Laminaria-5 Reinstatement Project

Environment Plan Summary

AC/L5

Doc No. 2017-004-02-02-002, Rev 1

Rev.	Date	Description	Prepared	Reviewed	Approved
1	08/01/2018	Revised in response to NOPSEMA assessment	G. Pinzone	P. Shepherd	I. Cashion
0	21/12/2017	Issued to NOPSEMA	G. Pinzone	P. Shepherd	I. Cashion
A	20/12/2017	Internal review	P. Shepherd	G. Pinzone	-

Table of Contents

Acronyms

AC/L5	Ashmore Cartier/Licence
ACF	Australian Conservation Foundation
AFANT	Amateur Fisherman's Association NT
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AHS	Australian Hydrographic Service
AIMS	Australian Institute of Marine Science
AIS	Automatic Identification System
AIV	Annulus Isolation Valve
ALARP	As Low As Reasonably Practicable
AMCS	Australian Marine Conservation Society
AMOSC	Australian Marine Oil Spill Centre
AMSA	Australian Maritime Safety Authority
API	American Petroleum Institute
APPEA	Australian Petroleum Production and Exploration Association
AS	Action Statement
ASBTIA	Australian Southern Bluefin Tuna Industry Association
BIA	Biologically Important Area
BOD	Biological Oxygen Demand
BPEM	Best Practice Environmental Management
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
CA	Conservation Advice
CAMBA	Agreement between the Government and Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986
CER	Irish Commission for Energy Regulation
CFA	Commonwealth Fisheries Association
CFL	Chemical Flying Lead
CH4	Methane
CHARM	Chemical Hazard and Risk Management
CMP	Conservation Management Plan
CMR	Commonwealth Marine Reserve
CO2	Carbon Dioxide
CoEP	Code of Environmental Practice

CPP	Central Production and Processing
Cth	Commonwealth
CWR	Centre for Whale Research
DAWR	Department of Agriculture and Water Resources
DEC	Department of Environment and Conservation (WA)
DENR	Department of Environment and Natural Resources (NT)
DIIS	Department of Industry, Innovation and Science (Cth)
DIPL	Department of Infrastructure, Planning and Logistics (NT)
DME	Department of Mines and Energy (NT)
DMIRS	Department of Mines, Industry Regulation and Safety (WA)
DoD	Department of Defence (Cth)
DoEE	Department of the Environment and Energy (Cth)
DoF	Department of Fisheries (WA)
DoT	Department of Transport (WA & NT)
DPaW	Department of Parks and Wildlife (WA)
DPIF	Department of Primary Industries and Fisheries (NT)
DPIR	Department of Primary Industries and Resources (NT)
EDP	Emergency Disconnect Package
EEZ	Exclusive Economic Zone
EFL	Electrical Flying Lead
EIA	Environmental Impact Assessment
EIAPP	Engine International Air Pollution Prevention
EMBA	Environmental that May Be Afffected
EP	Environment Plan
EPA	Environmental Protection Authority
EPO	Environmental Performance Outcome
EPS	Environmental Performance Standard
ERA	Environmental Risk Assessment
FPSO	Floating Production, Storage and Offtake (facility)
GHG	Greenhouse Gas/es
GMDSS	Global Maritime Distress Safety System
GMP	Garbage Management Plan
GoM	Gulf of Mexico
GOR	Gas to Oil Ratio
HAZID	Hazard Identification
HAZOP	Hazard Operations

HCMS	Harmonised Mandatory Control Scheme
HFL	Hydraulic Flying Lead
HFO	Heavy Fuel Oil
HSE	Health, Safety and Environment
HVAC	heating, venting and air conditioning
IADC	International Association of Drilling Contractors
IAPP	International Air Pollution Prevention (certificate)
IC	Incident Commander
ICS	Integrated Control System
IDGM	International Dangerous Goods Maritime
IFAW	International Fund for Animal Welfare
IMO	International Maritime Organisation
IMS	Invasive Marine Species
IMS	Integrated Management System
IMT	Incident Management Team
IOGP	International Association of Oil & Gas Producers
IOPC	International Oil Pollution Compensation
IOPP	International Oil Pollution Prevention (certificate)
IPIECA	International Petroleum Industry Environmental Conservation Association
ISPP	International Sewage Pollution Prevention (certificate)
ITF	Indonesian Through Flow
ITOPF	International Tanker Owners Pollution Federation Limited
JAMBA	Agreement between the Government and Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment 1974
JSA	Job Safety Analysis
KEF	Key Ecological Feature
KPI	Key Performance Indicator
LRP	Lower Riser Package
LoC	Loss of Containment
MARPOL	International Convention for the Prevention of Pollution from Ships
MBC	Maritime Border Command
MDO	Marine Diesel Oil
MNES	Matter/s of National Environmental Significance
MoC	Management of Change
MODIS	Moderate Resolution Imaging Spectrometer
MODU	Mobile Offshore Drilling Unit

MOP	Marine Oil Pollution
MRT	Marine Riser Tensioner
NE	*Northern Endeavour* (FPSO)
NOGA	Northern Oil and Gas
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NOPTA	National Offshore Petroleum Titles Administrator
NOx	Nitrous oxides
NSW	New South Wales
NT	Northern Territory
NTSC	NT Seafood Council
NTTOA	NT Trawler Owners Association
OCNS	Offshore Chemical Notification Scheme
ODS	Ozone-depleting Substance
OHS	Occupational Health and Safety
OIM	Offshore Installation Manager
OIW	Oil-in-Water
OMS	Operating Management System
OPEP	Oil Pollution Emergency Plan
OPGGS(E)	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
OPP	Offshore Petroleum Project
OSMP	Operational and Scientific Monitoring Program
OSPAR	Oslo-Paris (OSPAR) Convention 1992
OSRA	Oil Spill Response Atlas
OSRL	Oil Spill Response Ltd
OSRT	Oil Spill Response Team
OSTM	Oil Spill Trajectory Modelling
OWS	Oily Water Separator
PAH	Polyaromatic Hydrocarbons
PCE	pressure control equipment
PMS	Planned Maintenance System
PMST	Protected Matters Search Tool (under the EPBC Act)
PMV	Production Master Valve
POB	Persons on Board
PPA	Pearl Producers Australia
PPE	Personal Protective Equipment

PTW	Permit To Work
QA/QC	Quality Assurance/Quality Control
QPAR	Quarantine Pre-Apprival Report
RO	Reverse Osmosis
ROV	Remotely-Operated Vehicle
RP	Recovery Plan
SDS	Safety Data Sheet
SEEMP	Ship Energy Efficiency Management Plan
SEMC	State Emergency Management Committee
SFT	Surface Flow Tree
SG	Specific Gravity
SMPEP	Shipboard Marine Pollution Emergency Plan
SOx	Sulphur oxides
SSSV	Subsea Safety Valve
STCW	Standards of Training, Certification and Watchkeeping
STP	Sewage Treatment Plant
TEC	Threatened Ecological Community
TOGA	Timor Sea Oil and Gas
TRSSSV	Tubing Retrievable Subsea Safety Valve
TVD	total vertical depth
TVD	Total Vertical Depth
UNEP	United Nations Environment Program
UXO	Unexploded ordinance
VOC	Volatile Organic Compound
WA	Western Australia/n
WAFIC	WA Fishing Industry Council
WAMSI	WA Marine Science Institution
WORP	Work Over Riser Package
XOV	Cross over Valve

1 Introduction

1.1 Background

Timor Sea Oil and Gas Australia (TOGA) is the Titleholder (and 100% Operator) of the production licences AC/L5 in the Ashmore and Cartier Area and WA-18-L (offshore Western Australia) of the Bonaparte Basin. TOGA is owned and operated by Northern Oil and Gas Australia (NOGA).

The Laminaria-5ST1 well (herein referred to as Laminaria-5) is one of four wells clustered around the Laminaria central manifold located 5 km from the *Northern Endeavour* (NE) Floating Production, Storage and Offloading (FPSO) vessel. The FPSO produces light oil from the Laminaria and Corallina fields in AC/L5 (Figure 1.1 and Figure 1.2). The Laminaria-5 well was shut-in in 2009 and is currently suspended.

NOGA proposes to undertake well reinstatement on the Laminaria-5 wellhead to bring the well back into production. This activity is scheduled to occur during 2018, subject to the granting of regulatory approvals and the contract of a suitable Mobile Offshore Drilling Unit (MODU). The program will be completed approximately 30 days from the start of the campaign.

This EP Summary has been prepared in accordance with Subregulation 11(3)(4) of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009.

1.2 Proponent

TOGA is owned and operated by NOGA, the proponent for this project. TOGA operates under the parent company NOGA's Integrated Management system. The rest of the document refers only to NOGA to avoid confusion.

Details of the titleholder and liaison person for this project are provided in Table 1.1.

AGR Petroleum Services (AGR) is providing project management and well delivery services for the reinstatement activities, and Upstream Petroleum Solutions (UPS) is the operator of the NE FPSO facility. UPS will hand over the well to AGR for the duration of the project.

Table 1.1. Titleholder contact details

	Titleholder	Liaison Person
Name	Chris Dunlop	Ian Cashion
Position	General Manager / Asset Manager	HSEC Manager
Organisation	Timor Sea Oil & Gas Australia Pty Ltd	
ACN	111 708 868	
Address	Level 5, 1101 Hay Street, Perth, Western Australia, 6000	
Email address	cdunlop@northernoil.com.au	icashion@northernoil.com.au
Telephone number	08-6109 4000	

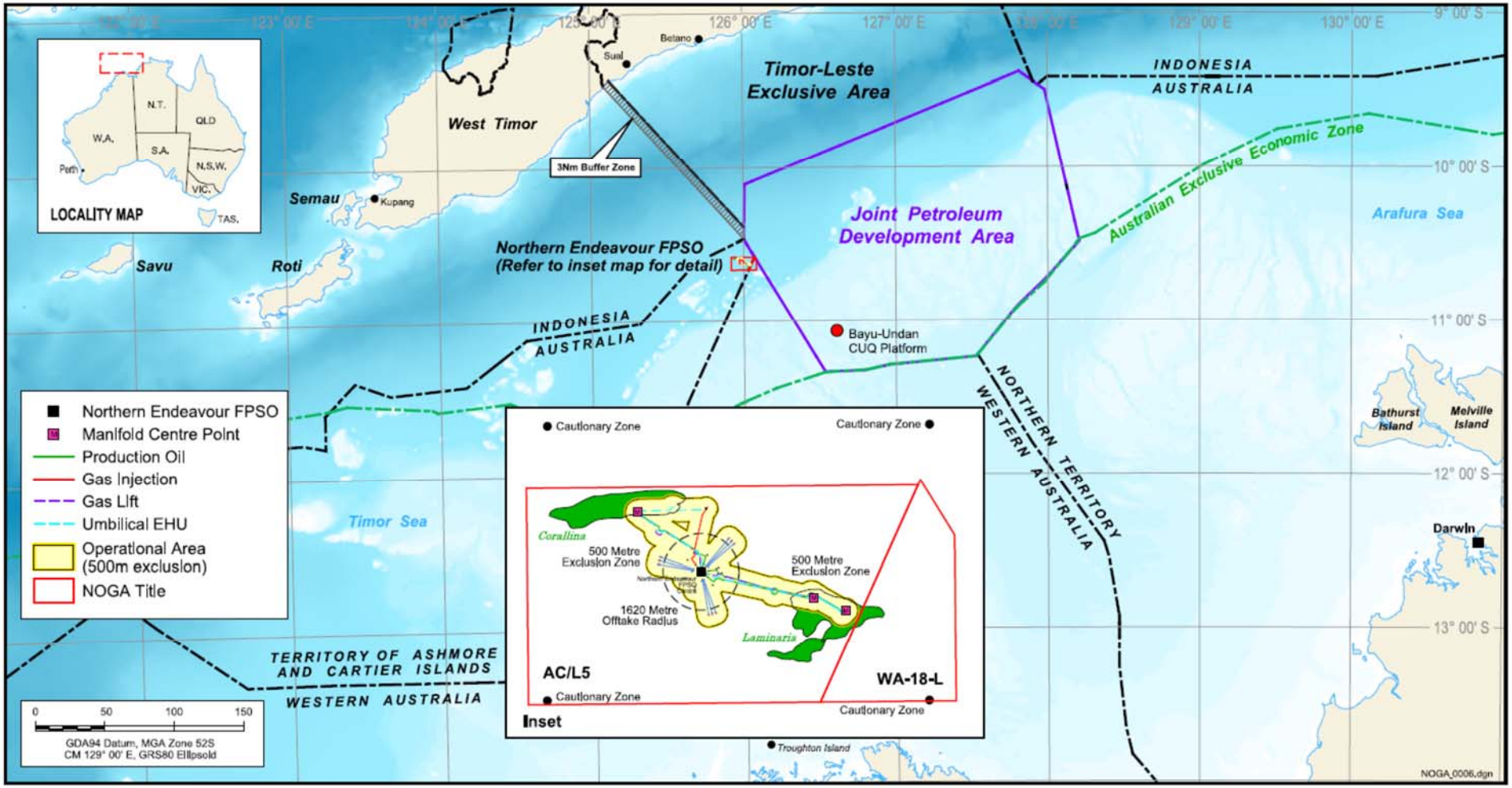


Figure 1.1 Location of the Laminaria field

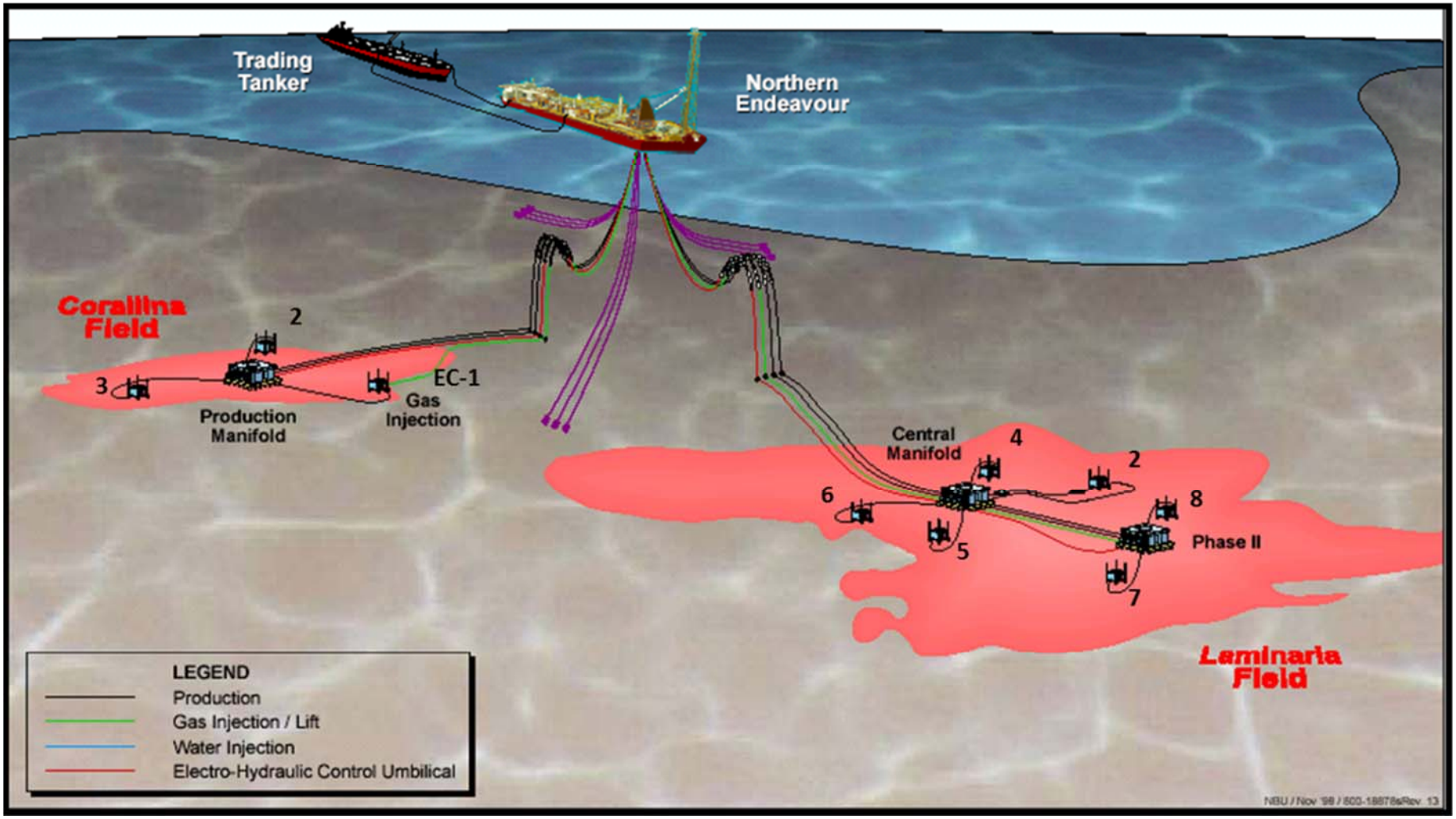


Figure 1.2 General arrangement of the Laminaria (and Corallina) Field

2 Activity Description

This chapter provides a description of the project, including its location, project objective, field characteristics, operational details, reinstatement program and well control and response.

2.1 Location

2.1.1 Project Location

The geographic coordinates for the Laminari-5 well is provided in Table 2.1. Water depth is approximately 350 m at this location. The NE FPSO and associated subsea infrastructure are marked on nautical maps, and are protected by a 500 m operational zone. The Laminaria-5 well is located 4.8 km from the NE FPSO.

Table 2.1. Location of Laminaria-5

Latitude (northing)	Longitude (easting)
10° 37’ 30.71”S	126° 1’ 45.281”E

(GDA94, Map Zone 52).

2.1.2 Proximity to Environmental and Social Features

The proximity of Laminaria-5 to environmental sensitivities and coastal populations is provided in Table 2.2.

Table 2.2 Distances to key environmental and social features in the EMBA

Location	Distance from Laminaria-5		Direction from Laminaria-5
	km	nm	
Towns			
Suai (Timor Leste)	162	87	Northwest
Darwin, NT	550	297	West-northwest
Broome, WA	908	490	Southwest
Commonwealth Marine Reserves			
Oceanic Shoals	99	53	South
Kimberley	289	156	South
Cartier Island	333	179	South
Ashmore Reef (also a Ramsar wetland)	346	187	Southwest
State Marine Parks			
Camden Sound Marine Park (WA)	528	285	South
Key Ecological Features			
Carbonate bank and terrace system of the Saul Shelf	99	53	South

Pinnacles of the Bonaparte Basin	132	72	Southeast
Carbonate bank and terrace system of the Van Diemen Rise	219	118	East
Ashmore Reef and Cartier Island and surrounding Commonwealth waters	322	174	Southwest
Ancient coastline at 125 m depth contour	330	178	Southwest
Continental slope demersal fish communities	333	180	Southwest
Islands			
Cartier	339	183	Southwest
Ashmore	364	196	Southwest
Browse	470	254	Southwest
Petroleum infrastructure			
Kitan field (operations ceased December 2015)	20	11	East
Bayu-Undan field (and gas pipeline)	85	46	Southeast
Ichthys gas pipeline	240	130	South
Montara wellhead platform	277	150	Southwest

2.1.3 Cautionary Area

A cautionary area for the Laminaria and Corallina wells and FPSO is marked on navigational maps (a Petroleum Safety Zone is not gazetted under Chapter 6, Part 6.6 of the OPGGS Act 2006), as shown in Figure 2.1.

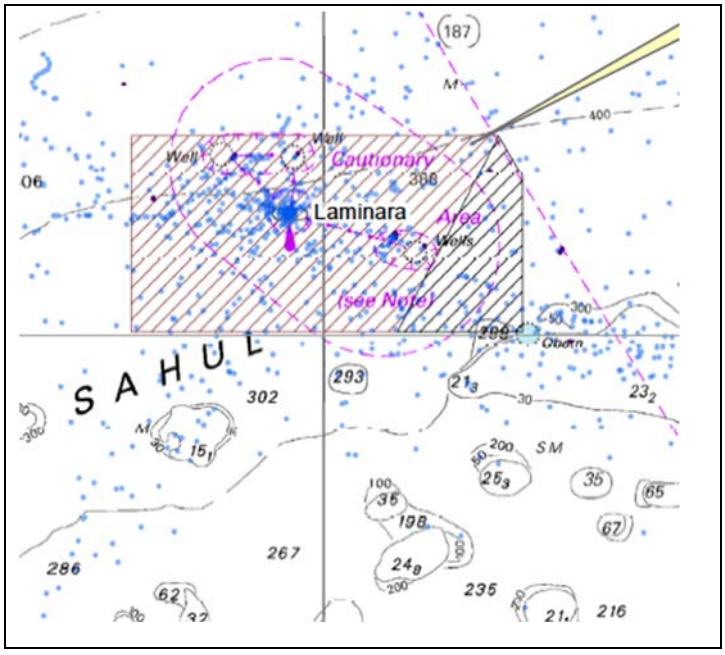


Figure 2.1. The Laminaria and Corallina fields cautionary area

2.2 Project Schedule

The project is scheduled to be undertaken and completed during 2018. It is anticipated that the project will take up to 30 days to complete.

2.3 Operational Details

This section provides details on the MODU, support vessels and helicopters for the project.

2.3.1 The MODU

NOGA will source and contract a conventionally moored semi-submersible MODU to undertake this reinstatement project. A MODU is the preferred platform for intervention activities as it allows for the use of the NOGA-owned Work Over Riser Package (WORP). This provides increased functionality while intervening on the well.

The MODU is likely to be one that is currently drilling in Australian or the nearby Joint Petroleum Development Area (JPDA) waters, though it may just as likely come from international waters. The final selection will be based on technical suitability and availability.

The waters of the project area make it too deep for a jack-up MODU to be used; jack-up MODUs are typically restricted to operating in waters less than 100 m deep.

Semi-Submersible MODU Operations

NOGA will ensure that the MODU is subject to screening and acceptance testing prior to entering service to ensure it meets the operational and safety requirements of the project. Additionally, NOGA will engage a third party specialist inspection company to conduct an independent Focused Limited Condition Survey to assess the condition of the MODU for operations. Particular attention during such a survey will be made to the following areas:

- Fire fighting and safety equipment;
- Verification of critical items within the maintenance systems;
- Electrical systems review and inspection;
- Rig structure, drilling and hoisting equipment and auxiliary marine systems;
- Personnel and equipment certification; and
- Cranes and related lifting equipment.

A full and detailed report will be compiled. Defects, corrective items or non-conformances will be agreed with the contractor and tracked to closure.

Maritime Safety

While on location, the MODU will be within the field's operational area, which will be actively monitored by the MODU's support vessels. The MODU contractor will issue a rig move notification and a rig positioning notification to the Australian Hydrographic Service (AHS) for the rig move on and off location, who will in turn publish the MODU's location in the Notice to Mariners (published fortnightly on the AHS website). A daily AusCoast warning of the MODU's location will also be issued to all vessels travelling through the region through the Global Maritime Distress Safety System (GMDSS) communication network.

In addition to the Automatic Identification System (AIS) on the MODU that will be visible on the radars of nearby vessels, one of the support vessels will provide radio notification about the operational area to nearby vessels to minimise the risk of collision with errant vessels.

Environmental Credentials

Although a MODU is not yet contracted, it will be subject to NOGA's pre-qualification process as described in the Marine Assurance Procedure (01-OPS-PC01) to ensure they meet NOGA's HSE requirements.
At a minimum, NOGA will ensure that the MODU has the following current and valid environmental credentials in place:

- IOPP certificate in accordance with MARPOL Annex I (enacted under AMSA Marine Orders Part 91, Marine Pollution Prevention – Oil);
- ISPP certificate in accordance with MARPOL Annex IV (enacted under AMSA Marine Orders Part 96, Marine Pollution Prevention – Sewage);
- IAPP certificate in accordance with MARPOL Annex VI (enacted under AMSA Marine Orders Part 97, Marine Pollution Prevention – Air Pollution);
- International Anti-fouling System certificate in accordance with the International Convention on the Control of Harmful Anti-fouling Systems on Ships 2008 (enacted under AMSA Marine Orders Part 98, Marine Pollution Prevention – Anti-fouling Systems).
- SMPEP in accordance with MARPOL Annex I (enacted under AMSA Marine Orders Part 93, Marine Pollution Prevention – Noxious Liquid Substances); and
- Garbage Management Plan in accordance with MARPOL Annex V (enacted under AMSA Marine Orders Part 95, Marine Pollution Prevention – Garbage).

2.3.2 Support Vessels

Up to three, but nominally two, vessels will be used to support the MODU. The vessels will be dimensioned and selected to ensure they can efficiently fulfil the following functions:

- Towing, anchor deployment and recovery operations;
- Supply food, fuel and bulk powders, fluids and other project materials;
- Collect waste;
- Assist in emergency response situations; and
- Monitor the 500-m radius PSZ around the MODU and intercept errant vessels.

To achieve those objectives, vessels of different sizes and capabilities will be considered, collectively referred to herein as support vessels.

There will be one vessel on standby at all times during the operations to provide support capability for the MODU in accordance with the MODU's Facility Safety Case.

2.4 Reinstatement Program

The key activities required to reinstate the Laminaria-5 well are described in this section.

2.4.1 Mobilisation and Preparation

The MODU will be towed by the support vessels to the Laminaria-5 location. After obtaining the appropriate field entry permit approval from the NE FPSO OIM, anchor deployment of the MODU will commence. Once the MODU's primary and secondary anchors have been deployed by the support vessels, a Remotely-Operated Vehicle (ROV) will be used to perform an 'as-found' survey of the Laminaria-5 SST. The aim of this is to ensure no obvious damage, leaks or defects on the tree system prior to commencing intervention works. Brushes attached to the ROV will also be used to clean the subsea tree (i.e., remove marine growth). The ROV will also assist in attaching guide wires to the wellhead structure. Formal control of

the well shall be handed over from the NE FPSO to the MODU for the duration of the intervention activities. This control shall be managed under a field permit.

2.4.2 Establishing Communication, Control and Access to the Well

Once the ROV has established the condition of the Laminaria-5 SST and associated subsea equipment, intervention activities will commence. The tree cap will be recovered on the dedicated drill pipe deployed running/recovery tool and brought back to surface.

The NOGA-owned Aker/Kvaerner Workover Riser System (WORS) will be installed in the moonpool and function tested. The WORS is designed to control subsea tree hydraulic functions from the MODU when connected to the SST. It also provides a conduit for access to both the production tubing and annulus bores of the well through the SST.

Comprising of Lower Riser Package (LRP), Emergency Disconnect Package (EDP), dual bore riser and Surface Flow Tree (SFT), the WORS will be deployed and connected to the subsea tree. A control line umbilical allows control of all valves on the tree through the work over system. Additionally, the EDP/LRP package contains valve arrangements to provide and maintain additional physical well barriers during the intervention activities. The LRP contains a shear/seal valve capable of being closed in an emergency while the EDP function allows for the riser package to be released from the SST. The valving arrangement in the SFT provides pressure control and dual well barriers at the rig side of the WORS system. The SFT allows for annulus and production hoses to be connected to the WORS. Activity-specific pressure control equipment (e.g., slickline lubricator) can be installed on either the production or annulus bore as required.

After pre-deployment checks are complete, the EDP/LRP package is rigged up to the first joint of dual bore riser. The package will then be deployed subsea on the riser from deck. Prior to land out, the SFT and landing joint will be moved to the drill floor and connected to the riser string. Surface lines and pressure-controlled equipment will then be made up to the surface flow tree. The MODU will then land out the EDP/ LRP package to the well and confirm that it is latched. This operation will be observed via the ROV to ensure a smooth and safe land out. Pressure and functionality checks will be completed prior to moving to the intervention phase. Top tension is applied via a tension frame attached to the MODU travelling assembly. Additional tension support may be provided by the MODU marine riser tensioners (MRT) if required as identified by riser analysis.

Additionally a bleed off or well test package will be installed on the deck of the MODU. The bleed off package will be connected to the SFT via pressure rated flexible hoses. A bleed-off is an event that equalises or relieves pressure from a vessel or system. At the conclusion of high-pressure tests or treatments, the pressure within the treatment lines and associated systems must be bled off safely to enable subsequent phases of the operation to continue. The bleed-off process must be conducted with a high degree of control to avoid the effect of sudden depressurisation, which may create shock forces and fluid-disposal hazards. The duration of bleed-back is expected to be less than 24 hours. The package will be designed to allow for cold venting of gas (if required), and flaring of gas for liquid hydrocarbons. The volume of liquid hydrocarbons is expected to be minimal; about 30 bbl, being the volume in the riser and the volume above the downhole safety valve.

The bleed-back package will be installed on the MODU prior to the intervention activities and subject to a full pre-start checklist, including pressure testing and verification of safety features.

With full functionality, communication and pressure integrity with the SST and WORS system established and verified, the SST valves can be manipulated to allow access to the well. Intervention activities can then commence.

2.4.3 Intervention Activities

The main intervention activities will involve establishing the status of the TRSSV and the location, and removal of, any restrictions to future production flow.

The valve arrangements in the LRP, SFT and surface pressure control equipment ensure a minimum of two barriers to be in place while slickline/wireline or coiled tubing tool strings are inserted into or removed from the well. Barrier requirements for all intervention activities are described in the Laminaria-5 reinstatement WOMP (01-HSE-PL03, Appendix 1). The bleed off package will be used to bleed off residual pressure and manage small hydrocarbon inventories released from the well during operations (such as tool string change outs); it is not planned to flow the well during operations.

The first activity will be to recover the 4¾" TKN tubing hanger plug from the tubing hanger from the well using slickline. Nominally the second activity will be to run an electric line-deployed downhole camera to ascertain and evaluate the condition of the TRSSV), as its current condition is unknown.

Subject to the evaluation of the condition of the TRSSV, future activities will either permanently lock out the TRSSV flapper, mill through the TRSSV and/or install a sleeve. It may be required to remove the TRSSV flapper with a downward firing charge (known as a "cannon") to allow break-up of the flapper leaving the valve body intact. There will be no replacement of the TRSSV.

With the TRSSV locked out or removed from service and full access regained to the well below this point, operations will continue to retrieve a slickline tool string (fish) currently left in the well. A flow-through debris device may also be installed in the event the fish is not recovered from the well. Flow modelling indicates minimal impact to production with the fish left in situ.

Once the well intervention activities are complete, the well will be temporarily suspended. Slickline or wireline-conveyed temporary suspension plugs will be installed in the tubing and annulus bores to provide two barriers to flow. With the suspension barriers tested and verified, operations to recover and replace the existing subsea tree can commence.

2.4.4 Tree Replacement

The currently installed SST will be unlocked hydraulically and recovered clear of the flowline support base. The MODU and SST package are skidded to a safe handling zone and the surface tree/landing joint and tension frame laid down prior to recovery of the subsea tree and EDP/LRP package on dual bore riser. The ROV will monitor this operation throughout. The existing SST will be removed from the EDP/LRP package and secured on the MODU.

The replacement SST will be made up to the EDP/LRP assembly and prepared for subsea deployment in the moonpool. Pressure and function tests will be performed prior to the entire package being run on dual bore riser in the same manner previously described. The SFT, tension frame and associated equipment shall be made up to the MODU travelling assembly. The MODU and SST package will be skidded back over the Laminaria-5 well, where the ROV will assist by observing the tree landing out and hydraulically locking on to the wellhead.

Function testing will take place in situ, including pressure testing of all connections, valves and control lines. Once the SST is confirmed as functional, all temporary barrier isolation plugs will be removed from the well and the well will be made ready for production.

A refurbished tree cap will be deployed and installed on the SST with drill pipe. Finally, the tree cap will be pressure tested and the deployment tool recovered on drill pipe. The ROV will connect the Hydraulic Flying Lead (HFL), Chemical Flying Lead (CFL) and Electrical Flying Lead (EFL) to the SST. The ROV will perform a final "As left" survey.

Control of the well will then be handed back to the NE FPSO to restart production. The MODU will make preparations to demobilise from the field.

2.4.5 Demobilisation

The secondary anchors and then the primary anchors will be recovered by the support vessels and the MODU will move off location. In the event that the MODU does not have additional work, it will be towed back to Port of Darwin.

2.5 Well Control

Well control is the process implemented to prevent a loss of well containment. A loss of well containment is an uncontrolled flow of formation fluids from a well that has suffered a failure of barrier systems such as the pressure control equipment, or when the well pressure has exceeded the working pressure of the pressure control equipment.

A loss of well control is prevented by monitoring the formation pressure and controlling the density (or weight) of wellbore fluids. The fluid density is considered the primary well control barrier. During well intervention activities (typically performed after the well has been brought on to production), it is common to perform activities on the well without primary hydrostatic fluid being in place.

During intervention activities the well may be managed under pressure. In this instance, physically verified primary and secondary barriers are managed, monitored and verified to maintain control of the well throughout the operation as detailed in the Laminaria-5 WOMP (Appendix I to the NE FPSO WOMP, 01-OPS-PL01). Equipment design and layout afford high levels of redundancy in maintaining two barriers at all times.

During this project, the dedicated NOGA-owned AKER/Kvaerner WORS will be installed on top of the SST and provide a pressure-containing conduit to the MODU for the purpose of conducting reinstatement activities. In a well control emergency, the MODU will have sufficient kill weight fluid to displace the well and regain primary hydrostatic (fluid) control.

A weighted calcium chloride (KCl) brine (nominal SG of 1.02) will be used to maintain hydrostatic pressure and will be treated with minor quantities of glycol, oxygen scavenger and biocide.

Barrier management during all operations will be managed according to the well barrier diagrams in the WOMP.

The WORS consists of the following major equipment items:

- LRP;
    - Dedicated hydraulic connector to attach and lock the WORS system to the top connection of the subsea tree.
    - Production Master Valve (PMV) – a hydraulically-activated gate type valve that fully closes and seals the 5” production bore.
    - Annulus Isolation Valve (AIV) – a hydraulically-actuated gate type valve that fully closes and seals the 2” annulus bore
    - Cross over Valve (XOV) – a valve that isolates the production and annulus bores of the WORS system. Normally closed, this valve allows for circulation of fluids from the annulus to the production bores as required during intervention activities.
    - Shear/Seal Ram – opposing pistons that move horizontally across the top of the well that are capable of cutting wireline and coiled tubing in the event of an emergency and isolating the production tubing bore.

- EDP – the EDP package is a hydraulically-actuated emergency disconnect device. In an emergency, the LRP and EDP valving and functions are automatically sequenced such that the LRP valves are closed prior to EDP connector releasing from the LRP. Top tension on the riser string lifts the EDP and riser clear of the closed in subsea tree/LRP arrangement.
- Hydraulic Control Lines – hydraulic control of the SST and EDP functions is maintained via a dedicated umbilical control bundle. The bundle contains up to 27 individual high-pressure control lines (rated between 1,500 psi and 7,500 psi depending on the function). This is deployed from surface and attached securely to the dual bore riser. An independently controlled hydraulic power unit (HPU) provides power via control panel on the MODU.
- Dual Bore Riser;
    - Rigid pipe with two (dual bores), being the 5” production bore and the 2” annulus bore. Typically in 45’ (15 m) lengths with short joints to allow for varying water depths. Joints are pressure rated to 5,000 psi.
    - Special purpose joints such as the lower stress joint, tension joint and cased wear joint allow for connection to the EDP, marine riser tensioners and the surface flow tree.
- SFT – a high-pressure rated valve arrangement consisting of multiple valves to allow for control and access to the production and annulus bores, side outlets (kill and production) to allow for circulation of well fluids, and top connections for activity specific pressure control equipment (PCE).
- Activity specific PCE – slickline, wireline and coiled tubing BOPs will be installed on top of the SFT to allow pressure control to be maintained during operations. PCE typically comprise of two valve arrangements to seal on or shear on wire or other downhole tools at surface.

2.5.1 Program-specific Source Control and Loss of Well Containment Measures

The NE FPSO Source Control Mobilisation Plan (01-HSE-PL11) describes the major considerations, activities and equipment required to prepare for the primary, secondary and tertiary source control methods in the event of a subsea well loss of containment under normal production conditions

These are:

- Primary method – Emergency well kill via bullheading formation from the NE Endeavour FPSO;
- Secondary – Replacement of subsea production tree with spare tree in Darwin; and
- Tertiary – Relief well drilling.

The NE FPSO Source Control Mobilisation Plan provides information for the mobilisation of the necessary equipment and personnel in the shortest time possible. Included are references to procedures and operations that have been performed in the past and may be applicable to each method.

Source Control Methods

Throughout the Laminaria-5 reinstatement project, the source control options vary due to the available methodologies. The source control methods used have been assigned based on the various stages of the project, as outlined in Table 2.5.

Table 2.5 Laminaria-5 source control priorities according to project stage

Project stage	Source control measure		
	Primary	Secondary	Tertiary
1. No workover riser system in place and subsea tree installed on wellhead	Emergency tree replacement	Emergency well kill from NE FPSO	Relief well drilling
2. WORS established on wellhead from MODU (assuming the MODU has access to the well with well kill capability)	Emergency well kill from MODU via the WORS	Emergency tree replacement using refurbished tree already on the MODU	Relief well drilling
3. Subsea tree removed from wellhead (assumed loss of FPSO connection to the well and consequent inability of well kill from the FPSO)	Emergency tree replacement	Emergency well kill from MODU via the WORS	Relief well drilling
4. New subsea tree installed on wellhead (as per 'as found' stage, described in the Production WOMP (01-OPS-PL01) with the difference that the available tree is not refurbished, but is the currently installed tree)	Emergency tree replacement (using the recovered tree)	Emergency well kill from NE FPSO	Relief well drilling

3 Stakeholder Consultation

NOGA recognises that stakeholder consultation goes beyond informing individuals or groups. NOGA has opened the channels of communication with stakeholders to provide an opportunity for open and honest communication that promotes integration of stakeholder values into its decision-making process. This provides the means for NOGA to identify interested individuals and groups as well as their needs, ideas, values, and issues of concern regarding the environmental and/or social impacts of activities related to activities associated with the NE FPSO Asset. Stakeholder engagement also provides information that can help avoid conflicts about locally important matters and help NOGA to identify who must be contacted in the unlikely event of an emergency situation.

In keeping with NOGA's HSE Policy and APPEA's Principles of Conduct, NOGA is also committed to open, on-going and effective engagement with the communities in which it operates and providing information that is clear, relevant and easily understandable. This section of the EP defines:

- Requirements for stakeholder consultation;
- Objectives of stakeholder consultation;
- Who needs to be considered in decision-making;
- When decisions must be completed;
- The on-going consultation schedule; and
- How commitments are documented and tracked to closure.

3.1 Regulatory Requirements

Section 280 of the OPGGS Act states that a person carrying out activities in an offshore permit area should not interfere with other users of the offshore area to a greater extent than is necessary for the reasonable exercise of the rights and performance of the duties of the first person. In order to determine what activities are being carried out and whether petroleum activities may interfere with existing users, consultation is required.

In relation to the content of an EP, more specific requirements are defined in the OPGGS(E) Regulation 11A. This regulation requires that a Titleholder consult with 'relevant persons' in the preparation of an EP.

Further guidance regarding the definition of functions, interests or activities is provided in NOPSEMA's Assessment of Environment Plans: Deciding on Consultation Requirements Guidelines (N-04750-GL1629, Rev 0, April 2016), as follows:

- Functions – a person or organisation's power, duty, authority or responsibilities;
- Activities – a thing or things that a person or group does or has done; and
- Interests – a person or organisation's rights, advantages, duties and liabilities; or a group or organisation having a common concern.

Regulation 14(9) of the OPGGS(E) also defines a requirement for consultation in relation to the Implementation Strategy defined in the EP. In addition, Regulation 16(b) of the OPGGS(E) requires that the EP contain a summary and full text of this consultation.

3.2 Stakeholder Consultation Objectives

The principal objectives of the consultation strategy are to:

- Initiate and maintain open communications between stakeholders and NOGA;
- Identify, establish and implement stakeholder engagement methods for on-going communications;
- Establish an open and transparent process for input;
- Proactively work with stakeholders on recommended strategies to minimise negative impacts and maximise positive impacts of the Asset's operation; and
- Provide a means for recording all initiatives in which communication and/or consultation is undertaken, and to track any commitments made by NOGA through to closure.

3.3 Stakeholder Identification

NOGA established contact with stakeholders when it took over operations of the NE FPSO and updated the Asset's operations EP (accepted by NOPSEMA in December 2016). NOGA identifies a stakeholder as:

> *Any affected persons, interested persons or organisations that are impacted by, or can impact, a project.*

Determining who the stakeholders for this Asset are previously involved the following:

- Reviewing the former Titleholder's Operations EP;
- Reviewing the former Titleholder's Decommissioning Project Consultation Plan;
- Reviewing Commonwealth and state fisheries jurisdictions and fishing effort (within the envelope of the EMBA); and
- Determining the Titleholders of nearby exploration permits and production licences through the NOPTA website.

Stakeholders identified for this project are listed in Table 3.1.

Table 3.1. Stakeholders identified for the NE FPSO Facility

Department or agency of the Commonwealth to which the activities to be carried out under the EP may be relevant	
National Offshore Petroleum Titles Administrator (NOPTA)	Australian Fisheries Management Authority (AFMA)
Maritime Border Command (MBC)	AMSA
Department of Industry, Innovation and Science (DIIS)	Department of Defence (DoD)
Department of Agriculture and Water Resources (DAWR)	Department of Foreign Affairs and Trade (DFAT)
DoEE (Parks Australia)	Australian Hydrological Office (AHO)
Each Department or agency of a State or the Northern Territory to which the activities to be carried out under the EP may be relevant	
WA Department of Fisheries (DoF)	NT Department of Primary Industries and Fisheries (DPIF)
The Department of the responsible State Minister, or the responsible Northern Territory Minister	

WA Department of Mines, Industry Regulation and Safety (DMIRS)	NT Department of Mines and Energy (DME)
A person or organisation whose functions, interests or activities may be affected by the activities to be carried out under the EP	
Fisheries	
WA Fishing Industry Council (WAFIC)	NT Seafood Council (NTSC)
Commonwealth Fisheries Association (CFA)	Amateur Fisherman's Association NT (AFANT)
RecFish West	Game Fishing Association Australia (WA)
NT Trawler Owners Association (NTTOA)	Northern Prawn Fishery Trawl Association
Australian Council of Prawn Fisheries	Northern Fishing Companies Association
JAMACLAN (for Commonwealth Trawl operations and Westmore Seafoods)	Northern Prawn Fishery Industry Pty Ltd
Northern Prawn Fishery (Qld) Trawl Assoc. Inc.	WA Seafoods
Kimberley Professional Fishermen's Assoc.	A. Raptis & Sons Pty Ltd
Pearl Producers Australia (PPA)	Australian Southern Bluefin Tuna Industry Association (ASBTIA)
Oil spill preparedness and response agencies	
AMSA – Marine Pollution	Australian Marine Oil Spill Centre (AMOSC)
NT Department of Transport (DoT) – Marine Safety Branch	WA DoT – Oil spill response coordination
WA Department of Parks and Wildlife (DPW)	
Nearby petroleum Titleholders	
ENI Australia Ltd	PTTEP Australasia (Ashmore Cartier) Pty Ltd
Inpex Operations Australia Pty Ltd	ConocoPhillips Australia Exploration Pty Ltd
Finder Exploration Pty Ltd	Shell Australia Pty Ltd
Woodside Energy Ltd	Murphy Oil Australia Pty Ltd
Melbana Energy Ltd	Bounty Oil and Gas NL
Santos Ltd	IPB Petroleum
Any other person or organisation that the titleholder considers relevant	
Marine conservation interests	
Centre for Whale Research (CWR)	Australian Conservation Foundation (ACF)
Australian Institute of Marine Science (AIMS)	Australian Marine Conservation Society (AMCS)
WA Marine Science Institution (WAMSI)	International Fund for Animal Welfare (IFAW)
The Wilderness Society	WWF

Other interests
Australian Petroleum Production and Exploration Association (APPEA)

3.4 Stakeholder Engagement

3.4.1 Issue of Information Flyer

NOGA is committed to timely and on-going consultation with stakeholders. Stakeholder engagement commenced for this project on the 30th of June 2017 when an information flyer was issued by email to stakeholders.

The information flyer provided an introduction to NOGA, details about the project, its potential impacts and mitigation measures (considered to be coarse given the early stage of the project when the flyer was issued), and contact details if further information is required.

3.4.2 Results of Consultation

Up until the point of EP acceptance, only 21 of the 71 stakeholders (or 30%) had opened the email, and only 2 of those 21 had responded to NOGA (excluding auto-replies).

Correspondence with stakeholders has been a combination of email exchanges and phone conversations. NOGA made follow up phone calls on the 15th of August to those stakeholders considered important to receive feedback from.

