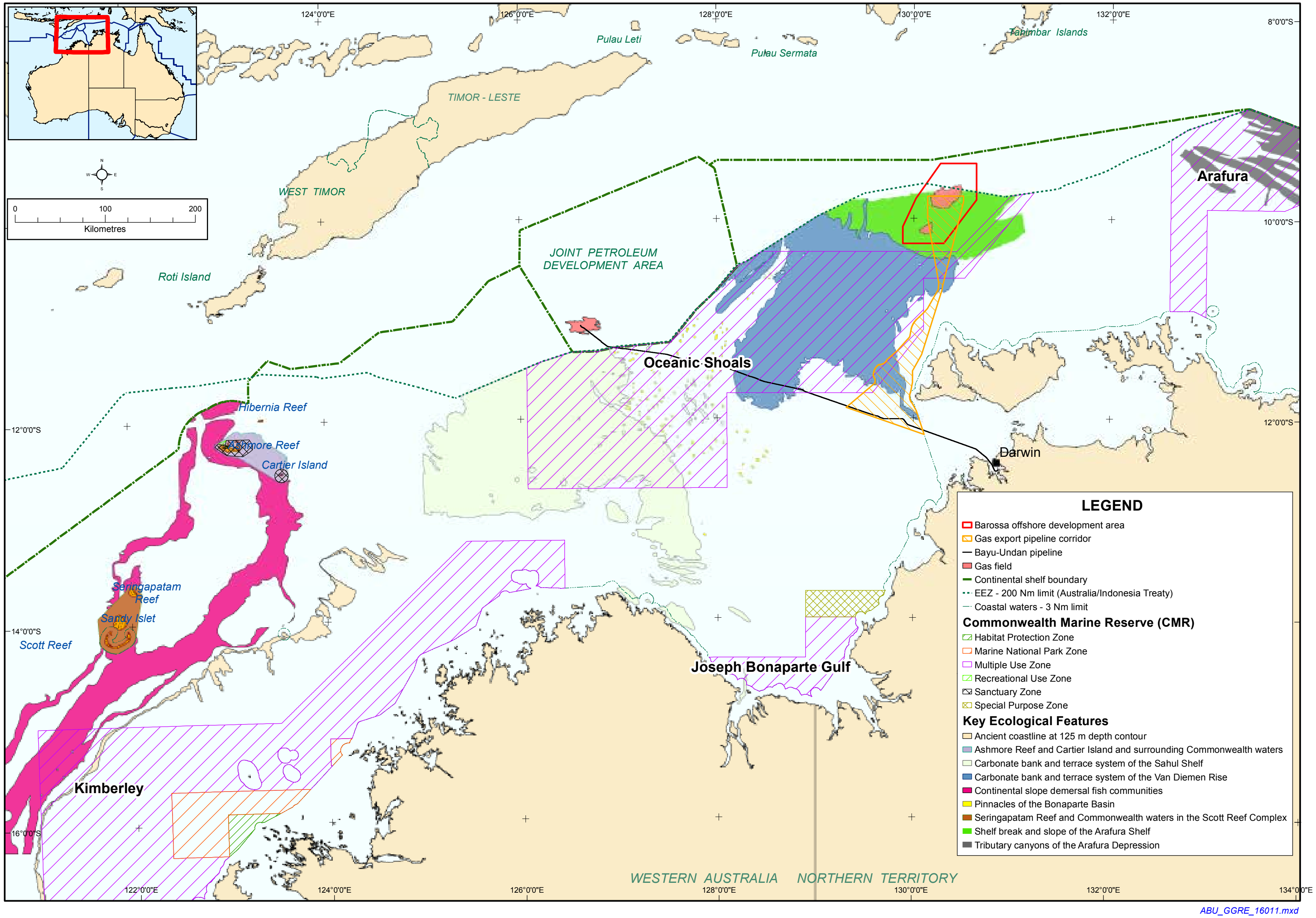


Figure 5-18: Commonwealth Marine Reserves and key ecological features

5.7.7 Listed threatened communities

There are no listed threatened communities, as defined under the EPBC Act, of relevance to the offshore context of this OPP.

5.7.8 Key ecological features

KEFs are considered to be of regional importance for either the marine region's biodiversity or ecosystem function and integrity. A search was conducted of the DoEE National Conservation Values Atlas to identify the KEFs of the Commonwealth marine environment that occur within or adjacent to the project area and area of influence (**Figure 5-18**). The results of the search are provided in **Table 5-7** (DSEWPaC 2012a, b, g, h).

Table 5-7: KEFs of relevance to the project

KEF	Values/description
Shelf break and slope of the Arafura Shelf	*Unique seafloor feature with ecological properties of regional significance* The shelf break and slope of the Arafura Shelf covers approximately 10,844 km^2 and is characterised by continental slope and patch reefs and hard substrate pinnacles. The ecosystem processes of the shelf break/slope are largely unknown. However, the ITF and surface wind-driven circulation are expected to influence nutrients, pelagic dispersal and species, and biological productivity in the region. Marine biota associated with the feature is largely of Timor–Indonesian Malay affinity. Records show at least 284 demersal fish species are found in the area, including commercially fished red snapper species (*Lutjanus erythropterus*). The area is also likely to support protected whale sharks, sharks and marine turtles. While the Barossa offshore development area occurs within the bounds of the KEF of the shelf break and slope of the Arafura Shelf, the ecological values associated with this unique seafloor feature (i.e. patch reefs and hard substrate pinnacles) were not observed during the Barossa marine studies program, nor are these topographically distinct features evident from the bathymetry data derived from multiple seismic surveys undertaken across this area.
Carbonate bank and terrace system of the Van Diemen Rise	*Unique seafloor feature with ecological properties of regional significance* The bank and terrace system of the Van Diemen Rise covers approximately 31,278 km^2 and forms part of the larger system associated with the Sahul Banks to the north and Londonderry Rise to the east. The feature is characterised by carbonate terrace, banks, channels and valleys, with variability in water depth and substrate composition considered to contribute to the presence of unique ecosystems in the channels. The variability in water depth and substrate composition across the feature may contribute to the presence of unique ecosystems in the channels. The carbonate banks and shoals found within the Van Diemen Rise make up 80% of the banks and shoals, 79% of the channels and valleys, and 63% of the terrace found across the NMR. The carbonate banks and shoals rise from depths of 100 m–200 m to within 10 m–40 m of the sea surface (Anderson et al. 2011). The feature provides habitat for a high diversity of sponges, soft corals and other sessile filter feeders; epifauna and infauna; and olive ridley turtles, sea snakes and sharks. Rich sponge gardens and octocorals have been identified on the eastern Joseph Bonaparte Gulf along the banks, ridges and some terraces. Plains and deep hole/valleys are characterised by scattered epifauna and infauna that include polychaetes and ascidians. Epibenthic communities such as the sponges found in the channels are likely to support first and second-order consumers. Pelagic fish such as mackerel, red snapper and a distinct gene pool of gold band snapper are found in the Van Diemen Rise. At its nearest point, this KEF is located approximately 3 km to the south-west of the Barossa offshore development area with a portion of this feature occurring within the gas export pipeline corridor.

KEF	Values/description
Pinnacles of the Bonaparte Basin	*Unique seafloor feature with ecological properties of regional significance* The pinnacles of the Bonaparte Basin cover more than 520 km² and are thought to be the eroded remnants of underlying strata. The pinnacles can be up to 50 m high and 50 km–100 km long and are thought to be the eroded remnants of the underlying strata. These vertical walls of the pinnacles are considered to generate local upwelling of nutrient-rich water, leading to phytoplankton productivity that attracts aggregations of planktivorous and predatory fish such as snapper, emperor, grouper and sawfishes, seabirds and foraging turtles. The pinnacles also provide areas of hard substrate in an otherwise relatively featureless environment and are, therefore, considered likely to support a high number of species, although further scientific information is required. This KEF is located approximately 150 km to the west south-west of the Barossa offshore development area and occurs within the area of influence.
Tributary canyons of the Arafura depression	*Unique seafloor feature with ecological properties of regional significance* The tributary canyons of the Arafura depression are around 80 m–100 m deep, 20 km wide and cover approximately 10,519 km². The canyons are an important feature as they are characterised by high ecological productivity and biodiversity of both benthic and pelagic habitats. Areas of high biodiversity and abundance generally correlate with harder substrates where sessile benthos such as sea whips and fans, soft corals, hydroids, crinoids and octocorals, some up to 50 cm in height, have been frequently found. In comparison, soft substrates tend to be associated with low-relief benthos that covers less than 5% of the surface area. The canyons are known to support a diverse array of invertebrates (e.g. sponges, corals, sea anemones, tunicates, worms, crustaceans, brittle stars and feather stars) and six small fish species. It is estimated that a further 500 species may be present, including species which endemic to the area. Water temperatures recorded in parts of the tributary canyons are generally higher (14–16 °C at approximately 230 m depth) than typical deep-sea environments (usually < 8 °C). However, despite these warmer temperatures, deep water fauna such as stalked crinoids, hexactinellid sponges and deep water pedunculate barnacles are known to occur. This KEF is located approximately 240 km to the east of the Barossa offshore development area and occurs within the area of influence.
Carbonate bank and terrace system of the Sahul Shelf	*Unique seafloor feature with ecological properties of regional significance* While there is limited scientific information available on the bank and terrace system of the Sahul Shelf, it is considered regionally important because of its likely ecological role in enhancing biodiversity and local productivity relative to its surrounds. The feature covers an area of approximately 41,158 km². The banks are characterised by hard substrate and flat tops at depths of 150 m–300 m, with each bank generally being < 10 km² in area and separated from each other by narrow meandering channels which are up to 150 m deep. The banks are thought to support a high diversity of organisms including reef-fish, sponges, soft and hard corals, gorgonians, bryozoans, ascidians and other sessile filter feeders. The banks are known to provide foraging areas for loggerhead, olive ridley and flatback turtles, with cetaceans and green and largetooth sawfish likely to occur in the area also. Warm water from the IFT is thought to drive nutrients from deepwater to shallower water up to 100 m in depth where sufficient light allows photosynthesis to occur. This KEF is located approximately 275 km to the south-west of the Barossa offshore development area and occurs within the area of influence.

KEF	Values/description
Continental slope demersal fish communities	*Communities with high species biodiversity and endemism* The demersal slope fish assemblages in the Timor Province, the Northwest Transition and the Northwest Province are characterised by high endemism and species diversity (more than 500 species, 76 of which are endemic). The level of endemism of demersal fish species in these bioregions is high compared to anywhere else along the Australian continental slope. The demersal fish species is made up of two distinct communities associated with the upper slope (water depths 225 m–500 m) and mid-slope (750 m–1,000 m). The KEF is located approximately 730 km to the south-west of the Barossa offshore development area and occurs within the area of influence.
Ashmore Reef and Cartier Island and surrounding Commonwealth waters	*High productivity and aggregations of marine life* Ashmore Reef is the largest of only three emergent oceanic reefs present in the north-eastern Indian Ocean and is the only oceanic reef in the region with vegetated islands. Ashmore Reef and Cartier Island and the surrounding Commonwealth waters are regionally and internationally important for feeding and breeding aggregations of seabirds, marine reptiles and mammal populations; they represent areas of enhanced primary productivity. Seabird rookeries on the reef/island are known to support up to 50,000 seabirds (26 species) and up to 2,000 waders (30 species) seasonally. A number of migratory wading birds use the area as part of their migration between Australia and the Northern Hemisphere. Ashmore Reef also supports a high diversity of coral species. Species at Ashmore and Cartier include more than 225 reef-building corals, 433 molluscs, 286 crustaceans, 192 echinoderms, and 709 species of fish. Thirteen species of sea snakes occur in high numbers at Ashmore and Cartier reefs but are believed to have experienced recent declines (**Section 5.6.3**). An estimated 11,000 green and hawksbill turtles feed over seagrass beds present on reef flats throughout the year. Sandy beaches provide important habitat for nesting green and hawksbill turtles throughout the year. Seagrass present at Ashmore Reef provides critical breeding (April–May) and foraging (throughout the year) habitat for a genetically distinct population of dugong. The KEF is located approximately 750 km to the south-west of the Barossa offshore development area and occurs within the area of influence.
Seringapatam Reef and Commonwealth waters in the Scott Reef complex	*High productivity and aggregations of marine life* Seringapatam Reef and the Commonwealth waters in the Scott Reef complex are regionally important as they support diverse aggregations of marine life, high primary productivity and high species richness associated with the reefs themselves. The coral communities at Seringapatam and Scott Reefs play a key role in maintaining species richness and aggregations of marine life. The reefs and the waters surrounding them attract aggregations of marine life including humpback whales on their northerly migration, Bryde's whales, pygmy blue whales, Antarctic minke whales, dwarf minke whales, minke whales, dwarf sperm whales, spinner dolphins and whale sharks. Green and hawksbill turtles nest during the summer months on Sandy Islet on South Scott Reef. These species also internest and forage in the surrounding waters. Scott Reef is a particularly biologically diverse system and includes more than 300 species of reef-building corals, approximately 400 mollusc species, 118 crustacean species, 117 echinoderm species, around 720 fish species and several species of sea snakes. As two of the few offshore reefs in the north-west, they provide an important biophysical environment in the region. The KEF is located approximately 930 km to the south-west of the Barossa offshore development area and occurs within the area of influence.

KEF	Values/description
Ancient coastline at 125 m depth contour	*Unique seafloor feature with ecological properties of regional significance* The ancient submerged coastline, particularly areas characterised by hard rocky substrate, provide biologically important habitats in areas otherwise dominated by soft sediments. The escarpment is likely to support sponges, corals, crinoids, molluscs, echinoderms and other benthic invertebrates representative of hard substrate fauna in the North West Shelf bioregion. The topographic complexity of the escarpments also promotes vertical mixing of the water column, providing relatively nutrient-rich local environments. The enhanced productivity may attract opportunistic feeding by humpback whales, whale sharks and large pelagic fish. Therefore, this feature may provide sites for higher diversity and enhanced species richness. The KEF is located approximately 650 km to the south-west of the Barossa offshore development area and occurs within the area of influence.

The DoEE Commonwealth Marine Report Cards for the North and North-west Marine Regions (DSEWPaC 2012e, f) provide a high level analysis of the anthropogenic pressures on the KEFs. The analysis defines five categories in which each pressure impacts on the designated KEF including 'of concern', 'of potential concern', 'of less concern', 'not of concern' and 'data deficient or not assessed'. For the purposes of this OPP only pressures applicable to the project activities outlined in **Section 4** have been considered. A summary of the pressure analysis is detailed in **Table 5-8**, with further description provided below for the pressures 'of potential concern'.

Table 5-8: KEFs anthropogenic pressure analysis

Pressure	Physical habitat modification	Invasive species	Noise pollution		Light pollution		Marine debris	Oil pollution	
	Offshore construction	Vessels	Vessels	Offshore construction	Oil and gas infrastructure	Vessels	Vessels	Oil rigs	Shipping
Shelf break and slope of the Arafura Shelf	Of less concern	Of less concern	Not of concern	Not of concern	Not of concern	Not of concern	Of less concern	Of potential concern	Of potential concern
Carbonate bank and terrace system of the Van Diemen Rise	Of less concern	Of less concern	Not of concern	Not of concern	Not of concern	Not of concern	Of less concern	Not of concern	Not of concern
Pinnacles Bonaparte Basin	Of less concern	Of less concern	Not of concern	Not of concern	Not of concern	Not of concern	Of less concern	Not of concern	Not of concern
Tributary canyons of the Arafura depression	Of potential concern	Of less concern	Not of concern	Not of concern	Not of concern	Not of concern	Of less concern	Of potential concern	Of potential concern
Carbonate bank and terrace system of the Sahul Shelf	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed
Continental slope demersal fish communities	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed
Ashmore Reef and Cartier Island and surrounding Commonwealth waters	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Of potential concern	Of potential concern	Of potential concern	Data deficient or not assessed
Seringapatam Reef and Commonwealth waters in the Scott Reef complex	Of potential concern	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Of potential concern	Of potential concern	Of potential concern	Data deficient or not assessed
Ancient coastline at 125 m depth contour	Not of concern	Not of concern	Of less concern	Of less concern	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Of less concern	Not of concern

Key

Red	Of concern
Yellow	Of potential concern
Green	Of less concern
Dark grey	Not of concern
White	Data deficient or not assessed

Physical habitat modification

Physical habitat modification is a pressure 'of potential concern' for the tributary canyons of the Arafura depression and Seringapatam Reef and Commonwealth waters in the Scott Reef complex. These KEFs are the location of oil and gas resources including the Torosa Field below north and south Scott Reefs as well as the sites for a number of exploratory programs in both KEFs. The installation of infrastructure may directly affect the benthic communities associated with these KEFs. Activities known to occur in these KEFs with the potential to apply pressure to the physical habitat include construction, commissioning and operation of offshore oil and gas facilities, suspended solids from disturbance to seabeds and vessel anchorage.

The Barossa project infrastructure is located approximately 240 km and 930 km from the tributary canyons of the Arafura depression and Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEFs respectively, and will not result in physical habitat modification to these features.

Invasive species

Invasive species have the potential to impact directly on benthic communities, coral and fish via competition for habitat and food resources. They are 'of potential concern' at two KEFs including Ashmore Reef and Cartier Island and surrounding Commonwealth waters, and Seringapatam Reef and Commonwealth waters in the Scott Reef Complex. The two key sources of invasive species introduction are ballast water exchange and vessel biofouling. Given the increased presence of oil and gas activities using many vessels in these KEFs they are susceptible to pressure from invasive species.

The project is located approximately 750 km and 930 km from the Ashmore Reef and Cartier Island and surrounding Commonwealth waters and Seringapatam Reef and Commonwealth waters in the Scott Reef complex KEFs respectively. Vessels associated with the project will not be transiting in or near the sensitive features associated with these KEFs and therefore are highly unlikely to result in the introduction of invasive species.

Marine debris

Marine debris (i.e. persistent solid material) is of potential concern at Ashmore Reef and Cartier Island and surrounding Commonwealth waters and at Seringapatam Reef and the Commonwealth waters in the Scott Reef Complex. Although information on marine debris is limited, key sources for the introduction of marine debris (e.g. shipping, construction, commercial fishing, traditional Indonesian fishing vessels and illegal vessels) are present within these KEFs. The aggregations of marine biota identified as values associated with these KEFs (**Table 5-8**) could be adversely affected by ingestion of or entanglement with marine debris.

The project is located approximately 750 km and 930 km from the Ashmore Reef and Cartier Island and surrounding Commonwealth waters and Seringapatam Reef and Commonwealth waters in the Scott Reef complex KEFs respectively. Marine debris and dropped objects associated with project activities are unlikely to materially affect seabed features associated with these KEFs.

Oil pollution

The North and North-west Marine Regions are areas subject to petroleum exploration, development and production and this is likely to increase. Shipping is likely to continue to expand in the region as a result of the growth of the resources sector. In particular, the shelf break and slope of the Arafura Shelf, tributary canyons of the Arafura depression, Ashmore Reef and Cartier Island and surrounding Commonwealth waters and Seringapatam Reef and Commonwealth waters in the Scott Reef complex KEFs contain habitats and species sensitive to the impacts from oil pollution.

The assessment of impact from oil pollution to the receptors within these designated KEFs in the area of influence is described in **Section 6.4.10**.

5.7.9 Commonwealth land

Commonwealth land includes land owned or leased by the Commonwealth or a Commonwealth agency, land in the external territories, and any other area of land that is included in a Commonwealth reserve (DSEWPaC 2013).

Given the remote offshore location context of this proposal within Commonwealth waters, the consideration of Commonwealth land is only of relevance to this OPP in the context of Ashmore Reef and Cartier Island (at least 750 km away), with reference to the area of influence. These features are discussed in detail in **Section 5.5.4**.

5.7.10 European and Indigenous heritage

There are no recorded European or Indigenous heritage sites within the project area and given the water depths and distance offshore for most of the project area, the area is not expected to support any Indigenous heritage values. Considering Indigenous fishing and subsistence activities are largely confined to inshore and coastal waters, these activities are not expected to occur in the project area. Therefore, it is considered highly unlikely that planned project activities within the project area will have any impact on Indigenous heritage values.

The Tiwi Islands have a number of sacred and significant sites that have heritage importance for both Tiwi and European people (**Figure 5-19**; Tiwi Land Council 2017). There are currently four registered sacred sites on the Tiwi Islands (Aboriginal Areas Protection Authority 2016). Another 56 sites of significance to Tiwi Islanders have been recorded, including two sites on the NT mainland (Tiwi Land Council 2003). The Tiwi Islands sites hold importance as they have high spiritual and cultural history value (Tiwi Land Council 2003).

As outlined in **Section 5.7.6**, Ashmore Reef is known to support important cultural and heritage sites, such as Indonesian artefacts (including ceramics and a relic cooking site) and grave sites which are located on the West, East and Middle Islands (Russell et al. 2004, cited in Hale and Butcher 2013; Commonwealth of Australia 2002). At least one Indonesian fisher is also buried on Cartier Island (Commonwealth of Australia 2002). It has been noted that the Indonesian cultural artefacts are deteriorating as a result of exposure to natural weathering processes (Commonwealth of Australia 2002).