No concerns or objections have been raised about the project. NOGA believes that the low rate of feedback and the low level of concern from stakeholders expressed to date (i.e., replies to the information flyer and low interest in the project expressed in follow up phone calls) is due to the following considerations:

- Remoteness of the project;
- Location outside of the AFZ (no Commonwealth or State/Territory fisheries operating around the project);
- Distance from Commonwealth Marine Reserves (CMRs) and state marine parks;
- No intersection with shipping fairways; and
- The associated FPSO has been operating since 1999 without any major incidents.

NOGA will continue to accept feedback from all stakeholders during the assessment of this EP and throughout the duration of the project.

A summary of consultation and an assessment of merit of stakeholder feedback are presented in Table 3.2.

3.4.3 Consultation in an Emergency

NOGA recognises that the relevance of stakeholders identified in this EP may change in the event of a non-routine event or emergency. Every effort has been made to identify stakeholders that may be impacted by a non-routine event or emergency, the largest of which is considered a Level 3 hydrocarbon spill. Therefore, any stakeholders known or likely to have operations within or be affected by a spill within the EMBA is included in NOGA's stakeholder register.

NOGA acknowledges that other stakeholders not identified in this EP may be affected, and that these may only become known to NOGA in such an event.

3.5 Ongoing Engagement

Stakeholder consultation will continue after the EP is accepted. Key milestones that will trigger further consultation include:

- EP acceptance and the availability of the EP Summary on the NOPSEMA website;
- Mobilisation of the MODU to the project location;
- Any significant incidents during the activity (e.g., large hydrocarbon spill); and
- Demobilisation from the project location.

Any claims or objections from stakeholders will be assessed and the EP then modified if required. If this relates to the identification of a new or significantly increased risk, the revised EP will be submitted to NOPSEMA for assessment.

The stakeholder consultation register remains a live document and will be updated on an as-required basis.

Table 3.2. Summary of stakeholder consultation

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
Department or agency of the Commonwealth to which the activities to be carried out under the EP may be relevant				
NOPTA	Administers offshore petroleum titles.	Flyer emailed: 30 June 2017.	Project information flyer was opened, but no response was provided.	No follow up with this stakeholder is necessary, as the NOGA title information is up to date.
AMSA (Nautical Safety Division)	Key regulator for marine safety, advisor on shipping lanes and traffic.	Flyer emailed: 30 June 2017. Follow up phone call: 08 August 2017.	No response to flyer. NOGA telephoned the Nautical and Hydrographic Advisor, who asked for the flyer to be re-issued to her. AMSA subsequently sent a map of the region showing vessel traffic for the period June 2016-June 2017 on the 14th of August.	NOGA re-issued the flyer. The shipping traffic map is included in Section 5.6.2 of the EP.
MBC	Key agency for border protection - need to be aware of FPSO location and operations. The FPSO Radio Operator needs to be aware of MBC's vessels, maintain communications on Ch 16 with vessels.	Flyer emailed: 30 June 2017.	No response to flyer.	NOGA does not believe follow up with MBC is necessary, as all relevant maritime navigation protocols are adhered to.
AFMA	Key agency regarding the provision of advice on fisheries that operate around the Asset.	Flyer emailed: 30 June 2017.	No response to flyer. NOGA's previous discussion with AFMA's Environment Manager during the preparation of the NE FPSO Operations EP indicated that there had been no response to emails because there was little fishing activity in the area. AFMA advised that the only possible fisheries operating near the location are the Northern Prawn, North West Slope and possibly the Western Tuna and Southern Bluefin Tuna fisheries (though young tuna using the region for migration are not targeted by the fisheries). AFMA also confirmed that the Western Skipjack Fishery is not active.	Research undertaken for the EP concurred with AFMA's statement of fisheries likely to be operating in the region (see Section 5.6.5).

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
DIIS	The Resources Division of the DIIS is one part of the Joint Authority for management of the JPDA, which adjoins the licence areas.	Flyer emailed: 30 June 2017. Follow up phone call: 08 August 2017. Follow up email: 15 August 2017	No response to flyer. NOGA telephoned the DIIS, who requested the flyer be reissued. No response to this additional email has been received to date.	NOGA does not believe follow up with the DIIS is necessary. As their feedback is unlikely to have any bearing on the content of the EP.
DAWR – Seaports Program	Key agency regarding quarantine clearance for vessels entering Australian waters from international waters.	Flyer emailed: 30 June 2017.	Project information flyer was opened, with only an automated response provided.	NOGA does not believe follow up with DAWR is necessary, as all relevant Commonwealth quarantine protocols will be adhered to.
DoD	Key agency regarding advice on offshore defence training.	Flyer emailed: 30 June 2017.	Project information flyer was opened, but no response was provided.	NOGA does not believe follow up with the DoD is necessary, as all relevant information gathered in 2016 for the FPSO Operations EP has been carried over to this EP.
AHO	Agency that issues Notice to Mariners (NTM). They require 6 weeks prior warning for issuing NTM.	Flyer emailed: 30 June 2017. Follow up phone call: 08 August 2017	No response to flyer. NOGA telephoned the AHO, who stated they have no concerns with the project and to notify them of the project timing closer to the time.	NOGA responded with thanks. Routine maritime notification requirements are included in Section 8.4.1 of the EP.
DoEE (Parks Australia)	Responsible for management of Commonwealth Marine Reserves. Likely to have some involvement in the case of a large hydrocarbon spill if CMRs are at risk.	Flyer emailed: 30 June 2017.	No response to flyer. NOGA's previous discussion with the DoEE during the preparation of the NE FPSO Operations EP indicated that several CMRs occur in the vicinity of the FPSO, for which transitional arrangements apply until a management plan comes into effect. When future management plans are prepared and come into effect, they expect Titleholders to revise and amend EPs accordingly.	NOGA has included the latest information from the Draft North and North-west CMR Management Plans in Section 5.4.1 of the EP.

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
DFAT	Needs to be aware of activities that may have impacts on neighbouring countries (e.g., large hydrocarbon spill), such as Timor Leste & Indonesia.	Flyer emailed: 30 June 2017.	No response to flyer. NOGA's previous discussion with the Assistant Secretary, Indonesia Program Delivery and Timor Leste Branch during the preparation of the NE FPSO Operations EP indicated that NOGA has been consulting with the DFAT office in Dili.	There is no need for NOGA to engage further regarding the EP, as commercial discussions between DFAT and NOGA took place during 2016.
Each Department or agency of a State or the Northern Territory to which the activities to be carried out under the EP may be relevant				
WA DoF	Manages State fisheries in adjacent WA waters.	Flyer emailed: 30 June 2017. Follow up phone call: 08 August 2017 Follow up email: 15 August 2017	No response to flyer. NOGA telephoned the DoF, who advised NOGA that they do not object to the proposal although a hydrocarbon spill at the well site is an identified risk and therefore a concern.	NOGA responded with thanks. The risk assessment for hydrocarbon releases is included in Section 7.2.5 and 7.2.7 of the EP.
NT NPIF	Manages State fisheries in adjacent NT waters.	Flyer emailed: 30 June 2017. Follow up phone call: 15 August 2017	No response to flyer. NOGA telephoned the NPIF and spoke with the former Aquatic Resource Management Officer who directed NOGA to the new person in that role. NOGA re-issued the flyer to the email address provided but no response has been received to date. NOGA's previous discussion with the NPIF indicated no concerns with petroleum operations in the project location.	NOGA re-issued the flyer to the email address provided. NOGA does not believe follow up with the NPIF is necessary given previous discussions indicated no concerns.
The Department of the responsible State Minister, or the responsible Northern Territory Minister				
WA DMIRS	Manages petroleum activities in adjacent WA waters. The DMIRS is the other half of the Joint Authority responsible for administering the JPDA.	Flyer emailed: 30 June 2017.	An Environmental Officer responded by email, stating that the DMIRS has reviewed the flyer and does not have any comments or requirements for further information. They asked that DMIRS be kept informed of activities.	NOGA responded with thanks by email, confirming that the DMIRS will be kept informed of future activities.

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
NT DME	Manages petroleum activities in adjacent WA waters.	Flyer emailed: 30 June 2017. Follow up phone call: 15 August 2017	No response to flyer. NOGA telephoned the DME, who said they would call back or email with a response. No such response has been received to date.	No need for a NOGA response based on the DME feedback.
A person or organisation whose functions, interests or activities may be affected by the activities to be carried out under the EP				
Peak fisheries associations				
WAFIC	The peak industry body representing the commercial fishing, pearling and aquaculture industries. Project area is located outside of the AFZ, but a large oil spill may extend into members' fisheries operations, breeding or feeding grounds.	Flyer emailed: 30 June 2017.	No response to flyer. NOGA's previous discussion with the Executive Officer, Resource Access during the preparation of the NE FPSO Operations EP indicated that as the Asset is outside the 200 nm AFZ boundary, WAFIC and state-managed fisheries are not relevant stakeholders and do not require ongoing communications as they will not be potentially affected by the activity.	NOGA does not believe follow up with WAFIC is necessary based on previous discussions.
NTSC	Peak representative body of the seafood industry in the NT, representing ~222 businesses. Project area is located outside of the AFZ, but a large oil spill may extend into members fishing grounds or feeding and breeding areas of target species.	Flyer emailed: 30 June 2017.	No response to flyer.	Based on the previous discussion with WAFIC, NOGA does not believe follow up with the NTSC is necessary.

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
CFA	The peak body representing the collective rights, responsibilities and interests of a diverse commercial fishing industry in Commonwealth regulated fisheries. Project area is located outside of the AFZ, but a large oil spill may extend into Commonwealth, WA or NT fisheries operations, breeding or feeding grounds.	Flyer emailed: 30 June 2017.	No response to flyer.	Based on the previous discussion with WAFIC, NOGA does not believe follow up with the CFA is necessary.
Recreational fisheries associations				
AFANT	The peak body representing recreational fishing interests in the NT. Association members are unlikely to be operating around the project area. A large oil spill is unlikely to extend into members' fishing grounds or breeding or feeding grounds for target species. Flyer sent as a courtesy.	Flyer emailed: 30 June 2017.	No response to flyer. NOGA's previous discussion with the AFANT Executive Officer during the preparation of the NE FPSO Operations EP indicated that the field is outside their area of interest due to their distance from the mainland.	Based on the previous discussion with the AFANT, NOGA does not believe follow up is necessary.

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
RecFish West	The peak body representing the interests of 740,000 recreational fishers in WA. RecFish West members are unlikely to be operating around the project area. A large oil spill is unlikely to extend into members' fishing grounds or breeding or feeding grounds for target species. Flyer sent as a courtesy.	Flyer emailed: 30 June 2017.	Project information flyer was opened, but no response was provided.	Based on the advice previously received from AFANT, NOGA does not believe follow up is necessary as recreational fishers are unlikely to operate anywhere near the project.
Game Fishing Association Australia (WA)	Represent a small, specialised interest. Project area is located outside of the AFZ, but a large oil spill may extend into member's fishing grounds or into the breeding or feeding grounds of target species.	Flyer emailed: 30 June 2017.	No response to initial and reminder emails.	Based on the advice previously received from AFANT, NOGA does not believe follow up is necessary as recreational fishers are unlikely to operate anywhere near the project.
Individual fisheries associations and representatives				
NTTOA	Members are unlikely to be operating in licence areas. The project is located outside of the AFZ, but a large oil spill may	Flyer emailed: 30 June 2017. Follow up phone call: 15 August 2017	No response flyer. NOGA telephoned but the member hung up once the purpose of the call was established.	Based on the response to the phone call, NOGA does not believe follow up is necessary.

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
	extend into fisheries operations or the breeding or feeding grounds of target species.			
Northern Prawn Fishery Trawl Association	Association members are unlikely to be operating in licence areas. The project is located outside of the AFZ, but a large oil spill may extend into member's fishing grounds or feeding and breeding areas of target species.	Flyer emailed: 30 June 2017. Follow up phone call: 15 August 2017	No response to flyer. NOGA telephoned and the association representative had no objections to the project.	Not applicable.
Australian Council of Prawn Fisheries	Association members are unlikely to be operating around the Asset. The Asset is located outside of the AFZ, but a large oil spill may extend into member's fishing grounds or feeding and breeding areas of target species.	Flyer emailed: 30 June 2017. Follow up phone call: 15 August 2017	Email bounced. NOGA telephoned and the association representative had no objections to the project.	Not applicable.
Northern Fishing Companies Association	Association members are unlikely to be operating around the Asset. The project is located outside of the AFZ, but a large oil spill may	Flyer emailed: 30 June 2017. Follow up phone call: 15 August 2017	Project information flyer was opened, but no response was provided. NOGA telephoned, but the phone number is not in service. Another email was sent but undelivered due to the domain not existing anymore.	Based on the advice previously received from WAFIC and the NT DPIF, NOGA elected not to follow up any further.

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
	extend into member's fishing grounds or feeding and breeding areas of target species.			
JAMACLAN	The Asset is located outside of the AFZ, but a large oil spill may extend into members fishing grounds or feeding and breeding areas of target species.	Flyer emailed: 30 June 2017. Follow up phone call: 15 August 2017	Email bounced. NOGA telephoned and the association representative had no objections to the project.	Not applicable.
Northern Prawn Fishery Industry Pty Ltd	The association is a collective of trawler operators, processors and marketers acting together as a single voice for the industry in the Northern Prawn Fishery, which spans the waters from Cape York to the Kimberley's. The project is located outside of the AFZ, but a large oil spill may extend into members fishing grounds or feeding and breeding areas of target species.	Flyer emailed: 30 June 2017. Follow up email: 15 August 2017	Project information flyer was opened, but no response was provided. No response provided to the follow up email.	Based on the advice previously received from WAFIC and the NT DPIF, NOGA does not believe follow up is necessary.
Northern Prawn Fishery (Qld) Trawl Assoc. Inc.	The project is located outside of the AFZ, but a large oil spill may extend into member's fishing grounds or	Flyer emailed: 30 June 2017.	Project information flyer was opened, but no response was provided.	Based on the advice previously received from WAFIC and the NT DPIF, NOGA does not believe follow up is necessary.

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
	feeding and breeding areas of target species.			
WA Seafoods	Seafood export company, focusing on prawns (banana and tiger). The project is located outside of the AFZ, but a large oil spill may extend into the company's fishing grounds or feeding and breeding areas of target species.	Flyer emailed: 30 June 2017. Follow up email: 15 August 2017	Project information flyer was opened, but no response was provided. No response provided to the follow up email.	Based on the advice previously received from WAFIC and the NT DPIF, NOGA does not believe follow up is necessary.
A. Raptis & Sons Pty Ltd	Raptis owns and operates 15 commercial fishing vessels that work out of the Northern Prawn Fishery, the Gulf of Carpentaria Developmental Finfish Trawl Fishery, the Gulf of Saint Vincent and the Great Australian Bight Trawl Fishery as well as participating in many international fishing operations. The project is located outside of the AFZ, but a large oil spill may extend into the company's fishing grounds or feeding and	Flyer emailed: 30 June 2017. Follow up email: 15 August 2017	Project information flyer was opened, but no response was provided. No response provided to the follow up email.	Based on the advice previously received from WAFIC and the NT DPIF, NOGA does not believe follow up is necessary.

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
	breeding areas of target species.			
Kimberley Professional Fishermen's Association	Association members are unlikely to be operating around the project area. The project is located outside of the AFZ. A large oil spill is unlikely to extend into members' fishing grounds or breeding or feeding grounds for target species. Flyer sent as a courtesy.	Flyer emailed: 30 June 2017.	No response to flyer.	Based on the advice previously received from WAFIC and the NT DPIF, NOGA does not believe follow up is necessary.
ASBTIA	This fishery is not currently active, and AFMA management arrangements are under review. No fishing takes place in the northern extent of this fishery. Flyer sent as a courtesy.	Flyer emailed: 30 June 2017.	Unsubscribed to the information flyer, with an automatically generated reason of 'no longer interested'.	Unsubscribing from the information flyer suggests no interest in the project. Based on this action, NOGA elected not to follow up this stakeholder.
PPA	Wild oysters are caught in waters 30 m or less, generally south of Lacapede Islands (near Broome), so the pearling industry shouldn't be impacted by the Asset.	Flyer emailed: 30 June 2017.	No response to flyer.	Based on previous discussions with the PPA regarding the location of its operations, NOGA does not believe follow up is necessary.

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
	Flyer sent as a courtesy only.			
Oil spill preparedness and response agencies				
AMSA – Marine Environment Pollution	Oil spill response Combat Agency for vessels in Commonwealth waters.	Flyer emailed: 30 June 2017.	No response to flyer. NOGA has maintained regular contact with AMSA in in accordance with their Advisory Note for the Offshore Petroleum Industry Consultation (see Table 4.2) stating that their preferred method of consultation with Titleholders to enter into an MoU.	NOGA has entered into an MoU with AMSA to provide support for oil spill response.
AMOSC NT DoT – Marine Safety Branch	AMOSC and Industry Consultation under the OPGGS Act 2011 (August 2012) Key industry agency that will assist with oil spill response if a spill enters NT state waters (within 3 nm of mainland and islands).	Flyer emailed: 30 June 2017.	No response to flyer.	NOGA is an AMOSC member. As the spill risk is unchanged from the OPEP prepared for the FPSO operations, NOGA does not believe follow up is necessary.
		Flyer emailed: 30 June 2017.	No response to flyer. NOGA's previous discussion with the NT DoT during the preparation of the NE FPSO Operations EP indicated that given the geographical location of the FPSO (and thus the project), the issue is better dealt with at the Commonwealth level and the NT Marine Safety Branch has no comments.	Based on previous discussions with the NT DoT, NOGA does not believe follow up is necessary.
WA DPW	Key industry agency that will assist with oil spill response if a spill enters WA state waters (within 3 nm of mainland and islands) and threatens protected areas or wildlife.	Flyer emailed: 30 June 2017.	Project information flyer was opened, but no response was provided.	NOGA OPEP and Oiled Wildlife Recovery Mobilisation Plan structured in accordance with WAOWRP requirements. As such, follow up with this stakeholder is not necessary.
WA DoT – Oil spill	Key industry agency that will assist with oil	Flyer emailed: 30 June 2017.	No response to flyer.	As the probability of hydrocarbons reaching WA state

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
response coordination	spill response if a spill enters WA state waters (within 3 nm of mainland and islands).			waters is extremely low and is unlikely to require an active on-sea or shoreline response (i.e., the DoT is unlikely to be required to respond), no follow up has been undertaken.
AMSA – Marine Environment Pollution	Oil spill response Combat Agency for vessels in Commonwealth waters.	Flyer emailed: 30 June 2017.	No response to flyer. NOGA has maintained regular contact with AMSA in in accordance with their Advisory Note for the Offshore Petroleum Industry Consultation (see Table 4.2) stating that their preferred method of consultation with Titleholders to enter into an MoU.	NOGA has entered into an MoU with AMSA to provide support for oil spill response.
Nearby petroleum Titleholders				
ENI Australia Ltd	Titleholder for exploration permit AC/P21, and operator of the Kitan Field, 20 km to the east of the project in the JPDA (the field ceased production in December 2015). Likely to be within the EMBA of the largest credible oil spill.	Flyer emailed: 30 June 2017.	No response to flyer.	As there are no ENI production facilities within the EMBA, NOGA does not believe follow up is necessary.
PTTEP Australasia (Ashmore Cartier) Pty Ltd	In a joint venture with ENI in the Kitan Field, 20 km to the east of the project in the JPDA (the field ceased production in December 2015).	Flyer emailed: 30 June 2017.	No response to flyer.	As there are no PTTEP production facilities within the EMBA, NOGA does not believe follow up is necessary.

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
	Titleholder for several licences and retention leases in the Ashmore/Cartier Area.			
Conoco Phillips Australia Exploration Pty Ltd	Operator of Bayu-Undan, 85 km SE of the project (JPDA 03-12 & 03-13). The Bayu-Undan facility is likely to be within the EMBA of the largest credible oil spill.	Flyer emailed: 30 June 2017.	No response to flyer.	Petroleum operators are familiar with hydrocarbon release risks from different activity types and associated response options. As such, NOGA does not believe follow up is necessary.
Inpex Operations Australia Pty Ltd	Inpex is a joint venture participant in the nearby Bayu-Undan project (11.4%) and the Kitan project (35%). Bayu-Undan is within the EMBA of the largest credible oil spill.	Flyer emailed: 30 June 2017.	No response to flyer.	Petroleum operators are familiar with hydrocarbon release risks from different activity types and associated response options. As such, NOGA does not believe follow up is necessary.
Santos	Santos is a joint venture participant in the nearby Bayu-Undan project (11.4%). Bayu-Undan is within the EMBA of the largest credible oil spill.	Flyer emailed: 30 June 2017.	Santos replied by email stating that they reviewed the information and the project will not impact on its functions, interests or activities and that they do not require any further information.	NOGA replied by email with thanks. No further action required.
Finder Exploration Pty Ltd	Titleholder of nearby exploration permits AC/P45, 52, 55, 56 and 61.	Flyer emailed: 30 June 2017.	No response to flyer.	Petroleum operators are familiar with hydrocarbon release risks from different activity types and associated response options. As

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
	These permits may be within the EMBA of the largest credible oil spill.			such, NOGA does not believe follow up is necessary.
Shell Australia Pty Ltd	Titleholder of nearby exploration permits AC/P41, 52 and RL/9. These permits may be within the EMBA of the largest credible oil spill.	Flyer emailed: 30 June 2017.	No response to flyer.	Petroleum operators are familiar with hydrocarbon release risks from different activity types and associated response options. As such, NOGA does not believe follow up is necessary.
Woodside Energy Ltd	Operator of Sunrise and Troubadour gas and condensate field development in the adjoining JPDA. Operator of AC/RL8 (Vulcan Sub-basin), NT/RL2 & 4 (Bonaparte Basin), WA-28-R, -29, -30, -31 & -32 (Browse Basin). Any future development of the Sunrise and Troubadour gas and condensate field may be in the EMBA of largest credible oil spill.	Flyer emailed: 30 June 2017.	Initial email bounced back. Flyer was re-issued to another appropriate email address. No response to date.	Petroleum operators are familiar with hydrocarbon release risks from different activity types and associated response options. As such, NOGA does not believe follow up is necessary.
Murphy Oil Australia Pty Ltd	Titleholder of AC/P57, -58 & -59 in the Ashmore/ Cartier Area. Will not be within EMBA of largest credible oil spill.	Flyer emailed: 30 June 2017.	Project information flyer was opened, but no response was provided.	Petroleum operators are familiar with hydrocarbon release risks from different activity types and associated response options. This, and the fact Murphy Oil has no activities in the EMBA, means

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
	Flyer sent as courtesy only.			NOGA does not believe follow up is necessary.
Melbana	Titleholder of AC/P50, AC/P51 and AC/P53. Will not be within EMBA of largest credible oil spill. Flyer sent as courtesy only.	Flyer emailed: 30 June 2017.	Project information flyer was opened, but no response was provided.	As Melbana has no activities in the EMBA, NOGA does not believe follow up is necessary.
Bounty Oil and Gas NL	Titleholder of AC/P32. Major growth project, with Azalea and East Swan prospects. Will not be within EMBA of largest credible spill. Flyer sent as courtesy only.	Flyer emailed: 30 June 2017.	No response to flyer.	As Bounty Oil and Gas has no activities in the EMBA, NOGA does not believe follow up is necessary.
IPB Petroleum	IPB has three exploration permits near the Ichthys and Prelude gas fields. Will not be within EMBA of largest credible spill. Flyer sent as courtesy only.	Flyer emailed: 30 June 2017.	Project information flyer was opened, but no response was provided.	As IPB Petroleum has no activities in the EMBA, NOGA does not believe follow up is necessary.
Any other person or organisation that the titleholder considers relevant				
Marine conservation interests				
CWR	Project is located too far outside of Australian waters for this	Flyer emailed: 30 June 2017.	No response to flyer.	Given that the project is located well outside of known whale BIAs, it is not considered essential to gain feedback from

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
	organisation to have any real interests. Flyer issued as a courtesy only.			the CWR, as information from the Jenners (operators of the CWR) has been incorporated in to the EP.
AIMS	Project is located too far outside of Australian waters for this organisation to have any real interests. Flyer issued as a courtesy only.	Flyer emailed: 30 June 2017.	No response to flyer.	NOGA does not consider it essential to gain feedback from this stakeholder, as the EP contains a significant level of detail on marine ecology of the region that the AIMS is unlikely to be able to augment.
WAMSI	Project is located too far outside of Australian waters for this organisation to have any real interests. Flyer issued as a courtesy only.	Flyer emailed: 30 June 2017.	No response to flyer.	NOGA does not consider it essential to gain feedback from this stakeholder, as the EP contains a significant level of detail on marine ecology of the region that the WAMSI is unlikely to be able to augment.
AMCS	Project is located too far outside of Australian waters for this organisation to have any real interests. Flyer issued as a courtesy only.	Flyer emailed: 30 June 2017.	Project information flyer was opened, but no response was provided.	NOGA does not consider it essential to gain feedback from this stakeholder, as the EP contains a significant level of detail on marine ecology of the region that the AMCS is unlikely to be able to augment.
ACF	Project is located too far outside of Australian waters for this organisation to have any real interests. Flyer issued as a courtesy only.	Flyer emailed: 30 June 2017.	No response to flyer.	NOGA does not consider it essential to gain feedback from this stakeholder, as the EP contains a significant level of detail on marine ecology of the region that the ACF is unlikely to be able to augment.

Stakeholder	Functions, interests and/or activities	Method and date of consultation	Concerns, impacts or claims raised by stakeholder	NOGA assessment of merit and feedback to stakeholder
IFAW	Project is located too far outside of Australian waters for this organisation to have any real interests. Flyer issued as a courtesy only.	Flyer emailed: 30 June 2017.	No response to flyer. NOGA's previous discussion with IFAW during the preparation of the NE FPSO Operations EP indicated that marine mammals are their main area of interest, and they aren't aware of any marine mammal issues in the Timor Sea. As such, they have no comments regarding activities in the area.	Given that the project is located well outside of known whale BIAs, and that relevant information regarding whale distribution and abundance has been incorporated in to the EP, NOGA is satisfied with IFAW's lack of interest.
The Wilderness Society	Project is located too far outside of Australian waters for this organisation to have any real interests. Flyer issued as a courtesy only.	Flyer emailed: 30 June 2017.	No response to flyer.	NOGA does not consider it essential to gain feedback from this stakeholder, as the EP contains a significant level of detail on marine ecology of the region that The Wilderness Society is unlikely to be able to augment.
WWF	Project is located too far outside of Australian waters for this organisation to have any real interests. Flyer issued as a courtesy only.	Flyer emailed: 30 June 2017.	No response to flyer.	NOGA does not consider it essential to gain feedback from this stakeholder, as the EP contains a significant level of detail on marine ecology of the region that the WWF is unlikely to be able to augment.
Other interests				
APPEA	Industry advocate. Flyer issued as a courtesy only.	Flyer emailed: 30 June 2017.	Project information flyer was opened, but no response was provided.	No response from APPEA is necessary from APPEA given that they are an industry representative rather than an asset holder.

4 Description of the Environment

A description of the existing environment that may be affected by the planned and unplanned activities of the project is presented in this section. It includes a description of relevant natural (physical and biological), cultural and socio-economic aspects of the environment, as well as details of relevant values and sensitivities.

Wherever possible, the EMBA for the worst-case loss of hydrocarbons is used to define the boundary within which the marine environment is described in this chapter. The EMBA is defined as:

> *The predicted extent of exposure of sea-surface (at or above 1 g/m^2) and dissolved and entrained hydrocarbons (at or above 500 ppb), and shorelines with accumulated hydrocarbons ≥ 100 g/m^2, as a result of the loss of hydrocarbons (18,962 m^3, or 246 m^2/day) resulting from an 11-week subsea well blowout or from a 105 m^3 diesel spill under annualised metocean conditions.*

The description covers the aspects of the receiving environment relevant for consideration of the environmental risks and impacts of planned and unplanned activities relating to the Laminaria-5 reinstatement project.

4.1 Regional Setting

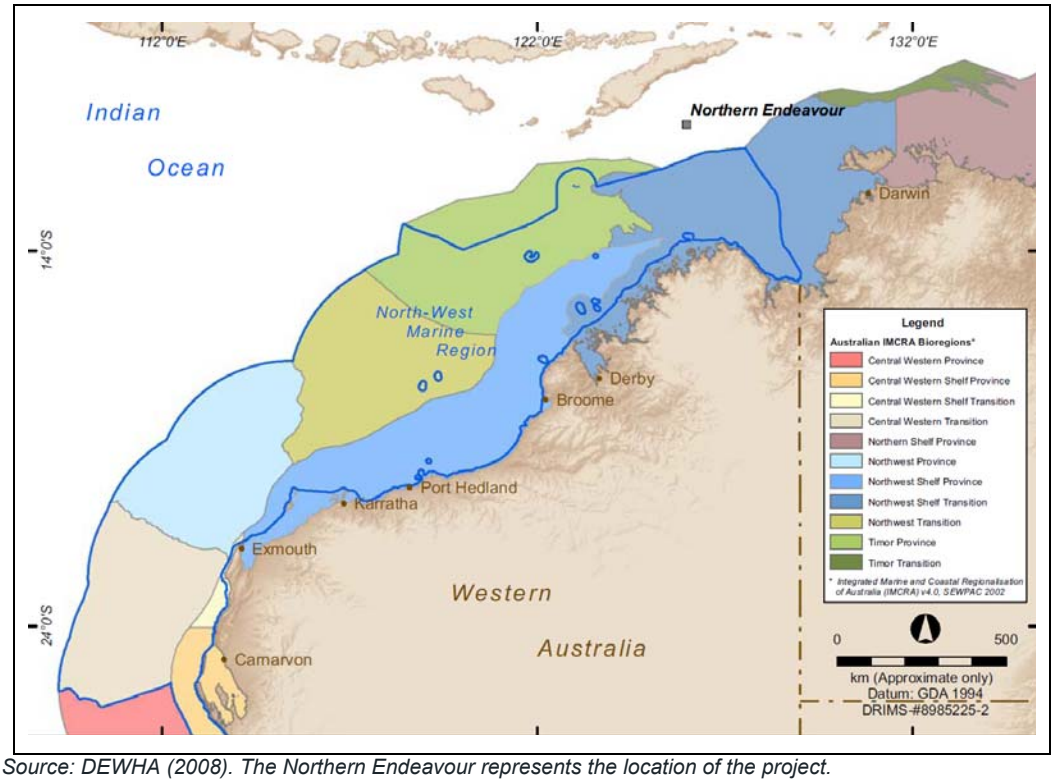
The project area is located within the Commonwealth waters of the Timor Sea close to the Australian and Indonesian maritime boundary. It is located approximately 360 km north of the Kimberley coast, 340 km north east of Cartier Island and approximately 155 km south east of Timor Island, in water depths of approximately 350 m. The location is outside Australia's Exclusive Economic Zone (EEZ) in Australian territorial water classified as Extended Continental Shelf. The facility also lies outside areas defined under the Integrated Marine and Coastal Regionalisation of Australia (IMCRA v4.0). However, the adjacent Sahul Shelf area to the south of the facility is contiguous with that of the Northwest Shelf Transition Province, which straddles the North-West Marine Region and the North Marine Region (DSEWPaC 2012a; DSEWPaC 2012b) (Figure 5.1).

This region is characterised by the following biophysical features:

- Climatic conditions are humid tropical monsoonal;
- Strong seasonal winds and relatively low off-shore tropical cyclone activity;
- Surface ocean circulation is dominated by the Indonesian Through Flow (ITF). The ITF dominates the majority of the water column and generally flows westwards through the Timor Trench (also known as the Timor Trough). During the summer, southwest winds associated with the cause a weakening of the ITF and may push some of its waters eastwards (DEWHA, 2008). During summer, mixing and upwelling processes can occur around the shelf break in the Timor Trench (DEWHA, 2008; Brewer *et al*., 2007).
- Seabed geomorphology of the region is complex and includes the Timor Trench (running parallel to Timor Island), large shallow shelf area (such as the Sahul Shelf), a system of numerous submerged shoals (Sahul Shelf shoals which include: Karmt, Big Bank and Echo Shoals), large bank areas (such as the West Londonderry Rise), terraces, pinnacles (in the Joseph Bonaparte Gulf), valleys (such as the Malita Shelf Valley) and basins (such as the Joseph Bonaparte Basin).
- The seabed in the Northwest Shelf Transition Province consists of sediments that are dominated by carbonate sands and soft muds (DEWHA, 2008). The sediments are approximately 80% carbonate derived (Brewer *et al*., 2007). The distribution and

re-suspension of sediments on the inner shelf is strongly influenced by the strength of tides across the continental shelf as well as episodic cyclones. Further offshore, on the mid to outer shelf and on the slope, sediment movement is primarily influenced by ocean currents and internal tides, the latter causing re-suspension and net down-slope deposition of sediments (DEWHA, 2008).

- The region has high species richness, but a relatively low level of endemism, i.e. species particular to the region in comparison to other areas of Australian waters. Furthermore, the majority of the region's species are tropical and are recorded in other areas of the Indian Ocean and western Pacific Ocean.
- Benthic communities range from nearshore benthic primary producer habitats such as seagrass beds, coral communities and mangrove forests to offshore, deepwater soft sediment seabed habitats (associated with low density sessile and mobile benthos such as sponges, molluscs and echinoids), and offshore submerged shoals (documented productive areas with primary producer habitats such as extensive macro-algal beds, coral communities and seagrass beds and associated reef habitat fish assemblages and sessile and mobile invertebrate biota.
- Presence of internationally significant migratory routes, resident and temporary populations, breeding and/or feeding grounds for a number of EPBC Act listed threatened and migratory marine species, including blue whales, marine turtles, whale sharks, great white sharks, green sawfish seabirds and migratory shorebirds.
- Key ecological features in the region include the carbonate bank and terrace system of the Sahul Shelf which likely enhance local productivity and the pinnacles of the Bonaparte Gulf, and the Ashmore Reef, Cartier Island and Oceanic Shoals CMRs (CMRs), which provide hard substrate habitat for a diversity of species. Numerous offshore submerged shoals are also notable features in the region.



Source: DEWHA (2008). The Northern Endeavour represents the location of the project.

Figure 4.1. North West marine Region and location of the project

4.2 Physical Environment

4.2.1 Climate

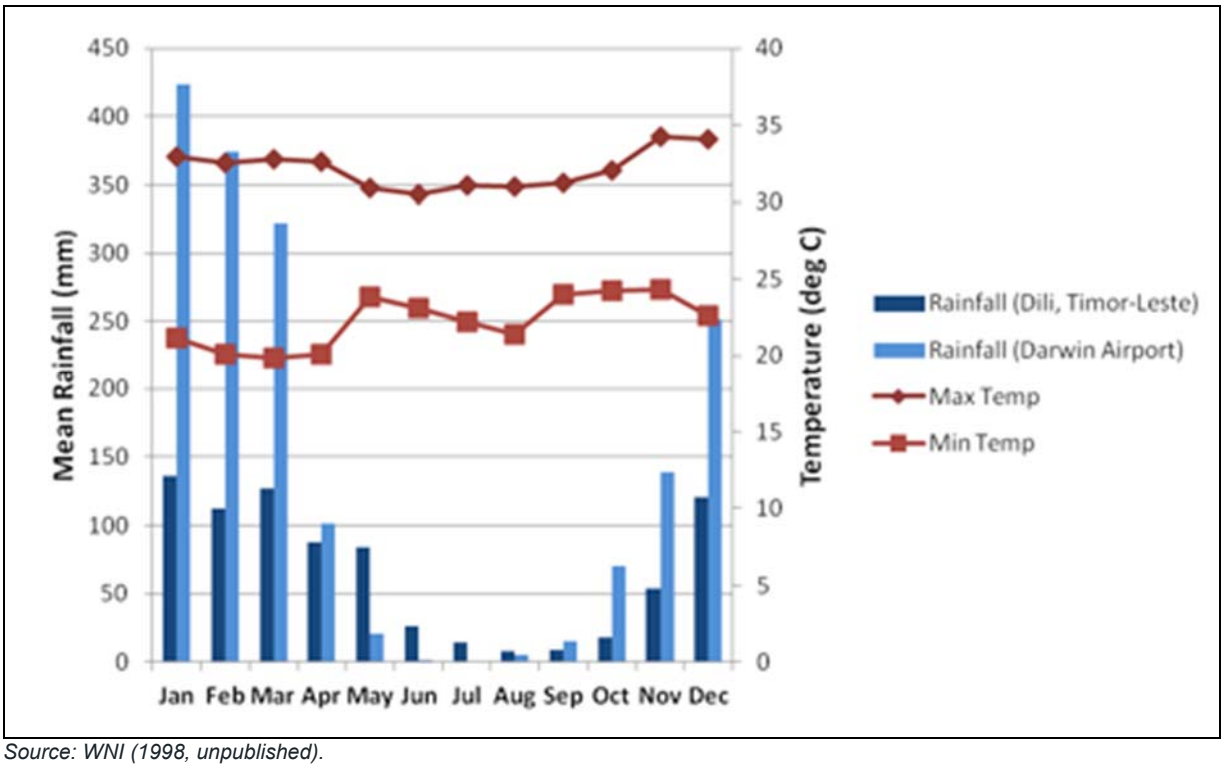
The climate within the Timor Sea region is humid tropical, characterised by seasonal reversals of the prevailing wind. The region experienced a summer wet season from November to March and a milder drier winter season between April to September. There is a transition between these two seasons, generally in April and September/October.

During the wet season, northwest winds are associated with higher moisture and generate regular thunderstorm activity and high rainfall. During the dry season, steady south-easterly winds generated over inland Australia dominate the region resulting in dry and warm conditions and are associated with calmer less variable conditions and less rainfall and low relative humidity (BOM, 2012).

Air temperatures in the region, as measured at the nearby Jabiru facility, follow seasonal trends (Figure 4.2). Average monthly temperatures recorded at the facility for the period 1983 to 1994 ranged from a minimum of 19.8ºC to 34.2ºC.

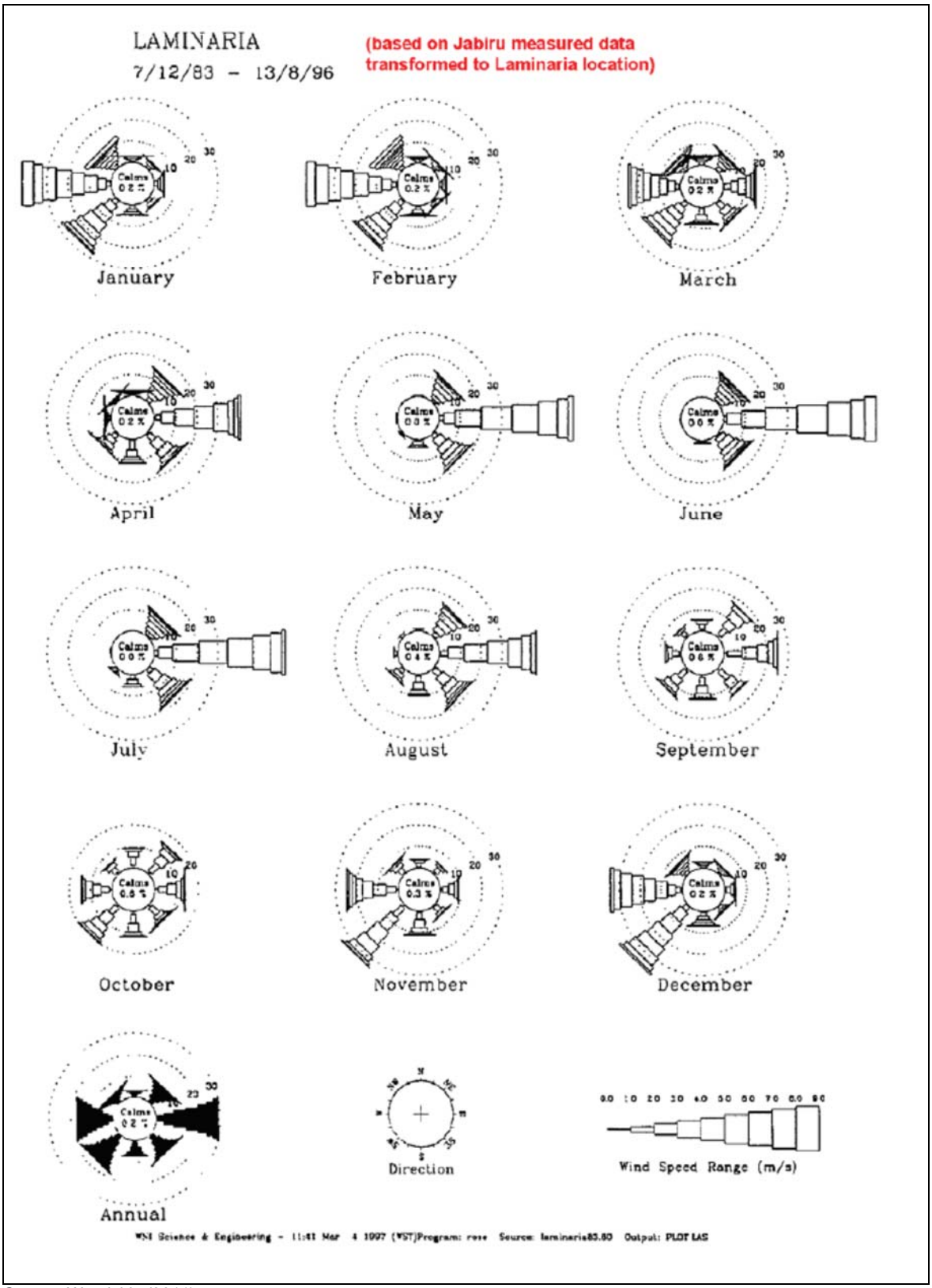
Winds vary seasonally, with a tendency for winds from the easterly quadrants to dominate in the winter dry season (April to September) and from the westerly quadrant in the summer wet season (November to March) (Figure 5.3). The summer south-westerly winds are driven by high pressure cells that pass from west to east over the Australian continent. During winter months the relative position of the high pressure cells moves further north, leading to prevailing south-easterly winds blowing from the mainland (Pearce *et al*., 2003). Throughout the summer, there are regular surges in the monsoonal flow resulting in winds increasing typically to 8 – 12 m/s for periods of 1 to 3 days. Occasionally these monsoonal wind surges may attain speeds of 20 m/s. In addition, squalls lasting typically less than half an hour can occur during summer thunderstorms. Winds during these squalls can reach speeds of up to 25 m/s. Less frequent but larger storms lasting several hours with instantaneous wind gusts of up to 45 m/s can also occur in summer. Winds typically weaken and are more variable during the winter dry season (Figure 4.4).

Tropical cyclones generally form south of the equator in the eastern Indian Ocean and in Arafura and Timor Seas during the summer. In the Timor Sea most of the storms are tropical lows or developing storms passing to the south of the NE FPSO Operational Area (Figure 4.4). Tropical cyclone activity can occur between November and April, with on average 1.24 storms per year pass within 300 km of the NE facility and an average of 3.99 storms per year pass within 1000 km. Figure 4.4 shows the tracks of tropical cyclones from 1999/2000 (when the FPSO was commissioned) to 2015/16 that have affected the Timor Sea area.



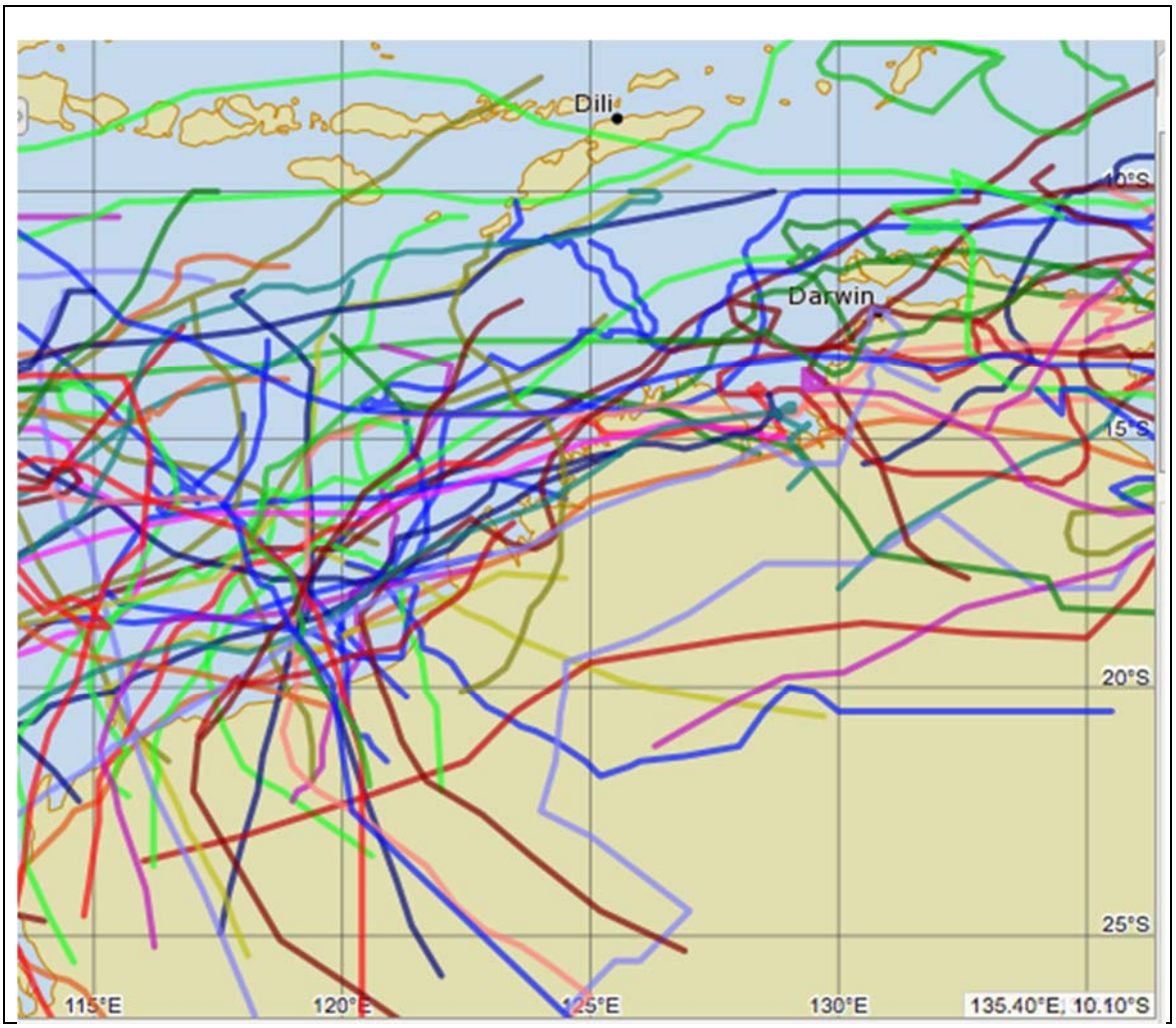
Source: WNI (1998, unpublished).