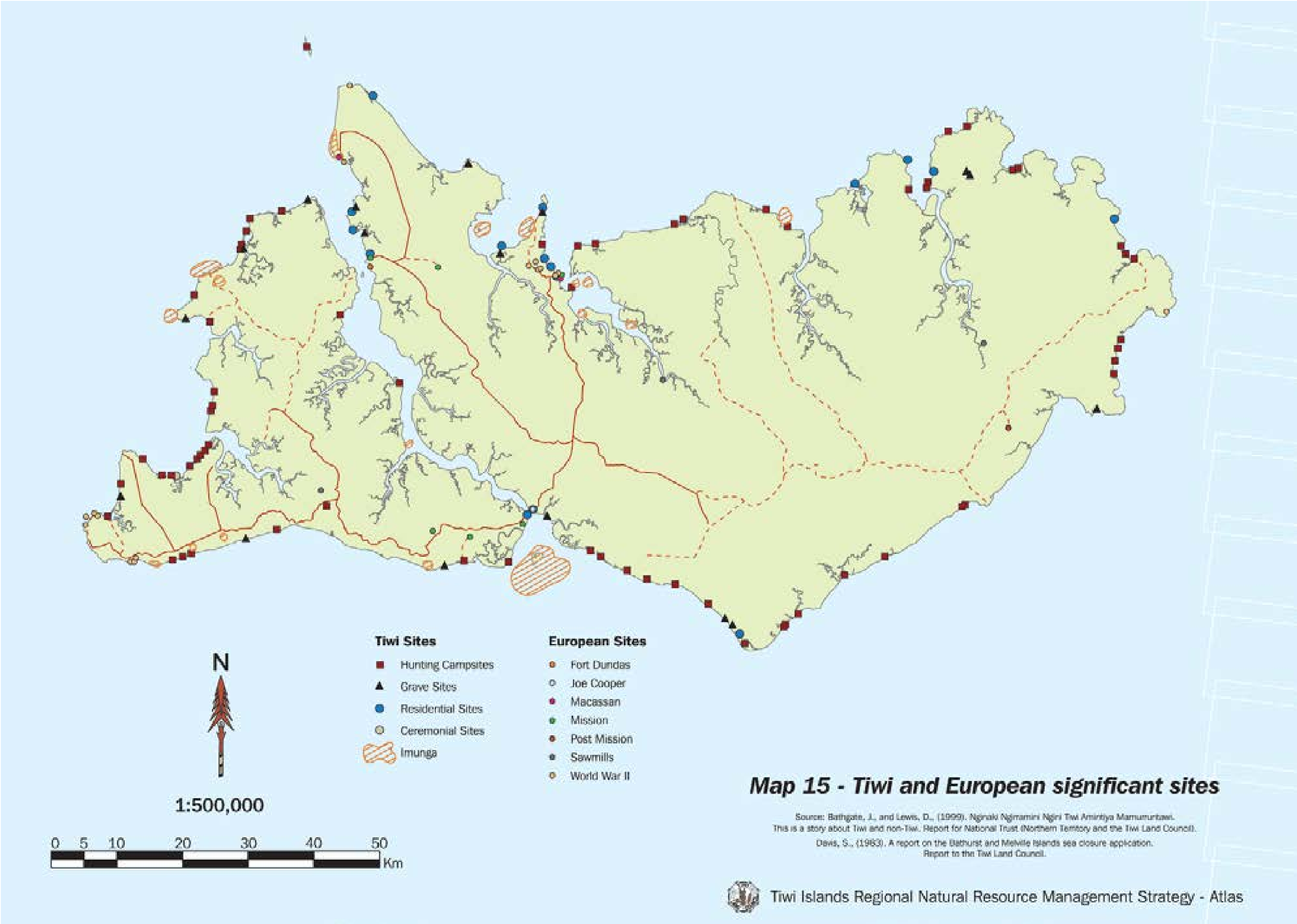


Figure 5-19: Significant Tiwi and European sites on the Tiwi Islands

5.7.11 Marine archaeology

There are no known shipwreck protected zones or shipwrecks within, or in the immediate surrounds of, the Barossa offshore development area, based on a search of the Australian National Shipwreck Database (DoEE 2017m). However, one known historic shipwreck in the Timor Sea, a steamer ship named the *Florence D* that was sunk in 1942 during World War II, is located to the north-west of Bathurst Island (in water depths of 16 m) in the gas export pipeline corridor. The shipwreck is protected under the Commonwealth *Historic Shipwrecks Act 1976* and has a designated 797 m radial protection zone (DoEE 2017m).

In addition to the *Florence D* steamer ship, two historic shipwrecks are known to occur in the area of influence; a steamer ship (*Don Isidro USAT*) that was sunk adjacent to the west coast of Bathurst Island and a submarine (*I-124*) sunk in the Beagle Gulf. Both vessels were sunk in 1942 during World War II and are listed under the *Historic Shipwrecks Act 1976*. The *Don Isidro USAT* is located approximately 9 km east of the gas export pipeline corridor in water depths of 6 m, while the submarine is located approximately 3 km east of the southern end of the gas export pipeline corridor in water depths of 42 m.

5.7.12 Commercial fisheries

Commercial fisheries considered of potential relevance to the project area were defined based on their proximity, specifically if their boundaries overlapped the project area, and whether they occurred within the area of influence. The details of the key fisheries are described below.

In summary, there are a number of fisheries in the region, with five currently active in the project area. Based on consultations to date, ConocoPhillips understand there are no areas of high fishing activity in the vicinity of the project.

Commonwealth managed fisheries

Five Commonwealth managed commercial fisheries, which are managed by the Australian Fisheries Management Authority (AFMA), overlap the project area and/or occur in the area of influence (**Figure 5-20**; AFMA 2017):

- Northern Prawn Fishery
- North West Slope Trawl Fishery (NWSTF)
- Southern Bluefin Tuna Fishery
- Western Skipjack Fishery
- Western Tuna and Billfish Fishery.

NT managed fisheries

Six NT managed commercial fisheries overlap the project area and/or occur in the area of influence (**Figure 5-21**; Department of Primary Industry and Fisheries (DPIF) 2017):

- Aquarium Fishery
- Coastal Line Fishery (gas export pipeline only)
- Demersal Fishery
- Offshore Net and Line Fishery
- Spanish Mackerel Fishery
- Timor Reef Fishery.

WA-managed fisheries

Three WA managed commercial fisheries occur within the area of influence (**Figure 5-21**; Department of Fisheries (DoF) 2015):

- Mackerel Managed Fishery
- Northern Demersal Scalefish Managed Fishery (NDSF)
- Northern shark fisheries – comprising the state managed WA North Coast Shark Fishery in the Pilbara and western Kimberley, and the Joint Authority Northern Shark Fishery in the eastern Kimberley.

A summary of the commercial fisheries is provided in **Table 5-9**.

Table 5-9: Commercial fisheries of potential relevance to the project

Commercial fishery	Context: Project area	Context: Area of influence	Description
Commonwealth managed			
Northern Prawn Fishery (managed by AFMA)	✓	✓	The Northern Prawn Fishery management area extends over the Australia's northern coast, between Cape York in Queensland and Cape Londonderry in WA, from the low water mark to the outer edge of the Australian Fishing Zone (AFZ) (AFMA 2017). The majority of the fishing effort within the Northern Prawn Fishery occurs in the southern and western areas of the Gulf of Carpentaria, Joseph Bonaparte Gulf and along the Arnhem Land coast (Department of Agriculture and Water Resources (DoAWR) 2016a). The key target species are banana prawns, tiger prawns and endeavour prawns. There are two fishing seasons, with the season end date depending on catch rates (AFMA 2017): • Season 1 (mainly banana prawns caught): 1 April – 15 June • Season 2 (mainly tiger prawns caught): 1 August – end of November There are currently 52 boats operating with statutory fishing rights (DoAWR 2016a). A total of 8,189 boat-days were reported in the 2013 fishing season (DoAWR 2016a). The areas of low, medium and high fishing effort are distant from the Barossa offshore development area (> 64 km). A portion of the gas export pipeline corridor overlaps an area of low fishing effort to the east of the Tiwi Islands (**Figure 5-22**). In general, there is little to no activity in the Northern Prawn Fishery in water depths > 100 m.
NWSTF		✓	The NWSTF extends eastward from 114° E to about 125° E off the WA coast between the 200 m isobath and the outer limit of the Australian Fishing Zone, but not taking into account Australian–Indonesian Memorandum of Understanding (MoU) (DoAWR 2016a). The principal species fished are scampi, mixed snappers, deepwater prawns and mixed finfish, however, the NWSTF has predominantly been a scampi fishery in recent years (DoAWR 2016a). A total of four fishing permits have been allocated to the entire NWSTF area in 2012–2013 (DoAWR 2016a). Only one or two vessels have been active in the area in recent fishing seasons since 2008–2009 (DoAWR 2016a). The fishing season is between June to July and December to April. Considering the location of the fishery, and low levels of active fishing, planned operations associated with the project are not expected to affect the NWSTF. Consultation undertaken in 2015/2016, in relation to an appraisal drilling campaign and 3D seismic survey, with this fishery did not identify any concerns.

Commercial fishery	Context		Description
	Project area	Area of influence	
Southern Bluefin Tuna Fishery (managed by AFMA)	✓	✓	The Southern Bluefin Tuna Fishery operates around Australia and extends to the high seas fishing zone (out to 200 nm from the coast) (AFMA 2017). Although the fishery extends across the project area, no fishing was undertaken in this area in 2014–2015 (DoAWR 2016a). Fishing activity is focussed in southern Australian states of South Australia and Victoria (DoAWR 2016a). Therefore, while the management area overlaps the project, no activity is expected within the project area or area of influence.
Western Skipjack Tuna Fishery (managed by AFMA)	✓	✓	Skipjack tuna are widely distributed throughout tropical waters of the Indian and Pacific Oceans. Two stocks of skipjack tuna are thought to exist in Australian waters: one on the east coast and one on the west coast (DoAWR 2016a). Skipjack tuna is the only target species in the fishery. Although 14 fishing permits have been allocated within the Western Skipjack Tuna Fishery, no fishing activity has been undertaken since 2008–2009 (DoAWR 2016a). Therefore, the project is not expected to affect this fishery. Consultation undertaken in 2015/2016 with this fishery, in relation to an appraisal drilling campaign and 3D seismic survey in the Barossa Field area, did not identify any concerns.
Western Tuna and Billfish Fishery (managed by AFMA)	✓	✓	The Western Tuna and Billfish Fishery management area extends over a large area westward from Cape York Peninsula (142°30′E) off Queensland, around the west coast of WA and eastward, across the Great Australian Bight to 141°E at the South Australian/Victorian border (AFMA 2017). The fishery has operated at low levels of effort since the early 2000s due to economic conditions, with less than five vessels active in the fishery each year since 2005 (DoAWR 2016a). In recent years, effort has concentrated off south-west WA and South Australia (DoAWR 2016a). Target species include bigeye tuna, yellow fin tuna, broadbill swordfish and striped marlin (AFMA 2017). While the management area overlaps the project, this fishery is not considered to be active within the area.