Figure 4.2. Mean monthly rainfall from Timor (Timor-Leste NDMG, BOM, CSIRO, 2013) and Darwin Airport (BOM, 2013), daily maximum and daily minimum temperatures from Jibiru from December 1983 to December 1994



Source: Woodside (2011).

Figure 4.3. Monthly wind roses measured at Jabiru from 1983-1996, transformed to Laminaria field location

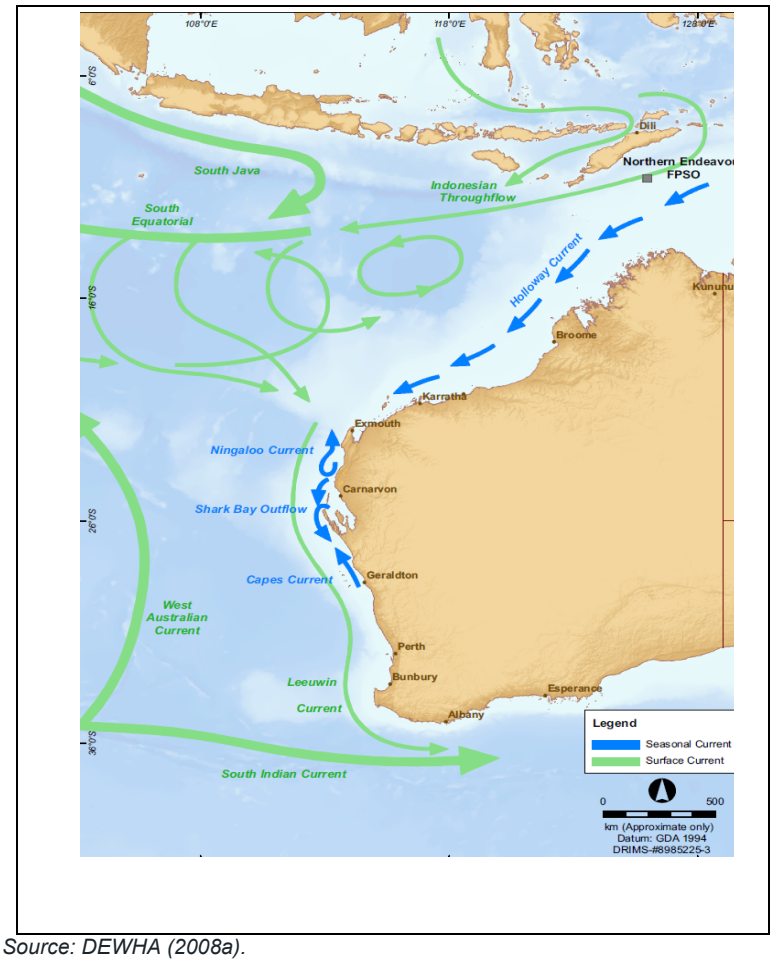


Source: BoM (2017).

Figure 4.4. Tracks of tropical cyclones (1999/2000 to 2015/16) affecting the Timor Sea

4.2.2 Oceanography

Throughout the year, water circulation in the region is dominated by the southwest flowing ITF and this is the predominant current flow affecting the project area. The ITF dominates the majority of the water column and generally flows westwards through the Timor Trench (also known as the Timor Trough). During the summer, south westerly winds cause a weakening of the ITF by pushing some of its waters eastwards building a pressure gradient in adjacent the Banda and Arafura Seas (DEWHA, 2008). During this period, short lived mixing and upwelling processes can occur around the shelf break in the Timor Trench delivering cold deep water onto the shelf (DEWHA, 2008; Brewer *et al*., 2007; Holloway and Nye, 1985). At the end of the summer (March/April), this pressure is released, causing a south-westerly flow of water across the Sahul Shelf known as the Holloway Current (DEWHA, 2008; Holloway & Nye, 1985; James *et al*., 2004). The Indonesian Through flow contributes to the westward flowing South Equatorial Current and the continued southward flow of currents along the coast of the North West Shelf via the Holloway Current or via the Eastern Gyral Current (Figure 4.5).



Source: DEWHA (2008a).

Figure 4.5. Generalised schematic of ocean circulation for the wider North West Marine Region

4.2.3 Water Quality

Mean monthly surface water temperatures in the region vary between about 26°C and 31°C. Seawater temperature records collected from Laminaria field over a one-year period show surface waters reached their maximum average temperatures in the period from November to April (average approximately 29.5°C) and were coolest in the period of July, August and September (average approximately 27.3°C). Similarly, near-seabed seawater temperatures (360 m water depth) were warmest in May (average approximately 10.4°C) and are coolest in September (average approximately 9.8°C) (WNI, 1998).

The region is influenced by the delivery of warm lower-salinity waters via the ITF. Recorded salinities in the Timor Sea attain 34.51 to 34.75 Practical Salinity Unit (PSU) and average salinity in the North West Shelf Transition is 34.8 PSU (Brewer *et al.*, 2007).

Offshore waters are generally very clear. Nearshore waters are highly turbid, particularly in summer, because of the interaction of high tides with increased inputs of sediments, organic material and freshwater from summer rains, in addition to the influence of cyclones (DEWHA, 2008).

4.2.4 Bathymetry and Seabed Composition

The Timor Sea encompasses the Sahul Shelf and Timor Trench and is a region of complex bathymetry. The Sahul Shelf is characterised as a large shallow platform extending across the inner and middle continental shelf approximately 300 km out from and parallel to the northern Australian coastline. It has complex bathymetry consisting of a series of rises,

depressions, banks, terraces and channels as a result of Pleistocene sea level changes (van Andel & Veevers, 1967; Baker *et al*., 2008). In its centre is a broad depression called the Bonaparte Basin (or Bonaparte Depression), where numerous pinnacles (up to 50 m high and 50 to 100 km long) and submerged shoals/banks occur. The edge of the Sahul Shelf is bounded by extensive areas known as the Van Diemen Rise on its north east side of the shelf and the Londonderry Rise on the north west side of the shelf.

The Sahul Shelf also has numerous submerged shoals and banks including a series of shoals that rise sharply from the continental slope along its northern outer edge (Edgerley, 1974) (Figure 4.6). The carbonate bank and terrace system of the Sahul Shelf and pinnacles of the Boneparte Basin are key ecological features of the Northwest Shelf Transition. The Sahul Shelf is separated from the island of Timor by the Timor Trough (also known as the Timor Trench), where water depths drop to more than 2,000 m.

The project area itself lies on the outer shelf/continental slope in an area of uniformly smooth seabed ranging in depth from approximately 330 to 390 m, with an average slope of 1:120 (Fugro, 1995). Surface sediments in the project area are composed primarily of calcium carbonate material (approximately 80%), typically comprising approximately 50% silt, 30% clay and 20% sand particles. These surficial sediments, consisting of soft marine clays, form a layer tens of metres thick within the permit area (Fugro, 1995). ROV footage collected in May 2001 indicated that the muddy seabed immediately around the NE FPSO is characterised as flat and featureless. The muddy nature of seabed sediments in the area are typical of surface seabed sediments from the continental slope in the Timor Sea region that are comprise of sandy and silty clays (van Andel & Veevers, 1967).

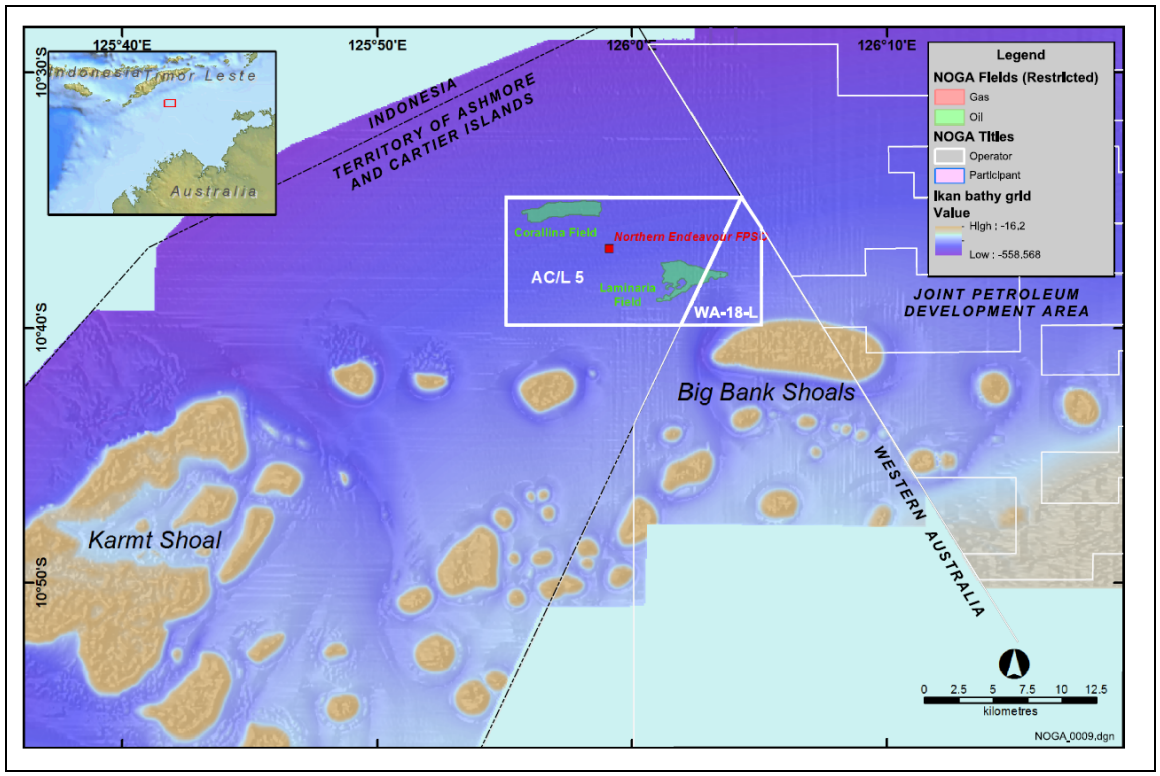


Figure 4.6. Submerged shoals around the Laminaria field

By comparison, seabed sediments of the continental shelf (i.e., the Sahul Shelf) are predominantly carbonate sands mostly transported by strong tidal currents and seasonal cyclones (van Andel & Veevers, 1967). Terrigenous sediments (terrestrial in origin) reach the Sahul Shelf from large river systems (Lees, 1992).

4.3 Biological Environment

Interrogation of the EPBC Act A Protected Matters Search Tool (PMST) database provides the key means by which species are identified for the area, and are discussed in this section.

Additionally, Biologically Important Areas (BIAs) are identified for those species that may occur within the survey area and EMBA. BIAs are spatially defined areas, defined by the DoEE based on expert scientific knowledge, where aggregations of individuals of a species are known to display biologically important behaviour such as breeding, foraging, resting or migration (DoEE, 2017a). The BIAs do not represent a species' full distribution range.

Wherever possible, recovery plans, conservation management plans and conservation advice is used to described the current science on the species of concern.

4.3.1 Benthic Communities

The benthos in the deeper continental slope waters to the north of the Sahul Shelf are characterised by sparse invertebrate assemblages (Pinceratto and Oliver, 1996). A number of targeted surveys to investigate epibenthos and infauna of the slope and shelf environments of the Timor Sea were carried out by Woodside as the previous Titleholder.

A survey undertaken in 1996 found deep waters were characterised by low abundance, low diversity benthic infauna dominated by polychaetes and crustaceans, which were generally characteristic of the region (Hanley Caswell and Associates, 1996). A similar sampling program has since been conducted in the adjacent AC/P8 permit where low abundance benthic fauna was also recorded. Trawls conducted by Woodside in depths ranging between 320 and 340 m on the continental slope 120 km to the northeast of Laminaria field have indicated that epibenthic fauna in the area were sparsely distributed.

The scarcity of benthic fauna on the continental slope is not dissimilar to shallower areas of the Sahul Shelf in the region. Much of the outer mid-shelf is covered by a relatively featureless, sandy-mud seabed with a sparse covering of sessile organisms dominated by filter-feeding heterotrophs such as gorgonians, sponges, soft corals, echinoderms, ascidians and bryozoans and supporting mobile invertebrates such as echinoderms, prawns and detritus-feeding crabs (Brewer *et al*., 2007; DEWHA, 2008).

Sea floor communities in deeper shelf waters receive insufficient light to sustain ecologically sensitive primary producer habitats and communities such as seagrasses, macroalgae or zooxanthellate scleractinian (reef building) corals. Given the depth of water of the project area, and as indicated by the results of seabed surveys, these benthic primary producer groups do not occur in the project area. Nonetheless, infrastructure in the upper water column and euphotic zone may support the photo-dependent sessile benthos such as macroalgae in the upper water column.

Sedimentary infauna associated with soft unconsolidated sediments of the NE FPSO Operational Area is widespread and well represented along the continental shelf and upper slopes in the region (Brewer *et al*., 2007). Consequently, in the context of the contiguous extent of habitats across the region, benthic habitat within the project area, which consists primarily of soft unconsolidated sediments, is considered to be of relatively low environmental sensitivity.

4.3.2 Plankton

Plankton refers to marine flora and fauna that comprise the primary producing phytoplankton (cyanobacteria and other microalgae) and secondary consuming zooplankton (animal) comprising crustaceans (copepods), and the larvae and eggs of fish and invertebrates (meroplankton).

Plankton blooms ('productivity events') are triggered by seasonal and sporadic upwelling events in the offshore waters of the Timor Sea. Productivity events are associated with the north and south continental edge of the Timor Trench and includes the area of the Sahul Shelf shoals. These productivity events are a key process in supporting the foundational trophic functional group driving many of the region's offshore marine ecosystems.

The ITF current delivers oligotrophic (nutrient-poor) waters to the offshore waters of the region (which include that of the project area) supporting low phytoplankton biomass and low primary productivity (Brewer *et al*., 2007). Seasonal upwelling of deeper nutrient-rich water and mixing results in localised and sporadic high phytoplankton productivity along the Sahul Shelf, particularly along channels that allow water to flow onto the shelf and immediately offshore of the shelf (DEWHA, 2008; Brewer *et al*., 2007). The euphotic zone of the outer shelf extends to 100 m depth (Pinceratto, 1997) and diatoms and cyanobacteria are the predominant phytoplankton contributors. It is expected that the dominant primary consumers are copepods, with a wide range of secondary consumers, comprising larger planktonic taxa (including meroplankton such as larval fish and invertebrates) (Brewer *et al*., 2007). Zooplankton recorded from several shoal locations on the outer Sahul Shelf were dominated by copepods with a diverse, abundant and spatially variable assemblages present at the time of sampling (Heyward *et al*., 2007).

Six years of Moderate Resolution Imaging Spectrometer (MODIS) Aqua satellite datasets from the North-West Marine Region (between November 2002 and December 2008) showed that chlorophyll (and inferred phytoplankton) levels are low in summer months (December to March) and higher in winter months (June to August) (Schroeder *et al*., 2009). Further observations associated with the low chlorophyll levels in summer include light limitations on plankton growth due to high cloud cover, or nutrient limitations from an overlying surface layer that is low in nutrients (or both). However, it is likely that much of the primary production is taking place below the surface, where the MODIS imagery does not penetrate (Schroeder *et al*., 2009).

4.3.3 Fish

There are 40 fish species recorded in the EPBC Act PMST as potentially occurring in the EMBA (Table 4.1); comprising nine sharks and rays and 31 pipefish, pipehorses and seahorses. These species are described in this section, with greater detail presented for the threatened and migratory species.

Table 4.1. EPBC Act-listed fish species that may occur within the project EMBA

Scientific name	Common name	EPBC Act status			BIA within the EMBA?	Recovery Plan in place?
		Listed threatened species	Listed migratory species	Listed marine species		
Sharks and rays						
Carcharodon carcharias	Great white shark	V	Yes	-	-	RP
Glyphis garricki	Northern river shark	V	-	-	-	Multi-species RP
Isurus oxyrinchus	Shortfin mako	-	Yes	-	-	-
Isurus paucus	Longfin mako	-	Yes	-	-	-
Manta alfredi	Reef manta ray	-	Yes	Yes	-	-

Scientific name	Common name	EPBC Act status			BIA within the EMBA?	Recovery Plan in place?
		Listed threatened species	Listed migratory species	Listed marine species		
Manta birostris	Giant manta ray	-	Yes	Yes	-	-
Pristis pristis	Largetooth sawfish	V	Yes	-	-	Multi-species RP
Pristis zijsron	Green sawfish	V	Yes	-	-	
Rhincodon typus	Whale shark	V	Yes	-	Possible	CA
Pipefish, pipehorses, seahorses						
Bhanotis fasciolata	Corrugated pipefish	-	-	Yes	-	-
Campichthy tricarinatus	Three-keel pipefish	-	-	Yes	-	-
Choeroichthys brachysoma	Pacific short-bodied pipefish	-	-	Yes	-	-
Choeroichthys suillus	Pig-snouted pipefish	-	-	Yes	-	-
Corythoichthys amplexus	Fijian banded pipefish	-	-	Yes	-	-
Corythoichthys flavofasciatus	Reticulate pipefish	-	-	Yes	-	-
Corythoichthys intestinalis	Australian messmate pipefish	-	-	Yes	-	-
Corythoichthys schultzi	Schultz's pipefish	-	-	Yes	-	-
Cosmocampus banneri	Roughridge pipefish	-	-	Yes	-	-
Doryrhamphus dactyliophorus	Banded pipefish	-	-	Yes	-	-
Doryrhamphus excisus	Bluestripe pipefish	-	-	Yes	-	-
Doryrhamphus janssi	Cleaner pipefish	-	-	Yes	-	-
Filicampus tigris	Tiger pipefish	-	-	Yes	-	-
Halicampus brocki	Brock's pipefish	-	-	Yes	-	-
Halicampus dunckeri	Red-hair pipefish	-	-	Yes	-	-
Halicampus grayi	Mud pipefish	-	-	Yes	-	-
Halicampus spinirostris	Spiny-snout pipefish	-	-	Yes	-	-
Haliichthys taeniophorus	Ribboned pipehorse	-	-	Yes	-	-

Scientific name	Common name	EPBC Act status			BIA within the EMBA?	Recovery Plan in place?
		Listed threatened species	Listed migratory species	Listed marine species		
Hippichthys penicillus	Beady pipefish	-	-	Yes	-	-
Hippocampus histrix	Spiny seahorse	-	-	Yes	-	-
Hippocampus kuda	Spotted seahorse	-	-	Yes	-	-
Hippocampus planifrons	Flat-faced seahorse	-	-	Yes	-	-
Hippocampus spinosissimus	Hedgehog seahorse	-	-	Yes	-	-
Micrognathus micronotopterus	Tidepool pipefish	-	-	Yes	-	-
Solegnathus hardwickii	Pallid pipehorse	-	-	Yes	-	-
Solegnathus lettiensis	Gunther's pipehorse	-	-	Yes	-	-
Solenostomus cyanopterus	Robust ghost pipefish	-	-	Yes	-	-
Solenostomus paegnius	Rough-snout ghost pipefish	-	-	Yes	-	-
Syngnathoides biaculeatus	Double-end pipehorse	-	-	Yes	-	-
Trachyrhamphus bicoarctatus	Bentstick pipefish	-	-	Yes	-	-
Trachyrhamphus longirostris	Straightstick pipefish	-	-	Yes	-	-

Key

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

Key

EPBC status (@ Dec 2016)	V	Vulnerable
	E	Endangered
	CE	Critically endangered

BIA	A	Aggregation
	D	Distribution (i.e., presence only)
	F	Foraging
	M	Migration
Recovery plans	CA	Conservation Advice
(under the EPBC Act 1999)	CMP	Conservation Management Plan
	RP	Recovery Plan
(under the FFG Act 1988)	AS	Action Statement

Great white shark (vulnerable, migratory)

The great white shark (*Carcharodon carcharias*) may occur within the EMBA. Great white sharks are known to live for 30 years or more (Bruce, 2008) and with a range extending from central Queensland, around the southern coastline and up to the North West Cape in Western Australia (Last & Stevens *et al*., 2009). Great white sharks are highly mobile apex predators, with a low density and a widely dispersed population (DSEWPC, 2013).

This species may transverse the EMBA infrequently throughout the year.

Northern river shark (vulnerable)

The northern river shark (*Glyphis garricki*) lives in rivers and estuaries of northern Australia between Derby in WA and Nhulunbuy in the NT. As with all sawfish and river sharks, little is know about the growth rates and breeding ecology of this species (DoE, 2014). Only adults have been recorded in offshore waters (DoE, 2014).

Largetooth sawfish (vulnerable)

Most records for largetooth sawfish (*Pristis pristis*) (previously referred to as the freshwater sawfish) are of juvenile and sub-adult animals in rivers of northern Australia, from Port Hedland in WA across to Townsville in Queensland (DoE, 2015a). The species is considered locally extinct through much of its former range (DoE, 2015a).

Green sawfish (vulnerable)

The green sawfish (*Pristic zijsron*) is commonly found in freshwater rivers and estuarine environments (Thorburn *et al*., 2003) in northern Australia, from Shark Bay in WA to the Whitsundays in Queensland (DoE, 2015c). They are most frequently found in very shallow water but have been found hundreds of kilometres offshore (DoE, 2015b). Green sawfish are found in Indonesian and Australian waters and may migrate between the two countries (Stevens *et al*., 2005). The species is considered locally extinct through much of its former range (DoE, 2015b).

The project is far removed from freshwater and estuarine environments, though due to their migration between Australia and Indonesia, this species may be found in the EMBA. Only adults are known to occur in waters this deep, with juveniles restricted to coastal areas (DoE, 2015b).

Whale shark (vulnerable, migratory)

The whale shark (*Rhincodon typus*) is a migratory fish that visits Australian waters seasonally between March and July, aggregating at the Ningaloo Reef on the west coast of WA when upwellings of cold, nutrient-rich water result in high krill productivity, their key food source. Ningaloo Reef is located 1,750 km to the southwest of the project location, however whale sharks may pass through the EMBA on their annual migration.

Shortfin mako shark (migratory)

The shortfin mako (*Isurus oxyrinchus*) has a circum-global distribution inhabiting tropical and temperate waters, and is wide-ranging oceanic (to water depths of 600 m) and pelagic shark that grows up to 4 m long (TSSC, 2014). The shortfin mako is a highly migratory species, with one juvenile females recorded as travelling over 13,000 km in the Southern and Indian Oceans (TSSC, 2014). Given the ecology of the species, it may be encountered in the project area.

Longfin mako shark (migratory)

The longfin mako (*Isurus paucus*) is widely distributed around Australia, from Geraldton in WA to Port Stephens in NSW, and has a circum-global distribution in tropical and warm-temperate oceanic waters (Fishes of Australia, 2017). Little is known of the biology of this species, though it occurs in water depths of up to 200 m and grows up to 4 m long. It may occur within the shallower waters of the project's EMBA.

Manta rays (migratory)

The reef manta ray (*Manta alfredi*) and giant manta ray (*Manta birostris*) are migratory species, with no listing advice or recovery plans in place. These species have a circum-global distribution, usually found offshore, but often around oceanic islands and is more common in tropical waters than cooler waters (Fishes of Australia, 2017). As the name suggests, the reef manta is found around offshore reefs and seamounts.

They grow to a disc width of between 5 and 7 m, using their large flaps on either side of the head to direct zooplankton and small fish into their wide mouth. Manta rays have suffered from over-fishing across many parts of their range, with these species prized for their gill rakers (Fishes of Australia, 2017).

Signathids (pipefish, seahorse, pipehorse)

Thirty-one species of signathids (pipefish, seahorse, pipehorse) are listed as potentially occurring in the EMBA. Signathids are generally wide-ranging species occurring in shallow waters (up to about 20 m) that require seabed vegetation and hard substrates to cling to. Given the assumed absence of this habitat in the Laminaria Field (due to the light-limiting water depths), these species are unlikely to be present in the project area. They may be present in the shallowest waters of the EMBA, nearshore Indonesia.

Other fish

No teleost fish species that are listed under the EPBC Act were identified as potentially occurring within the NE FPSO Operational Area by the PMST, however it is possible that listed species such as seahorses and pipefish species occur in shallow, nearshore waters.

Shell (2009) reports that pelagic scalefish that occur in the Timor Sea region include billfish, tunas and mackerels. Key species are swordfish (*Xiphius gladus*), blue marlin (*Makaira mazara*), black marlin (*Makaira indica*), sailfish (*Istiophorus platypterus*), yellowfin tuna (*Thunnus albacares*), long tail tuna (*Thunnus tonggol*), grey mackerel (*Scomberomorus semifasciatus*) and Spanish mackerel (*Scomberomorus commerson*). Demersal species found in the region include red emperor (*Lutjanus sebae*), goldband snapper (*Pristipomoides multidens*) and a range of other snappers (Lutjanidae), emperors (Lethrinidae) and cods (Serranidae). The likelihood of occurence of any large or significant populations of these species residing within the deep waters of the region is remote, as these species are strongly associated with shallow environments such as nearshore shelf systems and offshore reefs and atolls.

The project area comprises featureless, flat soft sediment seabed, and consequently the fish fauna are not expected to be abundant and diversity is expected to be limited due to the lack of habitat complexity. It is noted however that fish abundance and diversity increases with presence of artificial infrastructure (Gagnon, 2001).

4.3.4 Mammals

There are 26 marine mammals recorded in the EPBC Act PMST as potentially occurring in the EMBA (Table 4.2); 15 whales and 11 dolphins. The threatened and migratory species listed in Table 5.2 are described in this section.

Table 4.2. EPBC Act-listed marine mammals species that may occur within the EMBA

Scientific name	Common name	EPBC Act status			BIA within the EMBA?	Recovery Plan in place?
		Listed threatened species	Listed migratory species	Listed marine species		
Whales						
Balaenoptera bonaerensis	Antarctic minke whale	-	Yes	Yes	-	-
Balaenoptera borealis	Sei whale	V	Yes	Yes	-	CA
Balaenoptera edeni	Bryde's whale	-	Yes	Yes	-	-
Balaenoptera musculus	Blue whale (pygmy)	E	Yes	Yes	Yes	RP
Balaenoptera physalus	Fin whale	V	Yes	Yes	-	CA
Feresa attenuata	Pygmy killer whale	-	-	Yes	-	-
Globicephala macrorhyn-chus	Short-finned pilot whale	-	-	Yes	-	-
Kogia breviceps	Pygmy sperm whale	-	-	Yes	-	-
Kogia simus	Dwarf sperm whale	-	-	Yes	-	-
Megaptera novaeangliae	Humpback whale	V	Yes	Yes	-	CA
Mesoplodon densirostris	Blainville's beaked whale	-	-	Yes	-	-
Peponocephala electra	Melon-headed whale	-	-	Yes	-	-
Physeter macrocephalus	Sperm whale	-	Yes	Yes	-	-
Pseudorca crassidens	False killer whale	-	-	Yes	-	-
Ziphius cavirostris	Cuvier's beaked whale	-	-	Yes	-	-
Dolphins						

Scientific name	Common name	EPBC Act status			BIA within the EMBA?	Recovery Plan in place?
		Listed threatened species	Listed migratory species	Listed marine species		
Delphinus delphis	Common dolphin	-	-	Yes	-	-
Grampus griseus	Risso's dolphin	-	-	Yes	-	-
Lagenodelphis hosei	Fraser's dolphin	-	-	Yes	-	-
Orcinus orca	Killer whale	-	Yes	Yes	-	-
Stenella attenuata	Spotted dolphin	-	-	Yes	-	-
Stenella coeruleoalba	Striped dolphin	-	-	Yes	-	-
Stenella longirostris	Long-snouted spinner dolphin	-	-	Yes	-	-
Steno bredanensis	Rough-toothed dolphin	-	-	Yes	-	-
Tursiops aduncus	Indian Ocean bottlenose dolphin	-	-	Yes	-	-
Tursiops aduncus (Arafura/Timor Sea populations)	Spotted bottlenose dolphin (Arafura/ Timor Sea populations)	-	-	Yes	-	-
Tursiops truncatus	Bottlenose dolphin	-	-	Yes	-	-

Humpback whale (Vulnerable, migratory)

The humpback whale (*Megaptera novaeangliae*) is the most commonly sighted whale along the WA coastline. The species is observed annually completing their seasonal northern and southern migrations to and from the Camden Sound area of the west Kimberley (Jenner *et al*., 2001) in the winter and spring months, after feeding in Antarctic waters during the summer months (Bannister and Hedley, 2001).

The Kimberley coast from the Lacepede Islands to north of Camden Sound is the main breeding and calving area for the WA population of humpback whales. Large concentrations of humpbacks area observed in Camden Sound and Pender Bay between July and October each year. Satellite tracking shows that migratory areas do not extend as far as north or west as the NE FPSO Operational Area (Double *et al*., 2010; 2012a), which aligns with DoE (2015d) distribution mapping (Figure 5.7 and Figure 5.8). Records from 2011 until mid-June 2016 indicate no sightings of humpback whales have occurred within the NE FPSO

Operational Area. The likelihood of humpback whales in NE FPSO Operational Area is therefore remote.

The humpback whale migration routes are reported to be within the continental shelf boundary (200 m bathymetry) (Jenner *et al*., 2001) (see Figure 5.7) and migrations occur between June and October each year. Tagged humpback whale data confirm the northerly migration route is located close to the WA coastline, often within a few tens of kilometres from shore and the width of the migratory corridor is generally less than 60 km (Double et al, 2011).

TSSC (2015b) mapping for the migration routes of the humpback whale confirm that the NE FPSO operational area is not located within or near the whale's seasonal northerly and southerly migration routes.

The Humpback Whale Recovery Plan 2005-2010 (DEH, 2005) is no longer in force. Mapping in the current conservation advice for the humpback whale (TSSC, 2015b) indicates that there is no key habitat in the EMBA, with the humpback whale's core range, calving and resting grounds located a significant distance to the southwest. While the EMBA overlaps the 'likely species range' (where humpback whales may be present on a seasonal basis), so too do most Australian waters (and those beyond the Australian EEZ), so project activities will not limit the habitat available to this species.

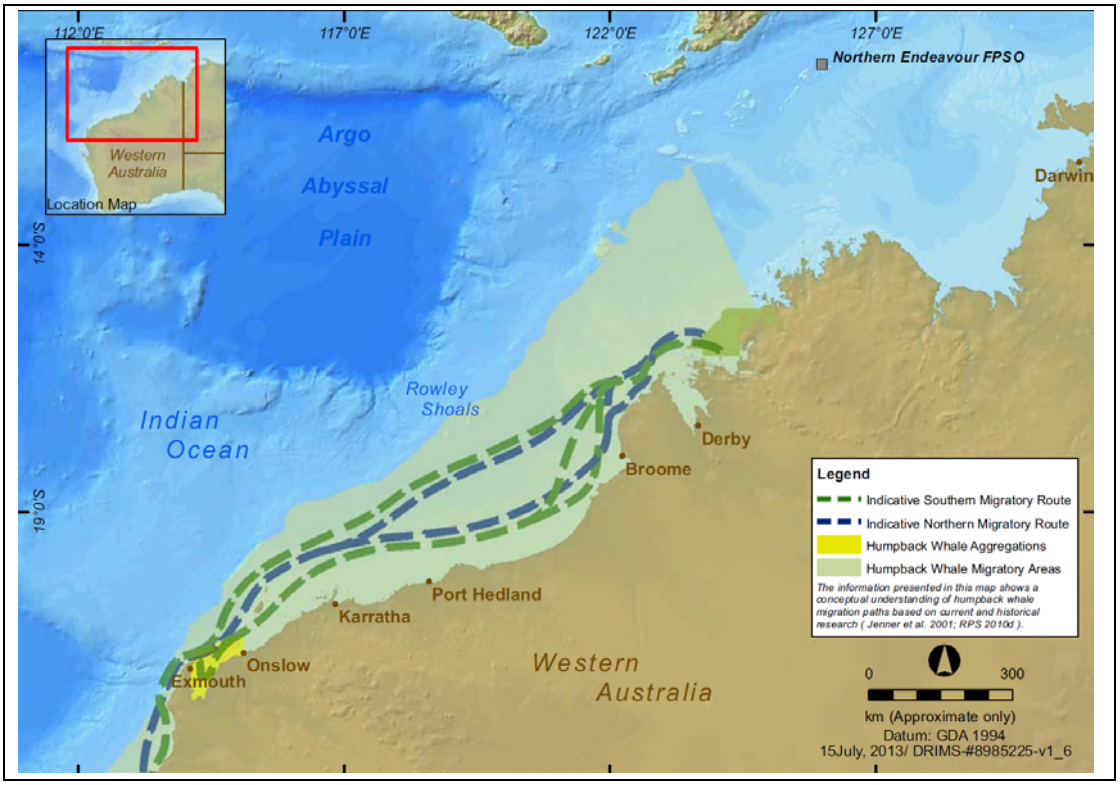
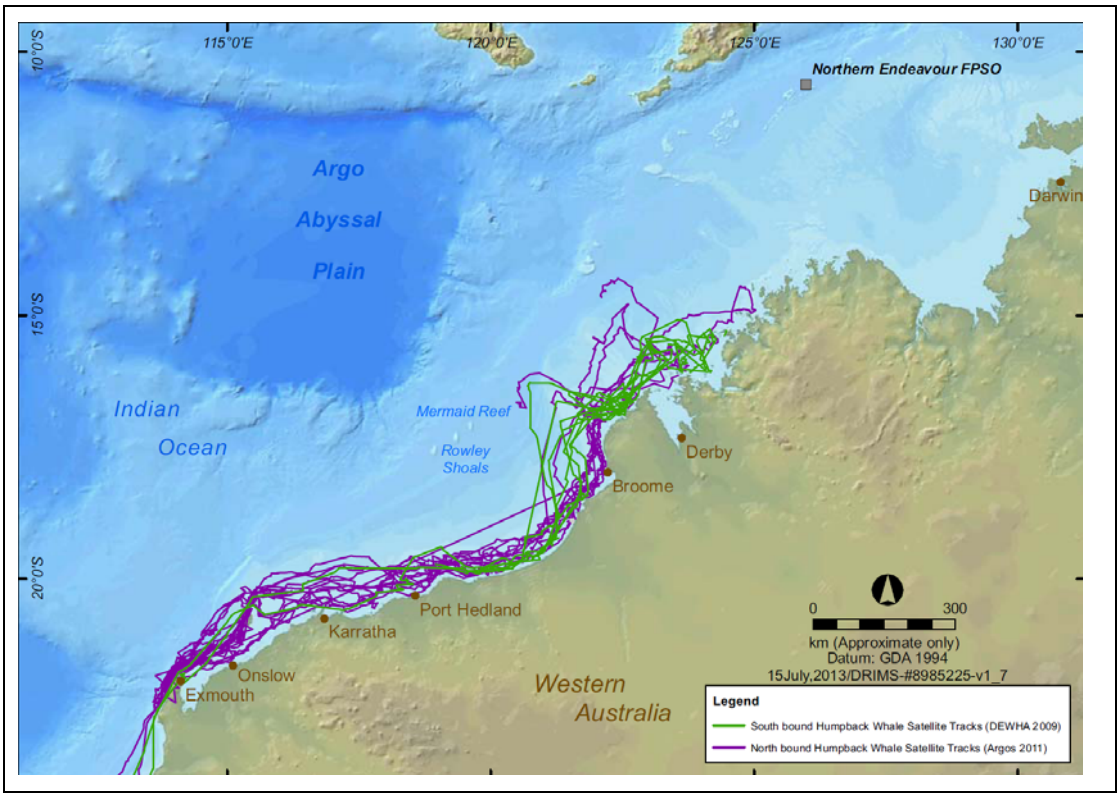


Figure 4.7. Humpback whale migration routes in North West Australia in relation to the NE FPSO



Source: Double et al (2010; 2012a).

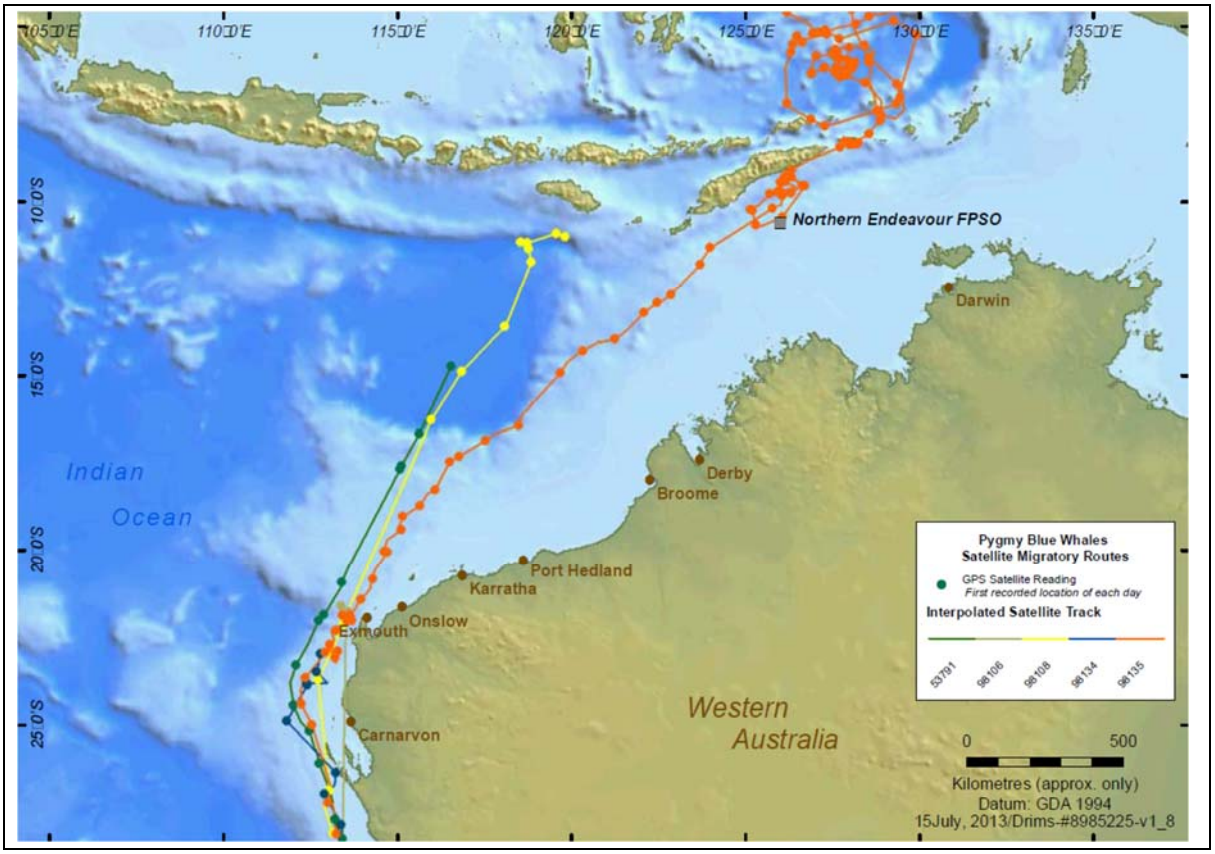
Figure 4.8. Humpback whale northern migratory tracks as recorded by satellite tracking

Blue whale (Endangered, migratory)

There are two recognised subspecies of blue whale in the Southern Hemisphere, which are both recorded in Australian waters. These are the southern (or 'true') blue whale (*Balaenoptera musculus intermedia*) and the 'pygmy' blue whale (*Balaenoptera musculus brevicauda*) (DoE, 2015c). In general, southern blue whales occur in waters south of 60°S (close to Antarctica) and pygmy blue whales occur in waters north of 55°S (i.e., not in the Antarctic) (DoE, 2015c). On this basis, nearly all blue whales within the EMBA are likely to be pygmy blue whales.

Pygmy blue whales are highly mobile species that exhibit seasonal migratory movements between Australia and Indonesia (DoE, 2015c). Satellite tag tracks and detection acoustically by noise loggers indicate general migration patterns and key feeding and breeding areas. Satellite telemetry results showed pygmy blue whales migrating from the Perth Canyon and Naturaliste Plateau region in March/April and reaching Indonesia in June where they remain until at least September (Double *et al*., 2014). They then migrate south along the edge of the WA continental slope and finish by December in the subtropical frontal zone. Lower rates of travel and relatively higher occupancy were recorded for the Perth Canyon/Naturaliste Plateau, North West Cape/Ningaloo Reef, Indonesian waters and the subtropical frontal zone (Bonney upwelling, South Australia). Furthermore, pygmy blue whales can be found as far south as the Antarctic Convergence Zone. Satellite tagging conducted in 2011 confirmed the Perth Canyon/Naturaliste Plateau and possibly North West Cape/Ningaloo Reef as areas of activity off the WA coast where pygmy blue whales aggregate to feed with some predictability (Double *et al*., 2011; DoE, 2015c). Geographe Bay in southern WA (approximately 2,500 km south of the activity) is also a known resting place from October to December. Satellite tracking of pygmy blue whales in 2009 showed whales departing the Perth Canyon, heading up the west coast to the North West Cape and then on to the Banda and Molucca Seas via

the Timor Sea (Double *et al*., 2012b). In the lower latitudes, visiting pygmy blue whales are breeding and there are reported calving areas in Indonesian waters and more recently evidence of feeding aggregations associated with frontal formations that occur within the Banda and Molucca Seas (Double *et al*., 2014). Anecdotal observations of potential feeding aggregations on the outer continental shelf of the Timor Sea south of Timor-Leste was reported by marine mammal observers on a marine seismic survey during September and December 2007 (ENI, 2007a; b), though the DoE (2015) do not note this area as a foraging region. Eighteen individuals (13 pods) positively identified in the September survey period confirmed the presence of pygmy blue whales off the southern coast of Timor-Leste. The whales exhibited deep diving feeding behaviour in waters between approximately 1,000–2,500 m depth. No pygmy blue whales were observed in the December survey period. The presence of pygmy blue whales to the south of Timor-Leste was also confirmed from satellite telemetry, with one individual whale travelling to the southern continental edge of Timor-Leste to the north of the NE FPSO facility and then continuing along Timor-Leste into the Molucca Sea (Figure 5.9).



Source: Double et al (2010; 2012a).

Figure 4.9. Pygmy blue whale satellite tracks showing migration routes between Australia and Indonesia and the location of the NE FPSO

Based on acoustic data, pygmy blue whales are likely to travel alone or in small groups. Typically, solitary whales are recorded calling, although larger groups of calling animals are occasionally detected (as recorded by noise loggers) for WA waters. In general, sightings of transiting pygmy blue whales are likely to be uncommon within the project area, however, migratory routes and opportunistic feeding aggregations at frontal formations (upwellings) in offshore, deepwater areas to the south of Timor and Timor-Leste indicate pygmy blue whales may be present in the wider region, particularly the winter months (June to September).

The DoE (2015c) state that it is not possible to define habitat critical to the survival of blue whales. However, a BIA for distribution and migration for the pygmy whale overlaps the

EMBA. The nearest BIA for foraging occurs around the Scott Reef complex (570 km to the southeast of the activity).

Fin whale (Vulnerable, migratory)

The fin whale (*Balaenoptera physalus*) is the second-largest whale species after the blue whale, growing up to 27 m long and weighing up to 70 tonnes (TSSC, 2015b). It is a cosmopolitan species and is found from polar to tropical waters (more commonly in temperate waters) (TSSC, 2015b).

There are stranding records of this species from most Australian states, but they are considered rare in Australian waters (Bannister *et al*., 1996), with available information suggesting they are more common in deeper water (DEH, 2005). The total abundance and population trends of fin whales in Australian waters is unknown (TSSC, 2015b). They show well-defined long annual migrations between higher latitude feeding grounds in summer to lower latitude breeding ground in winter (TSSC, 2015b). Migratory movements are essentially north–south with little longitudinal dispersion.

The Conservation Advice for fin whales (TSSC, 2015b) identifies vessel strike and anthropogenic noise as threats to the species, the latter important as it may mask vocalisations or cause injury or death. Based upon the species preference for offshore waters (although noting the absence of a BIA in Australian waters), this species may occur within the EMBA.

Sei whale (Vulnerable, migratory)

Sei whales are found primarily found in deep water oceanic habitats, and in Australia they are present in Commonwealth waters, but recorded infrequently off the WA and NT coasts (TSSC, 2015c). This species generally grows to 12-16 m in length. Mating and calving occur mainly during winter, but low-latitude breeding grounds have not been identified (TSSC, 2015c). Sei whales are thought to complete long annual seasonal migrations from subpolar summer feeding grounds to lower altitude winter breeding grounds, though details of these activities are unknown. However, sei whales appear to be more commonly recorded in colder waters than warmer waters (TSSC, 2015c).

It is unlikely that sei whales occur within the EMBA and there is no BIA for this species in the EMBA.

Antarctic minke whales (Migratory)

The Antarctic minke whale (*Balaenoptera bonaerensis*) is distributed worldwide in oceanic habitats, feeding in cold waters and migrating to warmer waters to breed (Bannister et al, 1996). However, detailed information on timing and location of north- and south-bound migrations, and location of breeding grounds is not well known. Antarctic minke whales have been recorded off all Australian states and are thought to migrate up the WA coast to approximately 20°S (Bannister *et al*., 1996) to feed and possibly breed in winter.

It is unlikely that Antarctic minke whales occur within the EMBA and there is no BIA for this species in the EMBA.

Bryde's whale (Migratory)

Bryde's whale (*Balaenoptera edeni*) is restricted to tropical and temperate waters and has been recorded off all Australian states (Bannister *et al*., 1996). Bryde's whale occurs in both oceanic and inshore waters with the only key localities recognised in WA being in the Abrolhos Islands and North of Shark Bay (Bannister *et al*., 1996). Two forms of the species are recognised: inshore and offshore. The offshore form is thought to migrate seasonally, heading towards warmer tropical waters during the winter.

Given there are only three key localities for Bryde's whale in Australia (the Abrolhos Islands, North Shark Bay and off Queensland (Bannister *et al*., 1996)), the likelihood of occurrence of Bryde's whales within the EMBA is remote, possibly limited to a few individuals transiting the area There is no BIA for this species in the EMBA.

Sperm whale (Migratory)

Sperm whales (*Physeter macrocephalus*) are distributed worldwide in deep waters (greater than 200 m) off continental shelves and sometimes near shelf edges, averaging 20 to 30 nm offshore (Bannister *et al*., 1996). The sperm whale and is known to migrate northwards in winter and southwards in summer (DoEE, 2017b). However, detailed information on the distribution of sperm whales off WA is not available for the timing of north and south-bound migrations. Sperm whales have been recorded in deep water off North West Cape on the west coast of WA (Jenner *et al*., 2010; RPS, 2010; Woodside, 2011), and appear to occasionally venture into shallower waters in other areas (RPS, 2010). There are no key localities recognised in the Northern Territory and the only key locality recognised in WA for sperm whales is along the southern coastline between Cape Leeuwin and Esperance (Bannister *et al*., 1996).

There is no BIA for this species around the EMBA. The likelihood of occurrence of sperm whales within the EMBA is remote, possibly limited to a few individuals transiting the area.

Beaked whales (Listed marine species)

Several beaked whales are listed in the PMST as having the potential to occur within the EMBA (see Table 4.2). In Australia, these species have not been well studied, and key localities are not known to occur in Australia. Most beaked whales are deep-water species.

The most common and widespread species known to occur in Australian waters is the strap-toothed beaked whale (*Mesoplodon layardii*), which occurs in waters deeper than 200 m. Their population size is unknown, and oceanic (deep-water) squid form the bulk of their diet (DoEE, 2017b). Due to their preference for deep water, this species is unlikely to occur within the EMBA.

Dolphins

None of the 11 dolphin species listed in the PMST are listed as threatened. Many dolphins are cosmopolitan species that are generally restricted to continental shelf environments. A brief description of these dolphin species is provided below.

- The **common dolphin** (*Delphinus delphis*) is an abundant species, widely distributed from tropical to cool temperate waters, and generally further offshore than the bottlenose, although small groups may venture close to the coast and enter bays and inlets. They have been recorded in waters off all Australian states and territories (DoEE, 2017b).

- **Risso's dolphin** (*Grampus griseus*) is a widely distributed species found in deep waters of the continental slope and outer shelf from the tropics to temperate regions.

This species prefers warm temperate to tropical waters with depths greater than 1,000 m, although they do sometimes extend their range into cooler latitudes in summer (Bannister *et al*., 1996). In Australia, the species has been recorded from all states except Tasmania and the NT. Fraser Island (off the southern Queensland coast) has the only suspected 'resident' population in Australia (Bannister *et al*., 1996). There are no known calving areas in Australian waters. The lack of resident populations and calving areas in Australia indicates there are no critical areas (and no BIA) for the species within the EMBA.

- **Fraser's dolphin** (*Lagenodelphis hosei*) is a stocky dolphin that is found in tropical and subtropical pelagic and oceanic habitats. In Australia, it is found in waters north of 30°S and deeper than 1,000 m (DoEE, 2017b). This suggests the species is unlikely to be found in the EMBA.

- The **killer whale** (*Orcinus orca*) (the largest member of the dolphin family) are thought to be the most cosmopolitan of all cetaceans and appear to be more common in cold, deep waters, though they have often been observed along the continental slope and shelf particularly near seal colonies (Bannister *et al*., 1996). The killer whale is widely distributed from polar to equatorial regions and has been recorded in all Australian waters with concentrations around Tasmania. The only recognised key locality in Australia is Macquarie Island and Heard Island in the Southern Ocean (Bannister *et al*., 1996). The habitat of killer whales includes oceanic, pelagic and neritic (relatively shallow waters over the continental shelf) regions, in both warm and cold waters (DoEE, 2017b). The breeding season is variable and the species moves seasonally to areas of food supply (Bannister *et al*., 1996; Morrice *et al*., 2004). It is possible that killer whales may occur in the EMBA, however given the long distance to the nearest seal colonies (on the south coast of WA), the EMBA is unlikely to represent an important habitat for this species and significant numbers of this species.

- The **spotted dolphin** (*Stenella attenuata*) has been recorded in all Australian tropical and subtropical waters, and some temperate waters in WA. They inhabit nearshore and oceanic habitats, and the population size in Australia remains unknown (DoEE, 2017b). They feed on small pelagic fish and squids. Given their widespread distribution throughout tropical waters, this species may occur within the EMBA.

- The **striped dolphin** (*Stenella coeruleoalba*) is a species found in deep temperate to tropical waters, with a wide global distribution (DoEE, 2017b). The distribution and population size of the species in Australian waters is unknown, with records only from standings, though sightings have only been made where surface waters exceed a temperature of 25°C (DoEE, 2017b). Given the sea surface temperatures in the EMBA are likely to be over this threshold (see Section 5.2.3), it is assumed the species could occur within the EMBA.

- The **long-snouted spinner dolphin** (*Stenella longirostris*) is another dolphin species that is poorly understood in Australian waters, with their population size and distribution unknown (DoEE, 2017b). However, they are known to be primarily pelagic and in Australia are known to be association with shallow water (less than 50 m deep) (DoEE, 2017b). This suggests they are unlikely to occur around the project area but may occur in the shallower areas of the EMBA.

- The **rough-toothed dolphin** (*Steno bredanensis*) is recorded in pelagic and oceanic waters in WA, the NT, Queensland and southern NSW where surface

waters exceed 25°C in temperature, but the sparse nature of sightings means its current area of occupancy is difficult to define (DoEE, 2017b). While its Australian population is unknown, it is thought to be abundant (DoEE, 2017b). Given the sea surface temperatures in the EMBA are likely to be over this threshold (see Section 5.2.3), it is assumed the species could occur within the EMBA.

- The **Indian Ocean bottlenose dolphin** (*Tursiops aduncus*) is distributed around the entire Australian mainland, but as the common name suggests, occur mainly in tropical and sub-tropical waters, usually coastal and shallow offshore areas. The species is thought to be common in discreet areas of eastern, northern and western Australia, though the total population size is not known (DoEE, 2017b). No critical habitats are known to occur within the EMBA.

- The **Indian Ocean bottlenose dolphin** (*T. aduncus*) (Arafura/Timor Sea populations) resemble bottlenose dolphins, but as the name suggests, are restricted to northern Australian regions in inshore areas such as bays and estuaries and shallow offshore coastal areas (DoEE, 2017b). They are thought to be common, and may occur in the shallow water areas of the EMBA close to Indonesia.

- The **bottlenose dolphin** (*Tursiops truncatus*) has a worldwide distribution from tropical to temperate waters. While the species is primarily coastal, they are found inshore and on the shelf and open oceans as well, and as such may be found within the EMBA.

4.3.5 Reptiles

There are 22 reptile species (6 turtles and 16 seasnakes) recorded in the EPBC Act PMST as potentially occurring in the EMBA (Table 4.3). The threatened and migratory species are described in this section.

Table 4.3. EPBC Act-listed reptile species that may occur within the project EMBA

Scientific name	Common name	EPBC Act status			BIA within the EMBA?	Recovery Plan in place?
		Listed threatened species	Listed migratory species	Listed marine species		
Turtles						
Caretta caretta	Loggerhead turtle	E	Yes	-	Foraging	Generic RP for all marine turtles
Chelonia mydas	Green turtle	V	Yes	-	Inter-nesting	
Dermochelys coriacea	Leatherback turtle	E	Yes	-	-	
Eretmochelys imbricate	Hawksbill turtle	V	Yes	-	Inter-nesting	
Lepidochelys olivacea	Olive Ridley turtle	E	Yes	-	-	
Natator depressus	Flatback turtle	V	Yes	-	Foraging	
Seasnakes						
Acalytophis peronei	Horned seasnake	-	-	Yes	-	-

Scientific name	Common name	EPBC Act status			BIA within the EMBA?	Recovery Plan in place?
		Listed threatened species	Listed migratory species	Listed marine species		
Aipysurus apraefrontalis	Short-nosed seasnake	-	-	Yes	-	-
Aipysurus duboisii	Dubois' seasnake	-	-	Yes	-	-
Aipysurus foliosquama	Leaf-nosed seasnake	-	-	Yes	-	-
Aipysurus laevis	Olive seasnake	-	-	Yes	-	-
Astrotia stokesii	Stokes' seasnake	-	-	Yes	-	-
Diseira kingii	Spectacled seasnake	-	-	Yes	-	-
Disteira major	Olive-headed seasnake	-	-	Yes	-	-
Emydocephalus annulatus	Turtle-headed seasnake	-	-	Yes	-	-
Enhydrina schistose	Beaked seasnake	-	-	Yes	-	-
Hydrophis atriceps	Black-headed seasnake	-	-	Yes	-	-
Hydrophis coggeri	Slender-necked seasnake	-	-	Yes	-	-
Hydrophis elegans	Elegant seasnake	-	-	Yes	-	-
Hydrophis ornatus	Spotted seasnake	-	-	Yes	-	-
Lapemis hardwickii	Spine-bellied seasnake	-	-	Yes	-	-
Pelamis platurus	Yellow-bellied seasnake	-	-	Yes	-	-

Sea snakes

Seasnakes occur in the Northwest Shelf Transition Province in waters up to approximately 100 m depth and are reported to occur in offshore and nearshore waters. Ashmore Reef and Cartier Island have been recognised for their high diversity and density of seasnakes (DSEWPAC, 2012c). Sea snakes occupy diverse habitats including coral reefs, turbid water habitats and deeper water (Guinea *et al*., 2004). Species exhibit habitat preferences depending on water depth, benthic habitat, turbidity and season (Heatwole and Cogger, 1993).

Seasnakes of the families Hydrophidae and Laticaudidae are widespread in the region, and are protected under the EPBC Act. The PMST lists 16 species of seasnake under the EPBC Act that may occur in the EMBA, none of which are listed as threatened or migratory.

Turtles

Table 4.4 provides details of the marine turtle species identified, including breeding and nesting seasons, diet and key habitats. All six marine turtle species recorded for the North West Transition province are listed in the EPBC Act PMST and may occur within the EMBA.

Five of the turtle species (green, hawksbill, flatback, leatherback and Olive Ridley) have significant nesting beaches along the mainland coast and islands in the region including Ashmore Reef, the Tiwi Islands and Cobourg Peninsula (DSEWPAC, 2012b; DoEE, 2017c).

There are no documented turtle feeding, nesting or foraging areas in the project area. Given the distance offshore (approximately 360 km north of the Kimberley coastline and 155 km south east from Timor Island), distance from shallow shoals (10 km), depth range of surrounding offshore waters (330 to 390 m), and absence of potential nesting or foraging sites (i.e., no emergent islands, reef habitat or shallow shoals), the project area is not considered an important habitat for marine turtles. While there are significant nesting sites along the mainland coast and islands of the region, the primary nesting locations (such as Ashmore Reef) are at least 300 km from the project area. The series of shoals and banks that occur on the outer continental edge of the Sahul Shelf may serve as foraging habitat for turtles. The closest submerged bank to the project area is located approximately 10 km to the southeast.

Post-nesting migratory routes recorded for green and flatback turtles at the Lacapede Islands (and green turtle tracking for post-nesting individuals from Scott Reef indicate no overlap with the project area. In relation to the wider region, most tagged individuals were recorded travelling eastwards along the Kimberley coast to the Joseph Bonaparte Gulf with some tracked as far as the Arafura Sea. The satellite tracks indicate green turtles generally remain in nearshore waters along the Kimberley coastline, while flatback turtles stay further offshore and are known to frequent the submerged shoals of the Sahul Bank (RPS, 2012b).

Table 4.4. Key information on marine turtle ecology in northwest Australia

Species	Key season	Diet	Key habitats	BIA
Green turtle	Breeding: Approximately September to March. Nesting: November to April. Peak period from January to February. Year-round nesting occurs at South Scott Reef and Ashmore Reef (peaks in summer) (Figure 5.10).	Seagrasses and algae.	Nearshore reefal habitats in the photic zone. Major nesting sites: Tiwi Islands (Melville and Bathurst Islands), Cobourg Peninsula (Garig Gunak Barlu National Park, NT, offshore islands between Croker Island and Goulburn Island, Lacepede Islands, North West Cape, Barrow Island, Montebello Islands, Muiron Islands and some islands of the Dampier Archipelago. Smaller rookeries occur adjacent to the Kimberley region (such as Browse Island, Maret Island, Cassini Island and other islands of the Boneparte Archipelago) and Sandy Islet (Scott Reef). Nesting also occurs Casaurina Beach (Darwin). Ashmore Reef is a significant breeding area. Records show it is a critical nesting and inter-nesting habitat as well as supporting significantly large feeding aggregations of green turtles.	Inter-nesting areas around offshore islands in the region, with foraging area through the Bonaparte Gulf.
Loggerhead turtle	Breeding: Approximately September to March Nesting: Late October to late March. Peak period from late December to early January (Figure 5.11).	Carnivorous - feeding mainly on molluscs and crustaceans.	Nearshore and island coral reefs, bays and estuaries in tropical and warm temperate latitudes. Distribution: Shark Bay to North West Cape and as far north as Muiron Islands and Dampier Archipelago. Nesting not reported from the North Marine Region.	Foraging area in the northwestern part of the Bonaparte Gulf and around Broome.
Hawksbill turtle	Nesting: All year round with peak in September to January (Figure 5.12).	Mainly sponges – also seagrasses, algae, soft	Nearshore and offshore reefal habitats. Major nesting sites: coasts and islands off east Arnhem Land (such as Groote Eylant and surrounds).	Inter-nesting around Scott Reef and Ashmore Reef, along with east Arnhem Land.

Species	Key season	Diet	Key habitats	BIA
		corals and shellfish.	Small numbers nest at Ashmore Reef. Small numbers nesting in the Kimberley Also (such as at One Arm Point in King Sound). Small numbers recorded at Melville Island and Oxley Island (offshore Coubourg Peninsula, east of Melville Island).	
Flatback turtle	Nesting: November to March with peak period in January. (in the far north, nesting occurs in dry season winter months) (Figure 5.13).	Carnivorous - feeding mainly on soft bodied prey such as sea cucumbers, soft corals and jellyfish.	Nearshore and offshore sub-tidal and soft-bottomed habitats of offshore islands. Major nesting sites: Melville and Bathurst Islands and to the east at Coubourg Peninsula. Smaller rookeries occur in Camden Sound (at Slate Island), on numerous islands of the Buccaneer and Boneparte Archipelago as well as at coast and island locations along the Josephe Bonaparte Gulf. Nesting habitat areas are distributed from the Lacepede Islands to Exmouth. Other significant rookeries include Eighty Mile Beach, Roebuck Bay, Thevenard Island, the Montebello Islands, Varanus Island, the Lowendal Islands, and islands of the Dampier Archipelago.	Foraging area in the northwestern part of the Bonaparte Gulf, with inter-nesting areas around many Australian mainland coastlines.
Olive Ridley turtle	Nesting: All year round with peak in April to November (Figure 5.14).	Carnivorous – feeding mainly on crustaceans and molluscs.	Nearshore and offshore tropical and subtropical waters. Low intensity nesting in Northern Territory and possibly North Kimberley. Significant nesting habitat: north-west Arnhem Land (including Melville Island, Bathurst Island, Coubourg Peninsula, McCluer Island Groups and Grant Island).	Foraging area through the Bonaparte Gulf, with inter-nesting areas around Darwin and east around Arnhem Land.

Species	Key season	Diet	Key habitats	BIA
Leatherback turtle	Nesting: December to January (Figure 5.15).	Carnivorous - feeding mainly in the open ocean on jellyfish and other soft-bodied invertebrates.	Nearshore, coastal tropical and temperate waters. Significant nesting area at Danger Point (Coubourg Peninsular). Low numbers recorded nesting at Cobourg Peninsula and northwest Arnhem Land. This species may be encountered within the NWS but noted that there are no known nesting sites within WA.	Small inter-nesting area at the northern tip of northwest Arnhem Land.

Source: DoEE (2017c).

4.3.6 Avifauna

Seabirds may transit the area on occasion, but the deep waters and distance to emergent land make it unlikely that the project area or EMBA comprises important habitat to birds. There are no islands with seabird colonies within the immediate vicinity of the proposed project area (Cartier Island and Ashmore Island are 88 km and 129 km to the west, respectively).

Birds that occur year round or as seasonal visitors in the region, such as petrels and shearwaters, are likely to be common in and around the project area. Woodside supported a survey of pelagic seabird populations in the northeast Indian Ocean, which revealed that foraging seabirds were typically clumped in areas adjacent to islands. This may be because islands provide shelter, while anomalies in surface water concentrate food seasonally. Most birds encountered offshore were foraging in flocks of 20 to more than 200 individuals, often of different species, and commonly associated with schools of pelagic fish, such as tuna. Foraging groups typically comprise sooty terns (*Sterna fuscata*), wedge-tailed shearwaters (*Puffinus pacificus*) and the occasional frigatebird (*Fregata* spp.). The most commonly encountered seabirds that were not foraging were wedge-tailed shearwaters and Bulwer's petrels (*Bulweria bulweria*), however, these two species were only recorded in low densities.

DSEWPC (2011) reports that Ashmore Reef and Cartier Island are important breeding areas for the brown booby (*Sula leucogaster*), which breeds from February to October, and the red-footed booby (*Sula sula*), which breeds year-round with most egg laying between April and June. The great frigatebird (*Fregatea minor*) is reported to be a widespread pelagic seabird, with breeding take place on numerous tropical islands, including in small numbers on Ashmore Reef (DSEWPaC, 2011a). The lesser frigatebird (*F.ariel*) is also known to breed on Ashmore Reef and Cartier Island (from March to September), and may be present in the region outside of the breeding season (DSEWPaC, 2011a).

The little tern (*Sternula albifrons*), a widespread species throughout Australia, is known to rest on Ashmore Reef and Cartier Island, feeding on small fish, crustaceans and insects. The roseate tern (*S. dougallii*) is found in northern Australian waters around offshore coral and continental islands, with breeding populations recorded from Ashmore Reef. Fewer than 20 pairs of the white-tailed tropicbird (*Phaethon lepturus*) breed on Ashmore Reef from May to October (DSEWPaC, 2011).

There are 13 bird species recorded in the EPBC Act PMST as potentially occurring in the EMBA (Table 4.5), which are described in this section.

Table 4.5. EPBC Act-listed bird species that may occur within the project EMBA

Scientific name	Common name	EPBC Act status			BIA within the EMBA?	Recovery Plan in place?
		Listed threatened species	Listed migratory species	Listed marine species		
Anous tenuirostris melanops	Australian lesser noddy	V	-	-	-	
Anous stolidus	Common noddy	-	Yes	Yes	-	
Calonectris leucomelas	Streaked shearwater	-	Yes	Yes	-	

Fregata ariel	Lesser frigatebird	-	Yes	Yes	Yes: breeding, foraging	
Fregata minor	Great frigatebird	-	Yes	Yes	Yes: breeding, foraging	
Papasula abbotti	Abbott's booby	E	-	Yes	-	
Sula sula	Red-footed booby	-	Yes	Yes	Yes: breeding, foraging	
Migratory wetland species						
Actitis hypoleucos	Common sandpiper	-	Yes	Yes	-	
Calidris acuminata	Sharp-tailed sandpiper	-	Yes	Yes	-	
Calidris canutus	Red knot	E	Yes	Yes	-	
Calidris ferruginea	Curlew sandpiper	CE	Yes	Yes	-	
Calidris melanotos	Pectoral sandpiper	-	Yes	Yes	-	
Numenius madagascar-iensis	Eastern curlew	CE	Yes	Yes	-	

Australian Lesser Noddy (vulnerable)

The Australian lesser noddy usually occupies coral-limestone islands densely fringed with white mangrove (*Avicennia marina*) in which it roosts at night. This species feeds on small fish and tends to remain around its breeding island (DoEE, 2017b). The Australian lesser noddy breeds on islands in the Indian Ocean, possibly including Ashmore Reef. Flegg (2003) indicates this species is restricted in distribution to a small coastal area south of Shark Bay in WA, making it unlikely this species will be encountered in the EMBA.

Common Noddy (migratory)

The common noddy breeds colonially in trees or on the ground on tropical islands and beaches, dispersing to nearby coastal seas. It is a widespread species around the north coast of Australia (Flegg, 2003) and the west coast of WA (DoEE, 2017b). It is a gregarious species that normally occurs in flocks, and breeding colonies have been recorded from 50 islands (mostly in Queensland), varying in size from a few pairs to more than 100,000 pairs. The species usually feeds on fish by gleaning from the sea surface. During the non-breeding period, the species occurs in groups throughout the pelagic zone (DoEE, 2017b). The species may occur in the EMBA.

Streaked Shearwater (migratory)

The streaked shearwater occurs all along the Australian northwest, northern and eastern coasts, though is scarcer in northern and eastern waters (Flegg, 2003). It breeds in Japan, Russia and China before migrating south (CSIRO, 2017).

Lesser Frigatebird (migratory)

The lesser frigatebird is an oceanic species, breeding on tropical islands including those off the northern coast of Australia in the Indian and Pacific Oceans (Flegg, 2003; CSIRO, 2017). They are distributed from the mid-west coast of WA across northern Australia and south to southern NSW (Flegg, 2003, DoEE, 2017b). Outside of the breeding season (timing unknown), the species is sedentary (CSIRO, 2017).

Great Frigatebird (migratory)

The greater frigatebird is an oceanic species, breeding on tropical islands including those off the northern coast of Australia (Flegg, 2003). They are distributed around the tropical north coast of Australia, south to Brisbane in Queensland (Flegg, 2003, DoEE, 2017b). They feed on fish taken from the sea surface in pelagic waters within 80 km of their breeding colonies (CSIRO, 2017). There is a paucity of information regarding this species' migration patterns.

Abbot's Booby (migratory)

Abbot's booby is recorded from Broome and several islands offshore northwest Australia (e.g., Christmas Island), feeding on fish and squid presumably by plunge feeding (CSIRO, 2017). The nest colonially between April and October, laying a single egg. Christmas Island appears to be an important area for their food source, where cold upwellings supply a seasonal abundance of food (CSIRO, 2017).

Red-footed Booby (migratory)

The red-footed booby is an oceanic species that nests on islands off the northern Australian coast, with nesting recorded from islands off the northwest coast of Australia (Flegg, 2003; CSIRO, 2017). There is a paucity of information regarding this species' general ecology.

Migratory Wetland Species

The six migratory wetland species listed in Table 5.5 are not described here as the EMBA does not extend to wetland areas used by these species, these being areas such as Ashmore Reef, Cartier Island and Scott Reef. While these species may overfly the project area and EMBA during their migration, the EMBA does not provide important habitat for these species.

4.3.7 Marine Pests

There is a paucity of information regarding the marine pests that may be present in the project's EMBA, and the Timor Sea generally.

The Marine Pests Interactive Map (DAWR, 2017) indicates that there are no introduced marine pests established in the Port of Darwin, where project vessels will transit to and from for this project. The back-up port for the project, Broome, also has no introduced marine pests recorded according to the database.

4.4 Areas of Conservation Significance

The environmental values and sensitivities of the receiving environment for the EMBA are described in this section. The offshore environment of the Timor Sea and surrounds contains environmental features of high value or sensitivity. These include Commonwealth offshore waters, Ramsar-listed wetlands, CMRs, State Marine Parks, shoals and the key areas of importance for critical life stages (such as feeding and breeding) for listed marine species (resident and temporary visitors). These features include habitats or species that are

particularly vulnerable or that provide valuable ecological services such as coral reefs, mangroves, seagrass meadows and macroalgae.

4.4.1 Commonwealth Marine Areas

Commonwealth Marine Reserves

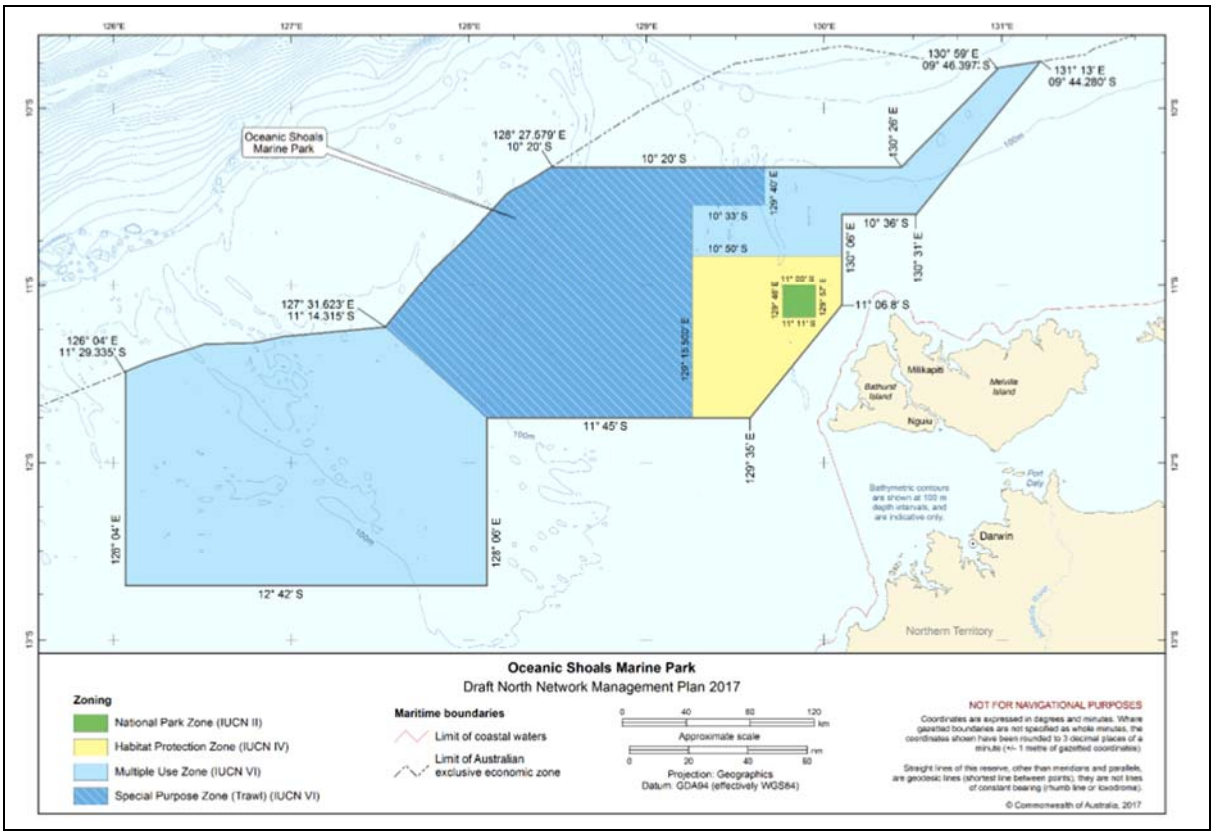
In 2012, the Commonwealth government established 21 marine reserves within the North and North-west bioregions. These CMRs are currently under transitional arrangements until management plans come into effect. Draft management plans were released in July 2017 (DNP, 2017a;b). The CMRs located within the EMBA are described here.

Oceanic Shoals CMR

The Oceanic Shoals CMR (Figure 4.16) covers an area of 71,743 km^2 and lies within the Timor Sea with its northern boundary on the edge of Australia's EEZ, with waters depths ranging from less than 15 m to 500 m in the deepest parts. Its nearest boundary is located 99 km (53 nm) south of the project. Bathurst and Melville islands (Tiwi islands) lie east of the Reserve.

Major conservation values of the reserve (DNP, 2013; 2017a) include:

- Important resting area between egg laying (interesting area) for the flatback turtle and olive ridley turtle;
- Important foraging area for the threatened loggerhead turtle and olive ridley turtle;
- Examples of ecosystems representative of the Northwest Shelf Transition;
- Key ecological features including:
    - Carbonate bank and terrace system of the Van Diemen Rise – an area characterised by terraces, banks, channels and valleys that support sponges, soft corals, polychaetes, ascidians, turtles, snakes and sharks;
    - Carbonate bank and terrace system of the Sahul Shelf – an area characterised by terraces, banks, channels and valleys that support sponges, soft corals, sessile filter feeders, polychaetes and ascidians;
    - Pinnacles of the Bonaparte Basin – an area that contains the largest concentration of pinnacles along the Australian margin, where local upwellings of nutrient-rich water attract aggregations of fish, seabirds and turtles; and
    - Shelf break and slope of the Arafura Shelf – an area characterised by continental slope, patch reefs and hard substrate pinnacles that support over 280 demersal fish species.



Source: DNP (2017a).

Figure 4.16. The Oceanic Shoals CMR

Ashmore Reef CMR

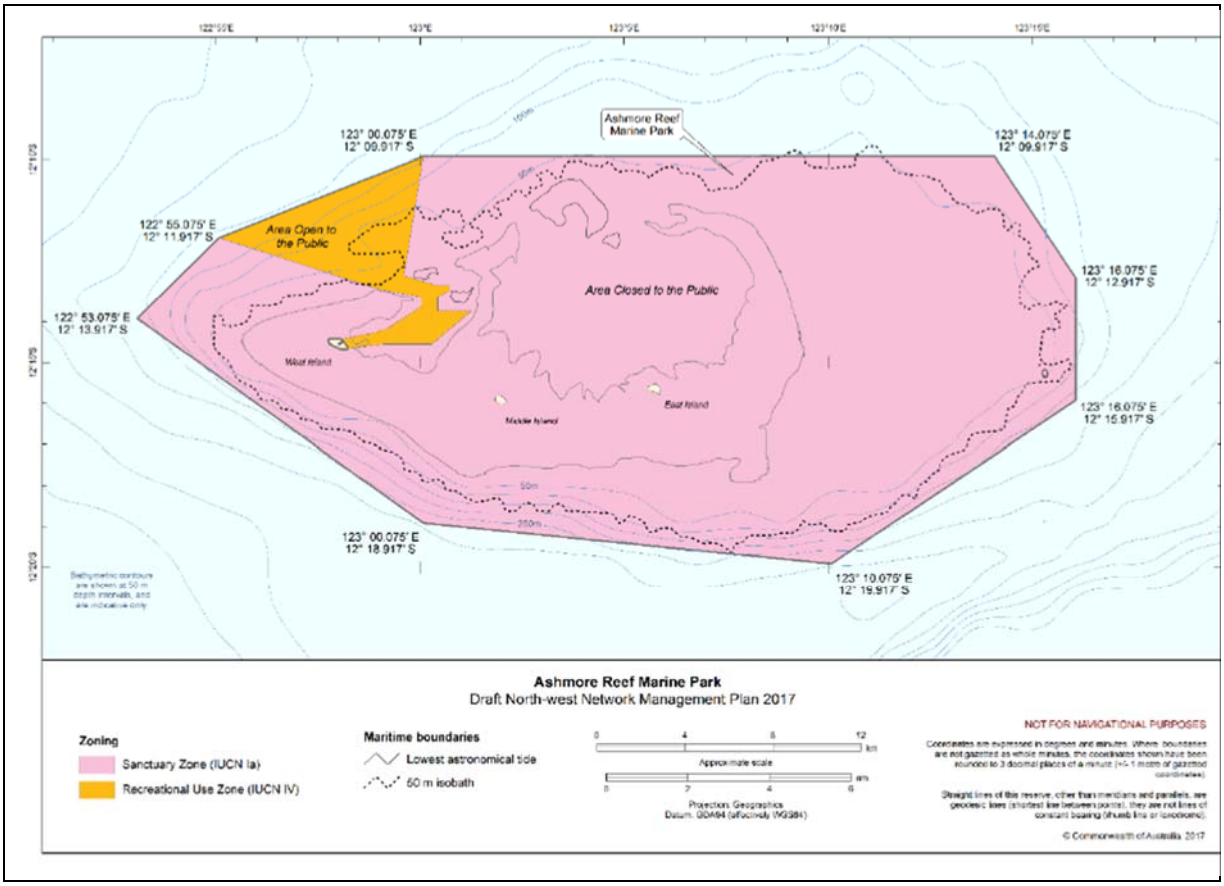
The Ashmore Reef CMR (Figure 5.17) covers an area of 583 km^2 and the majority is classified as a Strict Nature Reserve (DNP, 2017b). Furthermore, the island is a Ramsar-listed wetland. Its nearest boundary is located 346 km (187 nm) southwest of the project.

Key conservation values of the reserve include (DNP, 2013; 2017b):

- The presence of two extensive lagoons, shifting sand flats and cays, seagrass meadows and a large reef flat (covering an area of approximately 239 km^2).
- Ashmore Reef was designated a Ramsar Wetland of International Importance in 2003 as its islands provide a resting place for migratory shorebirds and support large seabird breeding colonies such as brown booby and great frigatebird;
- Biologically rich habitat including primary producer habitat (mangroves, seagrass beds and coral reefs) and their associated benthic communities, demersal fish communities and other biota;
- Regionally important nesting, inter-nesting, foraging areas for marine turtles (particularly green but also hawksbill and loggerhead). An estimated 11,000 marine turtles feed in the area throughout the year;
- Isolated, small dugong population of less than 50 individuals that breeds and feeds around the reef. This population is thought to be genetically distinct from other Australian populations;
- Important seabird rookeries and staging points/feeding areas for migratory sea/shorebirds (including: colonies of bridled terns, common noddies, brown

boobies, eastern reef egrets, frigatebirds, tropicbirds, red-footed boobies, roseate terns, crested terns and lesser crested terns);

- International significance for seasnake abundance and diversity; and
- Importance cultural and heritage sites: Indonesian artefacts and grave sites.



Source: DNP (2017b).

Figure 4.17. Ashmore Reef CMR

Cartier Island CMR

The Cartier Island CMR (Figure 5.18) covers an area of 172 km^2 and is located approximately 45 km southeast of Ashmore Reef. Its nearest boundary is located 332 km (179 nm) south of the project.

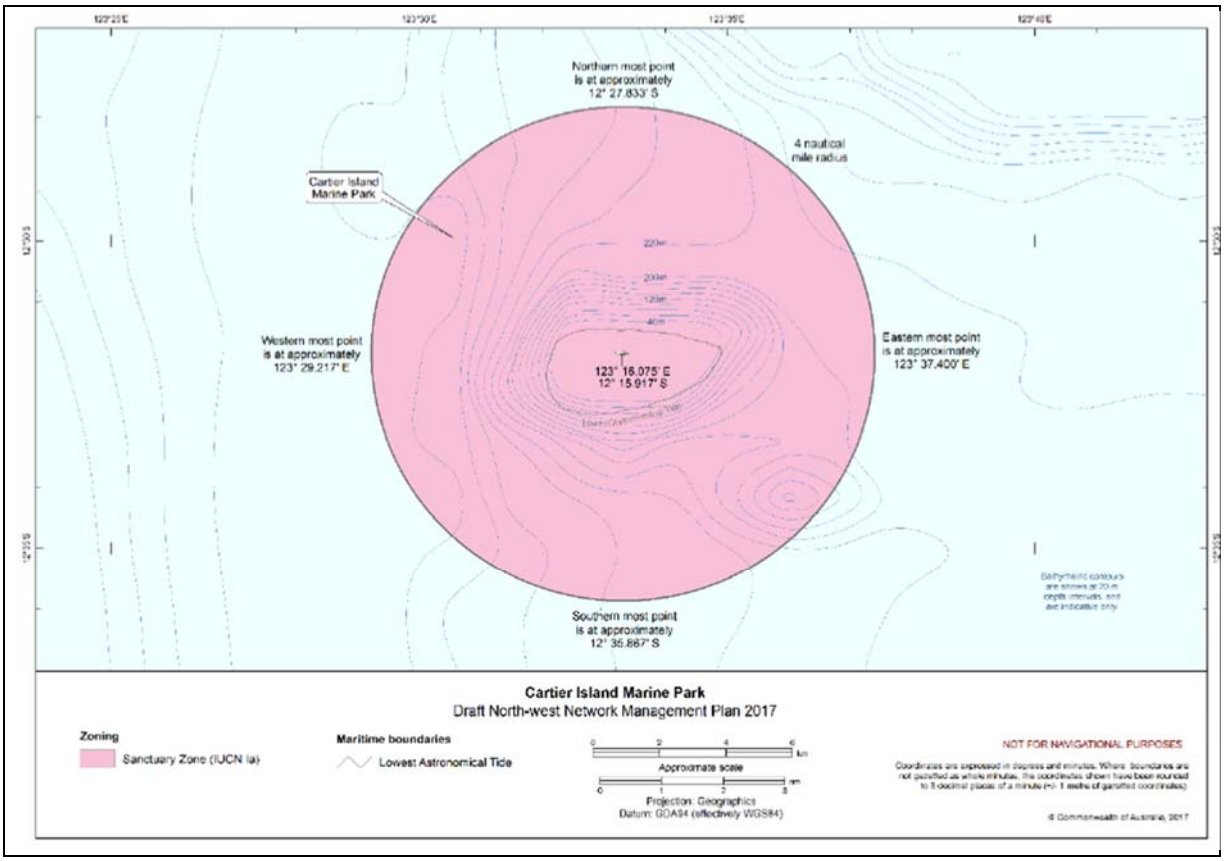


Figure 4.18. Cartier Island CMR

The reserve is classified as a sanctuary zone and the CMR's key conservation values include (DNP, 2013; 2017b):

- An unvegetated sand island, extensive reef flat and subtidal reef system surrounding the island, a small submerged pinnacle (Wave Governor Bank and two shallow pools to the northeast of the island);
- Key ecological features:
    - Ashmore Reef and Cartier Island and surround Commonwealth waters – areas of enhanced productivity in an otherwise low-nutrient environment, of regional importance for feeding and breeding aggregations of birds and marine life.
    - Continental slope demersal fish communities – an area of high diversity in demersal fish assemblages.
- Internationally significant for its abundance and diversity of seasnakes;
- Large and significant feeding populations of green, hawksbill and loggerhead turtles occur around the reefs;
- Supports some of the most important seabird rookeries on the North West Shelf including colonies of bridled terns, common noddies, brown boobies, eastern reef egrets, frigatebirds, tropicbirds, red-footed boobies, roseate terns, crested terns and lesser crested terns;
- Important staging points/feeding areas for many migratory seabirds;
- Cultural and heritage site: *Ann Millicent* historic shipwreck;

- Cartier Island and the surrounding marine area within a 10 km radius was a gazetted Defence Practice Area up to 20 July 2011 and used in the past as an air weapons range. Although the site is no longer an active weapons range, there is a substantial risk that unexploded ordnances (UXO) remain in the area; and
- Ashmore and Cartier CMR areas have historical and cultural significance. In particular, traditional Indonesian fishers have an historic and ongoing cultural and economic association with the islands and reefs of the region (CoA, 2002).

Kimberley CMR

The Kimberley CMR (Figure 5.19) covers an area of 74,469 km^2 and is located approximately 100 km north of Broome. Its nearest boundary is located 290 km (156 nm) south of the project.

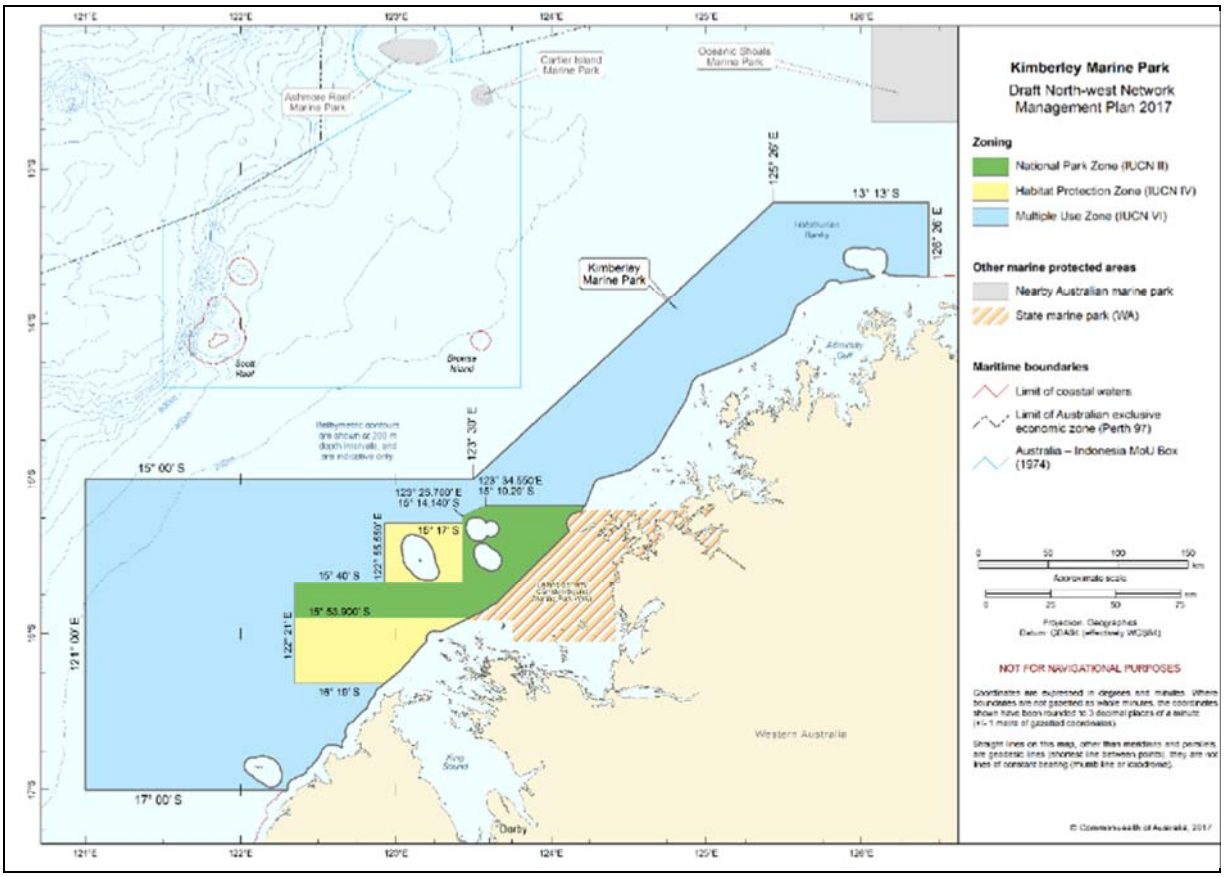


Figure 4.19. The Kimberley CMR

The CMR's key conservation values include (2017b):

- Ecosystems representative of the Northwest Shelf Province, Northwest Shelf Transition and the Timor Province;
- Key ecological features:
    - The ancient coastline at the 125-m depth contour – where rocky escarpments are thought to provide biologically important habitats in areas otherwise dominated by soft sediments.
    - Continental slope demersal fish communities – an area of high diversity in demersal fish assemblages.