Commercial fishery	Context		Description
	Project area	Area of influence	
NT-managed			
Aquarium Fishery	✓	✓	The Aquarium Fishery is a small-scale, multi-species fishery that prospects freshwater, estuarine and marine habitats to the outer boundary of the AFZ. The harvest of most marine species occurs within 100 km of Nhulunbuy and Darwin (DPIF 2017a), though one license holder does collect from two offshore locations; Evans Shoal and Lynedoch Bank. During September to May the licence holder rotates between the shoal/bank for one week each month There are only 12 aquarium fishing/display fishery licensees (DPIF 2015). Fishing activities may occur year-round. However, the licence holder collecting from the offshore locations advised that they are unlikely to be operating in the months of June to August due to the inclement weather conditions at that time of the year. Aquarium fishing/display fishery licensees can use barrier, cast, scoop, drag and skimmer nets, hand pumps, freshwater pots and hand-held instruments to collect aquarium species. The catch is collected by divers that rely on surface-supplied air from a vessel (DPIF 2015). The commercial catch can be separated into invertebrates and finfish. Invertebrate catch is mainly comprised of hermit crabs, various snails, whelks and more recently hard and soft corals. The finfish catch is diverse but predominantly consists of rainbowfish, catfishes and scats (DPIF 2017a). While the Aquarium Fishery overlaps the project, significant interactions between the fishery with the project are not expected as fishing activities offshore are primarily focussed around shoals/banks which are distant from the Barossa offshore development area.
Coastal Line Fishery (jointly managed by the Northern Territory Fisheries Joint Authority (NTFJA) and the Fisheries Division of the NT DPIF)	✓ (gas export pipeline only)	✓	The fishery extends along the NT coast from the high water mark to 15 nm from the low water mark, with some restrictions in place around registered Aboriginal sacred sites and protected areas (DPIF 2017a). The majority of the fishing activity is concentrated around rocky reefs along the coastline within 150 km of Darwin (DPIF 2015). The fishery comprises commercial, recreational, charter and Indigenous sectors and there is considerable overlap in the range of species harvested. The commercial sector predominantly targets black jewfish and golden snapper with key secondary species including emperors, cods and other snappers (DPIF 2014). The fishery is restricted to 52 licences with approximately one third of these being active in 2015 (Northern Territory Seafood Council (NTSC) 2016a). Only eight licences have quota to fish in the western zone, which is west of Cobourg Peninsula. Fishing activities occur year round. Considering that fishing activity is mainly focussed around rocky reefs along the Darwin coast, some fishing may occur in the vicinity of the southern end of the gas export pipeline corridor.

Commercial fishery	Context		Description
	Project area	Area of influence	
Demersal Fishery (jointly managed by the NTFJA and the Fisheries Division of the NT DPIF)	✓	✓	The fishery extends from waters 15 nm from the coastal waters mark to the outer limit of the AFZ, excluding the area of the Timor Reef Fishery (DPIF 2017a). The main target species of the fishery are red snappers and goldband snappers with key bycatch species being painted sweetlip, red emperor and cods (DPIF 2017a). In 2012, eight active licences (using eight vessels) fished for 980 boat-days in the fishery (DPIF 2014). There are currently 19 licences issued for the fishery, with around nine active (NTSC 2016b). The fishery operates year round. Fish traps, hand lines and droplines are permitted throughout the fishery and demersal trawl nets are permitted in two defined zones (**Figure 5-21**) (DPIF 2017a). The semi-demersal trawl zones does not overlap the project area, with the closest zone in the Joseph Bonaparte Gulf located approximately 36 km to the south-west of the southern end of the gas export pipeline. The fishery does not overlap the Barossa offshore development area. However, some fishing effort (though not using trawling techniques) may occur within the gas export pipeline corridor. Consultation undertaken in 2015/2016 with this fishery, in relation to an appraisal drilling campaign in the Barossa Field, did not identify any concerns.
Offshore Net and Line Fishery (jointly managed by the NTFJA and the Fisheries Division of the NT DPIF)	✓	✓	The fishery covers an area of over 522,000 km^2 and extends from the NT high water mark to the boundary of the AFZ (DPIF 2017a). The majority of the fishing effort is in the coastal zone (within 12 nm of the coast) and immediately offshore in the Gulf of Carpentaria (DPIF 2017a). Limited effort was undertaken in the outer offshore area of the fishery during 2012, which is consistent with previous years (DPIF 2014). The target species of the fishery are blacktip sharks and grey mackerel, with a variety of other sharks and pelagic finfish caught as byproduct (DPIF 2017a). The number of licences for the fishery is restricted to 17(DPIF 2017a) and only 10 boats operated in 2015 (DoAWR 2016a. In 2015, 405 boat-days were spent fishing, representing a 32% decrease from effort levels in 2014 (DoAWR 2016a). The effort was also well below the peak of 1,801 boat-days recorded in 2003. The decline in fishing effort is thought to be due to a drop in shark fin prices (NT Government 2015, cited in DoAWR 2016a) Given the large area of the fishery and that the majority of the fishing effort is within 12 nm of the coast, interactions between the fishery associated with the project are not expected to occur. Consultation undertaken in 2015/2016 with this fishery, in relation to an appraisal drilling campaign and 3D seismic survey in the Barossa Field area, did not identify any concerns.

Commercial fishery	Context		Description
	Project area	Area of influence	
Spanish Mackerel Fishery (jointly managed by the NTFJA and the Fisheries Division of the NT DPIF)	✓	✓	The fishery extends from the NT waters seaward off the coast and river mouths to the outer limit of the AFZ (DPIF 2015a). The majority of the fishing effort occurs in the vicinity of reefs, headlands and shoals and includes waters near Bathurst Island, New Year Island, the Wessel Islands around to Groote Eylandt, the Sir Edward Pellew Group of islands and suitable fishing grounds on the western and eastern mainland coasts (DPIF 2017a, DPIF 2015). The target species of the fishery is the narrow-barred spanish mackerel, however, a small number of other mackerels are also taken. In 2012, there were 16 fishery licences of which 12 were actively operating (DPIF 2014). The 2012 fishing effort was 719 boat-days; a decrease from 813 boat-days in 2011 but an increase from the 672 boat-days in 2010 (DPIF 2014). Some fishing may occur in the vicinity of the southern end of the gas export pipeline. However, the fishery is not expected to be active in the Barossa offshore development area. Consultation undertaken in 2015/2016 with this fishery, in relation to an appraisal drilling campaign and 3D seismic survey in the Barossa Field area, did not identify any concerns.

Commercial fishery	Context		Description
	Project area	Area of influence	
Timor Reef Fishery (jointly managed by the NTFJA and Fisheries Division of the NT DPIF)	✓	✓	The Timor Reef Fishery operates in remote offshore waters in the Timor Sea in a defined area approximately 370 km north-west of Darwin. The fishery encompasses extends north-west of Darwin to the WA-NT border and to the outer limit of the AFZ and covers an area of approximately 28,811 km^2 (DPIF 2017a). The target species is goldband snapper, with other tropical snappers such as crimson snapper and saddletail snapper also consisting of part of the catch. The majority of the fishing effort is undertaken using drop-lines and occurs primarily in the 100 m–200 m depth range. Data for the period 1995–2004 shows that the highest commercial productivity for drop-line catch is very localised and is predominantly associated with the shelf geomorphic unit, in the 110 m–120 m depth range (Lloyd and Puig 2009). These depth ranges intersect the southern portion of the Barossa offshore development area (**Figure 5-23**). **Figure 5-23** shows that the southern portion of the Barossa offshore development area overlaps the highest productivity zones for the drop-line catch. Consultation undertaken with the commercial fishermen who operate in the Timor Reef Fishery, for the 2016 Caldita-Barossa 3D seismic survey, identified that in recent times fishing effort has increased to the south-west area of the fishery (at least 50 km from the Barossa offshore development area). There is no closed season for the Timor Reef Fishery, however, the fishery is normally most productive between October and May. There is less activity during the dry season months of June to August as strong northerly winds often prevent fishermen going to sea. There are currently 15 licences issued for the fishery (DPIF 2017a). These licences are held by three individual fishers. In 2012 seven vessels actively fished over a period of 938 boat-days, an increase of 14 boat-days from 2011 (DPIF 2014). Stakeholder consultation undertaken with DPIF and the NTSC in 2016, for the appraisal drilling campaign, confirmed there are only two active fishers currently operating in the fishery. One fisher is using traps to target goldband snapper in water depths between 80 m–150 m (maximum of 250 m) along reef fronts and on sand flats located near pinnacles. The other active licence holder is currently using trawl gear as part of a gear trial.

Commercial fishery	Context: Project area	Context: Area of influence	Description
Mackerel Managed Fishery		✓	The Mackerel Managed Fishery in WA extends from the West Coast Bioregion (which runs from east Augusta to north of Kalbarri) to the WA–NT border within state waters (the coastline out to 3 nm) (DoF 2015. The fishery is divided into three fishing areas; Area 1 (Kimberley), Area 2 (Pilbara) and Area 3 (Gascoyne/West Coast) (DoF 2015). During 2014–2015, 14 licenses were allocated in Area 1 (Kimberley). Licence holders are only allowed to only fish for mackerel by trolling or handline (DoF 2015). A total of 11 boats operated in 2013, with three vessels operating in Area 1 (Kimberley) (DoF 2015). A total of 673 fishing days of effort were reported in 2014, with more than 53% of these days in Area 1 (Kimberley). The higher fishing effort in the Kimberley reflects the tropical distribution of mackerel species. Commercial fishers target Spanish mackerel in coastal areas around reefs, shoals and headlands (DoF 2015) and, as such, the shoals/banks in proximity to the project may be subject to commercial mackerel fishing. The interaction of this fishery with the Barossa project is only of relevance to the area of influence.
NDSF		✓	The fishery operates in waters off the Kimberley coast adjacent to the state of WA out to 200 nm (Commonwealth and state waters). The fishery is divided into two fishing area; Area 1 (inshore) and Area 2 (offshore) (DoF 2015). Area 2 (offshore) is further divided into three zones; Zone A represents the inshore developmental area; Zone B comprises the area with most of the historical fishing activity; while Zone C represents an offshore deep slope developmental area (water depths > 200 m) (DoF 2015). The target species for the NDSF are the goldband snapper and red emperor and the fishing season is unrestricted, therefore, fishing occurs year round. Eleven licenses for fishing within Zone C have been issued and the allowable effort allocated for these licences is used by eight vessels (DoF 2015). In 2014, the annual effort capacity was 616 fishing days for Zone A, 986 fishing days in Zone B and 1,100 fishing days for Zone C (offshore waters > 200 m) (DoF 2015). The interaction of this fishery with the Barossa project is only of relevance to the area of influence.
Northern Shark Fisheries		✓	The northern shark fisheries comprise the state managed WA North Coast Shark Fishery in the Pilbara and western Kimberley, and the Joint Authority Northern Shark Fishery in the eastern Kimberley. The Northern Shark Fishery has not operated since 2008–2009 (DoAWR 2016a). Given the distance to the project, and that the fishery is not active, interactions are not expected to occur.