- Breeding and foraring areas for seabirds, inter-nesting and nesting habitat for marine turtles, breeding, calving and foraging habitat for inshore dolphins, calving, migratory pathway and nursing habitat for humpback whales, migratory pathway for pygmy blue whales, foraging habitat for dugong and foraging habitat for whale sharks; and
- Contains more than 40 known shipwrecks.

Key Ecological Features

Key Ecological Features (KEFs) are elements of the Commonwealth ocean that are considered to be of regional importance for either a region's biodiversity or its ecosystem function and integrity. KEFs are not MNES and have no legal status in their own right (DoEE, 2017d).

Thirteen KEFs are identified within the North-west Marine Region, and eight identified within the Northern Marine Region. One KEF occurs within the EMBA, with four others located in close proximity to the EMBA. These KEFS are described in Table 4.7 (with distances from Laminaria-5 noted).

Table 4.7. Summary of the KEFs present within the EMBA

KEF	Marine region	Description
Within the EMBA		
Carbonate bank and terrace system of the Sahul Shelf *99 km (53 nm) south*	North-west	The key value of this KEF is its unique seafloor features. Little is known about the bank and terrace system of the Sahul Shelf but it is regionally important because of its likely ecological role in enhancing biodiversity and local productivity relative to its surrounds. 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 be foraging areas for loggerhead, olive ridley and flatback turtles, and cetaceans and green and freshwater sawfish may occur in the area.
In close proximity to the EMBA		
Pinnacles of the Bonaparte Basin *132 km (72 nm) southeast*	North-west	More than 110 pinnalces are found in this KEF, occupying an area of more than 520 km^2 and can be 50-100 km long. These pinnacles provide areas of hard substrate in an otherwise soft sediment environment and are thus important for sessile species. Rising steeply from depths of about 80 m some pinnacles emerge to within 30 m of the water surface, allowing light-dependent organisms to thrive. Pinnacles that rise to within 45 m water depth support more biodiversity. Communities present on these pinnacles include sessile benthic invertebrates such as hard and soft corals, sponges, whips, fans, bryozoans and aggregations of demersal fish species such as snappers, emperors and groupers. The pinnacles are also recognised as a biodiversity hotspot for sponges as they are home to more sponge species and different communities than the surrounding seafloor
Ashmore Reef and Cartier Island and	North-west	The key value of this KEF is its high productivity and aggregations of marine life.

KEF	Marine region	Description
surrounding Commonwealth waters *322 km (174 nm) southwest*		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 important for feeding and breeding aggregations of birds and other marine life, and are areas of enhanced primary productivity in an otherwise low-nutrient environment. Ashmore Reef supports the highest number of coral species of any reef off the west Australian coast.
Ancient coastline at 125 m depth contour *330 km (178 nm) southwest*	North-west	The shelf of the North-west Marine Region contains several terraces and steps which reflect changes in sea level that occurred over the last 100,000 years. The most prominent of these features occurs as an escarpment along the North West Shelf and Sahul Shelf at a depth of 125 m. The ancient submerged coastline provides areas of hard substrate and therefore may provide sites for higher diversity and enhanced species richness relative to surrounding areas of predominantly soft sediment. Little is known about fauna associated with the hard substrate of the escarpment but it is likely to include sponges, corals, crinoids, molluscs, echinoderms and other benthic invertebrates representative of hard substrate fauna in the North West Shelf bioregion. The escarpment may also facilitate increased availability of nutrients off the Pilbara by interacting with internal waves and enhancing vertical mixing of water layers. Enhanced productivity associated with the sessile communities and increased nutrient availability may attract larger marine life such as whale sharks and large pelagic fish.
Continental Slope Demersal Fish Communities *333 km (180 nm) southwest*	North-west	The key value of this KEF is its high levels of endemism. The diversity of demersal fish assemblages on the continental slope in the Timor Province, the Northwest Transition and the Northwest Province is high compared to elsewhere along the continental slope.

Source: DoEE (2017d).

Threatened Ecological Communities

An ecological community is a group of native plants, animals and other organisms that naturally occur together and interact in a unique habitat. Its structure, composition and distribution are determined by environmental factors such as soil type, position within the landscape/seascape (e.g., altitude/depth), climate, and water availability, chemistry and movement (e.g., oceanic currents). Species within each ecological community interact with and depend on each other for food or shelter. An ecological community becomes classified as a Threatened Ecological Community (TEC) in order to provide a form of landscape or systems-level conservation (including threatened species).

The PMST and TEC database (DoEE, 2017e) indicates that there are no TECs in or around the project area or within the EMBA.

4.4.2 Commonwealth Heritage List

The Commonwealth Heritage List is a list of natural, Indigenous and historic heritage places owned or controlled by the Australian Government. These include places connected to defence, communications, customs and other government activities that also reflect Australia's development as a nation.

There are 19 Commonwealth Heritage List sites in WA and 12 in the NT, along with 49 in external territories. The Commonwealth heritage sites located within the EMBA and closest to the Laminaria-5 well are described herein (<1% probability of contact with surface, entrained or dissolved Laminaria crude or MDO).

Scott Reef

Scott Reef (Place ID: 105480) is a significant component of a disjunct chain of shelf edge reefs separated from Indonesia by the Timor Trough. The place is regionally significant both because of its high representation of species not found in coastal waters off Western Australia and for the unusual nature of its fauna which has affinities with the oceanic reef habitats of the Indo-West Pacific as well as the reefs of the Indonesian region. Scott Reef is important for its contribution to understanding long term geomorphological and reef formation processes (DoEE, 2017f).

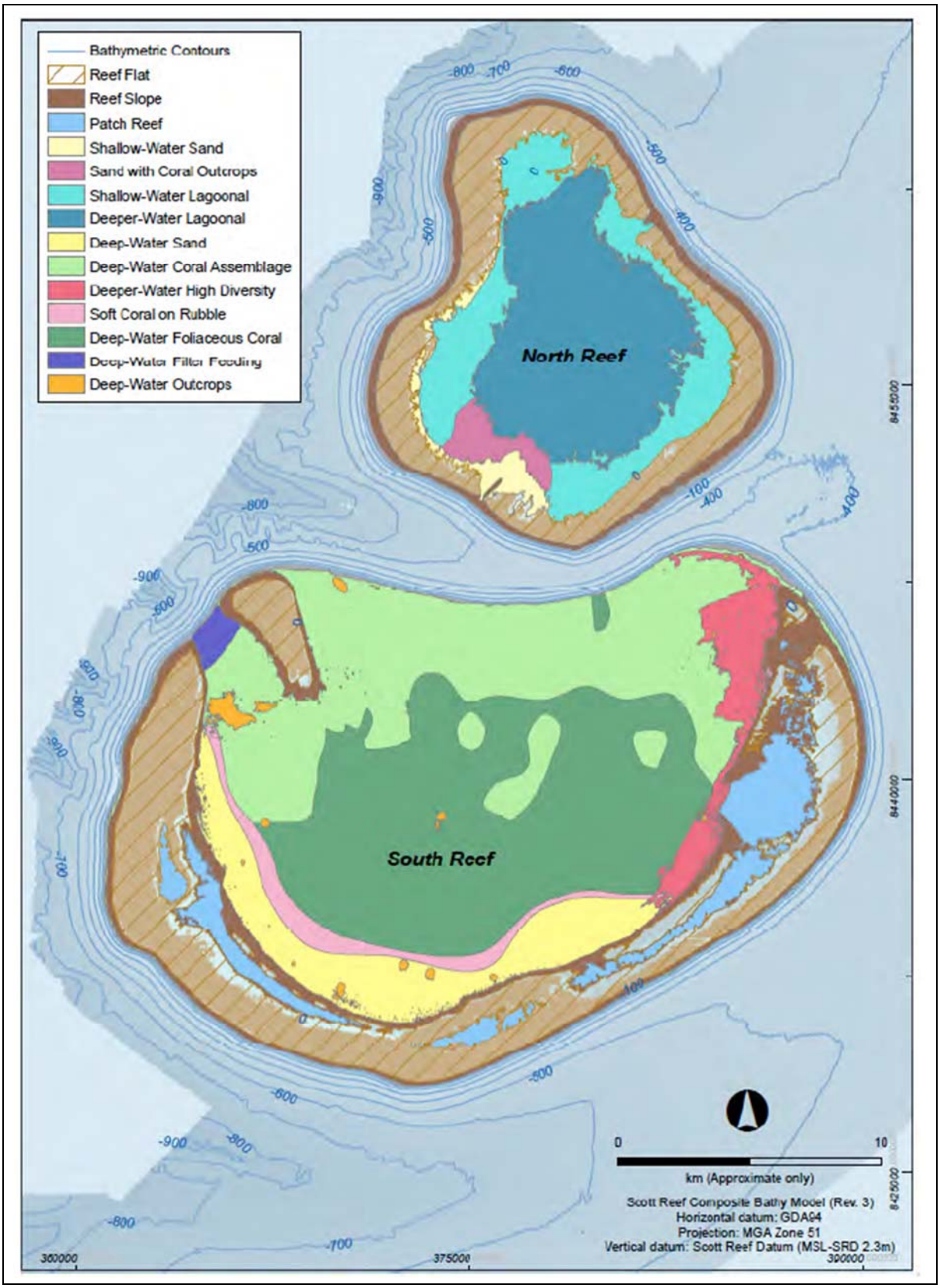
Scott Reef (North and South) is a group of atoll-like reefs located 575 km (310 nm) southwest of Laminaria-5 on the edge of the continental shelf. The reefs are distinguished as follows (Smith *et al*., 2013):

- Scott Reef South (also called Horseshoe Reef or South Reef) is a large crescent-shaped formation that has a rare and unusual double reef crest. The reef with its lagoon covers an area of 144 km^2; and

- Scott Reef North consists of a large, approximately circular-shaped. The reef is composed of a narrow reef-crest that is backed by broad reef flats — much of which becomes exposed at low tide — and a deep central lagoon that is connected to the open sea by two delta-like channels. The reef with its lagoon covers an area of 106 km^2.

Nearly 1,900 species have been recorded at the reef. Habitat types of the reef are illustrated in Figure 5.20. Scott reef was subject to a natural mass bleaching event in 1998 that resulted in the loss of about 80% of its coral cover. It has taken 12 years for the reef to recover, indicating it is a resilient reef (Gilmore *et al*., 2013; Smith *et al*., 2013).

Scott Reef supports a rich assemblage of fish species. In the shallow waters of the reef (0-20 m below surface), a survey undertaken by the WA Museum at North Reef in 2006 found 271 fish species, 31% of which were confined to the outer reef. There were 325 fish species recorded from South Reef during the same survey, with only 18% confined to the outer reef (Woodside, 2011). The composition of fish species at Scott Reef is reportedly similar to other oceanic reefs in the tropical Indo-West region, but contain far more damselfish species that are absent at Rowley Shoals (300 km to the south). The most abundant species at Scott Reef belong to the Pomacentridae family (small and brightly coloured damselfish and anemonefish) (Woodside, 2011).



Source: Woodside (2011).

Figure 4.20. Habitats of Scott Reef

In the deeper waters of South Reef (20-63 m), the WA Museum survey recorded 228 demersal and pelagic fish species (Woodside, 2011). The coral bleaching event of 1998 changed fish species composition at the reef, as reef habitat changed from coral to turf to coralline algae. Fish numbers declined from 1998 to 2004, but have increased with the recovery of hard corals from 2005 to 2008. Shark numbers have decreased in the last decade, likely to be related to over-fishing (Woodside, 2011).

Sandy Islet (or Island) is an important habitat for migrating animals in the largely landless expanse of the Timor Sea. The island is an important nesting site for green turtles and occasionally hawksbill turtles (summer nesting, but variable year to year) (Smith *et al*., 2013).

Seringapatam Reef

Seringapatam Reef (Site ID: 105243) covers an area of 55 km^2 and is located 24 km north of Scott Reef and 548 km (295 nm) southwest of Laminaria-5. It is a small circular-shaped reef, which rises from the seabed with a narrow reef rim enclosing a deep lagoon.

Seringapatam Reef has biogeographic significance due to the presence of species that are at or close to the limits of their geographic ranges, including fish known previously only from Indonesian waters. Seringapatam Reef is a significant component of a disjunct chain of shelf edge reefs separated from Indonesia by the Timor Trough. The place is regionally significant both because of its high representation of species not found in coastal waters off WA and for the unusual nature of its fauna which has affinities with the oceanic reef habitats of the Indo-West Pacific as well as the reefs of the Indonesian region (DoEE, 2017f).

Much of the reef is exposed at low tide, but there are no emergent sandy cays. Scott and Seringapatam reefs combined contain 213 species of coral, 279 species of molluscs, 56 decapod crustacea, 117 echinoderm species and 482 fish species (Smith *et al*., 2013). Fish communities at Seringapatam Reef are closely linked to those at Scott Reef.

Ashmore Reef and islets

See also Section 4.4.5 for a description of Ashmore Reef.

Ashmore Reef (Place ID: 105218) has major significance as a staging point for wading birds migrating between Australia and the northern hemisphere, including 43 species listed on one or both of the CAMBA and JAMBA and provides habitat for three species of sea snakes with very restricted distributions (DoEE, 2017f). In addition to being a Commonwealth Heritage Site, it is also listed as the Ashmore Reef CMR, with the reef and surrounding waters covering an area of 583 km^2.

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. Seagrass in the shallows of the lagoon provides food for a population of between 10 and 60 dugong (*Dugong dugon*) (Woodside, 2011), which may be genetically distinct from other populations on the Kimberley coast (DEWHA, 2008).

The three islands located within the lagoon — West Island (32 ha), East Island (16 ha), and Middle Island (13 ha) — are mostly flat, being composed of coarse sand with a few areas of

exposed beach rock and limestone outcrops. All of the islands are vegetated with shrubs and herbs. Ashmore Reef is as an important breeding site for seabirds such as the common noddy (*Anous stolidus*), sooty tern (*Sterna fuscata*), bridled tern (*S. anaethetus*) and crested tern (*S. bergii*). In all, 20 species are known to breed on the islands. Many other bird species use the reef as a stopover point on migrations to and from the north — such as the eastern curlew (Arenaria interpres) and Mongolian plover (Charadrius mongolus). In total, 78 bird species have been recorded at Ashmore, with 35 of these cited in international agreements between the Australian Government and the governments of China, Japan and the Republic of Korea concerning the conservation of migratory birds and their habitats (DoEE, 2017f).

The reef also provides habitat to a diverse marine fauna that includes dugong (*Dugong dugon*), loggerhead turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), and an important and unique population of sea snake species — some of which are endemic to the area (DoEE, 2017f).

The marine fauna at Ashmore Reef has the highest diversity of the reefs on the North-West Shelf, with the mollusc fauna being substantially more diverse here (433 species) than either Scott and Seringapatam Reefs (279 species) or Rowley Shoals (DoEE, 2017f). Ninety-nine species of decapod crustaceans have been recorded at Ashmore Reef compared with 56 for Scott and Seringapatam Reefs) and 178 echinoderms species have been recorded (compared with 119 species for Scott and Seringapatam and 90 species for Rowley Shoals).

A total of 560 fish species have also been recorded at the reef, with the most species-rich fish families being the Gobiidae (small to mid-sized gobies, 66 species), Pomacentridae (small and brightly coloured damselfish and anemonefish, 66 species), Labridae (wrasse, 54 species) and Apogonidae (36 species) (DoEE, 2017f).

Ashmore Reef is protected as the Ashmore Reef National Nature Reserve (583 km^2) and was proclaimed in August 1983 (DEWHA, 2008).

4.4.3 World Heritage Sites

World Heritage sites are places that are important to and belong to everyone, irrespective of where they are located. They have universal value that transcends the value they hold for a particular nation. These qualities are expressed in the *Convention concerning the Protection of the World Cultural and Natural Heritage* (the World Heritage Convention).

The World Heritage Convention aims to promote cooperation among nations to protect heritage from around the world that is of such outstanding universal value that its conservation is important for current and future generations (DoEE, 2017g).

There are no World Heritage Sites within the project's EMBA, with the nearest marine site being 'The Ningaloo Coast' in WA (1,750 km to the southwest of the project) (DoEE, 2017g).

4.4.4 National Heritage Places

The National Heritage List is Australia's list of natural, historic and Indigenous places of outstanding significance to the nation. Australia's national heritage comprises exceptional natural and cultural places that contribute to Australia's national identity. It also encompasses those places that reveal the richness of Australia's extraordinarily diverse natural heritage (DoEE, 2017h).

There are no National Heritage Places within the project's EMBA, with the nearest marine National Heritage Place being the Dampier Archipelago in WA (1,460 km to the southwest of the project) (DoEE, 2017h).

4.4.5 Wetlands of International Importance

The Convention on Wetlands of International Importance (the Ramsar Convention) was signed in Ramsar, Iran on 2 February 1971. The Ramsar Convention aims to halt the worldwide loss of wetlands and to conserve, through wise use and management, those that remain. The Convention encourages member countries to nominate sites containing representative, rare or unique wetlands, or that are important for conserving biological diversity, to the List of Wetlands of International Importance (Ramsar List). Australia was one of the first countries to become a Contracting Party to the Convention in 1974.

The Ashmore Reef National Nature Reserve is the only Ramsar wetland occurring within the project's EMBA (DoEE, 2017i). Ashmore Reef is described in Section 4.4.1. A summary of the ecological character of the Ashmore Reef Ramsar wetland is outlined in Table 4.8. The boundary of the Ashmore Reef Ramsar site matches that of the Ashmore Reef CMR.

Table 4.8. Summary of the ecological character of the Ashmore Reef Ramsar-listed wetland

Component/process	Description
Supporting components and processes	
Climate	• Arid tropical monsoonal climate. • Located outside the main belt of tropical cyclones in the Timor Sea.
Geomorphic setting	• Located in an area of high oil and gas reserves, with active hydrocarbon seeps. • Geomorphic groups within the site include reef slope, reef crest, reef flat, back reef sands, lagoons and islands.
Tides and currents	• Strong seasonal influences of the Indonesian Through flow and Holloway currents. • Internal waves are a feature of the region and Ashmore Reef Ramsar site may act to break these resulting in increased nutrients from bottom waters. • High-energy environment with spring tides over 4.5 metres and large flushing on tidal cycles.
Water quality	• Seasonal variations in temperature and salinity in ocean and lagoon water. • Water clarity, turbidity and other water quality parameters remain a knowledge gap.
Vegetation	• Five species of seagrass recorded with *Thalassia hemprichii* dominant, comprising over 85% of total cover. • Total cover of 470 hectares, but much of this is sparse and there is only 220 hectares with a mean cover of greater than 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.
Critical components and processes	
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. • Total coral cover was low around the time of listing following the 1998 bleaching event, but recovered to baseline levels. • Over 600 species of mollusc, including two endemic species.

Component/process	Description
	• Over 180 species of echinoderm, including 18 species of sea cucumber. • Sea cucumber density is highly variable, but on average exceeds 30/ha. • 99 species of decapod crustacean.
Fish	• Over 750 species of fish, including five species of fish and three species of threatened shark. • Predominantly shallow water, benthic taxa that are common throughout the Indo-Pacific. • Density of small reef fishes is around 20,000 to 40,000/ha. • Low density of sharks (less than one per hectare).
Seasnakes	• Prior to listing there was a high diversity and population, peaking in 1998 with an estimated total population of 40,000 snakes in the site. • By the time of listing in 2002, the site was on a trajectory of decline and diversity and abundance was low.
Turtles	• Three species of marine turtle: green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and loggerhead (*Caretta caretta*), all of which are 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 bird recorded within the Ramsar site. • 47 species listed under international migratory agreements. • Average of around 48,000 seabirds and shorebirds annually. • Six species are regularly recorded in numbers greater than one per cent of the population. • Nesting of 20 species, 14 of which regularly breed in the site.
Dugong	• Small but significant population, that may breed within the site. • Data deficient.

Source: Hale & Butcher (2013).

4.4.6 State Protected Areas

There are no state marine parks intersected by the EMBA.

4.5 Cultural Heritage

4.5.1 Aboriginal Archaeological Heritage

Given its remote offshore and deep-water location, the activity area and EMBA does not have known sites of Aboriginal archaeological heritage. Such sites are restricted to nearshore areas of the mainland.

4.5.2 European Archaeological Heritage

There are no known sites of European cultural or heritage significance within the EMBA. The islands of several oceanic reef systems, namely Ashmore Reef and Cartier Island do contain Indonesia artefacts (ceramics and graves) within the protected reserve areas.

There are no listed historic and other shipwrecks or heritage sites within the activity area, however, the National Shipwreck Database lists three shipwrecks as occurring within the EMBA, as listed in Table 4.9 (DoEE, 2017k). There are no historic shipwreck protected zones (exclusion zones established to protect fragile or sensitive shipwrecks) in the EMBA.

Table 4.9. Historic shipwrecks in the EMBA

Vessel name	Year wrecked	Location	Latitude	Longitude
Ann Millicent	1888	Cartier Island	-12.54	123.54
*Enchantress**	1874	New Island, Brecknock Harbour, Boneparte Archipelago	Not listed	Not listed
Voladora	1926	Jones Island	Not listed	Not listed

** Geographic coordinates not available on the Australian National Shipwreck Database.*

4.6 Socio-economic Environment

The project and project EMBA are located in a remote part of the Timor Sea. The description of the socio-economic environment of the project reflects this remoteness.

4.6.1 Settlements

The nearest settlement on the Australian mainland to the project EMBA is Darwin. Darwin is the capital city of the Northern Territory, with a population of 142,258 (2015 data). The largest number of businesses in Darwin are associated with construction, real estate services, professional, scientific and technical services, followed by 'other services' (ABS, 2017).

The Australian coastline south of the project EMBA is extremely remote, with the few settlements present being Aboriginal communities (e.g., Wadeye), or those related to maintaining mining or petroleum infrastructure (such as the Blacktip gas plant) or associated infrastructure (such as the Truscott airbase).

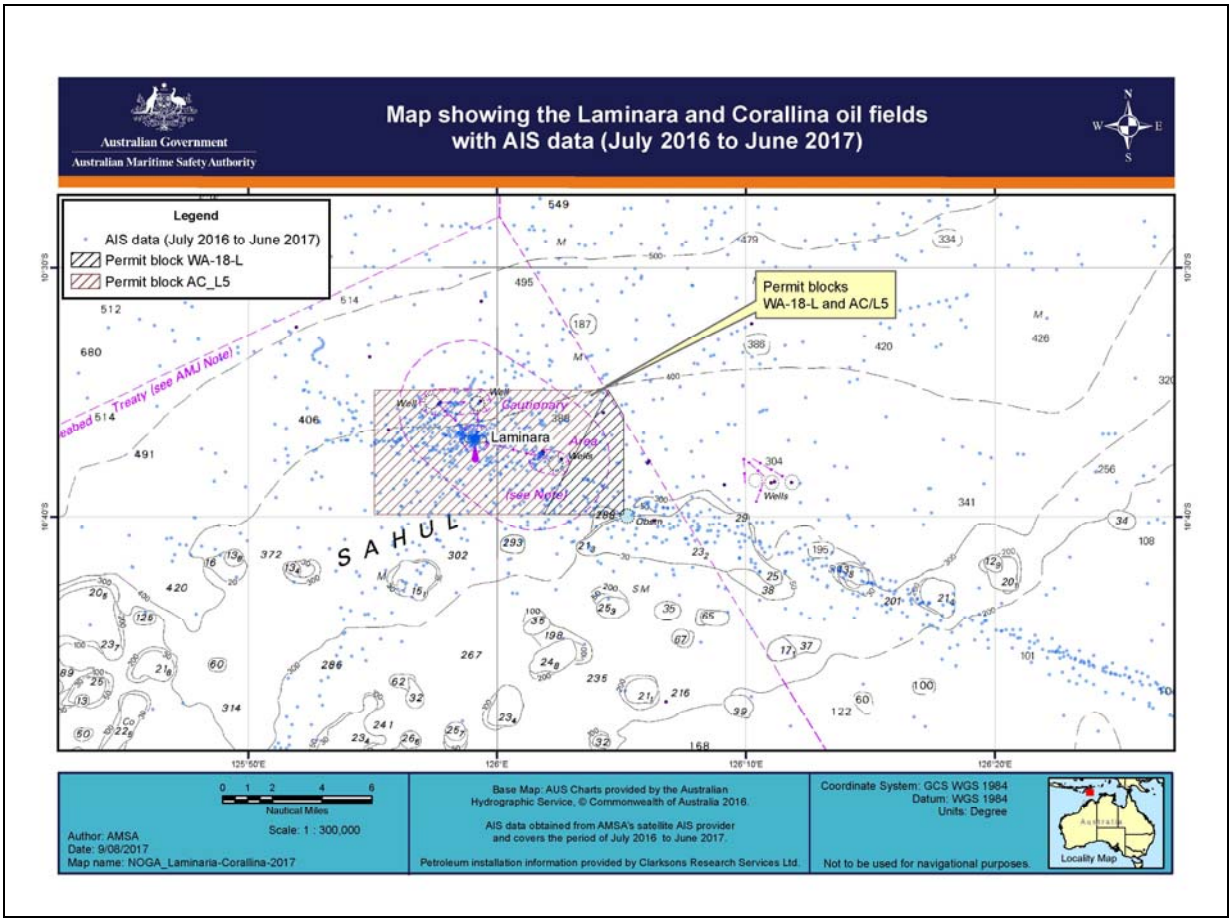
4.6.2 Shipping

The Timor Sea region supports commercial shipping activity, the majority of which is associated with support vessel activity for the oil and gas industry, including the NE FPSO facility (Figure 4.21). Major shipping routes in the area are associated with entry to the ports of Darwin, Port Hedland and Dampier.

Shipping activities in the region include:

- International bulk freighters/tankers arriving and departing from Dampier, Port Hedland and Darwin, including mineral ore, hydrocarbons (LNG, liquefied petroleum gas, condensate) and salt carriers;
- Domestic support/supply vessels servicing offshore facilities;
- Construction vessels/barges/dredges; and
- Offshore support vessels.

AMSA has introduced a network of commercial shipping fairways on the North West Shelf in order to reduce the risk of vessel collisions with offshore infrastructure. The fairways are not mandatory, but AMSA strongly recommends commercial vessels remain within the fairway when transiting the region. The activity area is distant from these fairways.



Source: AMSA (2017).

Figure 4.21. Vessel density map for the activity area for June 2016–June 2017

4.6.3 Traditional Fishing

Fisheries under Indonesian jurisdiction in the vicinity of the activity area are not actively managed. Regular observations of Indonesian and East Timorese line fishing vessels are made from the NE FPSO. Sharks are presumed to be the major target species, however, tuna, mackerel and possibly reef fish from the shoals may also be targeted.

Indonesian fishers have sailed to and actively fished Australia's northern shore for more than three centuries, targeting trepang (sea cucumber), shark fin and other marine resources such as trochus shells. During the last 30 years, access to Australian waters has been restricted and an area designated for Indonesian fishers to fish was established in 1974. The 'MoU 74' was agreed between the Australian and Indonesian governments and permits fishing by traditional methods and is located on the northwest continental shelf, including the emergent reefs and associated cays/islands of Ashmore Reef, Cartier Island, Seringapatam, Scott Reef and Browse Island. Traditional Indonesian fishers continue to regularly visit Ashmore Reef reserve for fresh water, shelter and to visit grave sites (CoA, 2002).

The MoU 74 came into effect in 1975, and later restrictions to fishing activities were made with the designation of Ashmore Reef and Cartier Island as nature reserves (1989) and the definition of the traditional nature of the fishing activities (including the prohibition of motorised vessels) in 1988. Given the changes to the original MoU 74 and nature of the target, emergent reefs, Scott Reef is the principal reef to which Indonesian fishers regularly sail on a seasonal basis. The majority of Indonesian fishers travel to Scott Reef from the islands of Roti (near West Timor) and Tonduk and Rass (in East Java) during July to October. Studies carried out by Woodside in partnership with the Australian National University tracked the fishers and

their fishing patterns at Scott Reef over 2007 and 2008. Target marine resources fished were shallow water lagoon trepan and trochus shells, and some finfish taken primarily for consumption. Estimates of the monetary value of the resources gathered were as much as 50% of the fishers' total annual income and hence the fishing trips to Scott Reef are a major source of income (Woodside, 2011).

Indonesian fishers may travel through the activity area en route to the MoU74 area.

4.6.4 Recreational Fishing

No tourism activities are known to take place in or around the activity area given its remote offshore and deep-water location.

Recreational fishing generally tends to be concentrated in state waters adjacent to coastal population areas (DEWHA, 2008). Commercial tour operators and recreational fishing charters visit the Ashmore Reef and Cartier Island areas intermittently, primarily for scuba diving and bird watching and game fishing.

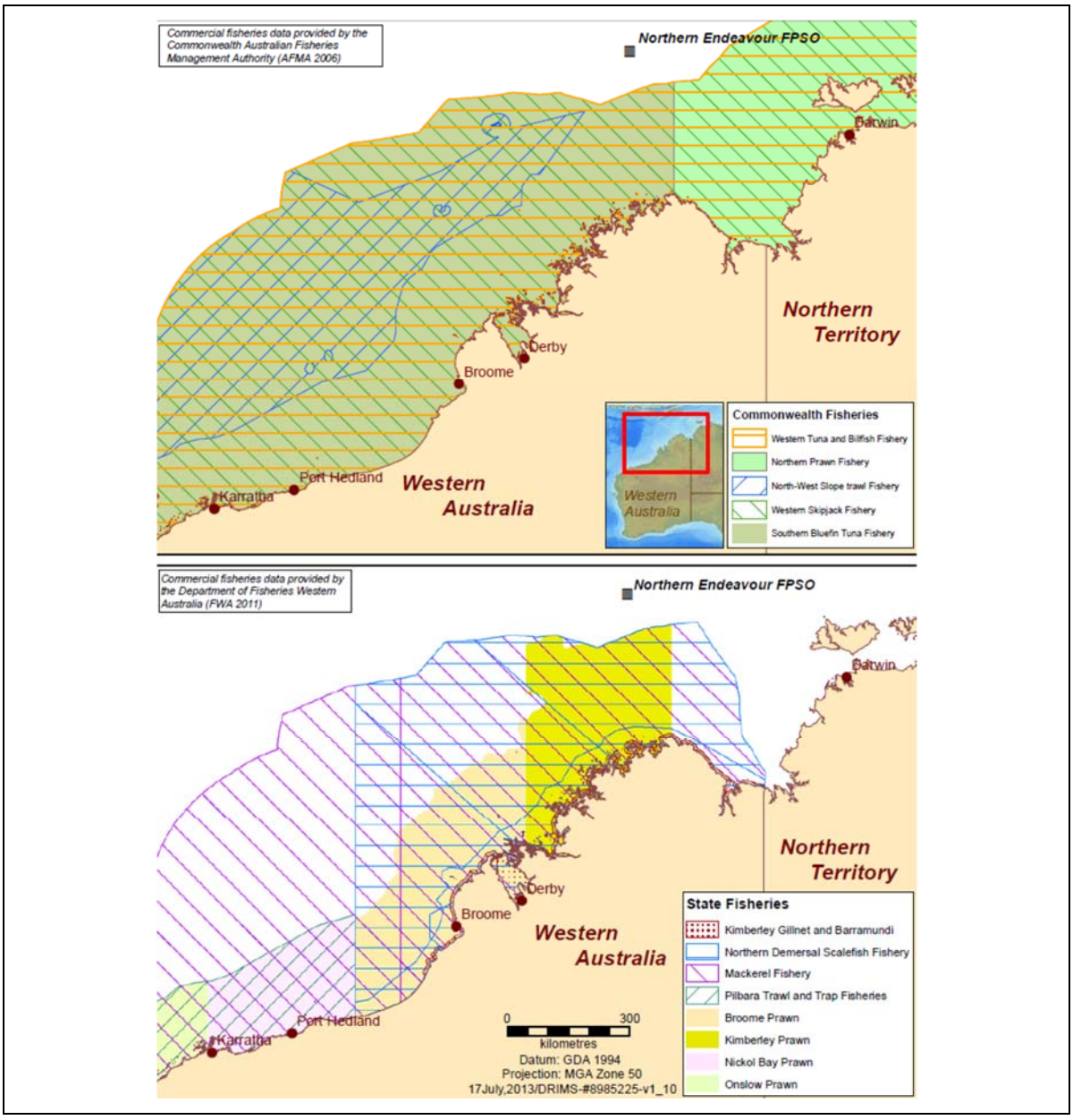
4.6.5 Commercial Fishing

The activity area is located outside the limit of the Australian Fishing Zone (AFZ) and adjacent to a number of Commonwealth- and State-managed fishery areas.

Figure 4.22 provides a general indication of the jurisdiction of the fishing grounds for the Commonwealth and State fisheries in relation to the activity area (using the NE FPSO as the reference point). These fisheries are described in further detail in this section.

Commonwealth-managed fisheries include all commercial fisheries operating within the AFZ, which extends 200 nm from the mainland coast. The project is located in an offshore area outside the AFZ.

Commonwealth and state fisheries with jurisdiction to fish the waters of the EMBA are described in Table 4.10.



Source: AFMA (2011), DoF (2011).

Figure 4.22. North Western Commonwealth (top) and State (bottom) Fisheries in relation to the NE FPSO Operational Area

Table 4.10. Summary of Commonwealth and State-managed fisheries with jurisdiction to fish within the EMBA

Fishery	Target species	Geographic extent of fishery	Does fishing activity intersect project area or diesel spill EMBA?	Fishing season	Fishing method	Catch data and economic value
Commonwealth						
North West Slope Trawl	Predominantly Australian scampi (*Metanephrops australiensis*), with smaller quantities of velvet scampi (*M. velutinus*) and Boschma's scampi (*M. boscmai*).	Operates off north-western Australia from 114°E to 125°E, roughly between the 200 m isobath and the outer boundary of the AFZ. A large area of the Australia–Indonesia MOU Box (see Section 5.6.3) falls within the fishery (Figure 5.25).	**Project area – No** based on 2015 fishing intensity data. The north western-most area of the fishery, closest to the project area, is subject to a partial closure. **Hydrocarbon spill EMBA – Yes** based on 2014-15 fishing intensity data.	12-month season, beginning 1st July.	Demersal trawl gear is used over soft, muddy sediments or sandy habitats, typically at depths of 350 to 600 m.	Only one vessel has been active since 2012-13. Catch of 33.4 tonnes in 2014-15 and 33.3 tonnes in 2013-14, with the value reported as confidential.
Western Tuna and Billfish	Swordfish (*Xiphias gladius*) is the key target species, with bigeye tuna (*Thunnus obesus*), yellowfin tuna (*T. albacares*), striped marlin (*Tetrapturus audax*) and some albacore (*Thunnus alalunga*) taken.	Operates in the Exclusive Economic Zone (EEZ) and high seas of the Indian Ocean (Figure 5.26). Most effort is concentrated south of the North West Cape in WA.	**Project area – No** based on 2015 fishing intensity data. **Hydrocarbon spill EMBA – No** based on 2015 fishing intensity data.	12-month season, beginning 1st February.	Mostly pelagic longline, with some minor-line fishing also employed.	Since 2005, fewer than 5 vessels have been active in the fishery each year. 440 tonnes caught in 2015 and 361 tonnes caught in 2014, with the value reported as confidential.
Skipjack Tuna - Western	Indian Ocean skipjack tuna (*Katsuwonus pelamis*).	Most effort concentrated south of the North West Cape in WA.	**Project area – No**, no fishing since the 2008-09 season. **Hydrocarbon spill EMBA – No**, no fishing since the 2008-09 season.	Not currently active.	Predominantly purse seine (98% of the catch). The remainder is pole-and-line.	No fishing effort since the 2008-09 season.

Fishery	Target species	Geographic extent of fishery	Does fishing activity intersect project area or diesel spill EMBA?	Fishing season	Fishing method	Catch data and economic value
Southern Bluefin Tuna	Southern bluefin tuna (*Thunnus maccoyii*).	Most effort concentrated Great Australian Bight and northeast of Eden in NSW (Figure 5.27). The northeast Indian Ocean is a spawning ground for the species.	**Project area – No**, based on 2015 fishing intensity data. **Hydrocarbon spill EMBA – No**, based on 2015 fishing intensity data (but spawning grounds intersected).	12-month season, beginning 1st December.	Predominantly purse seine. Key landing port is Port Lincoln, SA.	5,519 tonnes caught in 2014-15, valued at $36.8 million. 5,420 tonnes caught in 2013-14, valued at $40.1 million.
Northern Prawn	White banana prawn (*Fenneropenaeus merguiensis*), red-legged banana prawn (*F. indicus*). The highest catches are taken offshore from mangrove forests, which are the juvenile nursery areas. Tiger prawns (*Penaeus esculentus* and *P. semisulcatus*).	White banana prawn is mainly caught during the day on the eastern side of the Gulf of Carpentaria. Red-legged banana prawn is mainly caught in Joseph Bonaparte Gulf (Figure 5.28). Tiger prawns are primarily taken at night.	**Project area – No**, based on 2015 fishing intensity data. **Hydrocarbon spill EMBA – No**, based on 2015 fishing intensity data.	6-12 week season for banana prawn starting in April. Tiger prawns fished from August to November.	Otter trawl gear, the fishery	In the 2013, 2014 and 2015 fishing seasons, 52 vessels operated in this fishery. The 2015 catch was 7,825 tonnes valued at $106.8 million, and in 2014 it was 8,707 tonnes valued at $117.2 tonnes.
State						
Mackeral (Area 1: Kimberley Sector)	Spanish mackerel (*Scomberomorus commerson*), with some grey mackerel (*S. semifasciatus*).	Extends from Geraldton to the WA/NT border. Most catch effort is recorded north of Geraldton, along the Kimberley and Pilbara coasts Figure 5.29). Project area is adjacent to Area 1 - Kimberley	**Project area – No** based on advice from WAFIC. **Hydrocarbon spill EMBA – Yes** based on FRDC data.	Unknown.	Near-surface trawling gear and handlines from small vessels in coastal areas around reefs, shoals and headlands.	Area 1 has a total allowable commercial catch (TACC) of 205 t for Spanish and other mackerel, and 60 tonnes for grey mackerel. 322 tonnes of Spanish mackerel

Fishery	Target species	Geographic extent of fishery	Does fishing activity intersect project area or diesel spill EMBA?	Fishing season	Fishing method	Catch data and economic value
		(121º E to WA/NT border).				and 3.5 tonnes of grey mackerel were landed in 2014 across all three areas, with three vessels operating in the Kimberley sector. The value of the fishery is not reported.
North Coast Demersal Scalefish (Kimberley Sector)	Goldband snapper (*Pristipomoides multidens*), red emperor (*Lutjanus sebae*) are the key species. Others include crimson snapper (*Lutjanus erythropterus*), bluespotted emperor (*Lethrinus punctulatus*), saddletail snapper (*Lutjanus malabaricus*), brownstripe snapper (*Lutjanus vitta*), Rankin cod (*Epinephelus multinotatus*), rosy threadfin bream (*Nemipterus furcosus*) and	The Kimberley sector operates in WA waters extending out to the AFZ east of 120ºE (Figure 5.30). Inshore fishing zone (Area 1) and Offshore fishing zone (Area 2), with the latter being further sub-divided into zones A, B and C (the northern areas of these zones are closest to the project area, more than 80 km away).	**Project area – No** based on advice from WAFIC. **Hydrocarbon spill EMBA – No** based on advice from WAFIC but **yes** based on FRDC data.	Each licence can nominate a five-month block period of the year.	Handline, dropline and fish traps, but has been primarily trap-based since 2002.	Over the last six years, annual catches have exceeded 1,000 tonnes. Eight vessels operated in the fishery during the 2014 fishing season, with a catch of 1,111 tonnes and an estimated value to fishers of $5-10 million.

Fishery	Target species	Geographic extent of fishery	Does fishing activity intersect project area or diesel spill EMBA?	Fishing season	Fishing method	Catch data and economic value
	spangled emperor (*Lethrinus nebulosus*).					
Northern Prawn Managed (Kimberley sector)	Mainly banana prawns (*Penaeus merguiensis*), with some catches of tiger prawn (*P. esculentus*), endeavour prawn (*Metapenaeus endeavouri*) and western king prawn (*P. latisulcatus*).	Boundaries of the Kimberley sector are all WA waters of the Indian Ocean lying east of 123º 45' E and west of 126º 58' E, abutting the western boundary of the Commonwealth-managed Northern Prawn Fishery (Figure 5.31). This is located more than 80 km from the project area.	**Project area – No** based on advice from WAFIC. **Hydrocarbon spill EMBA – No** based on advice from WAFIC and FRDC data.	Unknown. May be the same or similar to the AFMA-managed northern prawn fishery.	Trawling activities using otter trawl nets occur in coastal areas around islands, headlands and outer bay areas along the Kimberley coast.	121 vessels licenced to operate in the fishery (Fletcher & Santoro, 2015). Only nine boats operated in the fishery during the 2014 fishing season

Patterson *et al (2016), Fletcher et al (2017), FRDC (2017). AFMA (2017).*

4.6.6 Petroleum Production

The activity area is located within an area of established oil and gas operations. Table 4.11 details petroleum facilities located in proximity to the NE FPSO Operational Area.

Table 4.11. Petroleum facilities in the EMBA

Facility	Distance from project
Kitan field (operated by Eni), ceased production in December 2015.	~ 20 km east
Bayu-Undan field (operated by ConocoPhillips), consists of a central production and processing (CPP) complex comprising production wells, subsea infrastructure, two platforms, a FPSO and an un-manned wellhead platform 7 km east of the CPP, with a 500-km, 26-inch diameter pipeline to Darwin for processing at an onshore LNG facility. The field has been in production since 2006.	~ 85 km southeast
Montara field (operated by PTTEP) consists of production wells, subsea infrastructure, an un-manned wellhead platform and FPSO. Production commenced in mid-2013.	~ 280 km southwest

4.6.7 Defence

Illegal fishing, prohibited imports and exports, quarantine threats and illegal activity in protected areas make the northern region of Australia a key area for border protection activities.

The Headquarters Northern Command is the military element of Border Protection Command, and is located in Darwin. It coordinates and controls military operations in Australia's north. Military exercises are undertaken in large areas of the coastal waters adjacent to the NT, on the eastern side of the Bonaparte Gulf (DEWHA, 2008a;b). Defence activities do not extend to the project area or the EMBA.

5 Impact and Risk Assessment Methodology

This section describes the environmental impact and risk assessment methodology employed for the proposed Laminaria-5 reinstatement project.

5.1 Risk Assessment Approach

Effective risk management is vital to delivering NOGA's objectives, success and continued growth. NOGA is committed to managing all impacts and risk in a proactive and effective manner. NOGA's risk management process is detailed in its Hazard Identification and Risk Management Procedure (00-HSE-PC01) and adopts a risk management methodology consistent with the AS/ISO 31000:2009 (Risk Management Principles).

The risk management methodology provides a framework to demonstrate:

- The identified risks and impacts are reduced to ALARP, which meets the requirements of Regulation 10A(b) of the OPGGS(E); and
- The acceptability of risks and impacts, which meets the requirements of Regulation 10A(c) of the OPGGS(E).

5.2 Risk Management Process

The key steps of the NOGA risk management framework are shown in Figure 5.1. A description of each step and how it is applied to NOGA's offshore activities is provided in this section.

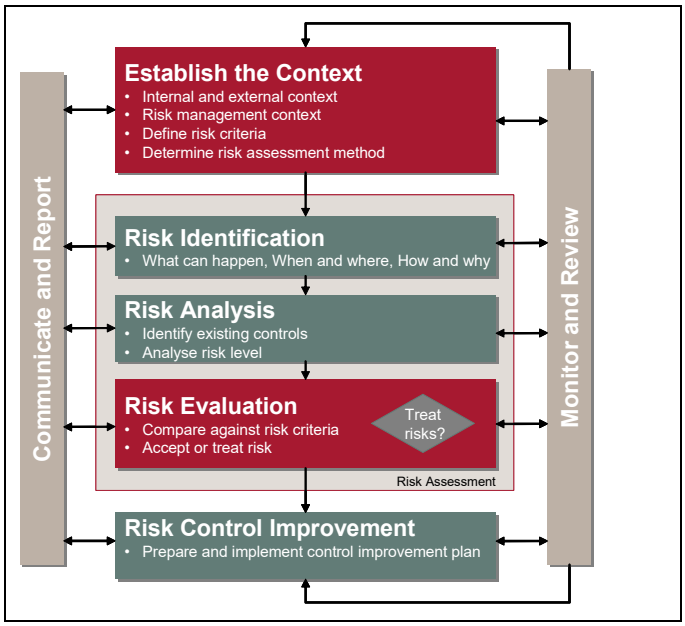


Figure 5.1. NOGA's risk management framework

5.2.1 Risk Identification

The objective of a risk assessment is to assess identified risks and apply appropriate control measures to eliminate, control or mitigate the risk to ALARP and to determine if the risk is acceptable.

An environmental risk assessment workshop was conducted by NOGA and AGR on the 5th of July 2017 to identify environmental impacts and risks associated with the project.

5.2.2 Risk Analysis

The EP details and evaluate the environmental impacts and risks for an activity, including control measures used to reduce the impacts and risks of the activity to ALARP and an acceptable level.

The key process used for analysing impact and risk is to determine the likelihood and the consequence of the event occurring, as detailed herein.

Determining Consequence

In accordance with ISO31000:2009, NOGA defines 'consequence' as:

The outcome of an event affecting objectives. Consequence can be certain or uncertain, can have positive or negative effects on objectives and can be expressed qualitatively or quantitatively.

Inherent consequence is determined based on the assumption that some controls have failed. Where more than one impact applies (i.e., environmental and legal/compliance), the consequence level for the highest severity impact is selected. Consequence descriptions are provided in Table 6.2 over page. The residual consequence is determined based on the assumption that all controls work effectively.

Determining Likelihood

In accordance with ISO31000:2009, NOGA defines 'consequence' as:

The chance of something happening.

Likelihood is determined from the description in Table 5.3 that best fits the chance of the selected likelihood occurring, assuming reasonable effectiveness of the control measures. So, likelihood is not the chance of the hazard occurring, but rather the likelihood of the consequence materialising.

Table 5.3. NOGA likelihood categories

Rating	Description
Remote	Theoretically possible but not occurred yet in industry.
Highly unlikely	Has occurred once or twice in industry.
Unlikely	Has occurred many times in industry but not in NOGA.
Possible	Has occurred previously at NOGA or on NOGA project.
Likely	Could occur in most circumstances. Happens at least once a year.
Very likely	Expected to occur in most circumstances. Multiple occurrences in a year.

Table 5.2. NOGA consequence categories

Category	Negligible	Minor	Moderate	Major	Severe	Catastrophic
Health and safety	First aid treatment.	Medical treatment.	Alternative duties/ restricted work.	Lost time injury – partial disability.	Single fatality/permanent disability.	Multiple fatalities.
Environment	Slight and temporary <1 year – localised effect on ecosystem, species or habitat.	Minor, short-term (1 to 2 years) impacts, but not affecting ecosystem or function.	Moderate, medium-term (2 to 5 years) impacts, but not affecting ecosystem function.	Major long-term (5 to 10 years) impact on ecosystems, species or habitat.	Serious long-term (>10 years) impact on highly valued ecosystems species or habitat.	Permanent impact on highly valued ecosystems or habitat.
Social/ cultural	Minor, temporary impact to a community or areas/items of cultural significance.	Minor short-term (<5 years) impact to a community or areas/items of cultural significance.	Moderate, medium-term (5 to 10 years) impact to a community or highly valued areas/assets/items of cultural significance.	Major long-term (10 years) impact to a community or social infrastructure or highly valued areas/items of cultural significance.	Serious, long-term (>10 years) impact to the community, social infrastructure or highly valued areas /items of significance.	Permanent long-term impact to a community or social infrastructure or highly valued areas/items of international cultural significance.
Financial/ asset	Less than $1M.	Loss from $1-$2M.	Loss from $2M to $10M.	Loss from $10M to $20M.	Loss from $20M to $50M.	Loss >$50M.

5.2.3 Identification of Control Measures

Identification of control measures that can be used to prevent, minimise, mitigate or manage the effects of the environmental impact or risk were discussed during the risk workshop, and are generally based on the experience of the personnel attending the workshop who have specialised knowledge of the legislative requirements and industry guidelines associated with the hazards and the practical experience of working offshore.

5.2.4 Risk Rating

A risk rating process is undertaken to assign a level of risk to each impact or risk, measured in terms of consequence and likelihood. The assigned risk level is the residual risk (i.e., risk with controls in place). The risk ratings are assigned through reference to the NOGA risk matrix.

Recognising that the OPGGS(E) recognise environmental impacts and risks differ from each other, NOGA defines each as follows:

- **Impacts** result from activities that are an inherent part of the activity and will result in a change to the environment or a component of the environment, whether adverse or beneficial. For example, treated sewage discharges from the MODU will occur and will create impacts for the marine environment and cannot be avoided for the activity to achieve its aims.
    - For planned events therefore, only a consequence level is assigned, based on the knowledge and experience of the project team. An ‘inherent’ consequence is determined based on the assumption that some controls fail. A ‘residual’ consequence is determined based on the assumption that all controls function as required.
- **Risks** result from activities where a change to the environment or component of the environment may occur as a result of an event associated with the activity (i.e., there may be impacts if the event actually occurs). Risk is a combination of the consequences of an event and the associated likelihood of the event occurring. For example, a hydrocarbon spill may occur if the MODU’s fuel tank is punctured by a collision. The risk of this event is determined by assessing the consequence of the impact (using factors such as the type and volume of fuel and the nature of the receiving environment) and the likelihood of this event happening (which may be determined qualitatively or quantitatively).
    - For unplanned events therefore, the risk rating is based on ‘multiplying’ consequence by likelihood. The recommended form of action for each risk level if provided in Table 5.4. An ‘inherent’ risk rating is determined based on the assumption that some controls fail. A ‘residual’ risk rating is determined based on the assumption that all controls function as required.

Table 5.4. NOGA's risk rating matrix

	Consequence					
Likelihood	Negligible	Minor	Moderate	Major	Severe	Catastrophic
Very likely						
Likely						
Possible						
Unlikely						
Highly unlikely						
Remote						

Low	Broadly acceptable. Activity can proceed under normal site supervision with standard task risk assessment processes and site operating procedures.
Medium	Risk reduction measure to be included in the continuous improvement process. Site supervisors may approve activities in this band.
High	Risk reduction measures to be implemented as a matter of urgency. NOGA Senior Management must approve activities in this band.
Severe	Unacceptable. Immediate action required; operations to cease immediately until activity has been re-planned and risk has been reduced to ALARP and NOGA Management has approved. Short-term reduction to reduce the risk level to be put in place immediately, individual removed from the exposure. Identify additional or alternative permanent risk reduction measure to be implemented as a matter of high priority.

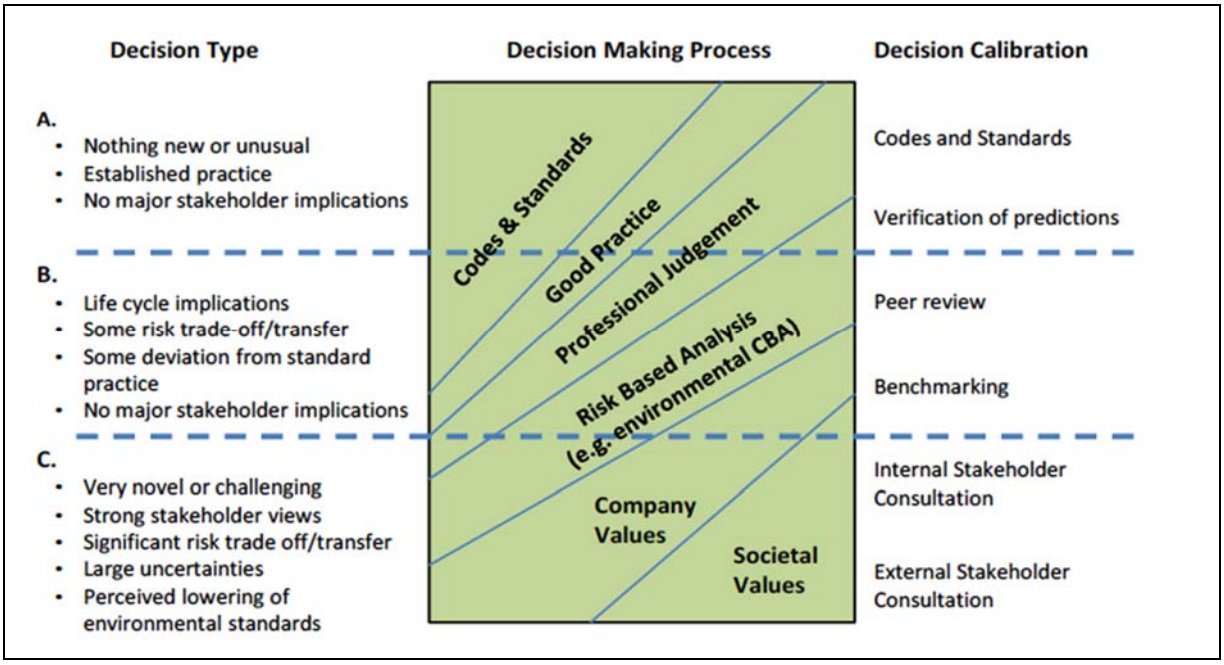
5.3 Risk Evaluation

To support the risk assessment process, the *Industry Guidelines on a Framework for Risk Related Decision Support* (UKOOA, 1999) was applied during the environmental risk assessment workshop to determine the level of supporting evidence that may be required to draw sound conclusions regarding risk level and whether the risk is acceptable and ALARP. This is to ensure:

- Activities do not pose an unacceptable environmental risk;
- Appropriate focus is placed on activities where the risk is anticipated to be tolerable and demonstrated to be ALARP; and
- Appropriate effort is applied to the management of risks based on the uncertainty of the risk, the complexity and risk rating.

The framework, as outlined in Figure 5.2, provides appropriate tools, commensurate to the level of uncertainty or novelty associated with the risk (referred to as the decision type A, B or C). The decision type is selected based on an informed discussion around the uncertainty of the risk, and it is agreed by the risk assessment workshop participants and documented in the Environmental Risk Register.

This framework enables personnel to appropriately understand a risk, determine if the risk can be demonstrated to be ALARP and acceptable, as discussed in this section.



Source: UKOOA (1999).

Figure 5.2. Risk-related decision support framework

5.3.1 Demonstrating ALARP

The ALARP Principle states that it must be possible to demonstrate that the cost involved in reducing the risk further would be grossly disproportionate to the benefit gained. The ALARP Principle arises from the fact that infinite time, effort and money could be spent attempting to reduce a risk or impact to zero.

NOPSEMA's Guideline on EP Decision-making (GL1721, Rev 3, May 2017) states that in order to demonstrate ALARP, a titleholder must implement all available control measures where the cost is not grossly disproportionate to the environmental benefit gained from implementing the control measures. There is no universally accepted guidance to applying the ALARP principle to environmental assessments. For this EP, the guidance provided in NOPSEMA's Guideline has been applied, and augmented where deemed necessary.

6 Environmental Impact and Risk Assessment

This chapter presents the impact and risk assessment for the environmental impacts and risks identified for proposed project using the methodology described in Chapter 5. A summary of the impact and risk ratings for each hazard identified and assessed in this chapter is presented in Table 6.1.

Table 6.1. Laminaria-5 reinstatement project impact and risk ranking summary

#	Known hazards (impacts)	Consequence
1	Seabed disturbance	Minor
2	Discharge of weighted brine	Minor
3	Atmospheric emissions	Minor
4	Artificial light emissions	Minor
5	Discharge of treated sewage and grey water	Minor
6	Discharge of cooling and desalination brine water	Minor
7	Discharge of putrescible waste	Minor
8	Discharge of oily water	Minor
#	Potential hazards (risks)	Risk rating
9	Accidental disposal of hazardous and non-hazardous waste overboard	Low
10	Introduction and establishment of IMS	Medium
11	Displacement of or interference with other marine users	Medium
12	Liquid hydrocarbon dropout from flaring	Low
13	Diesel spill from MODU	Medium
14	Spill of bulk hydrocarbons and chemicals	Low
15	Loss of well containment	Medium

6.1 Known Hazards (Impact Assessment)

This section presents the Environmental Impact Assessment (EIA) for the known hazards associated with the Laminaria-5 reinstatement project. As detailed in Section 5.2.4, only consequence is assigned to these impacts; likelihood is not included.

6.1.1 Seabed Disturbance

Hazard

The following activities will result in seabed disturbance:

- MODU anchoring – eight anchors will be deployed into the seabed to keep the MODU in position. Some anchor chain drag may also occur. The anchors are only in place for the duration of the activity.
- Wellhead reinstatement works – localised disturbance created by activity at the wellhead.

- Temporary storage of equipment – subsea tooling basket (measuring 4 m x 4 m) may need to be temporarily stored on the seabed during HFL replacements.

Evaluation of Environmental Impacts

The area of benthic habitat that will be disturbed is limited to that occupied by the anchors, reinstatement works and temporary storage of a tooling basket.

There are no known sensitive seabed features in the project area. Surveys of seabed disturbance created by MODUs, such as anchoring and spud can depressions, indicate that recovery of benthic fauna in soft sediment substrates (such as those in the project area), occurs between 6-12 months after disturbance (URS, 2001). In deepwater environments such as that of the project area, this may take longer, and is dependent on the degree of disturbance of sediments and habitat characteristics. Depressions in the seabed will act as traps for marine detritus and sand, which will quickly fill and be re-colonised by benthic organisms (Currie and Isaac, 2004).

The area that will be disturbed is very small compared with the overall extent of the equivalent seabed habitat in the region and consequently, there will be no long-term impacts to the diversity and abundance of benthic fauna, with impacts being extremely localised.

Controls

- The MODU Barge Master will ensure that anchors are secured to the seabed in line with the MODU Mooring Procedure.
- The MODU Barge Master monitors the MODU anchor tensioning at regular intervals to ensure it is within tolerances specified in the mooring procedure so that the MODU remains securely anchored without excessive dragging.
- Anchors will be installed and proof loaded in accordance with the mooring analysis, which includes rating for cyclonic weather events.
- Anchor Survival tensions are applied by the winches and measured by the load cells on the winch prior to de-manning in order to allow rig to weather vane around the survival location and prevent anchor drag.

The impact consequence for seabed disturbance is assessed as ‘negligible.’

6.1.2 Discharge of Weighted Brine

Hazard

A potassium chloride (KCl)-based brine will be used for the activity (see Section 3.6.2). Brine returned to the MODU via the dual bore riser will be discharged overboard. Brine contains a high percentage of salts and dissolved minerals.

Known and Potential Environmental Impacts

The known and potential environmental impacts of the discharge of weighted brine are:

- Temporary and localised increase in sea surface salinity and turbidity.

The key receptors in the EMBA are plankton and pelagic fish species.

Evaluation of Environmental Impacts

Once discharged above the waterline, the brine will sink through the water column where it will be rapidly mixed with receiving waters, and dispersed by ocean currents. Potassium chloride is a natural component of seawater and is highly soluble and readily dispersed.

Controls

- Only 'D'/'E' (non-CHARM) or 'Gold'/'Silver' (CHARM) OCNS-rated chemicals are used in the brine system in order to minimise ecotoxicity impacts to fauna.
- A fluid scrubber will strip hydrocarbons from the brine (to <15 ppm) prior to re-use or recharge.

The impact consequence for the discharge of weighted brine is assessed as 'negligible.'

6.1.3 Atmospheric Emissions

Hazard

The use of fuel (specifically MDO) to power engines, generators and mobile and fixed plant (e.g., ROV, crane) will result in gaseous emissions of greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), along with non-GHG such as sulphur oxides (SOx) and nitrous oxides (NOx). Combustion emissions will be expelled from exhaust stacks several metres above deck level to ensure adequate aerial dispersion.

The annulus of Laminaria-5 is filled with approximately 3,100 Sm^3 of lift gas. If this gas leaks during the reinstatement activity, it will last for about 30 seconds (assuming a full bore diameter of 4¾"). A leak through a 1" hole would last for about 10 minutes.

Known and Potential Environmental Impacts

The known and potential environmental impacts of atmospheric emissions are:

- Localised and temporary decrease in air quality due to particulate matter from diesel combustion; and
- Contribution to the global GHG effect.

Evaluation of Environmental Impacts

There will be a localised and temporary decrease in air quality from diesel combustion.

Controls

- Only low-sulphur (<3.5% m/m) marine-grade diesel will be used in order to minimise SOx emissions.
- All combustion equipment is maintained in accordance with the MODU's Planned Maintenance System (PMS) (or equivalent).
- MODU fuel consumption is monitored and abnormally high consumption investigated.
- If incineration is undertaken, the incinerator has a valid IMO certificate in place.
- Personnel responsible for operation of the incinerator are trained.
- A high efficiency flare burner is used during flaring to minimise the likelihood of generating black smoke.
- Flaring is undertaken for the shortest possible duration while allowing for bleed-off objectives to be met.
- In accordance with the Surface Equipment Bleed Off Plan, the Third-Party Contractor Supervisor ensures pre-start checks are undertaken prior to the well test to ensure equipment will work efficiently and gas will rapidly disperse.

- Cold venting is undertaken in accordance with vendor procedures, including undertaking pre-start checks to ensure vented gas will rapidly disperse and that the volume of gas vented is recorded.
- The HVAC system is maintained in accordance with the PMS to ensure operation to design specifications.

The impact consequence for atmospheric emissions is assessed as 'negligible.'

6.1.4 Artificial Light Emissions

Hazard

Artificial light emissions will occur for the duration of the activity, resulting from:

- MODU operations – deck and navigational lighting, kept on 24 hours a day for maritime safety and crew safety purposes;
- ROV operations – underwater light when submerged to illuminate an area of interest (e.g., the wellhead); and
- Flaring.

Known and Potential Environmental Impacts

The known and potential environmental impacts of artificial lighting offshore are:

- Localised light glow that may act as an attractant to light-sensitive species (e.g., seabirds, squid, turtle hatchlings), in turn affecting predator-prey dynamics; and
- Attraction of light-sensitive species during breeding periods (e.g., turtle hatchlings).

Evaluation of Environmental Impacts

Seabirds may be attracted to the light glow. Bright lighting can disorientate birds, thereby increasing the likelihood of seabird injury or mortality through collision with infrastructure, or mortality from starvation due to disrupted foraging at sea (Wiese *et al*., 2001).

Studies conducted between 1992 and 2002 in the North Sea confirmed that artificial light was the reason that birds were attracted to and accumulated around illuminated offshore infrastructure (Marquenie *et al*., 2008) and that lighting can attract birds from large catchment areas (Wiese *et al*., 2001). The light may provide enhanced capability for seabirds to forage at night. There are no actions within the National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-16 (DSEWPaC, 2011b) that are compromised by light emissions from this project.

Light pollution along, or adjacent to, turtle nesting beaches poses a particular issue for turtles because it alters critical nocturnal behaviours, particularly the selection of nesting sites and the passage of adult females and emerging hatchlings from the beach to the sea (Limpus, 2009 in DSEWPaC, 2011a). The impacts of these changes include a decrease in nesting success, and beach avoidance by nesting females and disorientation, leading to increased mortality through predation. Turtle hatchlings are particularly sensitive to artificial light as they orientate towards light (typically the horizon / wave breaking zone) when emerging from the nest. Hatchlings attracted to artificial light as they emerge from a nest can result in disorientation and increased risk of predation.

Similarly, when hatchlings have successfully reached the ocean the attraction and congregation of hatchlings around offshore lights may increase predation from seabirds and sharks. Given that the nearest turtle nesting beaches are so distant (the project area is located 333 km to the north of Cartier Island and 346 km northeast of Ashmore Reef), lighting will not be an attractant for turtle hatchlings emerging from their nests as any light glow will be well over the horizon.

Controls

- To minimise light glow while ensuring the MODU is visible to third-party vessels, lighting is managed in line with the:
    - Vessel Safety Case.
    - AMSA Marine Orders Part 21 (Safety of navigation and emergency procedures).
    - AMSA Marine Orders Part 30 (Prevention of Collisions).
- Flaring is undertaken for the shortest possible duration while allowing for bleed-off objectives to be met.

The impact consequence for artificial light emissions is assessed as 'negligible.'

6.1.5 Discharge of Treated Sewage and Grey Water

Hazard

The use of ablution, laundry and galley facilities by crew will result in the discharge of treated sewage (water containing faecal matter and urine, collected by toilets and medical sinks) and grey water (domestic waste water generated from galley sinks, laundry facilities, showers and washbasins) to the ocean from the MODU:

Known and Potential Environmental Impacts

The known and potential environmental impacts of treated sewage and grey water discharges is the temporary and localised increase in the content of nutrients in the surrounding surface waters.

Evaluation of Environmental Impacts

Treated sewage and grey water discharges will be rapidly diluted in the surface layers of the water column and dispersed by currents. The biological oxygen demand (BOD) of the treated effluent is unlikely to lead to oxygen depletion of the receiving waters (Black *et al*., 1994), as it will be treated prior to release. Surface currents will also assist with oxygenation of the discharge once it is released.

Controls

- All sewage discharges are treated via an approved STP prior to overboard discharge.
- The STP is maintained in accordance with the PMS to ensure untreated sewage is not discharged.

The impact consequence for the discharge of treated sewage and grey water is assessed as 'negligible.'

6.1.6 Discharge of Cooling and Desalination Brine Water

Hazard

The following activities will result in the discharge of cooling and brine water to the ocean from the MODU:

- Seawater is used as a heat exchange medium for cooling machinery engines. Brine is created through the MODU desalination processes for potable water generation.

Known and Potential Environmental Impacts

The known and potential environmental impacts of cooling and desalination brine water discharges are:

- Temporary and localised increase in sea water temperature, causing thermal stress to marine biota;
- Temporary and localised increase in sea surface salinity, potentially causing harm to fauna unable to tolerate higher salinity; and
- Potential toxicity impacts to marine fauna.

Evaluation of Environmental Impacts

Once in the water column, cooling water will remain in the surface layer, where turbulent mixing and heat transfer with surrounding waters will occur. Prior to reaching background temperatures, the impact of increased seawater temperatures down current of the discharge may result in changes to the physiological processes of marine organisms, such as attraction or avoidance behaviour, stress or potential mortality.

Modelling of continuous waste water discharges (including cooling water) undertaken by Woodside for its Torosa South-1 drilling program in the Scott Reef complex found that discharge water temperature decreases quickly as it mixes with the receiving waters, with the discharge water temperature being less than 1°C above background levels within 100 m (horizontally) of the discharge point, and will be within background levels within 10 m vertically (Woodside, 2008).

Modelling undertaken for the BHP Petroleum Pyrenees FPSO Development in the Exmouth Basin (BHP, 2005) shows that based on a discharge of 100,000 m^3/day (~4,166 m^3/hr) at a water temperature of 25°C above that of the surrounding ocean, there is a 50% probability of the temperature of surface water within 25 to 50 m of the discharge point exceeding the ambient temperature by more than 2°C. This decreases to 1% within about 60 to 85 m of the discharge point, depending on seasonal variations in the water current.

Brine water will sink through the water column where it will be rapidly mixed with receiving waters, and disbursed by ocean currents. Walker and MacComb (1990) found that most marine species are able to tolerate short-term fluctuations in water salinity in the order of 20-30%, and it is expected that most pelagic species passing through a denser saline plume would not suffer adverse impacts. Other than plankton, pelagic species are mobile and would be subject to slightly elevated salinity levels for a very short time as they swim through the ‘plume.’

Controls

- The RO plant and equipment served by the cooling water system (e.g., main engines) is maintained in accordance with the MODU’s PMS to ensure that equipment is operating efficiently.
- The Electrolytic Marine Growth Protection System is maintained in accordance with the MODU’s PMS to ensure it is operating efficiently.

- Only ‘D’/’E’ (non-CHARM) or ‘Gold’/’Silver’ (CHARM) OCNS-rated chemicals will be used in the MODU water cooling system and brine to minimise ecotoxicity impacts to marine biota.
- Where for technical reasons a chemical outside this ranking may need to be used, a full assessment of the chemical will be undertaken to ensure environmental risks are reduced to ALARP.

The impact consequence for the discharge of cooling and desalination water is assessed as ‘negligible.’

6.1.7 Discharge of Putrescible Waste

Hazard

The generation and discharge of macerated food wastes from the MODU galley activity will result in the discharge of putrescible waste to the ocean.

Known and Potential Environmental Impacts

The known and potential environmental impacts of putrescible waste discharge are:

- Temporary and localised increase in the nutrient content of surrounding surface waters; and
- Increase in scavenging behaviour of marine fauna and seabirds.

Evaluation of Environmental Impacts

The overboard discharge of macerated food wastes has the result of creating a localised and temporary increase in the nutrient load of the surface waters. This may in turn act as a food source for scavenging marine fauna or seabirds, whose numbers may temporarily increase as a result. However, the rapid consumption of this food waste by scavenging fauna, and its physical and microbial breakdown ensures that the impacts of putrescible waste discharges are insignificant.

There are no sensitive environments or biological communities in the surface waters of the project area that are at risk from the discharge of putrescible wastes.

Controls

- A Garbage Management Plan (GMP) is in place and readily accessible to relevant crew and is implemented so as to prevent unauthorised overboard waste discharges.
- All food waste is macerated to ≤25 mm in size prior to overboard discharge using a MARPOL Annex V-compliant macerator to ensure rapid breakdown upon discharge.
- The macerator/s are maintained or replaced as per the PMS to ensure it is fully functional.
- In accordance with the GMP, all non-putrescible galley waste (i.e., packaging, cooking oils and grease) is securely stored prior to transfer to a support vessel for onshore recycling or disposal.

The impact consequence for the discharge of putrescible waste is assessed as ‘negligible.’

6.1.8 Discharge of Oily Water

Hazard

The following activities on the MODU will result in the discharge of oily water to the ocean:

- Deck washing, ocean spray and rain that capture trace quantities of contaminants;
- Discharge of bilge waters.

Deck water consists of rain and wash down water that may contain small amounts of detergents, oils and other materials used, spilt or stored on the deck floor.

Bilge tanks receive fluids from decks and machinery spaces on the MODU, which may contain contaminants such as oil, detergents, solvents, chemicals and solid waste.

Drains in hazardous areas are routed to slops tanks for treatment by an oily water separator (OWS), which ensures that all water discharged overboard meets the MARPOL threshold specification for 15 ppm oil-in-water (OIW). An auto-stop system ensures that any water above the 15 ppm threshold is automatically diverted back to the tanks rather than being discharged overboard. Residual oil and contaminated fluids/sludge is stored and offloaded via tote tanks for treatment ashore.

Known and Potential Environmental Impacts

The known and potential environmental impacts of the discharge of oily water are:

- Temporary and localised reduction of surrounding surface water quality; and
- Acute toxicity to marine fauna through ingestion.

Evaluation of Environmental Impacts

Traces of chemicals discharged to the ocean through open deck drainage and bilge discharges have a very low potential to temporarily reduce water quality and cause physiological damage to marine fauna that may ingest or absorb chemicals. Given the absence of sensitive habitat types in the water column of the project area, the greatest risk will be to plankton and pelagic fish. With appropriate controls in place, only trace quantities of contaminants would be expected in deck drainage and bilge water discharge, and these would be rapidly diluted, disbursed and degraded to undetectable levels.

Given the very small volumes of such chemicals or hydrocarbons (oil, grease) that may be accidentally discharged overboard, the high rates of dilution and dispersion in the open ocean environment and the temporary nature of the project, it is not expected that these very small quantities of hydrocarbons would induce acute or chronic toxicity impacts to marine fauna or plankton through ingestion or absorption through the skin.

Controls

- The hydrocarbon and chemical storage areas (e.g., engine room) are fully bunded and drain to the bilge water tank.
- Scupper plugs or equivalent drainage control measures are readily available to the deck crew so that deck drains can be blocked in the event of a hydrocarbon or chemical spill to deck to prevent or minimise discharge to the sea.
- The deck crews are competent in spill response and have appropriate response resources in order to prevent hydrocarbon or chemical spills going overboard

- SMPEP response kits are available in relevant locations, are fully stocked and used in the event of a spill to deck to prevent or minimise discharge overboard
- Bilge water is treated through an OWS set to prevent the discharge of water with a >15 ppm OIW content.
- The OWS is maintained in accordance with the PMS to ensure it does not discharge water containing >15 ppm oil.
- The residual oil from the OWS is pumped to tote tanks and transferred to shore for recycling, reuse or disposal.
- A Chemical locker is available, bunded and used for the storage of all non-bulk chemicals so as to prevent discharge overboard.
- Only biodegradable detergents will be used for deck cleaning (e.g., 'RigWash' with a 'Gold' CHARM ranking).

The impact consequence for the discharge of putrescible waste is assessed as 'negligible.'

6.2 Unplanned Events (Risk Assessment)

This section provides the environmental risk assessment (ERA) associated with unplanned events. As these are risks, rather than impacts, the risk assessment incorporates the consideration of 'likelihood' of the hazard occurring (along with the consequence of that hazard).

6.2.1 Accidental Disposal of Hazardous and Non-Hazardous Waste Overboard

Hazard

The handling and storage of materials and waste on the MODU have the potential to result in the accidental disposal of hazardous and non-hazardous materials and waste.

Small quantities of hazardous and non-hazardous materials will be used and waste will be created, and then handled and stored on the MODU and support vessels. In the normal course of operations, solid and liquid hazardous and non-hazardous materials and wastes will be back-loaded to shore for disposal to, or treatment at, licensed facilities. However, accidental releases to sea are a possibility, especially in rough ocean conditions when items may roll off or be blown off the deck.

The following non-hazardous materials and wastes will be disposed of to shore, but have the potential to be accidentally dropped or disposed overboard due to overfull bins or crane operator error:

- Paper and cardboard;
- Wooden pallets;
- Scrap steel, metal, aluminium, cans, etc.;
- Glass; and
- Plastics.

The following hazardous materials will be used and waste generated through the use of consumable products and will be disposed to shore, but may also be accidentally dropped or disposed overboard:

- Hydrocarbon-contaminated materials (e.g., oily rags, pipe dope, oil filters);
- Batteries, empty paint cans, aerosol cans, fluorescent tubes, printer cartridges;
- Contaminated personal protective equipment (PPE);
- Acids and solvents (laboratory wastes); and
- Radioactive logging tools.

Larger dropped objects (that may be hazardous or non-hazardous) may be lost to the sea through accidents with crane operations, including:

- Sea containers;
- Drill pipe and casing; and
- Entire skip bins/crates.

Potential Environmental Risks

The potential environmental impacts of accidental disposal of hazardous and non-hazardous materials and waste to the ocean are:

- Marine pollution;
- Injury and entanglement of marine fauna and seabirds; and
- Smothering or pollution of benthic habitats.
- Potential receptors include benthic species and habitats, plankton, fish, marine mammals, turtles and seabirds.

Evaluation of Environmental Risks

Hazardous materials and wastes released to the sea cause pollution and contamination, with either direct or indirect effects on marine organisms. For example, chemical spills can impact on marine life from plankton to pelagic fish communities, causing physiological damage through ingestion or absorption through the skin. Impacts from an accidental release would be limited to the immediate area surrounding the release, prior to the dilution of the chemical with the surrounding seawater. In an open ocean environment such as the project area, it is expected that any minor release would be rapidly diluted and dispersed, and thus temporary and localised.

If discharged overboard, non-hazardous wastes can cause smothering of benthic habitats as well as injury or death to marine fauna or seabirds through ingestion or entanglement. However, with the appropriate controls in place and given that the activity is not taking place in an area where there are likely to be high numbers of sensitive species, it is unlikely that this risk would be significant.

Controls

- Waste is segregated, stored and handled in accordance with the MARPOL Annex V-compliant GMP. This may include measures such as:
    - No discharge of general operational or maintenance wastes or plastics or plastic products of any kind.
    - Waste containers are covered with tightly fitting, secure lids to prevent any solid wastes from blowing overboard.

- All solid wastes are compacted (if possible) and stored in designated areas before being sent ashore for recycling, disposal or treatment.
- Any liquid waste storage on deck must have at least one barrier (i.e., bunding) to prevent deck spills entering the marine environment.
- This can include containment lips on deck (primary bunding) and/or secondary containment measures (bunding, containment pallet, transport packs, absorbent pad barriers) in place; and Correct segregation.

- MODU crew and visitors are inducted into waste management procedures in order to minimise the potential for unpermitted wastes being discharged overboard and to ensure effective waste segregation.
- Safety Data Sheet (SDS) registers are available in key locations (e.g., sack room, medic's office, chemical locker) and kept up to date so that chemical spills to deck can be safely managed.
- A project-specific waste manifest is established and maintained in order to track all waste types and volumes transferred ashore.
- The MODU handling and transfer procedure is in place and implemented by crane operators (and others) to prevent dropped objects.
- The MODU Crane Operators are trained to be competent in the MODU handling and transfer procedure to prevent dropped objects.
- The MODU-specific heavy weather procedures such as tying down tubing) will be implemented to prevent items being blown overboard (in the event of bad weather such as storms and cyclones).
- A PTW and JSA are undertaken for each transfer event, taking into account dropped object considerations.
- The MODU Fluids Management Plan is implemented in order to prevent the release of bulk brine.
- A chemical locker is available, bunded and used for the storage of all greases and non-bulk chemicals (i.e., those not in tote tanks) so as to prevent discharge overboard.
- The ROV is deployed to search for (and retrieve, where possible), non-buoyant dropped objects so that there are no obstacles on the seabed at the completion of the project and to confirm.
- Dropped objects left behind at the end of the project (that cannot be retrieved) will be reported internally and to NOPSEMA.

The risk assessment for the accidental disposal of waste overboard is:

Likelihood	Consequence	Risk rating
Unlikely	Negligible	Low

6.2.2 Introduction and Establishment of Invasive Marine Species

Hazard

The following MODU operations have the potential to result in the introduction of IMS to the project area:

- Discharge of ballast water containing foreign species; and
- Translocation of marine pests through biofouling of the hull or niches (e.g., sea chests, bilges, strainers).

The MODU is likely to be mobilised from Australian waters, but may just as likely be mobilised from international waters.

While on project location, the MODU will ballast and de-ballast to improve stability, even out stresses and adjust draft, list and trim, with regard to the weight of equipment on board at any one time. The DAWR Biosecurity department indicates that ballast water is responsible for 20-30% of all marine pest incursions into Australian waters (DAWR, 2015a).

Biofouling is the accumulation of aquatic microorganisms, algae, plants and animals on vessel hulls and submerged surfaces. More than 250 non-indigenous marine species have established in Australian waters, with research indicating that biofouling has been responsible for more foreign marine introductions than ballast water (Kinloch *et al*., 2003).

Potential Environmental Risks

The potential environmental risks of IMS introduction that result in the survival, colonisation and spread of foreign species are:

- Reduction in native marine species diversity and abundance;
- Displacement of native marine species;
- Socio-economic impacts on commercial resources (e.g., fisheries); and
- Changes to the conservation values of nearby CMRs and/or KEFs.

Evaluation of Environmental Risks

Marine pests can also damage marine and industrial infrastructure, such as encrusting jetties and marinas or blocking industrial water intake pipes. By building up on vessel hulls, they can slow the vessels down and increase fuel consumption.

The project area does not present a location conducive to IMS survival because it is:

- Located in deep oceanic water; and
- Distant from known areas of marine pests, with ports in northern and north-western Australia listed as having no IMS established in DAWR's marine pest interactive map database.

Controls

- NOGA undertakes a contractor pre-qualification to ensure vessel biofouling controls are in place.
- The anti-fouling system certification is current in accordance with AMSA Marine Order Part 98 (Anti-fouling systems).
- DAWR clearance is obtained to enter Australian waters in accordance with the Australian Ballast Water Management Requirements (v6, DAWR, 2016).
- Non-compliant discharges of domestic ballast water are to be reported to DAWR immediately
- Suspected or known introductions of IMS will be reported to the DAWR immediately.

The risk assessment for the introduction of IMS is:

Likelihood	Consequence	Risk rating
Highly unlikely	Major	Medium

6.2.3 Displacement of or Interference with Other Marine Users

Hazard

The physical presence of the MODU in the project area has the potential to result in the displacement of or interference with other marine users, such as commercial fishing vessels, merchant shipping vessels or traditional fishing vessels.

Potential Environmental Risks

The potential environmental risks of interference with other marine users are:

- Collisions between the MODU and third-party vessels (resulting in vessel damage).
- Damage to fishing equipment;
- Loss of commercial fish catches; and
- Disruption to commercial navigation.

Evaluation of Environmental Risks

The project area is located outside the limit of the AFZ and therefore does not overlap any Commonwealth or State managed fisheries. As such, there is a low risk of the MODU's presence interfering with commercial fishing operations. Since production at the NE FPSO commenced in 1999, there have been no recorded incidents with regards to fishing vessel interactions with the NE FPSO or subsea infrastructure, and no complaints received from fisheries operators regarding a reduction in fishing area.

Controls

- Anti-collision monitoring equipment (e.g., 24-hour radar watch, GMDSS and AIS) on the MODU is functional and used in accordance with AMSA Marine Orders Part 30 (Prevention of collisions).
- The Rig Move Notification is provided to AMSA prior to mobilisation to location and prior to demobilisation.
- The MODU Watch Keepers are appropriately qualified in accordance with International Convention of Standards of Training, Certification and Watchkeeping for Seafarers, (STCW95) GMDSS Proficiency to operate radio equipment in order to minimise the chance of collisions.
- NOGA ensures that a notification flyer, noting the MODU's location, is issued to stakeholders immediately prior to the MODU's arrival on location (i.e., during mobilisation to site).
- Constant communications between the MODU and support vessels are maintained to ensure the vessels are patrolling the safety zones at all times.
- The support vessel Masters issue warnings (e.g., radio warning, flares, lights/horns) to third-party vessels approaching the safety zone in order to prevent a collision.

- One of the support vessels will remain with the MODU at all times and will intercept approaching vessels that have not heeded radio advice about the presence of the MODU.

The risk assessment for the displacement of or interference with other marine users (using the financial definition of consequence) is:

Risk	Likelihood	Consequence	Risk rating
Displacement	Highly unlikely	Moderate	Medium
Interference	Highly unlikely	Moderate	Medium

6.2.4 Liquid Hydrocarbon Dropout from Flaring

Hazard

Flaring is the controlled burning of hydrocarbons and will be required to bleed off small volumes of annulus gas remaining the Laminaria-5 well. Efficient combustion in the flame depends on achieving good mixing between the fuel gas and air and on the absence of liquids. Where liquids are present (i.e., crude oil) and not completely 'knocked out' upstream of the flare boom, minor quantities (in the order of litres) of crude oil may occasionally emerge from the flare tip and spill on to the sea surface.

Potential Environmental Risks

The potential environmental risk of liquid hydrocarbon dropout from flaring is the temporary decrease in surface water quality.

Evaluation of Environmental Risks

The risk of Laminaria crude not being burned through the flare system is low given that it is such a light oil (i.e., it is easy to ignite and burn).

In the unlikely event that there is crude oil drop out, this is likely to be in the order of tens of litres only and thus have a low environmental risk. This is because of the small volume and the light nature of the oil, meaning it will quickly evaporate (see Section 3.4.2 for hydrocarbon characteristics and weathering characteristics). A temporary decrease in surface water quality is unlikely to have more than a minor impact to pelagic fauna species, such as plankton and fish. Acute and chronic toxicity impacts will not materialise due to the small volumes that may be spilled and the rapid weathering of the oil in tropical waters and warm ambient temperatures.

The risks from flaring of oil, gas or condensate are considered so minor that the OSPAR Commission concluded that there is no need to develop a background document (i.e., guideline) on the flaring of oil, gas or condensate (OSPAR, 2005).

Controls

- In accordance with the Surface Equipment Bleed Off Plan prepared by the contractor:
- An 'Evergreen' burner (or equivalent high-efficiency burner) is installed on the flare boom to reduce liquid drop out rates;
- Separator tanks are installed upstream of the flare boom in order to remove liquids prior to flaring and thus reduce the chance of liquid dropouts; and

- Dedicated MODU deck crew are in place to watch for liquid dropouts and notify the TPC Supervisor if drop out is observed so that the process can be quickly shut down.

The risk assessment liquid hydrocarbon dropout from flaring is:

Likelihood	Consequence	Risk rating
Unlikely	Negligible	Low

6.2.5 Diesel Spill from MODU

Hazard

Marine diesel oil (MDO) is the primary fuel used on the MODU (and support vessels). The following activities have the potential to result in an MDO spill from the MODU:

- A spill from refuelling (if refuelling of the MODU is required); and
- A collision between the MODU and a support vessel or third-party vessel.

The following notes apply to the assessment of this hazard:

- Note that it is unlikely that refuelling of the MODU on location will be required due to the brevity of the project (though it cannot be ruled out in case the MODU needs to remain on location longer than necessary due to unforeseen conditions); and
- A MDO spill from a support vessel is assessed in the NE FPSO Operations EP and is therefore not included here.

Table 6.2 outlines the physical characteristics of the MDO modelled.

Table 6.2. Characteristics of the MDO used in the OSTM

Characteristic	Volatiles (%)	Semi-volatiles (%)	Low volatiles (%)	Residuals (%)
Boiling point	<180	180-265	265-380	>380
MDO	6.0	34.6	54.5	5.0

MDO spill trajectory modelling

The most credible potential causal pathway for a large MDO spill from the MDO is considered to be a collision between the MODU and a third-party vessel.

Although a MODU contractor was not selected at the time of commissioning the oil spill trajectory modelling (OSTM), the following information regarding the maximum volume of MDO tanks on a semi-submersible MODU (obtained by AGR on a recent project in Australian waters) is considered typical for semi-submersible MODUs:

- Starboard tank 1 - 283 tonnes (331 m^3);
- Starboard tank 2 - 425 tonnes (496 m^3);
- Settling tank - 21 tonnes (25 m^3);
- Day tank - 7.7 tonnes (9 m^3).

The maximum draft of most petroleum support vessels (and similar sized vessels) is between 5 and 8 m. The only tank that is vulnerable to a collision is the settling tank, which is located

in the top of the starboard column and contains 21 tonnes when full, but is normally kept at 15-18 tonnes.

The project location is in a low-density shipping area, and an errant vessel collision with the MODU is an extremely unlikely event. The availability of a support vessel at all times to maintain guard and intercept any errant vessel mitigates the highly unlikely risk of collision with the MODU and the ability of a semi-submersible MODU to take evasive action by releasing a mooring can also be used as a last resort to ensure that full collisions are avoided. As noted above, the largest of the MODU tanks are typically protected by the position within a semi-submersible MODU structure. The largest potential spill is that of the MODU settling tank (25 m^3).

Likelihood. DNV (2011) provides the following statistics for the overall national exceedence frequencies for oil spills for offshore drilling:

- >1 tonne per year – 0.033;
- >10 tonnes per year – 0.016;
- >100 tonnes per year – 0.008;
- >1,000 tonnes per year – 0.004; and
- >10,000 tonnes per year – 0.002.

Consequence. In the extremely unlikely event that a vessel-to-MODU collision does occur that results in a release of MDO, stochastic trajectory analysis shows that no MDO >10 µm is predicted to remain on the water surface past 58 hours (or 2.4 days) of the spill and that no shoreline impact was predicted for the 10 µm thickness threshold.

Determining Spill Size

AMSA's Technical Guidelines for the Preparation of Marine Pollution Contingency Plans for Marine and Coastal Facilities (AMSA, 2013, pg 26) indicates that an appropriate indicative maximum credible spill volumes from a MODU (for MDO) should be based on a refuelling transfer rate x 15 minutes of flow.

However, NOGA has elected to base the maximum credible spill volume on a 105 m^3 spill volume (based on vessel fuel tank rupture due to collision with the NE FPSO) because:

- The refuelling spill size would be very low (in the order of several cubic metres) and not worth modelling, as the MDO would largely evaporate before it can spread;
- Exact MODU MDO storage volumes are as yet unknown; and
- The 105 m^3 spill volume is considered highly conservative based on the MODU MDO storage volumes noted earlier in this section.

Oil Spill Trajectory Modelling Results

Based on the information above, the OSTM scenario modelling is:

- MDO spill volume – 105 m^3;
- Spill duration – instantaneous; and
- Spill location – at surface at NE FPSO (4.8 km from the project location).

The mass balance forecast indicates that approximately 40% of the MDO is predicted to evaporate within 35 hours. Under calm conditions (wind speed of 2.6 m/s or 5 knots), the

majority of the remainder would then stay on the water surface where it would weather at a slower rate due to being comprised of the longer chain compounds with higher boiling points. Evaporation of the residual will slow significantly and it will then be exposed to more gradual biodegradation.

Under a weathering scenario, where the winds are variable and of greater strength, entrainment into the water column is indicated to be significant. Approximately 2 days after the spill, around 45% is forecast to have entrained and a further 45% is forecast to have evaporated, leaving only a small proportion of oil floating on the water surface. The residual component will tend to entrain beneath the surface under conditions that generate wind waves (> ~12 knots).