NT reef-fish protection areas

The NT DPIF (Fisheries Research division) have undertaken a review of the status of golden snapper and jewfish stocks and identified that stocks of these species have continued to decline, particularly at an accelerated rate in the greater Darwin area (DPIF 2017b). To address this issue, NT DPIF have proposed a system of protection areas that, combined with angler education, possession and vessel limits should achieve the necessary catch reductions needed to promote stock recovery (DPIF 2017b). There are five reef-fish protection areas; Bathurst Island, Melville Island, Charles Point Wide, Lorna Shoal and Moyle/Port Keats (**Figure 5-21**). These reef fish protection areas are temporary and will remain for at least five years (DPIF 2017b).

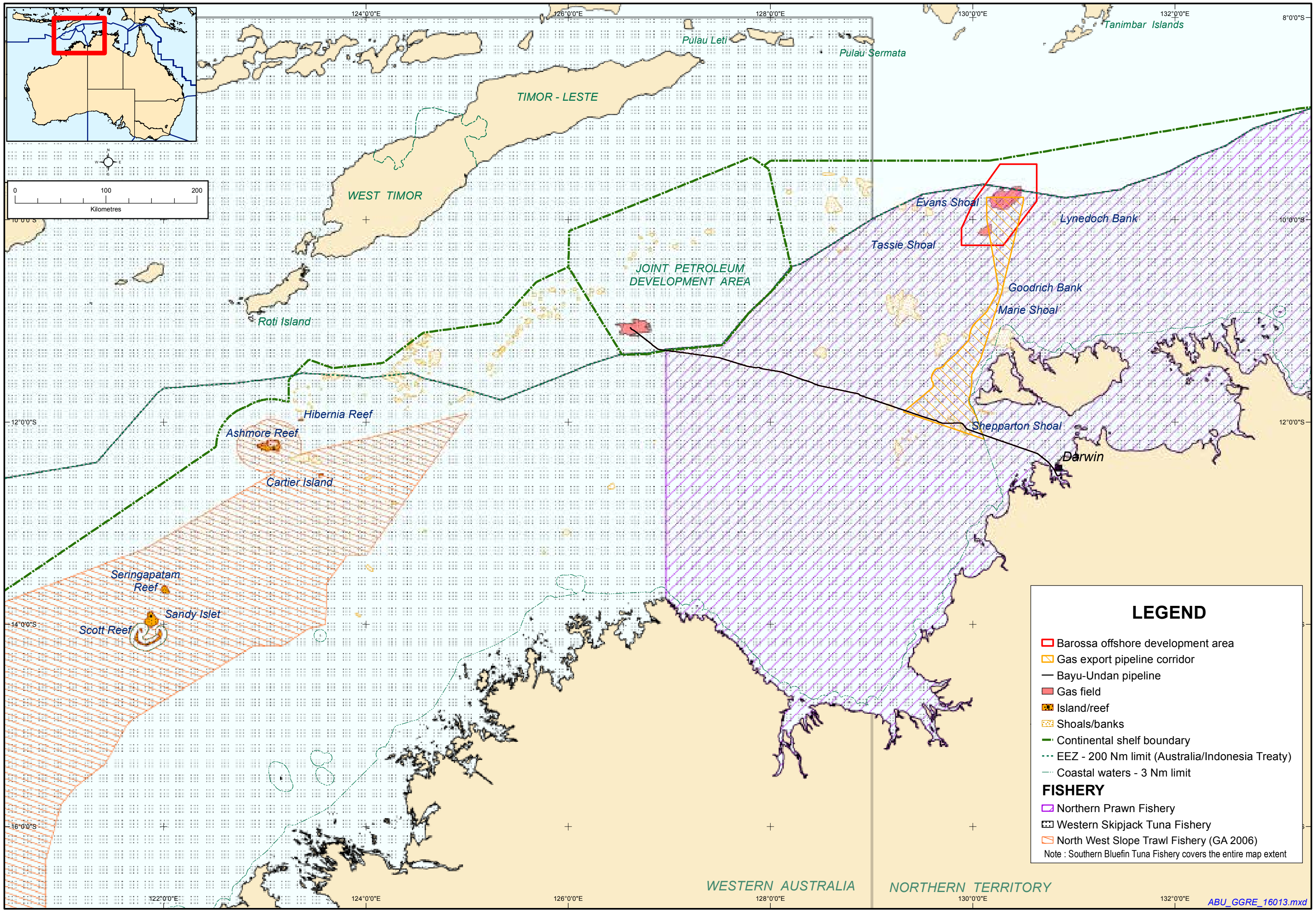


Figure 5-20: Commonwealth managed commercial fisheries

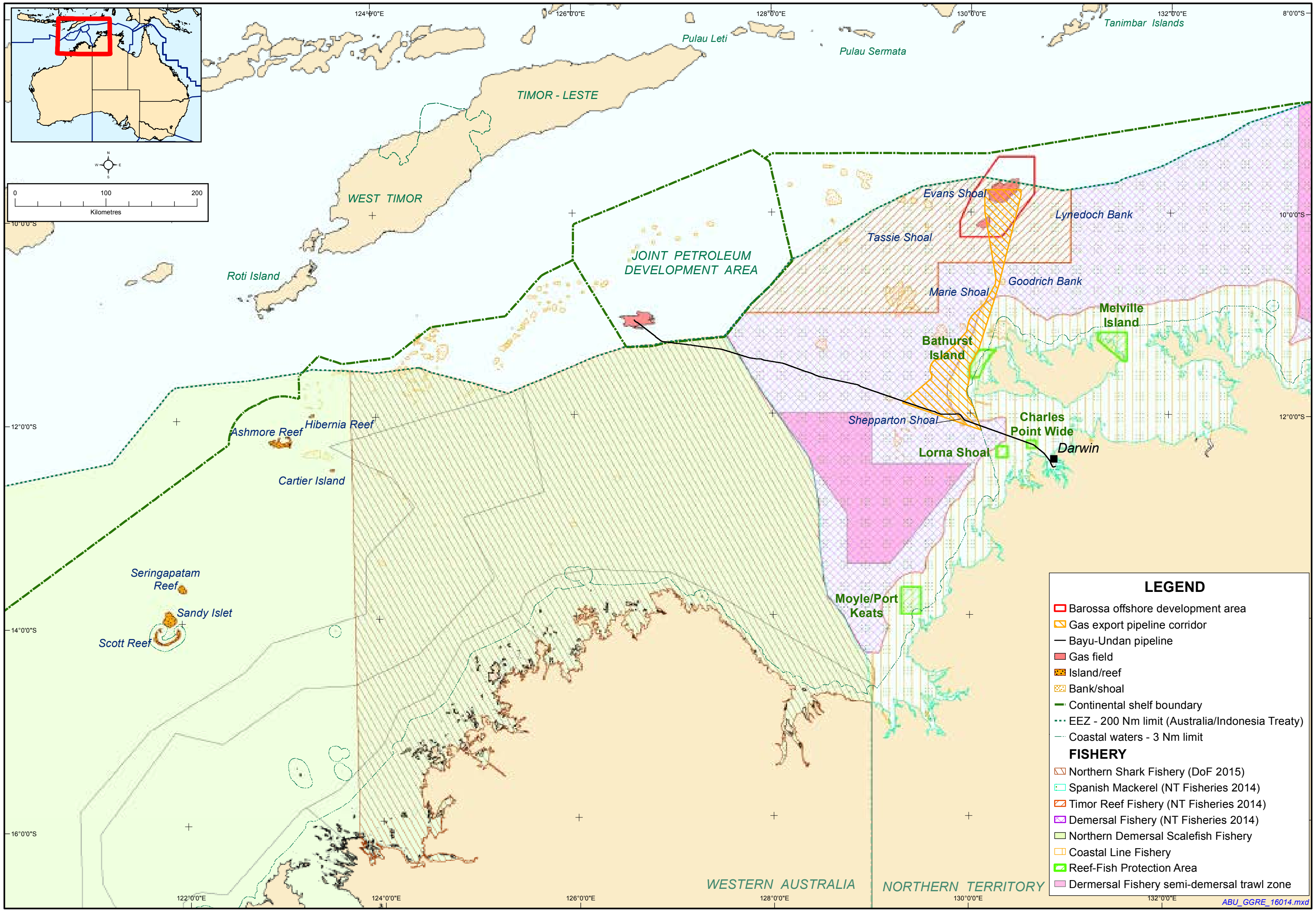
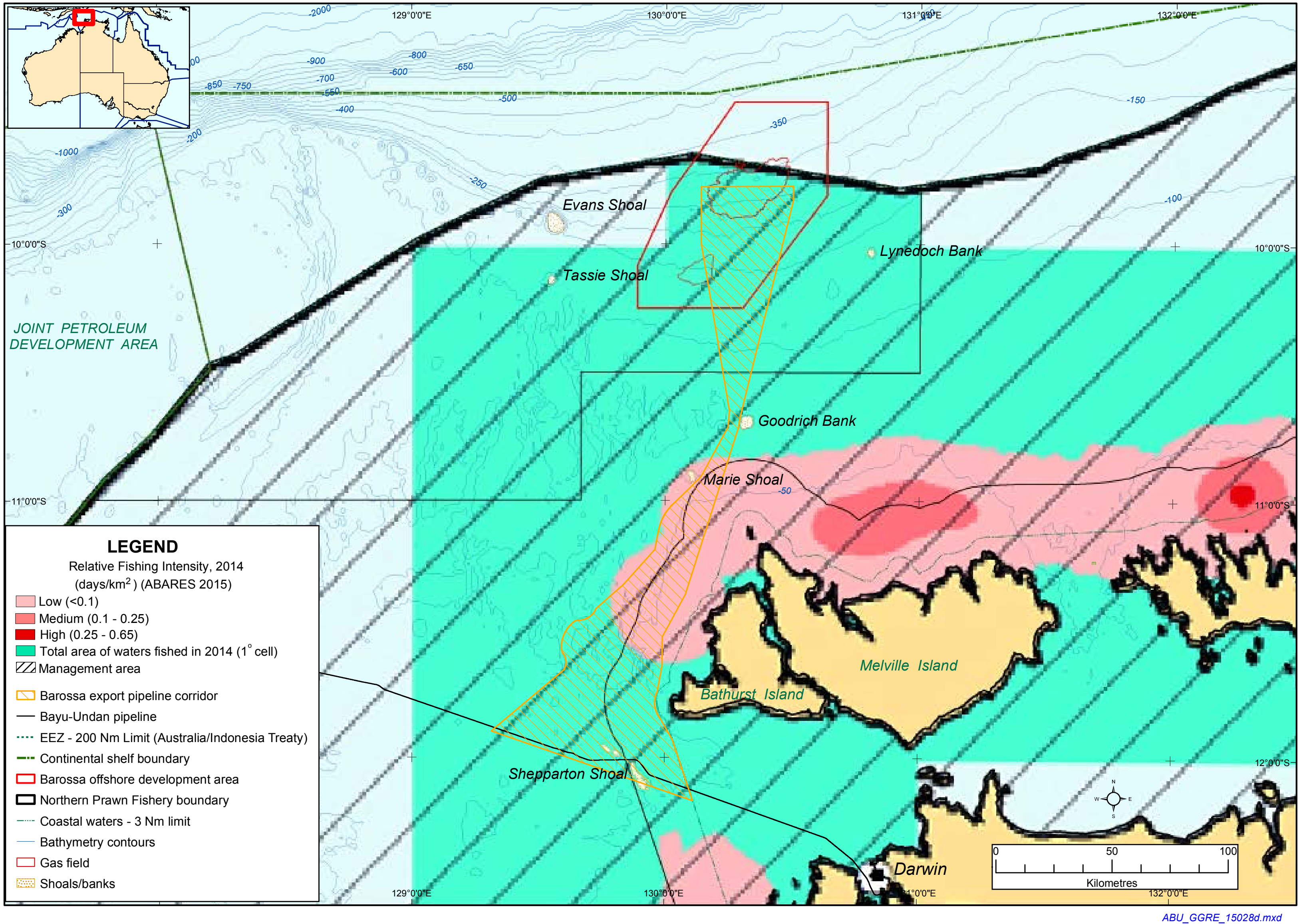
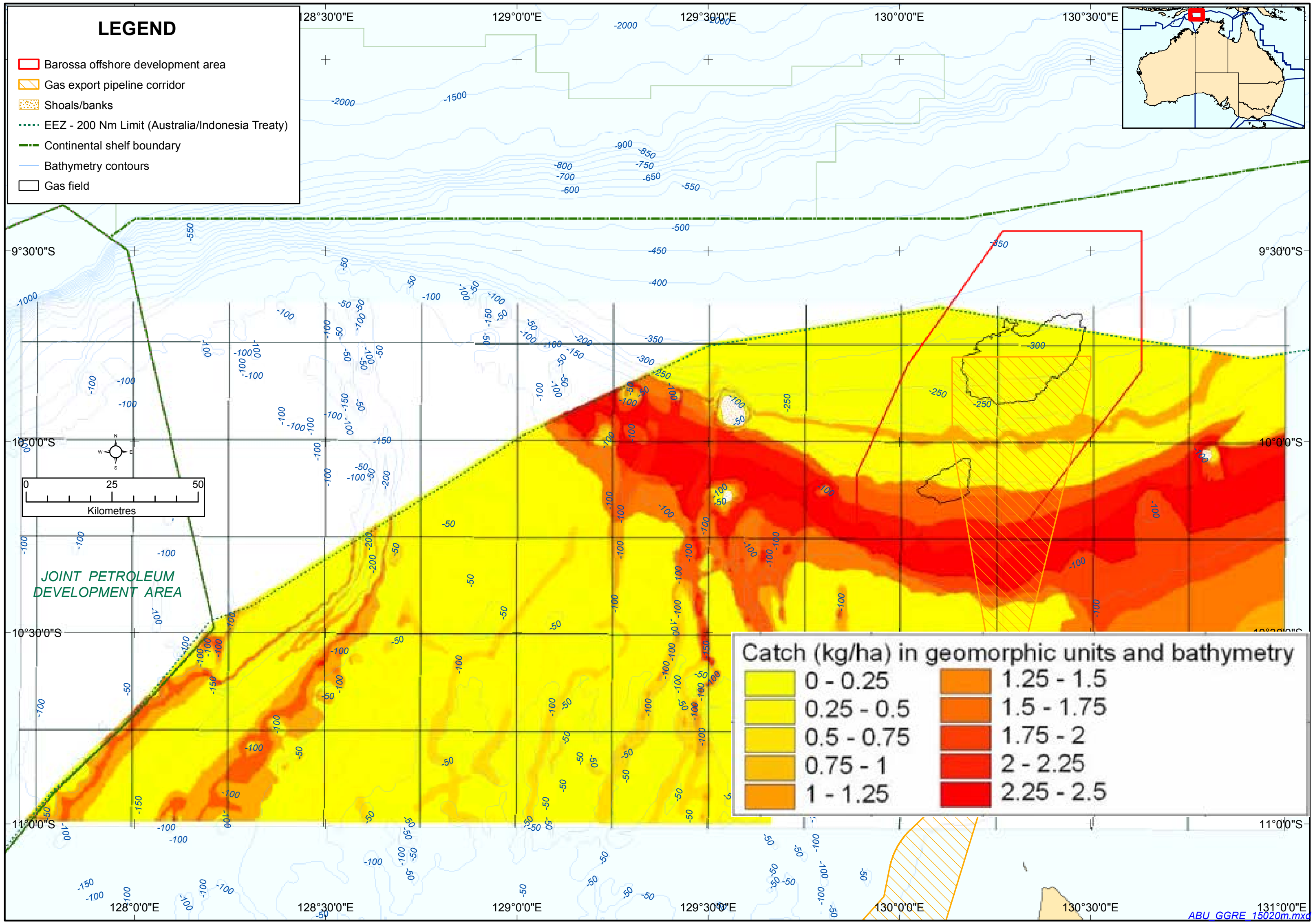