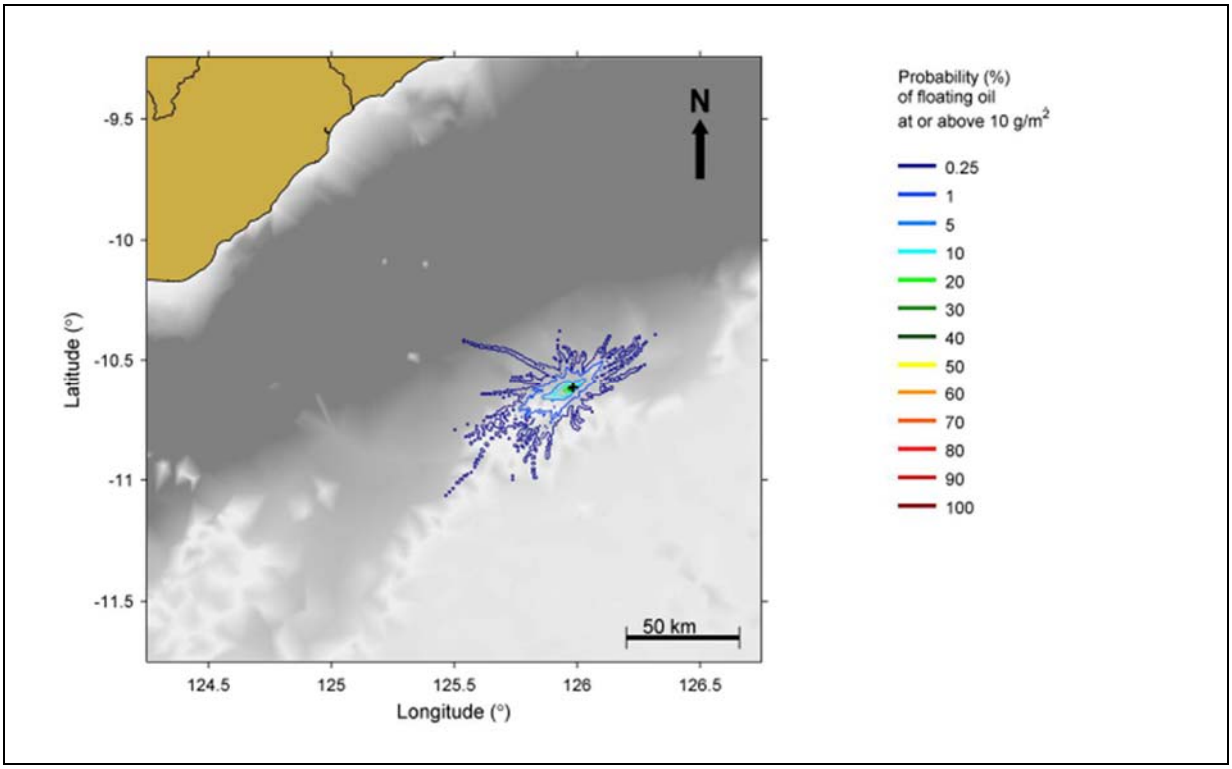
Table 6.3 summarises the OSTM results and Table 6.4 lists the probabilities of contact with various receptors. These results indicate that other than the open ocean, there is a very low probability (<0.25%) of contact with sensitivities at the 10 g/m^2 threshold.

Table 6.3. Summary of OSTM results for a 105 m^3 surface spill of MDO at the project location

Hydrocarbon phase	Threshold	Results
Surface (Figure 6.1)	10 g/m^2 (0.01 mm, 10 µm, metallic sheen)	A surface slick would form down current of the release location with the trajectory dependent on prevailing wind and current conditions at the time. The OSTM indicates locations within reach of surface oil concentrations above the threshold concentration are confined to areas up to 75 km away, with the potential to drift over the Sahul Shelf Shoals (including Big Bank Shoals). The sensitive locations are listed in Table 7.16.
Entrained (Figure 6.2)	500 ppb	A plume of entrained hydrocarbons would form down current of the release location with the trajectory dependent on prevailing wind and current conditions at the time. The OSTM indicates locations within reach of entrained hydrocarbons at concentrations at or above the threshold are confined to areas up to 25 km away.
Dissolved	500 ppb	The OSTM predicts dissolved aromatic hydrocarbon concentrations will remain well below the threshold, with no instances where the threshold is exceeded.
Shoreline	10 g/m^2 (2 tsp/m^2, oil stain)	The OSTM predicts that hydrocarbons have the potential to accumulate (≥ 100 g/m^2) at Rote Island (East Nusa Tenggara province), Indonesia.

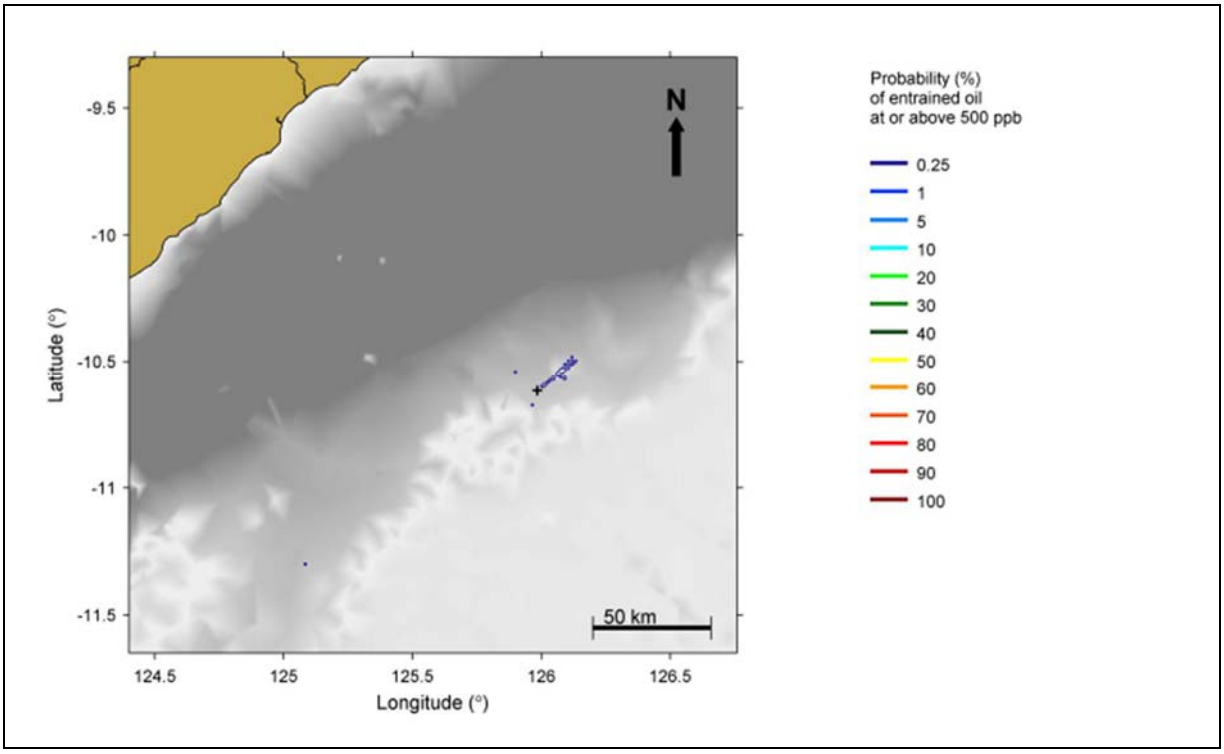
Table 6.4. Probabilities of contact with a surface spill of 105 m^3 of MDO

Location	Probability (%) of contact with oil ≥ 10 g/m^2	Minimum time (hours) to contact with receptor with oil ≥ 10 g/m^2	Maximum shoreline concentration (g/m^2) average over all replicate spills
Open ocean	0.5	13	N/A
International			
East Timor	<0.25	No contact	0.2
West Timor	<0.25	No contact	0.1
Rote Island	<0.25	No contact	4
Australia			
Melville Island	<0.25	No contact	No contact
Oceanic Shoals CMR	<0.25	No contact	No contact
Hibernia Reef	<0.25	No contact	No contact
Ashmore Reef CMR	<0.25	No contact	<0.1
Ashmore Reef	<0.25	No contact	<0.1
Cartier Island CMR	<0.25	No contact	<0.1
Cartier Island	<0.25	No contact	<0.1
Kimberley CMR	<0.25	No contact	No contact
Seringapatam Reef	<0.25	No contact	No contact
Scott Reef North	<0.25	No contact	No contact
Scott Reef South	<0.25	No contact	No contact
Browse Island	<0.25	No contact	No contact
Camden Sound	<0.25	No contact	No contact
Adele Island	<0.25	No contact	No contact
Lacapede islands	<0.25	No contact	No contact
Mermaid Reef	<0.25	No contact	No contact
Rowley Shoals	<0.25	No contact	No contact
Clerke Reef	<0.25	No contact	No contact
Eighty Mile Beach	<0.25	No contact	No contact
Glomar Shoals	<0.25	No contact	No contact
Rankin Bank	<0.25	No contact	No contact



Source: APASA (2013).

Figure 6.1. Predicted annualised probability of MDO concentration at or above 10 g/m^2 resulting from an instant release of 105 m^3 of MDO at the project location



Source: APASA (2013).

Figure 6.2. Predicted annualised probability of entrained MDO concentrations at or above 500 ppb resulting from an instant release of 105 m^3 of MDO at the project location

Potential Environmental Risks

The potential environmental risks of an MDO spill are:

- Temporary reduction in water quality;
- Injury or death of exposed marine fauna and seabirds exposed to the MDO; and
- Habitat damage where the spill reaches sensitive marine areas such as coral reefs or shorelines.

Evaluation of Environmental Risks

The impacts of a small release of MDO that readily evaporates is localised water column pollution and localised adverse effects on marine biota.

The biological consequences of a small MDO spill on open water receptors are minimal due to the small spatial and temporal scale of the predicted spill affected area, and the rapid weathering of the MDO.

Controls

- As per 'Displacement of or interference with other marine users' in Section 7.2.3.
- The MODU Barge Master implements the bunker transfer procedure in order to prevent a fuel spill. This includes measures including (but not limited to):
    - Ensuring that a PTW and risk assessment is completed for each bunkering event, taking into account spill response considerations.
    - Ensuring that the dry-break refuelling hose couplings assembly is in order to minimise the risk of a spill and hose floats are installed on the refuelling hose so that a hose leak is quickly and easily visible.
    - Ensuring that fuel transfer hoses are replaced in accordance with the PMS or when they are visibly degraded.
    - Ensuring that bunkering only commences during daylight hours and in calm sea conditions.
    - Ensuring that tank level indicators and level alarms are provided in the control room for the bunkering tanks.
    - Ensuring that communication (visual and/or audit) between the supply vessel and MODU are maintained throughout bunkering.
- The MODU OIM ensures that crew undertake spill response training every three months in accordance with the SMPEP and training matrix
- In accordance with the SMPEP, oil spill response kits are available in relevant locations around the MODU, are fully stocked and are used in the event of hydrocarbon or chemical spills to deck.
- A pre-campaign desktop emergency response exercise (incorporating a hydrocarbon spill) is conducted.

- A SIMOPs Plan will be prepared prior to project commencement to ensure that all risks emerging from simultaneous operations (between FPSO operations, FPSO support vessels, MODU and MODU support vessels) are thoroughly evaluated.
- The MODU OIM will report an NDO spill to the NOGA Client Representative and lead the onboard response in line with the SMPEP.
- The satellite-tracking buoy will be deployed from the nearby FPSO immediately after a Level 2 or 3 MDO spill in order to track the fate of the spill
- The Oil Spill Response Team (OSRT) Incident Commander (IC) will report to AMSA and NOPSEMA within 2 hours of becoming aware of the spill (see Section 8.4.2
- The OSRT IC ensures that operational monitoring studies are undertaken in accordance with the project OPEP in order to detect the extent of the MDO spill.
- The OSRT IC will provide the operational monitoring reports to relevant regulatory agencies in order to characterise environmental impacts from an MDO spill.

The risk assessment for a MDO spill is:

Likelihood	Consequence	Risk rating
Highly unlikely	Negligible	Low

6.2.6 Spill of Bulk Hydrocarbons and Chemicals

Hazard

The following activities have the potential to result in spills of chemicals and hydrocarbons to the sea:

- Crane transfers and equipment refuelling.

Crane transfers may result in accidental discharges of various products overboard or to deck, such as:

- Brine and chemical additives;
- Bulk chemicals (e.g., methanol);
- Hydraulic oil from the cranes' electric prime movers; and
- Assorted pumps, winches, power packs and generators.

Causes of spills overboard or releases within the water column include:

- The failure of surface equipment, riser joint or operator error or potential failure of the heave compensation system that results in a maximum release of 4.5 m^3 (~30 bbl) of Laminaria crude (a 350 m column in the riser with a diameter of 5-inches).
- Hose or connection failure (due to equipment condition or failure of the vessel to keep station);
- Failure to align valves correctly during transfer to tanks;
- Overfilling of tanks on MODU;
- Overfilling of aviation fuel tank on fuel unit or bulk storage tank of the MODU;
- Dropped objects from crane transfers; and

- Accidental or emergency disconnection of the riser.

Fluids stored in tanks (or pits) are pumped between tanks or to mixing equipment using transport pumps. The pipes through which they are pumped are under pressure. Possible causes of spills during these transfers include:

- Leaks due to the condition of pipes, connections, flanges and valves;
- Leaks from pump packers;
- Leaks from blocked mixing hoppers;
- Loss of storage tank integrity; and
- Failure to align valves correctly during transfer to tanks.

Jet A1 fuel used for helicopter refuelling has been excluded from OSTM and this assessment as only small volumes are typically stored on MODUs (~4 m^3), and spills of this fuel type evaporate quickly due to the very high levels of light ends.

Potential Environmental Risks

The potential environmental risks of the spill of bulk hydrocarbons or chemicals are:

- Temporary and localised reduction of surrounding water quality; and
- Acute toxicity to marine fauna through ingestion.

Evaluation of Environmental Impacts

The impact of the discharge of weighted brine is addressed in Section 6.1.2. The impacts of a bulk discharge of weighted brine will be no different, though the increased release volume means it will take longer to dilute and disperse through the water column.

Chemicals discharged in bulk to the marine environment have the potential to temporarily reduce water quality and cause physiological damage to marine fauna that may ingest or absorb chemicals. With the small volumes of chemicals kept on the MODU, the use of highly-ranked OCNS products, combined with the high rates of dilution and dispersion in the open ocean environment, it is not expected that acute or chronic toxicity impacts to marine fauna will occur through any accidental discharge of chemicals.

The impacts of a discharge of aviation fuel will be insignificant given the small volume stored on the MODU and its high volatility. It will evaporate quickly, not spread far beyond the point of release and is unlikely to result in acute or chronic toxicity to marine fauna exposed to the fuel.

Controls

- All hydrocarbons and chemicals are stored within secure receptacles within bunded areas or dedicated chemical lockers that drain to bilge tanks
- Where hydrocarbons and chemicals are stored within open draining decks, receptacles are stored on/in temporary bunds.
- The brine dump valve/s is locked, with the keys remaining secure in a key locker. A PTW will be required to unlock the dump valve/s, which involves an assessment by the OIM regarding the need for a specific operation.
- Planned maintenance is undertaken to the PMS schedule.

- The MODU OIM ensures that crew undertake spill response training every three months in accordance with the SMPEP and training matrix.
- In accordance with the SMPEP, oil spill response kits are available in relevant locations around the MODU, are fully stocked and are used in the event of hydrocarbon or chemical spills to deck.
- Quality control/assurance of all equipment is undertaken prior to mobilisation to site and at site.
- Pressure testing of equipment is undertaken.
- Emergency shutdown procedures are in place and implemented as required
- Only trained and competent operators are used for the project.
- A validation package is in place for the bleed back equipment.
- A riser analysis is undertaken prior to the riser being mobilised to the MODU.
- A MODU disconnect procedure is implemented in the event of barrier failure
- A crown-mounted compensator is in place, including pin-to-bottom failure mode protection.
- The MODU OIM will report a bulk spill to the NOGA Client Representative and lead the onboard response in line with the SMPEP
- The satellite-tracking buoy will be deployed from the nearby FPSO immediately after a Level 2 or 3 release of Laminaria crude from the riser as per the First Strike Plan.
- The OSRT IC will report to AMSA and NOPSEMA within 2 hours of becoming aware of the spill.
- The OSRT IC ensures that operational monitoring studies are undertaken in accordance with the project OPEP in order to detect the extent of the MDO spill.
- The OSRT IC will provide the operational monitoring reports to relevant regulatory agencies in order to characterise environmental impacts from an MDO spill

The risk assessment for a spill of bulk hydrocarbons or chemicals is:

Likelihood	Consequence	Risk rating
Highly unlikely	Negligible	Low

6.2.7 Loss of Well Containment

Hazard

There is a risk that Laminaria crude may be released subsea if:

- All barriers on the well fail (e.g., EDP, LRP). Last production from the well prior to it being shut in was 221 m^3 (1,400 bbl) per day with full gas lift. The most recent independent reservoir modelling estimates the well will produce approximately 48 m^3 (300 bbl) per day (with a 95% water cut) without gas lift (i.e., 2.4 m^3 or 15 bbl per day actual hydrocarbons).

The Laminaria field has been in production since 1999. The reservoir characteristics are well understood. No well control events have occurred during the construction of the original development wells, subsequent infill drilling and work overs/interventions. Currently producing wells in the field provide the FPSO with real time well and reservoir pressure information. Shallow gas hazards are not regionally present and were not observed during initial well

construction. Shallow gas is not anticipated to be encountered during the scope of intervention activities. Reservoir pressures of 4,730 psi at 3,250 m total vertical depth (TVD) are known. Shut in tubing head pressure is currently 2,130 psi. All well equipment is rated in excess of these values.

Spill trajectory modelling

Determining Spill Scenario

The most credible potential causal pathway for a large-scale loss of containment (LoC) of Laminaria crude is from a loss of well containment. Modelling was undertaken for a release of Laminaria crude from the Corallina-2 well (located 8.5 km northwest of Laminaria-5) based on a release rate of 246 m^3/day (1,547 bbl/day) for 11 weeks (the estimated time for a relief well to be mobilised to drill a relief well, resulting in a total release of 18,962 m^3). This release rate is marginally more than that predicted for the Laminaria-5 well (221 m^3 or 1,400 bbl per day) and is thus considered to be a suitable analogue with regards to OSTM. Given the reservoir modelling estimating that only 2.4 m^3 or 15 bbl per day of this flow is hydrocarbons, the OSTM results are therefore considered highly conservative.

Determining Spill Size

The hydrocarbon discharge rate is based on the average flow rate of an uncontrolled well over a 77-day period, representing a conservative uncontrolled release until a relief well kill can be performed.

OSTM Results

Upon release, initial volatilisation of the lightest hydrocarbons will occur due to sea surface heating and wind effects. This evaporation will generate large volumes of volatile organic compounds (VOCs), which may create a hazardous environment to personnel and a flammability problem in the vicinity of the spill and downwind of the oil slicks. The oil would also quickly spread on the sea surface and thin out resulting in a larger surface area of oil for increased evaporation for the lighter volatile hydrocarbon components. A high wind speed and high sea and air temperatures (summer conditions) would lead to increased evaporation and reduction in residues; alternatively lower sea and air temperature and wind speeds (winter conditions) would lower the evaporation rate.

The Laminaria crude oil assay data indicates that a large fraction of the whole oil is expected to evaporate over time scales of hours. Approximately 50% of the mass of the oil is likely to be lost to the atmosphere within the first hour of weathering with about 34% of the oil remaining after 8 hours of summer weathering. After 24 hours of weathering of a surface spill of Laminaria crude oil, approximately 75% by weight is expected to be lost to the atmosphere, with 25% by weight of the oil remaining. After 72 hours of weathering approximately 80% of the weight of the oil would be expected to be lost, with 20% remaining as residues.

Table 6.5 summarises the OSTM results. Table 6.6 lists the probabilities of contact with various receptors for sea surface oil, Table 6.7 lists the probabilities of contact with various receptors for entrained hydrocarbons and Table 6.8 lists the probabilities of contact with various receptors for dissolved aromatic hydrocarbons.

Table 6.5. Summary of OSTM results for a 246 m^3/day well release of Laminaria crude

Hydrocarbon phase	Threshold	Results

Surface (Figure 6.3)	10 g/m^2 (0.01 mm, 10 µm, metallic sheen)	Floating oil is not forecast to exceed 10 g/m^2 within the model domain, suggesting that the rapid evaporation would likely greatly erode any surface slicks within approximately 1 km of the release site. Floating oil with concentrations exceeding 1 g/m^2 is forecast to generally occur within an approximate radius of 30 km from the release site, with small isolated, transient patches possible up to approximately 200 km from the source. Floating oil is forecast to most likely drift in a westerly or south-westerly direction. Floating oil with a concentration of 1 g/m^2 or greater is forecast to pass over the Big Bank Shoals in at least one of the modelled replicates, arriving 277 hours (~11.5 days) after the commencement of the release. No other receptors are forecast to be contacted in any replicate at this threshold. No receptor with a shoreline is expected to be contacted by arriving oil at 1 g/m^2 or greater. Sensitive receptors where surface oil makes contact are listed in Table 7.22. *Note: Oil that is 1 µm thick is considered below levels that would cause environmental harm and it is more indicative of the areas perceived to be affected due to its visibility on the sea-surface and potential to trigger temporary closures of areas (i.e., fishing grounds) as a precautionary measure. It is also close to the practical limit of observing oil in the marine environment.* *The 1-10 µm thickness is likely to be observed in areas where the hydrocarbon is spread thinly, and as such has already undergone evaporation and weathering. The majority of the lighter, more toxic compounds will have been removed from the surface in that process. Ecological impacts at this thickness are unlikely.*
Entrained (Figure 6.4)	500 ppb	Entrained oil with concentrations exceeding 500 ppb is forecast to potentially extend up to 500 km from the release site, typically in isolated trajectories. The most likely direction of initial drift is north-easterly or south-westerly, with some probability of occurrence in most directions. The majority of oil is contained within ~100 km of the source. The highest concentrations of entrained oil will occur in the upper layer of the ocean. The probability of entrained oil concentrations of 500 ppb or greater reaching any receptor is predicted to be highest at Big Bank Shoals (4%), with a minimum time to contact of 49 hours. Contact is also forecast at Oceanic Shoals CMR in two replicates, with a minimum time of ~27 days. The worst-case instantaneous entrained oil concentrations reaching receptors are forecast at Big Bank Shoals (~2.6 ppm) and Oceanic Shoals CMR (~1.2 ppm). Worst-case instantaneous concentrations greater than 400 ppb are also forecast at Timor Leste (418 ppb), Pulau Roti (492 ppb) and at Hibernia Reef (404 ppb).
Dissolved	500 ppb	Dissolved aromatic hydrocarbon concentrations exceeding 500 ppb are forecast to potentially extend up to 50 km from the blowout site. Very isolated areas of the threshold being exceeded are forecast, with the scattered occurrences and maximum probability of less than 0.5% suggesting that for the majority of the time, concentrations will be much less than 500 ppb away from the spill site. This also indicates that a majority of the dissolution may take place at depth as the plume rises. No shoreline receptors are expected to be contacted at a concentration of 500 ppb or greater, with no contact recorded at any time in any replicate. The worst-case instantaneous dissolved aromatic hydrocarbon concentrations are expected in open ocean areas, being 334 ppb at Big Bank Shoals and 174 ppb at Oceanic Shoals CMR. The worst-case instantaneous concentration at any nearshore receptor is expected at Pulau Roti (133 ppb).
Shoreline	10 g/m^2 (2 tsp/m^2, oil stain)	Small amounts of weathered oil are forecast to accumulate on several of the more proximal receptors, such as East Timor (140 g/m^2 arriving after 30.5 days), West Timor (314 g/m^2 arriving after 7.3 days), Pulau Roti (227 g/m^2 arriving after 6.8 days) and Ashmore Reef. This oil would be considerably weathered following initial release. Note that these estimates of local potential accumulated concentrations along the shoreline sections are for the worst-case replicate, and are not estimates for concentrations along the full extent of the shorelines. Extrapolation to a total volume for a receptor coastline for example would likely lead to significant over-statement of the potential for oil accumulation on the shoreline.

Table 6.6. Probabilities of sea surface contact resulting from a 246 m^3/day, 77-day subsea release of Laminaria crude

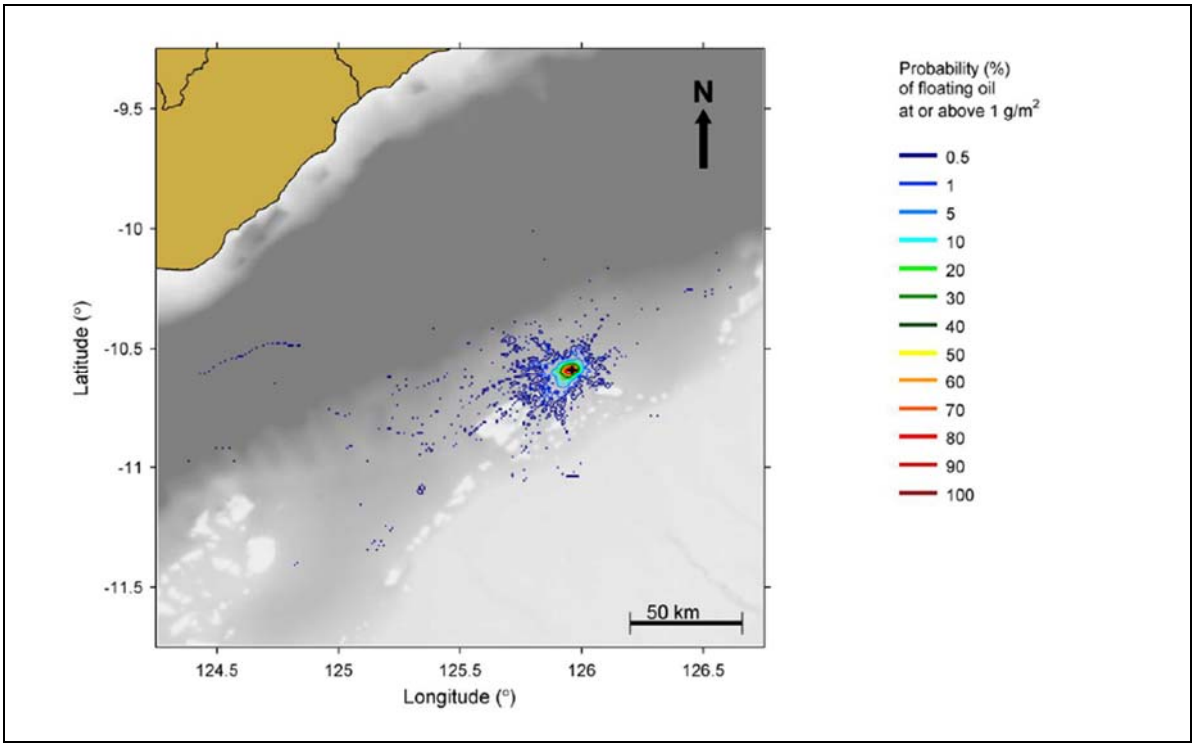
Location	Probability (%) of contact with oil ≥1 g/m^2	Minimum time (hours) to contact for films ≥1 g/m^2	Maximum shoreline concentration (g/m^2) averaged over all replicate spills
Open ocean	1	No contact	N/A
International			
East Timor	<0.5	No contact	1.4
West Timor	<0.5	No contact	2.8
Rote Island	<0.5	No contact	6.0
Australia			
Big Bank shoals	0.5	277	
Melville Island	<0.5	No contact	No contact
Oceanic Shoals CMR	<0.5	No contact	No contact
Hibernia Reef	<0.5	No contact	No contact
Ashmore Reef CMR	<0.5	No contact	1.4
Ashmore Reef	<0.5	No contact	1.4
Cartier Island CMR	<0.5	No contact	No contact
Cartier Island	<0.5	No contact	No contact
Kimberley CMR	<0.5	No contact	No contact
Seringapatam Reef	<0.5	No contact	No contact
Scott Reef North	<0.5	No contact	No contact
Scott Reef South	<0.5	No contact	No contact
Browse Island	<0.5	No contact	No contact
Camden Sound	<0.5	No contact	No contact
Adele Island	<0.5	No contact	No contact
Lacapede islands	<0.5	No contact	No contact
Mermaid Reef	<0.5	No contact	No contact
Rowley Shoals	<0.5	No contact	No contact
Clerke Reef	<0.5	No contact	No contact
Eighty Mile Beach	<0.5	No contact	No contact
Glomar Shoals	<0.5	No contact	No contact
Rankin Bank	<0.5	No contact	No contact

Table 6.7. Probabilities of contact with entrained oil resulting from a 246 m^3/day, 77-day subsea release of Laminaria crude

Location	Probability (%) of entrained hydrocarbon contact ≥500 ppb	Minimum time (hours) to nearshore waters ≥500 ppb	Maximum entrained hydrocarbon concentration (ppb) averaged over all replicate spills
Open ocean	<0.25	No contact	8
International			
East Timor	<0.25	No contact	<1
West Timor	<0.25	No contact	<1
Rote Island	<0.25	No contact	<1
Australia			
Big Bank shoals	<0.25	No contact	2
Melville Island	<0.25	No contact	No contact
Oceanic Shoals CMR	<0.25	No contact	<1
Hibernia Reef	<0.25	No contact	<1
Ashmore Reef CMR	<0.25	No contact	<1
Ashmore Reef	<0.25	No contact	<1
Cartier Island CMR	<0.25	No contact	<1
Cartier Island	<0.25	No contact	<1
Kimberley CMR	<0.25	No contact	<1
Seringapatam Reef	<0.25	No contact	<1
Scott Reef North	<0.25	No contact	<1
Scott Reef South	<0.25	No contact	<1
Browse Island	<0.25	No contact	<1
Camden Sound	<0.25	No contact	No contact
Adele Island	<0.25	No contact	No contact
Lacapede islands	<0.25	No contact	No contact
Mermaid Reef	<0.25	No contact	No contact
Rowley Shoals	<0.25	No contact	No contact
Clerke Reef	<0.25	No contact	No contact
Eighty Mile Beach	<0.25	No contact	No contact
Glomar Shoals	<0.25	No contact	No contact
Rankin Bank	<0.25	No contact	No contact

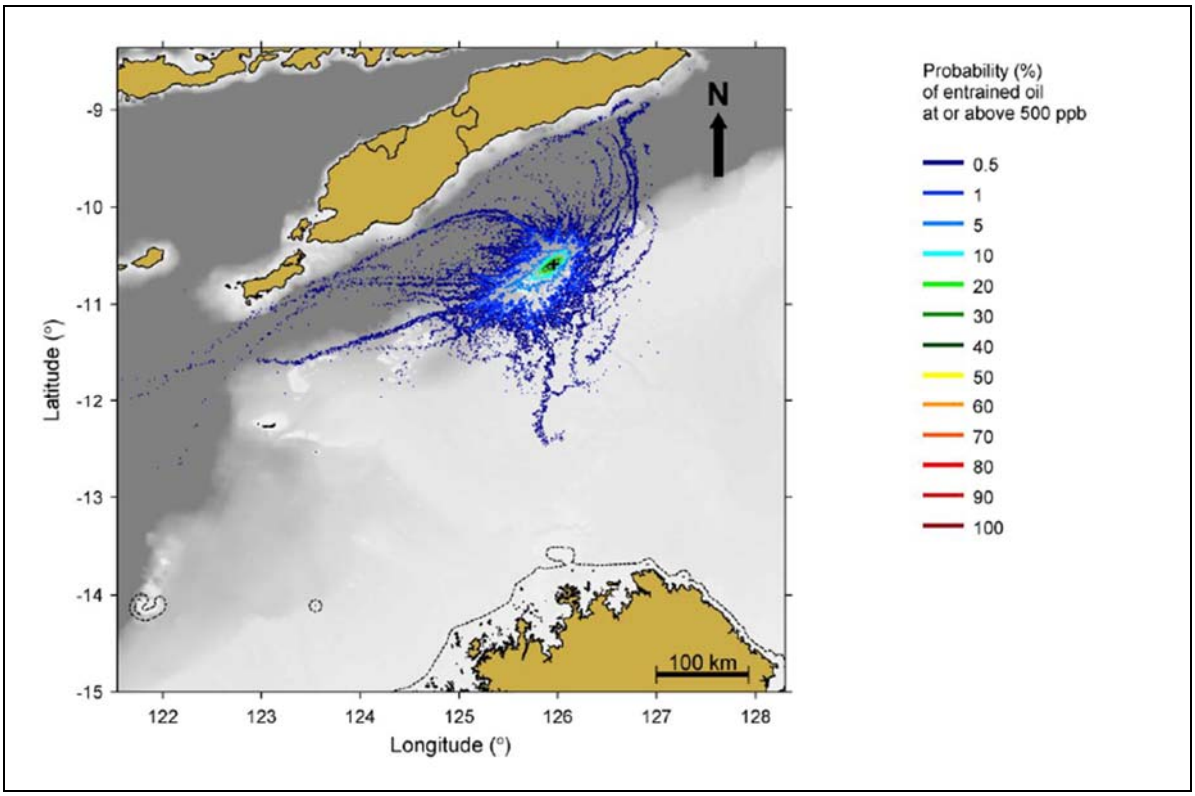
Table 6.8. Probabilities of contact with dissolved oil resulting from a 246 m^3/day, 77-day subsea release of Laminaria crude

Location	Probability (%) of dissolved aromatic contact concentration ≥500 ppb	Maximum dissolved aromatic hydrocarbon concentration (ppb) averaged over all replicate spills
Open ocean	<0.25	<1
International		
East Timor	<0.25	<1
West Timor	<0.25	<1
Rote Island	<0.25	<1
Australia		
Big Bank shoals	<0.25	2
Melville Island	<0.25	No contact
Oceanic Shoals CMR	<0.25	3
Hibernia Reef	<0.25	<1
Ashmore Reef CMR	<0.25	<1
Ashmore Reef	<0.25	<1
Cartier Island CMR	<0.25	2
Cartier Island	<0.25	2
Kimberley CMR	<0.25	<1
Seringapatam Reef	<0.25	<1
Scott Reef North	<0.25	<1
Scott Reef South	<0.25	<1
Browse Island	<0.25	No contact
Camden Sound	<0.25	No contact
Adele Island	<0.25	No contact
Lacapede islands	<0.25	No contact
Mermaid Reef	<0.25	No contact
Rowley Shoals	<0.25	No contact
Clerke Reef	<0.25	No contact
Eighty Mile Beach	<0.25	No contact
Glomar Shoals	<0.25	No contact
Rankin Bank	<0.25	No contact



Source: APASA (2013).

Figure 6.3. Predicted annualised probability of floating Laminaria crude concentration at or above 1 g/m² resulting from a 246 m³/day, 77-day subsea well blowout of Laminaria crude



Source: APASA (2013).

Figure 6.4. Predicted annualised probability of entrained Laminaria crude concentrations at or above 500 ppb resulting from 246 m³/day, 77-day subsea well blowout of Laminaria crude

Potential Environmental Risks

The potential environmental risks of a subsea loss of hydrocarbons:

- Temporary and localised reduction of surrounding water quality; and
- Acute toxicity to marine fauna through exposure or ingestion.

Evaluation of Environmental Risks

The effects of a light oil spill on key biological receptors are described here.

Marine mammals

In the event of a major LoC from the well, there is the potential for surface, entrained and dissolved hydrocarbons exceeding threshold concentrations to disperse across the migratory routes of EPBC Act-listed whale species, such as the pygmy blue whale (northbound and southbound migrations). For example, a major spill in April to August or October to January would coincide with pygmy blue whale migration between Australia and Indonesia.

Ocean cetacean species traversing offshore open water or frequenting the oceanic reef systems may also be impacted if exposed to hydrocarbons. Accurate information on the measured impacts of hydrocarbon spills on marine mammals is limited due to the paucity of historical data from actual spills, due in most part to their reclusive and migratory behaviour, such as that of whales. The information presented herein is available from AMSA (2012), Etkins (1997) and IPIECA (1995).

The nature of the oil, location, volume, concentration levels, exposure time and how much it has weathered may also affect the potential impacts. Potential physiological effects, which (depending on species) are documented to likely include to varying degrees:

- Hypothermia due to conductance changes in skin, resulting in metabolic shock (expected to be more problematic for non-cetaceans in colder waters);
- Toxic effects and secondary organ dysfunction due to ingestion of oil;
- Congested lungs;
- Damaged airways;
- Interstitial emphysema due to inhalation of oil droplets and vapour;
- Gastrointestinal ulceration and haemorrhaging due to ingestion of oil during grooming and feeding;
- Eye and skin lesions from continuous exposure to oil;
- Decreased body mass due to restricted diet; and
- Stress due to oil exposure and behavioural changes.

Individual mammals exposed to hydrocarbons early in a spill may be exposed to its more toxic components by direct contact and ingestion and suffer greater toxicity per unit time and volume than those affected by a more weathered hydrocarbon.

Cetaceans in particular have mostly smooth skins with limited areas of pelage (hair covered skin) or rough surfaces such as barnacled skin. Oil tends to adhere to rough surfaces, hair or calluses of animals, so contact with hydrocarbons by whales and dolphins may cause only minor hydrocarbon adherence, with the likely biological consequences of this being irritation and sub-lethal stress.

The way a cetacean consumes its food affects the likelihood of it ingesting spilled hydrocarbon. Baleen whales (such as humpbacks) skim the surface for krill and are more likely to ingest oil than 'gulp feeders' (toothed whales). Further, oil may stick to the baleen while they 'filter feed' near slicks. Sticky, tar-like residues are particularly likely to foul the baleen plates. Fouling of whale baleen (e.g. pygmy blue whales) may disrupt feeding by decreasing the ability to intake prey. If prey (fish and plankton) is also contaminated, this can result in the absorption of toxic components of the hydrocarbons (PAHs). Feeding activity by pygmy blue whales has been recorded in the deeper offshore waters off southern Timor so there potential for impact associated with ingestion of hydrocarbons if the spill and timing of whale occurrence coincide. Toothed whales, including dolphins, are 'gulp-feeders' targeting specific prey at depth in the water column away from the surface slick and are likely to be less susceptible to the ingestion of hydrocarbons.

It has been stated that pelagic species will avoid hydrocarbon, mainly because of its noxious odours, but this has not been proven (though a number of field and experimental observations indicate whales and dolphins may be able to detect and avoid surface slicks). To the contrary, there have been observed instances where animals have swum directly into oiled areas without seeming to detect the slicks or because the slicks could not be avoided. The strong attraction to specific areas for breeding or feeding may override any tendency for cetaceans to avoid the noxious presence of hydrocarbons. So weathered or tar-like oil residues can still present a problem by fouling baleen whales feeding systems. Researchers have also indicated that inhalation of oil droplets, vapours and fumes is a distinct possibility if whales surface in slicks to breathe.

Exposure to hydrocarbons in this way could damage mucous membranes, damage airways or even cause death.

Seabirds

Offshore waters are potential foraging grounds for seabirds, which are vulnerable to contacting surface slicks during feeding or resting on the sea surface. Seabirds generally do not exhibit avoidance behaviour to floating hydrocarbons. Physical contact of seabirds with surface slicks is by the primary exposure pathways of immersion, ingestion and inhalation this may result in plumage fouling and hypothermia (loss of thermoregulation), decreased buoyancy and potential to drown, inability to fly or feed, anemia, pneumonia and irritation of eyes, skin, nasal cavities and mouths (AMSA, 2012; IPIECA, 2004) resulting in mortality due to oiling of feathers or the ingestion of hydrocarbons.

Longer-term exposure effects that may potentially impact seabird populations include a loss of reproductive success (loss of breeding adults) and malformation of eggs or chicks (AMSA, 2012). Given the long distance from the nearest seabird roosting, feeding and breeding areas, and the likely low abundance of seabirds foraging in the ZPI, the potential impact to seabird populations is considered low.

Marine reptiles

Adult sea turtles exhibit no avoidance behaviour when they encounter an oil slick (Odell and MacMurray, 1986). Contact with surface slicks can therefore result in hydrocarbon adherence to body surfaces (Gagnon and Rawson, 2010) causing irritation of mucous membranes in the nose, throat and eyes leading to inflammation and infection (Etkins, 1997). Oiling can also irritate and injure skin, which is most evident on pliable areas such as the neck and flippers (Lutcavage *et al*., 1995). A stress response associated with this exposure pathway includes an increase in the production of white blood cells, and even a short exposure to oil may affect the functioning of their salt gland (Lutcavage *et al*., 1995). Oil in surface waters may also impact turtles when they surface to breathe and inhale toxic vapours. Their

breathing pattern, involving large 'tidal' volumes and rapid inhalation before diving, results in direct exposure to petroleum vapours which are the most toxic component of the oil spill (Milton and Lutz, 2002). This can lead to lung damage and congestion, interstitial emphysema, inhalant pneumonia and neurological impairment (Etkins, 1997 and IPIECA, 1995).

Impacts to sea snakes from direct contact with surface hydrocarbons would result in similar physical effects to those recorded for turtles and would include potential damage to the dermis and irritation to mucous membranes of the eyes, nose and throat (Etkins, 1997). They may also be impacted when they return to the surface to breathe and inhale the toxic vapours associated with the hydrocarbons, resulting in damage to their respiratory system.

While marine turtles may be present in deep offshore open waters, offshore waters within the ZPI are distant from emergent features and individuals are likely to occur in low densities. Whether sub-lethal or lethal effects occur will depend on the weathering stage of the hydrocarbon and its inherent toxicity.

Plankton

Exposure to hydrocarbons in the water column can result in changes in species composition with declines or increases in one or more planktonic species or taxonomic groups (Batten, 1998). Phytoplankton may also experience decreased rates of photosynthesis (Goutz *et al*., 1984; Tomajka, 1985). For zooplankton, direct effects of contamination may include suffocation, changes in behaviour, or environmental changes that make them more susceptible to predation (Chamberlain and Robertson, 1999).

If phytoplankton are exposed to hydrocarbons at the sea surface, this may directly affect their ability to photosynthesize and would have implications for the next trophic level in the food chain (e.g. small fish). In addition, the presence of surface hydrocarbons may result in a reduction of light penetrating the water column, which could affect the rate of photosynthesis for phytoplankton in instances where there is prolonged presence of surface hydrocarbons over an extensive area such that the phytoplankton was restricted from exposure to light.

Oil can affect the rate of photosynthesis and inhibit growth in phytoplankton, depending on the concentration range. For example, photosynthesis is stimulated by low concentrations of oil in the water column (10-30 ppb), but become progressively inhibited above 50 ppb. Conversely, photosynthesis can be stimulated below 100 ppb for exposure to weathered oil (Volkman *et al*., 2004).

Impacts on plankton communities are likely to occur in areas where dissolved or entrained hydrocarbon threshold concentrations are exceeded, but communities are expected to recover quickly (within weeks or months). This is due to high population turnover with copious production within short generation times that also buffers the potential for long-term (i.e., years) population declines (ITOPF, 2011).

Fish

Fish mortalities are rarely observed to occur as a result of oil spills (ITOPF, 2011). Scholz et al (1992) concluded that fish do not generally experience acute mortality due to oil spills, and that it is rare to find fish kills after a spill, especially in open water environments. This has generally been attributed to the possibility that pelagic fish are able to detect and avoid surface waters underneath oil spills by swimming into deeper water or away from the affected areas. Fish that have been exposed to dissolved hydrocarbons are capable

of eliminating the toxicants once placed in clean water; hence individuals exposed to a spill are likely to recover (Concawe, 1996). Where fish mortalities have been recorded, the spills (resulting from the groundings of the tankers Amoco Cadiz in 1978 and the Florida in 1969) have occurred in sheltered bays.

Fish are most vulnerable when at the larval stage, however impacts would be over a small portion of the sea area in which they may occur and unlikely to result in any measurable impacts at a population level (especially in comparison to natural predation).

A spill of diesel or condensate from the NE facility is therefore unlikely to cause a major impact on short-term survival of open water pelagic fish but may result in a level of sub-lethal stress on fish. The potential impacts to fish populations in offshore open waters are considered to be minor.

Controls

- The well is reinstated in accordance with the Laminaria-5 WOMP and intervention program, including that
- Secondary and tertiary well barriers are installed and operational
- The SST connection to the WORS are tested and functionality of valves and controls confirmed prior to intervention commencing
- The OIM will run at least one (frequency determined by the ERP) well control exercise during the project in accordance with the Well Control Bridging document
- A desktop emergency response exercise is undertaken prior to the project commencing.
- Routine monitoring for unplanned releases from the well by relevant personnel is undertaken during intervention activities
- The following plans will be implemented in the event of a tier 3 (major spill) subsea loss of containment:
    - Oil Pollution First Strike Plan (01-HSE-PL01).
    - OPEP (01-HSE-PL02).
    - OSMP (01-HSE-PL04 and associated sub-plans).
- One or more of the following plans will be implemented to stop the LoC:
    - Emergency Tree Replacement Plan (01-HSE-PL16).
    - Emergency Well Kill Plan (01-HSE-PL17).
    - Relief Well Drilling Plan (01-HSE-PL27).
- The AGR Wellsite Representative will report a subsea loss of containment to the NOGA Asset Manager and lead the onboard response
- The NOGA HSEC Manager will report to AMSA and NOPSEMA within 2 hours of becoming aware of the spill (see Section 8.4.2).