Figure 5-21: NT and WA managed commercial fisheries and NT reef-fish protection areas



(source: DoAWR 2016a)

Figure 5-22: Northern Prawn Fishery relative fishing intensity (2015)



(source: Lloyd and Puig 2009)

Figure 5-23: Commercial productivity of the Timor Reef Fishery (dropline catch only) 1995-2004

5.7.13 Indigenous fishing

The majority of the project is located in remote offshore waters that are unlikely to be regularly accessed by traditional indigenous fishing activities as almost all Indigenous fishing effort is concentrated within 3 nm of the NT coast (DPIF 2015). However, the southern end of the gas export pipeline corridor in the vicinity of the Tiwi Islands may traverse an area of waters fished by Indigenous people (refer to discussion below). Some encounters with traditional Indonesian fisherman in the general vicinity of the Barossa offshore development area can be expected as they may pass through the area.

In a broader regional context, a traditional Indonesian Fishing area is established approximately 720 km south-west of the Barossa offshore development area, known as the MoU box. Under a MoU signed between Australia and Indonesia in November 1974, an agreement to permit traditional Indonesian fishing practices in the region was formalised (DSEWPaC 2012b). As such, Indonesian and Timorese fishermen are legally permitted to harvest marine products. This MoU box covers Scott Reef and surrounds, Seringapatam Reef, Browse Island, Ashmore Reef, Cartier Island and various banks, representing an area of approximately 50,000 km^2.

Indigenous fishing within the areas of the Ashmore Reef and Cartier Island CMRs is permitted. Fishers may access the reefs of Cartier Island and Seringapatam Reef, and visit Ashmore Reef for access to fresh water and to visit graves (DEWHA 2008c).

Trochus, sea cucumbers (holothurians), abalone, green snail, sponges, giant clams and finfish, including sharks, are targeted by the fishers, concentrating on the reefs or in the reef lagoons. While absolute fishing effort is difficult to estimate, in 2006, 100 Indonesian fishing vessels were recorded in the vicinity of Scott Reef (Woodside 2011) and vessels have also been observed during baseline studies undertaken by ConocoPhillips in the vicinity of Seringapatam and Scott Reefs. Peak fishing season is typically between August and October with fishers departing the region at the onset of the northwest monsoon season. Fishing pressure from Indonesian fishers has led to a decline in the target species at Seringapatam Reef and Scott Reef (DEWHA 2008c).

Tiwi Islands

A number of different fisheries operate in the vicinity of the Tiwi Islands, which occur in the vicinity of the southern end of the pipeline corridor and within the broader area of influence. However, there appears to be a significant overlap in the harvest of primary species by Indigenous, recreational and commercial fishers (DPIF 2014). For example, fish that are important to both recreational and Indigenous fishers and to the commercial Coastal Line Net Fishery include mullet, catfish, snappers, sharks, threadfins and trevallies (Henry and Lyle 2003, cited in DPIF 2014).

In general, Indigenous fishing effort is greatest near the larger aboriginal communities of Wurrumiyanga on Bathurst Island, and Pirlangimpi and Milikapiti on Melville Island (DPIF 2014). The Tiwi Islanders continue to undertake the customary harvesting of sea turtles and dugongs (Department of Environment and Water Resources 2006). Green turtles appear to be the main species harvested in the water while eggs of all turtle species are taken periodically. Dugongs are also taken occasionally.

The Darwin Aquaculture Centre is working with Tiwi Islander elders to trial the farming of the blacklip oyster, which forms part of the traditional diet for the islanders. The elders are aiming to grow enough blacklip oysters to boost seafood supplies to the community (DPIF 2014). Pilot scale trials are also underway using recent advances in culture methods for sea cucumbers, giant clams and tropical rock oysters (DPIF 2015).

In terms of fishing tour operators, the key target species in the vicinity of the Tiwi Islands has traditionally been barramundi (DPIF 2014).

5.7.14 Tourism and recreational activities

The Barossa offshore development area and majority of the gas export pipeline are located in offshore waters that are not likely to be accessed for tourism activities (recreational fishing and boating and charter boats operations) which tend to be centred on nearshore waters, islands and coastal areas. A number of fishing charters operate in the coastal waters along the NT coastline (within 3 nm) and in the vicinity of the Melville and Bathurst Islands (DPIF 2015). These waters are also used by recreational fishers. Consultation undertaken by ConocoPhillips identified one fishing charter operator who conducts a number of tours in open offshore waters in the vicinity of Evans Shoal and Goodrich Bank during the main fishing season (September to December).

A specimen shell collection enterprise occurs around Ashmore Reef and Cartier Island. Fishing and diving charter companies offer tours to fishing spots off the WA coast, including Seringapatam Reef, and dive spots which include Ashmore Reef, Cartier Island, Hibernia Reef and Seringapatam Reef. These offshore areas are encompassed in the area of influence.

Tourism on the mainland of the Tiwi Islands is focussed on fishing, local arts and crafts, and Indigenous cultural tours.

In summary, there are limited recreational activities observed or expected to occur in the deep water offshore environment of the Barossa offshore development area and the majority of the export pipeline. Nonetheless, some occasional activity may be encountered within the regional marine environment, including within the area of influence.

5.7.15 Mariculture activities

The project area is located in offshore waters that are not accessed for aquaculture activities. Mariculture activities occur in NT coastal waters, which occur in the broader region, and include collection of marine fauna for marine aquariums and specimen shell (e.g. pearl oysters) collection.

5.7.16 Defence activities

The Australian Border Force undertakes civil and maritime surveillance (and enforcement) in Australian offshore maritime waters, which includes the Exclusive Economic Zone. As part of their role, Australian Border Force and Australian Customs monitor illegal foreign fishing activity within the boundaries of the MoU Box (**Section 5.7.13**) and the AFZ, which extends to approximately 200 nm from the mainland.

There are no designated military/defence exercise areas in the immediate vicinity of the project. However, regionally relevant activities include the North Australian Exercise Area (NAXA), a maritime military zone administered by the Department of Defence. The NAXA extends approximately 300 km north and west from just east of Darwin into the Arafura Sea and is used for offshore naval exercises and onshore weapon-firing training (Department of Defence 2015).

Consultation undertaken by ConocoPhillips in 2016 identified that the Department of Defence uses the Exclusive Economic Zone as a submarine exercise area.

5.7.17 Ports and commercial shipping

The closest major commercial port to the project area is Darwin, approximately 300 km south of the project area. The Darwin Port Corporation serves a number of shipping and cargo markets, including cruise and naval vessels, livestock exports, dry bulk ore, offshore oil and gas rig services, and container and general cargo (Darwin Port Corporation 2014).

Darwin Port experienced a record number of approximately 3,178 visits from trading vessels in 2013/14; a significant increase of 418 vessels (15%) from the previous year (Darwin Port Corporation 2014). A large portion of the increase in trading vessels in the past two years (total increase of 107%) within Darwin Harbour is attributable to construction of the INPEX Ichthys project (Darwin Port Corporation 2014).

While the port of Darwin remains the primary active port in the region, there is small-scale port activity to the south and east of the project area, at the Tiwi Islands. Port Melville is located on Melville Island (approximately 122 km north of Darwin) and is situated on the Apsley Strait, immediately south of Barlow Point and the community of Pirlangimpi. The wharf infrastructure at Port Melville was constructed in 2013.

Port Melville provides for the export of woodchips for Tiwi Plantations Corporation, and the shipment of equipment and supplies for other projects. The facility is capable of 24-hour operation, although most operations are undertaken during daylight hours. Most vessels enter and exit the Apsley Strait from its northern entrance. This is except for barges travelling between Darwin and Port Melville, which enter and exit the Apsley Strait from its southern entrance.

Cargo transferred at Port Melville currently includes:

- woodchip exports to overseas destinations – up to 12 vessels per year
- cargo movements between Darwin and Port Melville for on-site operations as required.

Total projected monthly vessel movements (excluding pilot vessels) in 2015 is 23, increasing to 28.5 in 2019, however this is subject to commercial arrangements in support of the plantation export and other future uses.

Figure 5-24 provides the shipping routes within waters of the Timor Sea, and shows the main commercial shipping channel tracking approximately 90 km to the south-west of the Barossa offshore development area (AMSA 2017). Smaller pockets of activity, and the pathways tracking to these pockets, in the Barossa offshore development area correlate with previous ConocoPhillips appraisal activities and the movement of support vessels.

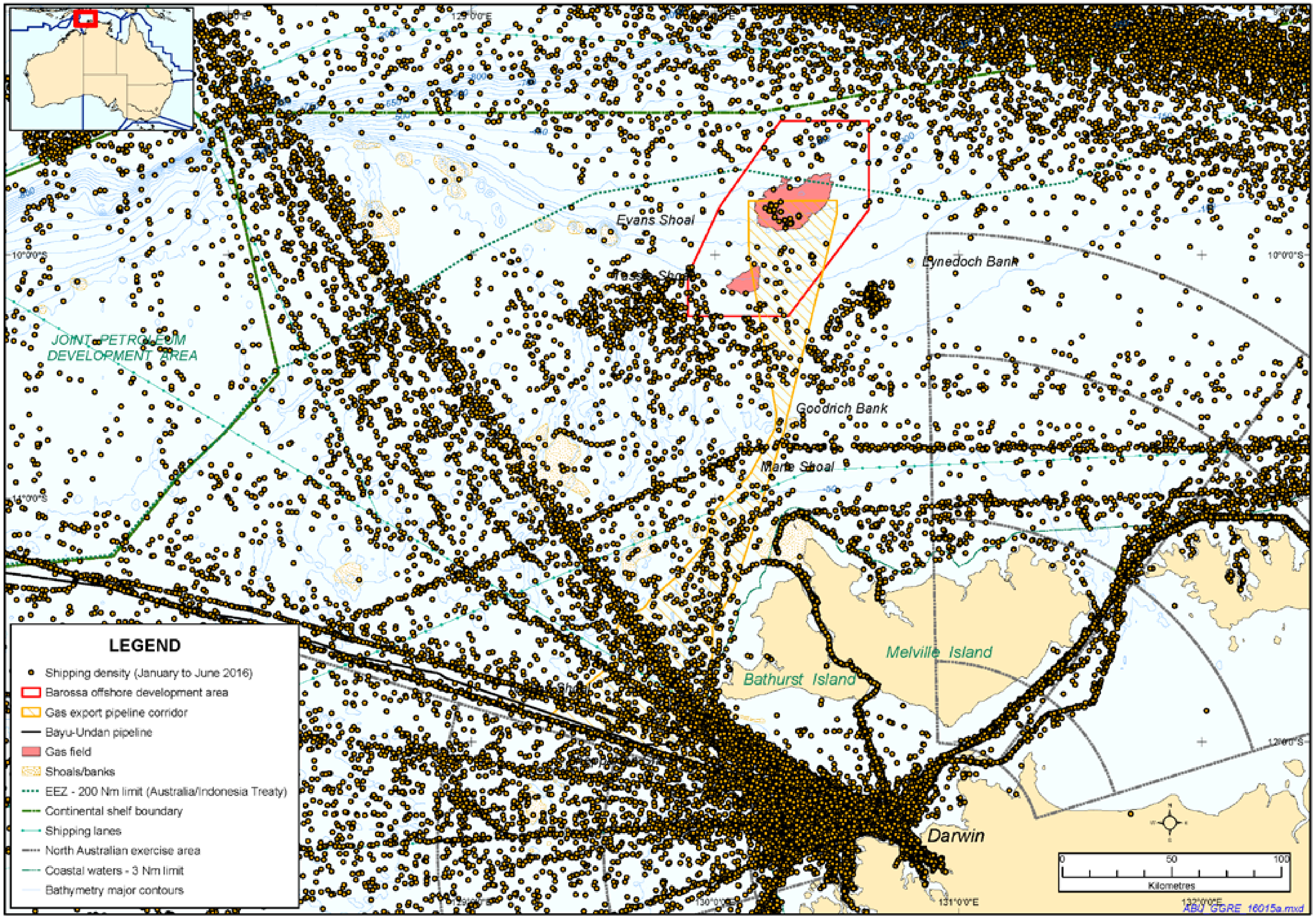


Figure 5-24: Shipping density

5.7.18 Offshore petroleum exploration and operations

There are a number of oil and gas companies holding petroleum permits in the vicinity of project area. However, there are no established oil and gas operations within, or in the immediate surrounds.

The closest operational production facilities and in-field subsea infrastructure are associated with the ConocoPhillips operated Bayu-Undan platform approximately 360 km to the west-south-west. Other subsea infrastructure includes the Bayu-Undan to Darwin gas pipeline and Ichthys gas pipeline to the south-west.

Petroleum retention leases and exploration permit leases within the broader region are currently held by various oil and gas operators (and subsidiaries), including Woodside Energy Ltd, Shell Development (Australia) Pty Ltd, ConocoPhillips STL Pty Ltd, Osaka Gas Australia Pty Ltd, Eni, Magellan, Murphy Oil, Alpha Oil and Natural Gas, Total, Origin Energy, MEO Australia Ltd., Santos, INPEX and PTTEP Australia.

5.7.19 Scientific research

Scientific expeditions and surveys occur on occasion across the broader offshore Timor Sea and Browse Basin, with the majority of these studies undertaken by AIMS, university institutions and WAM. The WA State Government has also published a Kimberley Science and Conservation Strategy (2011) and the North Kimberley Marine Park Joint Management Plan (2016), which has been supported by a number of surveys of the northern Kimberley Islands and coastline.

5.7.20 Indonesian and Timor coastlines

The Barossa offshore development area is located approximately 120 km south of the Indonesia coastline, 530 km east south-east of the West-Timor coastline and 335 km east south-east of the Timor-Leste coastline. While planned project operations are not expected to have any impacts on Indonesian and Timor-Leste waters and shorelines, the area of influence takes into account these values. The coastlines of these countries support a range of habitats and communities, including sand and gravel beaches, rocky shores and cliffs, intertidal mud flats, mangroves, seagrass and coral reefs (Tomascik et al. 1997; Asian Development Bank 2014). The coastal waters provide habitat for a number of protected species, including humphead wrasses, marine turtles, giant clams, some mollusc species, crustaceans, cetaceans (dolphins and whales) and dugongs, and commercially important species of fish, shrimps and shellfish (Asian Development Bank 2014). Nearshore waters also support significant capture fisheries (commercial and subsistence) that contribute to the nation’s economy and employment (Asian Development Bank 2014). ConocoPhillips has established communication lines with DFAT with regards to spill response. ConocoPhillips also has offices in Indonesia with a team of local support resources.

5.8 Summary of key environmental, cultural and socio-economic values and sensitivities

Table 5-10 provides a summary of the environmental, cultural and socio-economic features discussed in **Section 5.4** to **Section 5.7**. It identifies the relevant values and sensitivities in the context of both the project area and the area of influence.

Identification of the relevant values and sensitivities assisted in informing the focus of the environmental risk assessment process (as presented in **Section 6**), and were used as the basis for determining the level of detail that is appropriate to the nature and scale of each impact or risk.

In order to refine the basis for relevance of the values and sensitivities presented in **Table 5-10**, it is important to understand the seasonal windows in which key marine fauna (or critical activities such as breeding and migration occur) or socio-economic activities are present. The seasonal presence of the key marine fauna species identified in the EPBC Protected Matters search and cultural and socio-economic values is presented in **Table 5-11** to **Table 5-13**. The data presented in these tables estimating seasonal presence is a summary of the information presented in **Section 5.6** and is based on the publicly available literature outlined in **Section 5.1**.