The risk assessment for a loss of well containment is:

Likelihood	Consequence	Risk rating
Highly unlikely	Moderate	Medium

6.3 Spill Response Activities

In the event of a Level 2 or 3 hydrocarbon spill, NOGA has the following plans in place that will be implemented:

- Crisis Management Plan (00-MGT-001) – details the requirements and framework for incident response and crisis management. The objectives of the plan is to ensure that emergency and crisis management procedures and capabilities enable NOGA to prevent, prepare, respond and recover from incidents (or a crisis) that impacts upon its people, environment, assets or reputation.
- Laminaria-5 Bridging ERP (2017-004-02-01-001) – outlines actions to be taken by various personnel to respond to an emergency.
- Oil Pollution First Strike Plan (01-HSE-PL01) – outlines initial oil spill response actions to be taken in the event of a Level 2 or 3 oil spill.
- OPEP (01-HSE-PL02) – address spill preparedness and response for the NE facility (but can be equally applied to this project). The OPEP has been compiled in consultation with a range of regulatory authorities and response organisations (such as AMOSC and OSRL).
- OSMP (01-HSE-PL05) – describes the operational and scientific that will be undertaken to monitor the trajectory and impacts of an unplanned Level 2 or 3 hydrocarbon or chemical spill. All operational and scientific studies apply.
- Emergency Tree Replacement Plan (01-HSE-PL16) if required;
- Emergency Well Kill Plan (01-HSE-PL17) if required; and
- Relief Well Drilling Plan (01-HSE-PL27) if required.

The Level 2 and 3 spill response options for the Laminaria-5 reinstatement project are:

- Source control;
  - Well kill via the FPSO.
  - Subsea tree replacement.
  - Well relief drilling.
- Offshore response;
  - Natural degradation/dispersion.
  - Wildlife hazing.
  - Shoreline protection booming
- Nearshore/onshore response;
  - Natural degradation/dispersion.
  - Shoreline protection booming.
  - Oiled wildlife response (including hazing and/or recovery).
  - Containment and recovery.

Oil spill response strategies determined as unsuitable based on Laminaria oil and reservoir conditions are:

- Well capping;

- Dispersant application (surface and subsea);
- In-situ burning; and
- Shoreline cleanup.

6.3.1 Oil Spill Response Manning and Resource Management

NOGA utilises the Australasian Inter-Service Incident Management System (AIIMS) system of incident management for all emergencies including hydrocarbon spills. This allows NOGA to respond in a scalable structure both for time and location, that takes maximum advantage of its contractual arrangements with the NE FPSO Operator (Upstream P.S.) as well as its contract oil spill response agencies.

In consultation with AMOSC and OSRL, NOGA has analysed the required personnel for a Level 2 and 3 oil spill response to verify it has sufficient resources to meet the various control strategies in the event of a worst-case scenario. This is summarised in Table 6.9.

Table 6.9. Minimum personnel requirements for a Level 2 or 3 hydrocarbon spill

Response strategy	Personnel required	Trained personnel available	Source of personnel
Incident Management Team			
Incident Controller	2	3	NOGA
Deputy Incident Controller	2	3	UPS, AMOSC
Planning Officer	2	40 in total	Staff contracts, FPSO operations and maintenance contract
Logistics Officer	2		
Operations Officer	2		
Finance/Admin Officer	2		
Escalation personnel	Event-based	44	AMOSC & OSRL membership
Environment coordinator	2	11	AMOSC, OSRL, Jacobs, Aventus Consulting
Operational monitoring			
Trajectory modelling	1	Numerous	RPS APASA
Aerial surveillance	1	2	OSRL
Satellite monitoring	1	Numerous	OSRL
Vessel-based water sampling	2 + field personnel	Numerous	Jacobs
Pre-emptive receptor assessment	2 on vessel, 2 in plane	Numerous	Jacobs
Monitoring of contaminated resources	5	44	AMOSC (Core Group)
		Numerous	Jacobs
Scientific monitoring			

Response strategy	Personnel required	Trained personnel available	Source of personnel
Desktop review and assessment of hydrocarbons in marine waters	4	Numerous	Jacobs + general consultancy market in the event of escalation
Assessment of the presence, quantity and character of hydrocarbons in marine sediments	6	Numerous	Jacobs + general consultancy market in the event of escalation
Assessment of impacts and recovery of subtidal and intertidal benthos	7	Numerous	Jacobs + general consultancy market in the event of escalation
Assessment of impacts and recovery of seabird and shorebird populations	4	Numerous	Jacobs + general consultancy market in the event of escalation
Assessment of impacts and recovery of nesting marine turtle populations	4	Numerous	Jacobs + general consultancy market in the event of escalation
Desktop assessment of impacts to other non-avian marine megafauna	1	Numerous	Jacobs + general consultancy market in the event of escalation
Assessment of impacts and recovery of marine fish	8	Numerous	Jacobs + general consultancy market in the event of escalation
Assessment of physiological impacts to commercially important fish and shellfish species (fish health and seafood quality/safety) and recovery	4	Numerous	Jacobs + general consultancy market in the event of escalation
Containment and recovery			
Operations Lead	2 (back-to-back)	44	AMOSC (Core Group)
Boom deployment vessel	6 (back-to-back)		
Boom tow vessel	2 (back-to-back)		
Shoreline protection and deflection			
Operations Lead	2 (back-to-back)	44	AMOSC (Core Group)
Boom Deployment	2 (back-to-back)		

Response strategy	Personnel required	Trained personnel available	Source of personnel
Oiled Wildlife Response			
Oiled Wildlife Coordinator	1	3	Sea Alarm
Wildlife Advisor	1	1	AMOSC, WA DPaW
Oiled Wildlife Site Execution Structure	Depends on event response size	TBA	Sea Alarm, Dwyertech

6.3.2 Oil Spill Response Risk Assessment

A summary of the environmental risk assessment for oil spill response strategies is presented in Table 6.10. The residual risk for each response strategy is assessed as 'low.'

Table 6.10. Summary risk assessment for oil spill response strategies

Strategy	Risks	Control measures
Source control		
Well kill via the FPSO	Noise, air and light emissions. Routine overboard emissions of sewage and putrescible waste, cooling and brine water, and bilge water. Discharge of waste. Introduction of IMS.	Preparedness The Emergency Well Kill Plan details the requirements for mobilisation and deployment of all required equipment and personnel. Well kill pumps available from Halliburton and Schlumberger in Perth (3 pumps available). OSV on contract to NOGA, with availability and routes known and tracked by the Darwin Supply Base Manager. The Road Transportation Contract inclusive of Provision of Freight Distribution and Warehousing Services applicable to other intrastate and interstate equipment transfer requirements. Response The Emergency Well Kill Plan (01/HSEPL17) contains required treatment concentration that is required to successfully inhibit kill fluid. Treatment chemicals are OCNS rated Gold or Silver (CHARM) or 'D' or 'E' (non-CHARM). Oxygen scavenger and biocide inventories are sufficient to carry out treatment. The well kill is undertaken in accordance with NOGA's Emergency Well Kill Plan (01/HSE/PL17).
Subsea tree replacement	Noise, air and light emissions. Routine overboard emissions of sewage and putrescible waste, cooling and brine water, and bilge water.	Preparedness Tree is maintained in NOGA's Darwin warehouse in accordance with CMMS. Contract with AGR subsea engineering consultancy is in place in order to gain immediate access to engineering expertise.

Strategy	Risks	Control measures
	Discharge of waste. Introduction of IMS.	Contract is in place with WWCI to provide specialist well control engineering services. The Emergency Tree Replacement procedures detail the requirements for mobilisation and deployment of all required equipment and personnel. NOGA has a signed MoU with APPEA for mutual aid assistance in the event of a well blowout to enable it to source equipment and resources from other petroleum operators. NOGA has an established relationship with Clarksons Petou to provide information and brokerage services for emergency response vessels. <u>Response</u> The SST replacement is undertaken in accordance with NOGA's Emergency Tree Replacement procedures (01/HSE/PL16).
Relief well drilling	Noise, air and light emissions. Routine overboard emissions of sewage and putrescible waste, cooling and brine water, and bilge water. Discharge of waste. Introduction of IMS.	<u>Preparedness</u> NOGA has in place a Drilling Relief Well Plan that outlines the key costs and activities to take place in order to activate this response. NOGA has a signed MoU in place with APPEA for the Mutual Aid Agreement with other operators in order to obtain a MODU, support services and equipment. Contractual agreement is in place to ensure mobilisation of well control specialist personnel upon request. Contractual agreement is in place to ensure mobilisation of engineering specialists upon request. Contractual agreement in place to ensure mobilisation of drilling environment advisors upon request. OPEP readiness review exercises are undertaken annually to verify that relief well resources are available for mobilisation. <u>Response</u> The relief well drilling is undertaken in accordance with NOGA's Drilling Relief Well Plan (01/HSE/PL27).
Offshore, nearshore or onshore response		
Wildlife hazing	Noise, air and light emissions. Routine overboard emissions of sewage and putrescible waste, cooling and brine water, and bilge water. Discharge of waste. Introduction of IMS.	<u>Preparedness</u> NOGA has in place contracts/agreements in place with various companies/agencies to provide oiled wildlife response (OWR) at short-notice, including AMOSC, AMSA, OSRL, Programmed Marine Services, Bhagwan Marine, Clarkson Petou, Tutt Bryant (road transport), Air North and CHC helicopters. An OWR NEBA is prepared ahead of developing an Oiled Wildlife Incident Action Plan (IAP).

Strategy	Risks	Control measures
	Hazing of target animals may deter non-target animals from resting, feeding, breeding or other normal behaviours; Euthanasia of affected animals that cannot be treated or have no chance of rehabilitation. The disposal of oily water and detergents washed off animals. The generation and disposal of OWR-related waste (e.g., PPE, transport boxes, used medical supplies such as syringes, etc.). Disturbance/stress due to captivity/ rehabilitation.	NOGA develops an Oiled Wildlife IAP ahead of the deployment of OWR resources. OPEP readiness review exercises are undertaken annually to verify that shoreline protection resources are available for mobilisation. <u>Response</u> OWR activities are undertaken in accordance with the Oiled Wildlife IAP. Authority from the WA DPaW to commence OWR within WA state waters is provided.
Shoreline protection booming	Noise, air and light emissions. Routine overboard emissions of sewage and putrescible waste, cooling and brine water, and bilge water. Discharge of waste. Introduction of IMS. Oil loss during water decanting and oil transfers. Damage to nearshore and shoreline habitats from anchoring and shoreline foot access.	<u>Preparedness</u> NOGA has in place an Oil Pollution First Strike Plan (01-HSE-PL01), OPEP (01-HSE-PL02) and Shoreline Protection Mobilisation Plan (01-HSE-PL07) that detail response activities. NOGA has in place contracts/agreements in place with various companies/agencies to provide oil spill monitoring at short-notice, including AMOSC, AMSA, OSRL, RPS APASA, Programmed Marine Services, Bhagwan Marine, Clarkson Petou, Tutt Bryant (road transport), Air North and Bond/Babcock helicopters. OPEP readiness review exercises are undertaken annually to verify that shoreline protection resources are available for mobilisation. Operational personnel must have IMO1 training. <u>Response</u> Shoreline protection operations are undertaken in accordance with NOGA's Shoreline Protection Mobilisation Plan (01-HSE-PL07). NOGA's Working in Hot Environments (00/HSEQ/OHS/PC09) procedures are enforced during on-site activities. An adequate number of personnel are in place at booming locations to maintain and attend to the operability of booms, including the release of trapped fauna.

Strategy	Risks	Control measures
Containment and recovery	Noise, air and light emissions. Routine overboard emissions of sewage and putrescible waste, cooling and brine water, and bilge water. Discharge of waste. Introduction of IMS. Oil loss during water decanting and oil transfers.	<u>Preparedness</u> NOGA has in place a Containment and Recovery Mobilisation Plan (01-HSE-PL08) that details containment and recovery resources and proposed operations. NOGA has in place contracts/agreements in place with various companies/agencies to provide containment and recovery resources at short-notice, including AMOSC, AMSA, OSRL, RPS APASA, Programmed Marine Services, Bhagwan Marine, Clarkson Petou, Tutt Bryant (road transport), Air North and Bond/Babcock helicopters. Lead Containment and Recovery operational personnel must have IMO1 training. A minimum of three sets of containment and recovery equipment are available in Darwin for mobilisation by Day 3. <u>Response</u> Containment and recovery operations are undertaken in accordance with NOGA's Containment and Recovery Mobilisation Plan (01/HSE/PL08). An oil storage tanker is mobilised to the response location within 3 days of the decision to commence containment and response operations. Vessels do not enter shallow water (<20 m) or protected areas. All vessels used in the containment and recovery operation are washed prior to re-entering the port. Operations will comply with MARPOL Annex 1, Regulation 4.3 (Exceptions). Decanting operations take place during daylight hours only. Water is decanted only into the apex of the containment boom. Decanting only occurs following a minimum residence time of 30 minutes to allow settling of water: oil interface. Records maintained in daily log and include volume decanted, location and date/time.
Shoreline protection booming	Noise, air and light emissions. Routine overboard emissions of sewage and putrescible waste, cooling and brine water, and bilge water. Discharge of waste. Introduction of IMS.	<u>Preparedness</u> NOGA has in place an Oil Pollution First Strike Plan (01-HSE-PL01), OPEP (01-HSE-PL02) and Shoreline Protection Mobilisation Plan (01-HSE-PL07) that detail response activities. NOGA has in place contracts/agreements in place with various companies/agencies to provide containment and recovery resources at short-notice, including AMOSC, AMSA, OSRL, RPS APASA, Programmed Marine Services, Bhagwan Marine, Clarkson Petou, Tutt Bryant (road transport), Air North and Bond/Babcock helicopters.

Strategy	Risks	Control measures
	Oil loss during water decanting and oil transfers. Damage to nearshore and shoreline habitats from anchoring and shoreline foot access.	OPEP readiness review exercises are undertaken annually to verify that shoreline protection resources are available for mobilisation. Operational personnel must have IMO1 training. <u>Response</u> Shoreline protection operations are undertaken in accordance with NOGA's Shoreline Protection Mobilisation Plan (01-HSE-PL07). NOGA's Working in Hot Environments (00/HSEQ/OHS/PC09) procedures are enforced during on-site activities. An adequate number of personnel are in place at booming locations to maintain and attend to the operability of booms, including the release of trapped fauna.

7 Implementation Strategy

NOGA's EMS is the overarching EMS for the field, however for this project environmental management will be managed by the AGR management system.

NOGA has audited the AGR system for compliance with its own. Where there are interfaces, such as for Management of Change (MoC), these interfaces are described in this section.

The AGR Project Manager is responsible for ensuring that all EPO and EPS outlined in this EP are implemented, monitored and complied with for the during of the activity. The AGR Project Manager and AGR systems will also monitor continuously for any new risks arising, or any changes to the activity to ensure all risks are managed to ALARP and acceptable levels for the duration of the activity.

NOGA project personnel and the Asset Manager will monitor AGR performance through daily participation in the morning calls, through review of daily reports and weekly project meetings.

If there are new environmental risks identified or changes in environmental management required, the AGR Project Manager will notify the NOGA Asset Manager and project team immediately.

7.1.1 Roles and Responsibilities

The organisational structure for this project consists of onshore and offshore personnel working for NOGA, AGR, the MODU contractor and UPS. This section provides an overview on what their environmental responsibilities are for key project roles.

AGR will provide the specialised personnel for this project. Project management will be carried out from AGR's office in Perth to enable access to the systems and resources including AGR's drilling emergency response facilities.

Table 7.1 outlines the environmental roles and responsibilities for key personnel involved in the Laminaria-5 reinstatement project. It is important to note that the MODU contractor will retain day-to-day control and management of the MODU through the Offshore Installation Manager (OIM). The OIM has over-riding authority and responsibility to make decisions with respect to environment protection and pollution prevention and to request assistance as may be necessary.

Table 7.1. Environmental roles and responsibilities for key personnel involved with the Laminaria-5 reinstatement project

Role	Responsibilities
NOGA	
Asset Manager	• Provides leadership, direction, technical assurance and financial approval within the delegated authority for well reinstatement and well engineering and intervention operations. • Ensures compliance with the NOGA HSE Policy. • Approves AGR engineering and planning work. • Approves the Laminaria-5 Well Reinstatement Programme and WOMP.
Principal Subsea Engineer	• Ensures AGR's engineering and planning work is in compliance with NOGA standards and company objectives. • Reviews the Laminaria-5 Well Reinstatement Programme and WOMP. • Advises AGR's engineering team on engineering aspects of the project.
HSEC Manager	• Provides HSE advice and assistance to NOGA Asset Manager. • Develops and maintains all HSE-related documentation (EP, ERP, and OPEP) and ensures all HSE approvals are in place prior to MODU mobilisation. • Ensures stakeholder consultation is undertaken and issues arising are closed out in a timely manner. • Monitors environmental performance and reports to the NOGA Asset Manager regarding opportunities for improvement. • Prepares and ensures delivery of environmental content at inductions. • Ensures onging EP compliance inspection are undertaken on the MODU during the project. • Prepares the EP end-of-programme performance report. • Reports environmental incidents to NOPSEMA and other stakeholders. • Participates in audits and incident investigations and assists in the determination of appropriate corrective actions. • Reviews this EP and ensures that resources are in place to ensure it is properly implemented.
AGR	
Project Manager	• Ensures overall compliance with AGR and NOGA HSE policies and standards. • Ensures overall compliance with the accepted EP. • Ensures that NOGA is provided with timely and complete information to enable reports of environmental incidents to regulatory authorities as required. • Leads the Incident Management Team (IMT) in the development of a response strategy in the event of a spill incident. • Monitors Key Performance Indicators (KPIs), ensuring all EP objectives are met. • Ensures all staff and contractors understand their obligations with respect to the management of environmental risk and are appropriately inducted, trained and competent in work activities undertaken. • Reports environmental incidents to the NOGA HSEC Manager.
HSEC Manager	• Provides HSE advice and assistance to NOGA management and AGR.

Role	Responsibilities
	• Manages and monitors closeout of environmental non-conformances, corrective actions and audit recommendations. • Participates in audits and incident investigations and assists in the determination of appropriate corrective actions.
Senior Well Engineer	• Prepares the well design, including intervention, fluids and bleed off programmes. • Prepares Well Barrier Diagrams for each phase of the well reinstatement. • Liaises with key third-party contractors regarding equipment selection and operation for input to well reinstatement designs and programmes. • Prepares data for statutory submissions to regulatory authorities, including the WOMP. • Prepares and participates in well integrity risk assessment.
Subsea Engineer	• Prepares all subsea equipment interfaces and oversees the dual bore riser/ control system refurbishment.
Wellsite Supervisor	• Implements the project on a daily basis on the MODU, in consultation with NOGA's Principal Subsea Engineer and AGR's Project Manager. • Ensures third-party compliance with NOGA's HSE policies and standards. • Ensures all staff and contractors understand their obligations with respect to the management of environmental risk and are appropriately inducted, trained and competent in work activities undertaken. • Reports environmental incidents to the NOGA HSEC Manager. • Assumes the role of On-scene Commander upon activation of the OSCP. • Maintains clear communication between NOGA, AGR, UPS and the MODU contractor.
MODU Contractor	
OIM	• Oversees all work activities and work programs ensuring work is undertaken in accordance with procedures, work instructions and in compliance with all legislative requirements and EP commitments. • Ensures all offshore personnel understand their obligations with respect to the management of environmental risk. • Ensures the MODU training matrix is fully implemented. • Ensure rig-entry HSE inductions are conducted. • Ensures waste disposal complies with MARPOL requirements. • Monitors closeout of non-conformances, corrective actions and audit recommendations. • Reports all incidents, near misses and dangerous occurrences to the AGR Subsea Manager in accordance with the incident reporting system. • Manages and coordinates offshore emergency response activities.
UPS	
FPSO OIM	• Reviews the Laminaria-5 reinstatement program. • Reviews the WOMP. • Undertakes handover and handback of the Laminaria-5 well in accordance with the NOGA procedures. • Participates in any Management of Change reviews that may impact or affect the Laminaria-5 well integrity or WOMP.

Role	Responsibilities
	• Communicates with the UPS Operations Manager for any changes to the reinstatement programme.

7.1.2 Environmental Awareness

Environmental awareness training will be undertaken to ensure that project personnel are aware of their EP-related responsibilities and to ensure environmental risks and impacts are continually being reduced to ALARP, and EPO and EPS are achieved.

For a project of short duration such as the Laminaria-5 reinstatement project, this will be achieved primarily by conducting a HSE induction at the commencement of the activity, with a focus on waste and chemical management, spill prevention and response, and incident reporting mechanisms.

In addition to the initial induction, environmental issues will be covered during the MODU onboarding induction, during daily toolbox talks and weekly HSE meetings to remind personnel of their environmental responsibilities.

7.1.3 Emergency and Oil Spill Response Training

All personnel involved in crisis and emergency management are required to commit to ongoing training, process improvement and participation in emergency and crisis response (both real and simulated).

Training includes task-specific training and role based training. Oil spill task specific training (IMO 2 and 3 or PMAMIR320 and PMAMIR418B)) is typically undertaken by either the Australian Marine Oil Spill Centre (AMOSC) or OSRL, whereas role based training includes a combination of courses (i.e. Command and Control) and 'on the job' experience (i.e. participation in crisis or emergency management exercises). Emergency and oil spill training is undertaken in accordance with a training schedule and exercise schedule.

7.1.4 Reporting

The EP contains a detailed outline and internal and external routine and incident reporting requirements. These requirements will reiterated to all personnel throughout the project.

7.1.5 Auditing and Assurance

Assurance is the process used to provide confidence to NOGA's internal and external stakeholders that its activities are meeting their objectives and delivering on agreed targets. This involves demonstrating that the process and performance risks are being effectively managed.

Environmental assurance activities will be conducted on a continuous basis during the project to:

- Verify environmental impacts and risks are being effectively managed in accordance with this EP;
- Monitor, review and evaluate the effectiveness and compliance with relevant standards, procedures and environmental performance outcomes;
- Verify effectiveness of the Implementation Strategy outlined in the EP; and
- Identify potential non-compliances.

The outputs of the assurance process are the corrective actions that feed the improvement process. Therefore, assurance is a key driver of continuous improvement.
The key means by which the EP commitments will be monitored is through regular inspections by the AGR Wellsite Supervisor. The AGR Wellsite Supervisor will be provided with an EP commitments list (based on the EPO and EPS).

A summary of the commitments provided in the Implementation Strategy is outlined in Table 7.2.

Table 7.2. Summary of the Laminaria-5 implementation strategy commitments

Environmental Performance Objective	Environmental Performance Standard	Measurement criteria
Competency and Training		
All project personnel are aware of their environmental responsibilities.	All project personnel are inducted into the EP commitments and general HSE requirements, along with the MODU-specific HSE requirements.	Induction presentation verifies all necessary information is provided.
		Project induction attendance sheets verify all project personnel are inducted.
		MODU onboarding attendance sheets verify all personnel are inducted.
	Address environmental issues as required during relevant toolbox sessions and Sunday Safety Meetings.	Well Manager and/or Daily Operations Reports records verify that environmental issues are addressed during relevant toolbox sessions and Sunday Safety Meetings.
Project personnel identified as having emergency response responsibilities are adequately trained to fulfil their role.	NOGA and UPS personnel holding positions identified within the IMT will undertake training relevant to their role (e.g., IMO 2/3 or PMAMIR320 and PMAMIR418B).	Certification (relevant to role) verifies training is current for personnel identified on the IMT.
	MODU contractor personnel undertake role-based training relevant to their role (e.g., Command and Control courses, on the job' experience).	Certification (relevant to role) verifies training is current for personnel identified with emergency response roles.
		Training matrix readily identifies currency of training and certifications.
Reporting		
NOGA, AGR, MODU contractor and UPS senior personnel are kept informed of daily project activities.	The AGR Wellsite Supervisor issues a Daily Report to all relevant senior project personnel.	Daily reports and distribution lists verify that all senior project personnel are notified of daily activities.
Regulatory and referral agencies are aware of the project timeframe.	Notification of project start and end dates are communicated to NOPSEMA and the AHO.	Emails (with completed proformas for NOPSEMA) verify that notifications of project start and end dates have been communicated.

Environmental Performance Objective	Environmental Performance Standard	Measurement criteria
NOPSEMA is kept informed of environmental compliance (or breach thereof) in line with regulatory requirements.	Recordable environmental incident report is submitted to NOPSEMA by the 15th of each month.	Completed report is available, with associated email correspondence or website upload, to verify report issue.
	An end-of-project report is submitted to NOPSEMA within 3 months of project completion, outlining compliance against the EPS in this EP.	
	NOPSEMA is notified of all reportable incidents as soon as possible (but at least within 2 hours of occurrence or becoming aware of incident).	Reportable incident reports verify notifications were provided within 2 hours of incident or becoming aware of incident.
Monitoring, Auditing and Managing Compliance		
Emissions and discharges (where measuring capability exists) from the project are quantified.	Environmental monitoring is undertaken in accordance with the requirements of Table 8.4 of the EP.	The project-specific environmental register quantifies measurable (or calculable) emissions and discharges.
Environmental assurance activities are undertaken and reported to ensure the EP is being appropriately implemented.	The Wellsite Supervisor undertakes regular inspections (against the EP commitments register) throughout the MODU to determine EP compliance levels.	Inspection reports verify that inspections are undertaken.
	EP non-compliances are recorded in the AGR GO system and actioned/tracked through to resolution.	Non-compliances are listed and described in the AGR GO system, including actions taken to rectify the issue.
Proposed variations to the project design or environmental management practices are assessed against the relevant MoC procedures.	MoC will be managed in line with NOGA's MoC procedure (00-SP-DOC-PC05) and AGR's Management of Risk and Control of Change procedure (AGR-WDP-M04).	MoC records verify that the MoC process has been appropriately applied.
Emergency Preparedness and Response		
Emergency response strategies are tested to ensure effectiveness.	A desktop exercise involving NOGA, AGR, the MODU contractor and UPS, and undertaken by an independent facilitator, will be undertaken prior to or during the project to test procedures, skills and teamwork.	An emergency response exercise report verifies that the exercise was conducted and that plans are effective.

8 References

ABS. 2017. Population statistics for Darwin. A WWW database accessed at http://stat.abs.gov.au/itt/r.jsp?RegionSummary&region=701&dataset=ABS_REGIONAL_ASGS&geoconcept=REGION&datasetASGS=ABS_REGIONAL_ASGS&datasetLGA=ABS_REGIONAL_LGA&regionLGA=REGION&regionASGS=REGION.

AFMA. 2017. Fisheries. A WWW database accessed at http://www.afma.gov.au/fisheries/. Australian Fisheries Management Authority. Canberra.

AMSA. 2017. Email communication from Luke Pugsley (Nautical and Hydrographic Advisor, AMSA). 14 August 2017. Australian Maritime Safety Authority. Canberra.

APASA. 2012. Marine diesel fuel oil spills and weathering. Memorandum from Trevor Gilbert, Director Maritime, Environment and Chemical Services at APASA, to Phil Harrick, HSEQ Manager, AGR Petroleum Services. 24th June 2012.

APASA. 2013. Northern Endeavour Oil Production Facility Quantitative Spill Risk Assessment. Document Number: DRIMS#9241681. Report produced for Woodside, Perth, WA.

AQIS. 2009 National biofouling management guidance for the petroleum production and exploration industry (AQIS, 2009).

Baker, C., Potter, A., Tran, M. and Heap, A.D. 2008. Sedimentology and Geomorphology of the North West Marine Region of Australia. Geoscience Australia Record 2008/07. Geoscience Australia, Canberra.

Bannister J.L, and Hedley S.L. 2001. Southern hemisphere Group IV Humpback whales: their status from recent aerial survey. *Memoirs of the Queensland Museum* 47 (2): 587-598.

Bannister, J.L., Kemper, C.M. and Warnecke, R.M. 1996. The Action Plan for Australian Cetaceans. Australian Nature Conservation Agency, Canberra.

BHP. 2005. Pyrenees Development Draft Environmental Impact Statement (EIS). BHP Billiton. Perth.

BHP. 1997. Big Bank Shoals of the Timor Sea – An Environmental Resource Atlas. BHP Petroleum, Melbourne.

BoM. 2013. Climate Statistics of Australian Locations A WWW database accessed in 2013 at http://www.bom.gov.au/climate/data/index.shtml. Bureau of Meteorology

BoM. 2017. Cyclone tracks. A WWW database accessed in 2017 at http://www.bom.gov.au/cyclone/history/tracks/index.shtml. Bureau of Meteorology

Brewer, D., Lyne, V., Skewes, T. and Rothlisberg, P. 2007. Trophic systems of the North West Marine Region. A report to the Department of the Environment, Water, Heritage and the Arts by CISRO Marine and Atmospheric Research. August 2007. CSIRO Cleveland.

Bruce, B.D. 2008. The biology and ecology of the white shark (*Carcharodon carcharias*). In M. Camhi, & E. K. Pikitch, Sharks of the Open Ocean (pp 69–81). Blackwell Scientific, Oxford.

CSIRO. 2017. Atlas of Living Australia - various bird species. A WWW database accessed at http://www.ala.org.au. Commonwealth Scientific Industry and Research Organisation.

Currie, D.R. and Isaacs, L.R. 2005. Impact of exploratory offshore drilling on benthic communities in the Minerva gas field, Port Campbell, Australia. *Marine Environmental Research* 59: 217-233.

Dall, W., Hill, B.J., Rothlisberg, P.C. and Staples, D.J. 1990. The biology of the Penaediae. Advances in Marine Biology. J. H. S. a. S. Blaxter, A. J. London, Academic Press. 27: 333-356.

Danoun, R. 2007. Desalination Plants: Potential impacts of brine discharge on marine life. The University of Sydney.

DAWR. 2017. Marine pests interactive map. A WWW database accessed at http://www.marinepests.gov.au/Pages/marinepest-map.aspx. Department of Agriculture and Water Resources. Canberra.

DAWR. 2016. The Australian Ballast Water Management Requirements (v6). A WWW document accessed at http://www.agriculture.gov.au/biosecurity/avm/vessels/ballast/australian-ballast-water-management-requirements-version6. Department of Agriculture and Water Resources.

DEC. 2008. Rowley Shoals Marine Park. Department of Environment and Conservation and Department of Fisheries. Perth.

DEH. 2005. Humpback Whale Recovery Plan 2005-2010. Department of the Environment and Heritage. Canberra.

DEWHA. 2008. The North Marine Bioregional Plan Bioregional Profile. Department of the Environment, Water, Heritage and the Arts. Canberra.

DEWHA. 2008. The North-West Marine Bioregional Plan: Bioregional Profile. Department of Environment, Water, Heritage and the Arts. Canberra.

DNP. 2013. North-west Commonwealth Marine Reserves Network Management Plan 2014-24. Director of National Parks.

DNP. 2017a. Draft North-west Commonwealth Marine Reserves Network Management Plan. 2017. Director of National Parks. Canberra.

DNP. 2017b. Draft North Commonwealth Marine Reserves Network Management Plan. 2017. Director of National Parks. Canberra.

DNV. 2011. Assessment of the Risk of Pollution from Marine Oil Spills in Australian Ports and Waters. Final Report. Report No PP002916, Rev 4. Report for Australian Maritime Safety Authority. Det Norske Veritas. London.

DoE. 2014. Approved Conservation Advice for *Glyphis garricki* (northern river shark). Department of the Environment. Canberra.

DoE. 2015a. Approved Conservation Advice for *Pristis pristis* (largetooth sawfish). Department of the Environment. Canberra.

DoE. 2015b. Approved Conservation Advice for Green Sawfish. Department of the Environment. Canberra.

DoE. 2015c. Conservation Management Plan for the Blue Whales 2015-2025. Department of the Environment. Canberra.

DoEE. 2017a. Biologically Important Areas. A WWW database accessed at http://www.environment.gov.au/marine/marine-species/bias. Department of the Environment and Energy. Canberra.

DoEE. 2017b. Species Profile and Threats Database. A WWW database accessed at http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl. Department of the Environment and Energy. Canberra.

DoEE. 2017c. Recovery Plan for Marine Turtles in Australia. A WWW database accessed at http://www.environment.gov.au/marine/publications/recovery-planmarine-turtles-australia-2017. Department of the Environment and Energy. Canberra.

DoEE. 2017d. Key Ecological Features. A WWW database accessed at https://environment.gov.au/sprat-public/action/kef/view/62. Department of the Environment and Energy. Canberra.

DoEE. 2017e. EPBC Area Protected Matters Report, run on 1 May 2017. http://www.environment.gov.au/epbc/pmst/index.html. Department of the Environment and Energy. Canberra.

DoEE. 2017f. Australia's Commonwealth Heritage List. A WWW database accessed at http://www.environment.gov.au/topics/heritage/heritage-places/ commonwealth-heritage-list. Department of the Environment and Energy. Canberra.

DoEE. 2017g. Australia's World Heritage List. A WWW database accessed at http://www.environment.gov.au/heritage/places/world-heritage-list. Department of the Environment and Energy. Canberra.

DoEE. 2017h. Australia's National Heritage List. A WWW database accessed at http://www.environment.gov.au/heritage/places/national-heritage-list. Department of the Environment and Energy. Canberra.

DoEE. 2017i. Australian Ramsar Wetlands. A WWW database accessed at http://www.environment.gov.au/cgi-bin/wetlands/alphablist.pl. Department of the Environment and Energy. Canberra.

DoEE. 2017j. Nationally Important Wetlands. A WWW database accessed at http://www.environment.gov.au/cgi-bin/wetlands/search.pl?smode=DOIW. Department of the Environment and Energy. Canberra

DoEE. 2017k. Australian National Shipwreck Database. A WWW database accessed at https://dmzapp17p.ris.environment.gov.au/shipwreck/public/wreck/search.do;jsessionid=624517E77FC8FA606AA179083E0882B1. Department of the Environment and Energy. Canberra.

Double, M.C., Gales, N., Jenner, K.C.S. and Jenner, N.M. 2010. Satellite tracking of south-bound female humpback whales in the Kimberley region of Western Australia. Australian Marine Mammal Centre, Kingston.

Double, M.C., Jenner, K.C.S., Jenner, M.N., Ball, I., Childerhouse, S., Laverick, S., and Gales, N. 2012a. Satellite tracking of northbound humpback whales (*Megaptera novaeangliae*) off Western Australia. Draft Final Report. Australian Marine Mammal Centre, December 2012, unpublished.

Double, M.C., Jenner, K.C.S., Jenner, M.N., Ball, I., Laverick, S., and Gales, N. 2012b. Satellite tracking of pygmy blue whales (*Balaenoptera musculus brevicauda*) off Western Australia. Final report to Woodside Energy Ltd. Australian Marine Mammal Centre, May 2012.

Double, MC, Andrews-Goff, V, Jenner, KCS, Jenner, M, Laverick, SM, Branch, TA and NJ, Gales (2014). Migratory movements of pygmy blue whales (*Balaenoptera musculus brevicauda*) between Australia and Indonesia as revealed by satellite telemetry. PLOS ONE vol. 9 (4): 1-11.

DSEWPaC. 2013. Recovery Plan for the White Shark (Carchardon carcharias). Department of Sustainability, Environment, Water, Population and Communities. Canberra.

DSEWPaC. 2012a. Marine Bioregional plan for the North-west Marine Region. Department of Sustainability, Environment, Water, Population and Communities. Canberra.

DSEWPaC. 2012b. Species Group report card – marine reptiles Supporting the marine bioregional plan for the North-west Marine Region. Department of Sustainability, Environment, Water, Population and Communities. Canberra.

DSEWPaC. 2011a. Marine bioregional plan for the North-west Marine Region. Draft for Consultation. Department of Sustainability, Environment, Water, Population and Communities. Canberra.

DSEWPaC. 2011b. National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016. Department of Sustainability, Environment, Water, Population and Communities. Australian Antarctic Division. Canberra.

Dunlop, N.J., Surman, C.A. and Wooller, R.D. 1995. Distribution and abundance of seabirds in the eastern Indian Ocean: an analysis of potential interactions with the offshore petroleum industry, Report to APPEA, Canberra.

Eni. 2007a. Marine Mammal Observer Field Report for September 2007, Final report from Western Whale Research for Eni Timor Leste. 13 pp.

Eni. 2007b. Marine Mammal Observer Field Report for December 2007, Final report from Western Whale Research for Eni Timor Leste. 11 pp.

Flegg, J. 2003. Photographic Field Guide. Birds of Australia. 2nd Edition. Australian Museum/Reed New Holland Publications. Sydney.

Fletcher, W.J., Mumme, M.D., and Webster, F.J. (eds) 2017. Status Reports of the Fisheries and Aquatic Resources of Western Australia 2015/16: The State of the Fisheries. Department of Fisheries. Perth.

FRDC. 2017. Status of Australian Fish Stocks Reports. A WWW database accessed at http://www.fish.gov.au. Fisheries Research Development Corporation.

French-McCay, D.P. 2004. Oil spill impact modeling: Development and validation. Environmental Toxicology and Chemistry. 23(10):2441–2456.

Gilmore, J.P., Smith, L.D., Heywood, A.J., Baird, A.H. and Pratchett, M.S. 2013. Recovery of an isolated coral reef system following severe disturbance. *Science Daily*. A WWW article accessed at http://www.sciencedaily.com.

Hale, J. and Butcher, R. 2013. Ashmore Reef Commonwealth Marine Reserve Ramsar Site. Ecological Character Description. A report to the Department of Environment. Canberra.

Heyward, A., Jones, R., Meeuwig, J., Burns, K., Radford, B., Colquhoun, J., Cappo, M., Case, M. O'Leary, R., Fisher, R., Meekan, M. and Stowar, M. 2012. Monitoring Study S5 banks and Sholas, Montara 2011 Offshore banks Assessment Survey. Report for PTTEP Australasia (Ashmore Cartier) Pty. Ltd. Australian Institute of Marine Science. Townsville.

Heyward, A., Moore, C., Radford, B. and Colquhoun, J. 2010. Monitoring Program for the Montara Well Release Timor Sea: Final Report on the Nature of Barracouta and Vulcan Shoals. Report prepared by the Australian Institute of Marine Science for PTTEP Australasia (Ashmore Cartier) Pty Ltd.

Heywood, A., Moore, C., Radford, B. and Colquhoun, J. 2010. Monitoring Program for the Montara Well Release Timor Sea: Final Report on the Nature of Barracouta and Vulcan Shoals. Report prepared by the Australian Institute of Marine Science for PTTEP Australasia (Ashmore Cartier) Pty Ltd.

Holloway, P.E. and Nye, H.C., 1985. Leeuwin Current and wind distributions on the southern part of the Australian North West Shelf between January 1982 and July 1983. *Australian Journal of Marine and Freshwater Research* 36: 123-137.

Hooper, J.N.A. 1994. Coral reef sponges of the Sahul Shelf — a case for habitat preservation. *Memoirs of the Queensland Museum* 36: 93–106.

Inpex. 2010. Ichthys Gas Field Development. Draft Environmental Impact Statement. Inpex Browse Ltd. Perth.

ITOPF. 2011. Effects of Oil Pollution on the Marine Environment. Technical Information Paper. Technical paper No. 13. The International Tank Owners Pollution Federation Limited.

Jenner, K.C.S., Jenner, M.N.M. and McCabe, K.A. 2001. Geographical and temporal movements of humpback whales in Western Australian waters, APPEA Journal 2001: 749-765.

Kimberley Coast. 2014. Adele Island. A WWW resource accessed at http://kimberleycoast.com.au/iconic-places/adele-island.

Kinloch, M., Summerson, R. and Curran, D. 2003. Domestic vessel movements and the spread of marine pests. Risks and management approaches. A report to the Department of Agriculture, Fisheries and Forestry.

Last, P.R. and Stevens, J.D. 2009. Sharks and Rays of Australia (Second Edition). CSIRO Publishing. Victoria.

Lindquist, D., Shaw, R. and Hernandez, F Jr. 2005. Distribution patterns of larval and juvenile fishes at offshore petroleum platforms in the north-central Gulf of Mexico. *Estuar Coast Shelf Sci* 62(4):655–665.

Marquenie, J., Donners, M., Poot, H., Steckel, W. and de Wit, B. 2008. Adapting the spectral composition of artificial lighting to safeguard the environment, Petroleum and Chemical Industry Conference Europe – Electrical and Instrumentation Applications, 2008, PCIC Europe 2008.

Meekan, M. G., Wilson, S. G., Halford, A. and Retzel, A. 2001. A comparison of catches of fishes and invertebrates by two light trap designs, in tropical NW Australia. *Mar. Biol.* 139: 373 – 381.

MESA. 2017. Marine Pests of Australia. New Zealand Screw Shell. A WWW database accessed at http://www.mesa.edu.au/marine_pests/ marine_pests07.asp. Marine Education Society of Australasia.

Milicich, M. J., Meekan, M. G. and Doherty, P. J. 1992. Larval supply: a good predictor of recruitment in three species of reef fish (Pomacentridae). *Mar Ecol Prog Ser*. 86: 153-166.

OSPAR. 2005. Flaring of oil, condensate and gas from well testing. Justification for the conclusion that there is no need for a Background Document on flaring of oil, condensate and gas from well testing. OSPAR Commission.

Patterson, H., Noriega, R., Georgeson, L., Stobutzki, I. and Curtotti, R. 2016. Fishery status reports 2016. Australian Bureau of Agricultural and Resource Economics and Sciences. Canberra.

Pearce, A., Buchan, S., Chiffings, T., D'Adamo, N., Fandry, C., Fearns, P., Mills, D., Phillips, R. and Simpson, C. 2003. A review of the oceanography of the Dampier Archipelago, Western Australia. Museum of Western Australia, Perth.

Pinceratto, E. 1997. 'Physical environment', in Heyward, A., Pinceratto, E. and Smith, L. (eds), Big bank shoals of the Timor Sea: an environmental resource atlas, BHP Petroleum, Melbourne, pp. 7–12.

Pinceratto. E.J., and Oliver, G. 1996. Cooperative industry approach to environmental investigations in the Timor Sea. *APPEA Journal* 36(1): 650-654.

Pinzone, G. 2013. Personal observations of resting seabirds on the *Stena Clyde* semi-submersible drill rig. Kidukidu-1 well, Gulf of Papua. August 2013. Giulio Pinzone, Principal Environmental Consultant, Aventus Consulting Pty Ltd.

Shaw, R. F., Lindquist, D. C., Benfield, M. C., Farooqi, T., Plunket, J. T. 2002. Offshore petroleum platforms: functional significance for larval fish across longitudinal and latitudinal gradients. Prepared by the Coastal Fisheries Institute, Louisiana State University. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2002-077, p. 107.

Shell. 2009. Prelude Floating LNG Project. Draft Environmental Impact Statement. EPBC 2008/4146. Shell Development (Australia) Pty Ltd. October 2009.

Simmonds, M., Dolman, S. and Weilgart, L. 2004. Oceans of Noise. Whale and Dolphin Conservation Society. Wiltshire.

Smith, L., Cook, K. and Pincock, S. 2013. Discovering Scott Reef. 20 Years of Exploration and Research. Woodside & the Australian Institute of Marine Science.

Thorburn, D.C., Peverell, S., Stevens, S., Last, J.D., and Rowland, A.J, 2003. Status of freshwater and estuarine elasmobranchs in Northern Australia. Report to Natural Heritage Trust, Canberra

TSSC. 2014. Listing Advice. *Isurus oxyrinchus* (shortfin mako). Threatened Species Scientific Committee.

TSSC. 2015a. Conservation Advice Megaptera novaeangliae (humpback whale). Threatened Species Scientific Committee. A WWW publication accessed in 2016 at http://www.environment.gov.au/biodiversity/threatened/species/pubs/38-conservation-advice-10102015.pdf

TSSC. 2015b. Conservation Advice *Balaenoptera physalus* (fin whale). Threatened Species Scientific Committee.

TSSC. 2015c. Conservation Advice *Balaenoptera borealis* (sei whale). Threatened Species Scientific Committee.

URS. 2001. Review of Environmental Impacts of Petroleum Exploration and Appraisal Activities in Commonwealth Waters. Report prepared for the Department of Science & Resources.

Walker, D.I. and McComb, A.J. 1990. Salinity response of the seagrass *Amphibolus antartica*: an experimental validation of field results. Aquatic Botany 36: 359-366.

Wiese, F. K., Montevecci, W. A., Davoren, G. K., Huettmann, F., Diamond, A. W. and Linke, J. 2001. Seabirds at risk around off shore oil platforms in the northwest Atlantic. *Mar. Poll. Bull*. 42:1285-1290

Woodside. 2011. Browse LNG Development. Draft Upstream Environmental Impact Statement. EPBC Referral 2008/4111. Woodside Energy Ltd. Perth.

Woodside. 2008. Browse LNG Development. Torosa South-1 Pilot Appraisal Well Environment Plan. Woodside Energy Ltd. Perth.