Table 5-10: Summary of environmental, socio-economic and cultural values and sensitivities and associated relevance to the project

Value/sensitivity	Present in the project area	Particular values/sensitivities of relevance	Present in the area of influence	Particular values/sensitivities of relevance	Factor grouping in the risk-based impact assessment (Table 6-7)
Physical environment					
Climate	Not relevant given the nature and scale of the project				Not applicable
Oceanography	Not relevant given the nature and scale of the project				Not applicable
Bathymetry and seabed features	✓	Seabed features	✓	Seabed features	Physical environment (including water, sediment and air quality, background/ambient underwater noise and seabed features)
Water quality	✓	Water quality	✓	Water quality	
Sediment quality	✓	Sediment quality	✓	Sediment quality	
Air quality and meteorology	✓	Air quality			
Underwater noise	✓	Marine mammals Marine reptiles			
Biological environment					
Benthic habitats and communities	✓	Benthic habitats and communities associated with predominantly silty sand, with some hard substrate within the gas export pipeline corridor	✓	May be affected by the potential scenario of an unplanned discharge (as discussed in **Section 6.4.10**).	Physical environment (seabed features)
Shoals, banks, and other regional seabed features of reference	✓	Shepparton Shoal is within the gas export pipeline corridor.	✓	The shoals/banks nearest to the project area include Evans Shoal, Tassie Shoal, Lynedoch Bank, Goodrich Bank and Marie Shoal. May be affected by the potential scenario of an unplanned discharge (as discussed in **Section 6.4.10**).	Shoals and banks
Offshore reefs and islands			✓	Tiwi Islands Ashmore Reef Cartier Island Hibernia Reef Seringapatam Reef Scott Reef	Tiwi Islands Other offshore reefs and islands and NT/WA mainland coastline

Value/sensitivity	Present in the project area	Particular values/sensitivities of relevance	Present in the area of influence	Particular values/sensitivities of relevance	Factor grouping in the risk-based impact assessment (Table 6-7)
NT and WA mainland coastline			✓	May be affected by the potential scenario of an unplanned discharge (as discussed in **Section 6.4.10**).	Other offshore reefs, islands and NT/WA mainland coastline
Plankton	✓		✓		Plankton
Listed threatened and migratory species of conservation significance	✓	19 threatened species and 38 migratory species	✓	27 threatened and 68 migratory species	Marine mammals Marine reptiles Birds Sharks and rays Fish
Cultural and socio-economic environment					
World heritage properties	Not relevant – there are no designated world heritage areas within the project area or area of influence				Not applicable
National heritage places			✓	Ashmore Reef and Cartier Island National Nature Reserve	Other offshore reefs, islands and NT/WA mainland coastline
Commonwealth heritage places			✓	Ashmore Reef Seringapatam Reef Scott Reef	Commonwealth heritage places
Declared Ramsar wetlands			✓	Ashmore Reef	Other offshore reefs, islands and NT/WA mainland coastline
CMRs	✓	Oceanic Shoals (gas export pipeline corridor)	✓	Oceanic Shoals, Arafura, Arnhem, Kimberley, Ashmore Reef, Cartier Island	CMRs
Listed threatened communities	Not relevant – there are no listed threatened communities, as defined under the EPBC Act				Not applicable
Commonwealth marine area	Not relevant – no distinct values or sensitivities associated with this feature which are not captured in other values and sensitivities elsewhere				Not applicable

Value/sensitivity	Present in the project area	Particular values/sensitivities of relevance	Present in the area of influence	Particular values/sensitivities of relevance	Factor grouping in the risk-based impact assessment (Table 6-7)
KEFs	✓	Shelf break and slope of the Arafura Shelf (Barossa offshore development area and gas export pipeline corridor) Carbonate bank and terrace system of the Van Diemen Rise (gas export pipeline corridor)	✓	Shelf break and slope of the Arafura Shelf Carbonate bank and terrace system of the Van Diemen Rise Pinnacles of the Bonaparte Basin Tributary canyons of the Arafura depression Carbonate bank and terrace system of the Sahul Shelf Continental slope demersal fish communities Ashmore Reef and Cartier Island and surrounding Commonwealth waters Seringapatam Reef and Commonwealth waters in the Scott Reef complex Ancient coastline at 125 m depth contour	KEFs
Commonwealth land			✓	Ashmore Reef Cartier Island	CMRs
Indigenous heritage			✓	Tiwi Islands Ashmore Reef May be affected under the potential scenario of an unplanned discharge (as discussed in **Section 6.4.10**).	Tiwi Islands Other offshore reefs and islands and NT/WA mainland coastline
Marine archaeology	✓	One historic shipwreck (a steamer ship) is known to be present within the gas export pipeline corridor	✓	Two historic shipwrecks – a steamer ship sunk adjacent to the west coast of Bathurst Island and a submarine sunk in the Beagle Gulf	Marine archaeology
Commercial fisheries	✓	Commonwealth: Northern Prawn Fishery, Southern Bluefin Tuna Fishery, Western Skipjack Tuna Fishery, Western Tuna and Billfish Fishery NT: Aquarium Fishery, Coastal Line Fishery, Demersal Fishery, Offshore Net and Line Fishery, Spanish Mackerel Fishery, Timor Reef Fishery	✓	Commonwealth: Northern Prawn Fishery, NWSTF, Southern Bluefin Tuna Fishery, Western Skipjack Tuna Fishery, Western Tuna and Billfish Fishery NT: Aquarium Fishery, Coastal Line Fishery, Demersal Fishery, Offshore Net and Line Fishery, Spanish Mackerel Fishery, Timor Reef Fishery WA: Mackerel Managed Fishery, NDSF, Northern Shark Fisheries	Commercial fishing

Value/sensitivity	Present in the project area	Particular values/sensitivities of relevance	Present in the area of influence	Particular values/sensitivities of relevance	Factor grouping in the risk-based impact assessment (Table 6-7)
Indigenous fishing	✓	Tiwi Islands (in the vicinity of the southern end of the gas export pipeline corridor)	✓	MoU box	Recreational and traditional fishing
Tourism and recreational activities	✓	Evans Shoal Goodrich Bank Tiwi Islands	✓	Ashmore Reef Cartier Island Hibernia Reef Seringapatam Reef Scott Reef	Tourism, recreation and scientific research
Scientific research	✓	Scientific expeditions and surveys occur on occasion across the broader offshore Timor Sea	✓	Scientific expeditions and surveys occur on occasion across the broader offshore Timor Sea and Browse Basin	
Mariculture activities			✓	Collection of marine fauna for marine aquariums and specimen shell (e.g. pearl oysters) collection	Commercial fishing Recreational and traditional fishing
Defence activities			✓	NAXA	Defence activities
Ports and commercial shipping	✓	Commercial shipping	✓	Commercial shipping	Commercial shipping
Offshore petroleum exploration and operations			✓	The closest operational production facilities – the ConocoPhillips Bayu-Undan platform – is approximately 360 km to the west-south-west of the Barossa offshore development area	Offshore petroleum exploration and operations
Indonesian and Timor shorelines			✓	May be affected by the potential scenario of an unplanned discharge (as discussed in **Section 6.4.10**).	Other offshore reefs, islands and NT/WA mainland coastline

Table 5-11: Seasonal presence of key marine fauna predominantly relevant to the Barossa offshore development area

Environmental value/sensitivity	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
Pygmy blue whale – migration												
Bryde's whale – presence												
Humpback whale – migration and breeding[1]												
Sei whale[2]												
Fin whale[2]												
Omura's whales – presence												
Antarctic minke whale[1, 2]												
Killer whale[1, 2]												
Sperm whale[1, 2]												
Flatback turtle (Arafura genetic stock) – presence												
Green turtle (Cobourg Peninsula genetic stock) – presence												
Olive ridley (NT genetic stock) – presence												
Loggerhead turtles – presence												
Leatherback turtles – presence												
Hawksbill turtles – presence												
Sea snakes – presence												
Seabirds – feeding, aggregation, breeding												
Migratory shorebirds – aggregation, breeding												
Migratory seabird – streaked shearwater												

Environmental value/sensitivity	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
Migratory seabird – fork-tailed swift – presence (note, species is almost exclusively aerial when over Australian waters)												
Migratory wetland – curlew sandpiper – presence												
Migratory wetland – eastern curlew – presence												
Migratory seabird – common noddy – presence												
Migratory seabird – greater frigatebird- breeding												
Migratory seabird – lesser frigatebird – breeding												
Whale shark[1]												
Great white shark[1, 2]												
Grey nurse shark												

Key

	Species likely to be present in the region
	Peak presence/occurrence (presence of animals reliable and predictable each year) or increased activity

[1] Relevant predominantly to the area of influence.

[2] The movements and distributions of the species are not well documented and it has therefore been assumed, as a conservative approach, that they may be present year-round.

Table 5-12: Seasonal presence of key marine fauna predominantly relevant to the gas export pipeline corridor

Environmental value/sensitivity	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
Flatback turtle (Arafura genetic stock) – nesting												
Flatback turtle (Arafura genetic stock – internesting												
Green turtle (Cobourg Peninsula genetic stock) – nesting												
Green turtle (Cobourg Peninsula genetic stock) – internesting												
Olive ridley (NT genetic stock) – nesting												
Olive ridley (NT genetic stock) – internesting												
Loggerhead turtles – presence												
Leatherback turtles – nesting												
Hawksbill turtles – presence												
Seabirds – feeding, aggregation, breeding												
Migratory shorebirds – aggregation, breeding												
Migratory seabird – crested tern – breeding on Tiwi Islands												
Migratory seabird – streaked shearwater												
Migratory seabird – fork-tailed swift – presence (note, species is almost exclusively aerial when over Australian waters)												
Migratory wetland – curlew sandpiper – presence												
Migratory wetland – eastern curlew – presence												
Migratory seabird – common noddy – presence												
Migratory seabird – greater frigatebird- breeding												
Migratory seabird – lesser frigatebird – breeding												
Migratory wetland – osprey – presence												
Dugong – presence (Tiwi Islands)												
Spotted bottlenose dolphin (Arafura/Timor Sea populations) – foraging, feeding and breeding												
Indo-pacific humpback dolphin – presence												

Environmental value/sensitivity	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
Australian snubfin dolphin – breeding, calving												
Sea snakes – presence												
Shortfin mako – presence												
Longfin mako – presence												
Speartooth shark – pupping												
Northern river shark – pupping												
Green sawfish, largetooth sawfish, dwarf sawfish, narrow sawfish – pupping												
Reef manta ray												
Giant manta ray												
Whale shark												
Great white shark[1]												
Grey nurse shark[2]												

Key

	Species likely to be present in the region
	Peak presence/occurrence (presence of animals reliable and predictable each year)

[1] The movements and distributions of the species are not well documented and it has therefore been assumed, as a conservative approach, that they may be present year-round.

[2] Relevant predominantly to the area of influence.

Table 5-13: Seasonal presence of key cultural and socio-economic values in the project area

Environmental value/sensitivity	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
Northern Prawn Fishery (Cwlth)												
NWSTF (Cwlth)												
Southern Bluefin Tuna Fishery (Cwlth)[1]												
Western Skipjack Tuna Fishery (Cwlth)[1]												
Western Tuna and Billfish Fishery (Cwlth)[1]												
Aquarium Fishery (NT) – Evans Shoal and Lynedoch Bank												
Coastal Line Fishery (NT)												
Demersal Fishery (NT)												
Offshore Net and Line Fishery (NT)												
Spanish Mackerel Fishery (NT)												
Timor Reef Fishery (NT)												
Mackerel Managed Fishery (WA)												
NDSF (WA)												
Northern Shark Fisheries (WA) [2]												
Fishing charters – Evans Shoal and Goodrich Bank												
Indigenous fishing												

Key	
	Activity likely to be present in the region
	Peak/increased activity

[1] While the project overlaps the project area, the fisheries are highly unlikely to operate in the area or have been inactive for several years.

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